Midtown Stormwater Management Plan Report

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Town of Oakville
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Midtown Implementation Program Management Services
November 24, 2025

Midtown Stormwater Management Plan Report

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Executive Summary

Midtown Oakville is identified as the Town's Urban Growth Centre and is central to the urban structure of Oakville. When fully built out, Midtown is expected to accommodate more than 13,000 residents and 7,000 jobs in a vibrant, livable, and mixed-use community anchored by the Oakville GO Station. The Midtown Oakville Stormwater Management (SWM) Plan establishes a technical and policy framework to support sustainable urban intensification within Midtown Oakville through the implementation of stormwater management infrastructure, consistent with provincial and municipal objectives for flood control, water quality, erosion mitigation, and water balance.

Future land uses follow the approved Official Plan Addendum (OPA 70) in February 2025 and include urban core areas, employment areas and parks and open spaces (Schedule L1 Land Use). The proposed parks and open spaces are distributed across the Midtown area and vary in size and geometry. There are three main road types: local, collector and arterial. The right-of-way (ROW) varies accordingly and ranges in width from 20 to 36 metres. The Oakville Midtown Study area is shown in Figure ES 1.

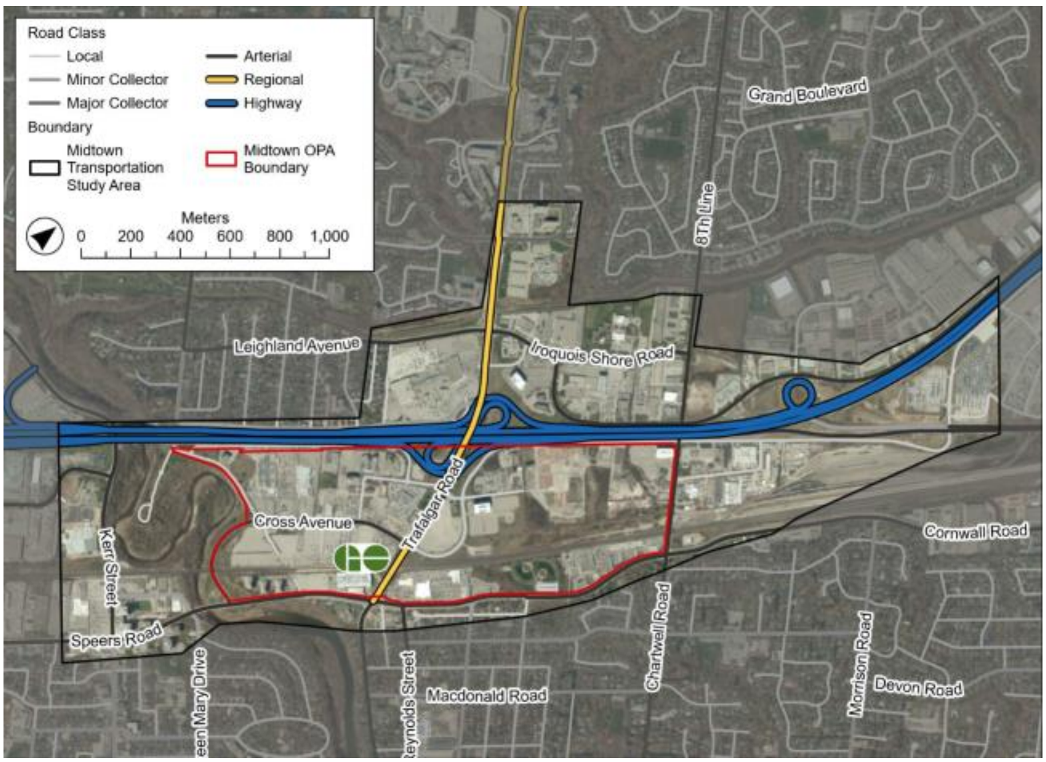

Figure ES 1. Midtown Oakville Study Area

ES.1 Study Process and Objectives

The Midtown SWM Plan has been completed as a Schedule B undertaking of the Municipal Engineers Association (MCEA) Class Environmental Assessment Process (Municipal Engineers Association's Municipal Class Environmental Assessment October 2000, as amended in 2007, 2011, 2015 & 2023). Accordingly, the following phased approach has been taken:

- Phase 1: Identify the problem (deficiency) or opportunity

- Phase 2: Identify alternative solutions to address the problem or opportunity

The Midtown SWM Plan was undertaken to address the following objectives:

- Assess the performance of the Midtown drainage system under current and future conditions.
- Identify deficiencies and opportunities for infrastructure improvements.
- Establish stormwater management criteria aligned with the Ministry of the Environment, Conservation and Protection (MECP), Conservation Halton, and Town's guidelines and policies.
- Identify and evaluate stormwater management measures to address municipal and environmental targets.
- Recommend a preferred solution and SWM strategies that will be integrated with ongoing planning documents, including the Midtown Transportation Plan and Designing Midtown.

ES.2 Consultation

The development of the Midtown Stormwater Management Plan was guided by a comprehensive and inclusive consultation process that engaged a wide range of stakeholders, including residents, businesses, indigenous communities, public agencies, and utility providers at various stages throughout the project. Two Public Information Centres (PICs) were held at key milestones in March and June of 2025 to present findings, gather feedback, and refine the plan. These sessions were coordinated with the Midtown Official Plan Amendment (OPA) process to ensure alignment and consistency. Interactive tools such as polling and decision-ranking exercises were used to encourage participation.

ES.3 Problem and Opportunity Statement

The Midtown area (OPA boundary) covers approximately 125 hectares divided among three subwatersheds: Sixteen Mile Creek, Lower Morrison West, and Lower Morrison East (Figure ES 2). The Midtown area is underdeveloped and has an urban drainage system with capacity issues. It lacks stormwater management measures to reduce the extent and severity of urban and riverine flooding. A Stormwater Management Plan must be developed to accommodate future growth and expansion of the road network as per the Official Plan Amendment (OPA 70) and Transportation Plan recommendations. Figure ES 3 shows the preferred 2051 Midtown Transportation Network. The Midtown Stormwater Plan will determine how the Town's stormwater infrastructure will support growth in a sustainable and financially responsible manner. It will identify stormwater quantity and quality measures to address relevant provincial and municipal policies and guidelines. Based on a multi-criteria evaluation, preferred solutions will be proposed to achieve a multitude of municipal and environmental targets.

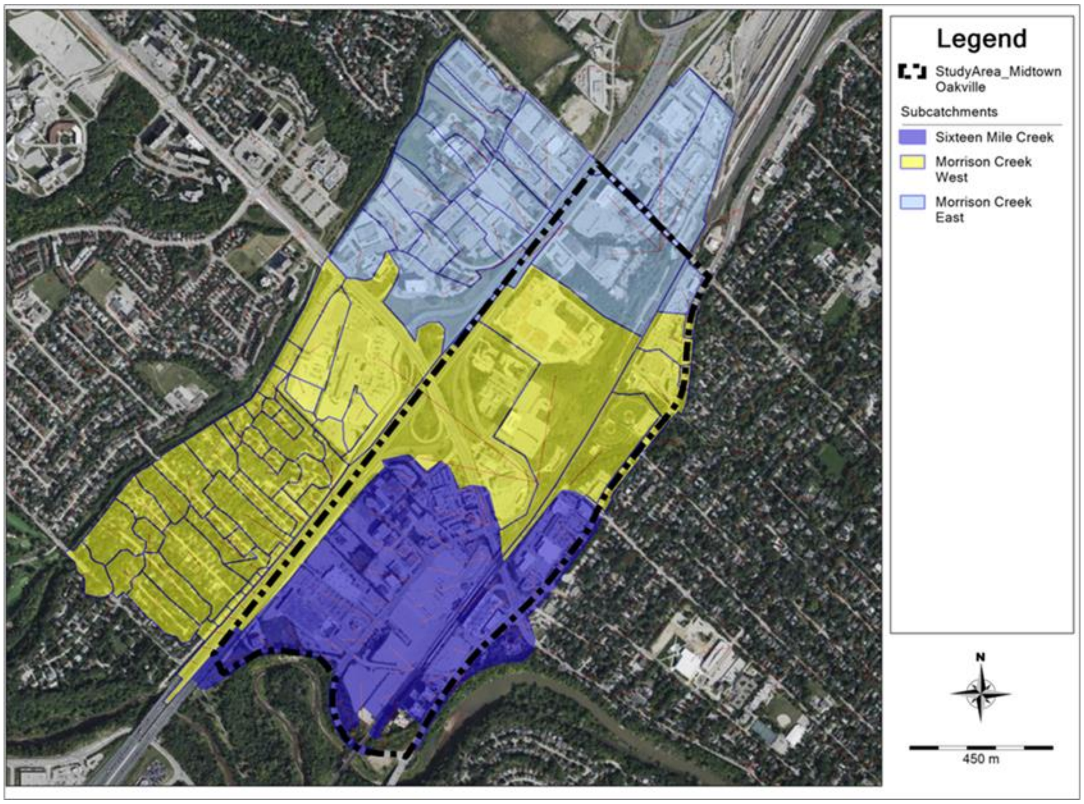

Figure ES 2. Midtown Oakville Subwatersheds and External Catchments

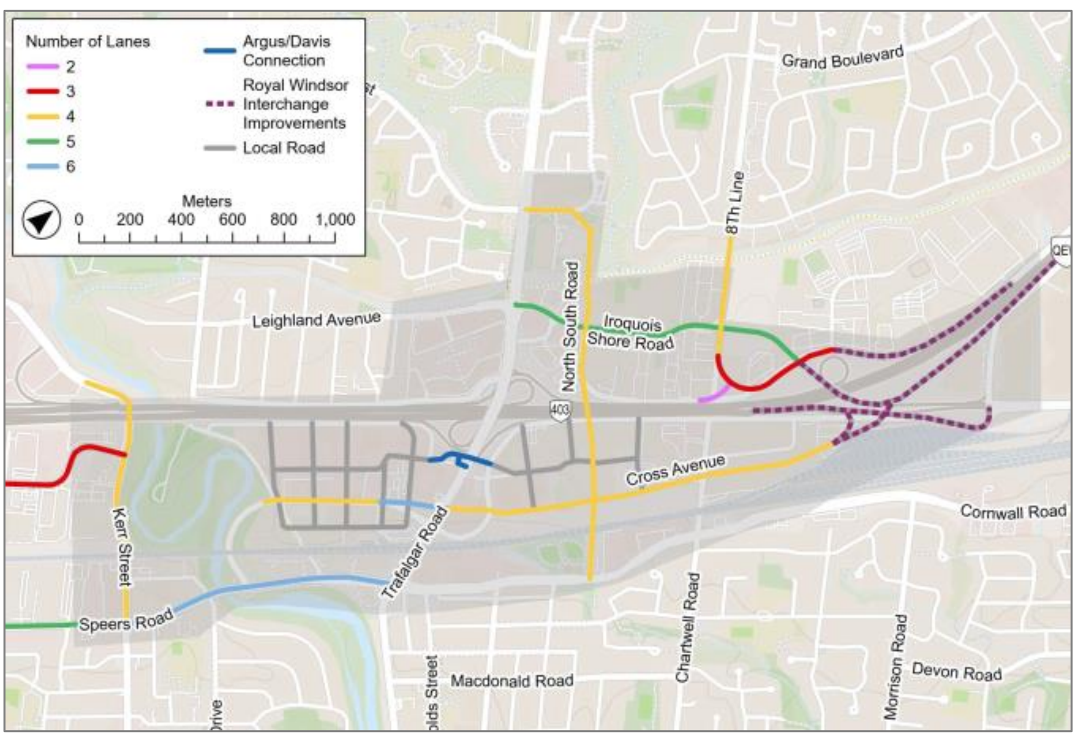

Figure ES 3. Preferred 2051 Midtown Road Network

ES.4 Assessment of Drainage System under Future Conditions

Hydrologic and hydraulic modeling was conducted using the PCSWMM modeling software. The model integrates minor (storm sewer) and major (overland) systems under dual-drainage representation. Two modeling scenarios were developed, namely existing condition (current state) and proposed-uncontrolled condition (i.e. future development without SWM measures). Existing and future-uncontrolled conditions were simulated for 5-year, 100-year, and regional (Hurricane Hazel) events using the Town's IDF curves and 24-hour Chicago distribution. The results of the model indicate extensive storm sewer surcharge and surface ponding under both conditions. Under future-uncontrolled conditions, numerous storm sewer pipes are expected to be fully surcharged during 5-year events, with significant ponding (> 0.3 m) along Argus-Davis Road and Cross Avenue. Downstream impacts would include elevated peak flows to the Lower Morrison and Sixteen Mile Creek systems.

ES.5 Alternative Solutions

Three (3) alternatives were considered to mitigate drainage deficiencies and address stormwater quantity and quality control across the Midtown area:

- **Alternative 0: Business as Usual:** This alternative serves as a baseline for all alternatives and includes committed and planned projects
- **Alternative 1: Storage and Conveyance:** This alternative includes storage and conveyance measures with focus on detention and peak flow attenuation.
- **Alternative 2: Storage, Conveyance and Green Infrastructure:** In addition to conveyance improvements and underground storage, Green Infrastructure (GI) and Low Impact Development (LID) can provide storm quality management and runoff volume reduction in addition to runoff quantity control. These measures include but not limited to soil cells, permeable pavement, stormwater planters and green roofs.

The alternatives were evaluated based on technical, environmental, social, and cost criteria (Figure ES 4). The three alternatives were screened from Least Preferred to Most Preferred. Based on the results of this semi-quantitative evaluation, the most preferred alternative was carried forward for implementation

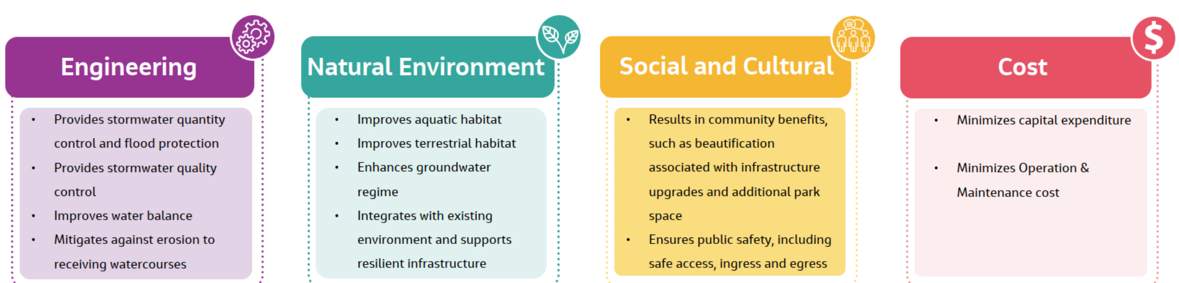

Figure ES 4. Evaluation Criteria

ES.6 Preferred Solution

Alternative 2, Storage, Conveyance and Green Infrastructure, was carried forward as the preferred alternative (solution) based on the evaluation criteria noted. Alternative 2 generally resulted in improved engineering, natural environment and social /cultural conditions with moderate to higher capital and maintenance costs compared to the other two alternatives.

Figure ES 5 provides an overview of the preferred SWM measures. Key infrastructure components of the preferred solution include:

- Stormwater management measures on Private Properties, including onsite quantity control measures (e.g. underground storage facilities), onsite water balance and erosion control measures (e.g. permeable pavement, stormwater planters and green roofs), and onsite quality control, including Manufactured Treatment Devices (MTDs).
- Stormwater management measures along the Right of Way (RoW), including conveyance quantity control (e.g. Pipe upsizing and Super Pipes), water balance and erosion control measures (e.g. permeable pavement, soil cells and stormwater planters), and quality control, including MTDs.
- Stormwater management measures within Public Parks, including offline quantity control (e.g. underground storage facilities) and Green Infrastructure (e.g. soil cells and permeable pavement).

Figure ES 5. Preferred SWM Measures across Midtown Oakville

ES.7 Stormwater Management Criteria

The proposed stormwater management criteria apply to Midtown Oakville in addition to external catchments draining as part of the Lower Morrison Creek system. Areas north of the Diversion Channel and those located within the Wedgewood Creek subwatershed are not included in the proposed Midtown criteria. The 2014 Midtown Class EA applies to those areas, unless specified otherwise by the Town.

ES.7.1 Quantity Control

The minimum storage volumes identified for each subwatershed (Table ES 1) must be satisfied by all future developments within the Midtown area and the external catchment areas, including private properties and road rights-of-way to ensure consistency with the study's objectives.

The following process is proposed for implementing quantity control criteria at the development block level across the study area:

- Future development within the Midtown area, including the proposed roads, is to utilize the PCSWMM model to simulate proposed development and size required storage facilities.
- Initial storage sizing shall be based on the unitary storage rates in Table ES 1.

