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Appendix D: Drainage and Stormwater Management Report

The Regional Municipality of Halton

Regional Road 25 Transportation Corridor Improvements MCEA

Drainage and Stormwater Management Report
Volume I – Main Report

Tuesday, August 4, 2026

CIMA+ Project No. B001514

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The Regional Municipality of Halton

Drainage and Stormwater Management Report

Regional Road 25 Transportation Corridor Improvements MCEA

From Speers Road to Derry Road West

CIMA+ Project no B001514

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1 Introduction

1.1 Project Description

The Regional Municipality of Halton has retained CIMA+ to complete a Schedule C Municipal Class Environmental Assessment (MCEA) for the improvements of Regional Road 25 from Speers Road to Derry Road West. The study area is shown in Figure 1 below.

Figure 1: Study Area Location

Located near the geographic centre of Halton Region, Regional Road 25 (RR25) is a key north-south arterial corridor that spans the Region and serves as a vital transportation spine, connecting the communities of Oakville, Milton, and Halton Hills.

Currently, this segment of RR25 consists of a four-lane cross-section, with two lanes in each direction and auxiliary turning lanes at all signalized intersections. The proposed project involves widening RR25 to an urban six-lane cross-section, incorporating active transportation facilities within a 47-metre right-of-way.

Within the project limits, there are twenty-five (25) drainage crossing structures including the Sixteen Mile Creek bridge located between Derry Road West and Speers Road. Culverts C01 through C11 drain west to east and discharge into Fourteen Mile Creek.

Culverts C13 through C24 discharge into Sixteen Mile Creek. The entire study area falls under the jurisdiction of Conservation Halton (CH).

1.2 Study Purpose

This Drainage and Stormwater Management (SWM) Report outlines the key characteristics of the existing and proposed drainage systems. It documents the hydrologic assessments conducted to support stormwater management design, including the reconfiguration of existing drainage features and the design of new infrastructure required to accommodate the proposed roadway improvements and hydraulic assessment of drainage crossings as well as the preliminary design for the mitigation of impact to the regulated areas.

1.3 Scope of Work

The scope of work entails the following key tasks:

- Conduct a comprehensive assessment of the existing drainage system, including flow patterns, system constraints, and design requirements, in accordance with current standards and policies.
- Develop drainage mosaics illustrating contributing drainage areas, outlet locations, and existing/proposed stormwater management facilities.
- Assess and document overland flow targets or both existing and proposed conditions, covering the road corridor and external drainage areas, and assess the need for peak flow control measures.
- Design both major and minor drainage systems, including new storm sewer components as required.
- Hydraulic assessment and flood hazard assessment of the preliminary design.
- Preliminary design of measures necessary to mitigate impacts to the regulated area.
- Evaluate the capacity of the existing storm sewer system and design upgrades or new components to accommodate future flows.
- Investigate opportunities for incorporating Low Impact Development (LID) measures and assess stormwater quality and quantity control requirements in accordance with the Region’s, Towns’ and Conservation Halton’s (CH) guidelines.

All project related maps and figures are included in Appendix A.

1.4 Potential Drainage Impacts

Road improvement projects can alter existing drainage patterns and impact watercourse characteristics, primarily due to the increase in impervious surfaces and associated construction activities. Potential impacts may include:

- Increased surface runoff, resulting in higher peak flow rates and greater erosion potential within receiving watercourses.
- Elevated pollutant and sediment loading in stormwater and meltwater runoff.
- Alterations to watercourse morphology, affecting base flows, flood levels, flood plain and overall water quality.
- Modifications to existing drainage boundaries due to road widening and associated construction activities.
- Disruption or modification of hydrologically significant features such as natural ponding areas, infiltration zones, and existing dams.

2 Background Information and Site Description

2.1 Background Information Review

The following documents have been reviewed as a part of the study:

- Town of Oakville Development Engineering Procedures and Guidelines, September 2023
- Town of Milton Engineering and Parks Standards Manual, September 2024
- Conservation Halton Guidelines for Stormwater Management Engineering Submissions, June 2024
- Stormwater Management Planning and Design Manual, 2003 of Ministry of Environment, Conservation and Park (MECP) (former MOE)
- Highway Drainage Design Standards, Ontario Ministry of Transportation (MTO), 2023
- Erosion and Sediment Control Guide for Urban Construction. TRCA 2019
- Soil Survey Reports on43, Soil Survey Reports for Ontario, 1971
- Runoff Volume Control Targets for Ontario, prepared for MECP by Aquafor Beech Limited, October 2016
- Various as-built drawings of Regional Road 25 between Derry Road & Speers Road

- Stormwater Management Pond Design Brief Bronte Creek-Phase 1 (Bronte SE Facility) Monarch/Liptay Partnership, prepared by Stantec Consulting Ltd., October 2003.
- Bronte Creek Phase 1 Stormwater Management Facility Operation and Maintenance Manual, prepared by Stantec Consulting Ltd., July 2015
- Stormwater Management Design Brief, Upper Glen Abby Greens within the West Oak Trails Community Extension, prepared by Urbantech Consulting, October 2003.
- Dundas Street (Regional Road 5) Corridor Improvement, Brant Street to Bronte Road Class EA Study, MMM, May 2015.
- Fourteen Mile Creek and McCraney Creek Watershed Planning Study, Triton Engineering Services, Feb 1992.
- Sixteen Mile Creek Watershed Plan,1996
- Halton Region, Extension and Raised Median on Bronte Road, prepared by D.M. Wills Associates Ltd., Aug 2021
- Site Plan of various development works in the vicinity of Regional Road 25
- Various HEC-RAS Models received from Conservation Halton, which are:
    - Folder: A07012, Models: 14mc.prj, Model for Fourteen Mile Creek, vertical datum CGVD28:78. This model is not georeferenced.
    - Folder: A09M70, Models: Milton_Operations_centre.prj, vertical datum CGVD28:78. The model is georeferenced but not in UTM coordinate system.
    - Folder: A11M78, Models: 16MileWestReach5.prj, Model for Sixteen Mile Creek tributary, Reach 5, vertical datum CGVD28:78. The model is georeferenced.
    - Folder: A12O42, Models: 14_Mile_E_Bronte_19Jun14.prj, vertical datum CGVD28:78. The model is not georeferenced.
    - Folder: A15M49, Models: SWS2A_Proposed_Geo.prj, vertical datum CGVD28:78. The model is georeferenced. It is for Sixteen Mile Creek tributary, Reach SWS-2-A.
    - Folder: A16M67, Model: SWtributary.prj, Model for Sixteen Mile Creek tributary, vertical datum CGVD28:78
    - Folder: 16MC, Model: 16MC.prj, This model is for Sixteen Mile Creek and the model is georeferenced with vertical datum CGVD28:78.

    - Folder: Generic Regulations, Model: 1) BronteMain.prj, 2) 16MileWest reach4.prj, vertical datum CGVD28:78. The model is georeferenced.
    - Folder: MPR571, Model: Reach2.prj, Vertical datum CGVD28:78 The model is georeferenced. This model is valid only to the downstream of Upper Middle Road.
    - Folder: Urban_Milton, Model: HEC-RASModel-Trim.prj, The model is georeferenced and a trimmed version of Sixteen Mile Creek model. The vertical datum for this model is CGVD2013
- Spill Flood Hazard Policies Technical Guide, April 2025 of Conservation Halton
- South Milton Urban Expansion Area Subwatershed Study, prepared by Amec Foster Wheeler, Feb 2023
- External Storm Drainage Area Plan, West Country Milton Property LTD Phase 1, prepared by TMIG, March 2015
- SWM POND ‘ I’ Plan view, West Country Milton Property LTD Phase 1, prepared by TYLIN, March 2015
- Boyne Survey Block 2 Subwatershed Impact Study, prepared by MTE Consultants, August 2016

2.2 Site Investigation

A field investigation of the existing drainage features along Regional Road 25 was conducted by CIMA+ staff on July 23, 2024. The objective of the investigation was to assess current drainage conditions, verify drainage patterns, document the physical characteristics of existing roadside ditches and storm inlets, identify areas of erosion, and provide recommendations for rehabilitation or replacement where necessary.

The site reconnaissance involved both office and field tasks, completed following a review of background information and notes from previous studies.

The following activities were conducted during the field inspection:

- Visual inspection of all roadside ditches and storm inlets within the study limits, including both upstream and downstream ends. Observations included the type, size, material, condition, cover depth, and flow direction.
- Assessment of upstream and downstream channel characteristics to evaluate flow conditions and physical features.
- Inspection of road embankments and channel banks to identify areas showing signs of erosion or instability.

- Compilation of a photographic inventory of all existing roadside ditches on both sides of the corridor within the study area.
- Verification of drainage divide lines to confirm the overall drainage mosaic and watershed boundaries.
- Identification and documentation of any visible deficiencies in the existing highway drainage system.

Following deficiencies are observed during field inspection:

- The ditch downstream of Culvert C23 is overgrown with vegetation and requires clearing.
- Invasive plant species have been identified around the downstream ends of Culverts C20 and C22; removal is recommended.
- Dense vegetation downstream of Culvert C21 should be cleared to restore proper flow conditions.
- The downstream end of Culvert C14 is severely damaged, with evidence of erosion; rehabilitation is required.
- Downstream sections of Culverts C12 and C13 are obstructed by heavy vegetation, which should be removed.
- Vegetation overgrowth has rendered the downstream end of Culvert C10 inaccessible; invasive species should be cleared to allow for inspection and maintenance.
- Sediment accumulation and upstream corrosion were observed at Culvert C09; cleaning and structural evaluation are recommended.
- Excessive vegetation was noted around the downstream end of Culvert C05; removal is necessary.
- Vegetation around the downstream end of Culvert C06 requires clearing to maintain flow capacity.

There are four (4) bridges within the study limit. Bridges B01 to B03 are for rail and roadway crossings. Only Bridge B04 is for watercourse crossing, this bridge conveys flow of Sixteen Mile Creek.

Table 1 below provides the summary and condition of existing culverts and **Volume II Appendix A** includes photographs of the drainage site investigation.

Table 1: Summary and Condition of Existing Culverts

Drainage Culvert ID	Structure ID	Sta. No.	Location	Flow Direction	Invert U/S	Invert D/S	length (m)	Size	Material	Shape	Condition	Potential Action
C01	25-1157510 CU01	2+995	365 m South of Upper Middle Road	West to East	125.52	125.17	40.1	3660mm Span x 2440mm Rise	Concrete	Open footing with low flow channel	Not accessible	Retain / Extension
C02	25-1157510 CU03	3+132	227 m South of Upper Middle Road	West to East	126.27	125.93	47.5	1830mm Span x 1520mm Rise	Concrete	Box	Not accessible	Retain / Extension, if only meets hydraulic requirement
C03	25-1157560 CU01	3+565	205 m North of Upper Middle Road	West to East	123.62	123.54	47	Twin 4200mm Span x 2800mm Rise	Concrete	Twin Culvert, Box	Not accessible	Retain
C04	n/a	5+955	155 m North of William Halton Parkway	West to East	156.32	156.19	47.5	1050mm	HDPE	Circular, Smooth Inside	Good Heavy vegetation on both u/s and d/s ends	Extend if meets hydraulics
C05	n/a	6+565	347 m South of 407 ETR	West to East	162.79	162.54	44.1	2100mm Span x 1600mm Rise	CSP	Arch	Fair Heavy vegetation on downstream, require cleaning	May need to replace depending on hydraulics
C06	25-1157720 CU01	7+421	103 m South of Burnhamthorpe Road	West to East	169.95 170.08	169.19 169.20	34.0	Twin 800mm	CSP	Twin, Circular	Fair Requires vegetation cleaning on downstream end	May need to replace depending on hydraulics
C07	25-1157750 CU04	7+734	209 m North of Burnhamthorpe Road	West to East	171.70 171.68	171.36 171.57	37.1	Twin1200mm Span x 900mm Rise	CSP	Arch	Fair Ends are in good condition but corrosion at bottom	Replace
C08	25-1157750 CU05	7+960	430 m North of Burnhamthorpe Road	West to East	172.66	172.46	38.7	2400mm Span x 900mm Rise	Concrete	Twin, Box	Good condition	Extend, if it works for road widening
C09	25-1157750 CU06	8+356	89 m South of Henderson Road	West to East	179.02	178.46	39.1	1200mm	CSP	Circular	U/s face distorted, sediment accumulation at the bottom, light corrosion at bottom	Replace
C10	25-1157810 CU03	8+570	128 m North of Henderson Road	West to East	185.11	184.01	38.9	900mm	CSP	Circular	U/s fair condition. Heavy invasive plant species on downstream, culvert not visible, requires cleanout	Depending on road widening, this may need to be eliminated
C11	25-1157810 CU01	8+812	370 m North of Henderson Road	West to East	189.45	189.02	34.9	1550mm Span x 1200mm Rise	CSP	Arch	Fair condition, bottoms are corroded	Replace
C12	25-1157810 CU05	9+149	707 m North of Henderson Road	East to West	187.15	187.03	35.1	800mm	CSP	Circular	Fair condition. Significant vegetation on the downstream channel, cleanout required.	Replace
C13	25-1157810 CU02	9+415	394 m South of Lower Base Line	East to West	183.33	182.92	35.9	1200mm	CSP	Circular	Fair condition. Significant vegetation and blockage on downstream end.	Replace
C14	25-1157820 CU01	9+754	55 m South of Lower Base Line	East to West	178.39	178.09	35.0	900mm	CSP	Circular	Poor condition. Downstream end damaged. Erosion observed on d/s end.	Replace
C15	25-1157850 CU05	10+000	190 m North of Lower Base Line	West to East	173.49	173.31	48.2	7315 m Span x 1830m Rise	Concrete	Conspan Arch	Good condition. U/s Opening 1.9m, d/s opening 1.6m	Retain. May need to increase retaining wall height
C16	25-1157850 CU07	10+418	610 m North of Lower Base Line	West to East	178.05	178.17	34.2	1550mm Span x 1000mm Rise	CSP	Arch	Fair condition. Observed sediment deposition and corrosion at the bottom of the culvert.	Replace
C17	25-1157860 CU01	11+247	50 m North of Halton Waste Management Access	West to East	178.57 178.60	178.17 178.18	38.1	Twin 800mm	CSP	Twin, Circular	Good condition, however, significant sediment accumulation on the upstream end. Opening available on upstream is about 0.50m only.	Replace
C18	25-1157860 CU03	11+455	260 m North of Halton Waste Management Access	West to East	177.01	176.55	36.4	1200mm	CSP	Circular	Good condition, however, only 0.60m opening available on downstream end. Upstream good.	Replace
C19	25-1157860 CU05	11+650	450 m North of Halton Waste Management Access	West to East	175.10	175.10	43.4	6100 m Span x 1900m Rise	Concrete	Arch	Good condition. U/s Opening 1.9m, d/s opening 1.6m due to siltation	Retain and extend
C20	n/a	12+840	40 m South of Britannia Road	East to West	182.14	181.80	38.4	1200mm	Concrete	Circular	Good condition but requires cleaning on the downstream end for the invasive plant species.	Extend
C21	25-1157910 CU02	12+946	78 m North of Britannia Road	East to West	183.42	183.28	39.1	1200mm	Concrete	Circular	Good condition. Headwall with grates on downstream, no grates on upstream. Vegetation cleanout is required on the downstream channel.	Extend
C22	25-1157910 CU03	13+440	258 m North of Etheridge Avenue	East to West	186.05	185.81	31.6	1830mm Span x 910mm Rise	Concrete	Box	Good condition Cleanout is required on the d/s channel.	Extend, if meets hydraulic requirements
B04	25-1157950 BR01	14+730	307 m North of Louis St. Laurent Avenue	West to East	Deck width 23.5m			30m span	Concrete	Bridge	Good condition	Widen bridge deck
C23	25-1157950 CU01	15+245	720 m South of Derry Road	East to West	183.82	183.59	31.6	1830mm Span x 910mm Rise	Concrete	Box	Good condition. significant sediment accumulation. Available opening on the downstream is only 0.40m.	Extend
C24	25-1157950 CU03	15+720	250 m South of Derry Road	East to West	183.43	182.955	46.9	3300mm Span x 3000mm Rise	Concrete	Box	Culvert on deep Vallely. Structural condition is poor.	Replace

3 Design Standard and Criteria

3.1 Design Criteria

This section provides an overview of the SWM design criteria for the study area. These criteria are based on the Town of Milton Engineering and Parks Standards Manual (2024), Town of Oakville Development Engineering Procedures and Guidelines (2023), Conservation Halton Guidelines for Stormwater Management Engineering Submissions (2024), Ministry of the Environment, Conservation and Parks (MECP) and the Ontario Ministry of Transportation (MTO) Highway Drainage Design Standards (2023).

3.1.1 Region of Halton Requirements

Currently Halton Region does not have any specific guideline for Drainage and Stormwater Management design. Therefore, site specific requirements based on municipal jurisdiction, Conservation Halton, MTO Highway Drainage Design Standards are considered for the design.

3.1.2 Town of Oakville Requirements

The requirements of the Town of Oakville include:

- The system of street gutters, catch basins, and storm sewers shall be designed for the 5-year storm
- The 100-year return period storm shall be used for the major system design.
- The 24-hour Chicago design storm distribution type should be used to develop hydrographs for urban and rural basins and for determining the required detention storage.
- Post- to pre-development peak flow for the 10-year, 25-year and 100-year storms.
- The minimum initial time of concentration (tc) is to be 10 minutes.
- For circular concrete pipes, the minimum acceptable full flowing velocity is 0.75 m/second, and the maximum acceptable full flowing velocity is 4.0 m/second.
- Restrict the change on velocity between the inlet and outlet pipes to 0.6 m/second.
- Water quality controls are to be implemented on all developments in accordance with the applicable approved subwatershed plan/EIR or the established criteria for the receiving body. The Stormwater Management Planning and Design

Manual (MOE 2003) shall be referenced for the appropriate method of quality control to achieve the targeted levels per the given receiving system.

- LID facilities are to be sized to retain runoff occurring from a 25 mm event

3.1.3 Town of Milton Requirements

The requirements of the Town of Milton include:

- The minor or conveyance system, comprising of street gutters, catch basins and storm sewers, shall be designed to a 1 in 5-year un-surcharged standard.
- The design flow in any pipe section shall not exceed 85 % of the full flow capacity of the pipe section.
- In no case shall the gradient be less than 0.5% for pipes less than or equal to 525 mm in diameter, and 0.25% for pipe greater than or equal to 600 mm in diameter.
- Inlet time of Concentration (Tc) to be considered for storm sewer design is 10 minutes.
- Generally, the obvert of storm sewers are to be placed 1.5 m below the finished grade at the centreline of the road or at a minimum 1.0 m below the dwelling basement floor elevation. In special circumstances storm sewers with less than 1.5 m of cover will be permitted. Storm sewers with less than 1.2 m of cover must be insulated and have calculations provided in accordance with OPSD 1109.030.
- Under full flow conditions, the allowable velocity is to be no less than 0.75 m/s and no greater than 6.0 m/s, unless otherwise approved by the Town.
- It is required to provide water quality control in accordance with the specified level of control outlined within the higher-level study (where available). Where a higher level study does not exist, the Town requires Level 1 Protection (Enhanced – 80% Average Annual Removal of Total Suspended Solids) for all developments.

3.1.4 Conservation Halton (CH) Requirements

Requirements of CH were extracted from the Conservation Halton's Stormwater Management Engineering Submission Guidelines, June 2024. The following is a summary of the stormwater management requirements:

- **SWM Quantity Control**: Control post-development flows to pre-development levels for 1:2-year through 1:100-year storm events.

- **Erosion Control**: CH typically recommends that the runoff from a 25 mm design storm be retained or detained and released over a period of at least 24-hours for sites, even those sites that outlet directly to a storm sewer.

3.1.5 MECP Design Requirements

The MECP Stormwater Management Planning and Design Manual 2003 has included following guidelines for runoff quality and quantity control.

a) Water Quality and Quantity

- Additional stormwater runoff from new pavement can impact receiving watercourse and flood conditions. Quality and quantity control measures to treat stormwater runoff should be considered for all new impervious areas and, where possible, existing surfaces.
- A Stormwater Management Plan should be prepared in accordance with the MECP Stormwater Management Planning and Design Manual 2003.

b) Runoff Volume Control Targets

The MECP developed Runoff Volume Control targets (RFCT) for Ontario for linear infrastructure and retrofits to provide guidance for the implementation of low impact development. The report titled Runoff Volume Control Targets for Ontario was prepared by Aquafor Beech in October 2016 for MECP and recommends the following:

- For linear roadway reconstruction projects, the recommendation is to achieve volume control to the Maximum Extent Possible (MEP) using all known, available, and reasonable methods, given the site restrictions to achieve the maximum volume control.

3.1.6 MTO Hydraulic Design Standards

The MTO's Highway Drainage Design Standards prescribe standards for designing Surface Drainage Systems (SD) and Water Crossings (WC). The standards that are relevant to this study are as follows:

- **WC-1 Design Flows (Bridges and Culverts**): The minimum Design Flow for structure on urban arterial road is 50 year with total span less than or equal to 6.0 m and 100 year with total span greater than 6.0 m.
- **WC-7 Culvert Crossings on a Watercourse**: The minimum freeboard to the edge of pavement at or near the culvert during the design storm is 1.0 m. However, due to site specific constraints, this may not be achieved in every culvert structure.

3.1.7 Rainfall IDF and Storm Distribution

Intensity-Duration-Frequency (IDF) parameters for various return period design storms were obtained from the Town of Milton Engineering and Parks Standards Manual (2024) and Town of Oakville Development Engineering Procedures and Guidelines (2023).

The parameters are summarized in **Table 2** and **Table 3** along with the 12 hour and 24 hour rainfall depths. The storm duration which results in the yields the lowest pre-development peak flow and the highest post-development peak flow will be used for the study. Storm distribution and parameter details are included in **Volume II Appendix C**.

Table 2 and **Table 3** provide IDF parameters and rainfall depth for the Town of Milton and Town of Oakville, respectively.

Table 2: Town of Milton Rainfall IDF Information

Parameters	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	779	959	1089	1234	1323	1435
B	6	5.7	5.7	5.5	5.3	5.2
C	0.8206	0.8024	0.7955	0.7863	0.7786	0.7751
12-hr Rainfall Depth (mm)	42.0	58.3	69.3	83.4	94.1	104.4
24-hr Rainfall Depth (mm)	47.7	67.0	80.1	97.0	110.0	122.4

Table 3: Town of Oakville Rainfall IDF Information

Parameters	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	725	1170	1400	1680	1960	2150
B	4.8	5.8	5.8	5.6	5.8	5.7
C	0.808	0.843	0.848	0.851	0.861	0.861
12-hr Rainfall Depth (mm)	42.5	54.4	63.0	74.1	81.0	88.8
24-hr Rainfall Depth (mm)	48.7	60.9	70.2	82.5	89.5	98.1

3.2 Design Approach

The linear nature of the roadway project presents several challenges in addressing drainage and stormwater management impacts associated with the roadway rehabilitation. Key constraints include land availability, utility conflicts, and ongoing operations and maintenance. Given the characteristics of the subject area and proposed roadway widening, the stormwater management assessment will follow the approach outlined below:

- Document existing conditions, including the identification of stormwater outlets, roadside ditches, drainage topography, soil types, land use, floodplain limits, and other relevant drainage features and constraints.
- Evaluate existing and proposed hydrologic flows, and assess the potential impacts on the receiving watercourses resulting from the roadway improvements.
- Assess stormwater management requirements related to water quality, quantity, and erosion control, and explore options to achieve the water balance target where feasible.
- Identify potential opportunities for the integration of Low Impact Development (LID) features to support sustainable stormwater management.

4 Drainage and Hydraulic Analysis

4.1 Existing Drainage Conditions

This section provides details about the existing land use, soil and drainage conditions of the study area.

Exhibit 1 to **Exhibit 17** illustrates drainage mosaics of the study area under existing conditions. All figures are included in **Volume II Appendix B**.

4.1.1 Existing Soil and Land Use

The existing segment of Regional Road 25 between Derry Road and Speers Road consists of a four-lane cross-section. According to Ontario Soil Map No. 43, which covers Halton County, the predominant soil types within the study area include Chinguacousy clay loam, Jeddo clay loam, Oneida clay loam, Grimsby sandy loam, Brandy sandy loam, and Fox sandy loam.

Based on the Ministry of Transportation of Ontario (MTO) hydrologic soil group classification, the hydrologic soil types for these soils are as follows:

- Brandy sandy loam and Fox sandy loam - Group AB

- Grimsby sandy loam - Group A
- Chinguacousy clay loam and Jeddo clay loam - Group C
- Oneida clay loam - Group D

4.1.2 Existing Drainage Pattern

The existing Regional Road 25 (RR25) corridor between Derry Road and Speers Road includes a combination of rural and urban cross-sections, each with distinct drainage characteristics:

- **Speers Road to 150 m north of Wyecroft Road**: This southern stretch of the roadway is fully urbanized, with roadway runoff conveyed via existing storm sewers and directed in a southerly direction along Bronte Road.
- **150 m north of Wyecroft Road to 200 m north of Charles Cornwall Road**: This segment of the roadway is served by the QEW East SWM Pond (SWMP-1) for stormwater management.
- **200 m north of Charles Cornwall Road to Upper Middle Road West**: In this section, runoff is conveyed by storm sewers to Fourteen Mile Creek via four distinct outlets.
- **Upper Middle Road West to 250 m north of Upper Middle Road West**: Runoff of this stretch of RR25 is conveyed by storm sewers towards Upper Middle Road West discharged to Fourteen Mile Creek.
- **250 m north of Upper Middle West to 150 m north of Westoak Trails Boulevard Road**: This stretch of the roadway is fully urban; roadway runoff is conveyed by storm sewers and directed to the Bronte Creek SE SWM Pond (SWMP-2), which provides both quantity and quality control.
- **150 m north of Westoak Trails Boulevard to William Halton Parkway**: The road segment has fully urban cross-section. Runoff is conveyed by storm sewers to the existing Mattamy Stormwater Management Pond (SWMP-3)
- **William Halton Parkway to approximately 200 m south of Highway 407**: This stretch transitions into a half-urban cross-section. Runoff from the west half is conveyed by storm sewer; and runoff from the east side is directed into a roadside ditch, captured by a ditch inlet at Station 6+055, and conveyed through storm sewers along Bronte Road to the existing Mattamy SWM Pond.
- **Approximately 200 m south of Highway 407 to Britannia Road**: This segment consists of a rural cross-section, where roadway runoff flows as sheet flow into roadside ditches on both the east and west sides. These ditches ultimately

discharge to Sixteen Mile Creek and Fourteen Mile Creek through various outlets.

- **Britannia Road to Louis St. Laurent Avenue**: This section has a half-urban cross-section. Runoff is conveyed via roadside ditches on the west side and storm sewers on the east side toward three different outlets. A portion of west ditch drainage discharges to West Country Milton SWM Pond (SWMP-4) which provides both quantity and quality control.
- **Louis St. Laurent Avenue to Derry Road**: This segment features an urban cross-section, where roadway runoff is conveyed by a storm sewer system and discharged into Sixteen Mile Creek.

In addition to the four existing SWM ponds QEW East SWM Pond, (SWMP-1), Bronte Creek SE SWM Pond, (SWMP-2), Mattamy SWM Pond (SWMP-3) and West Country Milton SWM Pond (SWMP-4), there are eight oil/grit separator (OGS) units located within the project limits. Furthermore, grassed roadway embankments and ditches throughout the corridor also contribute to the quality treatment of roadway runoff to some extent.

The drainage pattern of the study area is separated into thirty-two (32) outlet areas. The existing drainage mosaic is shown in **Exhibits 1** to **18** in **Volume II Appendix B**. Drainage boundaries were defined by reviewing the various previous study reports and drawings. The following sections provide a brief discussion on the existing drainage condition and pattern of Regional Road 25 within the study limit.

1) **Outlet to Speers Road**
    - Roadway runoff from the existing segment of Regional Road 25, extending from the southern project limit to Station 0+922 (identified as Catchment 595, with a total drainage area of 4.75 ha), is conveyed via the existing storm sewer system in a southerly direction toward Speers Road. This catchment includes approximately 2.31 ha of impervious area.
2) **Outlet to QEW EAST SWM Pond (SWMP-1)**
    - From Station 0+922 to 1+042:
        - Roadway runoff from Regional Road 25 between approximately Station 0+922 and Station 1+042 is captured within Catchment 585, which has a total drainage area of 0.82 ha, including approximately 0.49 ha of impervious area. Runoff from this segment is conveyed northward through the existing storm sewer system and discharges to the QEW SWM Pond. Additionally, the storm sewer system in this segment also conveys runoff from external Catchments 570,

575, and 580, which together contribute an additional 3.64 hectares of drainage area.

- From Station 1+042 to 2+362:
  - Runoff from Regional Road 25 between approximately Station 1+042 and Station 2+362 is conveyed southward by the existing storm sewer system and discharged to the QEW SWM Pond. This section includes Catchments 540 and 545 (refer Exhibits 19 and 20), with a combined roadway drainage area of 6.41 ha, of which approximately 4.20 ha is imperviousness. In addition to roadway runoff, this storm sewer system also receives flow from external Catchments 550, 555, 560, and 565, which contribute a total of 8.61 hectares of additional drainage area.
- The total roadway drainage area which outlets to QEW SWM pond from Catchments 540, 545 and 580 is 7.23 ha, out of which approximately 4.69 ha area is impervious area.

3) Outlet to Fourteen Mile Creek Tributary at the D/S of Culvert C01

- From Station 2+362 to 3+021:
  - Roadway runoff from Regional Road 25 between approximately Station 2+362 and Station 3+021 is conveyed via the existing storm sewer system and discharges to Fourteen Mile Creek through a 750 mm concrete sewer. The outfall is located on the east side of Regional Road 25 near Station 2+923. Catchment 535 covers a total drainage area of 2.71 ha, with approximately 2.03 ha area of imperviousness.
- From Station 3+021 to 3+360:
  - Similarly, runoff from the segment between Station 3+021 and Station 3+360 is collected in Catchment 530, with a drainage area of 1.47 ha, including approximately 1.02 ha of impervious surface. Runoff is conveyed by the existing storm sewer system and discharged to Fourteen Mile Creek through a 600 mm concrete sewer, which outfalls on the east side of Regional Road 25 near Station 3+053.
- Total Contribution to Fourteen Mile Creek tributary:
  - The combined roadway drainage area from Catchments 530 and 535 discharging to Fourteen Mile Creek is 4.18 ha, of which approximately 3.05 ha is impervious area.

- Two existing Oil/Grit Separator (OGS) units are located on the east side of Regional Road 25 – OGS 1 near Station 2+923 and OGS 2 near Station 3+053. These units provide water quality treatment for roadway runoff from Catchments 535 and 530, respectively.

4) **Outlet to Fourteen Mile Creek via storm sewer along Upper Middle Road West**
    - Roadway runoff from existing Regional Road 25 from approximately St 3+360 to St 3+620 (Catchment 515 and 520) is conveyed by two independent existing storm sewers to Upper Middle Road West.
    - Runoff from Catchment 515 which has a drainage area of 0.69 ha, flows westward via storm sewer along Upper Middle Road and ultimately drains into a tributary of Fourteen Mile Creek.
    - Runoff from Catchment 520 (drainage area 0.64 ha) flows southward where it combines with runoff from Upper Middle Road West catchment (Catchment 525, drainage area 0.66 ha). The combined flow is further conveyed by storm sewer eastward then discharged into Fourteen Mile Creek.
    - Roadway Catchments 515 and 520 consist of approximately 0.51 ha and 0.43 ha of impervious areas, respectively.
5) **Outlet to Bronte Creek SE SWM POND (SWMP-2)**
    - Roadway runoff from existing Regional Road 25 from approximately St 3+620 to St 4+307 (Catchment 505, drainage area 4.70 ha) is conveyed by existing storm sewers which discharges to Bronte Creek South-East (SE) SWM Pond. Out of the total drainage area, approximately 2.22 ha area consists of impervious area. The SWM pond is located approximately 310 m north of Upper Middle Road to the west of Regional Road 25.
    - In addition to roadway drainage, Regional Road 25 storm sewer within this segment also conveys minor flow from external area Catchment 500 (drainage area 1.07 ha)
    - According to Stormwater Management Pond Design Brief prepared for Bronte Creek-Phase 1 (SE Facility), prepared by Stantec, Bronte Creek SE SWM Pond (SWMP-2) also provides quantity and quality control for flow from external Catchment 510 (drainage area 10.2 ha) and major storm flow from existing Catchments430, 435, 440,445, 450,465, 470, 485, 490 and 495.

- The total major flow which outlets to SWMP-2 from Catchments 430, 435, 440,445, 450, 465, 470, 485, 490, 495 and 505 is 12.39 ha, out of which approximately 7.12 ha area is impervious area.

6) Outlet to Mattamy SWM Pond (SWMP-3)

- Minor runoff from existing Regional Road 25 from approximately St 4+307 to St 6+570 is directed to Mattamy SWM Pond by existing storm sewers. Runoff from Catchments 440 and 445 drains towards a roadside ditch located on the east side of Regional Road 25. This runoff is captured by ditch inlets and conveyed by storm sewer which connects to the existing storm sewer along Regional Road 25. Additionally, roadway runoff from Catchments 435, 450, 470 and 495 is conveyed by existing storm sewers and the combined flow discharge to Mattamy Pond for quantity and quality control. The total drainage area from Catchment 435, 440, 445, 450, 470 and 495 is 9.96 ha with approximately 6.13 ha of impervious area.
- In addition to the roadway drainage, Regional Road 25 storm sewer within this segment also conveys runoff from external areas Catchments 430, 465, 485and 490.Total drainage area of these four external catchments is 2.43 ha.
- According to Stormwater Management Pond Design Brief prepared by Urbantech, Mattamy SWM Pond (SWMP-3) also provides quantity and quality control for the minor storm (5 year) flow from external Catchment 498 (drainage area 5.00 ha) and runoff from external Catchment 499 (drainage area 32.3 ha). The total drainage area from these two catchments is 37.3 ha.