Table ES 1. Quantity Control Unit Storage Requirement for Future Development

Subwatershed Area Within Midtown Oakville	Total Quantity Storage Required (m^3)	Total Impervious Area (ha)	Unitary Storage for Quantity Control (m^3/Impervious ha)
Lower Morrison East	11139.5	52.6	211.8
Lower Morrison West	12213.8	61.2	199.7
Sixteen Mile Creek	3111.9	42.6	73.1

- Demonstrating Compliance with Quantity Control Criteria:
    - After applying the minimum storage from Table ES 1, each development application must demonstrate the following:
        - Flood Control (Watershed Hydrology): Post-development ultimate discharge to the receiving water body must not exceed allowable flow targets.
        - Water Quantity Control (Minor and Major Systems): The proposed design must ensure no flooding or surcharge occurs in either the minor or major conveyance systems. Design storm requirements are 1:5-year return period for the minor system and1:100-year return period for the major system.
- Requirements if Non-Compliance Is Identified:

  If PCSWMM modelling shows downstream impacts or failure to meet any criteria:
    - A more conservative approach shall be applied, such that post-development 100-year peak flows must be controlled to the 5-year pre-development peak flow rate, or storage volume must be increased until all criteria in Section 2 are met.
    - Revised conditions must be verified again using PCSWMM.
- Alternative to PCSWMM: If a proponent chooses not to use PCSWMM, they must complete a downstream capacity assessment using acceptable engineering tools (e.g., storm sewer design sheets or equivalent). This assessment must confirm compliance with the Town's ECA requirements (ECA Number: 314-S701) for Flood Control (Watershed Hydrology) and Water Quantity (Minor and Major System).

ES.7.2 Water Balance and Erosion Control

Future development within the Midtown area, including proposed roadworks, is required to provide retention of 25 mm applied to impervious surfaces, with proponents directed to utilize the findings of the Midtown Stormwater Plan, which demonstrate that retaining these runoff volumes can effectively reduce the impact of frequent flows and help mitigate downstream erosion.

It has been determined that future development must provide the following to satisfy the water balance and erosion control criteria:

- 122.6 m^3/Imp.ha for Sixteen Mile Creek
- 93.1 m^3/Imp.ha for Lower Morrison West and
- 104.2 m^3/Imp.ha for Lower Morrison East

To accommodate site constraints and conform to provincial and municipal guidelines, including the Environmental Compliance Approval for a Municipal Stormwater Management System (ECA Number: 314-S701), the 25 mm runoff volume reduction target shall follow the hierarchical order as per Appendix A of the ECA:

1. Retention (Infiltration, reuse, or evapotranspiration)
2. Filtration (Absorption and increased depression storage)
3. Conventional stormwater management (Detention and attenuation)

Step 3 should proceed only once Maximum Extent Possible has been attained for Steps 1 and 2 for retention (Step 1) and filtration (Step 2).

ES.7.3 Quality Control

Future development within the Midtown area, including the proposed roads, is to achieve Enhanced Level 1 Protection (80% long-term removal of TSS) as per the Stormwater Management Planning and Design Manual (MECP, 2003). Following the guidelines of Conservation Halton and the Town of Oakville Development Manual, a Treatment Train approach is recommended for quality control along the proposed roads. These may include oil/grit separators (OGS) units, CB Shields and feasible Green Infrastructure/LID measures.

ES.8 Implementation

ES.8.1 Coordination with Midtown Oakville Transportation Plan

The development of Midtown is expected to occur over the long-term and timing of growth will primarily be driven by the development community and market conditions. A prioritization of major roadways and road infrastructure is documented in the Midtown Transportation Plan; stormwater management will be required in alignment with these timelines and as illustrated in Figure ES 3.

- Short Term: 2026-2035 (within the 10-year Capital Plan)
- Medium Term: 2036-2041
- Long Term: 2041-2051

In alignment with the Transportation Plan, the timing and phasing of development and associated road network improvements may necessitate additional drainage analysis and stormwater management measures to demonstrate compliance with established SWM criteria and objectives. This report provides a Stormwater Management Plan and recommendations based on scales larger than block-level considerations. As site condition information—including grading and local drainage pathways—is currently unavailable, and significant data gaps remain regarding the existing storm sewer system (such as pipe sizes and rim elevations), future assessments will be required as part of specific development proposals or infrastructure improvement projects to ensure effective stormwater management.

ES.8.2 Implementation on Private Properties

It is the responsibility of all proponents to follow the Town's policies and procedures for drainage and stormwater management, apply stormwater criteria and targets established by the Midtown Stormwater Plan and confirm drainage capacity and functionality. Future development is to provide retention of 25 mm of runoff generated from contributing impervious surfaces within each block and along the local roads. Proponents are to utilize the Midtown Stormwater Plan's findings and recommendations, which demonstrate that the retained runoff volumes could reduce runoff volume and mitigate downstream erosion. Future development is required to meet Enhanced Level 1 Protection as per the Ministry of Environment's Stormwater Management Planning and Design Manual (2003).

ES.8.3 Implementation of the Transportation Plan Proposed Roads Improvements

It is the responsibility of the proponent to design and construct stormwater quantity and quality measures along local roads to achieve unitary storage targets stipulated in the Midtown SWM Plan and confirm that the minor and major drainage are functioning as per municipal standards and as appropriate for the type of project. The location, depth and connectivity of the new storm sewers to the municipal drainage system shall be subject to the approval of the Town in consultation with Conservation Halton.

A Treatment Train approach is encouraged to achieve water quality and runoff volume reduction targets. This approach should align with the CLI-ECA agreement (ECA Number: 314-S701) and related SWM criteria, including peak flow control, water quality control, water balance and erosion control.

Along all major roads, including Cross Avenue, North-South and Argus-Davis Road, the capacity and functionality of proposed stormwater quantity and quality measures shall be demonstrated. Hydraulic modelling using appropriate software shall be completed to quantify peak flows, required storage volumes, and determine Hydraulic Grade Line (HGL).

ES.8.4 Implementation within Parks

Parks shall be designed to support the broader stormwater management system across Midtown and as part of a Treatment Train approach to achieve stormwater quantity and quality targets, where appropriate subject to the parks' programming and recreational uses, policies and requirements.

ES.8.5 Financial Implications

The high-level cost estimate for stormwater management infrastructure improvements (in 2025 dollars) is $16 million. This estimate encompasses the installation of new storm sewer pipes and the implementation of stormwater management measures for both detention and retention purposes. The proposed drainage and SWM measures are planned along public rights-of-way and within proposed park spaces. The estimate will be further refined and validated through the forthcoming Functional Servicing Report and Design.

Contents

Appendices

Acronyms and abbreviations

EA	Environmental Assessment
EL.	Elevation
Jacobs	Jacobs Engineering Group Inc.
ha	hectare(s)
km	kilometre(s)
km/h	kilometres per hour
CH	Conservation Halton
m	metre(s)
m^2	metre(s) squared
mm	millimetre(s)
MCEA	Municipal Class Environmental Assessment
MECP	Ministry of Environment, Conservation and Parks
MNRF	Ministry of Natural Resources and Forestry
MTO	Ministry of Transportation of Ontario
PIC	Public Information Centre
the Town	Town of Oakville

ROW	right-of-way
SWM	Stormwater Management

1. Introduction

The Town of Oakville (the Town) has retained Jacobs to prepare a Stormwater Management (SWM) Master Plan for the Midtown area within the Town of Oakville. The Midtown SWM Master Plan (Midtown SWM-MP) will support growth and development based on the updated Official Plan Addendum (OPA) and future road network based on the Transportation Plan.

Future land uses follow the proposed Official Plan Addendum approval (February 2025) and include urban core areas, employment areas and parks and open spaces (Schedule L1 Land Use). The proposed parks and open spaces are distributed across the Midtown area and vary in size and geometry. There are three main road types: local, collector and arterial. The right-of-way (ROW) varies accordingly and ranges in width from 20 to 36 metres. The Midtown study area, including the road network and the development blocks, is shown in Figure 1-1.

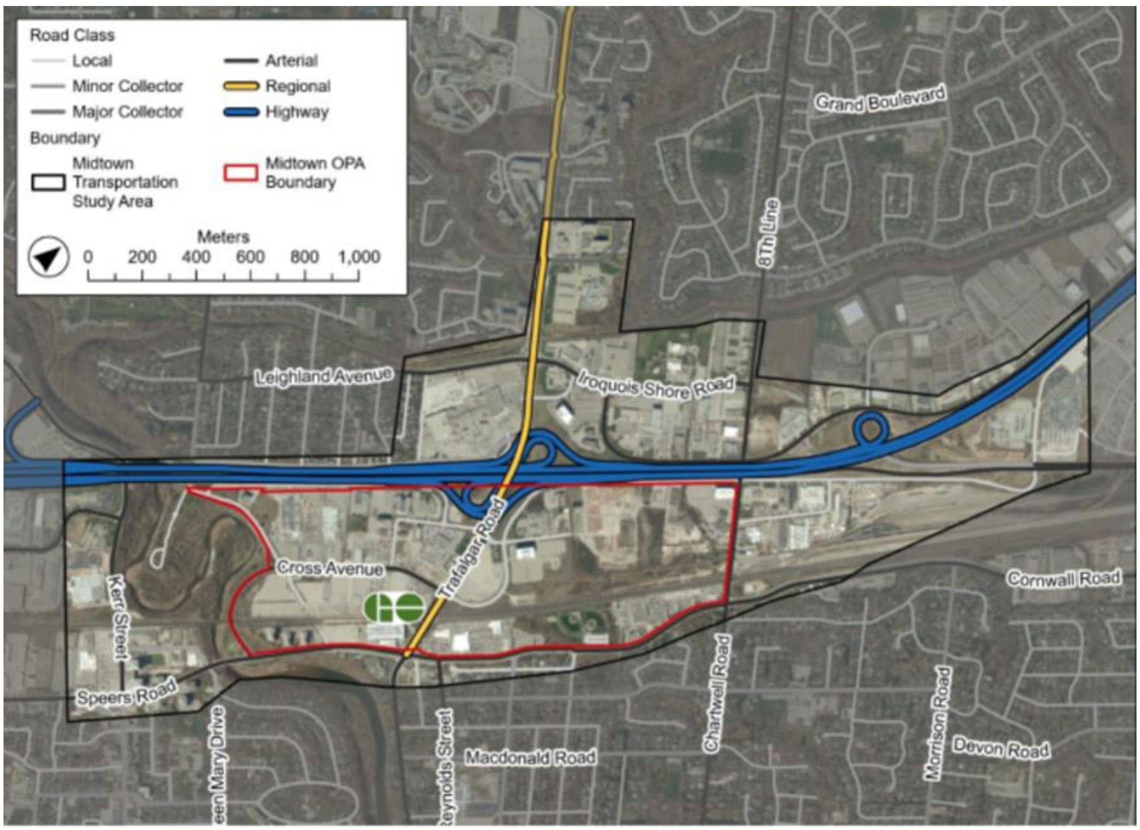

Figure 1-1. Midtown Oakville Study Area

Midtown Oakville is a highly urbanized area that lacks stormwater management facilities to retain, detain and/or treat surface runoff generated from private and public properties. If left uncontrolled, future areas draining into Lower Morrison Creek and Sixteen Mile Creek would incur increases in peak flows, storm sewer capacity issues and potential riverine flooding. By proposing feasible and sustainable stormwater management measures across the study area, this master plan and the development process will ensure negative environmental and socio-economic impacts are mitigated as per provincial and municipal policy direction and guidelines.

1.1 Study Objectives

The Midtown SWM Master Plan (Midtown SWM-MP) intends to fulfill the following objectives:

- Assess existing drainage conditions, including storm sewer surcharge and surface ponding along the Right of Way.
- Assess the impact of future development and confirm constraints and opportunities.
- Identify and evaluate stormwater management measures for private and public areas to address municipal and environmental targets and comply with provincial and municipal policies and guidelines.
- Update and verify targets and criteria established by previous studies, including stream erosion and flood risk.
- Establish stormwater management strategies.

Building on these objectives, the development community will be required to:

- Follow the Town's policies and procedures for drainage and stormwater management.
- Apply the stormwater criteria, targets and policies established by the Midtown Stormwater Master Plan and confirm drainage capacity and functionality at a block-by-block level.
- Develop drainage plans, grading plans and specific SWM strategies and implementation plans.

1.2 Study Process

The Midtown SWM-MP has been completed as a Schedule B undertaking of the Municipal Engineers Association (MCEA) Class Environmental Assessment Process (Municipal Engineers Association's Municipal Class Environmental Assessment October 2000, as amended in 2007, 2011, 2015 & 2023). Accordingly, the following phased approach has been taken:

- Phase 1: Identify the problem (deficiency) or opportunity
- Phase 2: Identify alternative solutions to address the problem or opportunity

The Midtown SWM Master Plan will be a vital component of the overall Midtown Oakville program and must be fully integrated with the Transportation Plan and the public realm and servicing objectives. The SWM Master Plan will satisfy Phase 1 and 2 of the Municipal Class EA process and will build on the 2014 Midtown Oakville Class EA to develop SWM strategies and technical direction to support growth and development.

Key tasks covered in this report include the following:

1. Background Review
2. Stormwater Planning Context
3. Characterization of Existing Conditions
4. Problem / Opportunity Statement
5. Hydrologic and Hydraulic Modeling Approach

6. Assessment of the Drainage System
7. Downstream Impact Assessment
8. Identification and Evaluation of Alternative Solutions
9. Midtown Stormwater Criteria and Strategies
10. Implementation Plan

Important supporting documents and files, including as-built drawings, catchment delineation and parametrization, hydrologic and hydraulic analyses, mapping of drainage conditions under different scenarios and relevant summary tables are provided in Appendices A through I.

2. Background Review

Several studies pertaining to drainage, flood assessment and mitigation, within Midtown Oakville and upstream and downstream of it, have been completed between 2008 and the present. These studies and related hydrologic and hydraulic models and analyses have been reviewed to develop an informed understanding of existing drainage patterns, metrics and areas of concern. Supporting data, drawings and GIS shapefiles have been assembled from various sources, including the Town of Oakville, Halton Region, Conservation Halton, and online provincial tools.

2.1 Technical Studies

2.1.1 Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993)

This study developed the regulatory flood model and flood hazard mapping for the Lower Morrison and Lower Wedgewood Creeks. The OTTHYMO model results confirmed that the 100-year storm is greater than the regional storm and should be considered as the Regulatory Flood along the upper portions of the Lower Morrison Creek. Flood damage areas were assessed as part of this study and flood control measures, including structural and non-structural measures, were proposed.

The study estimated peak flows under post and pre-development conditions and concluded that applying the post-to-pre control criteria to the undeveloped sites would result in higher than existing downstream peak flow rates. Therefore, the study proposed overcontrol measures to mitigate flooding and erosion issues downstream of the study area, encompassing Lower Morrison and Lower Wedgewood Creeks to the point they drain to Lake Ontario.

2.1.2 Town-wide Flood Study Town of Oakville (Philips, 2008)

This study identified areas of concern for flooding within the Town of Oakville, with a focus on open waterway systems. It reviewed historical studies, floodplain mapping and conducted site reconnaissance. Most of the flooding mechanisms relate to culvert capacity issues, properties being too close to the watercourse and/or reduced floodplain or channel capacity.

2.1.3 Midtown Oakville Class EA (COLE, 2014)

As part of the 2014 Midtown Oakville Class EA study, hydrologic and hydraulic modelling was carried out to determine target peak flow rates for each of the four (4) subwatersheds to which the Midtown study area drains. Existing drainage conditions were simulated using the Visual OTTHYMO software. Peak runoff rates were compared with flows from the Lower Morrison / Wedgewood Creeks – Flood Erosion and Master Drainage Plan Study (R.V. Anderson, 1993). With respect to the Morrison/Wedgewood Diversion Channel (MWDC), the study indicated the potential for a spill of flood waters during extreme storm conditions which could affect lands within the vicinity of the diversion channel, as well as properties further downstream, including Midtown Oakville. The Midtown Oakville Class EA proposed unitary storage rates for quantity control, however, the proposed criteria did not include erosion control targets.

2.1.4 Town of Oakville Stormwater Management Master Plan (Wood, 2019)

The Town of Oakville SWM Master Plan was primarily driven by addressing the age of existing infrastructure (greater than 50 years old) and limited stormwater management practices. The study developed a calibrated PCSWMM model that covers parts of the Midtown study area, specifically areas east of Trafalgar Road (Figure 2-1). The PCSWMM model developed as part of the Town's master plan has been used in subsequent studies (i.e. Flood Mitigation Opportunities Study, WSP, 2024) and will be used in this study.

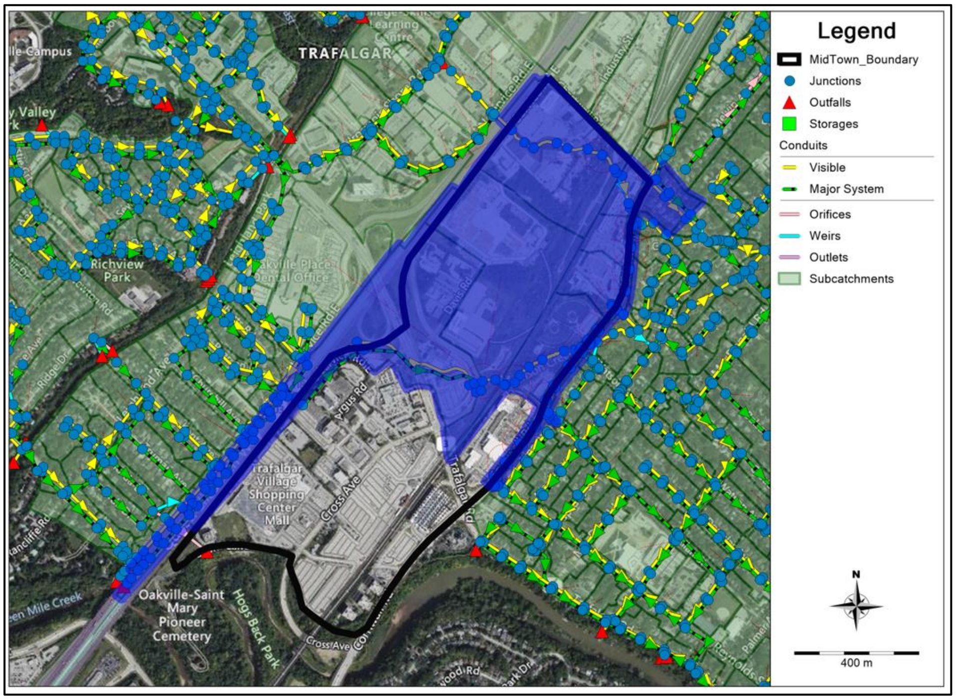

Figure 2-1. Modelled Subcatchments (blue-shaded areas) within Midtown Oakville based on the Town's SWM Master Plan (Wood, 2019)

2.1.5 Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood (LM/LW) Creeks (Wood, 2024)

The overarching objective of this study was to gain a better understanding of flood risk within the two creek systems, and to assess flood mitigation alternatives leading to recommended capital projects for flood mitigation. The hydrology and hydraulic modelling for Lower Morrison and Lower Wedgewood Creeks was updated based on the PCSWMM model completed as part of the Town of Oakville SWM Master Plan (2019). The study revisited issues highlighted in previous reports and determine if there are any new flood-prone sites within the two subwatersheds. The study reviewed previous stormwater management criteria for the two subwatersheds and covered some gaps, specifically concerning erosion control. The findings from this study were not incorporated into regulatory flood plain mapping.

2.1.6 Conservation Halton Studies

Conservation Halton (CH) has recently completed studies to mitigate flood impacts of the diversion channel. These include:

- Flood Risk Mapping and Spill Quantification – Morrison-Wedgewood Diversion Channel (Morrison Hershfield, March 2020)

- Addendum to Flood Risk Mapping and Spill Quantification – Morrison-Wedgewood Diversion Channel, Baseline Model Update (Morrison Hershfield, March 2021)
- Flood Hazard Mapping Study: Sixteen Mile Creek to Lower Morrison Creek (May 2025)
- Spill Hazard Policy Review and Update (April 2025)

Final report and mapping of the spill, including related policy can be found on the Conservation Halton website: Mapping and Studies - Conservation Halton

2.2 Supporting Data and Drawings

The Town of Oakville provided high-resolution LIDAR data, which was compared to provincial data available through Ontario GeoHub. Additionally, base mapping of the study area has built on GIS data from the Town, including storm sewers, maintenance holes, catch basins, laterals, outfalls, aerial imagery, existing road network and land use mapping.

3. Stormwater Planning Context

The Midtown SWM-MP is a municipal planning document that will guide the implementation of stormwater management infrastructure within the Midtown area. This will include the replacement of existing infrastructure and implementation of new infrastructure at various scales to achieve objectives and targets in accordance with provincial and local policy and technical direction.

3.1 Provincial Policies and Guidelines

At the provincial level, stormwater-related acts and policies include the Water Resources Act, Environmental Protection Act and the Provincial Planning Statement (2024), all emphasizing environmental objectives and principles for stormwater management and treatment at various scales.

3.1.1 The Provincial Planning Statement PPS (2024)

The Provincial Planning Statement PPS (2024) calls for the incorporation of climate change considerations in planning for and the development of infrastructure, including stormwater management systems and public service facilities. Planning for stormwater management shall, among other actions, minimize or where possible prevent or reduce increases in stormwater volumes and contaminant loads and align with any comprehensive municipal plans that consider cumulative impacts of stormwater from development on a watershed scale.

3.1.2 Provincial Stormwater (SWM) Guidelines

The Stormwater Management Planning and Design Manual (MECP, 2003) provides technical and procedural guidance for the planning, design, and review of various types of End-of-Pipe SWM facilities, comprising wet ponds, dry ponds, hybrid ponds and engineered wetlands. The Draft Low Impact Development Stormwater Management Guidance Manual (MECP, 2022) promotes the implementation of a "Treatment Train" approach to stormwater management and a shift towards an ecosystem-based water balance perspective. The LID Guidance Manual provides Runoff Volume Control Targets and promotes retention practices to reduce runoff volumes, including infiltration, filtration, evapotranspiration, harvesting and reuse.

3.2 Municipal Policies and Guidelines

3.2.1 Livable Oakville (2025)

This document includes the following stormwater-related policy direction:

- Midtown Oakville is identified as an Urban Growth Centre in the Growth Plan and is planned to accommodate a significant portion of Oakville and Halton's required intensification.
- The provision of stormwater drainage facilities shall be in accordance with master plans established through subwatershed studies, where applicable, or the Town's engineering standards.
- All developments shall follow the current Provincial and Federal guidelines for stormwater management (best management practices). The Town also encourages innovative stormwater management strategies, especially within the Growth Areas.

3.2.2 Official Plan Amendment (February 2025)

Section 20.5.3 of the Town of Oakville's Official Plan Amendment requires development planning to implement stormwater management techniques in accordance with the policies of the Official Plan and the recommendations of previous technical studies and subsequent updates. The incorporation of green infrastructure that enhances ecological functions and supports stormwater management is also required.

3.2.3 Town of Oakville Development Engineering Procedures and Guidelines Manual (2023):

As part of the Town's procedures and guidelines, stormwater-related guidance includes:

- New developments shall be designed to mitigate impacts to watercourses, wetlands, valley features, and fish habitat, including erosion, flooding, water quality, water balance, and other potentially detrimental impacts.
- Stormwater quantity control (i.e., control of peak flow rates of runoff) is required where increased storm runoff, due to development and associated catchment modifications, will cause detrimental impacts via flooding and erosion.
- 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 province published the Stormwater Management Planning and Design Manual (MOE 2003), which shall be referenced for the appropriate method of quality control to achieve the targeted levels per the given receiving system.
- A treatment train approach is strongly encouraged. At-source controls are encouraged, where soil conditions allow for infiltration and biological treatment. Properly sized LID facilities (i.e., to retain the runoff from a 25 mm event) will be credited as providing adequate water quality control.
- The Town supports the use of manufactured treatment devices, including OGSs, filter-based treatment units, and catch basin inserts.

3.3 Stormwater Management Criteria Relevant to the Study Area

Over the years, a range of Stormwater Management (SWM) criteria have been established for study areas that incorporates parts or all of the Midtown Oakville area. These studies include:

- Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993)
    - Area coverage: Lower Morrison and Lower Wedgewood subwatersheds
- Midtown Oakville Class EA (Cole, 2014)
    - Area coverage: Sixteen Mile, Lower Morrison and Lower Wedgewood subwatersheds
- Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood (LM/LW) Creeks (WSP, 2024)
    - Area coverage: Lower Morrison and Lower Wedgewood subwatersheds

- Environmental Compliance Approval for a Municipal Stormwater Management System (ECA Number: 314-S701, Appendix A)
  - Area coverage: Town of Oakville

It should be noted that proposing spill mitigation measures has not been part of this work. Therefore, there will be no criteria for managing flood spill from the Morrison-Wedgewood Diversion Channel.

3.3.1 Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993)

This study developed the regulatory flood model and flood hazard mapping for the Lower Morrison and Lower Wedgewood Creeks. The OTTHYMO model results confirmed that the 100-year storm is greater than the Regional storm and should be considered as the Regulatory Flood along the upper portions of the Lower Morrison Creek. Flood damage areas were assessed as part of this study and flood control measures, including structural and non-structural measures, were proposed.

The study estimated peak flows under post and pre-development conditions and concluded that applying the post-to-pre control criteria to the undeveloped sites would result in higher than existing downstream peak flow rates. Therefore, the study proposed overcontrol measures to mitigate flooding and erosion issues downstream of the study area, encompassing Lower Morrison and Lower Wedgewood Creeks to the point they drain to Lake Ontario.

Proposed SWM criteria included the following:

- Site stormwater should be controlled to 50% of pre-development peak flow rates to control downstream erosion
- If erosion is not a concern, downstream peak flow rates should be controlled to 70% of pre-development peak flow rates to maintain existing flood levels along the Lower Morrison/Wedgewood Creeks
- Until more detailed modeling is conducted, post-development peak flow rates should be limited to 50% or 70% of pre-development levels where erosion is not a concern.

3.3.2 Midtown Oakville Class EA (Cole, 2014)

This study focused on the Midtown area in addition to external catchments north of QEW and east of Chartwell Road. Previous SWM targets and recommendations were updated and compared with the Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993).

Criteria included the following:

- Stormwater Quantity Control (Peak Flow control) – any future development is to utilize the hydrology model from this study to demonstrate that the target flows and minimum storage requirements are met. Specifically, this translates to:
  - Sixteen Mile Creek: 68.2 m^3/ha
  - Lower Morrison Creek: 280.9 m^3/ha
- In terms of target flows, the Midtown Oakville Class EA found that 50% of existing flows estimated for the Lower Morrison subwatershed were much higher than the existing flows in the 1993 MDP

study, therefore the lower flow values from the previous study were proposed as target flows. Since the 2014 study, the Town has been using the quantity control storage requirements and proponents have not been required to update the model.

- Stormwater Runoff Volume Reduction (Water Balance) - Provide retention of 5 mm over the entire area of the proposed development as per the City of Toronto's Wet Weather Flow Management Guidelines (November 2006); or retain stormwater onsite to achieve an equivalent annual volume of infiltration as per development conditions, as per Section 3.2 of the MOE Stormwater Management Planning and Design Manual (March 2003). This objective could be achieved in part through LID measures. Since the 2014 study, the Town has been using the 25 mm in accordance with MECP general recommendations. Proponents have not been required to update the model.
- Erosion Control – Not assessed. Water balance target assumed to provide inherent benefits.
- Stormwater Quality Control – any new development is required to meet MECP Enhanced Level 1 Protection (80% long-term removal of TSS), as per the Ministry of Environment's Stormwater Management Planning and Design Manual (2003). Quality treatment by LIDS should be considered, particularly as these would also provide downstream erosion reduction benefits (SWM criteria for erosion control was not directly assessed in this EA).

3.3.3 Town of Oakville Stormwater Management Master Plan (Wood, 2019)

The Town of Oakville SWM Master Plan covers part of Midtown, specifically east of Trafalgar Road, draining to the Lower Morrison Creek system. As noted earlier, the study was primarily driven by addressing the age of existing infrastructure (greater than 50 years old) and limited stormwater management practices. The study included a calibrated PCSWMM model and high-level SWM strategies.

3.3.4 Flood Mitigation Opportunities Study Lower Morrison and Lower Wedgewood (LM/LW) Creeks (WSP, 2024)

The findings of this study include an updated set of runoff quantity and quality for the Lower Morrison portion of the Midtown area.

- Erosion Control: A unitary storage of 160 m3/imp. ha has been determined to be more than sufficient to provide erosion control for Lower Morrison and Lower Wedgewood Creeks
- Quantity Control (Table 5.35):
    - Unitary Storage – No LID:
        - Lower Morrison West Branch: 180 m^3/imp. ha
        - Lower Morrison East Branch: 210 m^3/imp. ha
    - Unitary Storage – with LID:
        - Lower Morrison West Branch: N/A (25mm capture provides sufficient storage to reduce future peak flows to target peak flows)
        - Lower Morrison East Branch: 125 m3/imp. ha

*Unitary storage rates are to be applied to the entire site impervious coverage, therefore if there is no increase in impervious coverage for a site, the total storage rates would still be applied when it develops.

According to this study, the erosion control target established can be provided through the 25 mm capture proposed to meet water balance targets.

3.3.5 Environmental Compliance Approval for a Municipal Stormwater Management System (ECA Number: 314-S701)

The Town's ECA-CLI agreement with the Province of Ontario (i.e. MECP) is intended for the town's owned infrastructure and "When it is necessary to use Privately Owned Stormwater Works in the Stormwater Treatment Train to achieve Appendix A criteria as part of or as a result of an Alteration (Section 5.2.6 of Schedule D).

According to ECA Number: 314-S701, a "Stormwater Treatment Train" means a series of Stormwater Management Facilities designed to meet Stormwater management objectives (e.g., Appendix A) for a given area, and can consist of a combination of Manufactured Treatment Units (MTDs), LIDs and end-of-pipe controls to achieve a multitude of SWM criteria tabulated in Appendix A, including water balance, erosion control, flood control (watershed hydrology), water quantity (minor and major systems), and water quality.

- **Water Balance**

Control as per the criteria identified in the water balance assessment completed in one or more of the following studies, if undertaken: a watershed/subwatershed plan; Source Protection Plan (Assessment Report component); Master Stormwater Management Plan, Master Environmental Servicing Plan; Class EA, or similar approach. The Town of Oakville SWM Master Plan (2019) recommended 25mm capture to be applied to impervious areas for intensified land use conditions.

- **Erosion Control (Watershed)**

The Flood Mitigation Study (2024) proposed 25 mm retention targets for erosion control targets, also applied to impervious areas. Accordingly, and as noted in Section 5.4.6 of the same study, "Erosion control storages will be provided by the 25 mm retention. each tributary including area upstream of Midtown and the "equivalent" storage provided by 25mm capture. Being consistent with the Oakville Masterplan, the 25mm capture has only been applied to the impervious area."

- **Flood Control (Watershed Hydrology)**

Manage peak flow control as per watershed/subwatershed plans, municipal criteria being a minimum 100-year return storm (except for site-specific considerations and proximity to receiving water bodies), municipal guidelines and standards, Individual/Class EA, ECA, Master Plan, as appropriate for the type of the project. Unitary storage requirements based on controlling to the same flow rates as the 1993 RVA Study Midtown have been used for storage requirements for water quantity control.

- **Water Quantity (Minor and Major System)**

Follow the Town of Oakville Development Engineering Procedures and Guidelines Manual (2023) to define standards for managing surface runoff along both the minor and major systems.

- **Water Quality**

Apply an enhanced level of protection (80% for suspended solids removal).

4. Characterization of Existing Conditions

The following sections present an overall characterization of existing conditions within Midtown Oakville. This characterization includes watershed context, hydrogeological conditions and existing infrastructure conditions. For a detailed assessment of existing drainage, readers are referred to Chapter 7.

4.1 Watershed Context

The Midtown area, covering the OPA lands as noted in Chapter 1, drains three subwatersheds, namely, Sixteen Mile Creek, Lower Morrison West and Lower Morrison East (Figure 4-1). Within the OPA lands (dashed line), the Lower Morrison subwatershed occupies the largest area, approximately 71.2 hectares (Morrison West: 53.60 ha and Morrison East: 17.60 ha), while the Sixteen Mile creek subwatershed occupies approximately 54.98 hectares. Compared to the area covered by the 2014 Class EA study, the OPA lands and external catchments (north of QEW and east of Chartwell Road), do not cover the Lower Wedgewood creek subwatershed or areas to the north of the Diversion Channel and south of Cornwall Road.