7) Outlet to Fourteen Mile Creek via Dundas Street West Storm Sewer

- Runoff from Catchment 475 (drainage area 0.54 ha) is conveyed by a ditch on the west side of Regional Road 25, where it is captured by a ditch inlet connected to the storm sewer system. This flow then combines with runoff from Catchment 480 (drainage area 0.43 ha). The combined flow, from a total drainage area of 0.97 ha, is conveyed westerly along Dundas Street West and ultimately discharge to Fourteen Mile Creek.
- The total impervious area contributing to this combined flow is approximately 0.61 ha, suggesting a weighted imperviousness of approximately 63% across the two catchments.

8) Outlet to Fourteen Mile Creek via Culvert C-WH1 at William Halton Parkway

- Runoff from Catchment 455 (drainage area 9.99 ha) drains overland towards a 975 mm diameter HDPE culvert (Culvert C04), which crosses

Regional Road 25. This flow combines with runoff from Catchment 460 (drainage area 3.03 ha) and the combined flow drains towards Culvert C-WH1 which crosses William Halton Parkway and ultimately discharges to Fourteen Mile Creek.

- Total contributing area from these two Catchments 455 and 460 is 13.02 ha, including 0.72 ha of impervious area.

9) Outlet to Fourteen Mile Creek Tributary via Culvert C05

- Roadway runoff from Catchment 395 (drainage area 0.66 ha) and 410 (drainage area 0.24 ha) drains overland towards roadside ditches on the west side of Regional Road 25. This flow combines with runoff from external Catchments 400, 4071, 4072 and is conveyed by the existing 407 ETR Culverts 407-3 and 407-4.
- The outflow from 407 ETR Culvert 407-4 combines with runoff from roadway Catchment 420 (drainage area 0.27 ha) and external Catchment 415 (2.03 ha). The combined flow is conveyed to the east side ditch through an existing 2100 mm span x 1600 mm rise CSP arch culvert (Culvert C05) which ultimately discharges to a tributary of Fourteen Mile Creek.
- Roadway Catchment 425 (drainage area 0.36 ha) drain as sheet flow on the east side ditch of Regional Road 25 and ultimately combines with the flow from Culvert C05.
- The total drainage area discharging to the tributary of Fourteen Mile Creek at the downstream of Culvert C05 from Catchments 395, 400, 410, 415, 420, 425, 4071 and 4072 is approximately 73.16 ha, of which approximately 5.55 ha is impervious area.

10) Outlet to Fourteen Mile Creek near 407 ETR

- As shown in **Exhibit 8**, runoff from Catchment 4076 (drainage area 2.16 ha) drains overland and is conveyed by an existing Culvert 407-8 to the east side ditch of 407 ETR ramp. The flow drains further southerly to the downstream of Culvert C05 and ultimately discharges to Fourteen Mile Creek.
- Runoff from Catchment 4073 (drainage area 6.62 ha) drains overland towards the existing Culvert 407-1 where it combines with runoff from Catchment 4074 (drainage area 2.12 ha) and flows towards Culvert 407-2. The combined runoff is conveyed through this culvert system and discharges to Fourteen Mile Creek. This outfall is located at the west side of 407-ETR.

- Roadway runoff from Catchment 405 (drainage area 0.62 ha) drains overland to the east side ditch of Regional Road 25. The flow is further conveyed easterly to Fourteen Mile Creek and then continue southerly through two 407 ETR Culverts 407-5 and 407-7. Runoff from Catchment 4075 (3.03 ha) also drains to this Fourteen Mile Creek.

11) Outlet to Fourteen Mile Creek via Culvert C06

- Runoff from Regional Road 25, between approximately St 7+420 and St 7+670, corresponding to Catchments 385 and 390, drain as sheet flow to the west and east side ditches along the roadway. The west side ditch is conveyed to the east side through a twin 800 mm diameter CSP culvert (Culvert C06) which ultimately drains into Fourteen Mile Creek. The total drainage area of these two catchments is 1.28 ha, out of which approximately 0.73 ha is impervious area.

12) Outlet to Fourteen Mile Creek via Culvert C07

- Road runoff from Regional Road 25 between approximately St 7+720 and St 7+862, corresponding to Catchments 375 and 380, drain as sheet flow to the west and east side ditches along the roadway. Runoff from external Catchment 370 (drainage area 8.60 ha) and ditch drainage from the west side are conveyed to the east side via a twin 1200 mm diameter CSP culvert (Culvert C07) and combines with the flow from east side ditch. The combined flow ultimately discharges into Fourteen Mile Creek. The total roadway drainage area from Catchments 375 and 380 is 0.80 ha, out of which approximately 0.51 ha is impervious area.

13) Outlet to Fourteen Mile Creek via Culvert C08

- Roadway runoff from Regional Road 25 from approximately St 7+862 to St 8+328 (Catchments 360 and 365) drain as sheet flow to the west and east side ditches along the roadway. Runoff from External Catchment 355 (drainage area 16.40 ha) and the west side ditch drainage is conveyed to the east side via a 2400 mm span x 900 mm rise concrete box culvert (Culvert C08) towards Fourteen Mile Creek. The total roadway drainage area from Catchment 360 and 365 is 3.10 ha, out of which approximately 1.38 ha is impervious area.
- The total drainage area which outlets to Fourteen Mile Creek at the downstream of Culvert C08 (Catchment 355, 360 and 365) is 19.50 ha, out of that approximately 5.32 ha is impervious area.

14) Outlet to Fourteen Mile Creek via Culvert C09

- Runoff from Regional Road 25, between approximately St 8+328 and St 8+560 (Catchments 345 and 350), drains as sheet flow to the west and east side ditches along the roadway. Runoff from external Catchment 330 (drainage area 3.93 ha) and the west side ditch drainage is conveyed to the east side via a 1100 mm diameter CSP Culvert (Culvert C09) which ultimately discharges to Fourteen Mile Creek. The total roadway drainage area from Catchment 345 and 350 is 0.77 ha, out of which approximately 0.56 ha is impervious area.
- The total drainage area which outlets to Fourteen Mile Creek at the downstream of Culvert C09 (Catchment 330, 345 and 350) is 4.70 ha, out of that approximately 1.38 ha is impervious area.

15) Outlet to Fourteen Mile Creek via Culvert C10

- Runoff from Regional Road 25 between approximately St 8+560 and St 8+811, corresponds to Catchments 335 and 340, drains as sheet flow to the west and east side ditches along the roadway. The west side ditch drainage is conveyed to the east side through a 900 mm diameter CSP culvert (Culvert C10) and ultimately discharges to Fourteen Mile Creek.
- The total roadway area which outlets to Fourteen Mile Creek at the downstream of Culvert C10 (Catchments 335 and 340) is 1.29 ha, out of that approximately 0.58 ha is impervious area.

16) Outlet to Fourteen Mile Creek via Culvert C11

- Runoff from Regional Road 25 between St 8+760 to St 8+904 (Catchments 325 and 326) drain overland to the west and east side ditches along the roadway. The west side ditch drainage is conveyed to the east side through a 1550 mm span x 1200 mm rise CSP arch culvert (Culvert C11) and discharges to Fourteen Mile Creek.
- The total drainage area which outlets to Fourteen Mile Creek at the downstream of Culvert C11 (Catchments 325 and 326) is 1.74 ha, of which approximately 0.30 ha is impervious area.

17) Outlet to Sixteen Mile Creek Tributary via Culvert C12

- Runoff from Regional Road 25 between St 8+848 and St 9+184 drains overland towards the west and east side ditches along the roadway. The combined flow from external Catchment 314 (drainage area 2.27 ha) and roadway Catchment 315 (drainage area 0.69 ha) is conveyed to the west side ditch through an 800 mm diameter CSP culvert (Culvert C12) where it combines with the overland flow from roadway Catchment 317 (drainage

area 0.57 ha). The combined flow further conveyed northerly towards the tributary of Sixteen Mile Creek.

- The total drainage area at downstream of Culvert C12 which outlets to a tributary of Sixteen Mile Creek (Catchments 314, 315 and 317) is 3.53 ha, of which approximately 0.77 ha is impervious area.

18) Outlet to Sixteen Mile Creek Tributary via Culvert C13

- Runoff from Regional Road 25, between approximately St 9+184 and St 9+444 corresponding to Catchments 310 and 320, drain overland towards the west and east side ditches along the roadway. Runoff from Catchment 311 (drainage area 7.11 ha) as well as the east side ditch drainage is conveyed to the west side through a 1150 mm diameter CSP culvert (Culvert C13). The combined flow from roadway and external catchments further conveyed northerly towards a tributary of Sixteen Mile Creek. The total roadway drainage area from Catchment 310 and 320 is 1.04 ha, out of which approximately 0.70 ha is impervious area.
- The total drainage area at downstream of Culvert C13 (Catchments 310, 311 and 320) is 8.15 ha, out of that approximately 0.89 ha is impervious area.

19) Outlet to Sixteen Mile Creek Tributary via Culvert C14

- Between St 9+444 and St 9+803 of Regional Road 25, combined runoff from external Catchment 295 (drainage area 3.70 ha) and east side roadway Catchment 300 (drainage area 0.80 ha) is conveyed to the west side ditch of Regional Road 25 via a 900 mm diameter CSP culvert (Culvert C14) where it combines with the west side ditch drainage from roadway Catchment 305 (drainage area 1.01 ha). The total roadway drainage area from Catchments 300 and 305 is 1.81 ha, of which approximately 0.99 ha is impervious area.
- The total contributing drainage area to a tributary of Sixteen Mile Creek, downstream of Culvert C14, from Catchments 295, 300 and 305 is 5.51 ha, of which approximately 3.40 ha is impervious area.

20) Outlet to Sixteen Mile Creek Tributary via Culvert C15

- Surface runoff generated from Regional Road 25 between St 9+803 and St 10+421 corresponding to Catchments 275, 280, 285 and 290, drain overland towards the west and east side ditches along the roadway. The ditch drainage on the west side is conveyed to the east side through a 7.315 m span x 1.830 m rise concrete arch culvert (Culvert C15). This culvert conveys flow of a tributary of Sixteen Mile Creek.

- The total drainage area which outlets to Sixteen Mile Creek tributary at downstream of Culvert C15 (Catchments 275, 280, 285 and 290) is 3.10 ha, of which approximately 1.41 ha area is impervious area.
- Runoff from Catchment 270 (drainage area 3.03 ha) drains as sheet flow towards the tributary of Sixteen Mile Creek.

21) Outlet to Sixteen Mile Creek Tributary via Culvert C16

- Surface runoff from Regional Road 25 between St 10+421 and St 11+015 (Catchments 260 and 265) drain overland towards the west and east side ditches along the roadway. Flow from roadway Catchment 260 (drainage area 1.13 ha) combines with runoff f from Catchment 255 (drainage area 6.53 ha) and is conveyed to the east side through a 1.45 m span x 1.0 m rise CSP arch (Culvert C16) towards a tributary of Sixteen Mile Creek. The total roadway drainage area from Catchments 260 and 265 is 3.51 ha, of which approximately 1.53 ha is impervious area.
- The total drainage area which outlets to the tributary of Sixteen Mile Creek at downstream of Culvert C16 (Catchments 255, 260 and 265) is 10.04 ha, of which approximately 1.83 ha is impervious area.

22) Outlet to Sixteen Mile Creek Tributary via Culvert C17

- Surface runoff of Regional Road 25 between St 11+004 and St 11+276 (Catchments 240) is conveyed by the west side ditch towards Culvert C17. Runoff is then conveyed to the east side through an 800 mm diameter CSP culvert (Culvert C17) towards a tributary of Sixteen Mile Creek. Roadway Catchment 245 also drains overland on the downstream of Culvert C17. A total of 3.90 ha drainage area from Catchment 240 and 245 drains on the downstream of Culvert C17.
- Runoff from Catchment 250 (drainage area 0.93 ha) drains as sheet flow towards the ditch on the east side of Regional Road 25 and get captured by a ditch inlet which ultimately discharges to a tributary of Sixteen Mile Creek. This catchment has approximately 0.22 ha of impervious area.

23) Outlet to Sixteen Mile Creek Tributary via Culvert C18

- Surface runoff from external Catchment 232 (drainage area 15.4 ha) and Catchment 230 (drainage area 1.67 ha) of Regional Road 25 drains overland on the upstream (west) side Culvert C18 which is a 1200 mm diameter CSP Culvert. The culvert conveys runoff to the east side of Regional Road 25 and combines with the surface runoff form Catchments 234 and 237, which then ultimately drains to a tributary of Sixteen Mile

creek. The total roadway drainage area from Catchments 230, 234 and 237 is 2.45 ha, of which approximately 0.79 ha is impervious area.

- The total drainage area which outlets to a tributary of Sixteen Mile Creek from the downstream of Culvert C18 is 17.85 ha, of which approximately 4.06 ha is impervious area.

24) Outlet to Sixteen Mile Creek Tributary via Culvert C19

- Culvert C19 is a 6.10 m span x 1.90 m rise concrete arch culvert. This culvert facilitates the flow of a major tributary of Sixteen Mile Creek. Runoff from Regional Road 25 between St 11+549 and St 12+452 (Catchments 210, 215, 220 and 225) drains overland via west and east side ditches towards Culvert 19.
- The total drainage area which outlets to a tributary of Sixteen Mile Creek via Culvert C19 is 3.83 ha, of which approximately 2.30 ha is impervious area.

25) Outlet to Sixteen Mile Creek Tributary via Culvert C20

- Runoff from external Catchment 195 (drainage area 7.52 ha) and roadway catchment 200 drains overland to the upstream (east) side of Culvert C20, a 1200 mm diameter concrete Culvert. The culvert conveys runoff to the west side of Regional Road 25 and combines with the flow of Catchment 205. The combined flow ultimately drains to the tributary of Sixteen Mile Creek. The total roadway drainage area from Catchment 200 and 205 is 1.60 ha, out of which approximately 0.95 ha is impervious area.
- The total drainage area which outlets to the downstream of Culvert C20 (Catchments 195, 200 and 205) is 9.12 ha, of which approximately 1.24 ha is impervious area.

26) Outlet to Sixteen Mile Creek Tributary via Britannia Road

- Runoff from Regional Road 25 Catchments 185 and 190 and Britannia Road external Catchment 193 (drainage area 1.06 ha) is conveyed by storm sewers westerly along Britannia Road and discharge to a tributary of Sixteen Mile Creek.
- The total roadway drainage area which outlets to Britannia Road from Catchments 185 and 190 is 0.69 ha, out of that approximately 0.46 ha is impervious area.

27) Outlet to Sixteen Mile Creek Tributary via Culvert C21

- Runoff from Regional Road 25 from approximately St 12+960 to St 13+398 is conveyed by storm sewers as well as west side ditch along the roadway. Combined runoff from external Catchment 170 (drainage area

9.22 ha) and roadway Catchment 175 (drainage area 0.82 ha) is conveyed to west side of Regional Road 25 via a 1200 mm diameter concrete culvert (Culvert C21) where it combines with the west side ditch drainage from Catchment 180 (drainage area 0.78 ha)and discharges to the tributary of Sixteen Mile Creek.

- The total roadway drainage area from Catchment 175 and 180 is 1.58 ha, out of which approximately 1.06 ha is impervious area.
- The total drainage area (Catchments 170, 175 and 185) which outlets to the tributary of Sixteen Mile Creek from the downstream of Culvert C21 is 10.80 ha, of which approximately 1.50 ha is impervious area.

28) Outlet to Sixteen Mile Creek Tributary at D/S of Culvert C22

- Regional Road 25 between St 13+312 and St 14+348, runoff from the east half of the roadway (Catchments 145 and 155) is conveyed by storm sewers which outlets to Culvert C22. Runoff from external Catchment 165 (drainage area 3.95 ha) combined with the runoff from Catchment 145 and 155 is conveyed to the west side of the roadway via a 1.8 m span x 0.90 m concrete box culvert (Culvert C22) towards the west side ditch. The flow further combines with the west side ditch drainage from Catchment 1502 (drainage area 0.29 ha) and discharge to channel SWS-2A, which is a tributary of Sixteen Mile Creek.
- Roadway Catchments 140 and 1501 drain to the west side ditch and get captured by a DICB. The flow is discharge to an existing SWM Pond (SWMP-4) within Country Homes Subdivision for quantity and quality control before discharge to channel SWS-2A.
- According to the drainage area plan prepared by TMIG, the West Country Milton SWM Pond (SWMP-4) also provides quantity and quality control for runoff from external Catchments 158 and 159. The total drainage area from these two Catchments is 33.08 ha.
- The total roadway drainage area from Catchments 140, 145, 1501, 1502 and 155 is 4.30 ha, out of which approximately 2.51 ha is impervious area. Including the external Catchment 165, the total drainage area which drains to a tributary of Sixteen Mile Creek is 8.25 ha.

29) Outlet to Sixteen Mile Creek through Louis St. Laurent Avenue Storm Sewer

- Runoff from existing Regional Road 25 Catchment 135 (drainage area 0.31 ha) is conveyed storm sewers and connected to Louis St. Laurent

Avenue storm sewer system. The flow is ultimately discharge to Sixteen Mile Creek. This catchment has approximately 0.22 ha of impervious area.

30) Outlet to Sixteen Mile Creek near the Bridge B04

- From approximately Station 14+394 to Station 14+688 along Regional Road 25, roadway runoff from Catchment 130, which has a drainage area of 1.39 ha, is conveyed in a northerly direction by an existing storm sewer system. This flow is ultimately discharged into Sixteen Mile Creek through a 675 mm diameter concrete storm sewer outfall on the west side of Regional Road 25 at Station 14+683.
- Similarly, runoff from Regional Road 25 from approximately St 14+688 to St 15+259 (Catchment 120, drainage area 1.37 ha) is conveyed southerly along the roadway by existing storm sewers and discharged into the Sixteen Mile Creek via a 675 mm diameter concrete storm sewer. This system outfalls at the west side of Regional Road 25 at St 14+834.
- The total roadway drainage area from Catchments 120 to 130 is 2.76 ha, of which approximately 2.11 ha is impervious area.
- In addition to roadway drainage, runoff from external area (Catchments 125, drainage area 2.36 ha) drains overland to Sixteen Mile Creek at the downstream of Bridge B04.

31) Outlet to Sixteen Mile Creek at D/S of Culvert C23

- Roadway runoff from existing Regional Road 25 from approximately St 15+259 to St 15+748 (Catchment 110) is conveyed by storm sewers southerly and outlets to the downstream of 1.8 m span x 0.90 m rise concrete box culvert (Culvert C23). This catchment has approximately 1.19 ha of impervious area.
- In addition to roadway drainage, runoff from external Catchments 115 and 122 (total drainage area 5.62 ha) drains overland to the upstream (east) side of Culvert C23 and the culvert ultimately discharged to Sixteen Mile Creek.
- The total drainage area which outlets to Sixteen Mile Creek from downstream of Culvert C23 (Catchments 110, 115 and 122) is 7.78 ha.

32) Outlet to Sixteen Mile Creek at D/S of Culvert C24

- Roadway runoff from Regional Road 25 from St.15+748 to St.16+160 (Catchments 100 and 105) is conveyed by storm sewers southerly along the roadway and outlets on the downstream of Culvert C24. The total drainage area of these two catchments is 2.21 ha. Culvert C24 is a 3.30 m span x 3.0 m rise concrete box culvert.

4.1.3 Existing Hydrologic Modelling

The purpose of the hydrologic modelling was to simulate the hydrologic response of the areas contributing drainage with the study limit during various return period rainfall events. The hydrologic event simulation modelling is completed by using the Visual OTTHYMO hydrologic modelling tool.

The methodology used to develop the hydrologic model can be summarized as follows:

- Drainage area boundaries were defined based on existing storm sewers, as built drawings, information received from the CH, road profile and contours.
- Modelling parameters were estimated for each drainage area based on the delineated drainage areas, land use distribution (confirmed with a topographic mapping and aerial photo), soil distribution, and slopes of the overland and channel flow paths.
- The hydrologic response for drainage areas with a directly connected impervious land use greater than 20 percent was simulated using the Standard instantaneous unit hydrograph (STANDHYD).
- The hydrologic response for drainage areas with a directly connected impervious land use less than 20 percent was simulated using the Nash instantaneous unit hydrograph (NASHHYD).
- Runoff hydrographs were generated at key points of interest.

Hydrologic assessment was carried out using the 12 hour and 24-hour Chicago storm distributions as per Conservation Halton Guidelines for Stormwater Management Engineering Submissions (June 2024). IDF data provided in the Town of Milton and Town of Oakville's manuals was used for the hydrologic modelling for Sixteen Mile Creek and Fourteen Mile Creek, respectively.

Among these two different storm distributions, the one which yields the highest peak flows will be considered to have a conservative design in the post development.

The existing conditions hydrologic modelling input parameters as well hydrologic modelling schematic and summary output details are included in **Volume II Appendix C**.

Table 4 and **Table 5** summarizes and compares the results of the existing conditions hydrologic modelling which was carried out using the two different storm distributions. The table shows comparison at specific node point and catchments within Sixteen Mile Creek and Fourteen Mile Creek, respectively. The node points and catchments are shown in hydrologic modelling schematic.

Table 4: Existing Conditions Hydrologic Modelling Summary - Fourteen Mile Creek Watershed

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
595	12-hr Chicago	0.508	0.737	0.904	1.120	1.276	1.429	1
595	**24-hr Chicago**	**0.512**	**0.743**	**0.918**	**1.135**	**1.293**	**1.448**	1

HYD 595 gives the flow from catchment 595 that drains southerly to Speers Road.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
591	12-hr Chicago	2.031	2.927	3.536	4.430	5.057	5.737	2
591	**24-hr Chicago**	**2.046**	**2.963**	**3.584**	**4.487**	**5.122**	**5.895**	2

HYD 591 gives the total flow from catchments 540-590 that are draining to the QEW SWM pond.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
536	12-hr Chicago	0.691	1.001	1.200	1.469	1.666	1.856	3, 4
536	**24-hr Chicago**	**0.695**	**1.008**	**1.209**	**1.481**	**1.679**	**1.870**	3, 4

HYD 536 gives the total flow from Catchments 530 and 535 that outlets to Fourteen Mile Creek Tributary via Culvert C01

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
515	12-hr Chicago	0.117	0.170	0.203	0.247	0.280	0.311	4
515	**24-hr Chicago**	**0.117**	**0.171**	**0.204**	**0.249**	**0.282**	**0.314**	4

HYD 515 give total flow from Catchment 515 that drains westerly via Upper Middle Road West and outlets to the tributary of Fourteen Mile Creek.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
652	12-hr Chicago	2.68	4.58	5.98	7.92	9.31	10.77	5
652	**24-hr Chicago**	**3.01**	**4.97**	**6.44**	**8.46**	**9.88**	**11.41**	5

HYD 652 provides the flow from Culvert C02. The Regional Storm flow is 18.86 m^3/s.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
527	12-hr Chicago	0.210	0.302	0.368	0.450	0.510	0.568	4
527	**24-hr Chicago**	**0.211**	**0.304**	**0.371**	**0.454**	**0.514**	**0.573**	4

HYD 527 give total flow from Catchments 520 and 525 draining easterly to Fourteen Mile Creek via storm sewers along Upper Middle Road West.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
512	12-hr Chicago	1.519	2.221	3.254	4.541	5.482	6.607	5, 6, 7
512	**24-hr Chicago**	**1.541**	**2.271**	**3.296**	**4.603**	**5.578**	**6.833**	5, 6, 7

HYD 512 gives the total flow from roadway Catchment 430 to 495 (major flow), Catchments 500 (minor flow) and flow from Catchment 510 that draining to Bronte Creek SE SWM Pond (SWMP-2).

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
702	12-hr Chicago	0.049	0.058	0.066	0.281	0.620	1.117	5, 6, 7
702	**24-hr Chicago**	**0.050**	**0.059**	**0.074**	**0.335**	**0.756**	**1.277**	5, 6, 7

HYD 702 gives the outflow from Bronte Creek SE SWM Pond (SWMP-2).

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
502	12-hr Chicago	4.006	5.946	6.993	8.253	9.186	10.118	5, 6, 7
502	**24-hr Chicago**	**4.059**	**6.055**	**7.145**	**8.437**	**9.385**	**10.339**	5, 6, 7

HYD 502 gives total flow from Catchments 430 to 495 (minor flow) and from Catchments 498 (minor flow) and Catchment 499 that draining to Mattamy SWM Pond (SWMP-3).

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
703	12-hr Chicago	0.181	0.373	0.560	0.829	1.034	1.256	5, 6, 7
703	**24-hr Chicago**	**0.196**	**0.421**	**0.624**	**0.918**	**1.132**	**1.370**	5, 6, 7

HYD 703 gives the outflow from Mattamy SWM Pond (SWMP-3)

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
802	12-hr Chicago	0.230	0.431	0.624	1.109	1.585	2.174	5, 6, 7
802	**24-hr Chicago**	**0.246**	**0.480**	**0.689**	**1.248**	**1.791**	**2.414**	5, 6, 7

HYD 802 gives total flow from SWMP-3 and SWM-4 that drains to 14 Mile Creek

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
482	12-hr Chicago	0.089	0.128	0.153	0.187	0.212	0.235	7
482	**24-hr Chicago**	**0.090**	**0.129**	**0.155**	**0.189**	**0.214**	**0.238**	7

HYD 482 includes the total flow from Catchments 475 and 480 that outlets via Dundas St West.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
455	12-hr Chicago	0.121	0.215	0.287	0.389	0.464	0.544	7
455	**24-hr Chicago**	**0.137**	**0.235**	**0.312**	**0.420**	**0.497**	**0.581**	7

HYD 455 gives the flow from Catchment 455 which drains to Culvert C04.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
462	12-hr Chicago	0.181	0.277	0.362	0.470	0.557	0.648	7
462	**24-hr Chicago**	**0.194**	**0.297**	**0.385**	**0.506**	**0.595**	**0.761**	7

HYD 462 give the total flow from Catchments 455 and 460 which drains to Culvert C-WH1.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
426	12-hr Chicago	0.573	0.906	1.189	1.588	1.871	2.179	8, 9
426	**24-hr Chicago**	**0.602**	**0.983**	**1.284**	**1.704**	**1.994**	**2.317**	8, 9

HYD 426 gives the total flow from Catchments 395, 400, 410, 415, 420, 425, 4071 and 4072 which draining to the downstream of Culvert C05.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
4076	12-hr Chicago	0.253	0.363	0.442	0.545	0.619	0.733	8
4076	**24-hr Chicago**	**0.256**	**0.372**	**0.448**	**0.551**	**0.626**	**0.745**	8

HYD 4076 give the flow from Catchment 4076 which drains via Culvert 407-8.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
409	12-hr Chicago	0.238	0.355	0.445	0.564	0.649	0.784	8
409	**24-hr Chicago**	**0.250**	**0.377**	**0.466**	**0.590**	**0.677**	**0.820**	8

HYD 409 gives the total flow from Catchments 4073 and 4074 that drains to Fourteen Mile Creek tributary at the downstream of Culvert C407-2

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
408	12-hr Chicago	0.480	0.697	0.850	1.050	1.195	1.336	10
408	**24-hr Chicago**	**0.486**	**0.703**	**0.863**	**1.063**	**1.210**	**1.353**	10

HYD 408 gives the flow from Catchments 405 and 4075 which drains to Fourteen Mile Creek via Culvert C407-7.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
392	12-hr Chicago	0.171	0.251	0.303	0.387	0.442	0.505	9
392	**24-hr Chicago**	**0.172**	**0.255**	**0.307**	**0.393**	**0.449**	**0.513**	9

HYD 392 gives the total flow from Catchments 385 and 390 at the downstream of Culvert C06.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
382	12-hr Chicago	0.594	0.898	1.172	1.496	1.732	1.970	9
382	**24-hr Chicago**	0.621	0.919	1.207	1.543	1.784	2.030	9

HYD 382 gives the total flow from Catchments 370, 375 and 380 at the downstream of Culvert C07.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
369	12-hr Chicago	1.144	1.750	2.160	2.919	3.467	3.967	9
369	**24-hr Chicago**	**1.169**	**1.799**	**2.225**	**3.050**	**3.590**	**4.108**	9

HYD 369 gives the total flow from Catchments 355, 360 and 365 at the downstream of Culvert C08.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
351	12-hr Chicago	0.335	0.515	0.649	0.822	0.950	1.240	10
351	**24-hr Chicago**	**0.343**	**0.531**	**0.669**	**0.848**	**0.979**	**1.284**	10

HYD 351 gives the total flow from Catchments 330, 345 and 350 at the downstream of Culvert C09.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
342	12-hr Chicago	0.138	0.203	0.246	0.330	0.380	0.429	11
342	**24-hr Chicago**	**0.140**	**0.206**	**0.250**	**0.338**	**0.388**	**0.439**	11

HYD 342 includes the total flow from Catchments 335 and 340 at the downstream of Culvert C10.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
327	12-hr Chicago	0.036	0.063	0.083	0.109	0.129	0.151	11
327	**24-hr Chicago**	**0.041**	**0.068**	**0.089**	**0.117**	**0.138**	**0.160**	11

HYD 327 gives the total flow from Catchments 325 and 326 at the downstream of Culvert C11.

Table 5: Existing Conditions Hydrologic Modelling Summary- Sixteen Mile Creek Watershed

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
318	12-hr Chicago	0.202	0.295	0.361	0.449	0.540	0.621	11
318	**24-hr Chicago**	**0.210**	**0.309**	**0.379**	**0.481**	**0.571**	**0.656**	11

HYD 318 gives the total flow from Catchments 314, 315 and 317 at the downstream of Culvert C12.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
322	12-hr Chicago	0.203	0.331	0.439	0.582	0.694	0.810	11
322	**24-hr Chicago**	**0.218**	**0.367**	**0.483**	**0.637**	**0.757**	**0.880**	11

HYD 322 gives the total flow from Catchments 310, 311 and 320 at the downstream of Culvert C13.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
307	12-hr Chicago	0.741	1.019	1.206	1.514	1.748	1.958	12
307	**24-hr Chicago**	**0.746**	**1.031**	**1.222**	**1.571**	**1.783**	**1.998**	12

HYD 307 gives the total flow from Catchments 295, 300 and 305 at the downstream of Culvert C14.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
294	12-hr Chicago	0.353	0.496	0.594	0.723	0.878	0.994	12
294	**24-hr Chicago**	**0.359**	**0.508**	**0.610**	**0.764**	**0.908**	**1.029**	12

HYD 294 includes the total flow from Catchments 270, 275, 280, 285 and 290 at the downstream of Culvert C15 draining to Sixteen Mile Creek Tributary.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
267	12-hr Chicago	0.348	0.494	0.596	0.731	0.859	1.040	12, 13
267	**24-hr Chicago**	**0.354**	**0.510**	**0.618**	**0.762**	**0.898**	**1.093**	12, 13

HYD 267 gives the total flow from Catchments 255, 260 and 265 at the downstream of Culvert C16.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
246	12-hr Chicago	0.244	0.369	0.457	0.577	0.670	0.893	13
246	**24-hr Chicago**	**0.251**	**0.385**	**0.479**	**0.607**	**0.705**	**0.947**	13

HYD 246 gives the total flow from Catchments 240 and 245 at the downstream of Culvert C17.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
238	12-hr Chicago	0.903	1.339	1.795	2.304	2.738	3.160	13
238	**24-hr Chicago**	**0.936**	**1.514**	**1.901**	**2.445**	**2.911**	**3.356**	13

HYD 238 gives total flow from Catchments 230, 232, 234 and 237 at the downstream of Culvert C18.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
226	12-hr Chicago	0.516	0.707	0.859	1.047	1.215	1.361	14
226	**24-hr Chicago**	0.519	0.716	0.873	1.067	1.241	1.391	14

HYD 226 gives total flow from Catchments 210, 215, 220 and 225 at the downstream of Culvert C19.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
207	12-hr Chicago	0.253	0.375	0.464	0.587	0.708	0.820	14, 15
207	**24-hr Chicago**	**0.266**	**0.400**	**0.497**	**0.643**	**0.763**	**0.883**	14, 15

HYD 207 gives total flow from Catchments 195, 200 and 205 draining to Sixteen Mile Creek at the downstream of Culvert C20.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
196	12-hr Chicago	0.229	0.311	0.369	0.442	0.504	0.581	15
196	**24-hr Chicago**	**0.231**	**0.317**	**0.375**	**0.449**	**0.513**	**0.594**	15

HYD 196 gives total flow from Catchments 185, 190 and 193 that outlets via Britannia Road.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
182	12-hr Chicago	0.250	0.351	0.441	0.546	0.626	0.711	15
182	**24-hr Chicago**	**0.256**	**0.367**	**0.465**	**0.579**	**0.667**	**0.758**	15

HYD 182 gives the total flow from Catchments 170, 175 and 180 draining to Sixteen Mile Creek tributary at the downstream of Culvert C21.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
163	12-hr Chicago	3.274	4.825	5.860	7.221	8.230	9.337	15, 16
163	**24-hr Chicago**	3.334	4.946	6.014	7.409	8.453	9.649	15, 16

HYD 163 gives total flow from Catchments 140, 1501, 158 and 159 that draining to West Country Milton SWM Pond (SWMP-4).

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
704	12-hr Chicago	0.019	0.216	0.407	0.688	0.979	1.275	15, 16
704	**24-hr Chicago**	0.043	0.270	0.493	0.854	1.181	1.510	15, 16

HYD 704 gives outflow from West Country Milton SWM Pond (SWMP-4).

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
169	12-hr Chicago	0.341	0.484	0.587	0.839	1.192	1.574	15, 16
169	**24-hr Chicago**	**0.351**	**0.506**	**0.614**	**1.039**	**1.457**	**1.881**	15, 16

HYD 169 gives the total flow from roadway Catchments 140, 145, 1501, 1502, 155,and external Catchments 158, 159 and 165 that draining Sixteen Mile Creek tributary at the downstream of Culvert C22.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
135	12-hr Chicago	0.049	0.069	0.081	0.096	0.108	0.120	16
135	**24-hr Chicago**	**0.049**	**0.069**	**0.081**	**0.097**	**0.109**	**0.121**	16

HYD 135 gives the flow from Catchment 135 that outlets via Louis St Laurent Avenue.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
133	12-hr Chicago	0.471	0.635	0.752	0.900	1.035	1.154	16, 17
133	**24-hr Chicago**	**0.475**	**0.645**	**0.764**	**0.914**	**1.055**	**1.177**	16, 17

HYD 133 gives the total flow from Catchments 120, 125 and 130 draining to Sixteen Mile Creek at the downstream of Bridge B04.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
124	12-hr Chicago	0.289	0.418	0.517	0.647	0.745	0.849	17
124	**24-hr Chicago**	**0.301**	**0.438**	**0.547**	**0.686**	**0.792**	**0.944**	17

HYD 124 gives the total flow from Catchments 110, 115 and 122 draining to Sixteen Mile Creek at the downstream of Culvert C23.