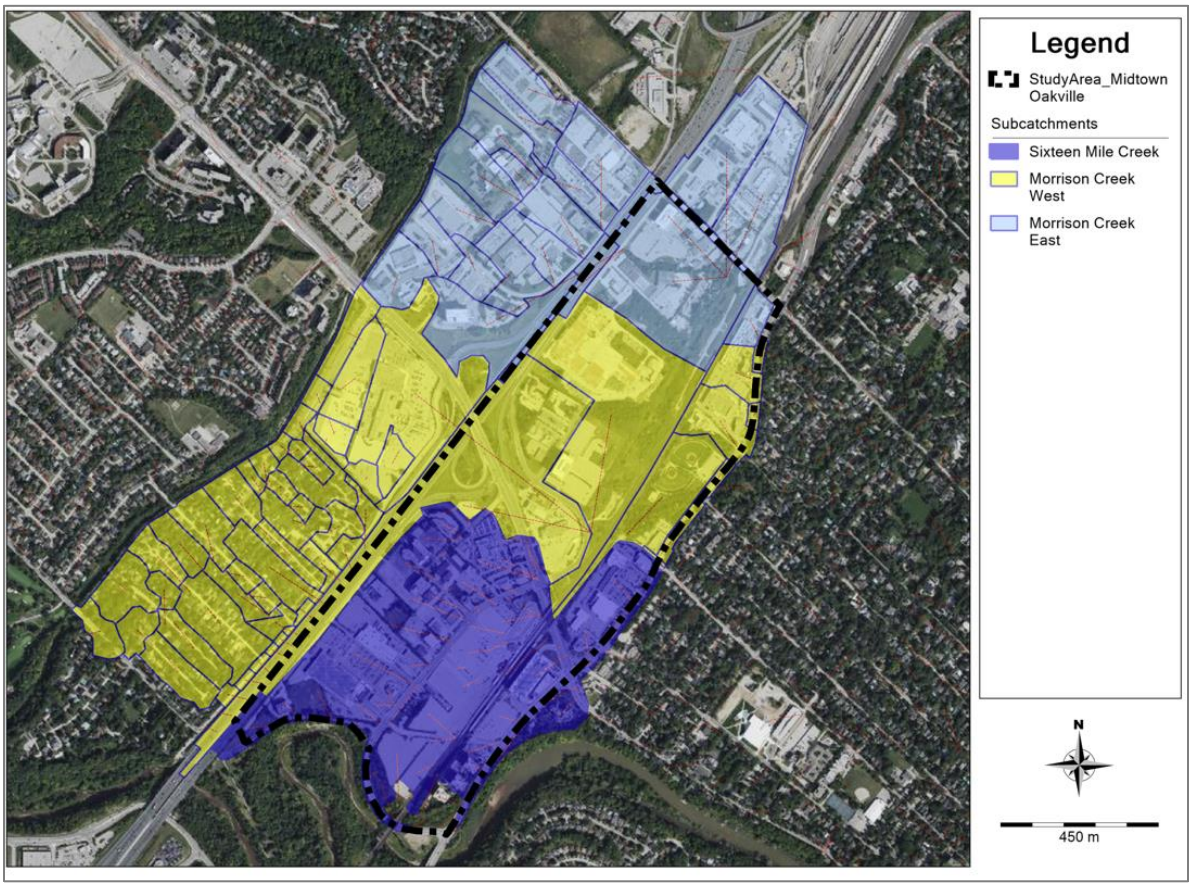

Figure 4-1. Midtown Oakville Contributing Subwatersheds (OPA lands represented by dashed line)

Table 4-1 Subwatersheds Covering Midtown Area

Subwatershed	Total Area (ha)	Weighted Average Imperviousness %
Lower Morrison West	53.60	51.1
Lower Morrison East	17.60	72.7
Sixteen Mile Creek	54.98	78.0

Outside the OPA lands, there are external catchments that drain into the Midtown area:

- Lower Morrison West (between QEW and the Diversion Channel (MWDC)): **55.67 ha, with a total impervious area of 31.40 ha.**
- Lower Morrison East (between QEW and the Diversion Channel (MWDC)): **39.9 ha, with a total impervious area of 28.48 ha.**
- Lower Morrison East (east of Chartwell Road): **12.2 ha, with a total impervious area of 10.4 ha.**

There are no external catchments draining into the Sixteen Creek subwatershed part of the OPA land.

4.2 Hydrogeological Conditions

Knowledge of the hydrogeological conditions within the study area, including groundwater elevations, shallow bedrock, swelling clays, and contaminated soils is necessary for proposing viable underground stormwater storage facilities and water balance opportunities. An overview of these conditions was completed, and constraints and opportunities were drawn using municipal guidance and development applications within Midtown Oakville, in addition to desktop analysis that consisted of provincial databases and maps.

4.2.1 Overview

The hydrogeology of Midtown Oakville is characterized by up to 6 m of glacial overburden consisting of Undifferentiated Upper Sediments, and Lower Newmarket Till hydro-stratigraphic units. The Undifferentiated Upper Sediments unit is typically 1 to 2 m thick and underlain by between 1 to 5 m thick Lower Newmarket Till.

In areas close to Sixteen Mile Creek, the Lower Newmarket Till pinches out with Undifferentiated Upper Sediments directly overlying Queenstown, and Georgian Bay shale bedrock. Queenstown and Georgian Bay shale bedrock underlays the entire Midtown Oakville area and is encountered between 1 to 6 m below ground surface, with the shallowest depth to bedrock in the area close to Sixteen Mile Creek.

The depth to groundwater is inferred to be between 2 to 25 m below ground surface, with groundwater found at the shallower depths close to Sixteen Mile Creek within the creek valley (Figure 4-2).

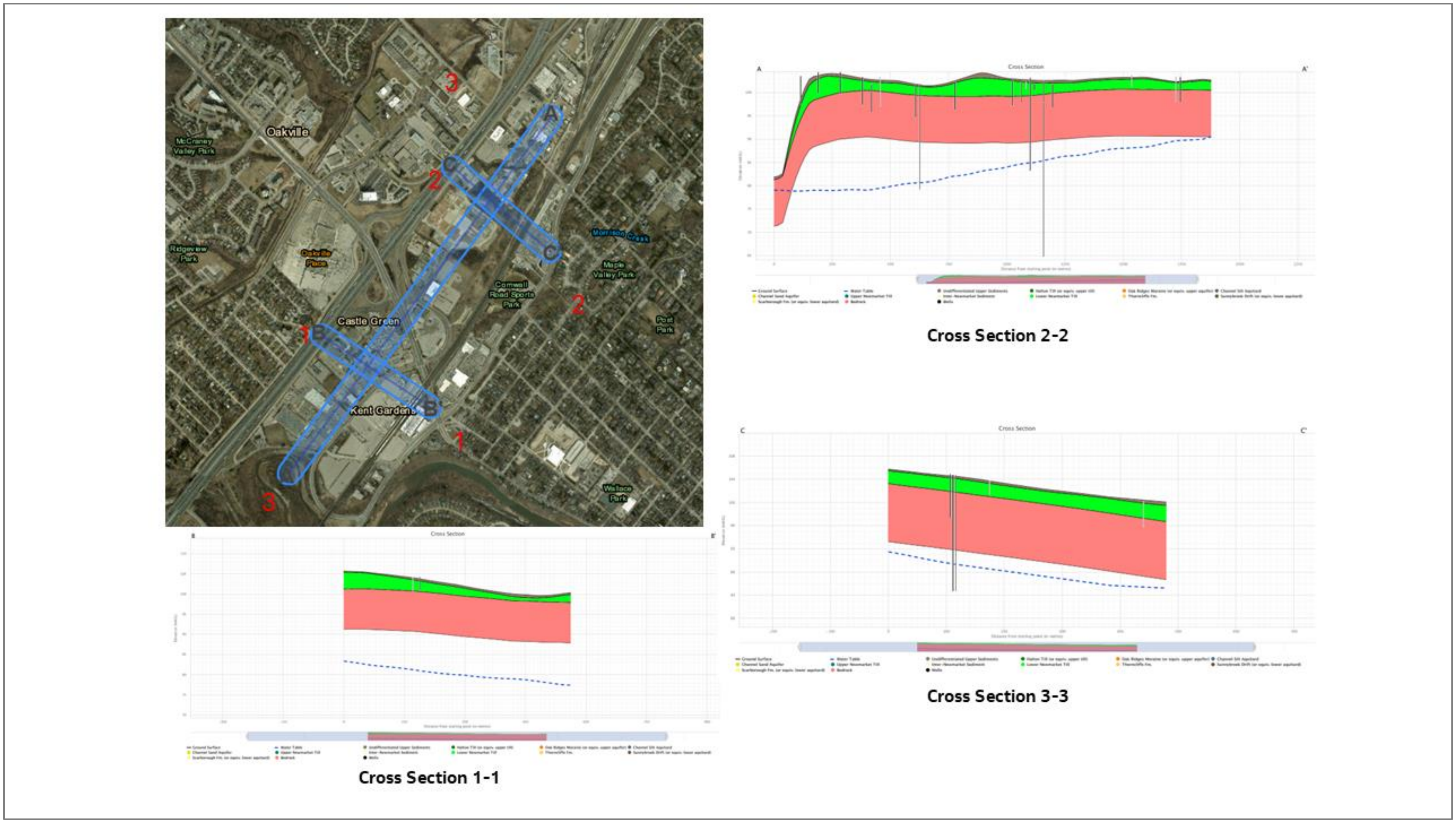

Figure 4-2. Hydrogeology Concept and Cross Sections within Midtown Oakville (Green: Upper Newmarket Till, Pink: Bedrock, Dashed line: Water Table)

4.2.2 Constraints and Opportunities for Infiltration

Understanding soil conditions and groundwater depths is crucial for determining constraints and opportunities for implementing SWM measures at various scales. Infiltration rates greater than 15 mm/hr. have been cited as feasible for water balance opportunities and infiltration-based SWM and Low Impact Development (LID) measures (MECP, 2003). Below this value, opportunities may still exist, but might demand more detailed investigations, including filed assessments, desktop analysis and modeling (MECP, 2022).

4.2.2.1 Soil Conditions

Geotechnical and hydrogeological investigations from various development applications were reviewed. These include Hydrogeology Reports from the South Service West area (420-468 South Service East) Cross Avenue (157 and 165 Cross Ave). Borehole data shows that the soil stratigraphy consisted of an upper layer of variable fill material overlying native clayey silt till with shallow bedrock. Geometric mean hydraulic conductivity (K) value was estimated as 4.97 x 10-7 m/s, indicating very low infiltration rates according to literature.

4.2.2.2 Groundwater Depths

As noted previously, groundwater depth across Midtown Oakville was inferred to be between 2 to 25 m below ground surface, with groundwater found at the shallower depths close to Sixteen Mile Creek within the creek valley. Site-specific data from the South Service West area showed groundwater depths ranging between 4.07 m and 7.56 m. Other data extracted from tests along Cross Avenue showed groundwater elevations between 2.1 to 21.6 mbgs.

4.3 Existing Infrastructure

The major drainage system within Midtown can be categorized as follows:

- Urban cross-section roads, including curb and gutter with storm sewers, manholes and catch basins. Areas with an urban cross section are most dominant within the study area and in particular west of Trafalgar Road.
- Rural cross-section roads, including ditches and driveway culverts. Areas with rural cross section include segments along South Service Road and Chartwell Road.

The GIS shapefiles provided by the Town did not include storm sewer pipe data within the study area. Therefore, further investigation was undertaken using as-built engineering drawings supplied by the Town (Appendix A).

Appendix A covers the drawing files used to extract and incorporate storm sewer pipes and outfalls into the hydrologic and hydraulic analysis. These drawings include Argus Road, Cross Avenue, portions of Trafalgar Road, and Cornwall Road west of Trafalgar.

Data gaps related to the storm drainage system have been identified and communicated to the Town. These include the following:

- Storm sewer pipe sizes at various locations
- Maintenance hole rim elevations and sewer pipe invert elevations
- Mismatch between some of the as-built drawings and physical reality
- Missing catch basins and manholes: large areas between South Service Road East and Cross Avenue lack documentation of catch basins and manholes. This area includes buildings, grassed surfaces, parking lots, and access roads.

Some of the gaps were left unaddressed, especially those related to lack of available information about sewer pipe diameters. Gaps related to rim and invert elevations were either interpolated or extracted from development applications and the existing PCSWMM model (WSP, 2024). In numerous instances, discrepancies were observed between rim elevations in the drawings and the existing topography derived from the Town's LiDAR data. Additionally, there were instances of incomplete information, particularly regarding catch basin rim elevations. To address these data inconsistencies and gaps, the following approach was implemented:

- Rim Elevations: LiDAR data was utilized to extract rim elevations for assets where discrepancies or missing information were identified.
- Pipe Diameters: In cases where pipe diameter information was absent, estimates were made based on available pipe size data from either downstream or upstream sections of the pipe network.
- Pipe and Manhole Inverts: When slope or invert data were missing, a best-estimate approach was employed. This involved interpolating values based on upstream and downstream pipe and manhole information to ensure gravity-driven flow towards the downstream sections.

A site visit was conducted on April 26, 2024, to identify manholes and catch basins located in sag (low) points and on-grade locations. This information was critical for accurately modeling the major overland flow routes and spillways, thereby improving the representation and characterization of existing drainage conditions. As no storm sewer pipe data was available for these areas in the Town’s as-built records, assumptions were made based on existing topography, engineering judgment, and logical flow paths. The following assumptions were made to confirm hydraulic connectivity and positive drainage within built-up areas:

4.3.1 South Service Road East to Cross Avenue:

It was assumed that surface runoff from these areas is collected by a network of catch basins and conveyed via storm sewers toward Argus Road (east), Cross Avenue (south), or Lyons Lane (west). A few areas also drain toward Trafalgar Road, discharging into Sixteen Mile Creek.

4.3.2 Cross Avenue to the Railway Corridor (including Metrolinx GO Station):

Pipes were not modeled in this area. It was assumed that runoff is captured by catch basins and conveyed north toward Cross Avenue or east toward Trafalgar Road. A ditch observed along the railway corridor, extending from Lyons Lane eastward to Cross Avenue, likely conveys flow to a culvert beneath Cross Avenue, discharging into Sixteen Mile Creek.

4.3.3 Railway Corridor to Cornwall Road:

It was assumed that runoff is captured by a series of catch basins and conveyed south toward Cornwall Road, east toward Sixteen Mile Creek via a culvert beneath Cross Avenue, or west toward Trafalgar Road.

5. Problem/Opportunity Statement

In the Municipal Class Environmental Assessment (MCEA) process, a Problem/Opportunity Statement is the culmination of Phase 1, clearly defining the problem, deficiency, or opportunity that necessitates a project, thereby setting the stage for identifying and evaluating alternative solutions (Phase 2).

For Oakville Midtown SWM MP, the Problem/Opportunity Statement is as follows:

> "The Midtown growth area in the Town of Oakville is underdeveloped and has an urban drainage system with capacity issues. It lacks stormwater management measures to reduce the extent and severity of urban and riverine flooding. A Stormwater Master Plan must be developed for the Town to accommodate future growth and expansion of road network as per the Official Plan Amendment.
>
> The Midtown Stormwater Master Plan will determine how the Town's stormwater infrastructure will support growth in a sustainable and financially responsible manner. It will identify stormwater quantity and quality measures for private and public areas to address relevant provincial and municipal policies and guidelines. Based on a comprehensive multi-criteria evaluation, preferred solutions will be proposed to be implemented at various scales to achieve a multitude of municipal and environmental targets."

5.1 Challenges

Key challenges within the Midtown study area include the following:

- High imperviousness
- Drainage infrastructure at (or over) capacity
- Riverine flooding
- Lack of historical stormwater management within the area
- Hydrogeology and various site constraints

5.1.1 High Imperviousness

Hard surfaces are known to reduce the amount of surface runoff infiltrating into the ground, and as a result increase the rate and volume of runoff discharging into the Town's storm drainage system. Average weighted imperviousness across the study area was found to be approximately 65.9%. Relatively higher imperviousness values are found within areas west of Trafalgar Road compared to the east of Trafalgar Road, which has more green spaces and pervious land cover.

5.1.2 Drainage Infrastructure at (or over) Capacity

There are concerns about storm sewer surcharge and possible surface ponding at various locations across the Midtown area. In the absence of proper mitigation or stormwater management measures, capacity of the existing municipal drainage system would be reduced, and the extent and severity of flooding would be increased.

5.1.3 Riverine Flooding

Flooding issues have been identified south of the Midtown area, including flood risk identified along Lower Morrison Creek, south of the railway (RV. Anderson, 1993). Conservation Halton (CH) has recently completed Flood Hazard Mapping Study: Sixteen Mile Creek to Lower Morrison Creek (May 2025). Final report and mapping of the spill, including related policy can be found on the Conservation Halton website: Mapping and Studies - Conservation Halton

5.1.4 Lack of Historical Stormwater Management

The Town of Oakville SWM Master Plan (Wood, 2019) did not cover the Midtown area. It was noted by the Town that, at present, there are no community stormwater management facilities, mostly due to the standards of the day when this area began to develop.

5.1.5 Hydrogeology and Various Site Constraints

It is understood that the future development density will be high, including limited green space and underground parking. According to the town's engineers, there are sporadic hydrogeological reports and the hydrogeology within the study area is not fully understood. Available information from provincial online sources and development applications shows low infiltration rates and shallow groundwater elevations in many areas across Midtown.

5.2 Opportunities

Opportunities as part of the Midtown Stormwater Master Plan include but not limited to:

- Providing adequate drainage infrastructure capacity and flexibility to adapt to increasingly extreme wet weather events
- Minimizing environmental impacts including natural and socio-economic impacts
- Identifying candidate locations along the proposed roads and parks to incorporate green infrastructure and LID measures
- Minimizing total capital, operation and maintenance, and lifecycle costs

6. Hydrologic and Hydraulic Modeling Approach

6.1 Overview

The PCSWMM modeling software was utilized to simulate the hydrology and hydraulics across the Midtown area. A calibrated PCSWMM model was originally developed as part of the Town of Oakville Stormwater Management Master Plan (Wood, 2019) and then updated as part of the Flood Mitigation Opportunity Study for Lower Morrison and Lower Wedgewood Creeks (WSP, 2024).

Upon receiving the updated model from the Town, it has been used as the base model for the Lower Morrison Creek system, including East and West Tributaries. As the base model did not include areas within Midtown that drain into Sixteen Mile Creek, the missing subcatchments were delineated and the model extended to cover the areas west of Trafalgar Road, specifically the drainage areas contributing to Sixteen Mile Creek between the QEW and Cornwall Road.

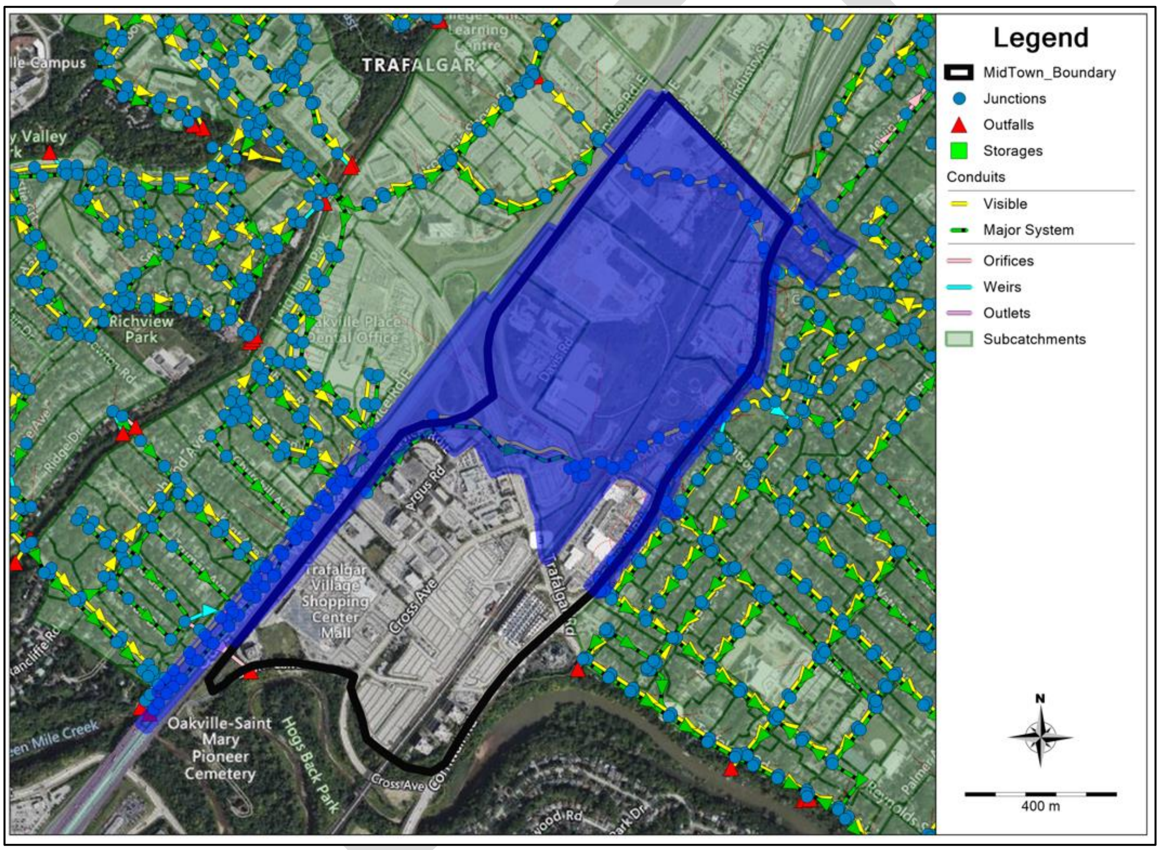

Figure 6-1. Modelled Subcatchments within the Study Area (blue-shaded) based on the Town of Oakville SWM Master Plan (Wood, 2019) and the Flood Mitigation Opportunity Study (WSP, 2024)

A dual-drainage approach has been developed to evaluate the performance of both the major system (overland flow and roadway conveyance) and the minor system (storm sewers) under various storm events and land use conditions. Accordingly, the PCSWMM model includes hydraulic elements and junctions representing the minor system, such as maintenance holes, catch basins, and storm sewer pipes, as well as components of the major system, including road rights-of-way, curb and gutter systems in urbanized areas, and roadside ditches along rural sections.

The PCSWMM model was run for both the 5-year and 100-year return period design storms using the Town of Oakville's Intensity-Duration-Frequency (IDF) parameters and the 24-hour Chicago distribution, in accordance with the Town of Oakville Development Engineering Procedures and Guidelines Manual (2023). These simulations were conducted to determine peak flow values at outfalls and key locations within the study area and various outlets at receiving watercourses. Additionally, the regional storm event (Hurricane Hazel) with a 12-hour duration, was simulated using the information obtained from Design Chart 1.03 in the MTO Drainage Management Manual.

6.2 Subcatchment Delineation

6.2.1 Existing Conditions

The Town's LIDAR was compared to that from Ontario GeoHub, and it was found that the GeoHub data, which provides a resolution of 0.5*0.5 meters, offers greater detail, however, it was observed that the Town's LiDAR, with a resolution of 1*1 meter, shows a more consistent flow pattern and accumulations within the study area. Since the Flood Mitigation Opportunity Study (WSP, 2024) had used the Town's topographic data, this was another reason to proceed with the Town's LiDAR.

The drainage area boundaries from previous studies, including the Midtown Oakville Class EA (Cole, 2014) and the Flood Mitigation Opportunity Study for Lower Morrison and Lower Wedgewood Creeks (WSP, 2024) were reviewed. The subcatchments draining to Sixteen Mile Creek were compared to those from the Midtown Oakville Class EA (Cole, 2014). Our results show better discretization and a larger number of outfalls than previously reported (Appendix B). In total, there are 70 catchment areas within the Sixteen Mile Creek subwatershed and 12 catchment areas within the Lower Morrison Creek subwatershed (9 draining into Lower Morrison West and 3 into Lower Morrison East). Two catchment areas, namely 30_3 and 299, located east of Trafalgar Road, were found to contribute flow to Sixteen Mile Creek. These two catchments had not been included in the base model (WSP, 2024). As such, they were incorporated into the current model to ensure accurate representation of their hydrologic contribution to the creek.

A total of 11 outfalls discharging to Sixteen Mile Creek have been identified within the study area west of Trafalgar Road. The majority of these are classified as minor system outfalls, where surface runoff is conveyed through underground storm sewers or culverts that discharge directly into the creek. In contrast, a few others were considered major system outfalls, where overland flow is conveyed to the creek via spill routes, typically activated when flow overtops curb elevations along roadways.

To the east of Trafalgar Road, a total of 12 catchment areas contribute flow to both the east and west branches of Morrison Creek. As represented in the base model (WSP, 2024), some of these subcatchments discharge directly to the creeks, while others were originally modeled such that flow is first captured by dual-drainage components (minor and major systems) and then conveyed to the creek through the existing storm sewer network. Contrary to Sixteen Mile Creek, explicit outfall elements were not coded within the study area to represent these connections.

A summary of the identified outfalls and their associated catchments and characteristics can be found in Appendix B.

6.2.2 Future Conditions

Imperviousness under future conditions is expected to be only approximately 2% higher than existing – 68.1% compared to 65.9%. The reason behind this is primarily related to that under existing conditions, the area coverage of hard surfaces, made up of industrial/commercial buildings and parking lots, is high.

And, although there will be more roads built as part of the future redevelopment plans, the proposed parks and buffers offset the impact of these additional roads.

For the future development scenarios, varying imperviousness values were assigned to proposed areas based on their respective land uses. This study adopted imperviousness values from the Town of Oakville Stormwater Management Master Plan (Wood, 2019), specifically those recommended in Tables 6.1.2 and 7.5.2.

Table 6-1, below, summarizes the future land use classifications and associated imperviousness values used in the PCSWMM model for the newly delineated subcatchments. Table 6-1 shows imperviousness values at the subwatershed scale.

Table 6-1. Future Subcatchments Imperviousness (%)

Land Use Classification	Imperviousness (%)
Park	10
Parks and Open Space	10
Natural Area	5
Office Employment	84
Community Commercial	85
Utility	26
Residential High Density	75
Main Street (Road)	95
Urban Core	95
Railway	26

Table 6-2. Future Subwatersheds Covering Midtown Area

Subwatershed	Total Area (ha)	Weighted Average Imperviousness %
Lower Morrison West	50.60	59
Lower Morrison East	18.90	73
Sixteen Mile Creek	56.88	75

All future land use types were added into the PCSWMM model. Typical cross sections and horizontal and vertical alignments of the proposed roads were obtained from the transportation engineering and urban design teams and coded into the future scenario models (i.e. uncontrolled and controlled conditions)

(Appendix E). The dual drainage configuration was updated to include minor and major drainage features, following the proposed roadways' plans and profiles.

Inlet capture was represented using a lumping approach in which catch basins were aggregated and input to the model at a junction. This approach the benefit of reducing the model complexity and runtimes, and it was used previously by the Flood Mitigation Opportunity Study (WSP, 2024).

6.3 Subcatchment Parametrization

The parametrization of the subcatchments has been updated and refined using tools and techniques within the PCSWMM software platform and ESRI ArcGIS. Imperviousness, which represents the coverage of hard surfaces (e.g. buildings and roads) within a given catchment, was determined based on aerial images and land use data and shapefiles from the Town. The Flood Mitigation Opportunity Study (WSP, 2024), which applied a detailed approach for estimating imperviousness for different land use types, was also considered.

Flow length was estimated for each catchment, as the average length for sheet flow, before becoming channelized. The slope for each catchment was determined using the LIDAR data. Depression storage, representing the depth of rainfall captured and detained for each catchment, was assigned as 1 mm of depression storage for impervious segments and 5 mm for pervious segments.

The Green and Ampt approach was selected to model the infiltration properties of soils. The approach includes variables such as saturated hydraulic conductivity, suction head and initial moisture deficit. Information found in development applications and provincial databases indicates that the topsoil across Midtown generally exhibit low infiltration rates. This means that water takes longer to move through the soil, leading to a higher potential for runoff and less groundwater recharge.

The subarea routing option, which defines how runoff from pervious and impervious surfaces is directed within each catchment, was set to "100% to outlet" for all newly delineated catchments west of Trafalgar Road. This assumption reflects the highly urbanized nature of the area, where runoff is typically captured by catchbasins and conveyed through storm sewers, with no stormwater management (SWM) facilities present. Manning's roughness coefficients were assigned as follows for the newly added catchments:

- Pervious areas: 0.15 (representing short grass)
- Impervious areas: 0.013

Input parameters for all subcatchments within the study area are provided in Appendix C.

6.4 Minor System Representation

Data received from the Town, including GIS shapefiles and scanned built-up drawings, were reviewed and incorporated into the PCSWMM model. Existing storm sewer pipes were represented as conduits and maintenance holes as junctions. Similar to the Flood Mitigation Opportunity Study (WSP, 2024), runoff generated from each subcatchment was initially conveyed to the major system component and then routed to the minor system through orifices representing catch basins, catch basin leads and maintenance hole leads, all of which were explicitly modeled.

Catch basin grates are represented as bottom-draw orifices and each catch basin is assumed to have an approximate opening area of 0.125 m^2, based on measurements of standard grate design used in Ontario. This opening area is then multiplied by the number of grates being represented in the subcatchments, with an equivalent square opening calculated. Separate orifices are used to represent the catch basin leads (side-draw) and maintenance hole leads (bottom-draw). Since modeling circular opening for catch basin leads in this approach can be complex, an equivalent rectangular area, which maintains the original lead height of 250 mm (single catch basin) or 300 mm (double catch basin), is specified for the side draw orifice.

It should be noted that for private properties, including commercial and industrial land uses, where stormwater infrastructure data was unavailable for developing a localized dual-drainage system, the total number of catch basin grates associated with subcatchments was recorded and appropriate inlet opening areas were then assigned to the nearest available system through dual-drainage linkage, typically located along the adjacent street.

6.5 Major System Representation

Under existing conditions, an urban cross-section was applied to all ROWs, except for Lyons Lane, which features a rural cross-section characterized by the absence of curb and gutter and the presence of ditches. The Town's design guidelines, along with aerial imagery, were used to define the standard cross-sections used in the model. South Service Road East (both west and east of Trafalgar Road) and Chartwell Road were not modeled under existing conditions, as lumped subcatchment areas were already represented in the base model (WSP, 2024).

Where the major and minor systems do not coincide, i.e., where flow paths diverge, major-minor flow splits were identified and explicitly modeled to reflect actual drainage behavior. For instance, along portions of Cross Avenue (from Argus Road to Lyons Lane) and Cornwall Road (from Old Mill Road to Cross Avenue), two parallel major system conduits were modeled, each with a half-street cross-section. This approach was adopted to reflect the fact that the major system on either side of the roadway may have separate outlets and that flow paths can diverge along the corridor. Modeling the conduits separately allows for a more accurate representation of flow splits and overland drainage behavior within these segments.

Weir elements were incorporated where necessary to simulate flow conveyance over physical barriers such as curbs. The direction of major system conduits in the model accurately reflects roadway slopes. Where two or more major system conduits converge, the model identifies these locations as low points. If a spillway is present at these low points, confirmed using LiDAR-derived topography, flow is conveyed downstream via a weir element, following the natural drainage direction based on existing elevations.

Under future conditions, the major system was updated to reflect the proposed road cross-sections and alignments within the Midtown study area. These new cross-sections have been incorporated into the model for all proposed scenario simulations.

7. Assessment of the Drainage System

The following sections discuss findings from the dual-drainage modeling under existing and future (uncontrolled) conditions. The performance of the minor and major systems has been investigated, and issues and concerns are highlighted to show specific impacts from future development on existing drainage infrastructure (i.e. minor and major). Summary tables with detailed results are provided in Appendix C.

7.1 Existing Transportation System

Midtown Oakville's existing transportation system is connected to the regional travel by direct access to the QEW and the broader provincial highway network via the Trafalgar Road and Royal Windsor Drive interchanges. The north-south Trafalgar Road corridor serves as a major north-south arterial route, connecting Midtown to broader Oakville and beyond, while Speers/Cornwall Road provides key east-west access across the Town. Trafalgar Road, north of Cornwall Road, is under the jurisdiction of Halton Region whereas Trafalgar Road, south of Cornwall Road, is a Town street. As such, this corridor requires coordinated planning and investment between both the Region and Town.

As noted in the Midtown Oakville Transportation Plan, the study area is surrounded by physical barriers that limit access and connectivity to adjacent communities. These barriers include the QEW / Highway 403 to the north, the rail corridor to the south, the Canadian National (CN) Oakville Yard sidings to the east and Sixteen Mile Creek to the west. Moreover, the Midtown area currently has limited sidewalk coverage and minimal dedicated cycling infrastructure, which restricts active transportation options.

7.2 Proposed Road Network

With the planned growth in Midtown and increased flow in traffic entering and exiting the area, a number of planned improvements as recommended from the 2014 Midtown Class EA were further validated and carried forward. Many of the improvements have been identified from the approved 2014 Midtown Class EA. New improvements include additional capacity improvements over major barriers (i.e. rail grade separation via the North-South Road extension instead of Chartwell Road). The alignment of Cross Avenue has also been updated from the previous study to align with the approved Midtown OPA (Figure 7-1). The following Table 7-1 presents information about key road right of way cross sections that were coded in the PCSWMM model.