Catchment / HYD ID	Storm Duration & Distribution	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
107	12-hr Chicago	0.389	0.528	0.618	0.736	0.821	0.921	17, 18
107	**24-hr Chicago**	**0.391**	**0.532**	**0.623**	**0.742**	**0.829**	**0.930**	17, 18

HYD 107 gives the total flow from Catchments 100 and 105 that draining to Sixteen Mile Creek at the downstream of Culvert C24.

Out of two storm distributions, the 24-hour Chicago storm distribution generated a conservative peak flow, therefore it is considered as the governing pre-development flow.

4.1.4 Storm Sewers under Existing Conditions

The existing conditions storm sewer capacity assessment was completed using the Rational Method. The following approaches were considered in the analysis:

- For the external area, flow values were taken from the Visual OTTHYMO hydrologic modelling results.
- Inlet time of concentrations (Tc) were set to 10-min as per the Town of Oakville and Town of Milton Guidelines.
- Rainfall data was taken from the Town of Oakville and Town of Milton Guidelines.

Existing Storm Sewer Capacity Assessment Capacity Assessment sheets are provided in **Volume II Appendix E**.

The results of existing storm sewer assessment show that:

a) Within the Town of Oakville Jurisdiction

- The 375 mm diameter storm sewer from MH31 to MH37 (St. 2+458 to St. 2+558) has 105% usage.
- The 450 mm diameter storm sewer from MH37 to MH41 (St. 2+558 to St. 2+658) has 101% usage.
- The 450 mm diameter storm sewer from MH75 to MH70 (St. 3+272 to St. 3+172) has 102% usage.
- All remaining storm sewers along Regional Road 25 are below 90% utilization.

b) Within the Town of Milton Jurisdiction

- The 300 mm diameter storm sewers from CB1 to CBMH2 (St. 12+610 to St. 12+652) and from CBMH2 to CBMH3 (St.12+652 to St.12+698) consist of 105% and 124% usage, respectively. This is due to the relatively flat slope, of about 0.30%, of the existing storm sewer.
- The 525 mm storm sewers from MHS6A to CBMH6 (St. 12+868 to St. 12+847) and from CBMH6 to CBMH 7 (St.12+847 to St.12+847) on Regional Road 25 consist of around 90% and 97% usage, respectively. This is due to the flow of external catchment 193.
- The 300 mm storm sewer from CBMH62 to CBMH20 (St.14+392 to St.14+408) on Regional Road 25 has around 90% usage.
- The 450 mm Storm Sewer from CBMH133 to CBMH127 (St.15+569 to St.15+520) on Regional Road 25 has around 97% usage. This is due to the flow of external catchments from the east side of Regional Road 25.
- All remaining storm sewer along Regional Road are below 85% utilization.

4.2 Proposed Drainage Conditions

4.2.1 Proposed Drainage Pattern

Under proposed conditions, Regional Road 25 between Wyecroft Road and Derry Road West will be upgraded from a 4-lane road section to a 6-lane urban road section with additional turning lanes at intersections. South of Wyecroft Road, 6-lane roadway will be transitioned to the 4-lane existing roadway. Runoff from Regional Road 25 will be captured by proposed storm sewers to its outlets and most of existing outlets are maintained under proposed conditions. Storage pipe facilities will be provided at different locations to control the flows from the roadways to pre-development conditions. Quality treatment of roadway runoff from all catchments is proposed and provided by Oil Grit Separators (OGSs) located after each of the storage pipe facilities prior to discharging to the watercourses. Wherever practical, treatment train approach will be considered.

The proposed drainage mosaic is shown in **Exhibit 18** to **Exhibit 34** in **Volume II Appendix B**.

Due to the road widening and other associated improvements of Regional Road 25, the following are the changes in each catchment compared to the existing condition:

1) **Outlet to Speers Road**
    - There will be no change in the drainage area and drainage pattern within Catchment 595 under the proposed conditions. However, the introduction of multi-use path (MUP) on the east side of the catchment will results in a slight increase in imperviousness. The imperviousness of this catchment under proposed scenario will be 2.57 ha which is an increase of 5% compared to existing conditions.
    - To mitigate the impact of this increase in impervious surface and ensure post-development peak flows do not exceed pre-development levels, a storage pipe facility is proposed. This facility will provide the necessary detention volume to control runoff and maintain the existing hydrologic response of the catchment.
2) **Outlet to QEW EAST SWM Pond (SWMP-1)**
    - From St. 0+922 to St. 1+042:
        - Roadway runoff from Catchment 585 will be conveyed by existing storm sewers and discharge to the QEW SWM Pond as in existing condition; however, the impervious area will increase from 0.49 ha to 0.56 ha due to the road widening which is an increase of 8%

compared to existing conditions. There will be no change in the drainage condition of external areas.

- From St. 1+042 to St. 2+362:
  - Runoff from Regional Road 25 within this stretch of the road (Catchments 540 and 545) will be conveyed by existing storm sewers and discharged to the QEW SWM Pond as in existing conditions. The impervious area within this stretch of Regional Road 25 will increase from 4.20 ha to 4.56 ha which is an increase of 5% compared to existing conditions. There will be no change in the drainage condition of external catchments.
- The total imperviousness area from the roadway (Catchments 540, 545 and 585) which outlets to the QEW SWM pond will increase from 4.69 ha to 5.12 ha. This will make an overall impervious coverage of 71%, which is an increase of 6% compared to existing conditions.
- To mitigate the impact of imperviousness increase, storage pipe facility will be needed to control the flows to pre-development levels before discharging to the QEW SWM Pond.
- The QEW SWM pond will continue to provide quality control for roadway Catchments 540, 545 and 585.

3) Outlet to Fourteen Mile Creek Tributary at the D/S of Culvert C01

- There will be no change in the drainage pattern and drainage area for both Catchments 535 and 530. Roadway runoff from these catchments will be conveyed by storm sewers and outlet to Fourteen Mile Creek Tributary, consistent with current conditions. However, the impervious coverage for Catchment 535 will increase from 69% to 86% and for Catchment 530 will increase from 75% to 89%.
- The total imperviousness area within roadway Catchments 530 and 535 will increase from 3.05 ha to 3.68 ha. This will make an overall impervious coverage of 88%, which is an increase of 15% compared to existing conditions.
- To offset the impact of impervious area increase, two storage pipe facilities will be provided to control the flows to pre-development levels before discharging to the Fourteen Mile Creek Tributary.
- The existing OGS units (OGS 1 and OGS 2) provide water quality treatment for roadway runoff. Additional new OGS units (OGS 1A and 2A) will be proposed to improve the runoff quality before discharging to the watercourse.

4) **Outlet to Fourteen Mile Creek through storm sewer along Upper Middle Road West**
    - There will be no change in the drainage area and pattern within roadway Catchment 515, but the impervious coverage will increase from 74% to 83%.
    - Similarly, there will be no change in the drainage pattern of roadway Catchment 520 and external Catchment 525 from existing condition; however, the imperviousness of Catchment 520 under proposed condition will increase by 17% from the existing conditions level.
    - To mitigate the impact of increased impervious area, two storage pipe facilities will be provided to control the flows to pre-development levels before discharging to the Fourteen Mile Creek.
    - Two OGS units (OGS 9 and 10) will be proposed to provide water quality treatment for roadway runoff before discharging to Fourteen Mile Creek.
5) **Outlet to Bronte Creek SE SWM Pond (SWMP-2)**
    - There will be no change in the drainage area and drainage pattern for roadway Catchment 505, but the impervious area will increase from 2.22 ha to 2.72 ha, which is an increase of 11%.
    - The drainage area of external Catchment 500 will increase from 1.07 ha to 1.14 ha due to minor change in road alignment.
    - Bronte Creek SE SWM Pond will continue receive major flow from Catchments 430 and 495. Compared to the existing condition, the total drainage area is increased from 12.39 ha to 13.23 ha and the total impervious area from these Catchments is increase from 7.12 ha to 9.34 ha, which is an increase of 13%.
    - There is no change on drainage pattern and drainage area for external area (Catchment 510) as the improvement of Regional Road 25 does not impact this external catchment.
    - A storage pipe facility will be provided to mitigate the impact of increased imperviousness. This facility is designed to attenuate runoff and control peak flows to pre-development levels before discharging to the SWMP-2.
    - The existing SWM pond will continue to provide quality control for the roadway area.
6) **Outlet to Mattamy SWM Pond (SWMP-3)**
    - Minor storm runoff from Regional Road 25 from approximately St. 4+307 to St. 6+570 will be directed to Mattamy SWM Pond as in existing

condition. Due to the widening of Regional Road 25, the total drainage area which drains to Mattamy SWM Pond will increase from 12.39 ha to 13.23 ha and the impervious coverage will increase from 7.12 ha under existing condition to 9.34 ha under proposed condition, which is 13% increase.

- There is no change on drainage pattern and drainage area for external area (Catchments 498 and 499) as the improvement of Regional Road 25 does not impact these external catchments.
- As the Mattamy SWM pond will provide control for minor storm event to the existing condition flow rate only, a storage pipe facility will be provided as an additional peak flow control measure for roadway runoff before discharging to the SWMP-3.
- The existing Mattamy SWM Pond (SWMP-3) will continue to provide quality control for the roadway area.

7) **Outlet to Fourteen Mile Creek via Dundas Street West Storm Sewer**
    - Due to minor shift of road centreline, the drainage area Regional Road 25 which drains to Dundas Street West by storm sewers will decrease from 0.97 ha (Catchment 475 and 480) to 0.51 ha (Catchment 480), but the impervious coverage will increase from 0.38 ha under existing condition to 0.47 ha under proposed condition. Due to a significant decrease in drainage area, no impact is expected to the existing outlet.
8) **Outlet to Fourteen Mile Creek via Culvert C-WH1 at William Halton Parkway**
    - There will be no change in the drainage pattern for Catchments 455 and 460. Due to the minor shift of road alignment, the drainage area of external Catchment 455 will decrease from 9.99 ha to 9.80 ha but there will be no change in imperviousness for this catchment.
    - Overall, at the downstream of C-WH1, the drainage area will decrease from 13.02 ha to 12.71 ha. Therefore, no impact is expected at this outlet.
9) **Outlet to Fourteen Mile Creek Tributary via Culvert C05**
    - Due to the urbanization of Regional Road 25, roadway runoff from approximately St. 6+570 to St. 7+150 will be conveyed by proposed storm sewers and discharged to Fourteen Mile Creek tributary via Culvert C05.
    - Runoff from Catchment 410 (drainage area 0.95 ha) will be conveyed by storm sewers in a north direction and discharge the outflow on the west side of Regional Road 25. The outflow will combine with the runoff from external Catchments 400, 4071, 4072, 415 to drains to Culvert C05.

- Runoff from Catchment 420 (drainage area 1.86 ha) will be conveyed by proposed storm sewers and will be discharged at the downstream of Culvert C05 which ultimately drains to Fourteen Mile Creek tributary.
- Compared to the existing condition, the total drainage area that drains to the downstream of Culvert C05 is decreased from 73.16 ha to 72.36 ha, but the impervious coverage is increased from 5.55 ha to 5.84 ha.
- To mitigate the impact of impervious area increase, two storage pipe facilities will be provided to control the flows to pre-development levels before discharging to the Fourteen Mile Creek tributary.
- Two OGS units (OGS 11 and 12) will be provided for water quality treatment of roadway runoff before discharging to the Fourteen Mile Creek tributary.

10) Outlet to Fourteen Mile Creek near 407-ETR

- There is no change in the drainage pattern for Catchment 4076. Due to the widening of Regional Road 25, the drainage area of Catchment 4076 is decreased from 2.16 ha to 1.65 ha, and the imperviousness is decreased from 52% under existing condition to 43% under proposed condition. There will be no impact to this catchment.
- Similarly, the total drainage area of Catchment 4073 and 4074 is decreased from 8.74 ha to 8.48 ha due to the widening of Regional Road 25 and the imperviousness also decreased from 18% under existing condition to 17% under proposed condition. Therefore, there will be no peak flow impact is expected due to road widening to these catchments.
- Due to the urbanization of Regional Road 25, two existing catchments are consolidated into one Catchment 405 (drainage area 1.13 ha). Roadway runoff from this catchment will be conveyed by storm sewers in south direction and discharged on the east side of Regional Road 25. The outflow will be further conveyed southerly to Fourteen Mile Creek through two 407 ETR Culverts 407-5 and 407-7. When compared to the Catchment 405 under existing condition, the drainage area is increased from 0.62 ha to 1.13 ha, and the impervious coverage is increased from 0.45 ha to 1.03 ha.
- To mitigate the impact of the increase of impervious area in Catchment 405, one storage pipe facility will be provided to control the flow to pre-development level before discharging to the Fourteen Mile Creek.
- One OGS unit (OGS 13) will be provided for water quality treatment of roadway runoff.

11) Outlet to Fourteen Mile Creek at the D/S of Culvert C06

- Runoff from Regional Road 25 from approximately St. 7+420 to St. 7+736 (Catchment 390) will be conveyed by proposed storm sewers southerly and discharged at the downstream of Culvert C06 on the east side of the roadway. The total drainage area which drains to the downstream of Culvert C06 will increase from 1.28 ha to 1.54 ha and the impervious area will increase from 0.73 ha to 1.21 ha. This will make an increase of 22% compared to the existing condition.
- To offset the impact of impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging to the downstream of Culvert C06.
- One OGS unit (OGS 14) is proposed to improve the runoff quality outlet.

12) Outlet to Fourteen Mile Creek at the D/S of Culvert C07

- Runoff from Regional Road 25 from approximately St. 7+736 to St. 7+861 (Catchment 375) will be conveyed by proposed storm sewers southerly and discharge at the downstream of Culvert C07 on the east side of the roadway. The total drainage area is decreased from 0.80ha (Catchments 375 and 380) to 0.49 ha (Catchment 375) at the outlet and the impervious area will decrease from 0.51 ha to 0.45 ha. Due to decrease in drainage area and impervious area, there will be no flow impact at the outlet.
- One OGS unit (OGS 15) is proposed to improve the quality of roadway runoff at this outlet.

13) Outlet to Fourteen Mile Creek at the D/S of Culvert C08, C08A

- Runoff from Regional Road 25 from approximately St. 7+861 to St. 8+360 (Catchments 360 and 368) will be conveyed by proposed storm sewers southerly and discharge at the downstream of Culvert C08. A new culvert which will be identified as C08A will be proposed Due to widening of the roadway.
- When compared with the existing condition, the total drainage area which drains to the D/S of Culvert C08 is increased from 19.50 ha (Catchment 355, 360 and 365) to 19.63 ha (Catchment 355, 360, 365 and 368) and the and the impervious area will increase from 5.32 ha to 5.84 ha.
- To offset the impervious increase impact, one storage pipe facility will be provided within Catchment 360 to control flows to pre-development levels before discharging to the downstream of Culvert C08.
- Three OGS units (OGS 16, 17 and 18) are proposed to improve the runoff quality before discharging to the downstream of Culvert C08.

14) Outlet to Fourteen Mile Creek at the D/S of Existing Culvert C09

- Due to widening of the roadway, existing Culvert C09 needs to be relocated to the north, the new culvert will be identified as C09A. The existing Culvert C10 will also be eliminated, and road runoff will be directed to a new Culvert C09A.
- Due to the elimination of the existing Culvert C10, runoff from Regional Road 25 from approximately St. 8+360 to St. 8+816 (Catchments 335 and 350) will be conveyed by proposed storm sewers southerly and discharge at the downstream of Culvert C09 which is on the east side of the roadway. The combined drainage area including the external area which drains to the downstream of Culvert C09 is increased from 4.28 ha (Catchments 330, 345 and 350) to 6.00 ha (Catchments 330, 335 and 350) and the impervious area will increase from 1.08 ha to 2.50 ha. This will make an increase of 17% compared to the existing condition.
- To mitigate the impact of impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging to the downstream of Culvert C09.
- Two OGS units (OGS 19 and 20) is proposed to improve the runoff quality of Regional Road 25 before discharging to the downstream of Culvert C09.

15) Outlet to Fourteen Mile Creek at the D/S of Culvert C11

- Runoff from Regional Road 25 Catchments 326 will be captured by catch basins and discharged at the downstream of Culvert C11 via storm sewer lateral, which ultimately drains to Fourteen Mile Creek.
- The total drainage area which outlets to Fourteen Mile Creek at downstream of Culvert C11 (Catchments 325 and 326) is decreased from 1.74ha under existing condition to 1.55 ha under proposed condition and the impervious area is also decreased from 0.30 ha to 0.24 ha. Therefore, there will be no impact at this outlet.

16) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C12

- Runoff from Regional Road 25 from approximately St 8+860 to St 9+146 (Catchments 315) will be conveyed by proposed storm sewers northerly and discharged at the downstream of Culvert C12 which is on the west side of the roadway. The flow ultimately drains to a tributary of Sixteen Mile Creek. There is no change on the drainage pattern and drainage area of external Catchment 314 as the improvement of Regional Road 25 does not impact the external catchment.

- Compared to the existing condition, the total roadway drainage area will decrease from 1.26 ha (Catchments 315 and 317) to 1.15 ha (Catchment 315), but the impervious area will increase from 0.76 ha to 1.05 ha. This will make an overall impervious coverage of 91%, which is an increase of 31% compared to the existing condition.
- To mitigate the impact impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging at the downstream of Culvert C12.
- One OGS unit (OGS 21) will be provided to improve the quality of runoff.

17) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C13

- Runoff from Regional Road 25 from approximately St. 9+146 to St. 9+411 (Catchments 310) will be conveyed by proposed storm sewers northerly and discharged at the downstream of Culvert C13, on the west side of the roadway. Outflow from this culvert ultimately discharges to a tributary of Sixteen Mile Creek. There is no change in the drainage pattern and area of external Catchment 311, as the improvement of Regional Road 25 does not impact this external catchment.
- Compared to the existing condition, the total roadway drainage area will increase from 1.04 ha (Catchments 310 and 320) to 1.08 ha (Catchment 310) and the impervious area will also increase from 0.36 ha to 0.99 ha. This will make an overall impervious coverage of 92%, which is an increase of 57% compared to the existing condition.
- To mitigate the impact impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging at the downstream of Culvert C13.
- One OGS unit (OGS 22) will be provided to improve the quality of runoff

18) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C14

- Runoff from Regional Road 25 from approximately St. 9+411 to St. 9+752 (Catchments 300) will be conveyed by proposed storm sewers northerly and discharged at the downstream of Culvert C14 on the west side of the roadway.
- Compared to the existing condition, the total drainage area draining at the downstream of Culvert C14 will decrease from 5.51 ha (Catchments 295, 300 and 305) to 5.41 ha (Catchments 295, 297, 300 and 305), but the impervious area will increase from 3.40 ha to 3.69 ha. This will make an overall impervious coverage of 68%, which is an increase of 6% compared to the existing condition.

- To mitigate the impact of impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging at the downstream of Culvert C14.
- One OGS unit (OGS 23) will be provided to improve the quality of runoff.

19) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C15

- Surface runoff of Regional Road 25 between St. 9+752 and St. 10+421 (Catchments 280 and 285) will be conveyed by proposed storm sewers towards Culvert C15. The total drainage area (Catchments 275, 280, 285 and 290) which drains to Culvert C15 is increased from 3.10 ha to 3.62 ha and the impervious area will increase from 1.41 ha to 2.50 ha. This will make an overall impervious coverage of 69%, which is an increase of 24% compared to the existing condition.
- To mitigate the impact of impervious area increase, two storage pipe facilities will be provided to control flows to pre-development levels before discharging at the downstream of Culvert C15.
- Similarly, two OGS units (OGS 24 and 25) will be provided to improve the quality of roadway runoff.

20) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C16

- Runoff from Regional Road 25 Catchment 260 will be conveyed by proposed storm sewers southerly and discharged at the downstream of Culvert C16 on the west side of the roadway.
- There is no change in the drainage pattern and drainage area of external Catchment 255.
- Compared to the existing condition, the total roadway drainage area draining at this outlet will decrease from 3.51 ha to 3.14 ha, but the impervious area will increase from 1.53 ha to 1.88 ha. This will make an overall impervious coverage of 60%, which is an increase of 16% compared to the existing condition.
- To mitigate the impact of impervious area increase, one storage pipe facility will be provided to control flows to pre-development levels before discharging at the downstream of Culvert C16.
- One OGS unit (OGS 26) will be provided to improve the quality of roadway runoff.

21) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C17

- Due to the urbanization of Regional Road 25, roadway Catchment 245 is separated, and runoff will be conveyed by proposed storm sewers

northerly and discharged at the downstream of Culvert C17 on the east side of the roadway. Due to this, the drainage area for Culvert 17 (Catchment 307) is decreased to 3.07ha. Similarly, drainage area of Catchment 250 is also decreased from 0.93 ha to 0.64 ha and discharges at the downstream of the culvert.

- Since the flow from Culverts C17 and C18 will discharge to the same tributary of Sixteen Mile Creek, the peak flow control at Culvert C17 seems not necessary as the combined flow will be balanced.
- One OGS unit (OGS 27) will be provided to improve the quality of roadway runoff before discharging at the downstream of Culvert C17.

22) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C18

- Runoff from Regional Road 25 from approximately St. 11+250 to St. 11+452 (Catchment 237) will be conveyed by proposed storm sewers northerly and discharged at the downstream of Culvert C18 on the east side of the roadway. Compared to the existing condition, the total roadway drainage area from Catchments 230, 234 and 237 will decrease from 2.45 ha to 1.97 ha and the impervious area will decrease from 0.79 ha to 0.77 ha. There is no change on the drainage pattern and drainage area of external area (Catchment 232) as the improvement of Regional Road 25 does not impact this external catchment.
- One OGS unit (OGS 28) is proposed to improve the runoff quality for this stretch of the roadway.
- At the downstream, flow from both C17 and C18 is connected to the tributary of Sixteen Mile Creek.
- The total drainage area which outlets to Sixteen Mile Creek via Culverts C17 and C18 from Catchments 230, 232, 234, 237, 240,245, 250 is decreased from 22.68 ha to 22.51 ha and the imperviousness is increased from 24% to 25%, which is negligible.

23) Outlet to Sixteen Mile Creek at the D/S of Culvert C19

- Runoff from Regional Road 25 from approximately St.11+452 to St. 12+508 (Catchments 210 and 225) will be conveyed by proposed storm sewers towards Culvert C19. Compared to the existing condition, the total roadway drainage area draining to C19 is increased from 3.83 ha (Catchments 210, 215, 220, 225) to 4.58 ha (Catchments 210, 215, 225) and the impervious area will increase from 2.30 ha to 3.83 ha. This will make an increase of 24% compared to the existing condition.

- To mitigate the impact of impervious area increase, storage pipe facility will be provided to control flows to the pre-development level before discharging to the downstream of Culvert C19.
- Two OGS units (OGS 29 and 30) are proposed to improve the runoff quality for this stretch of the roadway.

24) Outlet to Sixteen Mile Creek at the D/S of Culvert C20

- Runoff from Regional Road 25 from approximately St. 12+508 to St. 12+841 (Catchments 200) will be conveyed by proposed storm sewers northerly and discharge to the downstream of Culvert C20 on the west side of Regional Road 25.
- Compared to the existing condition, the total roadway drainage area will decrease from existing 1.60 ha to proposed 1.39 ha (Catchment 200) and the impervious area will increase from 0.95 ha to 1.27 ha. This will make an overall impervious coverage of 91%, which is an increase of 4% compared to the existing condition.
- A storage pipe facility will be provided to control flows to pre-development levels to mitigate the impact due to increased imperviousness. Overcontrol is provided in the storage pipe to offset the imperviousness increase in Catchment 185, i.e. Britannia Road intersection.
- One OGS unit (OGS 31) is proposed to improve the runoff quality for the stretch of Regional Road 25 before discharging to the downstream of Culvert C20.

25) Outlet to Sixteen Mile Creek Tributary via Britannia Road

- Runoff from Regional Road 25 from approximately St. 12+841 to St. 12+991 (Catchment 185) will be conveyed by existing and proposed storm sewers along Regional Road 25 towards Britannia Road and ultimately discharge to Sixteen Mile Creek. There is no change to the drainage area and pattern of external area (Catchment 193).
- Due to the urbanization, the total roadway drainage area will increase from 0.69 ha (Catchments 185 and 190) to 0.78 ha (Catchment 185) and the impervious area will increase from 0.46 ha to 0.76 ha. This will make an overall impervious coverage of 95%, which is an increase of 12% compared to the existing condition. To mitigate this imperviousness increases, overcontrol is provided in Catchment 200.

26) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C21

- Runoff from Regional Road 25 from approximately St. 12+991 to St. 13+398 (Catchment 175) will be conveyed by proposed storm sewers

along Regional Road 25 towards the D/S of Culvert C21. There is no change on drainage pattern and drainage area for external area (Catchment 170) as the improvement of Regional Road 25 does not impact this external catchment.

- Due to the urbanization, the total roadway drainage area will increase from 1.58 ha (Catchments 175 and 180) to 1.67 ha (Catchment 175) and the impervious area will increase from 1.06 ha to 1.49 ha. This will make an overall impervious coverage of 89%, which is an increase of 22% compared to the existing condition.
- One storage pipe facility will be provided to control flows to pre-development levels at this catchment to mitigate the impact of impervious area increase.
- Two OGS units (existing OGS 3 and new OGS 3A) will be provided to improve the runoff quality of Catchment 175 before discharging to the downstream of Culvert C21.

27) Outlet to Sixteen Mile Creek Tributary at the D/S of Culvert C22

- Runoff from Regional Road 25 from approximately St. 13+398 to St. 14+348 (Catchment 155) will be conveyed by proposed storm sewers along Regional Road 25.Minor flow will continue to discharge to Culvert C22 while major flow will discharge to West Country Milton SWM Pond (SWMP-4). There is no change on drainage pattern and drainage area for external area (Catchment 165) as the improvement of Regional Road 25 does not impact this external catchment. It is possible to discharge both minor and major storm from Regional Road 25 to SWMP-4. However, due to limited available information of outlet condition of the pond, it is recommended to review in detail during the detailed design phase.
- Due to the urbanization and adjustment of road alignment, the total roadway drainage area will decrease from 4.30 ha (existing Catchments 140, 145, 1501, 1502 and 155) to 4.13 ha (Catchment 155) but the impervious area will increase from 2.51 ha to 3.45 ha. This will make an overall impervious coverage of 84%, which is an increase of 12% compared to the existing condition.
- As the SWMP-4 provide control for only west half of the roadway under existing condition, a storage pipe facility will be provided to control peak flows to pre-development levels before discharging to SWMP-4.
- The existing West Country Milton SWM Pond (SWMP-4) and existing OGS 4 will continue to provide quality control for roadway area.

28) Outlet to Sixteen Mile Creek through Louis St. Laurent Avenue Storm Sewer

- There is no change in the drainage pattern and drainage area of Catchment 135. Runoff from this catchment will be conveyed by existing storm towards Louis St. Laurent Avenue and discharge to Sixteen Mile Creek as it is in existing condition. Due to the improvement of Regional Road 25, the impervious area will increase from 0.22 ha to 0.28 ha. This will make an overall impervious coverage of 90%, which is an increase of 19% compared to the existing condition.

29) Outlet to Sixteen Mile Creek near the Bridge 04

- Runoff from Regional Road 25 from approximately St. 14+395 to St. 14+689 (Catchment 130) will be conveyed by proposed storm sewers northerly along Regional Road 25 and discharged to Sixteen Mile Creek. This proposed storm sewer system utilizes the existing outfall located on the west side of Regional Road 25 at St 14+683.
- Similarly, Runoff from Regional Road 25 from approximately St.14+689 to St.15+259 (Catchment 120) will be conveyed by proposed storm sewers southerly along Regional Road 25 and discharges to the Sixteen Mile Creek. This proposed storm sewer system also utilizes the existing outfall located on the west side of Regional Road 25 at St 14+834.
- Due to the road widening of Regional Road 25, the total roadway drainage area of Catchment 120 at this outfall will increase from 1.39 ha to 1.54 ha and the impervious area will increase from 0.86 ha to 1.00 ha. Similarly, the roadway drainage area of Catchment 120 will increase from 1.37 ha to 1.81 ha and the impervious area will increase from 1.25 ha to 1.64 ha.
- Compared to the existing condition, there is no change in the total drainage area which drains to the downstream of Sixteen Mile Creek Bridge B04 (Catchments 120, 125, 126 and 130), but the total impervious area will increase from 2.44 ha to 2.87 ha. This will make an overall impervious coverage of 56%, which is an increase of 8% compared to the existing condition.
- To mitigate the impact of imperviousness increase, two storage pipe facilities will be provided to control flows to pre-development levels before discharging to the Sixteen Mile Creek.
- Two existing OGS units (OGS 5 and 6) will continue to provide water quality control for the roadway area. CB Shield can be installed at each catch basin to provide additional quality measure.

30) Outlet to Sixteen Mile Creek at the D/S of Culvert C23

- There is no change in the overall drainage area of 7.78 ha (Catchments 110, 115 and 122) compared to the existing condition which drains to Culvert C23, but the total impervious area is increased from 1.63 ha to 1.91 ha, which makes an increase of 4% imperviousness due to the road widening of Regional Road 25 from 4-lane to 6-lane.
- Road runoff is conveyed by proposed storm sewers utilizing the existing outfall at Culvert 23.
- One storage pipe facility is proposed to control flows to pre-development levels before discharging to Culvert C23.
- The existing OGS unit (OGS 7) will continue to provide water quality control for the roadway area. CB Shield can be installed at each catch basin to provide additional quality measure.

31) Outlet to Sixteen Mile Creek at D/S of Culvert C24

- There is no change in the drainage area and drainage pattern of Catchment 105. Based on the site plan of Connectt Development which located on the southeast side of Derry Road and Regional Road 25 intersection, the total impervious area in this catchment is increased from 0.62 ha to 0.65 ha, which is makes an increase in 1% compared to existing condition and can be considered negligible.
- Road runoff is conveyed by proposed storm sewers utilizing the existing outfall at Culvert 24.
- There is no change on drainage pattern and area of external Catchment 100 as the improvement of Regional Road 25 does not impact this external catchment.
- The existing OGS unit (OGS 8) will continue to provide water quality control for the roadway area. CB Shield can be installed at each catch basin to provide additional quality measure.

4.2.2 Proposed Conditions Hydrologic Modelling

The post conditions hydrologic modelling input parameters as well as hydrologic modelling schematic and summary output details are included in **Volume II Appendix C**.

Table 6 and **Table 7** summarize the results of the proposed conditions hydrologic modelling for uncontrolled and controlled scenarios as well as comparison with existing conditions for the 24-hour Chicago storm distribution at specific node point and catchments.

Table 6: Proposed Conditions Hydrologic Modelling Summary and Comparison - Fourteen Mile Creek Watershed

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
595	Existing	4.75	0.51	0.74	0.92	1.14	1.29	1.45	1
595	Proposed Uncontrolled	4.75	0.56	0.81	1.00	1.23	1.40	1.56	19
27	Proposed Controlled	4.75	0.43	0.62	0.76	0.94	1.07	1.20	19
	Diff. (Pr. Controlled - Ex)	**0.00**	**-0.08**	**-0.12**	**-0.15**	**-0.19**	**-0.22**	**-0.25**	

HYD 595 gives the flow from Catchment 595 that drains southerly along Regional Road 25 under existing and proposed uncontrolled conditions.

HYD 27 gives the flow from Catchment 595 that drains southerly along Regional Road 25 under proposed controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
591	Existing	22.21	2.05	2.96	3.58	4.49	5.12	5.90	2
591	Proposed Uncontrolled	22.21	2.15	3.09	3.77	4.65	5.31	6.09	20
591	Proposed Controlled	22.21	2.00	2.82	3.44	4.28	4.90	5.66	20
	Diff. (Pr. Controlled - Ex)	**0.00**	**-0.05**	**-0.15**	**-0.14**	**-0.21**	**-0.22**	**-0.23**	

HYD 591 gives total flow draining to QEW SWM pond.

HYD 591 includes the drainage from Catchments 540 to 590 under existing, proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
536	Existing	4.18	0.70	1.01	1.21	1.48	1.68	1.87	3, 4
536	Proposed Uncontrolled	4.18	0.83	1.17	1.40	1.71	1.94	2.15	21, 22
536	Proposed Controlled	4.18	0.75	1.01	1.15	1.32	1.47	1.63	21, 22
	Diff. (Pr. Controlled - Ex)	**0.00**	**0.06**	**0.01**	**-0.06**	**-0.17**	**-0.21**	**-0.24**	

HYD 536 gives the total flow from Catchments 530 and 535 that draining to Fourteen Mile Creek near Culvert C01 under existing, proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
515	Existing	0.69	0.12	0.17	0.20	0.25	0.28	0.31	4
515	Proposed Uncontrolled	0.69	0.13	0.19	0.22	0.28	0.31	0.35	22
22	Proposed Controlled	0.69	0.11	0.15	0.17	0.22	0.26	0.29	22
	Diff. (Pr. Controlled - Ex)	**0.00**	**-0.01**	**-0.02**	**-0.03**	**-0.03**	**-0.02**	**-0.02**	

HYD 515 give total flow from Catchment 515 draining to Upper Middle Road West which further drains westerly towards Fourteen Mile Creek under existing and proposed uncontrolled conditions.