Table 7-1. Rights-of-Way of Key Roads in Midtown

Road	Typology	Future Right-of-Way (ROW)
Cross Avenue west of North-South Road	Mobility Link	36 m
Cross Avenue east of North-South Road	Transit Corridor	30 m
Argus/Davis Road	Main Street	26 m
Local Roads	Neighborhood Street	20 m

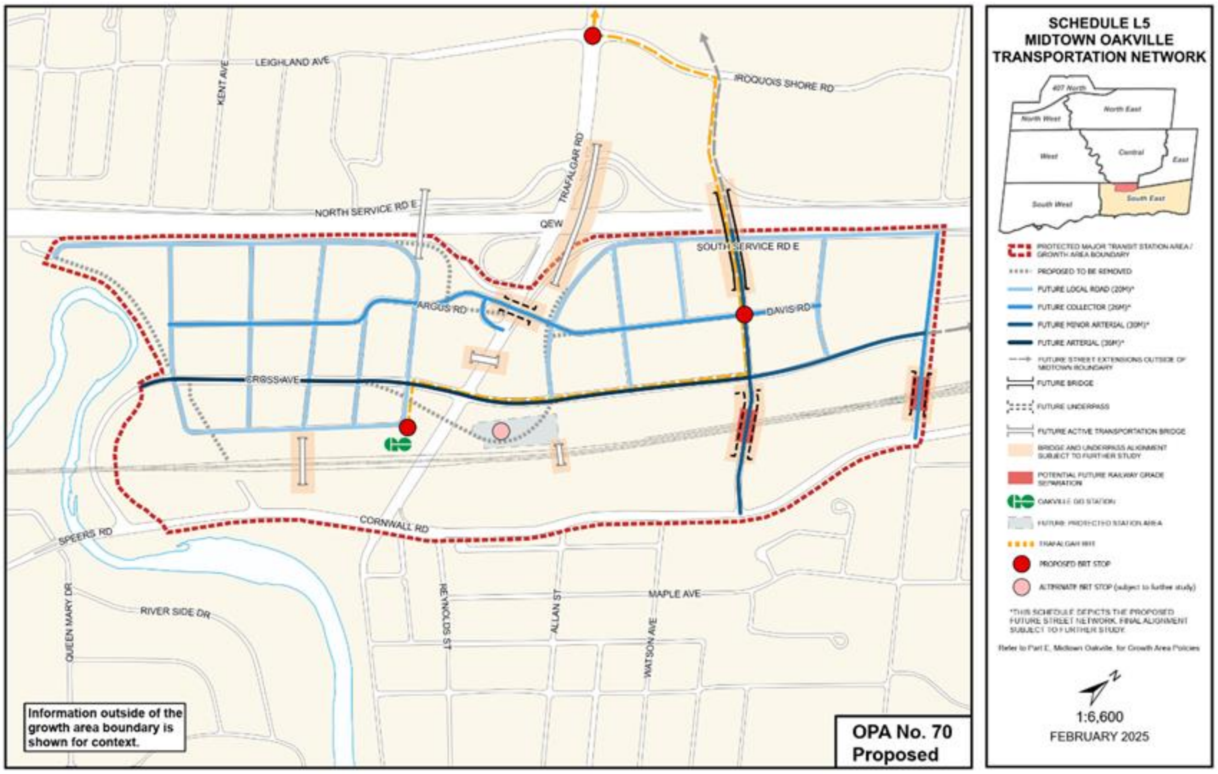

Figure 7-1. Schedule L5 – Transportation Network

7.3 Evaluation of Minor and Major Drainage Systems

As discussed in Chapter 6, the minor and major systems were coded into the PCSWMM model based on existing topography and proposed roads' alignment and cross sections. Two modeling scenarios were developed, namely existing and proposed-uncontrolled. The results of both simulations are discussed below in terms of storm sewer pipe capacity and surface ponding.

7.3.1 Minor System Performance under Existing Conditions

As previously discussed, the minor drainage system was modelled based on available as-built drawings. Where pipe data was unavailable, reasonable assumptions were applied as per Section 4.3 of this report.

7.3.1.1 Pipe Capacity and Surcharge

Simulation results from the 24-hour Chicago 5-year design storm indicate the following:

- Argus Road/South Service Road East to Sixteen Mile Creek Outfall near Lyons Lane via Cross Avenue:
    - Storm sewer pipes in this segment range in size from 300 mm to 1200 mm in diameter. Under existing conditions, approximately 75% of the pipes are fully surcharged (Max Depth / Full Depth >= 100%), indicating that they are operating at full capacity. An additional 10% of the pipes, while not fully surcharged, are flowing at more than 85% of their full depth.
- Cross Avenue to Trafalgar Road (under the bridge) to Sixteen Mile Creek outfall via Cornwall Road:

    - Storm sewer pipes in this segment range in size from 300 mm to 1200 mm. Under existing conditions, approximately 73% of the pipes are fully surcharged, and 4% of the remaining pipes are flowing at more than 85% of their full depth. The storm sewer system along Trafalgar Road between Cross Avenue and Cornwall Road seem to have insufficient capacity to convey the flow.

- Cornwall Road between Chartwell Road and Trafalgar Road:
    - Storm sewer pipes in this segment range in size from 300 mm to 525 mm in diameter. The dual-drainage system at this location was modeled and included in the baseline model (WSP, 2024). Simulations results indicate that even under the 5-year design event, all pipes are fully surcharged (Max Depth / Full Depth > 100%). This condition is primarily attributed to backwater effects from downstream Morrison Creek West, which restricts flow capacity of the upstream pipes and causes surcharge.

Hydraulic profiles for the storm sewer pipe segments are provided in Appendix D.

7.3.2 Major System Performance under Existing Conditions

The dual-drainage modeling approach enables the estimation of flow depths above ground, particularly at on-grade and in-sag catch basins located in low-lying areas. In this section, these flow depths represent baseline conditions when compared with results from the future-uncontrolled and future-controlled scenarios.

7.3.2.1 Surface Ponding

Under the Chicago 24-hour, 100-year design storm event, simulation results were analyzed to assess surface ponding across the study area. In this assessment, flow depths exceeding 15 cm at on-grade catch basins, and flow depths exceeding 30 cm at in-sag catch basins located at low points were flagged as they may result in curb overtopping or flow spillover to adjacent areas depending on site topography.

Key results are as follows:

- **Argus Road / South Service Road East:** Surface ponding ranged from 14 cm to 16 cm above on-grade catch basins and reached 29 cm at the low point.
- **Cross Avenue (Lyons Road to Trafalgar Road):** Ponding depths ranged from 8 cm to 34 cm above on-grade catch basins, indicating unacceptable conditions. No in-sag catch basins were identified in this segment.
- **Oakville GO parking lot** (east side near vegetated slope to Trafalgar Road under bridge): Ponding depths ranged from 11 cm to 29 cm across both on-grade and in-sag catchbasins.
- **Trafalgar Road (between Cross Avenue and Cornwall Road):** Surface ponding ranged from 16 cm to 1.4 m above on-grade and in-sag catch basins. The minor system connected to the in-sag catch basins under the bridge appears to lack capacity, resulting in significant ponding at low points. This bottleneck also affects upstream areas, contributing to ponding at Cross Avenue and Trafalgar Road intersection.
- **Cornwall Road** (east of Trafalgar Road, from south of the baseball diamond to north of Inglehart Street North): Ponding depths ranged from 7 cm to 42 cm above on-grade catch basins and from 38 cm to 97 cm above in-sag catch basins at low points, which are considered unacceptable.

Appendix E provides detailed results and surface ponding depth maps.

7.3.3 Minor System Performance under Future-uncontrolled Conditions

7.3.3.1 Overview

Under the future-uncontrolled scenario, which includes all planned developments and proposed roads within the study area, the dual-drainage system was further expanded to incorporate future local and major roads.

In accordance with to the Town's Development Engineering Procedures and Guidelines Manual (2023), a minimum pipe diameter of 300 mm and a minimum slope of 0.5% were applied for all new storm sewer pipes. The existing stormwater pipe segments from Argus Road to Cross Avenue and then to the Sixteen Mile Creek outfall, as well as from Cross Avenue through Trafalgar Road to the Cornwall Road outfall to Sixteen Mile Creek, remain unchanged.

It is expected that existing drainage patterns will be maintained in the future scenarios, eventually discharging into the same existing outlets (i.e., Sixteen Mile Creek, Morrison Creek East, or Morrison Creek West).

7.3.3.2 Pipe Capacity and Surcharge

- **South Service Road East to Sixteen Mile Creek Outfall near Lyons Lane via Cross Avenue:**
    - Storm sewer pipes in this segment range in size from 450 mm to 1200 mm in diameter. Simulation results indicate that approximately 62% of the pipes will be fully surcharged (Max Depth / Full Depth ≥ 100%), operating at full capacity. An additional 8% of the pipes, while not fully surcharged, are flowing at more than 85% of their full depth.
- **Cross Avenue to Trafalgar Road (under the bridge) to Sixteen Mile Creek outfall via Cornwall Road:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1200 mm in diameter. Approximately 73% of the pipes are fully surcharged, and 4% of the remaining pipes are flowing at more than 85% of their full depth. Overall, surcharge conditions have not changed compared to existing conditions and the storm sewer system along Trafalgar Road between Cross Avenue and Cornwall Road seems to have insufficient capacity to convey the flow, with downstream bottlenecks contributing to surcharge in upstream segments.
- **Cornwall Road between Chartwell Road and Trafalgar Road:**
    - Storm sewer pipes in this segment range in size from 300 mm to 525 mm in diameter. Simulation results indicate that even under the 5-year design event, all pipes are fully surcharged (Max Depth / Full Depth > 100%). This condition is primarily attributed to backwater effects from downstream Morrison Creek West, which restricts flow capacity of the upstream pipes and causes surcharge. Overall, surcharge conditions have not changed compared to existing conditions.
- **Proposed Argus Road to Sixteen Mile Creek Outfall Via Cross Avenue:**
    - Storm sewer pipes in this segment range in size from 675 mm to 1200 mm in diameter. Approximately 54% of the pipes are fully surcharged, and 8% of the remaining pipes are flowing at more than 85% of their full depth.

- **South Service Road East (East of Trafalgar) to Morrison Creek West:**
    - Storm sewer pipes in this segment range from 450 mm to 1500 mm in diameter. Approximately 43% of the pipes are fully surcharged, and the remaining pipes are flowing at less than 85% of their full depth.
- **Proposed North-South Connector to Davis Road (East of Trafalgar) and to Morrison Creek West:**
    - This system collects runoff from the proposed North-South Connector north of Davis Road, continues through Davis Road, intersects with South Service Road East and Cross Avenue, and ultimately discharges to Morrison Creek West located north of the railway and east of Trafalgar Road. Storm sewer pipes in this segment range in size from 300 mm to 1500 mm in diameter. Approximately 10% of the pipes are fully surcharged, and 30% of the remaining pipes are flowing at more than 85% of their full depth.
- **Proposed Cross Avenue (East of Trafalgar) to North-South Connector Underpass:**
    - Storm sewer pipes in this segment range in size from 450 mm to 600 mm in diameter. Simulations results indicate that even under the 5-year design event, all pipes are fully surcharged (Max Depth / Full Depth > 100%).
- **Proposed Cross Avenue (East of Trafalgar) to Morrison Creek West:**
    - Storm sewer pipes in this segment range in size from 825 mm to 1500 mm in diameter. All pipes are operating under free-flow conditions with no surcharge observed. The minor system discharges to Morrison Creek, located north of the railway and east of Trafalgar Road.
- **Proposed South Service Road East to Chartwell and Morrison Creek East:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1200 mm in diameter. Approximately 20% of the pipes are fully surcharged, and 7% of the remaining pipes are flowing at more than 85% of their full depth. This system collects runoff from the proposed South Service Road East and Chartwell Road and ultimately discharges to Morrison Creek East just north of the Maple Avenue and Linbrook Road intersection. It should be noted that the proposed dual-drainage system is connected to the existing dual-drainage system modeled in the baseline model (WSP, 2024) at Chartwell Road south of the railway corridor, prior to discharging to the creek.
- **Proposed Cross Avenue (East of Trafalgar) to Morrison Creek East:**
    - Storm sewer pipes in this segment are 525 mm in diameter. Simulations results indicate that even under the 5-year design event, all pipes are fully surcharged (Max Depth / Full Depth > 100%). This condition is primarily attributed to backwater effects from downstream Morrison Creek East, which restricts flow capacity of the upstream pipes and causes surcharge.

7.3.4 Major System Performance under Future-uncontrolled Conditions

The proposed road profiles and cross sections, as per the Transportation Plan, were used to identify low points and longitudinal slopes. Where elevation data was missing, appropriate engineering judgment was applied to ensure model connectivity and to maintain positive and consistent drainage patterns.

7.3.4.1 Surface Ponding

Under the Chicago 24-hour, 100-year design storm event, simulation results were analyzed to assess surface ponding across the study area. Key results are as follows:

- **Argus Road**: Surface ponding ranged from 8 cm to 19 cm above on-grade catch basins, indicating unacceptable conditions. Surface ponding reached 15 cm at the low point.
- **Cross Avenue West (Lyons Road to Trafalgar Road):** Ponding depths ranged from 8 cm to 23 cm above on-grade catch basins, indicating unacceptable conditions. No in-sag catch basins were identified in this segment.
- **Oakville GO parking lot** (Proposed utility blocks north of the Railway Corridor West of Trafalgar Road): Ponding depths ranged from 13 cm to 21 cm across both on-grade and in-sag catch basins.
- **Trafalgar Road (between Cross Avenue and Cornwall Road):** Surface ponding ranged from 9 cm to 1.48 m above on-grade and in-sag catch basins, indicating unacceptable conditions similar to existing conditions. The minor system connected to the in-sag catch basins under the bridge appears to lack capacity, resulting in significant ponding at low points. This bottleneck also affects upstream areas, contributing to ponding at the Cross Avenue and Trafalgar Road intersection.
- **Argus/Davis Road, North-South Connector, and Chartwell Underpasses:** Surface ponding depths of 44 cm, 1.51 m, and 62 cm were observed at the Argus/Davis Road, North-South Connector, and Chartwell underpasses, respectively, indicating unacceptable conditions. These ponding depths are primarily caused by downstream bottlenecks in the minor system and backwater effects from the receiving creeks, which contribute to significant surface ponding and potential above-ground flooding in these areas.
- **Davis Road East of Trafalgar:** Surface ponding ranged from 7 cm to 30 cm above on-grade catch basins, indicating unacceptable conditions. Surface ponding reached 33 cm at the low point.
- **Proposed Cross Avenue (From Trafalgar Road to Chartwell Road):** Surface ponding ranged from 3 cm to 27 cm above on-grade catch basins, indicating unacceptable conditions. Surface ponding ranged from 12 to 31 cm at the low points.
- **Cornwall Road** (east of Trafalgar Road, from south of the baseball diamond to north of Inglehart Street North): Ponding depths ranged from 6 cm to 40 cm above on-grade catch basins and from 28 cm to 95 cm above in-sag catch basins at low points, which are considered unacceptable.

Please refer to Appendix E for the modeling schematic illustrating surface ponding depths across the study area.

8. Downstream Impact Assessment

In the preceding chapter, the minor and major drainage systems were analyzed, and areas of concerns were highlighted. In this chapter, the peak flows under existing and future-uncontrolled scenarios are examined at the receiving watercourses.

8.1 Overview

The regulatory storm model for the Lower Morrison Creek has been based on the Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993), in which future conditions flow rates were used for regulatory mapping. As part of the 1993 study, the regulatory flood model and flood hazard mapping were simulated using the OTTHYMO modeling software. The results confirm that the 100-year storm is greater than the regional storm along the upper portions of the Lower Morrison Creek (which includes the Midtown area). Consequently, the 100-year storm event has been considered as the Regulatory Flood for Midtown Oakville.

The original model (OTTHYMO-89) has recently been converted into Visual Otthymo (VO 6.2) as part of the Sixteen Mile to Lower Morrison Creek Flood Hazard Mapping Study (CH, 2025). Appendix G includes a review of the converted regulatory model.

For Sixteen Mile Creek, the regulatory model has not been used as floodlines are generally contained within a confined valley, and the Midtown area is noted to represent a small portion of the total drainage area to Sixteen Mile Creek. The downstream impact assessment was completed by comparing peak flows between existing, future-uncontrolled and future-controlled conditions at the outfalls. The results can be found in Appendix F.

8.2 Future-uncontrolled Peak Flow Comparison

For the Lower Morrison Creek, peak flow rates under both the 100-year storm and the regional storm events were extracted from the VO 6.2 model at relevant locations. These peak flows were then compared with peak flows from the PCSWMM model at the same locations. Table 8-1 shows the results.

Table 8-1. Peak Flow Comparison Summary

Flow Node	Flow Node Location	Proposed-Uncontrolled Condition Peak Flows (m3/s)			
		100-Year		Regional	
		PCSWMM	VO	PCSWMM	VO
Tee15_LMC (**ADDHYD 14**)	West Tributary	17.426	**24.683**	14.871	**16.117**
J2353.323 (**ADDHYD 19**)	West Tributary south of Maple	19.667	**25.697**	17.171	**17.678**
J165 (**ADDHYD 20**)	East Tributary	21.136	**18.019**	16.334	**9.456**
J867.2666 Through M1 (**RouteChannel25**)	Main Branch at the Confluence	41.376	**34.04**	37.479	**32.17**

Table 8-1 shows that peak flows in the PCSWMM model are generally lower at the upstream end and higher at the downstream end compared with the reconstructed CH VO model. A key reason for the upstream discrepancy is that the Lower Morrison VO model (1993 study) included a larger drainage area—specifically, portion of Catchment M8 between the QEW and Cornwall Road, as illustrated in Figure 8-1 below and Appendix G. This portion of Catchment M8, however, has been confirmed in both the present study and the Flood Mitigation Opportunities Study (WSP, 2024) as part of the Sixteen Mile Creek Subwatershed. Consequently, peak flows for the 100-year and regional storm events were overstated in the VO model relative to the PCSWMM model.

At the downstream end, the opposite was observed: lower flows in the VO model compared to the PCSWMM model. This could be attributed to that the VO model had underestimated the contributing drainage areas from the East Tributary (i.e. Catchment M3 in Figure 8-1, Appendix G), resulting in lower peak flows generated from that branch, and consequently increasing the flow rates at the confluence.