HYD 22 give total flow from Catchment 515 draining to Upper Middle Road West which further drains westerly towards Fourteen Mile Creek under proposed controlled condition. It should be noted that quantity control is provided only for minor event.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
652	Existing	179.7	3.01	4.97	6.44	8.46	9.88	11.41	7
652	Proposed Uncontrolled	179.7	3.01	4.97	6.44	8.46	9.88	11.41	25

HYD 652 provide the flow for culvert C02. The Regional storm flow is 18.86 m3/s

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
527	Existing	1.30	0.21	0.30	0.37	0.45	0.51	0.57	4
527	Proposed Uncontrolled	1.30	0.24	0.34	0.41	0.50	0.56	0.62	22
527	Proposed Controlled	1.30	0.22	0.30	0.36	0.44	0.50	0.56	22
	Diff. (Pr. Controlled - Ex)	**0.00**	**0.01**	**0.00**	**-0.02**	**-0.02**	**-0.01**	**-0.01**	

HYD 527 give total flow from Catchments 520 and 525 draining to Upper Middle Road West which further drains in east direction towards Fourteen Mile Creek under existing, proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
512	Existing	28.36	1.54	2.27	3.30	4.60	5.58	6.83	5, 6, 7
512	Proposed Uncontrolled	29.27	1.65	2.42	3.59	5.10	6.36	7.48	23,24,25
512	Proposed Controlled	29.27	1.55	2.17	3.41	4.94	6.20	7.33	23,24,25
	Diff. (Pr. Controlled - Ex)	0.91	0.005	-0.103	0.118	0.333	0.621	0.493	

HYD 512 gives total flow draining SWMP-2.

HYD 512 includes the flow from Catchment 430 to 495 (major flow) and runoff from Catchments 500 (minor flow) and Catchment 505 under both existing and proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
702	Existing	28.36	0.05	0.06	0.07	0.34	0.76	1.28	5, 6, 7
702	Proposed Uncontrolled	29.27	0.05	0.06	0.11	0.44	0.95	1.54	23,24,25
	Proposed Controlled	29.27	0.04	0.04	0.05	0.24	0.62	1.05	23,24,25
	Diff. (Pr. Controlled - Ex)	**0.91**	**-0.013**	**-0.016**	**0.026**	**-0.093**	**-0.134**	**-0.224**	

HYD 702 gives the outflow from Bronte Creek SE SWM Pond (SWMP-2) under existing, proposed uncontrolled and proposed controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
502	Existing	49.69	4.06	6.06	7.14	8.44	9.39	10.34	5, 6, 7
502	Proposed Uncontrolled	50.53	4.54	6.77	7.86	9.15	10.10	11.06	23,24,25
502	Proposed Controlled	50.53	3.72	5.27	6.45	7.77	8.74	9.71	23,24,25
	Diff. (Pr. Controlled - Ex)	**0.84**	**-0.343**	**-0.782**	**-0.692**	**-0.671**	**-0.650**	**-0.626**	

HYD 502 gives total minor flow draining to Mattamy SWM Pond (SWMP-3).

HYD 502 includes the minor flow from Catchments 430 to 495 and flow from external Catchment 498 (minor flow) and Catchment 499 under existing, proposed uncontrolled and controlled conditions.

It should be noted that pipe storage only provides quantity control for minor event.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
703	Existing	49.69	0.20	0.42	0.62	0.92	1.13	1.37	5, 6, 7
703	Proposed Uncontrolled	50.53	0.21	0.48	0.70	1.00	1.22	1.47	23,24,25
703	Proposed Controlled	50.53	0.21	0.48	0.70	1.01	1.24	1.49	23,24,25
	Diff. (Pr. Controlled - Ex)	**0.84**	**0.016**	**0.056**	**0.076**	**0.092**	**0.104**	**0.122**	

HYD 703 gives the outflow from Mattamy SWM Pond (SWMP-3) under existing, proposed uncontrolled and proposed controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
802	Existing	78.05	0.25	0.48	0.69	1.25	1.79	2.41	5, 6, 7
802	Proposed Uncontrolled	79.80	0.26	0.54	0.78	1.42	2.01	2.67	23,24,25
802	Proposed Controlled	79.80	0.25	0.52	0.75	1.25	1.81	2.38	23,24,25
	Diff. (Pr. Controlled - Ex)	**1.75**	**0.002**	**0.039**	**0.059**	**0.001**	**0.014**	**-0.036**	

HYD 802 gives the outflow from Bronte Creek SE SWM Pond (SWMP-2) and Mattamy SWM Pond (SWMP-3) that draining to Fourteen Mile Creek under existing, proposed uncontrolled and proposed controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
480	Existing	0.97	0.09	0.13	0.16	0.19	0.21	0.24	7
480	Proposed Uncontrolled	0.51	0.06	0.09	0.12	0.15	0.17	0.19	25
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.46**	**-0.035**	**-0.036**	**-0.040**	**-0.043**	**-0.046**	**-0.048**	

HYD 482 includes the total flow from Catchments 475 and 480 which draining to Dundas Street W under existing condition.

HYD 480 includes the total flow from Catchment 480 which draining to Dundas Street W under proposed uncontrolled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
455	Existing	9.99	0.14	0.24	0.31	0.42	0.50	0.58	7
455	Proposed Uncontrolled	9.80	0.14	0.23	0.31	0.42	0.49	0.58	25
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.19**	**-0.002**	**-0.001**	**-0.002**	**-0.004**	**-0.004**	**-0.005**	

HYD 455 give flow from Catchments 455 draining to the D/S of Culvert C04 under existing and proposed uncontrolled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
462	Existing	13.02	0.19	0.30	0.39	0.51	0.60	0.76	7
462	Proposed Uncontrolled	12.71	0.19	0.29	0.38	0.50	0.59	0.74	25
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.31**	**-0.007**	**-0.003**	**-0.009**	**-0.005**	**-0.006**	**-0.025**	

HYD 462 give total flow from Catchments 455 and 460 draining to the D/S of Culvert C-WH1 under existing and proposed uncontrolled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
426	Existing	73.16	0.60	0.98	1.28	1.70	1.99	2.32	8, 9
426	Proposed Uncontrolled	73.72	0.80	1.17	1.43	1.80	2.05	2.35	26, 27
426	Proposed Controlled	73.72	0.71	1.04	1.28	1.70	1.99	2.31	26, 27
	Diff. (Pr. Controlled - Ex)	**0.56**	**0.11**	**0.05**	**0.00**	**0.00**	**-0.01**	**-0.01**	

HYD 426 gives total flow draining to D/S of Culvert C05.

HYD 426 includes the total flow from Catchments 395, 400, 410, 415, 420, 425, 4071 and 4072 under existing condition.

HYD 426 includes the total flow from Catchments 400, 410, 415, 420, 4071 and 4072 under proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
4076	Existing	2.16	0.25	0.36	0.44	0.55	0.62	0.73	8
4076	Proposed Uncontrolled	1.65	0.17	0.24	0.29	0.36	0.41	0.51	26
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.51**	**-0.088**	**-0.121**	**-0.148**	**-0.181**	**-0.205**	**-0.227**	

HYD 4076 give flow from Catchment 4076 draining to Fourteen Mile Creek under existing and proposed uncontrolled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
409	Existing	8.74	0.24	0.36	0.45	0.56	0.65	0.78	8
409	Proposed Uncontrolled	8.74	0.25	0.38	0.47	0.59	0.68	0.82	26
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**0**	**0.012**	**0.022**	**0.021**	**0.026**	**0.028**	**0.040**	

HYD 409 gives total flow draining to Fourteen Mile Creek at downstream of Culvert C407-1 and C407-2.

HYD 409 includes the drainage from Catchments 4073 and 4074 under existing and proposed uncontrolled conditions.

The peak flow increase will be attenuated by storage pipe control at other outlets that discharged to Fourteen Mile Creek at the D/S of Culvert C05, C06 and C407-7.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
408	Existing	4.15	0.49	0.70	0.86	1.06	1.21	1.35	10
408	Proposed Uncontrolled	4.22	0.55	0.78	0.95	1.17	1.33	1.55	26
408	Proposed Controlled	4.22	0.44	0.62	0.74	0.90	1.01	1.19	26
	Diff. (Pr. Controlled - Ex)	**0.07**	**-0.04**	**-0.08**	**-0.12**	**-0.17**	**-0.20**	**-0.16**	

HYD 408 gives the flow from Catchments 405 and 4075 that draining to Fourteen Mile Creek at the downstream of Culvert C407-7 under existing, proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
392	Existing	1.28	0.17	0.26	0.31	0.39	0.45	0.51	9
392	Proposed Uncontrolled	1.54	0.28	0.40	0.48	0.58	0.65	0.73	27
392	Proposed Controlled	1.54	0.24	0.34	0.37	0.42	0.46	0.50	27
	Diff. (Pr. Controlled - Ex)	**0.26**	**0.07**	**0.08**	**0.07**	**0.03**	**0.01**	**-0.01**	

HYD 392 gives total flow draining to Fourteen Mile Creek at the D/S of Culvert C06.

HYD 392 includes the drainage from Catchments 385 and 390 under existing, proposed uncontrolled and controlled conditions.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
382	Existing	9.40	0.62	0.92	1.21	1.54	1.78	2.03	9
382	Proposed Uncontrolled	9.13	0.61	0.90	1.18	1.49	1.72	1.96	27
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.26**	**-0.011**	**-0.018**	**-0.031**	**-0.050**	**-0.058**	**-0.066**	

HYD 382 gives total flow draining to Fourteen Mile Creek at D/S of Culvert C07.

HYD 382 includes the drainage from Catchments 370, 375 and 380 under existing condition and drainage from Catchments 370 and 375 under proposed uncontrolled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
369	Existing	19.50	1.17	1.80	2.23	3.05	3.59	4.11	9
369	Proposed Uncontrolled	19.63	1.27	1.93	2.37	3.20	3.70	4.22	27
369	Proposed Controlled	19.62	1.28	1.92	2.33	3.11	3.60	4.10	27
	Diff. (Pr. Controlled - Ex)	**0.12**	**0.11**	**0.12**	**0.10**	**0.06**	**0.01**	**-0.01**	

HYD 369 gives total flow draining to Fourteen Mile Creek at D/S of Culvert C08.

HYD 369 includes the drainage from Catchments 355, 360 and 365 under existing condition and the drainage from Catchments 355, 360, 365 and 368 under proposed uncontrolled and controlled conditions.

The peak flow increase will be attenuated by storage pipe control that discharged to Fourteen Mile Creek at the D/S of Culvert C07.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
351	Existing	4.70	0.34	0.53	0.67	0.85	0.98	1.28	10
352	Proposed Uncontrolled	6.00	0.60	0.90	1.10	1.37	1.57	1.95	28
352	Proposed Controlled	6.00	0.54	0.80	0.94	1.14	1.28	1.61	28
	Diff. (Pr. Controlled - Ex)	**1.30**	**0.19**	**0.27**	**0.27**	**0.29**	**0.30**	**0.33**	

HYD 351 gives total flow draining to Fourteen Mile Creek at downstream of Culvert C09.

HYD 352 includes the drainage from Catchments 330, 345 and 350 under existing condition and the drainage from Catchments 330 and 350 under proposed uncontrolled and controlled conditions.

The peak flow increase will be attenuated by storage pipe control that discharged to Fourteen Mile Creek at the D/S of Culvert C10.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
342	Existing	1.29	0.14	0.21	0.25	0.34	0.39	0.44	11
342	Proposed Uncontrolled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-1.29**	**-0.14**	**-0.21**	**-0.25**	**-0.34**	**-0.39**	**-0.44**	

HYD 342 includes the total flow draining to downstream of Culvert C10 from Catchments 335 and 340 under existing condition.

As Culvert C10 will be eliminated. There is no catchment draining to D/S of Culvert C10 under proposed uncontrolled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
327	Existing	1.74	0.04	0.07	0.09	0.12	0.14	0.16	11
327	Proposed Uncontrolled	1.55	0.05	0.07	0.08	0.10	0.12	0.13	29
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.19**	**0.004**	**-0.002**	**-0.008**	**-0.016**	**-0.022**	**-0.029**	

HYD 327 gives total flow draining to D/S of Culvert C11.

HYD 327 includes the drainage from Catchments 325 and 326 under existing and proposed uncontrolled conditions.

Table 7: Proposed Conditions Hydrologic Modelling Summary and Comparison - Sixteen Mile Creek Watershed

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
318	Existing	3.53	0.20	0.30	0.36	0.45	0.54	0.62	11
318	Proposed Uncontrolled	3.42	0.27	0.38	0.47	0.57	0.65	0.73	29
318	Proposed Controlled	3.42	0.25	0.35	0.42	0.53	0.60	0.67	29
	Diff. (Pr. Controlled - Ex)	**-0.11**	**0.05**	**0.06**	**0.06**	**0.08**	**0.05**	**0.05**	

HYD 318 gives total flow draining to D/S of Culvert C12.

HYD 318 includes the drainage from Catchments 314, 315 and 317 under existing condition and the drainage from Catchments 314 and 315 under proposed uncontrolled and controlled condition.

The peak flow increase will be attenuate by storage pipe control that discharged to Sixteen Mile Creek at Addhyd293.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
322	Existing	8.15	0.22	0.37	0.48	0.64	0.76	0.88	11
322	Proposed Uncontrolled	8.19	0.28	0.42	0.52	0.65	0.76	0.88	29
322	Proposed Controlled	8.19	0.27	0.42	0.53	0.69	0.80	0.94	29
	Diff. (Pr. Controlled - Ex)	**0.04**	**0.05**	**0.05**	**0.05**	**0.05**	**0.04**	**0.06**	

HYD 322 gives total flow draining to D/S of Culvert C13.

HYD 322 includes the drainage from Catchments 310, 311 and 320 under existing condition and the drainage from Catchments 310 and 311 under proposed uncontrolled and controlled condition.

The peak flow increase will be attenuate by storage pipe control that discharged to Sixteen Mile Creek at Addhyd293.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
307	Existing	5.51	0.75	1.03	1.22	1.57	1.78	2.00	12
307	Proposed Uncontrolled	5.41	0.81	1.11	1.31	1.66	1.86	2.08	30
307	Proposed Controlled	5.41	0.80	1.09	1.27	1.57	1.75	1.95	30
	Diff. (Pr. Controlled - Ex)	**-0.10**	**0.05**	**0.06**	**0.04**	**0.00**	**-0.03**	**-0.05**	

HYD 307 gives total flow draining to D/S of Culvert C14.

HYD 307 includes the drainage from Catchments 295, 300 and 305 under existing condition and the drainage from Catchments 295, 297 and 300 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
294	Existing	3.39	0.36	0.51	0.61	0.76	0.91	1.03	12
293	Proposed Uncontrolled	3.62	.58	0.79	0.93	1.11	1.26	1.40	30
293	Proposed Controlled	3.62	0.43	0.53	0.60	0.69	0.75	0.83	30
	Diff. (Pr. Controlled - Ex)	**0.52**	**0.07**	**0.03**	**-0.01**	**-0.08**	**-0.16**	**-0.20**	

HYD 294 includes the flow draining to Fourteen Mile Creek from Catchments 270, 275, 280, 285 and 290 under existing condition.

HYD 293 includes the total flow draining to Fourteen Mile Creek from Catchments 275, 280, 285 and 290 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
267	Existing	10.04	0.35	0.51	0.62	0.76	0.90	1.09	12, 13
272	Proposed Uncontrolled	9.67	0.41	0.56	0.67	0.82	0.92	1.03	30, 31
272	Proposed Controlled	9.67	0.41	0.52	0.58	0.68	0.77	0.86	30, 31
	Diff. (Pr. Controlled - Ex)	**-0.37**	**0.05**	**0.01**	**-0.04**	**-0.08**	**-0.13**	**-0.24**	

HYD 267 gives the total flow draining to D/S of Culvert C16 from Catchments 255, 260 and 265 under existing condition.

HYD 272 gives the total flow draining to D/S of Culvert C16 from Catchments 255, 260 and 265 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
246	Existing	3.90	0.25	0.39	0.48	0.61	0.71	0.95	13
246	Proposed Uncontrolled	4.50	0.42	0.63	0.78	0.98	1.13	1.29	31
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**0.60**	**0.170**	**0.246**	**0.300**	**0.369**	**0.427**	**0.339**	

HYD 246 gives total flow draining to D/S of Culvert C17.

HYD 246 includes the drainage from Catchments 240 and 245 under existing and proposed uncontrolled condition.

The peak flow increase will be attenuate by storage pipe control that discharged to Sixteen Mile Creek at D/S of Culvert C18

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
238	Existing	17.85	0.94	1.51	1.90	2.45	2.91	3.36	13
238	Proposed Uncontrolled	17.37	0.88	1.31	1.72	2.19	2.54	2.93	31
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**-0.48**	**-0.059**	**-0.205**	**-0.177**	**-0.259**	**-0.367**	**-0.423**	

HYD 238 gives total flow draining to D/S of Culvert C18.

HYD 238 includes the drainage from Catchments 230, 232, 234 and 237 under existing and proposed uncontrolled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
226	Existing	3.83	0.52	0.72	0.87	1.07	1.24	1.39	14
226	Proposed Uncontrolled	4.58	0.85	1.16	1.36	1.62	1.81	2.02	31, 32
226	Proposed Controlled	4.58	0.65	0.86	0.98	1.13	1.23	1.34	31, 32
	Diff. (Pr. Controlled - Ex)	**0.75**	**0.13**	**0.14**	**0.11**	**0.06**	**-0.01**	**-0.05**	

HYD 226 gives total flow draining to D/S of Culvert C19.

HYD 226 includes the drainage from Catchments 210, 215, 220 and 225 under existing condition and the drainage from Catchments 210, 215 and 225 under proposed condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
207	Existing	9.12	0.27	0.40	0.50	0.64	0.76	0.88	14, 15
207	Proposed Uncontrolled	8.90	0.33	0.48	0.59	0.73	0.84	0.95	32, 33
207	Proposed Controlled	8.90	0.23	0.37	0.47	0.63	0.76	0.89	32, 33
	Diff. (Pr. Controlled - Ex)	**-0.22**	**-0.039**	**-0.034**	**-0.025**	**-0.011**	**-0.004**	**0.01**	

HYD 207 gives total flow draining to D/S of Culvert C20.

HYD 207 includes the drainage from Catchments 195, 200 and 205 under existing condition and the drainage from Catchments 195 and 200 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
196	Existing	1.75	0.23	0.32	0.38	0.45	0.51	0.59	15
196	Proposed Uncontrolled	1.84	0.29	0.39	0.46	0.55	0.61	0.70	33
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**0.09**	**0.061**	**0.076**	**0.086**	**0.100**	**0.100**	**0.107**	

HYD 196 gives total flow that drains to Britannia Rd.

HYD 196 includes the drainage from Catchments 185, 190 and 193 under existing condition and the drainage from Catchments 185 and 193 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
182	Existing	10.80	0.26	0.37	0.47	0.58	0.67	0.76	15
182	Proposed Uncontrolled	10.89	0.35	0.49	0.58	0.72	0.82	0.92	33
182	Proposed Controlled	10.89	0.22	0.34	0.43	0.56	0.67	0.77	33
	Diff. (Pr. Controlled - Ex)	**0.09**	**-0.003**	**-0.024**	**-0.031**	**-0.016**	**-0.002**	**0.016**	

HYD 182 gives total flow draining to D/S of Culvert C21.

HYD 182 includes the drainage from Catchments 170, 175 and 180 under existing condition and the drainage from Catchments 170 and 175 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
169	Existing	41.33	0.35	0.51	0.61	1.04	1.46	1.88	15, 16
169	Proposed Uncontrolled	45.29	0.10	0.38	0.67	1.16	1.56	1.98	33, 34
169	Proposed Controlled	45.29	0.29	0.51	0.68	1.09	1.49	1.89	33, 34
	Diff. (Pr. Controlled - Ex)	**3.96**	**-0.061**	**0.008**	**0.063**	**0.048**	**0.028**	**0.008**	

HYD 169 gives total flow draining Sixteen Mile Creek at D/S of Culvert C22.

HYD 169 includes the drainage from roadway Catchments 140, 145, 1501, 1502, 155 and external Catchments 158, 159 and 165 under existing condition

HYD 169 includes the drainage from roadway Catchments 155 and external Catchments 158, 159 and 165 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
163	Existing	35.06	3.33	4.95	6.01	7.41	8.45	9.65	15, 16
168	Proposed Uncontrolled	37.21	3.82	5.60	6.61	7.92	8.90	9.99	33, 34
168	Proposed Controlled	37.21	3.49	5.01	6.01	7.32	9.30	9.39	33, 34
	Diff. (Pr. Controlled - Ex)	**2.15**	0.154	0.060	-0.004	-0.086	-0.156	-0.26	

HYD 163 gives total flow from Catchments 140, 1501, 158 and 159 that draining to SWMP-4 under existing condition

HYD 168 gives total flow from Catchments 155, 158 and 159 that draining to SWMP-4 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
704	Existing	35.06	0.04	0.27	0.49	0.85	1.18	1.51	15, 16
704	Proposed Uncontrolled	37.21	0.07	0.35	0.60	1.01	1.35	1.70	33, 34
704	Proposed Controlled	37.21	0.07	0.33	0.57	0.96	1.29	1.62	33, 34
	Diff. (Pr. Controlled - Ex)	**2.15**	0.025	0.059	0.072	0.102	0.105	0.111	

HYD 704 gives total outflow from West County Milton SWM Pond (SWMP-4).

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
135	Existing	0.31	0.05	0.07	0.08	0.10	0.11	0.12	16
135	Proposed Uncontrolled	0.31	0.06	0.08	0.10	0.12	0.13	0.14	34
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**0.00**	**0.014**	**0.015**	**0.017**	**0.019**	**0.020**	**0.021**	

HYD 135 gives flow from Catchment 135 that drains to Louis St Laurent Ave under existing and proposed uncontrolled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
133	Existing	5.12	0.48	0.65	0.76	0.91	1.06	1.18	16, 17
133	Proposed Uncontrolled	5.12	0.60	0.82	0.97	1.19	1.34	1.50	34, 35
133	Proposed Controlled	5.12	0.49	0.64	0.72	0.87	0.94	1.07	34, 35
	Diff. (Pr. Controlled - Ex)	**0.00**	**0.01**	**-0.01**	**-0.04**	**-0.05**	**-0.08**	**-0.11**	

HYD 133 gives total flow draining to Sixteen Mile Creek at the D/S of Bridge B04.

HYD 133 includes the drainage from Catchments 120, 125 and 130 under existing condition and the drainage from Catchments 120, 125, 126 and 130 under proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
124	Existing	7.78	0.30	0.44	0.55	0.69	0.79	0.94	17
124	Proposed Uncontrolled	7.78	0.36	0.52	0.65	0.81	0.93	1.05	35
124	Proposed Controlled	7.78	0.28	0.42	0.53	0.67	0.78	0.89	35
	Diff. (Pr. Controlled - Ex)	**0.00**	**-0.02**	**-0.02**	**-0.02**	**-0.02**	**-0.01**	**-0.05**	

HYD 124 gives total flow draining to D/S of Culvert C23.

HYD 124 includes the drainage from Catchments 110, 115 and 122 under existing and proposed uncontrolled and controlled condition.

Catchment / HYD ID	Scenario	Drainage Area (ha)	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Exhibit No.
107	Existing	2.21	0.39	0.53	0.62	0.74	0.83	0.93	17, 18
107	Proposed Uncontrolled	2.21	0.40	0.54	0.63	0.75	0.84	0.94	35, 36
	Proposed Controlled	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Diff. (Pr. Controlled - Ex)	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	

HYD 107 gives total flow draining to D/S of Culvert 24.

HYD 107 includes the drainage from Catchments 100 and 105 under existing and proposed uncontrolled condition.

The results provided in Table 6 and Table 7 indicate that, under proposed condition, the 100-year flow increases significantly at most outlets due to the increase in imperviousness.

To mitigate the impacts of increased sediment loading and peak flows to the receiving watercourses, stormwater management measures are required for both quality and quantity control. Therefore, to address increased flows and sediment loading at various outlets, superpipes and oil-grit separators will be provided along Regional Road 25. Further details regarding storage volume for peak flow control are provided in Section 6.3.

4.2.3 Storm Sewers Under Proposed Conditions

There are currently no existing storm sewers along Regional Road 25 approximately 280 m south of 407-ETR to Britannia Road as this stretch of the roadway is rural in nature. Under proposed conditions, new storm sewers are proposed along this stretch of Regional Road 25.

Additionally, the existing half-urban section of Regional Road 25 from Britannia Road to Louis St. Laurent Avenue will be upgraded to a fully urban road section, and undersized existing storm sewers within this segment will be replaced to increase the system capacity.

Refer to **Exhibit STM 1** to **Exhibit STM 10** in **Volume II Appendix B** for the sewershed boundary which was considered to determine the preliminary sizing of storm sewers.

Under proposed conditions, storm sewers along Regional Road 25 are analyzed using the Town of Milton IDF and Town of Oakville IDF data, based on a 5-year design storm and 10-minute time of concentration in accordance with the applicable municipal guidelines. The proposed superpipe will provide both peak flow attenuation and conveyance of runoff to downstream of crossing culverts. The results of the storm sewer assessments under proposed conditions show that:

- No storm sewers exceed 100% capacity, i.e., storm sewers are not in pipe full Conditions.
- Regional Road 25 between St 0+212 and St 0+922, the existing storm sewers size ranging from 525 mm to 1350 mm diameter circular pipes, will continue to convey roadway runoff from Catchment 595 to Speers Road.
- It should be noted that available drawing of Regional Road 25 does not show the pipe invert and pipe size between St 0+212 and St 1+042, pipe slope is assumed based on road profile for capacity assessment. Further investigation is recommended during detailed design to confirm the pipe slope and inverts.
- In the roadway stretch where existing storm sewers are utilized, the relocation of catch basins is necessary to accommodate widened road section.
- Existing outlet/outfall are utilized wherever practical.
- The existing storm sewer between St 5+370 and St 5+520 on the west side of Regional Road 25, which convey the runoff from Catchment 475 under existing condition, will be removed due to the road widening and improvement of Regional Road 25.

The summary of preliminary storm sewer sizing is provided in **Table 8**.

Table 8: Summary of Storm Sewers under Proposed Conditions

Station From	Station To	Pipe Size Range for Storm Sewers	Pipe Size for Storage System	Outlet Point
0+212	0+922	525 mm to 1350 mm Ø Circular	None	Bronte Road south of Speers Road
0+922	1+042	525 mm to 600 mm Ø Circular	None	QEW East SWM Pond
1+042	2+358	375 mm to 1200 mm Ø Circular	825 mm Ø Circular	QEW East SWM Pond

Station From	Station To	Pipe Size Range for Storm Sewers	Pipe Size for Storage System	Outlet Point
2+358	3+021	300 mm to 900 mm Ø Circular 1500 mm x 1200 mm Box	1500 mm x 1200 mm Box	Fourteen Mile Creek,
3+021	3+360	300 mm to 750 mm Ø Circular 1345 mm x 855 mm Elliptical	1345 mm x 855 mm Elliptical	Fourteen Mile Creek,
3+360	3+620	300 mm to 825 mm Ø Circular West Side 450 mm to 600 mm Ø Circular East Side	825 mm Ø Circular - West Side 600 mm Ø Circular - East Side	D/s of C01
3+620	4+307	450 mm to 1200 mm Ø Circular 1200 mm x 1200 mm Box	1200 mm x 1200 mm Box	Fourteen Mile Creek,
4+307	6+570	450 mm to 1200 mm Ø Circular 2400 mm x 1800 mm Box	2400 mm x 1800 mm Box	D/s of C01
6+570	6+976	450 mm to 1200 mm Ø Circular 2400 mm x 1800 mm Box	1800 mm x 1500 mm Box	Fourteen Mile Creek,
6+976	7+150	300 mm to 525 mm Ø Circular 1500 mm x 1200 mm Box	1500 mm x 1200 mm Box	Upper Middle Road
7+150	7+420	300 mm to 450 mm Ø Circular 1500 mm x 1200 mm Box	1500 mm x 1200 mm Box	Bronte SE SWM Pond
7+420	7+736	375 mm to 750 mm Ø Circular 1200 mm x 900 mm Box	1200 mm x 900 mm Box	Mattamy SWM Pond
7+736	7+861	450 mm Ø Circular	None	Fourteen Mile Creek,

Station From	Station To	Pipe Size Range for Storm Sewers	Pipe Size for Storage System	Outlet Point
7+861	7+961	525 mm Ø Circular	None	Fourteen Mile Creek, Tributary channel
7+961	8+070	375 mm Ø Circular	None	Fourteen Mile Creek,
8+070	8+360	300 mm to 825 mm Ø Circular 1800 mm x 1200 mm Box	1800 mm x 1200 mm Box	Fourteen Mile Creek, D/s of C08A
8+360	8+816	300 mm to 375 mm Ø Circular 965 mm x610 mm Elliptical 2400 mm x 1500 mm Box	2400mm x 1500 mm Box	Fourteen Mile Creek, D/s of C09A
8+816	8+860	300 mm Ø Circular	None	Fourteen Mile Creek Tributary, D/s of C11
8+860	9+146	300 mm to 750 mm Ø Circular 1345 mm x 855 mm Elliptical	1345 mm x 855 mm Elliptical	Sixteen Mile Creek Tributary, D/s of C12
9+146	9+411	300 mm to 1050 mm Ø Circular	1050 mm Ø Circular	Sixteen Mile Creek Tributary, D/s of C13
9+411	9+752	300 mm to 675 mm Ø Circular 1500 mm x 1200 mm Box	1500 mm x 1200 mm Box	Sixteen Mile Creek Tributary, D/s of C14
9+752	10+004	300 mm to 525 mm Ø Circular 1200 mm x 1200 mm Box	1200 mm x 1200 mm Box	Sixteen Mile Creek Tributary, D/s of C15

Station From	Station To	Pipe Size Range for Storm Sewers	Pipe Size for Storage System	Outlet Point
10+004	10+421	300 mm to 525 mm Ø Circular 1800 mm x 1200 mm Box	1800 mm x 1200 mm Box	Sixteen Mile Creek Tributary, D/s of C15
10+421	10+921	300 mm to 675 mm Ø Circular 1200 mm x 900 mm Box	1200 mm x 900 mm Box	Sixteen Mile Creek Tributary, D/s of C16
10+921	11+250	300 mm to 600 mm Ø Circular	None	Sixteen Mile Creek Tributary, D/s of C17
11+250	11+452	375 mm to 525 mm Ø Circular	None	Sixteen Mile Creek Tributary, D/s of C18
11+452	11+648	300 mm to 525 mm Ø Circular	None	Sixteen Mile Creek Tributary, D/s of C19
11+648	12+508	300 mm to 750 mm Ø Circular 1500 x 1200mm & 1500 x 1500mm Box	1500 mm x 1200 mm Box & 1500 mm x 1500 mm Box	Sixteen Mile Creek Tributary, D/s of C19
12+508	12+841	525 mm Ø Circular 1500 x 1200mm Box	1500 x 1200mm Box	Sixteen Mile Creek Tributary, D/s of C20
12+841	12+991	300 mm to 675 mm Ø Circular	None	Britannia Road storm sewer
12+991	13+398	300 mm to 675 mm Ø Circular 1800 mm x 1200 mm Box	1800 mm x 1200 mm Box	Sixteen Mile Creek Tributary, D/s of C21
13+398	14+348	300 mm to 750 mm Ø Circular 1500 mm x 900 mm Box	1500 mm x 900 mm Box	Sixteen Mile Creek Tributary, D/s of C22

Station From	Station To	Pipe Size Range for Storm Sewers	Pipe Size for Storage System	Outlet Point
14+348	13+394	300 mm to 375 mm Ø Circular	None	Louis St Laurent Avenue storm sewer
13+394	14+689	300 mm to 600 mm Ø Circular 1500 mm x 900 mm Box	1500 mm x 900 mm Box	Sixteen Mile Creek, Existing Outlet at St 14+682
14+689	15+259	300 mm to 1050 mm Ø Circular	900 mm and 1050 mm Ø Circular	Sixteen Mile Creek, Existing Outlet at St 14+835
15+259	15+748	300 mm to 1050 mm Ø Circular	1050 mm Ø Circular	Existing Outlet at Culvert C23
15+748	16+000	600 mm Ø Circular	None	Sixteen Mile Creek, Existing Outlet at St 15+735

Storm Sewer Capacity Assessment sheets for the proposed conditions are provided in **Volume II Appendix E**.

5 Hydraulic Assessment of Watercourse Crossings

Under existing conditions, there are 24 culverts and 1 bridge that cross Regional Road 25 within the study area. All crossing culverts provide drainage to Sixteen Mile Creek and Fourteen Mile Creek. The HEC-RAS and CulvertMaster hydraulic modeling tools were used to estimate the headwater and to assess the hydraulic capacity of each of the existing and proposed structures within the study area.

The design standards for the hydraulic assessment of culverts are based on the Town of Milton (2024), Town of Oakville (2024) and the MTO Highway Drainage Design Standards (HDDS) (2023).

The existing HEC-RAS data was received from Conservation Halton and used for the hydraulic modelling. Where no existing HEC-RAS model was available, the CulvertMaster hydraulic modeling software was used for the following reasons:

- Evaluates inlet and outlet-controlled headwater depths
- Simulates the hydraulic performance of culverts based on user specified flows
- Considers variable tailwater depths based on either outlet channel geometry or user specified depth discharge rating curves; and
- Incorporates an extensive database of standard culvert sizes, shapes and materials, and allows for the addition of custom culvert types and sizes.

5.1 Road Classification and Design Flow

The following provides the road classification and respective design flows for the culverts located within the study area:

- Regional Road 25 is classified as a major arterial road. The proposed right-of-way is 47 m as identified in the Halton Region 2011 Transportation Master Plan. The design flow for the culverts located along Regional Road 25 is the 50-yr flow for culvert spans less than or equal to 6.0 m.
- The design flow for the bridge located along Regional Road 25 is the 100-yr flow for total span greater than 6.0 m.

Table 9 below provides the summary of flow used for drainage crossings analysis under existing and proposed conditions.

Table 9: Summary of Flow for Regional Road 25 Drainage Crossings

Culvert ID	Scenario	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Regional Flow (m^3/s)	Comment
C01	Ex./Prop	0.646	1.085	1.422	1.894	**2.223**	2.585	6.492	
C02	Ex./Prop	3.006	4.973	6.443	8.464	**9.882**	11.414	20.01	
C03	Ex./Prop	5.870	8.08	10.20	14.80	15.90	**19.90**	61.40	From HEC-RAS Model
C04	Ex.	0.137	0.235	0.312	0.420	**0.497**	0.581	1.129	
	Prop.	0.135	0.234	0.310	0.416	**0.493**	0.576	1.111	

Culvert ID	Scenario	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Regional Flow (m^3/s)	Comment
C05	Ex.	0.594	0.980	1.280	1.699	**1.989**	2.312	6.479	
	Prop.	0.584	0.966	1.262	1.676	**1.963**	2.282	6.361	
C06	Ex.	0.080	0.118	0.143	0.193	**0.222**	0.251	0.106	
	Prop.	0.008	0.014	0.019	0.025	**0.030**	0.035	0.033	
C07	Ex.	0.562	0.836	1.100	1.412	**1.634**	1.863	1.263	
	Prop.	0.504	0.752	1.001	1.281	**1.485**	1.697	1.209	
C08	Ex.	0.965	1.497	1.858	2.595	**3.021**	3.463	2.447	
C08A	Prop.	0.844	1.318	1.639	2.297	**2.678**	3.076	2.279	
C09A	Prop.	0.224	0.363	0.462	0.596	**0.693**	0.977	0.589	
C11	Ex.	0.036	0.061	0.081	0.108	**0.127**	0.148	0.204	
	Prop.	0.028	0.049	0.065	0.088	**0.104**	0.122	0.179	
C12	Ex.	0.135	0.206	0.257	0.327	**0.397**	0.455	0.421	
	Prop.	0.072	0.128	0.170	0.228	**0.273**	0.319	0.322	
C13	Ex.	0.193	0.343	0.452	0.603	**0.718**	0.837	1.032	
	Prop.	0.177	0.319	0.426	0.571	**0.682**	0.797	0.966	
C14	Ex.	0.607	0.839	0.996	1.285	**1.451**	1.627	0.651	
	Prop.	0.534	0.738	0.876	1.130	**1.276**	1.429	0.566	
C15	Ex./Prop.	4.61	8.07	10.50	13.66	16.37	**19.10**	21.52	From HEC-RAS Model
C16	Ex.	0.161	0.227	0.274	0.336	**0.411**	0.465	0.809	
	Prop.	0.075	0.136	0.182	0.246	**0.296**	0.347	0.692	

Culvert ID	Scenario	2-yr Flow (m^3/s)	5-yr Flow (m^3/s)	10-yr Flow (m^3/s)	25-yr Flow (m^3/s)	50-yr Flow (m^3/s)	100-yr Flow (m^3/s)	Regional Flow (m^3/s)	Comment
C17	Ex.	0.212	0.331	0.416	0.527	**0.612**	0.843	0.514	
	Prop.	0.153	0.267	0.351	0.463	**0.548**	0.638	0.438	
C18	Ex.	0.852	1.396	1.758	2.256	**2.695**	3.112	2.399	
	Prop.	0.698	1.067	1.438	1.845	**2.161**	2.499	2.244	
C19	Ex./Prop.	4.490	6.400	7.830	9.320	11.430	**13.170**	41.00	From HEC-RAS Model
C20	Ex.	0.186	0.331	0.440	0.591	**0.702**	0.818	1.109	
	Prop.	0.162	0.293	0.392	0.530	**0.637**	0.748	0.998	
C21	Ex.	0.142	0.251	0.338	0.461	**0.558**	0.659	1.186	
	Prop.	0.223	0.343	0.434	0.563	**0.665**	0.774	1.274	
C22	Ex.	0.307	0.444	0.541	0.690	**0.808**	0.919	0.828	
	Prop.	0.501	0.577	0.634	0.715	**0.777**	0.843	1.140	
C23	Ex.	0.111	0.208	0.283	0.387	**0.468**	0.552	0.752	
	Prop.	0.097	0.181	0.246	0.336	**0.406**	0.479	0.652	
C24	Ex./Prop	25.83	37.24	45.51	57.54	67.78	**78.33**	46.88	From HEC-RAS Model
B04	Ex./prop.	85.54	125.06	156.29	194.90	223.60	**229.99**	411.41	From HEC-RAS Model

Note: The bold flow values are design storm flow.

5.2 Hydraulic Modelling and Impact Assessment

Under the current conditions, there are twenty-four water course crossing structures. The hydraulic performance of the drainage crossing structures was analyzed using the both HEC-RAS and CulvertMaster hydraulic models. The existing HEC-RAS hydraulic

models received from Conservation Halton were available only for Culverts C03, C15, C19, and C24 as well as for Sixteen Mile Creek Bridge B04. For all remaining culverts, HEC-RAS models were not available, therefore, CulvertMaster hydraulic model was used to assess the hydraulic performance.

The hydraulic assessment should be such that the preliminary design should not have unacceptable impacts to the regulated area including flood plain and slope erosion hazards.

5.2.1 Hydraulic Assessment of Watercourse Crossings using HEC-RAS Model

As noted above, the HEC-RAS models for Culverts C03, C15, C19, and C24, as well as Bridge B04 on Regional Road 25, were obtained from Conservation Halton (CH). These existing hydraulic models are utilized for the hydraulic assessment with some update applied wherever necessary.

In additional, a new HEC-RAS model for Culvert C02 was developed using survey data from CIMA+ (dated January 9, 2025) along with LiDAR surface data. The flow for Culvert C02 is provided in hydrologic modelling section at **Table 4** and **Table 6**.

All these culverts are within regulated watercourse. For the crossings located in a regulated area, the requirement for the design is to ensure no unacceptable impacts to natural hazards including the flood plain.

Following modifications are made to the existing conditions model provided by Conservation Halton (CH):

- **Culvert C03** (Folder: A07012, Models: “14mc.prj” – original model, “14mc_Ex_Updated.prj” – updated existing model and “14mc_Prop.prj” – proposed condition model):
    - The Regional Road 25 culvert at Reach 2, Station 214.55 is changed to culvert routine from original bridge routine.
    - The size of the culvert is updated to 4.264m Span x 3.048 m Rise Twin Culvert with 0.30m embedment, length 48.67m. In the original model culvert size was considered as twin 4.5m span x 2.5m rise.
    - Inverts are set as per as-built drawings: U/s Invert as 123.617, D/s Invert as 123.540
    - The road profile is updated as per latest survey (Vertical datum CGVD28:78).
    - For proposed condition, only the road profile is updated as per preliminary design profile of Regional Road 25.

- **Culvert C15** (Folder: A16M67, Model: “SWtributary.prj” – original model, “SWtributary_Ex_Updated.prj” – updated existing model, and “SWtributary_Pr1.prj” – proposed condition model):
    - The existing data for Sections 2000 and 535, and the existing culvert (River Sta. 800), have been updated based on the bathymetry survey data from CIMA+, dated January 9, 2025 to accommodate the culvert extension. The vertical datum of the survey data is CGVD28:78.
- **Culvert C19** (Folder: A11M78, Models: “16MileWestReach5.prj” – existing original model, “16MileWestReach5_ex_Updated.prj” - updated existing condition model and “16MileWestReach5_Pr.prj” – proposed condition model)
    - The existing sections 3009.924, 2985.033, and 2942.144 were removed and new Sections 3011.47, 2995.87, and 2903.9 are added based on the bathymetry survey data from CIMA+, dated January 9, 2025. The vertical datum of the survey data is CGVD28:78.
    - The existing culvert property at section Sta. 2962.603 and road profile are updated based on the survey data from CIMA+, dated January 9, 2025.
    - The existing culvert size is updated from 4.10m x 1.80m box to 6.10m x 1.90m concrete arch culvert.
- **Culvert C24** (Folder: 16MC, Model: “16MC.prj” – original model; “16MC_Ex_Update.prj” – existing updated model and “16MC_pr_Opt4.prj” – proposed conditions model)
    - Regional Road 25 Culvert size on reach “16 Mile Creek – E1” is updated to 3.29 m span x 3.0 m rise as per record drawing "M-5101". In the original model, the culvert size was considered as 3.0 m span x 2.60 m rise.
    - One river section 95 is added on the upstream to facilitate modelling for proposed extension of the culvert and road profile is also updated.
    - The cross-section data and road profile information is based on the vertical datum CGVD28:78.
- **Bridge B04** (Folder: 16MC, Model: “16MC.prj” – original model; “16MC_Ex_Update.prj” – existing updated model and “16MC_pr_Opt4.prj” – proposed conditions model)
    - The existing Deck/Roadway profile data for Sta.8296 were updated based on Aerial LiDAR survey data based on vertical datum CGVD28:78 from CIMA+, dated October 2022.
    - Regional Road 25 Road proposed profile at Sixteen Mile Creek Bridge Location (Reach M3) is updated based on the preliminary design

- The existing Sixteen Mile Creek Bridge B04 has a clear span 28.7 m. The existing bridge data has been updated under proposed condition for about 8.91 m extension of bridge (B04) deck, from 22.45 metres to 31.36 metres. This extension is required to align with the proposed improvement of the roadway corridor.

The parameters used for the hydraulic analysis of Culvert C02, C03, C15, C19 and C24 under the existing and the proposed conditions are provided in **Table 10** and **Table 11**.

Table 10: Culvert Parameters under Existing Condition

Parameters	C02	C03	C15	C19	C24
Culvert Material / Type	Concrete / Box	Concrete / Box	Concrete / Arch	Concrete / Arch	Concrete / Box
Top of Road Elev. at Low Point (m)	130.16	131.20	177.67	179.05	188.05
Culvert Length (m)	47.50	47.00	48.20	43.40	46.90
Culvert Slope (m/m)	0.0072	0.0016	0.0039	0.000	0.010
Manning's 'n'	0.013	0.013	0.035	0.013	0.013
Culvert Size (m)	1.83m S x 1.52m R	Twin, 4.20m S x 2.80m R	7.315m S x 1.83m R	6.10m S x 1.90m R	3.29m S x 3.00m R)
Upstream Invert (m)	126.27	123.617	173.492	175.098	183.43
Downstream Invert (m)	125.93	123.540	173.305	175.098	182.96
Embedment (m)	-	0.30	0.30	0.30	-

Table 11: Culvert Parameters under Proposed Condition

Parameters	C02	C03	C15	C19	C24
Culvert Material / Type	Concrete / Box	Concrete / Box	Concrete / Arch	Concrete / Arch	Concrete / Conspan Arch
Top of Road Elev. at Low Point (m)	130.24	131.20	177.70	179.05	188.05
Culvert Length (m)	54.50	47.00	55.70	62.50	47.00
Culvert Slope (m/m)	0.0064	0.0016	0.0037	0.001	0.012
Manning's 'n'	0.035	0.013	0.035	0.035	0.013
Culvert Size (m)	2.70m S x 2.10m R	Twin, 4.20m S x 2.80m R)	7.315m S x 1.83m R + 750mm Ø Relief Culvert	6.10m S x 1.90m R	12.80m S x 3.51m R
Upstream Invert (m)	126.27	123.617	173.510; 174.0(Relief)	175.140	184.90
Downstream Invert (m)	125.92	123.54	173.305; 173.8(Relief)	175.050	182.96
Embedment (m)	0.30	0.30	0.30	-	Open Footing

Note: "S: refers to Span and "R" refers to Rise.

The results from the HEC-RAS modeling are discussed below.

a) HEC-RAS Modelling Results of Sixteen Mile Creek Bridge (B04):

- Updated Existing Conditions:
  - The existing bridge has 30 m span with a deck width of 22.45 m.
  - The freeboard of 100-year design storm for the existing bridge is 1.27 m, which meets hydraulic requirements. The road low point elevation considered for the freeboard analysis is 185.55.

- The Regional Storm overtops the road by 0.21 m, which meets the minimum overtopping depth required to pass the emergency vehicles.

- Proposed Conditions:
  - Under the proposed conditions, the existing bridge will be extended approximately by 10.0 m on the downstream, maintaining the current size of the bridge.
  - The freeboard of 100-year design storm under the proposed condition is 1.30 m, which meets hydraulic requirements.
  - There is no change in the Regional storm water level.

Table 12 provides the comparison of hydraulic modelling results of Bridge B04 under existing original, updated existing and proposed conditions.

Table 12: Bridge B04 - Comparison of Hydraulic Modelling results

River Station	Profile	Q Total	Existing (Original)		Updated Existing		Proposed		WSL Diff.
		(m^3/s)	WSL (m)	Flow Vel. (m/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B) (m)	Flow Vel. (m/s)	Pr-Ex (B-A)
8328	2-year	85.54	183.08	1.23	183.08	1.23	183.07	1.24	-0.01
8328	5-year	125.06	183.48	1.57	183.48	1.58	183.46	1.58	-0.02
8328	10-year	156.29	183.74	1.81	183.74	1.82	183.72	1.83	-0.02
8328	25-year	194.9	184.04	2.08	184.03	2.09	184.01	2.10	-0.02
8328	50-year	223.6	184.24	2.27	184.24	2.27	184.21	2.28	-0.03
8328	100-year	229.99	184.28	2.30	184.28	2.31	184.25	2.32	-0.03
8328	Regional	411.41	185.67	0.54	185.76	0.53	185.76	0.53	0.00
8296		**Bridge (B04) at Regional Road 25**							
8267	2-year	85.54	182.86	1.92	182.86	1.92	182.86	1.92	0.00
8267	5-year	125.06	183.17	2.35	183.17	2.35	183.17	2.35	0.00
8267	10-year	156.29	183.36	2.67	183.36	2.67	183.36	2.67	0.00
8267	25-year	194.9	183.56	3.04	183.56	3.04	183.56	3.04	0.00
8267	50-year	223.6	183.68	3.31	183.68	3.31	183.68	3.31	0.00
8267	100-year	229.99	183.71	3.37	183.71	3.37	183.71	3.37	0.00
8267	Regional	411.41	184.40	4.67	184.40	4.67	184.40	4.67	0.00

Comparing to existing original versus updated existing scenarios, there is some change in the Regional Storm flood elevation which is due to update of the existing road profile as the Regional Storm flow overtops Regional Road 25. The updated existing model show that the existing bridge B04 meets the freeboard for the100-year design storm and relief flow depth for the regulatory storm.

The results provided in **Table 12** shows that there will be no increase in water level for the 2-year to the Regional storm events due to the widening of bridge deck which illustrates that there will be no change in the existing flood plain due to the preliminary design. The bridge meets the freeboard and relief flow depth requirements as in existing condition.

The Regional storm floodline map of Sixteen Mile Creek at Bridge 04 site under existing and proposed conditions is shown in **Exhibit 37**.

b) HEC-RAS Modelling Results of Culverts:

1) Culvert C02

- Existing Conditions:
  - The existing culvert, size 1.83 m span x 1.52 m rise concrete box, has a freeboard of 1.30 m for the 50-year design storm to the road low point elevation of 130.16, which meets the required freeboard of 1.0 m.
  - The HW/D of the culvert is 1.70, which is higher than required value of 1.5, therefore, does not meet the requirement.
  - The Regional Storm overtops the road by 0.31 m which does not meet meets the minimum overtopping depth required to pass the emergency vehicles. A portion of Regional storm flow spills toward Culvert C01. This unmapped spill is shown in **Exhibit 38**.
  - The existing culvert meets the freeboard but does not meet the HW/D ratio and relief flow depth requirements. Therefore, the culvert does not meet hydraulic requirements fully.
- Proposed Conditions:
  - Due to widening of the roadway, the existing culvert does not meet the requirement, therefore the existing culvert will be replaced with a 2700 mm span x 2100 mm rise, 55m long concrete box culvert with 0.30 m embedment.
  - The proposed culvert will have 1.85 m of freeboard for the 50-year design storm to the road low point elevation of 130.24 which meets the 1.0 m requirement.
  - The proposed culvert will provide a flood death (HW/D ratio) of 1.18 which meet hydraulic requirements for the 50-year design storm.

- The Regional Storm water level does not overtop Regional Road 25 and will have a freeboard of 0.38 m. A small portion of Regional Storm spill toward Culvert C01. The preliminary design will have no negative impact to the existing unmapped spill to Culvert C01.
- The proposed culvert meets all hydraulic requirements which are freeboard, HW/D ratio and no overtopping or relief flow requirements.

Table 13 provide the comparison of hydraulic modelling results of Culvert C02 under existing and proposed conditions. The Regional storm floodline map of the watercourse at Culvert C02 is shown in **Exhibit 38**.

Table 13: Culvert C02 - Comparison of Hydraulic Modelling results

River Station	Profile	Q Total	Existing		Proposed		WSL Diff.
		(m^3/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B) (m)	Flow Vel. (m/s)	Pr-Ex (B-A)
167.42	2-year	3.01	127.41	0.26	127.45	0.24	0.04
167.42	5-year	4.97	127.86	0.18	127.80	0.20	-0.06
167.42	10-year	6.44	128.17	0.16	128.03	0.19	-0.14
167.42	25-year	8.46	128.55	0.15	128.31	0.18	-0.24
167.42	50-year	9.88	128.94	0.13	128.50	0.18	-0.44
167.42	100-year	11.41	129.42	0.11	128.69	0.18	-0.73
167.42	Regional	20.01	130.56	0.13	130.24	0.15	-0.32
162.42	2-year	3.01	127.37	0.86	127.43	0.68	0.06
162.42	5-year	4.97	127.81	0.95	127.76	0.83	-0.05
162.42	10-year	6.44	128.11	1.02	127.98	0.91	-0.13
162.42	25-year	8.46	128.49	1.09	128.26	1.01	-0.23
162.42	50-year	9.88	128.87	1.06	128.44	1.08	-0.43
162.42	100-year	11.41	129.36	1.02	128.62	1.13	-0.74
162.42	Regional	20.01	130.46	1.30	130.17	1.16	-0.29
116.7	**Culvert**		**1.83m x 1.52m Box**		**2.7m x 2.1m Box with 0.30m Embedment**		
105.44	2-year	3.01	126.58	2.04	126.58	2.04	0.00
105.44	5-year	4.97	126.74	2.42	126.74	2.42	0.00
105.44	10-year	6.44	126.85	2.62	126.85	2.64	0.00
105.44	25-year	8.46	126.98	2.89	126.98	2.88	0.00
105.44	50-year	9.88	127.06	3.04	127.06	3.05	0.00
105.44	100-year	11.41	127.15	3.20	127.15	3.19	0.00
105.44	Regional	20.01	127.45	0.53	127.59	3.86	0.14
100.44	2-year	3.01	126.33	1.41	126.33	1.41	0.00
100.44	5-year	4.97	126.39	1.52	126.39	1.52	0.00
100.44	10-year	6.44	126.42	1.58	126.42	1.58	0.00
100.44	25-year	8.46	126.48	1.64	126.48	1.64	0.00
100.44	50-year	9.88	126.49	1.82	126.49	1.82	0.00
100.44	100-year	11.41	126.51	1.87	126.51	1.87	0.00
100.44	Regional	20.01	126.6	2.21	126.60	2.21	0.00

As noted above, the existing culvert was 1.83 m span. After increasing the culvert span to 2.7 m under proposed condition, as illustrated in **Table 13** above, the preliminary design of the proposed road improvement is not resulting flooding on the upstream and downstream of the crossing.

Regional storm flood levels are decreased on the upstream and no impact on the downstream. Although, the result shows about 0.14 m increase in the Regional storm water level at downstream face of the culvert, but this will be within the Halton Region's road ROW and further at 5.0m downstream of the culvert, there is no increase. This increase at the face of the culvert is just due to the hydraulics of the culvert. The preliminary design will not be resulting flooding upstream and downstream of the crossing.

2) Culvert C03

- Updated Existing Conditions:
  - The existing Culvert C03 is a 47 m long, twin 4.267 m span x 3.048 m rise box culvert with 0.30 m embedment as per the as built drawing.
  - Due to the revision of culvert size and inverts, water surface elevations under updated existing condition are higher than the existing original model.
  - Since the overall span is more than 6.0m, the design storm for the culvert is the 100-year storm. The freeboard and HW/D of the existing culvert are 5.90 m and 0.70, respectively which meet hydraulic requirements for the 100-year design storm as per the updated existing model.
  - The Regional Storm flood elevation is 127.49. The Regional storm flood level will have 4.04 m of freeboard to the road low point elevation of 131.53. The Regional storm does not overtop Regional Road 25.
  - The existing culvert meets all hydraulic requirements which are freeboard, HW/D ratio and no overtopping during the Regional storm.
- Proposed Conditions:
  - The only update under the proposed condition is the road profile of proposed Regional Road 25 improvement. Since the existing culvert water surface elevation are lower the existing road profile during all storm events including the Regional storm, the increase in road profile does not provide any impact to flood elevation.
  - There is no change in water surface elevations under proposed conditions compared to updated existing condition. Due to higher road low point elevation, freeboards are further increased.

- Adjustment to culvert headwall height might be required to avoid encroachment of road grading to flood plain which will be reviewed during the detailed design phase. Also, the structural stability of existing head wall needs to be reviewed by a structural engineer.

The summary of hydraulic analysis results of Culvert C03 is provided in **Table 14**.

Table 14: Culvert C03 - Hydraulic Modelling results

Reach	River Station	Profile	Q Total (m^3/s)	Existing (Original)		Updated Existing / Proposed	
				WSL (m)	Vel Chnl. (n/s)	WSL (m)	Vel Chnl. (n/s)
Reach-2	215	Reg	61.40	127.30	0.71	127.65	0.55
Reach-2	215	100-yr	19.90	125.33	2.33	125.76	0.87
Reach-2	215	50-yr	15.90	125.29	2.23	125.56	1.00
Reach-2	215	25-yr	14.80	125.28	2.20	125.50	1.07
Reach-2	215	10-yr	10.20	125.22	2.01	125.22	2.01
Reach-2	215	5-yr	8.08	125.19	1.92	125.19	1.92
Reach-2	215	2-yr	5.87	125.16	1.73	125.16	1.73
Reach-2	214.6	Reg	61.40	127.09	1.91	127.49	1.56
Reach-2	214.6	100-yr	19.90	125.20	1.40	125.63	1.00
Reach-2	214.6	50-yr	15.90	125.05	1.24	125.43	0.89
Reach-2	214.6	25-yr	14.80	125.00	1.20	125.37	0.86
Reach-2	214.6	10-yr	10.20	124.80	0.98	125.11	0.71
Reach-2	214.6	5-yr	8.08	124.68	0.87	124.96	0.63
Reach-2	214.6	2-yr	5.87	124.54	0.74	124.79	0.53
Reach2	**214.55**		**Culvert**	**Twin 4.267 m span x 3.048 m rise box culvert**			
Reach-2	214.5	Reg	61.40	126.66	2.18	126.77	1.93
Reach-2	214.5	100-yr	19.90	125.18	1.42	125.31	1.20
Reach-2	214.5	50-yr	15.90	125.03	1.26	125.15	1.07
Reach-2	214.5	25-yr	14.80	124.99	1.21	125.11	1.03
Reach-2	214.5	10-yr	10.20	124.79	0.99	124.88	0.84
Reach-2	214.5	5-yr	8.08	124.67	0.87	124.76	0.75
Reach-2	214.5	2-yr	5.87	124.54	0.74	124.61	0.63

Since there is no modification is required for Culvert C03, there is no change in the results between updated existing and proposed conditions. There is also no difference in the Regional storm flood elevation between the updated existing condition and proposed condition.

The Regional storm floodline mapping of the watercourse at Culvert C03 is shown in **Exhibit 39**.

3) Culvert C15

- Updated Existing Conditions:
  - The existing Culvert C15 is a 48.2 m long, 7.315 m span x 1.83 m rise concrete conspan arch culvert.
  - Due to updated in rivers sections and road profile, the water surface elevations are higher in updated existing model compared to existing original model.
  - The freeboard and HW/D of the existing culvert are 1.31 m and1.41, respectively for the 100-year design storm which meet hydraulic requirements for the design storm. The road low point elevation under existing condition is 177.67.
  - There is no road overtopping for the Regional Storm. The available freeboard for the Regional Storm is 0.74 m.
  - Based on the updated existing conditions results the culvert meets all hydraulic requirements which are freeboard, HW/D ratio and no road overtopping during the Regional Storm.
- Proposed Conditions
  - A 7.5 m extension is required to the existing culvert on the west side. To eliminate flooding impact due to extension, a 750 mm diameter HDPE relief culvert will be required on a slightly higher elevation (u/s invert 174.00 and d/s invert 173.80).
  - With the addition of relief culvert, there is no flooding impact on the upstream and downstream; flood elevations are decreases during all storm events. An adjustment to headwall will be necessary on the east side (downstream) which will be reviewed during the detailed design phase.
  - The freeboard under proposed condition will be 1.39 m for the 100-year design storm. The road low point elevation under proposed condition is 177.70. The HW/D ratio under proposed condition will be 1.38 for the 100-year design storm.
  - With the addition of a relief culvert, it meets all hydraulic requirements which are free board, HW/D ratio and no road overtopping and no flooding impact on the upstream or downstream.

The comparison of hydraulic analysis results between existing (original), updated existing condition and proposed condition for Culvert C15 is provided in **Table 15**. The Regional storm floodplain map of the watercourse at Culvert C15 is shown in **Exhibit 40**.

Table 15: Culvert C15 - Comparison of Hydraulic Modelling results

River Station	Profile	Q Total	Existing (Original)		Updated Existing		Proposed		WSL Diff. (m) (B-A)
		(m^3/s)	WSL (m)	Flow Vel. (m/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B) (m)	Flow Vel. m/s)	
2040	2-year	4.61	174.56	1.44	174.70	1.09	174.67	1.14	-0.03
2040	5-year	8.07	174.77	1.64	175.07	1.02	175.02	1.09	-0.05
2040	10-year	10.50	174.96	1.54	175.32	0.96	175.27	1.02	-0.05
2040	25-year	13.66	175.27	1.33	175.67	0.88	175.49	1.05	-0.18
2040	50-year	16.37	175.50	1.25	175.95	0.84	175.89	0.88	-0.06
2040	100-year	19.10	175.90	1.01	176.45	0.69	176.37	0.72	-0.08
2040	Reg.	21.52	176.38	0.81	177.00	0.57	176.28	0.86	-0.72
2000	2-year	4.61	174.46	1.79	174.57	1.11	174.58	0.94	0.01
2000	5-year	8.07	174.70	1.87	174.95	1.24	174.94	1.06	-0.01
2000	10-year	10.50	174.94	1.61	175.21	1.29	175.19	1.10	-0.02
2000	25-year	13.66	175.26	1.35	175.56	1.32	175.39	1.23	-0.17
2000	50-year	16.37	175.49	1.26	175.85	1.29	175.81	1.10	-0.04
2000	100-year	19.10	175.89	1.02	176.36	1.22	176.31	1.04	-0.05
2000	Reg.	21.52	176.38	0.81	176.93	1.14	176.19	1.26	-0.74
800	**Culvert**	**7.315 m x 1.83m Concrete Conspan**					**7.5m extension to Ex. Culvert + 750mm Dia. Relief Culvert**		
535	2-year	6.82	173.98	0.97	174.12	1.83	174.12	1.79	0.00
535	5-year	11.98	174.14	1.20	174.28	2.38	174.27	2.31	-0.01
535	10-year	15.56	174.23	1.34	174.39	2.60	174.37	2.53	-0.02
535	25-year	20.16	174.33	1.49	174.52	2.83	174.49	2.75	-0.03
535	50-year	23.25	174.39	1.57	174.60	2.98	174.56	2.92	-0.04
535	100-year	27.73	174.46	1.71	174.71	3.15	174.66	3.08	-0.05
535	Reg.	32.10	174.53	1.82	174.81	3.32	174.76	3.23	-0.05
500	2-year	6.82	173.75	1.79	173.75	1.79	173.75	1.79	0.00
500	5-year	11.98	173.90	2.04	173.90	2.04	173.90	2.04	0.00
500	10-year	15.56	173.97	2.23	173.97	2.23	173.97	2.23	0.00
500	25-year	20.16	174.05	2.43	174.04	2.45	174.04	2.45	0.00
500	50-year	23.25	174.09	2.55	174.09	2.55	174.09	2.55	0.00
500	100-year	27.73	174.19	2.55	174.19	2.55	174.19	2.55	0.00
500	Reg.	32.10	174.31	2.45	174.31	2.45	174.31	2.45	0.00

As noted above, an extension to the existing culvert is required to accommodate proposed road widening. To avoid negative impact on flooding hazard on the upstream and downstream of the culvert, a 750mm dimeter relief culvert is added on the side of the existing culvert.

As illustrated in **Table 15** above, with the implementation of relief culvert, flood levels are decreased on both upstream and downstream and the proposed preliminary design for the road improvement will not increase the floodplain elevations on the upstream and downstream of the culvert.

4) **Culvert C19**

- Updated Existing Conditions:
  - The existing Culvert C19 is a 43.4 m long, 6.1 m span x 1.90 m rise concrete arch culvert.
  - The freeboard and HW/D of the existing culvert are 1.69 m and 1.19, respectively for the 100-year design storm which meet hydraulic requirements for the design storm.
  - The Regional Storm overtops the road by 0.27 m, which is sufficient for the minimum overtopping depth required to pass the emergency vehicles. The road low point elevation is 179.05.
  - The existing culvert meets all hydraulic requirements which are freeboard and HW/D ratio for the 100-year design storm and relief flow depth for the regulatory storm.
- Proposed Conditions:
  - Under the proposed conditions, the existing 6100 mm span x 1900 mm rise concrete arch culvert will be extended on the upstream side by about 8.8 m and downstream side by about 10.3 m, respectively.
  - The road low point elevation will be maintained to 179.05 as in updated existing condition to maintain the existing relief flow depth and to avoid flooding impact.
  - The freeboard and HW/D of the culvert under proposed condition are 1.66 m and 1.18, respectively for the 100-year design storm which meet the requirements for the design storm.
  - The Regional Storm overtops the road by 0.27 m, same as in updated existing condition, which meets the minimum overtopping depth required to pass the emergency vehicles.

- For the proposed condition, the existing culvert meets all hydraulic requirements such as freeboard and HW/D ratio for the 100-year design storm and relief flow depth for the Regulatory storm.
- Due to the extension of the culvert on the upstream, some realignment of watercourse would be necessary which is recommended to review during the detailed design phase.
- It is recommended to remove a layer of accumulated sediments inside the culvert to maintain the culvert opening.

The comparison of hydraulic analysis results between existing (original), updated existing and proposed conditions for Culvert C19 is provided in **Table 16**. The Regional storm floodline map of the watercourse at Culvert C19 is shown in **Exhibit 41**.

Table 16: Culvert C19 - Comparison of Hydraulic Modelling results

River Sta	Profile	Q Total	Existing (Original)		Updated Existing		Proposed		WSL. Diff. (B-A)
		(m^3/s)	WSL (m)	Flow Vel. (m/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B)(m)	Flow Vel. (m/s)	
3011.47	2-Year	4.49	-	-	176.73	0.48	176.74	0.48	0.01
3011.47	5-year	6.40	-	-	176.90	0.50	176.91	0.50	0.01
3011.47	10-year	7.83	-	-	177.02	0.50	177.03	0.49	0.01
3011.47	20-year	9.32	-	-	177.15	0.49	177.16	0.48	0.01
3011.47	50-year	11.43	-	-	177.31	0.48	177.33	0.47	0.02
3011.47	100-Year	13.17	-	-	177.44	0.47	177.47	0.45	0.03
3011.47	Reg.	41.00	-	-	179.47	0.34	179.47	0.34	0.00
2995.87	2-Year	4.49	-	-	176.70	0.78	176.70	0.77	0.00
2995.87	5-year	6.40	-	-	176.85	0.91	176.86	0.90	0.01
2995.87	10-year	7.83	-	-	176.97	0.99	176.98	0.97	0.01
2995.87	20-year	9.32	-	-	177.08	1.05	177.10	1.03	0.02
2995.87	50-year	11.43	-	-	177.23	1.13	177.26	1.11	0.03
2995.87	100-Year	13.17	-	-	177.36	1.19	177.39	1.15	0.03
2995.87	Reg.	41.00	-	-	179.32	1.52	179.32	1.52	0.00
2962.603		**Culvert**	**(6.10m span x 1.90 Rise Concrete Arch)**						
2921.422	2-Year	4.49	-	-	176.57	1.70	176.57	1.70	0.00
2921.422	5-year	6.40	-	-	176.60	2.28	176.60	2.28	0.00
2921.422	10-year	7.83	-	-	176.69	2.37	176.69	2.37	0.00
2921.422	20-year	9.32	-	-	176.77	2.49	176.77	2.49	0.00
2921.422	50-year	11.43	-	-	176.87	2.64	176.87	2.64	0.00
2921.422	100-Year	13.17	-	-	176.95	2.76	176.95	2.76	0.00
2921.422	Reg.	41.00	-	-	177.45	1.13	177.45	1.13	0.00
2921.422	2-Year	4.49	176.79	0.67	176.61	0.60	176.61	0.60	0.00
2921.422	5-year	6.40	176.84	0.78	176.65	0.71	176.65	0.71	0.00
2921.422	10-year	7.83	176.88	0.80	176.70	0.73	176.70	0.73	0.00
2921.422	20-year	9.32	176.92	0.82	176.75	0.77	176.75	0.77	0.00
2921.422	50-year	11.43	176.97	0.84	176.81	0.80	176.81	0.80	0.00
2921.422	100-Year	13.17	177.00	0.86	176.85	0.84	176.85	0.84	0.00
2921.422	Reg.	41.00	177.54	0.98	177.43	1.08	177.43	1.08	0.00

The results provided in **Table 16** indicates that there is no increase in flood plain elevations upstream and downstream of the culvert during the Regional storm. There is a minor increase in the flood elevation from the 5-year to the 100-year storm event. The maximum increase is 0.03 m, occurring immediately upstream of the structure. This increase is minimal and falls within typical modelling tolerances.