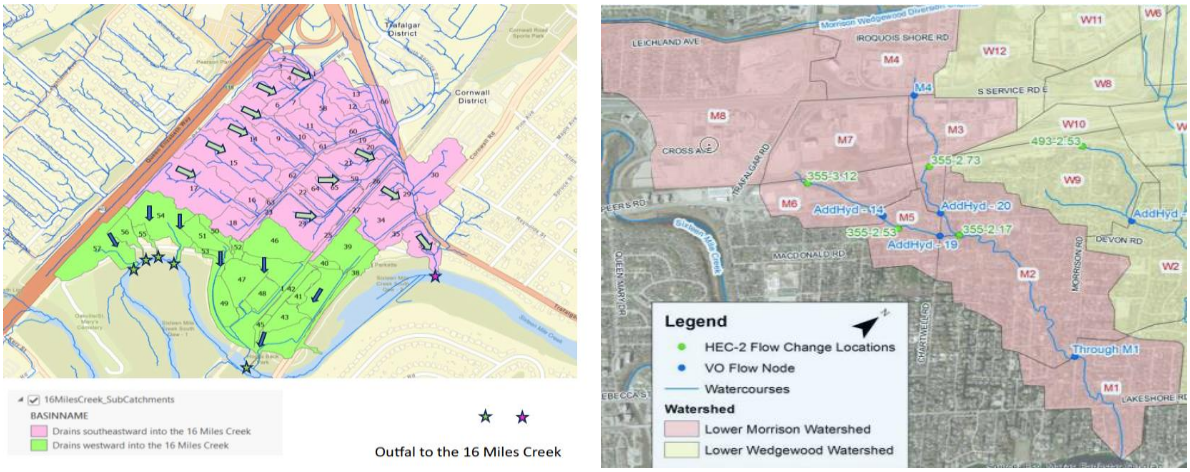

Figure 8-1. Differences between Catchment Delineation in the Regulatory Model/1993 Study (Right) and Midtown SWM Plan (Left)

8.3 Modeling Assumptions and Impact on Peak Flows

As noticed in Table 8-1, the results of the PCSWMM model do not agree with those in the regulatory model. In addition to the differences in catchment delineation and drainage patterns between the two models (Figure 8-1), the following needs to be considered when comparing the PCSWMM results to Conservation Halton's regulatory model:

- The Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993) investigated flood risk and erosion along the downstream system and recommended overcontrol measures to mitigate flooding and erosion issues downstream of the study area. More specifically, the 1993 study recommended that, until more detailed modeling is conducted, post-development peak flow rates should be limited to 50% or 70% of pre-development levels where erosion is not a concern.

- The PCSWMM model, utilized in the Midtown SWM Plan, is a detailed dual-drainage model that integrates elements from major and minor drainage systems, resulting in routing more flows along the Rights of Ways, which may have impacted the attenuation of peak flows from source to outfall locations.
- Hydrological parametrization in the PCSWMM model, specifically imperviousness values under existing conditions are different from those assumed in the regulatory model. Specifically, under future conditions, the PCSWMM model has relatively similar imperviousness values compared to existing conditions.
- The main purpose of the PCSWMM model is to characterize and assess drainage and stormwater management within the Midtown area. Therefore, it should not be used for Regulatory purposes or to define Regulatory floodplain limits.

9. Identification and Evaluation of Alternatives

Identifying and evaluating alternative solutions represents the core of Phase 2 of the Midtown SWM Master Plan. In this chapter, a short list of alternatives is presented and then screened based on a set of criteria that includes engineering, natural environment, social/cultural and cost. Finally, a detailed technical evaluation is completed using the PCSWMM model to confirm and verify stormwater management targets across Midtown Oakville.

9.1 Short List of Alternative Solutions

Three (3) alternatives were considered to mitigate drainage deficiencies and address stormwater quantity and quality control across the Midtown area:

- **Alternative 0: Business as Usual**: This alternative serves as a baseline for all alternatives and includes committed and planned projects
- **Alternative 1: Storage and Conveyance:** This alternative includes storage and conveyance measures with focus on detention and peak flow attenuation:
    - Underground Storage Facilities: These measures include manufactured storage facilities that could provide stormwater quantity management (peak flow control). Their implementation may take place within private properties and within parks and open spaces.
    - Conveyance improvement measures: These measures include pipe upsizing and super pipes to control peak flows along the Right of Way
- **Alternative 2: Storage, Conveyance and Green Infrastructure:** In addition to conveyance improvements and underground storage, Green Infrastructure (GI) and Low Impact Development (LID) can provide storm quality management and runoff volume reduction in addition to runoff quantity control. Green Infrastructure measures are proposed as part of a Treatment Train approach, whereby it can be implemented within private properties and in the public realm. Types of green infrastructure measures considered for implementation within the Right of Way, include Bioretention systems, Stormwater tree pits, and permeable surfaces.

9.2 Evaluation of Alternative Solutions

In support of the selection of alternative solutions and best approaches to manage stormwater quantity and quality, a multi-criteria analysis has been undertaken. The multi-criteria analysis integrates various environmental, engineering, and socio-economic concerns and considerations. It also investigates physical constraints that could hinder the implementation of certain SWM options. Four (4) sets of evaluation criteria were established, based on municipal, environmental and regulatory objectives. A total of twelve (12) indicators were used to assess alternative solutions and select preferred stormwater management measures at various scales.

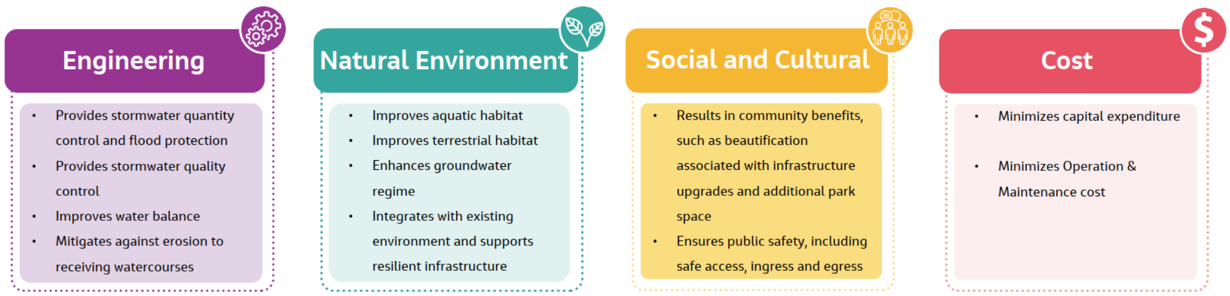

Figure 9-1. Evaluation Criteria

Key inputs to the multi-criteria evaluation exercise included the following:

- Stormwater planning context within Midtown Oakville, including municipal and provincial policies and guidelines;
- Assessment of the Drainage System (Chapter 7), including our understanding of the performance of the major and minor systems under existing and future-uncontrolled conditions; and
- Public input from two Public Information Centers (Appendix H), including public preference and ranking of traditional and innovative stormwater management measures presented as part of PIC 4 and PIC 5.

The three alternatives were screened from Least Preferred to Most Preferred. Based on the results of this semi-quantitative evaluation, the most preferred alternative was carried forward for implementation.

○ Least Preferred ◑ Less Preferred ● Most Preferred

	Description	Engineering	Natural Environment	Social and Cultural	Cost
Business as Usual "Base Scenario"	**Planned "Business as Usual" (BAU) Improvements** • Committed and planned projects • Serves as a "base" for all alternatives	○	○	○	●
Alternative #1	**Conveyance + Storage:** Onsite Control on Private Properties and Increasing Storm Sewer Capacity along ROW	◑ Improves conveyance and runoff quantity control but lacks water quality and water balance control	◔ As this option mostly deals with conveyance, it does not improve linkages with aquatic and terrestrial habitat	◔ Provides limited healthy living opportunities. Does not add to beautification. Received lowest score in previous PIC	◕ Low to moderate capital and maintenance costs.
Preferred Alternative #2	**Conveyance, Storage and Green Infrastructure:** Combination of Stormwater Control Measures	● Improves water quality and balance, mitigate erosion in conjunction with conveyance control	● Improves aquatic and terrestrial habitat and integrates with the natural environment	◕ Provides healthy living opportunities and beautification. May require more social awareness	◑ Moderate to high capital and maintenance costs. May require additional costs for integrating with conveyance measures

Figure 9-2. Screening of Alternative Solutions and Selection of Preferred Alternative

9.3 Detailed Description of the Preferred Alternative

As presented in Figure 9-2, Alternative 2 was carried forward as the preferred alternative (solution). The preferred alternative follows a Treatment-Train approach and includes conventional stormwater management measures (e.g. pipe upsizing) and innovative LID measures (e.g. soil cells and permeable pavement). More specifically, this alternative can be broken down into the following key components:

- **Stormwater management measures within Private Properties:**
    - Onsite quantity control (e.g. underground storage facilities)
    - Onsite water balance control/erosion control, including implementing Green Infrastructure / LID measures within private properties based on feasibility and site restrictions.
    - Onsite quality control, including Manufactured Treatment Devices (MTDs): Oil and Grit Separators (OGS) units, CB Shields and Green Infrastructure / LID measures based on feasibility and site restrictions.
- **Stormwater management measures along the Right of Way (RoW)**
    - Conveyance quantity control: Pipe upsizing and Super Pipes
    - Green Infrastructure / LID, including soil cells, permeable pavement, stormwater planters, infiltration where appropriate (Refer to Chapter 11 for more detail)
    - Manufactured Treatment Devices (MTDs): These measures include Oil and Grit Separators (OGS) units, CB Shields and are used to enhance stormwater treatment performance and control runoff quality. According to provincial and municipal water quality criteria, 80% TSS removal efficiency is required as a minimum.
- **Stormwater management measures within Public Parks**
    - Offline quantity control (e.g. underground storage facilities)
    - Offline green Infrastructure, including soil cells and permeable pavement.

Table 9-1 presents a breakdown of these measures with the type of infrastructure and control target. These measures are based on best common practice and technical guidelines, including the Low Impact Development Stormwater Management Planning and Design Guide (TRCA, 2010) and the Draft Low Impact Development Stormwater Management Guidance Manual (MECP, 2022).

As indicated below, SWM measures across the study area, including within private properties, along the RoW, and within parks, are proposed to achieve quantity control targets, quality control, water balance and erosion control targets. This will be done using various mechanisms and types of infrastructure that have been implemented at different scales and within various municipal boundaries in Ontario.

Table 9-1. Breakdown of the Preferred Alternative, Type of Infrastructure and Control Target

Preferred Alternative / SWM Measure	Type of Infrastructure	Quantity Control Target	Quality Control Target	Water Balance and Erosion Target **
Stormwater management measures within Private Properties	Underground storage facilities ***	Yes	N/A	Yes
	Green Infrastructure/ LID measures	Yes	Yes	Yes
	OGS units and CB Shields	N/A	Yes	N/A

Preferred Alternative / SWM Measure	Type of Infrastructure	Quantity Control Target	Quality Control Target	Water Balance and Erosion Target **
Stormwater management measures along the Right of Way (RoW)	Pipe upsizing, Super Pipes	Yes	N/A	N/A
	Green Infrastructure / LID	Yes	Yes	Yes
	OGS units and CB Shields	N/A	Yes	N/A
Stormwater management measures within Public Parks	Underground storage facilities	Yes	N/A	Yes
	Green Infrastructure / LID	Yes	Yes	Yes

** It is common practice to treat water balance and erosion control as a single target, particularly when they share the same storm event or runoff volume reduction criteria. Since both use the 25 mm storm event as the basis for evaluation, they are grouped under the same entry. This approach is supported by conservation authorities in Ontario, including Conservation Halton.

*** Underground storage facilities are assumed to have active storage for quantity control and dead storage for retention (including water reuse) opportunities.

9.4 Evaluation of the Preferred Alternative - Controlled Scenario

In this chapter, the performance of Alternative 2 and its proposed SWM measures will be analyzed and discussed in terms of municipal and provincial targets, including quantity control, water balance and erosion control, and downstream impact on the receiving watercourses. Summary tables of results are provided in Appendix C.

Figure 9 below shows the breakdown of the catchment areas (Midtown Oakville and external catchments) in which the SWM targets and criteria are evaluated. Accordingly, SWM control assumptions and target setting will apply not only to the Midtown area, but also to the external catchments, including those between the QEW and the Diversion Channel and the two catchments east of Chartwell Road. Catchments north of the Diversion Channel, along the Morrison Creek were not included in this analysis.

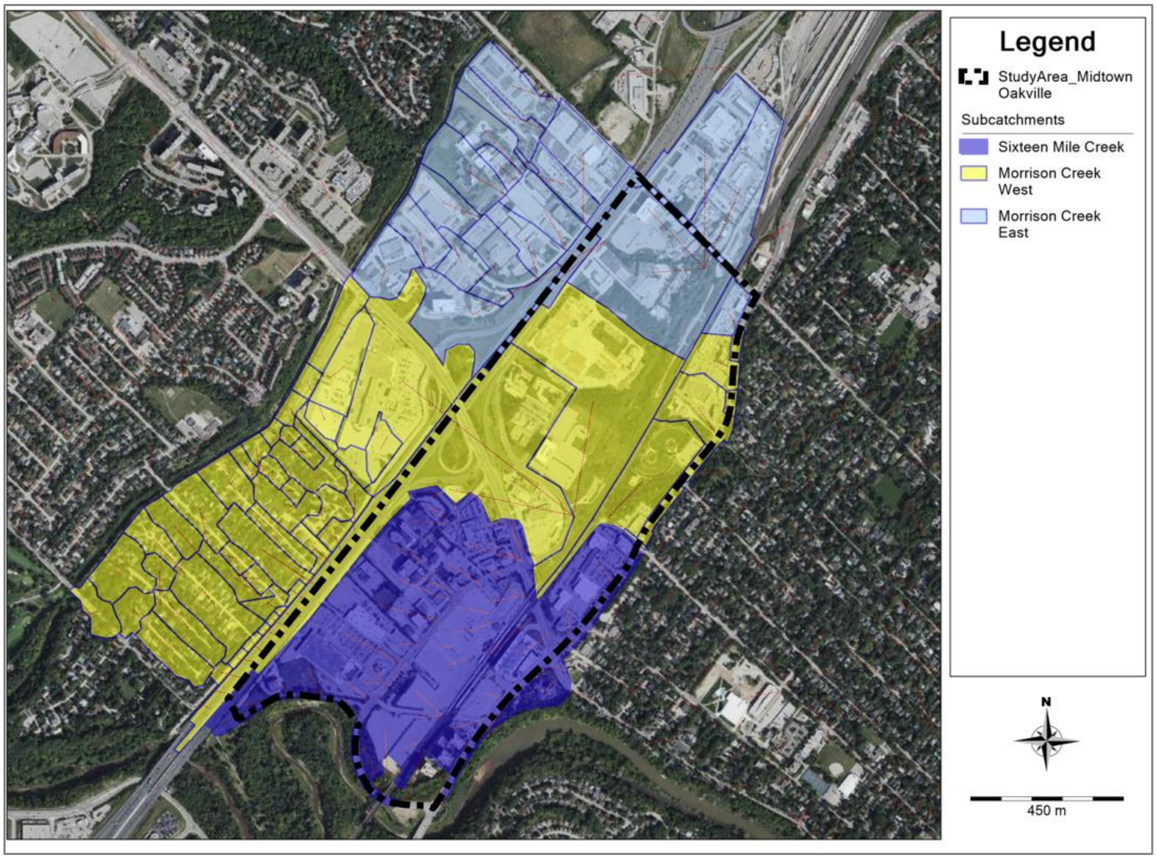

Figure 9-3. Catchment Areas (Midtown Oakville and External Catchments) in which the SWM Targets and Criteria are Evaluated

9.4.1 Quantity Control

The Lower Morrison/Wedgewood Creeks Flood, Erosion and Master Drainage Plan (R.V. Andreson,1993) had found that the 100-year storm was greater than the regional storm along the upper portions of the Lower Morrison Creek and therefore should be considered as the Regulatory Flood for the Midtown area. This has been confirmed after reviewing the reconstructed Conservation Halton (CH) Visual OTTHYMO (VO) regulatory model (Conservation Halton, 2024) and comparing the results with the PCSWMM future-uncontrolled scenario (Chapter 8 and Appendix G).

To provide the necessary 100-year storage requirement, thirty (30) stormwater storage facilities have been strategically distributed across the three delineated subwatersheds within Midtown Oakville. Specifically, ten (10) facilities are situated within the Sixteen Mile Creek subwatershed, twelve (12) within the Lower Morrison Creek West subwatershed, and eight (8) within the Lower Morrison Creek East subwatershed.

The implementation of these storage facilities is intended to achieve the following objectives:

- Reduce surcharge and increase pipe capacity downstream of future development
- Reduce surface ponding depths to existing levels or lower along road rights-of-way, including at on-grade and in-sag catch basins, underpasses, and overland flow routes.
- Mitigate downstream impact on the receiving watercourses:
- Mitigate peak flows at the Sixteen Mile Creek outfalls

- Meet peak flow targets for Lower Morrison Creek East and West based on the reconstructed Conservation Halton (CH) Visual OTTHYMO (VO) regulatory model downstream of the study area.