5) Culvert C24

- Updated Existing Conditions:
  - The existing Culvert C24 is a 46.9m long, 3.30 m span x 3.0 m rise box culvert.
  - Comparing the results of existing (original) model with updated existing model, the updated existing model shows lower water surface elevations due to the update in culvert size.
  - The 50-year design storm overtops the Regional Road 25 by 1.89 m and the culvert provide HW/D of 2.17, which show that the existing culvert does not meet hydraulic requirements for the 50-year design storm. The road low point elevation is 188.05.
  - The 100-year storm is considered as the Regulatory Storm as it higher than the Regional Storm flow. The Regulatory (100-year) Storm overtops Regional Road 25 by 2.06 m and the Regional Storm overtops by 0.78 m. These overtopping depths exceed the minimum overtopping depth required to pass the emergency vehicles.
  - The existing culvert do not meet all three hydraulic requirements (freeboard, HW/D ratio and relief flow depth).
  - From the 10-year to Regulatory storm flow spill from the roadway to the west side. There is also an unmapped spill from Sixteen Mile Creek to the east side of the roadway which is shown in **Exhibit 37**.
- Proposed Conditions:
  - Under the proposed conditions, the existing culvert will be replaced by a 12.80m span x 3.51m rise, 57.2m long conspan concrete open footing culvert.
  - Since the culvert will be more than 6.0m span, the design storm will be the 100-year storm.

- The proposed culvert will provide 1.51m freeboard to the road low point elevation of 188.05 during 100-year storm event. The culvert meets the freeboard requirement for the design storm.
- The proposed culvert will have flood depth (HW/D ratio) of 0.98 for the design storm which meets the requirements.
- Both the Regulatory Storm and the Regional Storm will not overtop Regional Road 25.
- Flood elevation upstream of the structure decrease for all storm events. There is no flooding impact upstream of the structure.
- The proposed open footing conspan structure meets all three hydraulic requirements (freeboard, HW/D ratio and relief flow depth).

The comparison of hydraulic analysis results between existing and proposed conditions for Culvert C24 is provided in **Table 17**.

Table 17: Culvert C24- Comparison of Hydraulic Modelling results

River Station	Profile	Q Total	Existing (Original)		Updated Existing		Proposed		WSL Diff. (B-A) (m)
		(m^3/s)	WSL (m)	Flow Vel. (m/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B) (m)	Flow Vel. (m/s)	
154	2-year	25.83	186.78	0.44	186.76	0.45	186.21	0.76	-0.55
154	5-year	37.24	188.35	0.28	188.14	0.31	186.55	0.77	-1.59
154	10-year	45.51	189.79	0.22	189.27	0.26	186.79	0.78	-2.48
154	25-year	57.54	189.88	0.27	189.79	0.28	187.09	0.79	-2.70
154	50-year	67.78	190.06	0.31	188.52	0.48	187.34	0.81	-1.18
154	100-year	78.33	190.18	0.35	190.12	0.35	187.58	0.83	-2.54
154	Regional	46.88	189.83	0.23	189.02	0.28	187.16	0.62	-1.86
95	2-year				186.74	0.85	185.50	3.52	-1.24
95	5-year				188.13	0.53	185.86	3.65	-2.27
95	10-year				189.26	0.41	186.02	3.92	-3.24
95	25-year				189.79	0.44	186.23	4.25	-3.56
95	50-year				188.51	0.81	186.39	4.52	-2.12
95	100-year				190.12	0.54	186.54	4.76	-3.58
95	Regional				189.02	0.46	186.92	2.33	-2.10
65		**Culvert**	**3.29m Span x 3.0m Rise Box**				**12.8m span x 3.51m Rise, Conspan Arch Open Footing**		
35	2-year	25.83	185.49	1.21	185.58	2.27	185.53	1.36	-0.05
35	5-year	37.24	185.7	1.54	185.59	3.26	185.71	1.77	0.12
35	10-year	45.51	185.84	1.73	185.64	3.90	185.83	2.03	0.19
35	25-year	57.54	186.01	2.00	185.72	4.74	185.95	2.42	0.23
35	50-year	67.78	186.15	2.19	185.99	5.01	186.05	2.73	0.06
35	100-year	78.33	186.15	2.53	186.24	5.26	186.05	3.15	-0.19
35	Regional	46.88	187.16	1.02	187.01	2.48	186.94	0.31	-0.07

River Station	Profile	Q Total	Existing (Original)		Updated Existing		Proposed		WSL Diff. (B-A) (m)
		(m^3/s)	WSL (m)	Flow Vel. (m/s)	WSL (A) (m)	Flow Vel. (m/s)	WSL (B) (m)	Flow Vel. (m/s)	
8267	2-year	85.54	182.86	1.92	182.86	1.92	182.86	1.92	0.00
8267	5-year	125.06	183.17	2.35	183.17	2.35	183.17	2.35	0.00
8267	10-year	156.29	183.36	2.67	183.36	2.67	183.36	2.67	0.00
8267	25-year	194.90	183.56	3.04	183.56	3.04	183.56	3.04	0.00
8267	50-year	223.60	183.68	3.31	183.68	3.31	183.68	3.31	0.00
8267	100-year	229.99	183.71	3.37	183.71	3.37	183.71	3.37	0.00
8267	Regional	411.41	184.4	4.67	184.4	4.67	184.40	4.67	0.00

The existing structure is located within the regulated flood plain hazard of Sixteen Mile Creek. The results provided in **Table 17** shows that there is no negative impact on the Regulatory Storm (100-year) flood plain upstream and the downstream or on adjacent properties.

A floodline map is prepared for the Regulatory Storm (100-year storm) of the watercourse at Culvert C24 and is shown in **Exhibit 37**.

There is no spill from Regional Road 25 to the west side of the road way due to improved culvert size. Since there is no change in Sixten Mile Creek's regulatory storm flood level, there is no negative impact to the existing unmapped spill south of Culvert C24.

A mitigation measure is recommended during the detailed design phase for the increased flow velocities on the immediately upstream of the structure. Although the proposed condition flow velocities on the downstream are lower than existing condition, some mitigation measure is also recommended on the downstream to avoid potential channel erosion.

The details of the HEC-RAS hydraulic modelling results for the existing and the proposed conditions are attached in **Appendix D**.

5.2.2 Hydraulic Assessment of Culverts using CulvertMaster

Out of 24 crossing culverts, remaining 19 crossing culverts are analysed using CulvertMaster hydraulic model. The design storm (50-year), 100-year, and the Regional storm peak flows, along with the physical culvert characteristics (e.g., inverts, size and length) were included into CulvertMaster to determine the upstream head water elevation (HGL) for each culvert. The tailwater elevations (TWL) were determined from the downstream channel geometry for each culvert.

Based on a review of the hydraulic assessment and the existing and proposed conditions, followings are the preliminary recommendation:

1) **Culvert C01**: Under the proposed conditions, the existing 3660 mm span x 2440 mm rise concrete box will be extended on the upstream and downstream by 1.00 m and 7.00 m, respectively maintaining the existing size of the culvert. A headwall/retaining wall will be required to accommodate this extension. The structural stability of the headwall wall should be verified by a structural engineer.
2) **Culvert C04**: Under the proposed conditions, the existing 1050 mm HDPE circular pipe will be extended on the upstream and downstream sides by about 3.70 m and 4.40 m, respectively.
3) **Culvert C05**: Under the proposed conditions, the existing 2100 mm span x 1600 mm rise CSP arch culvert will be replaced with a 2700 mm span x 1800 mm rise concrete box culvert, with 0.30 m embedment. The proposed culvert will have a total length of 55.9 m.
4) **Culvert C06**: Under the proposed conditions, the existing twin 800 mm diameter CSP culvert will be replaced with 900 mm diameter concrete pipe culvert. The proposed culvert will have a total length of 52.2 m.
5) **Culvert C07**: Under the proposed conditions, the existing twin CSP culvert will be replaced by a 2400 mm span x 1200 mm rise, 52.7m long concrete box culvert with 0.30m embedment.
6) **Culvert C08**: Due to the widening of Regional Road 25, the inlet of the existing Culvert C08 will not function as intended and will be plugged; however, the culvert will remain in place and used solely as a storm outlet.
7) **Culvert C08A**: A new Culvert C08A will be installed approximately 110 m north of the existing culvert to convey drainage from Catchment 355. The proposed culvert will be a 3000 mm span by 1200 mm rise concrete box, 65.5 m in length, with 0.30 m embedment.

   In addition, a drainage channel approximately 180 m long and 2.0 m wide will be constructed downstream of Culvert C08A to convey flow toward a tributary of Fourteen Mile Creek, necessitated by the widening of Regional Road 25. Upstream, approximately 40 m of channel realignment will also be required.

   On the downstream side of the relocated culvert C08A, a naturalized swale will be designed during the detailed design stage to connect with the existing swale further downstream.
8) **Culvert C09**: Due to the widening of Regional Road 25, the inlet of the existing Culvert C09 will not function, the existing culvert can be either eliminated or filled with concrete and abandoned.
9) **Culvert C09A**: To convey runoff of existing culvert, a new Culvert C09A of size 975 mm diameter, 69.0 m long, concrete pipe will be installed at the intersection

of Henderson Road at St. 8+440. A ditch inlet may be required at the inlet end of the culvert depending on the grading plan to maintain the cover for the culvert.

10) **Culvert C10**: The existing 900 mm diameter CSP culvert will be removed as this culvert will not function due to widening. Runoff will be directed to culvert C09A which ultimately discharging to the tributary of Fourteen Mile Creek.
11) **Culvert C11**: Under the proposed conditions, the existing CSP arch culvert will be replaced by a 1500 mm span x 1200 mm rise, 51.9 m long concrete box culvert with 0.30m embedment.
12) **Culvert C12**: The existing 800 mm diameter CSP culvert will be replaced with a 52.1 m long, 825 mm diameter concrete pipe culvert.
13) **Culvert C13:** The existing 1200 mm diameter CSP culvert will be replaced with a 51.4 m long, 825 mm diameter concrete pipe culvert.
14) **Culvert C14**: The existing 900 mm diameter CSP culvert will be replaced with a 58.2 m long, 1050 mm diameter concrete pipe culvert.
15) **Culvert C16**: Under the proposed conditions, the existing CSP arch culvert will be replaced with a 1200 mm diameter concrete pipe culvert. The proposed culvert will have a total length of 49.7 m. Due to widening of the roadway, approximately 80m long channel will be required on the downstream at the toe of road embankment to convey the flow from culvert.
16) **Culvert C17**: Under proposed condition, the existing twin 800 mm diameter CSP culvert will be replaced with a 51.3 m long, 1200 mm span x 1200 mm rise concrete box culvert with 0.30 m embedment.
17) **Culvert C18**: The existing 1200 mm diameter CSP culvert will be replaced with a 60 m long, 2100 mm span x 1200 mm rise concrete box culvert with 0.30 m embedment.
18) **Culvert C20**: Under the proposed conditions, the existing 1200 mm diameter concrete pipe culvert will be extended on the upstream and downstream sides by about 9.8 m and 9.2 m, respectively. The culvert will have a total length of 57.2m.
19) **Culvert C21**: Under the proposed conditions, the existing 1200 mm diameter concrete pipe culvert will be extended on the upstream and downstream sides by about 9.8 m and 11.6 m, respectively. Additionally, a new 900 mm diameter, 60.5m long concrete pipe will be added as a relief culvert.
20) **Culvert C22**: Under the proposed conditions, the existing 1830 m span x 910 mm rise concrete box culvert will be replaced with a 52.6m long, 3.90 m span x 1.80 m rise concrete box with 0.30 m embedment.
21) **Culvert C23**: Under the proposed conditions, the existing 1830 mm span x 910 mm rise concrete box will be extended by about 11.0 m on the upstream side.

Table 18 summarizes the proposed recommendations for all 24 (twenty-four) watercourse crossings.

Similarly, **Table 19** and **Table 20** summarizes the results of the hydraulic assessment of culverts under existing and proposed conditions, respectively.

The CulvertMaster output files and summary of the HEC-RAS hydraulic modelling under the existing and proposed conditions are included in **Appendix D**.

Table 18: Summary of Recommendation for all Watercourse Crossings

Maintain Existing Structure
Replace with a New Structure
Eliminate / Abandon structures

Table18: Summary of Recommendation for all Watercourse Crossings

Culvert ID	Sta. No.	Existing Size	Type / Structure	Watercourse Type	Proposed Action	Size of Existing, if Maintained	Proposed/Extended Length	Recommended Size
C01	2+995	3.66m Span x 2.44m Rise Concrete Box	Structural Culvert	Regulated	Extend Existing Culvert	3.66m Span x 2.44m Rise Concrete Box	1.0m on U/S and 7.0m on D/S Total Length = 48.1m	Same as Existing
C02	3+132	1.8m Span x 1.5m Rise Concrete Box	Non-Structural, Culvert	Regulated	Replace with a new culvert		55m	2.7m Span x 2.1m Rise Concrete Box with 0.30m Embedment
C03	3+565	Twin 4.2m Span x 2.8m Rise, Concrete Box	Structural, Culvert	Regulated	Adjustment of Headwall Height	Twin 4.2m Span x 2.8m Rise Concrete Box	N/A	Same as Existing
C04	5+955	1050mm Ø HDPE Pipe	Non-Structural, Culvert	Non-regulated	Extend Existing Culvert	1050mm Ø HDPE Pipe	3.7m on U/S and 4.4m on D/S Total length = 55.6m	Same as Existing
C05	6+565	1.8m Span x 1.5m Rise CSP Arch	Non-Structural, Culvert	Regulated	Replace with a New Culvert		55.9m	2.7m Span x 1.80m Rise Concrete Box with 0.30m Embedment
C06	7+421	800mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		52.2m	900mm Ø Concrete Pipe
C07	7+734	1.2m Span x 0.90m Rise CSP Arch	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		52.7m	2.4m span x 1.20m Rise Concrete Box with 0.30m embedment
C08	7+960	2.40 m Span x 0.90m Rise, Concrete Box	Non-Structural, Culvert	Non-regulated	Plug Existing Culvert on the Westside & Relocate to North	2.40 m Span x 0.90m Rise Concrete Box	N/A	N/A
C08A	8+070	N/A	Structural, Culvert	Non-regulated	Install New Culvert North of Existing C08		65.5m	3.0m Span x 1.2m Rise Concrete Box with 0.30m Embedment
C09	8+357	1200mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Eliminate Existing and Relocate to North and		N/A	N/A
C09A	8+450	N/A	Non-Structural, Culvert	Non-regulated	Install New Culvert North of Existing C09		69.0m	975mm Ø Concrete Pipe
C10	8+562	900mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Eliminate, Runoff direct to C09A		N/A	N/A
C11	8+812	1.55m Span x 1.20m Rise CSP Arch	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		51.9m	1.5m Span x 1.20m Rise Concrete Box with 0.30m Embedment
C12	9+150	800mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		52.1m	825mm Ø Concrete Pipe
C13	9+145	1200mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		51.4m	825mm Ø Concrete Pipe
C14	9+754	900mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		58.2m	1050mm Ø Concrete Pipe

Maintain Existing Structure
Replace with a New Structure
Eliminate / Abandon structures

Table18: Summary of Recommendation for all Watercourse Crossings

Culvert ID	Sta. No.	Existing Size	Type / Structure	Watercourse Type	Proposed Action	Size of Existing, if Maintained	Proposed/Extended Length	Recommended Size
C15	10+000	7.315m Span x 1.83m Rise Concrete Arch	**Structural, Culvert**	**Regulated**	Extend on westside, add 750mm Ø Relief Culvert and adjust Retaining wall on eastside	7.315m Span x 1.83m Rise Concrete Arch	Extend 7.5m on Westside Total Length = 55.7m	Extend Existing Culvert plus add 750mm Ø HDPE Relief Culvert
C16	10+418	1.55m Span x 1.00m Rise CSP Arch	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		49.7m	1200mm Ø Concrete Pipe
C17	11+250	800mm Ø CSP Pipe	Non-Structural, Culvert	Non-regulated	Replace with a New Culvert		51.3m	1.2m Span x 1.20m Rise Concrete Box with 0.30m Embedment
C18	11+462	1200mm Ø CSP Pipe	Non-Structural, Culvert	**Regulated**	Replace with a New Culvert		60.0m	2.10m Span x 1.20m Rise Concrete Box with 0.30m Embedment
C19	11+648	6.10m Span x 1.90m Rise Concrete Arch	**Structural, Culvert**	**Regulated**	Extend Existing Culvert	6.10m Span x 1.90m Rise Concrete Arch	8.8m on U/S and 10.3m on D/S Total Length = 62.5m	Same as Existing
C20	12+838	1200mm Ø Conc. Pipe	Non-Structural, Culvert	Non-regulated	Extend Existing Culvert	1200mmØ Concrete Pipe	9.8m on U/S and 9.2m on D/S Total Length = 57.2m	Same as Existing
C21	12+956	1200mm Ø Conc. Pipe	Non-Structural, Culvert	Non-regulated	Extend Existing Culvert and add 900mm Ø Relief Culvert	1200mmØ Concrete Pipe	9.8m on U/S and 11.6m on D/S + New Culvert 60.5m Long	Existing plus New 900mm Ø Concrete Pipe
C22	13+440	1.83m Span x 0.91m Rise Concrete Box	**Structural, Culvert**	**Regulated**	Replace with a New Culvert		52.6m	3.90m Span x 1.80m Rise Concrete Box with 0.30m Embedment
B04	14+725	28.7m clear Span	**Structural, Bridge**	**Regulated**	Widen Bridge Deck on the Eastside	28.7m Clear Span	8.91m	Same as Existing
C23	15+245	1.83m Span x 0.91m Rise Concrete Box	Non-Structural Culvert	**Regulated**	Extend Existing Culvert	1.83m Span x 0.91m Rise Concrete Box	11.0m on U/S Total Length = 42.6m	Same as Existing
C24	15+720	3.30m Span x 3.0m Rise Concrete Box	**Structural, Bridge**	**Regulated**	Replace with a New Culvert/Bridge		57.2m	Conspan 12.80m Span x 3.51m Rise Open Footing Concrete structure

Note: U/S = Upstream; D/S = Downstream

Table 19: Hydraulic Assessment of Culverts Under Existing Conditions

Culvert ID	St. No.	Location	Culvert Dimensions				Material / Type	Drainage Area	Peak Flow (m^3/s)			Invert Elevation (m)		Road Elev. at Low Point	HWL (m)			Velocity (m/s)		H/D of Culvert	Available Freeboard (m)	Performance Criteria Satisfied?				Comments
			Width (m)	Height (m)	Length (m)	Number of Barrels		(ha)	50-Yr	100-Yr	Regional Flow	U/S	D/S	(m)	50-Yr	100-Yr	Regional flow	50-Yr	100-Yr	Design Storm	Design Storm	Meets Freeboard?	H/D ≤ 1.5	Overtopping for 100-yr?	Overtopping for Regional?	
C01	2+995	365 m South of Upper Middle Road	3.66	2.44	40.1	1.0	Concrete / Box Open footing	68.90	2.223	2.585	6.492	125.52	125.17	129.54	126.08	126.14	126.66	1.71	1.83	0.23	3.46	Yes	Yes	No	No	Structural Culvert
C02	3+132	227 m South of Upper Middle Road	1.83	1.52	47.5	1.0	Concrete / Box	179.69	9.882	11.414	20.005	126.27	125.93	130.16	128.87	129.36	130.46	1.06	1.02	1.71	1.29	Yes	No	No	Yes	
C03	3+565	205 m North of Upper Middle Road	4.27	3.05	47.0	2.0	Twin cell Concrete Box, 0.3m Embankment	N/A	15.900	19.900	61.400	123.62	123.54	131.53	125.43	125.63	127.49	1.00	1.00	0.70	5.90	Yes	Yes	No	No	Open Footing, Structural Culvert, Updated Existing Condition
C04	5+955	155 m North of William Halton Parkway	1.05	1.05	47.5	1.0	HDPE / Circular	9.99	0.497	0.581	1.129	156.32	156.19	158.17	156.88	156.93	157.21	1.68	1.76	0.53	1.29	Yes	Yes	No	No	
C05	6+565	347 m South of 407 ETR	2.10	1.60	44.1	1.0	CSP / Arc	72.80	1.989	2.312	6.479	162.71	162.54	165.68	163.67	163.76	165.09	2.07	2.17	0.60	2.01	Yes	Yes	No	No	
C06	7+421	103 m South of Burnhamthorpe Road	0.80	0.80	34.0	2.0	CSP / Circular	0.74	0.222	0.251	0.106	169.95 170.08	169.19 169.20	171.52	170.34	170.36	170.23	1.51	1.56	0.49	1.18	Yes	Yes	No	No	
C07	7+734	209 m North of Burnhamthorpe Road	1.20	0.90	37.1	2.0	CSP / Arch	9.01	1.634	1.863	1.263	171.70 171.68	171.36 171.57	173.87	172.44	172.51	172.32	1.90	2.03	0.82	1.43	Yes	Yes	No	No	
C08	7+960	430 m North of Burnhamthorpe Road	2.40	0.90	38.7	2.0	Concrete / Box	17.58	3.021	3.463	2.447	172.66	172.38	174.29	173.26	173.32	173.18	1.54	1.64	0.67	1.03	Yes	Yes	No	No	
C09	8+356	89 m South of Henderson Road	1.20	1.20	39.1	1.0	CSP / Circular	4.28	0.818	1.104	0.606	179.02	178.46	181.30	179.85	180.00	179.73	1.99	2.16	0.69	1.45	Yes	Yes	No	No	
C10	8+570	128 m North of Henderson Road	0.90	0.90	38.9	1.0	CSP / Circular	0.70	0.213	0.241	0.101	185.11	184.01	187.00	185.56	185.59	185.68	1.78	1.85	0.50	1.44	Yes	Yes	No	No	
C11	8+812	370 m North of Henderson Road	1.55	1.20	34.9	1.0	CSP/ Arch	1.55	0.127	0.148	0.204	189.45	189.02	191.36	189.70	189.72	189.77	1.02	1.06	0.21	1.66	Yes	Yes	No	No	
C12	9+149	707 m North of Henderson Road	0.80	0.80	35.1	1.0	CSP / Circular	2.96	0.397	0.455	0.421	187.15	187.03	188.61	187.81	187.87	187.84	1.70	1.77	0.82	0.80	No	Yes	No	No	
C13	9+415	394 m South of Lower Base Line	1.20	1.20	35.9	1.0	CSP/ Circular	7.62	0.718	0.837	1.032	183.33	182.92	185.22	184.09	184.16	184.26	1.81	1.90	0.63	1.13	Yes	Yes	No	No	
C14	9+754	55 m South of Lower Base Line	0.90	0.90	35.0	1.0	CSP / Circular	4.50	1.451	1.627	0.651	178.39	178.09	180.00	180.06	180.15	179.18	2.65	2.69	1.86	-0.06	No	No	Yes	No	
C15	10+000	190 m North of Lower Base Line	7.32	1.83	48.2	1.0	Concrete/ Arch	N/A	16.370	19.100	21.520	173.49	173.31	177.67	175.85	176.36	176.93	1.29	1.22	1.41	1.31	Yes	Yes	No	No	0.3 m embedment is included. Culvert inverts at U/S and D/S are top of the stone. Structutal Culvert, Updated Existing Condition
C16	10+418	610 m North of Lower Base Line	1.55	1.00	34.2	1.0	CSP/ Arch	7.66	0.411	0.465	0.809	178.05	178.17	180.00	178.65	178.67	178.88	1.45	1.50	0.60	1.35	Yes	Yes	No	No	
C17	11+250	260 m North of Halton Waste Management Access	0.80	0.80	38.1	2.0	CSP / Circular	3.62	0.612	0.843	0.514	178.57 178.60	178.17 178.18	180.12	179.13	179.24	179.08	1.58	1.75	0.70	0.99	No	Yes	No	No	
C18	11+455	260 m North of Halton Waste Management Access	1.20	1.20	36.4	1.0	CSP / Circular	17.07	2.695	3.112	2.399	177.01	176.55	179.13	178.68	179.03	178.54	2.91	3.14	1.39	0.45	No	Yes	No	No	
C19	11+648	260 m North of Halton Waste Management Access	6.10	1.90	43.4	1.0	Concrete/ Arch	N/A	11.430	13.170	41.000	175.098	175.098	179.05	177.23	177.36	179.32	1.13	1.19	1.19	1.69	Yes	Yes	No	Yes	Structural Culvert, Updated Existing Condition
C20	12+838	40 m South of Britannia Road	1.20	1.20	38.2	1.0	Concrete / Circular	8.37	0.702	0.818	1.109	182.14	181.80	183.82	182.84	182.90	183.04	2.49	2.58	0.58	0.98	No	Yes	No	No	
C21	12+956	78 m North of Britannia Road	1.20	1.20	39.1	1.0	Concrete / Circular	10.04	0.558	0.659	1.186	183.42	183.28	185.31	183.99	184.04	184.28	1.69	1.77	0.48	1.32	Yes	Yes	No	No	
C22	13+440	258 m North of Etheridge Avenue	1.83	0.91	31.6	1.0	Concrete / Box	5.98	0.808	0.919	0.828	186.05	185.81	189.03	186.55	186.60	186.56	2.09	2.19	0.55	2.48	Yes	Yes	No	No	
B04	14+725	300 m north of Louis St. Laurent Avenue	Existing 16Mile Creek Bridge, 28.7m clear span				Bridge			229.990	411.110			185.55		184.28	185.76	2.27	2.31		1.31	Yes	Yes	No	Yes	Structural Bridge, Updated Existing Condition
C23	15+245	720 m South of Derry Road	1.83	0.91	31.6	1.0	Concrete / Box	5.62	0.468	0.552	0.752	183.82	183.59	185.94	184.15	184.19	184.27	1.69	1.79	0.36	1.79	Yes	Yes	No	No	
C24	15+720	250 m South of Derry Road	3.30	3.00	46.9	1.0	Concrete / Box Open footing	N/A	67.780	78.430	46.880	183.43	182.96	188.05	189.95	190.11	188.83	0.53	0.68	2.17	-1.90	No	No	Yes	Yes	Structural Culvert

Note: 1. Applied design storm for Culverts is the 50-year. For Culvert C03, C15 and C19, design storm is the 100-year flow.

HWL = Head Water Elevation
H/D = Headwater / Depth Ratio

U/S = Upstream
D/S = Downstream

Table 20: Hydraulic Assessment of Culverts Under Proposed Conditions

Culvert ID	St. No.	Location	Culvert Dimensions				Material / Type	Drainage Area	Peak Flow (m^3/s)			Invert Elevation (m)		Road Elev. at Low Point	HWL (m)			Velocity (m/s)		H/D of Culvert	Available Freeboard (m)	Performance Criteria Satisfied?				Comments
			Width (m)	Height (m)	Length (m)	Number of Barrels		(ha)	50-Yr	100-Yr	Regional Flow	U/S	D/S	(m)	50-Yr	100-Yr	Regional flow	50-Yr	100-Yr	Design Storm	Design Storm	Meets Freeboard?	H/D ≤ 1.5	Overtopping for 100-yr?	Overtopping for Regional?	
C01	2+995	365 m South of Upper Middle Road	3.66	2.44	47.1	1.0	Concrete / Box Open footing	68.90	2.223	2.585	6.492	125.520	125.110	129.58	126.08	126.14	126.67	1.71	1.83	0.23	3.50	Yes	Yes	No	No	Extension at D/S by 7.0m. A new retaining wall at D/S is required. The retaining wall should be verified by a structural engineer in the detailed design phase.
C02	3+132	227 m South of Upper Middle Road	2.70	2.10	55.0	1.0	Concrete / Box with 0.30m embedment	179.69	9.882	11.414	20.006	126.270	125.920	130.24	128.44	128.62	130.17	1.08	1.13	1.16	1.80	Yes	Yes	No	No	An existing culvert is replaced with 2.7 x 2.1 conc./box culvert that includes 0.3m embedment. A new retaining wall at D/S and U/S is required, which requires review from a structural engineer in the detailed design phase. The elevations of inverts are top of the embedment.
C03	3+565	205 m North of Upper Middle Road	4.27	3.05	47.0	2.0	Twin Cell, Concrete /Box	N/A	15.900	19.900	61.400	123.62	123.54	131.93	125.43	125.63	127.49	1.00	1.00	0.70	6.30	Yes	Yes	No	No	An existing culvert will remain. An increased height of headwall at D/S is required. The retaining wall needs to be verified by a structural engineer.
C04	5+955	155 m North of William Halton Parkway	1.05	1.05	55.6	1.0	HDPE / Circular	9.80	0.493	0.576	1.111	156.343	156.172	158.17	156.90	156.95	157.22	1.68	1.76	0.53	1.27	Yes	Yes	No	No	Extension at U/S and D/S by 3.7 m and 4.4m respectively.
C05	6+565	347 m South of 407 ETR	2.70	1.80	55.9	1.0	Concrete/Box with 0.3m embedment	71.86	1.963	2.282	6.361	162.770	162.540	165.95	163.50	163.58	164.34	1.91	2.01	0.41	2.45	Yes	Yes	No	No	An existing culvert is replaced with 2.7m x 1.8m conc. box culvert that includes 0.3m embedment. The invert elevation sat U/S and D/S are top of the embedment.
C06	7+421	103 m South of Burnhamthorpe Road	0.90	0.90	52.2	2.0	Concrete / Circular	0.23	0.030	0.035	0.033	170.000	169.000	171.55	170.14	170.15	170.15	1.33	1.40	0.16	1.41	Yes	Yes	No	No	The existing twin 0.6m CSP is replaced with 0.9m concrete circular pipe.
C07	7+734	209 m North of Burnhamthorpe Road	2.40	1.20	52.7	1.0	Concrete / Box	8.64	1.485	1.697	1.209	171.726	171.307	174.23	172.32	172.40	172.26	1.75	1.83	0.50	1.91	Yes	Yes	No	No	Replace an existing culvert with 2.4m x 1.2m conc. box including 0.3m embedment at the bottom.
C08A	8+070	540 m North of Burnhamthorpe Road	3.00	1.50	65.5	1.0	Concrete/ Box with 0.3m embedment	16.40	2.678	3.076	2.279	173.20	172.90	174.90	174.04	174.12	173.95	2.06	2.16	0.56	0.86	No	Yes	No	No	The existing culvert is replaced with 3.0 span x 1.2 rise concrete culvert. The culvert includes 0.3m embedment. The invert elevations are top of the embedment
C09A	8+450	89 m South of Henderson Road	0.975	0.975	54.8	1.0	Concrete / Circular	4.16	0.693	0.977	0.589	182.500	181.500	184.25	183.01	183.17	182.94	3.29	2.90	0.52	1.24	Yes	Yes	No	No	An existing C09 is relocated to St 8+450. A CB is required at the inlet of the culvert.
C10		Eliminated																								The Culvert C10 will be removed under the proposed conditions.
C11	8+812	370 m North of Henderson Road	1.50	1.20	51.9	1.0	Concrete / Box	1.38	0.104	0.122	0.179	189.450	189.020	191.30	189.60	189.61	189.66	0.96	1.01	0.13	1.70	Yes	Yes	No	No	Replace an existing culvert with 1.5m x 1.2m conc. box including 0.3m embedment at the bottom.
C12	9+150	707 m North of Henderson Road	0.825	0.825	52.1	1.0	Concrete/ Circular	2.27	0.273	0.319	0.322	187.186	186.989	188.80	187.63	187.67	187.67	1.49	1.56	0.54	1.17	Yes	Yes	No	No	Replace with a 825mm concrete culvert under the propose condition.
C13	9+415	394 m South of Lower Base Line	0.825	0.825	51.3	1.0	Concrete/ Circular	7.11	0.682	0.797	0.966	183.330	182.920	185.14	184.07	184.14	184.25	2.43	2.52	0.90	1.07	Yes	Yes	No	No	Replace with a 825mm concrete culvert under the propose condition.
C14	9+754	55 m South of Lower Base Line	1.05	1.05	58.19	1.0	Concrete/ Circular	3.91	1.276	1.429	0.566	178.390	178.090	180.36	179.35	179.42	178.99	2.41	2.48	0.91	1.01	Yes	Yes	No	No	Replace with a 1050mm concrete culvert under the propose condition.
C15	10+000	190 m North of Lower Base Line	7.32	1.83	55.7	1.0	Concrete/ Arch	N/A	16.370	19.100	21.520	173.510	173.310	177.70	175.81	176.31	176.19	1.10	1.04	1.26	1.39	Yes	Yes	No	No	The existing concrete arch culvert needs to be extended by 7.5m on the westside. A 750mm diameter HDPE relief culvert needs to be installed at u/s inv 174.00, d/s inv. 173.80 to reduce flooding impact.
C16	10+418	610 m North of Lower Base Line	1.20	1.20	49.7	1.0	Concrete/ Circular	9.67	0.296	0.347	0.692	178.150	178.100	180.03	178.60	178.63	178.85	1.31	1.37	0.37	1.43	Yes	Yes	No	No	Replace existing CSP with a 1200mm diameter Concrete Pipe Culvert.
C17	11+250	260 m North of Halton Waste Management Access	1.20	1.20	51.3	1.0	Concrete/ Box with 0.3m embedment	3.07	0.548	0.638	0.438	178.570	178.170	180.48	179.09	179.15	178.99	1.64	1.72	0.43	1.39	Yes	Yes	No	No	New culvert with 0.3m embedment at the bottom. The invert elevation sat U/S and D/S are top of the embedment.
C18	11+462	260 m North of Halton Waste Management Access	2.10	1.20	60.0	1.0	Concrete / Box with 0.3m embedment	16.31	2.161	2.499	2.244	176.800	176.500	178.77	177.72	177.84	177.74	2.40	2.52	0.77	1.05	Yes	Yes	No	No	The existing culvert is replaced with 2.10 span x 1.2 rise concrete culvert. The culvert includes 0.3m embedment. The invert elevations are top of the embedment
C19	11+648	260 m North of Halton Waste Management Access	6.10	1.90	62.5	1.0	Concrete/ Arch	N/A	11.430	13.170	41.000	175.140	175.050	179.05	177.26	177.39	179.32	1.11	1.15	1.18	1.66	Yes	Yes	No	Yes	Extension at U/S and D/S by 10.3m and 8.8m respectively.
C20	12+838	40 m South of Britannia Road	1.200	1.200	57.2	1.0	Concrete / Circular	7.51	0.637	0.748	0.998	182.200	181.708	184.03	182.86	182.92	183.05	2.40	2.51	0.55	1.17	Yes	Yes	No	No	Extension at U/S and D/S by 9.8m and 9.2m respectively.
C21	12+956	78 m North of Britannia Road	1.20	1.20	60.5	1.0	Concrete / Circular	10.89	0.665	0.774	1.274	183.469	183.222	185.19	183.94	183.98	184.14	1.60	1.67	0.51	1.25	Yes	Yes	No	No	A 900 mm Concrete/Circular is added. Extension at U/S and D/S by 9.8m and 11.6m respectively.
			0.90	0.90	60.5	1.0	Concrete / Circular											1.50	.1.57							
C22	13+440	258 m North of Etheridge Avenue	3.90	1.80	52.6	1.0	Concrete / Box with 0.3m embedment	8.08	0.777	0.843	1.140	186.095	185.750	189.09	186.38	186.40	186.46	0.97	0.99	0.19	2.71	Yes	Yes	No	No	The existing culvert is replaced with 3.9 span x1.8 rise concrete/box culvert. The new culvert includes 0.3m embedment. The invert elevation are top of the embedment.
B04	14+725	300 m north of Louis St. Laurent Avenue	Widening of Existing 16Mile Creek Bridge, 28.7m clear span				Bridge			229.990	411.110			185.55		184.25	185.76	0.53	2.33		1.30	Yes	Yes	No	Yes	Deck width of the bridge will be widened on the east (d/s) side by approximately 8.91m
C23	15+245	720 m South of Derry Road	1.83	0.91	42.6	1.0	Concrete / Box	4.88	0.406	0.479	0.652	183.865	183.590	185.94	184.16	184.19	184.27	1.56	1.65	0.32	1.78	Yes	Yes	No	No	Extension at U/S by 11.0m.
C24	15+720	250 m South of Derry Road	12.80	3.51	57.2	1.0	Conc. Conspan Open footing	N/A	67.780	78.330	46.880	183.610	182.955	188.05	186.39	186.54	186.92	4.52	4.76	0.98	1.51	Yes	Yes	No	No	Replace existing culvert with a open footing structure

Note:
1. Applied design storm considered for Culverts is the 50-year for span less than or equal to 6m span.
2. Design storm from Culverts C03, C15, C19, C24 and Bridge B1 is the 100-year storm, as the span of these structures is more than 6.0 m.

HWL= Head Water Elevation
H/D =Headwater / Depth Ratio
U/S = Upstream
D/S = Downstream

5.3 Fluvial Geomorphological Assessment

The fluvial geomorphological study of all regulated watercourse crossing is carried out by Geo Morphix Ltd. The Fluvial Geomorphological Report is provided as a separate volume.

The fluvial geomorphological assessment notes that, in general, crossings should extend across the anticipated zone of future channel migration, as defined by the meander belt or the 100-year erosion limit. However, implementing structures that span the full valley or meander belt is not always feasible or practical due to site-specific constraints and a range of technical, economic, and other considerations. In such cases, a balanced evaluation of the contributing factors and associated environmental impacts is typically more appropriate.

Followings are the overview of the proposed crossings for regulated features and restoration opportunities and requirements to address the riverine erosion hazard as per the fluvial report:

- *Multiple crossing extensions are proposed, with no proposed change to existing spans (C03, C15, B04, and C23). In addition, structures with spans less than the 100-year erosion limit (or 3x bankfull width) are "less preferred", as the probability of possible future channel with structures is increased, as is the potential for maintenance. For these crossing locations and/or where larger structure crossings cannot be accommodated due to site constraints, geomorphic design is required to address the erosion hazard through incorporation of bioengineering.*
- *Several features (C01, C02, C05, C08, C18, C22, C23) were characterized by historically modified/managed swale features, which are constructed as overwidened depressions with poorly defined bankfull channels. The overwidened state of the features is not representative of the channel-forming width and contributes to artificial span-to-width scores. These features have small drainage areas and were assessed to have low erosion potential. Actual ratios are expected to be increased, closer to the preferred crossing design targets.*
- *Structures C01, C15, C19, and C24 were characterized by relatively larger existing or proposed spans, which encompassed the bankfull channel and incorporate an erosion setback to either side of the channel. Nonetheless, outlet/inlet pool design is still proposed in these areas to restore surfaces disturbed by the road widening or culvert works and provide seamless flow*

transition to existing channel sections. The associated bioengineering will therefore offer additional erosion control benefit.

- *The sizing of proposed substrate materials would be guided by a review of hydraulic conditions (i.e.,tractive forces, flow competency) in the typical channel cross-sections. Upon selection of the final design configuration, proposed substrates and bioengineering materials would be hydraulically sized to limit entrainment up to the anticipated 100-year flow event or larger, as appropriate.*
- *Structure B04, which crosses the mainstem of 16MC, is understood to be proposed for extension. The crossing is situated downstream of a "dogleg" or right-angle turn in the channel, where lateral and vertical erosion pressures are increased. The channel was also partially constricted (narrowed) at this location. The erosion hazard was emphasized by a failed section of stone revetment, along the bank of 16MC within the crossing. For example, the boulders which made up the revetment were, leaving an exposed (bare/unprotected) section of bank next to the multi-use trail. The failed treatment underscores the need for robust materials with the current crossing configuration, such as armourstone or large boulders.*
- *Plunge pools are proposed at the inlet and outlet of channel crossings, where scour pools tend to form under natural conditions. The pools consist of over-excavated depressions with hydraulically sized substrates and parameters (width and depth) to help dissipate flow energy in proximity to crossing infrastructure.*
- *Based on resident fish species and their respective life cycles, in-stream work will be regulated by the fisheries timing window as set out by Department of Fisheries and Oceans Canada (DFO) and the Ministry of Natural Resources (MNR).*

Table 5 of the fluvial geomorphological report has noted that Culverts C05, C08, C15, and C19 require channel realignment. For culverts C23 and C24, channel realignment/rehabilitation is considered as provisional.

Refer Fluvial Geomorphological Report for more detail.

6 Stormwater Management System

6.1 General Overview

This section of the report documents the preliminary screening of SWM practices for the purpose of runoff quantity and quality treatment for the roadway areas. It should be noted that due to the limited area available along the linear infrastructure, there are limited possibility for the implementation of SWM practices.

Under existing conditions, there are eight OGS units providing water quality control for some stretch of Regional Road 25. There are four existing SWM ponds providing water quality and quantity control for Regional Road 25 located within the Town of Milton and Town of Oakville. One of the existing ponds falls under MTO jurisdiction. The widening of the roadway will increase the imperviousness along the proposed road right-of-way (ROW), thereby increasing the runoff from the roadway area. As discussed in **Section 4**, stormwater management solutions are required in order to restore the impacts back to or improve them from existing conditions.

The MOE (now MECP) Stormwater Planning and Design Manual has identified a broad range of stormwater management practices that may be considered for the runoff peak flow control and quality control of the project. The recommended practices that can be implemented as part of this project are:

- Storage pipe systems providing quantity control
- Manufactured treatment devices such as OGS for quality treatment
- LID Infiltration measures for water balance.

The stormwater management plan is designed to comply with the MTO standards summarized as follows:

- Minimize increases in flows up to the 100-year storm.
- Maintain or enhance the quality or runoff discharged from the right-of-way.
- Maintain water balance of the existing study area.

A variety of Low Impact Development (LID) measures can be used to retain and infiltrate rainfall, including Bio-Swales, Infiltration Trenches, Swales etc. as long as the required runoff volume can be captured and infiltrated. Due to the limited area available within the roadway ROW, best efforts will be made to implement these LID measures wherever possible.

Due to the characteristics of the subject area, the stormwater management assessment will consist of the following approaches:

- Documentation of existing conditions including the identification of outlets, drainage topography, typical cross sections, watercourses, discretized drainage areas, regulation and flood limits and other relevant drainage features and constraints.
- Identifying potential opportunities to implement Low Impact Development features such as bio-retention, grassed swales, or other infiltration techniques to reduce the impacts of the intersection improvements on stormwater.

6.2 Impact of Proposed Road Improvements

As discussed in **Section 4**, Regional Road 25 between Wyecroft Road and Derry Road West will be upgraded from a 4-lane road to a 6-lane urban road with additional turning lanes at the intersections. South of Wyecroft Road, the 6-lane road will be transitioned to the 4-lane existing roadway with proposed multi-use path on the east side. The proposed road widening and improvements will lead to an increase in impervious areas thereby increasing the peak flow rates. **Table 21** illustrates the summary of impact of the proposed road widening.

Table 21: Impact of Road widening

Station From – To/ Catchment ID	Existing Condition			Proposed Condition			Overall Imp. Increase %	Outlet Point	Exhibit No.
	Area (ha)	Imp. Area (ha)	Imp. %	Area (ha)	Imp. Area (ha)	Imp. %			
0+212 to 0+942	4.75	2.31	49%	4.75	2.57	54%	5%	Bronte Rd., South of Speers	19
0+942 to 2+362	7.23	4.69	65%	7.23	5.12	71%	6%	QEW East SWM Pond	19, 20, 21
2+362 to 3+360	4.18	3.05	73%	4.18	3.68	88%	15%	Culvert C01	21, 22
3+360 to 3+620	5.77	2.57	45%	5.84	3.09	53%	8%	Upper Middle Road STM	22
3+630 to 5+304	18.16	9.69	53%	19.07	12.43	65%	12%	Bronte SE SWM Pond	22, 23, 24
4+307 to 6+570	12.39	7.12	57%	13.23	9.34	71%	13%	Mattamy SWM Pond	23, 24, 25, 26
5+334 to 5+436	0.97	0.38	39%	0.51	0.47	93%	54%	Dundas Street West STM	25
Catchments 455 & 460	13.02	0.72	6%	12.71	0.71	6%	0%	William Halton Parkway	25
6+570 to 7+150	73.16	5.55	8%	72.36	5.84	8%	0%	Culvert C05	26
Catchment 4076	2.16	1.13	52%	1.65	0.71	43%	-9%	Culvert C407-7	26
Catchments 4073 & 4074	8.74	1.60	18	8.48	1.47	17	-1%	Culvert C407-2	26

Station From – To/ Catchment ID	Existing Condition			Proposed Condition			Overall Imp. Increase %	Outlet Point	Exhibit No.
	Area (ha)	Imp. Area (ha)	Imp. %	Area (ha)	Imp. Area (ha)	Imp. %			
7+150 to 7+420	0.62	0.45	73%	1.13	1.03	91%	18%	Culvert C407-5	26, 27
7+420 to 7+736	1.28	0.73	54%	1.54	1.21	79%	22%	Culvert C06	27
7+736 to 7+861	9.40	2.62	28	9.13	2.57	28	0%	Culvert C07	27
7+861 to 8+360	3.10	1.38	45%	3.22	1.90	59%	14%	Culvert C08	27
8+360 to 8+816	4.28	1.08	25%	6.00	2.50	42%	17%	Culvert C09	28
8+816 to 8+860	1.74	0.30	17%	1.55	0.24	15%	-2%	Culvert C11	29
8+860 to 9+146	3.53	0.77	22%	3.42	1.06	31%	9%	Culvert C12	29
9+146 to 9+411	8.15	0.55	7%	8.19	1.18	14%	7%	Culvert C13	29
9+411 to 9+752	1.81	0.99	55%	1.71	1.28	75%	20%	Culvert C14	30
9+752 to 10+421	3.51	1.53	60%	3.14	1.88	91%	31%	Culvert C15	30
10+421 to 10+921	8.15	1.53	44%	5.19	1.88	60%	16%	Culvert C16	30, 31
10+921 to 11+250	2.45	0.79	32%	1.97	0.77	39%	7%	Culvert C17	31
11+250 to 11+452	0.93	0.22	24%	0.64	0.01	2%	-22%	Culvert C18	31
11+452 to 12+508	2.45	2.30	32%	4.58	3.83	39%	7%	Culvert C19	32
12+508 to 12+841	1.60	0.95	59%	1.39	1.27	91%	32%	Culvert C20	33
12+841 to 12+991	0.69	0.46	67%	0.78	0.74	95%	28%	Britannia Road	33
12+991 to 13+398	1.58	1.06	67%	1.67	1.49	89%	22%	Culvert C21	33
13+398 to 14+348	4.30	2.51	58%	4.13	3.45	84%	26%	D/S of Culvert C22	33, 34
14+348 to 14+395	0.31	0.22	71%	0.31	0.28	90%	19%	Louis St. Laurent Avenue	34
14+395 to 15+259	5.12	2.44	48%	5.12	2.87	56%	8%	Bridge B04	34, 35
15+259 to 15+748	4.16	1.42	34%	4.16	1.70	41%	7%	C23	35
15+748 to 16+160	0.85	0.62	73%	0.85	0.65	76%	3%	Culvert C24	35, 36

The increase of the 100-year flow is due to the increase in impervious area which ranges from 0.34% to 52%, The 5-year flow increased up to 69% in some outlet locations. Therefore, to reduce the impacts of sediment loading as well as increased

peak flow to the receiving watercourses, storm water management measures are required for runoff quality and quantity control.

6.3 Proposed Stormwater Management Strategy

As discussed above, peak flow control is necessary, therefore, Super pipe (storage pipe) facilities are proposed at different locations to control the flows from the roadway to pre-development conditions. Quality treatment of roadway runoff from all catchments will be provided by Oil Grit Separators (OGSs) located after each of the storage pipe facilities as well as existing SWM facilities prior to discharging to the downstream of each crossing culverts. All OGS units will be sized for CA ETV particle size distribution. It is understood that OGS will be considered only up to 60% of removal efficiency; however, due to urbanization of the roadway, property and utility constraints, other treatment train approaches are not feasible at most of the outlets.

6.3.1 Peak Flow Control

Visual OTTHYMO Modelling was used to calculate the storage volume requirement to reduce the post-development flow back to the existing (pre-development) condition level for all events up to and including 100-year event in according with Conservation Halton Guidelines for Stormwater Management Engineering Submissions (2024).

Under existing conditions, the peak flow values for the 100-year storm were obtained from the Visual OTTHYMO Modelling result and these flows were considered as the release rate from the proposed storm sewer.

Due to property constraints for other surface stormwater management facilities, peak flow control for Regional Road 25 is provided by pipe storage system.

The preliminary sizing of peak flow control measures is presented in **Table 22**. It should be noted that this is a conceptual design intended to demonstrate the required level of flow control using a typical orifice configuration. It will be further reviewed during the detailed design phase. The stage-discharge-storage analysis details can be found in **Volume II Appendix F**. The storage pipe system, orifice sizing, and drawdown characteristics will be further evaluated during the detailed design stage. The Visual OTTHYMO Modelling comparison of pre- and post-development conditions, incorporating the conceptual peak flow control measures, is provided in **Volume II, Appendix C**. This demonstrates that post-development flows are effectively managed to pre-development levels through the implementation of these control features.

Table 22: Impact of Road widening

Pipe Storage ID	Location From - To	Required Storage Volume for the 100-yr Storm (m^3)	Post- to Pre-Target Release Rate (m^3/s)	Controlled Release Rate (m^3/s)	Provided Storage System for Peak Flow Control				Quality Control Mechanism	Outlet Point	Outlet Exhibit No.
					Pipe Size (mm)	Length (m)	Quantity Control Mechanism	Provide Volume (m^3)			
1	St 0+212 to St 0+922	386	1.448	1.201	1350 mm Ø	443	N/A	400	N/A	Bronte Rd., South of Speers Rd.	19
2	St 0+922 to St 1+042	199	0.746	0.561	825 mm Ø	383	450mm orifice @Invert Elevation 122.67	210	QEW SWM Pond (SWMP-1)	QEW SWM Pond (SWMP-1)	20
3	St 2+362 to St 3+021	297	1.227	1.078	1500 mm x1200 mm Box and existing 675 mm Ø	132 m Box Pipe Plus Existing STM Pipes	600mm orifice @Invert Elevation 125.77	315	OGS 1A and existing OGS 1	Culvert C01	21
4	St 3+021 to St 3+360	172	0.644	0.554	1345 mm x 855 mm Elliptical	210	450mm orifice @Invert Elevation 127.13	175	OGS 2A and existing OGS 2	Culvert C01	21, 22
5	St 3+360 to St 3+620	41	0.171	0.146	825 mm Ø	87	300mm orifice @Invert Elevation 129.35	50	OGS 10	Upper Middle Road STM	22
6	St 3+360 to St 3+620	32	0.140	0.140	600 mm Ø	158	250mm orifice @Invert Elevation 128.82	45	OGS 9	Upper Middle Road STM	22

Pipe Storage ID	Location From - To	Required Storage Volume for the 100-yr Storm (m^3)	Post- to Pre-Target Release Rate (m^3/s)	Controlled Release Rate (m^3/s)	Provided Storage System for Peak Flow Control				Quality Control Mechanism	Outlet Point	Outlet Exhibit No.
					Pipe Size (mm)	Length (m)	Quantity Control Mechanism	Provide Volume (m^3)			
7	St 3+620 to St 4+307	209	0.870	0.776	1200 mm x 1200mm Box	150	600mm orifice @Invert Elevation 129.85	216	Bronte SE SWM Pond	Bronte SE SWM Pond	22
8	St 4+307 to St 6+570	1360	2.298	1.690	2400 mm x 1800 mm Box	305	375mm orifice @Invert Elevation 136.88 and 675 mm orifice @Invert Elevation 137.20	1402	Mattamy SWM Pond	Mattamy SWM Pond	23
					1200mm Ø Pipe	75					
9	St 6+571 to St 6+976	280	0.700	0.637	1800 mm x 1500 mm Box	110	525mm orifice @Invert Elevation 164.57	300	OGS 11	Culvert C05	26
10	St 6+976 to St 7+149	108	0.415	0.367	1500 mm x 1200 mm Box	70	450mm orifice @Invert Elevation 172.03	130	OGS 12	Ditch	26
11	St 7+149 to St 7+420	261	0.287	0.268	1500 mm x 1200 mm Box	150	350mm orifice @Invert Elevation 168.62	290	OGS 13	Ditch	26, 27
12	St 7+420 to St 7+736	184	0.513	0.471	1200 mm x 900 mm Box	170	450mm orifice @Invert Elevation 169.63	185	OGS 14	Culvert C06	27
13	St 7+736 to St 8+360	150	0.750	0.714	1800 mm x 1200 mm Box	75	600mm orifice @Invert Elevation 172.81	150	OGS 18	Culvert C08A	28

Pipe Storage ID	Location From - To	Required Storage Volume for the 100-yr Storm (m^3)	Post- to Pre-Target Release Rate (m^3/s)	Controlled Release Rate (m^3/s)	Provided Storage System for Peak Flow Control				Quality Control Mechanism	Outlet Point	Outlet Exhibit No.
					Pipe Size (mm)	Length (m)	Quantity Control Mechanism	Provide Volume (m^3)			
14	St 8+360 to St 8+816	275	0.750	0.637	2400 mm x 1500 mm Box	85	525mm orifice @Invert Elevation 179.36	295	OGS 20	Culvert C09A	28
15	St 8+860 to St 9+146	116	0.454	0.404	1345 mm x 855 mm Elliptical	150	450mm orifice @Invert Elevation 187.60	130	OGS 21	Culvert C12	29
16	St 9+146 to St 9+411	107	0.403	0.389	1050 mm Ø	160	450mm orifice @Invert Elevation 183.78	140	OGS 22	Culvert C13	29
17	St 9+411 to St 9+752	132	0.620	0.496	1500 mm x 1200 mm Box	90	525mm orifice @Invert Elevation 178.93	165	OGS 23	Culvert C14	30
18 &19	St 9+752 to St 10+421	165 and 367	0.927	0.826	1200 mm x1200 mm Box & 1800 mm x1200 mm Box	145 and 180	375mm orifice @Invert Elevation 175.29	215 and 390	OGS 24	Culvert C15	30
							375mm orifice @Invert Elevation 175.33		OGS 25		30
20	St 10+421 to St 10+921	178	1.093	0.726	1200 mm x 900 mm Box	180	525mm orifice @Invert Elevation 177.91	205	OGS 26	Culvert C16	30, 31
21	St 11+452 to St 12+508	506	1.391	0.952	1500 mm x 1200 mm Box &1500	270	600mm orifice @Invert Elevation 176.92	570	OGS 30	Culvert C19	32

Pipe Storage ID	Location From - To	Required Storage Volume for the 100-yr Storm (m^3)	Post- to Pre-Target Release Rate (m^3/s)	Controlled Release Rate (m^3/s)	Provided Storage System for Peak Flow Control				Quality Control Mechanism	Outlet Point	Outlet Exhibit No.
					Pipe Size (mm)	Length (m)	Quantity Control Mechanism	Provide Volume (m^3)			
					mm x 1500 mm Box						
22	St 12+508 to St 12+841	141	0.571	0.157	1500 mm x 1200 mm Box	270	190mm orifice @Invert Elevation 182.10 and 200 mm orifice @Invert Elevation 183.50	490	OGS 31	Culvert C20	32, 33
23	St 12+991 to St 13+398	333	0.594	0.454	1800 mm x 1200 mm Box	170	325mm orifice @Invert Elevation 183.72 and 300 mm orifice @Invert Elevation 184.70	380	OGS 3A and existing OGS 3	Culvert C21	33
24	St 13+398 to St 14+348	457	1.470	1.288	1500 mm x 900 mm Box	355	375mm orifice @Invert Elevation 186.41	486	existing OGS 4 and SWMP-4	Culvert C22	33, 34
25 & 26	St 13+994 to St 14+699	111	1.177	0.448	1500 mm x 900 mm Box	100	525mm orifice @Invert Elevation 186.75	137	OGS 5	Bridge B04	34
	St 14+699 to St 15+259	277		1.068	900 mm Ø and 1050 mm Ø	360	450mm orifice @Invert Elevation 182.90	301	OGS 6	Bridge B04	35
27	St 15+259 to St 15+748	306	0.944	0.889	1050 mm Ø	350	375mm orifice @Invert Elevation 184.08	310	OGS 7	Culvert C23	35

For Pipe Storage 1, the provided storage volume is based solely on the existing 1350 mm diameter pipe. No orifice sizing has been included at this stage due to insufficient pipe information; therefore, further review will be required during the detailed design phase.

With the implementation of these pipe storage facilities, provide in the table above, the post-development flows are managed effectively to pre-development levels.

6.3.2 Review of Existing SWM Facilities and their Capacity

As discussed in the existing and proposed conditions drainage, there are four existing SWM ponds which are QEW East SWM Pond (SWMP-1), Bronte Creek SE SWM Pond (SWMP-2), Mattamy SWM Pond (SWMP-3) and West Country Milton SWM Pond (SWMP-4) that provide quantity and quality control for study area as well for a portion of existing Regional Road 25.

Out of four SWM facilities, SWMP-1 outlets to Bronte Creek. SWMP-2 and SWMP-3 outlets to Fourteen Mile Creek upstream of Culvert C03 and SWMP-4 outlet to a tributary of Sixteen Mile Creek.

6.3.2.1 SWM Facility Discharging to Bronte Creek: SWMP-1

SWMP-1 is located at the south-east quadrant of Highway 403 and Bronte Road (Regional Road 25) interchange. The SWM facility is managed by MTIO. There is no drainage plan and stage-storage-discharge information is available for QEW East SWM Pond (SWMP-1) from MTO. Due to unavailability of information, SWMP-1 is not included in the overall hydrological analysis and necessary peak flow control is provided through a pipe storage facility to maintain the flow to pre-development level before discharging to the existing SWM facility. Further review is recommended during the detailed design phase to confirm whether the SWMP-1 will have adequate capacity to provide quality and quantity control for the addition runoff from Regional Road 25.

6.3.2.2 SWM Facilities Discharging to Fourteen Mile Creek: SWMP-2 & SWMP-3

Mattamy SWM Pond (SWMP-3) and Bronte Creek SE SWM Pond (SWMP-2) are in series and both discharges to Fourteen Mile Creek to the upstream of Culvert C03. The outlet point of SWMP-3 is slightly upstream than outlet point of SWMP-2. Overall, the post-development total outflow from these two ponds should be less than or equal to the pre-development level.

Figure 2 shows the general schematic of flow conveyance from Regional Road 25 and residential blocks to SWM ponds. Further details of these two SWM facilities are discussed below.

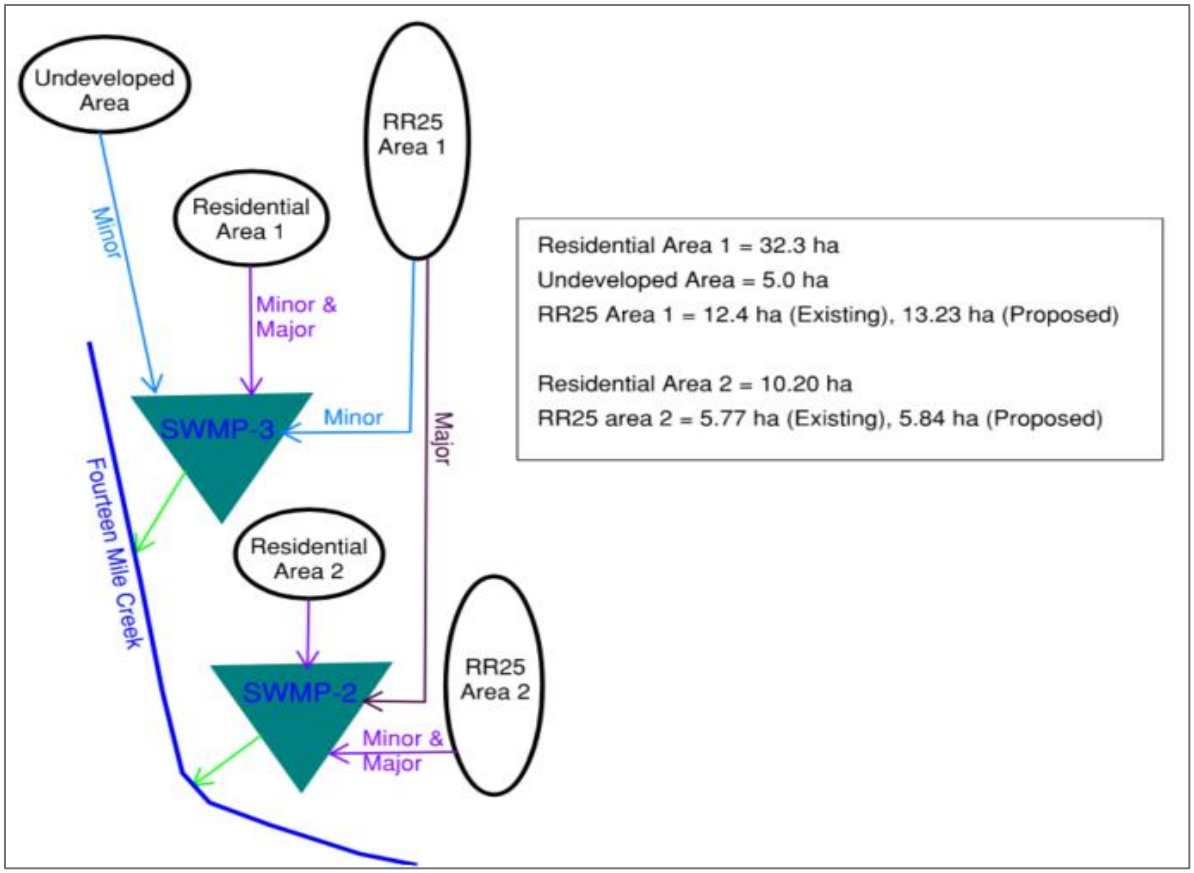

Figure 2: General Schematic of SWMP-3 and SWMP-2

a) Mattamy SWM Pond (SWMP-3)

A limited information is available in the Stormwater Management Design Brief prepared for Upper Glen Abbey Green (Mattamy SWM Pond, SWMP-3), prepared by Urbantech (Oct 2003), the wet SWM facility was designed to provide a service for 55.5 ha drainage area. The SWM pond is located on the west side of Regional Road 25, north-west of Richview Boulevard and Valleyridge Drive.

In the current condition, the service area is different than originally deigned. **Table 23** below provides some details of pond servicing condition and necessary permanent pool volumes as per original design, current condition and proposed condition as well as control features of existing SWMP-3.

Table 23: Servicing Condition of SWMP-3

Details	Original Design	Current Condition	Proposed Condition
Residential Service Area (Both Major & Minor)	33.0 ha	32.3 ha	32.3 ha
Undeveloped Area North of Dundas Street (Minor only)	5.0 ha	5.0 ha	5.0 ha
Regional Road 25 (Minor only, Major to SWMP-2)	17.5 ha	12.4 ha	13.23 ha
Total Servicing Area	55.5 ha	49.7 ha	50.53 ha
Overall Imperviousness	52.4 %	52.0%	56.0%
Required Permanent Pool Volume	7964 m^3	7132 m^3	7697 m^3
Available Permanent Pool Volume	8027 m^3	8027 m^3	8027 m^3
Existing Features of SWMP-3	Bond bottom elevation = 132.00 Permanent pool elevation = 133.50 100-year pond level = 135.1, Storage Volume provided = 9877 m^3 Control system: 325 mm Dia Orifice @ Invert Elev. 133.50 1.10 m x 0.75 weir @ Invert Elev. 134.35 Emergency overflow: 4.7 m bottom width, 3H:1V side slope, depth 0.30 m, top width 6.5 m, Top of pond elevation = n/a		

As per the original design, available active storage volume of the pond up to elevation 135.10 is 18,363 m3. The top of pond information is not available, however, based on the emergency weir depth of 0.30 m as noted in the report, the top of pond elevation should be just above weir flow depth which is likely be 135.50. The available permanent pool volume is enough to meet Enhanced level of water quality control under proposed condition.

A stage-discharge-storage table is developed from the existing stage-discharge storage information, extracted from the previous report. Both are included in **Volume II, Appendix F**. The existing condition SWM pond modelling result is provided on **Table 24** below.

Table 24: Existing Condition Pond Routing of SWMP-3

Event	Inflow to SWMP-3 (m^3/s)		Total Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)
	From Road Area (Minor only)	From External Area			
2-year	1.59	2.47	4.06	0.196	8371
5-year	2.30	3.76	6.06	0.421	11236
10-year	2.30	4.85	7.15	0.624	12858
25-year	2.30	6.14	8.44	0.918	14869
50-year	2.30	7.09	9.39	1.132	16227
100-year	2.30	8.04	10.34	1.370	17664

The maximum volume used under existing condition is 17664 m^3 and the total available volume is 18363 m^3.

Under proposed condition, the minor storm flow from 13.23 ha of Regional Road 25 area will be control by a pipe storage facility before directing the minor storm runoff to SWMP-3. A pipe storage facility (Pipe Storage # 8) 305 m long, 2400 mm x 1800 mm Concrete Box pipe as well as 75m long 1200 mm dimeter pipe is proposed along Regional Road 25. The total volume provided through the pipe storage is 1402 m^3. This pipe storage system discharges the controlled minor storm flow from the roadway to SWMP-3 to less than pre-development level. The major storm flow from the roadway area will be directed to SWMP-2. The proposed condition SWM pond modelling result is provided on **Table 25** below.

Table 25: Proposed Condition Pond Routing of SWMP-3

Event	Roadway Area Minor to Pipe Storage 8			Flow from External Area to Pond (m^3/s)	Total Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)	Change in Flow (Pr – Ex) (m^3/s)
	Inflow (m^3/s)	Outflow to Pond (m^3/s)	Volume Used (m^3)					
2-year	2.07	1.31	660	2.47	3.72	0.212	8901	0.016
5-year	3.01	1.69	1080	3.76	5.27	0.477	11717	0.056
10-year	3.05	1.81	1190	4.85	6.45	0.700	13392	0.076
25-year	3.05	1.87	1240	6.14	7.77	1.010	15469	0.092
50-year	3.05	1.97	1310	7.09	8.74	1.236	16863	0.104
100-year	3.05	2.16	1360	8.04	9.71	1.492	18372	0.122
Available Storage Volume			1402				18363	

Results provided in **Table 25** show that the minor storm flow from the roadway is controlled to less than pre-development level flow before discharging to SWMP-3. Utilizing the existing control system of the pond, the total used active storage volume for the pond under proposed condition is 18,372 m^3. In the existing report, the total storage

volume information up to the top of pond is not available and it is only available up to elevation 135.10, which is 18,363 m^3.

Due to limited information of the pond, no modification to the existing control system is proposed at this stage, as a result, the outflow from the pond is slightly higher than pre-development condition.

During the detailed design stage, it is recommended to conduct a bathymetric survey of SWMP-3 to determine the available storge volume of the pond, to confirm existing control features and their elevations, to confirm the top of pond elevation and to review potential retrofit option of the SWM pond to avoid pipe storage system along Regional Road 25 so that the total outflow can be managed by the SWM facility to pre-development level.

As shown in SWM Pond modelling schematic, the outflow from both SWMP-2 and SWMP-3 outlets into the same system (Fourteen Mile Creek), therefore, the total outflow from these two SWM facilities should be less than pre-development level.

b) **Bronte SE SWM Pond (SWMP-2**)

According to Stormwater Management Pond Design Brief prepared for Bronte Creek-Phase 1 (SE Facility), prepared by Stantec (Oct 2003), the wet SWM facility was designed to provide a service for 13.2 ha of drainage area which includes 2.71 ha area of Bronte Road. The SWM pond is located west of Bronte Road (Regional Road 25) just north of Fourteen Mile Creek crossing (Culvert C03). The pond also provides quantity control for the major storm flow of Regional Road 25 from Richview Boulevard to the south of Highway 407 as noted above in SWMP-3 description. The major storm drainage area was not considered for the quality control volume requirements.

Table 26 below provides some details of pond service area and necessary permanent pool volumes as per original design, current condition and proposed condition as well as control features of existing SWMP-2.

Table 26: Servicing Condition of SWMP-2

Details	Original Design	Current Condition	Proposed Condition
Residential Service Area (Both Major & Minor)	10.49 ha	10.20 ha	10.20 ha
Regional Road 25 and area east of roadway (Minor only)	2.71 ha	5.77 ha	5.84 ha
Total Area for Permanent Pool (PP) Volume	13.20 ha	15.97 ha	16.04 ha
Regional Road 25 (Major Only, Minor was on SWMP-3)	17.50 ha	12.40 ha	13.23 ha
Total Servicing Area	30.70 ha	28.37 ha	29.27 ha
Overall Imperviousness for PP Analysis	49 %	45%	47%
Required Permanent Pool Volume	1777 m^3	1996 m^3	2085 m^3
Available Permanent Pool Volume	1792 m^3	1792 m^3	1792 m^3
Existing Features of SWMP-2	Bond bottom elevation = 125.60 Permanent pool elevation = 127.60 Top of pond elevation = 130.10, Available volume = 7766 m3 Control system: 150 mm diameter orifice @ Invert 127.60 2m wide weir with 10H:1V side slope @ Invert 129.55 Control System recommended under Proposed Condition: 125 mm diameter orifice @ Invert 127.60 2m wide weir with 10H:1V side slope @ Invert 129.78		

As shown in the table above, the existing SWM pond does not meet the permanent pool volume requirement for Enhanced level of protection under current condition. There is a shortage of 204 m3 to meet the Enhanced level quality control requirement. The pond currently has just above 77% removal efficiency.

A stage-discharge-storage table is developed from the existing stage-discharge storage information, extracted from the previous report. Both are included in **Volume II, Appendix F**. The existing condition SWM pond modelling result is provided on **Table 27** below.

Table 27: Existing Condition Pond Routing of SWMP-2

Event	Inflow to SWMP-2 (m^3/s)		Total Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)
	From Road Area (Major + Minor)	From External Area			
2-year	0.59	0.96	1.55	0.050	2981
5-year	0.87	1.40	2.27	0.059	4280
10-year	1.52	1.78	3.30	0.074	5380
25-year	2.38	2.23	4.60	0.335	5998
50-year	3.03	2.55	5.58	0.756	6331
100-year	3.95	2.88	6.83	1.277	6663

The maximum volume used under existing condition is 6663 m3 and the total available volume is 7766 m^3.

Under proposed condition, there will be a total of 16.04 ha with about 47% of overall imperviousness for quality and quantity control and the major storm flow of Regional Road 25 (about 13.23 ha) from the north of Richview Boulevard, as noted in SWMP-3 analysis, for quantity control. For 16.04 ha of drainage area, a total of 2085 m^3 of permanent pool volume will be required. Under the proposed condition, there will be a shortage of about 295 m^3 of permanent pool storage volume to meet the enhanced level of protection.

As noted above, without any retrofit of existing SWM pond to increase the permanent pool volume, the existing pond will have just above 77% of removal efficiency. The potential retrofit of existing SWM Pond to increase permanent pool volume will be reviewed in the detailed design phase.

To meet the proposed condition peak flow control requirement, it is proposed to utilize both the pipe storage system along Regional Road 25 and SWMP-2. For the pipe storage system, (Pipe Storage # 7) a 150 m long, 1200 mm x 1200 mm concrete box pipe is proposed. This will provide a volume of about 216 m^3.

In addition, it is recommended to decrease the size of quality control orifice to 125 mm diameter and increase the weir flow elevation to an elevation of 129.78 of the existing SWM Pond to provide additional active storge volume. The proposed condition SWM pond modelling result is provided on **Table 28** below.

Table 28: Proposed Condition Pond Routing of SWMP-2

Event	Roadway Area Minor to Pipe Storage 7			To Pond from Roadway (Major + Controlled Min.) (m^3/s)	To Pond from External Area (m^3/s)	Total Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)	Change in flow (Pr – Ex) (m^3/s)
	Inflow (m^3/s)	Outflow (m^3/s)	Volume Used (m^3)						
2-year	0.69	0.59	101	0.59	0.96	1.55	0.037	3346	-0.013
5-year	1.02	0.78	188	0.78	1.40	2.17	0.043	4718	-0.016
10-year	1.02	0.84	201	1.64	1.78	3.41	0.048	5928	-0.026
25-year	1.02	0.89	202	2.71	2.23	4.94	0.242	6678	-0.093
50-year	1.02	0.99	207	3.65	2.55	6.20	0.622	7046	-0.134
100-year	1.02	1.00	**209**	4.45	2.88	7.33	1.053	**7469**	-0.224
Available Storage Volume			**216**					**7766**	

Results provided in **Table 28** shows that SWMP-2 has enough volume to control the flow to pre-development level.

As summarized in **Table 6** Proposed Condition Hydrological Modelling Summary, the combined outflow from SWMP-3 and SWMP-2 under existing and proposed controlled scenario is shown below in **Table 29** below.

Table 29: Combined Outflow from of SWMP-2 and SWMP-3

Description	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Combined Existing Condition Outflow (HYD 802), m^3/s	0.246	0.480	0.689	1.248	1.791	2.414
Combined Proposed Condition Controlled Outflow (HYD 802), m^3/s	0.248	0.519	0.748	1.249	1.805	2.378
Diff. (Pr. Controlled - Ex)	**0.002**	**0.039**	**0.059**	**0.001**	**0.014**	**-0.036**

The total outflow to Fourteen Mile Creek including both SWMP-2 and SWMP-3 is controlled to pre-development level and there will be no impact to the overall watershed hydrology.

During the detailed design stage, it is recommended to conduct a bathymetric survey of SWMP-2 to determine the available storge volume of the pond, to confirm existing control features and their elevations, to confirm the potential retrofit to increase the permanent pool volume for the enhanced level of protection.

6.3.2.3 SWM Facility Discharging to Tributary of Sixteen Mile Creek: SWMP-4

The SWM facility was designed for West Country Properties (Pond I) as per Boyne Survey Block 2 Subwatershed Impact Study Report prepared by MTE Consultants. The final design of the SWM Pond was carried out by TYLin in 2017. SWMP-4 is located west of Regional Road 25 between Whitelock Avenue and Etheridge Avenue. The pond was designed to control the Regional Storm flow.

The SWM pond design report for this pond is not available and no record of existing stage storage information. As per the information provided in as-built drawing sheet, an approximate stage-discharge-storage information sheet is developed which must be verified during the detailed design stage. **Figure 3** shows the general schematic of SWMP-4 under existing and proposed conditions.

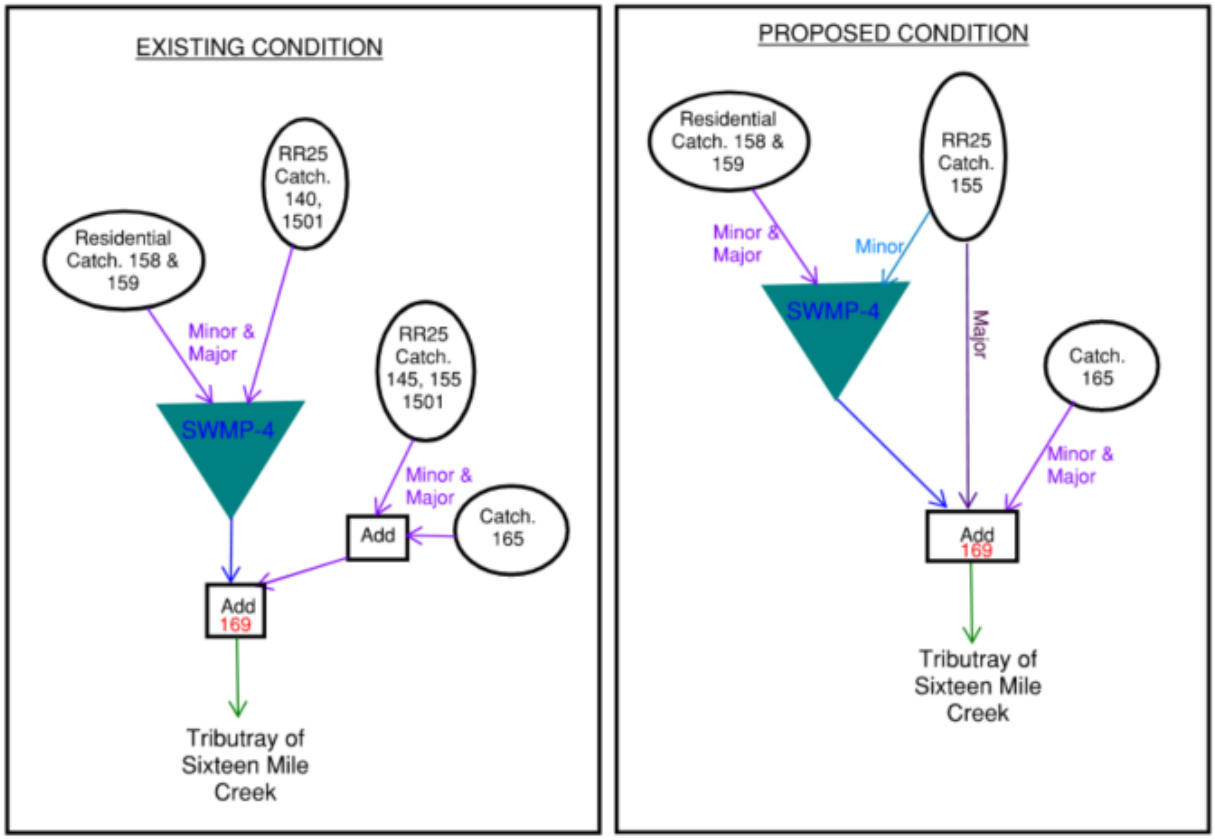

Figure 3: General Schematic of SWMP-4

Table 30 below provides some details of pond service area and other pertinent information as shown in as-built drawing for existing condition and proposed condition

Table 30: Servicing Condition of SWMP-4

Details	Existing Condition	Proposed Condition
Residential Service Area 158 & 159 (Both Major & Minor)	33.17 ha	33.17 ha
Roadway Area Catch. 140 and 1501 under Ex. Condition Catchment 155 under Pr. Condition	1.98 ha	4.13 ha
Total Servicing Area	35.15 ha	37.30 ha
Overall Imperviousness for PP Analysis	60%	62%
Required Permanent Pool Volume	6151 m^3	6602 m^3
Available Permanent Pool Volume	9768 m^3	9768 m^3
Existing Features of SWMP-2	Pond bottom elevation = 180.86 Permanent pool elevation = 183.35 Top of pond elevation = 186.80, Estimated active storage volume= 38,853 m^3 (approx.) up to Elevation 186.80 Control System: 150 mm Dia Orifice @ Invert 127.60 2m wide weir with 10H:1V side slope @ Invert 129.55	

As shown in the table above, there is enough permanent pool volume available to meet the Enhanced level of quality control.

A storage-discharge-storage data is developed from the information provided in as-built drawing which must be verified during the detailed design stage. Both are included in **Volume II, Appendix F**.

The existing condition SWM pond modelling result is provided on **Table 31** below.

Table 31: Existing Condition Pond Routing of SWMP-4

Event	Inflow to SWMP-4 (m^3/s)		SWMP-4			Flow from East (Road + Ext Area) (m^3/s)	Total Flow to Creek (m^3/s) (HYD 169)
	From Road Area	From External Area	Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)		
2-year	0.26	3.078	3.334	0.043	9884	0.346	**0.351**
5-year	0.35	4.596	4.946	0.270	11406	0.497	**0.506**
10-year	0.41	5.600	6.014	0.493	12906	0.603	**0.614**
25-year	0.50	6.913	7.409	0.854	14989	0.765	**1.039**
50-year	0.57	7.887	8.453	1.181	16512	0.896	**1.457**
100-year	0.67	8.979	9.649	1.510	18053	1.020	**1.881**

The maximum volume used under existing condition for 100-year event is 18,053 m3. As noted above, the pond was designed to control Regional storm flow. So, the estimated available pond volume is about 38,853 m^3.

Under proposed condition, there will be a total of 37.30 ha area with about 62% of overall imperviousness for quality and quantity control. For this drainage area, a total of 6602 m^3 of permanent pool volume will be required which is less than the available permanent pool volume, thus meets the Enhanced level of quality control requirement.

To meet the proposed condition peak flow control requirement, it is proposed to utilize both the pipe storage system along Regional Road 25 and SWMP-4. For the pipe storage system, (Pipe Storage # 24) a 355 m long, 1500 mm x 900 mm concrete box pipe is proposed. This will provide a volume of about 486 m3.

Due to unavailability of detailed pond information, no modification is proposed for the pond control system. This is recommended to review during the detailed design phase. The proposed condition SWM pond modelling result is provided on **Table 32** below.

Table 32: Proposed Condition Pond Routing of SWMP-4

Event	Roadway Area Minor to Pipe Storage 24			Ext Area for SWMP-4 (m^3/s)	SWMP-4			Total Flow to Creek (m^3/s) (HYD 169)	Change in flow (Pr – Ex) (m^3/s)
	Inflow (m^3/s)	Outflow (m^3/s)	Volume Used (m^3)		Inflow to Pond (m^3/s)	Outflow from Pond (m^3/s)	Storge Volume Used (m^3)		
2-year	0.746	0.658	177	3.078	3.488	0.068	10051	0.290	-0.061
5-year	1.008	0.840	240	4.596	5.006	0.329	11807	0.514	0.008
10-year	1.184	0.955	284	5.600	6.010	0.565	13388	0.677	0.063
25-year	1.412	1.106	344	6.913	7.323	0.956	15464	1.087	0.048
50-year	1.576	1.195	399	7.887	8.297	1.286	17008	1.485	0.028
100-year	1.750	1.288	457	8.979	9.389	1.621	18569	1.889	0.008
Available Storage Volume			486				38853		

As per the results provided in **Table 32**, there will be enough volume available to control the flow to pre-development level.

Comparing the total outflow to the tributary of Sixteen Mile Creek, the proposed condition outflow is close to the pre-development condition, just a minor increase is observed for the 5-year to the 100-year flow.

During the detailed design stage, it is recommended to explore more background information of SWMP-4 and conduct a bathymetric survey to determine the available storge volume as well as to determine the exact stage-storage-discharge information of the pond, confirm existing control features, their elevations and possibility of their

adjustment to match flow to pre-development level, and confirm the potential of eliminating pipe-storage facility on Regional Road 25.

6.3.3 Water Quality Control

As discussed previously, water quality control measure will be implemented by OGS units for the roadway area. Given the presence of sensitive surface water features within the study area, the application of the MECP's Enhanced Water Quality protection is recommended. All OGS units will be sized for CA ETV particle size distribution. It is understood that OGS will be considered only up to 60% of removal efficiency; however, due to urbanization of the roadway, property and utility constraints, other treatment train approaches are not feasible at most of the outlets. CB Shield can be installed at each catch basin to provide additional quality measure which can be reviewed during the detailed design phase. Preliminary sizing of oil and grit separators are provided in **Table 33**.

Table 33: Summary of Proposed OGS – Size and Removal efficiency

OGS ID	Location	Serving Catchment / (Area)	OGS Size/Model	Removal Efficiency	Outlet Culvert
1	St 2+928	535, (2.71ha) (Impervious increase 0.38 ha)	STC 9000 (Existing)	n/a	C01
1A			EFO6	64%	C01
2	St 3+056	530, (1.47 ha) (Impervious increase 0.76 ha)	STC 5000 (Existing)	n/a	C01
2A			EFO8	64	C01
3	St 12+970	175, (1.67 ha) (Impervious increase 0.94 ha)	CDS20-25W (Existing)	n/a	C21
3A			EFO10	62	C21
4	St 13+446	155, (4.13 ha) (Impervious increase 2.25 ha)	CDS20-20W (Existing)	n/a	C22
5	St 14+682	130, (1.54 ha)	CDS20-15W	60 (Assumed)	B04
6	St 14+840	120, (1.81 ha)	CDS20-25W	60 (Assumed)	B04
7	St 15+260	110, (2.90 ha)	CDS20-25W	60 (Assumed)	C23
8	St 15+744	100+105, (2.21 ha)	CDS20-15W	60 (Assumed)	C24
9	St 3+390	520, (0.64 ha)	EFO6	62	Upper Middle Road Storm Sewer

OGS ID	Location	Serving Catchment / (Area)	OGS Size/Model	Removal Efficiency	Outlet Culvert
10	St 3+350	515, (0.69 ha)	EFO6	62	Upper Middle Road Storm Sewer
11	St 6+575	420, (1.86 ha)	EFO10	61	C05
12	St 7+140	410, (0.95 ha)	EFO8	63	C407-3
13	St 7+260	405, (1.13 ha)	EFO8	61	C407-5
14	St 7+430	390, (1.31ha)	EFO8	60	C06
15	St 7+745	375, (0.49 ha)	EFO6	63	C07
16	St 7+880	368, (0.53 ha)	EFO6	64	C08
17	St 7+767	P207, (0.36 ha)	EFO4	60	C08
18	St 8+070	P203 to P206, (0.93 ha)	EFO8	63	C08A
19	St 8+370	P201/2 (0.31 ha)	EFO4	61	C09
20	St 8+435	P196 to P200 and P201/2 (1.42 ha)	EFO8	60	C09A
21	St 9+140	315 (1.15 ha)	EFO8	61	C12
22	St 9+408	310 (1.08 ha)	EFO8	63	C13
23	St 9+740	300 (1.36 ha)	EFO8	60	C14
24	St 9+985	280 (1.24 ha)	EFO8	61	C15
25	St 10+025	285 (1.70 ha)	EFO10	62	C15
26	St 10+430	260 (1.98 ha)	EFO10	60	C16
27	St 11+230	245 (1.43 ha)	EFO8	60	C17
28	St 11+435	237 (0.95 ha)	EFO8	63	C18
29	St 11+620	225 (0.77 ha)	EFO6	60	C19
30	St 11+660	210 (3.43 ha)	EFO12	60	C19
31	St 12+830	200 (1.39 ha)	EFO8	60	C20

It should be noted that:

- The proposed new OGS units 1A, 2A and 3A are supplemented to existing OGS and are sized based on increased impervious area with 100% imperviousness.
- It is assumed that the existing OGS units 5, 6, 7 and 8 will provide 60% TSS removal efficiency for the CA ETV particle size distribution. To improve the TSS removal efficiency for this stretch of roadway area, Silt trap can be installed on each catch basin.

Preliminary OGS sizing reports are included in **Appendix F**.

6.3.4 Low Impact Development Measures

Due to the property and grading constraint, there are few landscaping areas within the ROW that can be considered as potential areas for infiltration galleries to provide infiltration and erosion controls. As per the soil conditions discussed in Section 4.1.1, the soil types within the study area are primarily Oneida clay loam (Hydrologic Soil Group D) and Chinguacousy clam loam and Jeddo clay loam (Hydrologic Soil Group C). The infiltration potential is low, therefore there is limited opportunity for infiltration measures within the study area. For the preliminary analysis, an infiltration rate of 8 mm/hr is assumed for the Chinguacousy clay loam and Jeddo clay loam and infiltration rate of 20 mm/hr is assumed for Fox and Brady soil (Hydrologic Soil Group A) within the project site. Infiltration volume equivalent to 5 mm rainfall depth is calculated for the roadway area. The geotechnical investigation and infiltration test results are recommended during detailed design stage to confirm the infiltration rate. **Table 34** below provides a summary of the required infiltration volume to retain 5 mm runoff. For catchment ID, Refer to **Exhibits STM 1** to **STM 10**.

Table 34: Water Balance Requirements

Catchment ID	Exhibit No.	Total Area (ha)	Runoff Volume Equivalent to 5 mm Rainfall Depth (m^3)
P01 to P75	STM 4, STM 3, STM2, STM1	26.5	1325
P76 to P241	STM 8, STM 7, STM6, STM 5, STM 4, STM1,	46.0	2300
326	STM6	0.17	8.5
480	STM4	0.51	25.5
Total		**73**	**3650**

From the table above, a total of 3650 m^3 of runoff volume will need to be stored and infiltrated to meet the water balance requirement for the proposed roadway area. Due to the linear nature of the project as well as due to the constraints of various utilities, steep road profile and soil condition within the study area, it will not be feasible to meet the full infiltration volume requirements, therefore, infiltration volume will be provided to the

Maximum Extent Possible and infiltration galleries are proposed along Regional Road 25 wherever practical.

A total of 28 infiltration galleries is proposed within the road ROW which allows to store runoff and infiltrate into the subsurface within the drawdown time of 48 hours. A total of 202 m^3 of runoff volume can be stored and infiltrated by the proposed 28 infiltration galleries with 40% void volume. All these infiltration galleries are subject to confirm based on soil infiltration rate which will be confirmed during the detailed design phase.

The Preliminary Geotechnical Investigation Report for the Regional Road 25 (Bronte Road) Transportation Corridor Improvements from Speers Road to Derry Road, prepared by Thurber Engineering Ltd., was reviewed to assess soil conditions and groundwater levels. With the exception of location IG#20, the groundwater table is generally deep or the area is dry at the remaining infiltration gallery locations; therefore, no groundwater-related impacts are anticipated at those sites.

At IG#20, the groundwater table is located approximately 2.45 m below ground surface. Accordingly, a shallow infiltration gallery with a depth of 0.30 m is proposed at this location. In areas where the subsurface conditions consist of clay to silty clay soils, a shallow infiltration gallery with a depth of 0.30 m is recommended. The proposed depths of all infiltration galleries will be subject to further review during the detailed design stage, once infiltration testing results become available.

Table 35 below, along with **Exhibits 18** to **Exhibit 34** in **Appendix A**, outlines the locations where infiltration galleries can potentially be provided. These infiltration galleries are proposed to be installed on the landscaping area either east side or west side of Regional Road 25. Any constraints related to proposed utility line relocations and proposed linear infrastructure will be further investigated in detailed design progress.

Table 35: Location and Length of Potential Infiltration Galleries

Infiltration Gallery ID	Station		Location – East or West side of RR 25	Length (m)	Proposed Depth(m)
	From	To			
IG #1	0+280	0+320	West side	40	0.30
IG #2	1+860	1+910	West side	50	0.60
IG #3	2+308	2+358	West side	50	0.60
IG #4	2+510	2+560	East side	50	0.60
IG #5	2+930	2+970	East side	40	0.60
IG #6	3+183	3+223	East side	40	0.30
IG #7	3+515	3+555	West side	40	0.30
IG #8	3+515	3+555	East side	40	0.30

Infiltration Gallery ID	Station		Location – East or West side of RR 25	Length (m)	Proposed Depth(m)
	From	To			
IG #9	3+700	3+750	East side	45	0.30
IG #10	3+805	3+860	East side	55	0.30
IG #11	5+440	5+480	East side	40	0.30
IG #12	5+598	5+603	West side	45	0.30
IG #13	5+686	6+731	West side	45	0.30
IG #14	5+855	5+910	West side	55	0.30
IG #15	5+940	5+960	West side	20	0.30
IG #16	6+000	6+050	West side	50	0.30
IG #17	6+090	6+130	West side	40	0.30
IG #18	6+310	6+370	West side	60	0.30
IG #19	10+760	10+800	East side	40	0.45
IG #20	12+720	12+760	East side	40	0.30
IG #21	13+110	13+150	East side	40	0.30
IG #22	13+270	13+310	East side	40	0.30
IG #23	13+345	13+385	East side	40	0.30
IG #24	13+500	13+540	East side	40	0.30
IG #25	13+590	13+630	East side	40	0.30
IG #26	13+720	13+765	East side	45	0.30
IG #27	14+215	14+255	East side	40	0.30
IG #28	15+900	15+930	West side	30	0.30

7 Sediment and Erosion Control

The erosion and sedimentation which occur during construction, if uncontrolled, can result in a loss of topsoil, a disruption of nearby watercourses and a degradation of downstream water quality. During construction, erosion and sedimentation control measures should be implemented to prevent the migration of soils from the site. The following recommendations should be considered when developing the detailed Erosion and Sedimentation Control drawings:

General

- Daily inspections are to be carried out particularly after rain events and repairs.
- Any in-water work that is necessary must be conducted in dry conditions within the appropriate fisheries timing window indicated by the conservation authority.
- Construction measures such as coffer dam, bypass pumping or flume is required at detail design for flow isolation to work in dry condition.

- Appropriate treatment and control measures must be implemented if the construction activities require the discharge of water collected from dewatering operations to surface water features, or to storm sewer systems that ultimately discharge to a watercourse. These measures should be supported by a monitoring program to ensure that discharges meet applicable water quality standards and do not result in adverse effects on receiving waters.

Vegetative

- All areas not subject to active construction 30 days after area grading should be top soiled and seeded as per OPSS 572 immediately after completion of such grading.
- Immediately following seed application, a straw erosion control blanket should be installed on any exposed slopes adjacent to sensitive features, as per OPSS 572.05.07, 572.05.08 and 572.07.04.05.
- The erosion control matting / blankets shall be fully biodegradable.
- Finished slopes will be graded to an acceptable slope and planted according to applicable Guidelines. Large cuts should be terraced to minimize surface erosion.

Structural

- As construction proceeds, diversion swales should be graded where needed along the right-of-way boundaries to intercept drainage from external areas and direct it away from exposed surfaces.
- The locations of sediment / dewatering traps should be confirmed in the field by the on-site inspector and environmental inspector.
- Temporary sedimentation traps should be sized based on 125 m3/ha of drainage area.
- The integrity of all sediment trapping devices will be monitored regularly (at least weekly, and immediately following rain events) and properly maintained; such structures will be removed only after the soils of the construction areas have been stabilized and then only after the trapped sediments have been removed.
- The contractor will identify a contingency plan for accidental sediment release.
- All culvert work should be conducted “in the dry” and inside MNDMNRF’s timing window for fisheries where applicable.
- All dewatering for culvert installation should be directed to a sediment / dewatering trap.

- Straw bale flow and/or rock checks should be provided in roadside ditches, especially in all ditches immediately upstream of their discharge into a watercourse.
- Additional erosion control works may be required during the course of construction. These may consist of silt fences, swales, and/or diversion berms. The location and need for these works will need to be established in the field.

LID Protection

- Where possible plan for the LID construction late in the construction project.
- Clear signage is critical to protecting LID areas, and signage indicating ‘no heavy equipment’ is particularly important for intended infiltration areas to avoid compaction of native soil in LID areas.
- Perimeter controls should be installed early and kept in place until the site is stabilized and vehicles are no longer tracking mud onto the pavement surfaces that drain into the LID measure.
- LIDs that are kept offline during construction require the installation and maintenance of an impermeable physical barrier at the inlet. For example, curb cuts that serve as inlets for bioretention areas can be blocked off from receiving flows with sandbags or wood.
- For LIDs that are receiving runoff, permeable barriers can be installed at the inlet to help settle and/or filter out suspended sediment before the water enters the infiltration area.
- ESC site inspections should be carried out weekly and before and after rain or snowmelt events to determine whether ESC measures installed are in good working order and functioning as intended.
- Stockpiles of construction materials should be stored down gradient of LIDs to the extent possible (≥ 30 m recommended), since they can be a significant source of sediment that may be washed into the LID area. Sediment controls (e.g. sediment fence, filter socks) should be installed around all stockpiles, particularly those that are located up gradient of LIDs.
- The underground infiltration facility should be kept offline until drainage area construction and stabilization are complete and vehicle mud tracking has ended.

Temporary silt fencing should be installed:

- Around sensitive vegetative features.
- Approximately 2 m from the final toe-of-slope for the roadway embankment widening areas.

- Runoff from excavated areas or unvegetated soil will not be permitted to discharge off site or directly into active or temporary watercourses or any natural areas.
- Heavy duty silt fence should be used at crossings locations where rare species are present.
- The contractor should abide by the requirements set out in the Erosion and Sediment Guideline for Urban Construction, Sustainable Technologies Evaluation Program, (2019).

The integration of these measures will minimize the impacts of erosion and sedimentation during the construction of Regional Road 25 within project limits.

8 Conclusions

Based on the preceding assessments and findings for the proposed project, the following conclusions can be made:

1) The study area lies within the watersheds of Sixteen Mile Creek and Fourteen Mile Creek. The existing Regional Road 25 between Speers Road and Derry Road West is a four-lane roadway and is proposed for widening from 4 to 6 lanes with the addition of active transportation facilities, intersection improvements and associated lane adjustments. Throughout the limits of the project, there are twenty-four (24) culverts crossing and one bridge between Speers Road and Derry Road West.
2) Under Existing Conditions:
    - A Visual OTTHYMO hydrologic model was developed to generate existing and proposed flows from the roadway corridor using the 12-hour and 24-hour Chicago Storm Distributions. Out of two storm distributions, the 24-hour Chicago storm distribution generated the highest peak flows, therefore, it is considered as the governing storm distribution.
    - There are four existing SWM facilities which are QEW East SWM Pond (SWMP-1) Bronte SE SWM Pond (SWMP-2), Mattamy SWM Pond (SWMP-3) and West Country Milton SWM Pond (SWMP-4) which were designed for runoff quality and quantity control. West Country Milton SWM Pond is located within Town of Milton between Louis St. Laurent Avenue and Britannia Road while the other three SWM facilities are located within the Town of Oakville between Dundas Street West to Speers Road.
3) Under existing condition, there are thirty-one (32) storm outlets along the Regional Road 25 study limit. These outlet points include 25 drainage crossings, existing SWM ponds and few storm sewer connections to existing systems.

4) Proposed Conditions:
    - The hydrological analysis for the post-development condition is analysed based on the 24-hour Chicago storm distribution and compared with the pre-development flows.
    - The widening and improvement of Regional Road 25 leads an increase in imperviousness and will cause an increase in 100-year flow up to 52% as well as the sediment loading at the outlets. To mitigate the impact of increased imperviousness, a total of 27 storage pipe facilities is considered for peak flow control. Post to pre flow control for the roadway will be provided by the storage pipe systems within the roadway.
    - Due to the limit available information of existing four SWM Ponds, the assessment of whether the proposed SWM facilities will adequately protect surface water feature, the further reviewed will be required during the detailed design phase.
5) Quality treatment of roadway runoff from all catchments is proposed to be provided thirty-four Oil Grit Separators (OGSs) units and three existing SWM facilities. Out of 34 OGS units, eight OGS units are existing facilities. Catch basin silt-trap can be installed for additional water quality measure which can be reviewed further during the detailed design phase.
6) A total of 28 infiltration galleries is proposed within the road ROW which allows to store runoff and infiltrate into the subsurface. These infiltration galleries are sized considering an assumed infiltration rate based on soil type considering for the drawdown time of 48 hours. A total of 202 m3 of runoff volume can be stored and infiltrated by the proposed 28 infiltration galleries. All these infiltration galleries are subject to confirm based on in-situ infiltration test and will be further reviewed during the detailed design stage.
7) Following are the recommended replacement and extension of watercourse crossing structures:
    - The Sixteen Mile Creek Bridge (B04) deck will be widened on the east side by approximately 8.91m.
    - Culverts C01, C04, C19, C20 and C23 will be extended on the upstream and/or downstream sides.
    - Culvert C03 will be maintained but the adjustment to retaining wall height will be required.
    - Culvert C02 will be replaced with a 2700 mm span x 2100 mm rise concrete box with 0.30 m embedment.

- Culvert C05 will be replaced with a 2700 mm span x 1800 mm rise concrete box culvert, with 0.30 m embedment.
- Culvert C06 will be replaced with a 900 mm diameter concrete pipe culvert.
- Culvert C07 will be replaced with a 2400 mm span x 1200 mm rise concrete box culvert, with 0.30 m embedment.
- Existing Culvert C08 will be remained as a storm outlet and a new Culvert C08A (3000 mm span x 1800 mm rise concrete box with 0.30 m embedment) will be installed.
- Existing Culvert C09 will be eliminated and a new Culvert C09A (975 mm diameter concrete pipe) will be installed north of existing culvert.
- Existing Culvert C10 will be removed.
- Culvert C11 will be replaced with a 1500 mm span x 1200 mm rise concrete box culvert, with 0.30 m embedment.
- Culvert C12 will be replaced with an 825 mm diameter concrete pipe culvert.
- Culvert C13 will be replaced with an 825 mm diameter concrete pipe culvert.
- Culvert C14 will be replaced with a 1050 mm diameter concrete pipe culvert.
- Culvert C15 will be extended by 7.5m on the west (upstream side, and 750mm diameter HDPE relief culvert will be added.
- Culvert C16 will be replaced with a 1200 mm diameter concrete pipe culvert.
- Culvert C17 will be replaced with a 1200 mm span x 1200 mm rise concrete box culvert with 0.30 m embedment.
- Culvert C18 will be replaced with a 2100 mm span x 1200 mm rise concrete box culvert with 0.30 m embedment.
- Culvert C21 will be extended on the upstream and downstream sides. Additionally, a new 900 mm diameter, 60.5m long concrete pipe will be added as a relief culvert.
- Culvert C22 will be replaced with a 3.90 m span x 1.80 m rise concrete box with 0.30 m embedment.
- Culvert C24 will be replaced by a 12.8m span x 3.51m rise concrete open footing structure.

8) As per the fluvial recommendation, inlet and outlet pool will be required at all culverts where extension and/or replacement is required. Necessary outlet pool design be completed during the detailed design stage.

Here is a list of detailed design commitment:

a) Collabration with adjacent development proponents to facilitate a coordinated drainage and stormwater management plan for the area such as the development site (Palermo) southwest of RR25 and Highway 407.

b) Confirmation of pipe invert and pipe size between St 0+212 and St 1+042 of Regional Road 25

c) Review of Culvert headwall/retaining wall at Culverts C01, C03 and C15.

d) The final design for the Sixteen Mile Creek Bridge B04 should include:

- A review of the location of the crown of the road to determine if it should be relocated to improve drainage.
- Geotechnical and structural assessment of foundation design.
- Mitigation of existing revetment works in the regulated area.

e) Watercourse realignment at upstream and downstream of Culvert C05, downstream of C07, upstream of C19, upstream and downstream of C08A, downstream of C09A, downstream of C16 and upstream of C19

f) Mitigation measures and design of erosion protection measures at each culvert inlet and outlet locations and increased flow velocity.

g) Further review of SWMP-1 to confirm whether the pond has adequate capacity to provide quality and quantity control for the addition runoff from Regional Road 25. If no information is available from MTO, it is recommended to conduct bathymetric survey.

h) Bathymetric survey of SWMP-2 to determine the available storage volume of the pond, to confirm existing control features and their elevations, and to confirm the potential retrofit to increase the permanent pool volume for the enhanced level of protection.

i) Bathymetric survey of SWMP-3 to determine the available storage volume of the pond, to confirm existing control features and their elevations, to confirm the top of pond elevation and to review potential retrofit option of the SWM pond to avoid pipe storage system along Regional Road 25.

j) Further review of SWMP-4 and conduct a bathymetric survey to determine the available storage volume as well as to determine the exact stage-storage-discharge information of the pond, confirm existing control features, their elevations and possibility of their adjustment to match flow to pre-

development level, and confirm the potential of eliminating pipe-storage facility on Regional Road 25.

k) Review the necessity of CBshield at various catchbasins.

l) Geotechnical investigation, groundwater information and infiltration tests to confirm the infiltration rate and suitability of infiltration galleries

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