Due to the wide scale of this SWM Plan and the lack of block-by-block grading information for the future development, the PCSWMM model has adopted a centralized SWM strategy, as opposed to a block-by-block approach. Each facility was designed to manage runoff from a combination of private developments and public lands, including municipal rights-of-way and parkland areas.

To determine unitary storage requirement for each subwatershed, the model estimates required storage volume (m^3) based on the impervious area managed by each storage facility. This volume is then normalized by the total impervious area within the subwatershed, including external catchments between QEW and Diversion Channel, to derive a unitary storage requirement expressed in m^3 per impervious hectare (m^3/imp.ha). This ensures that the modeled storage volumes are representative of all the contributing catchments and avoids over-controlling in some areas at the expense of other areas.

For the Sixteen Mile Creek subwatershed, the model estimates that a total of 3,111.9 m^3 of storage is required to manage surface runoff from approximately 20.89 hectares of impervious area. To account for the entire subwatershed, which contains 42.60 hectares of impervious cover, the resulting unitary storage requirement would be 73.1 m^3/imp.ha.

For the Lower Morrison Creek West subwatershed, the model estimates that a total of 12,213.8 m^3 of storage is required to control runoff from 22.80 hectares of impervious area. To account for the entire subwatershed, which contains an impervious area of 29.77 hectares results in a unitary storage requirement of 410.3 m^3/imp.ha.

For the Lower Morrison Creek East subwatershed, the model estimates that a total of 11,139.5 m^3 of storage is required to manage runoff from 21.94 hectares of impervious surface. The total impervious area in this subwatershed is 24.13 hectares, yielding a unitary storage requirement of 461.7 m^3/imp.ha. It is important to note that two external subcatchments (SLMC_67_1 and SLMC_68) with a combined impervious area of 10.405 ha, contribute runoff to the Midtown study area. These flows drain toward Chartwell Road and ultimately discharge into Lower Morrison Creek East. These external catchments are managed by SWM Facility 21.

The minimum storage volumes identified for each subwatershed must be satisfied by all future developments within the Midtown area and the external catchment areas as shown in Figure 9-3, including private properties and road rights-of-way to ensure consistency with the study's overarching objectives. Detailed storage calculations for each modeled facility are provided in Appendix F.

The minimum storage requirements are summarized in Table 9-2.

Table 9-2. Quantity Control Unit Storage Requirement for Future Development

Subwatershed Area Within Midtown Oakville	Total Quantity Storage Required (m^3)	Total Impervious Area (ha)	Unitary Storage for Quantity Control (m^3/Imp. ha)
Lower Morrison East	11139.5	52.606	211.8
Lower Morrison West	12213.8	61.176	199.7
Sixteen Mile Creek	3111.9	42.60	73.1

The unitary storage rates, presented in Table 9-2, should be applied to the areas shown in Figure 9, which includes the Midtown Oakville area according to the OPA in addition to external drainage areas north of

QEW and south the Diversion Channel, in addition to external catchments east of Chartwell Road. Section 11 of the Report provides further details on the proposed process to assess block level quantity control.

9.4.2 Water Balance

The PCSWMM model developed as part of the Midtown SWM Plan employs a Treatment Train approach, integrating both stormwater quantity control and water balance objectives. Each modeled storage facility is equipped with an outlet element configured with a tabular/head rating curve, which defines the retention depth required to infiltrate the initial 25 mm of runoff generated from contributing impervious surfaces. As soil data and infiltration values are scarce within the study area, the assumptions for site-specific infiltration rates and drawdown times should be confirmed at detailed design stages.

Any future development within the Midtown Oakville study area shall consider water balance by providing on-site retention (infiltration) of a 25 mm rainfall event. For the proposed storage facilities included in the model, a rating curve representing the capture of 25 mm of runoff from the contributing impervious area has been incorporated to account for this requirement.

Runoff volumes exceeding the retention depth are classified as extended detention storage, which is regulated through flow restrictions for the 100-year design storm event, applied to the same outlet rating curve. This dual-function outlet configuration ensures compliance with both water balance and peak flow control requirements. This approach is similar to what is being proposed in the development applications within the Midtown area. It is a practical way to address the impact of retention at a high-level stage before embarking on preliminary and detailed design for water balance features. Please refer to Appendix F for detailed information on the water balance outlet rating curves applied to each storage facility.

9.4.3 Erosion Control

In the absence of a site-specific erosion study, the detention of the 25 mm storm event may be used for stream erosion control. This approach has been implemented by Conservation Halton and other conservation authorities such as TRCA and CVC.

For the purpose of defining an erosion control target for the Midtown area and to assess the performance of the preferred alternative in achieving such a target, the 25 mm storm event was run under three scenarios: existing, future-uncontrolled and future-controlled.

Table 9-3 provides a peak flow comparison at outlets based on the 25mm event. The results show that under the future-controlled scenario, all outfalls have peak flows lower than existing, except for one instance, Outfall 16, in which future flows are higher. In the absence of site-specific information about this location and current status of channel morphology, it is difficult to ascertain if this local increase would negatively impact channel stability at that outfall.

Table 9-3. Peak Flow Comparison at Subwatershed Outlets: 25-mm Storm Event

Outlet/Flow Node ID	Location	25 mm Storm Event (m^3/s)	
		Existing	Future-controlled
OF11_54	Lyons Ln - Sixteen Mile Creek	0.21	0.195
108	Lyons Ln - Sixteen Mile Creek	0.248	0.125
91	Cross Ave - Sixteen Mile Creek	2.43	1.358
97	Cross Ave - Sixteen Mile Creek	0.046	0
10	Cross Ave - Sixteen Mile Creek	0.062	0.053
92	Cross Ave - Sixteen Mile Creek	0.069	0.013
204	Cross Ave - Sixteen Mile Creek	0	0
16	Cross Ave - Sixteen Mile Creek	0.067	0.082
217	Cornwall Rd - Sixteen Mile Creek	0.007	0.007
149	Cornwall Rd - Sixteen Mile Creek	2.392	2.026
OF2_37	Trafalgar Rd - Sixteen Mile Creek	0	0
Tee15_LMC	West Tributary	4.214	2.352
J2353.323	West Tributary south of Maple	4.512	2.684
J165	East Tributary	4.257	3.174
J867.2666	Main Branch at the Confluence	10.245	7.076

9.4.4 Minor System Performance

Under the future-controlled scenario, the minor drainage system benefits from the introduction of thirty (30) underground SWM facilities, installation of superpipes equipped with a flow control manhole structure, and upsizing of several storm sewer pipes. These measures collectively improve conveyance, mitigate risk of surcharge, and enhance peak flow control across the study area

9.4.4.1 Pipe Capacity and Surcharge

- **South Service Road East to Sixteen Mile Creek Outfall near Lyons Lane via Cross Avenue:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1800 mm in diameter. Simulation results indicate that none of the pipes would be fully surcharged (Max Depth / Full Depth ≥ 100%) and only 8% of the pipes, would be flowing at more than 85% of their full depth. Additionally, to provide post-to-pre-development peak flow control at the Sixteen Mile creek outfall (OF 91) located at Cross Avenue south of Lyons Lane, storage pipes (superpipes) with an on-line flow control manhole structure to regulate discharge to Sixteen Mile Creek, are proposed.

Table 9-4. South Service Rd to Sixteen Mile Creek Minor System Upgrades

Pipe Model ID	Existing Size (mm)	Proposed Size (mm)	Notes
14	450	750	One segment upsized; length: 40.5 m
15 and 16	600	750	Two segments upsized; length: 82 m
17 and 8	675	750	Two segments upsized; length: 85 m
12,13,18-21,7_1 and 7_2	750 - 1050	1500 - 1800	~500 m replaced with circular superpipes; slope range: 0.1% to 0.2%

- **Cross Avenue to Trafalgar Road (under the bridge) to Sixteen Mile Creek outfall via Cornwall Road:**
    - Storm sewer pipes along this segment range in size from 300 mm to 1200 mm in diameter. Simulation results indicate that approximately 54% of the pipes would be fully surcharged (Max Depth / Full Depth > 100%), while an additional 12% will be flowing at more than 85% of their full depth. Simulation results indicate that approximately 54% of the pipes will be fully surcharged (Max Depth / Full Depth > 100%), while an additional 12% would be flowing at more than 85% of their full depth. Compared to existing and future-uncontrolled conditions, surcharge levels are expected to improve due to the implementation of upstream stormwater management facilities and measures. However, the system along Trafalgar Road between Cross Avenue and Cornwall Road would continue to exhibit insufficient capacity, with downstream bottlenecks contributing to upstream surcharge even under the 5-year design storm. It is strongly recommended that the existing storm sewers beneath the Trafalgar Road bridge be assessed in detail and upsized where feasible to enhance minor system performance.
- **Cornwall Road between Chartwell Road and Trafalgar Road:**
    - Storm sewer pipes in this segment range in size from 300 mm to 525 mm in diameter. Simulations results indicate that even under the 5-year design event, all pipes are expected to be fully surcharged. This condition is primarily attributed to backwater effects from downstream Morrison Creek West, which restricts flow capacity of the upstream pipes and causes surcharge. Overall, surcharge conditions are not expected to deteriorate compared to both existing and future-uncontrolled conditions.
- **Proposed Argus Road to Sixteen Mile Creek Outfall Via Cross Avenue:**
    - Storm sewer pipes within this segment range in size from 600 mm to 1800 mm in diameter, including the previously described superpipes. Simulation results confirm that none of the pipes would be fully surcharged and only 14% would be flowing at more than 85 of their full depth. These results indicate a considerable improvement in surcharge conditions compared to the future-uncontrolled scenario.
- **South Service Road East (East of Trafalgar) to Morrison Creek West:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1500 mm in diameter. Simulation results confirm that none of the pipes would be fully surcharged, and all remaining pipes would be operating below 85% of their full depth. In this scenario, several pipe sizes were optimized and reduced as opposed to the uncontrolled scenario, as the system can convey the design flows without triggering surcharge conditions. These results indicate a significant improvement in minor system performance compared to the uncontrolled scenario.

- **Proposed North-South Connector to Davis Road (East of Trafalgar) and to Morrison Creek West:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1500 mm in diameter. Simulation results confirm that none of the pipes would be fully surcharged and only 10% would be flowing at more than 85 of their full depth. These results indicate a significant improvement in minor system performance compared to the uncontrolled scenario, reflecting the positive impact of proposed upstream SWM measures.
- **Proposed Cross Avenue (East of Trafalgar) to North-South Connector Underpass and then to Morrison Creek West:**
    - Storm sewer pipes in this segment range in size from 450 mm to 1050 mm in diameter. Simulation results confirm that none of the pipes in this segment would be fully surcharged, and all remaining pipes would be operating below 85%*of their full depth, indicating a marked improvement in minor system performance compared to the uncontrolled scenario.
    - Under the future controlled scenario, proposed road grading and elevation data indicate that the North-South connector underpass sits approximately 4 meters below the ground elevation of Cornwall Road, just south of the baseball diamond. As a result, gravity-based connection from the underpass to the existing storm system on Cornwall Road is not feasible and would require a pumped system. However, the minor system along Cornwall Road between Chartwell Road and Trafalgar Road is already operating at full capacity, and connecting additional flow from the underpass to this system is not recommended. To address this concern, a wet well with pumps and a forcemain are proposed to convey flow from the underpass to a proposed swale located east of the baseball diamond. This swale then runs parallel to the north side of Cornwall Road (south of baseball diamond) and ultimately discharges to Morrison Creek West. It should be noted that the wet well, pump and forcemain configuration is based on a preliminary design, and further detailed design analysis may be conducted as needed.
- **Proposed Cross Avenue (East of Trafalgar) to Morrison Creek West:**
    - Storm sewer pipes in this segment range in size from 825 mm to 1500 mm in diameter. All pipes are expected to operate under free-flow conditions with no surcharge. The minor system discharges to Morrison Creek, located north of the railway and east of Trafalgar Road.
- **Proposed South Service Road East to Chartwell and Morrison Creek East:**
    - Storm sewer pipes in this segment range in size from 300 mm to 1200 mm in diameter. Simulation results confirm that none of the pipes in this segment would be fully surcharged, and only 13% of the remaining pipes would be flowing at more than 85% of their full depth. These finding indicate a slight improvement in surcharge conditions compared to the uncontrolled scenario.
- **Proposed Cross Avenue (East of Trafalgar) to Morrison Creek East:**
    - Storm sewer pipes in this segment range in size from 600 mm to 675 mm in diameter. Simulation results confirm that none of the pipes in this segment would be fully surcharged, and only one pipe would be flowing at more than 85%. This condition is primarily attributed to backwater effects from downstream Morrison Creek East, which restricts flow capacity of the upstream pipes and causes surcharge.

Hydraulic profiles for the storm sewer pipe segments are provided in Appendix D.

9.4.5 Major System Performance

9.4.5.1 Surface ponding

Under the Chicago 24-hour, 100-year design storm event, simulation results were analyzed to assess surface ponding across the study area. Key results are as follows:

- **Argus Road:** Surface ponding depths in this area ranged from 4 cm to 10 cm above on-grade catch basins, with a maximum depth of 12 cm observed at the low point. Overall, simulation results indicate that ponding depths are expected to be within an acceptable and manageable range, demonstrating a reduction in surface flooding potential and an improvement compared to both existing and uncontrolled scenarios.

- **Cross Avenue West (Lyons Road to Trafalgar Road):** Ponding depths ranged from 5 cm to 15 cm above on-grade catch basins, demonstrating an improvement compared to both existing and uncontrolled scenarios.

- **Oakville GO parking lot** (Proposed utility blocks north of the Railway Corridor West of Trafalgar Road): Ponding depths ranged from 8 cm to 12 cm across both on-grade and in-sag catch basins.

- **Trafalgar Road (between Cross Avenue and Cornwall Road):** Surface ponding depths in this segment ranged from 9 cm to 82 cm above on-grade and in-sag catch basins, indicating unacceptable conditions. While these results still reflect capacity limitations within the minor system, particularly under the bridge, where detailed assessment is recommended, there would be a significant reduction in surface ponding compared to both the existing and future-uncontrolled scenarios. This suggests that the proposed SWM measures would have a positive impact, although further refinement may be required to fully address localized constraints.

- **Argus/Davis Road, North-South Connector, and Chartwell Underpasses**: Three proposed critical underpasses are located within the Midtown area. Surface ponding depths of 23 cm, 0.13 m, and 20 cm were observed at the Argus/Davis Road, North-South Connector, and Chartwell underpasses, respectively. These depths fall within acceptable limits and represent a clear improvement compared to the uncontrolled scenario. This reduction in ponding is attributed to the stormwater management measures implemented in the model, as explained earlier in this report.

- **Davis Road East of Trafalgar:** Surface ponding ranged from 6 cm to 15 cm above on-grade catch basins. Surface ponding would reach 14 cm at the low point. These depths fall within acceptable limits and represent a clear improvement compared to the uncontrolled scenario.

- **Proposed Cross Avenue (From Trafalgar Road to Chartwell Road):** Surface ponding ranged from 4 cm to 15 cm above on-grade catch basins, indicating acceptable conditions. Surface ponding would range from 6 to 16 cm at the low points. These depths fall within acceptable limits and represent a clear improvement compared to the uncontrolled scenario.

- **Cornwall Road** (east of Trafalgar Road, from south of the baseball diamond to north of Inglehart Street North): Ponding depths ranged from 6 cm to 40 cm above on-grade catch basins and from 25 cm to 95 cm above in-sag catch basins at low points, which are considered unacceptable, however they are better than existing and future-uncontrolled conditions.

Please refer to Appendix E for the modeling schematic illustrating surface ponding depths across the study area.

9.4.6 Peak Flows Comparison

As indicated in Chapter 8, four (4) flow nodes from the Lower Morrison Creek Visual OTTHymo model (Conservation Halton, 2025) were compared to future-uncontrolled flows from the PCSWMM model. As the results showed two of these nodes (One node along Lower Morrison East and another at the confluence) had higher uncontrolled peak flows, storage volumes had to be updated and refined.

Within the Sixteen Mile Creek subwatershed, there are currently eleven (11) outfalls in the model that discharge directly to Sixteen Mile Creek. Some of these outfalls are hydraulically connected to storm sewer systems that convey runoff from upstream urban catchments, while others function as major system outlets, primarily resulting from curb overtopping and overland flow routing.

In the absence of a recent regulatory model for the Sixteen Mile Creek, peak flows under the future-uncontrolled scenario could not be compared to flows nodes along the regulatory model. This matter was discussed with Conservation Halton and it was decided that future-uncontrolled and future-controlled flows shall be compared to existing peak flows at the outfalls to confirm quantity control targets.

Table 9-5 presents a comparison of peak flows at outfalls and flow nodes under the 5 and 100-year design storm events for the existing and future-controlled scenarios.

Under the future-uncontrolled scenario, some of the outfalls observe an increase in the 5-year peak flows up to 8% compared to existing conditions. These outfalls are primarily located in the upper sections of Sixteen Mile Creek. None of the flow nodes at Lower Morrison Creek show any increases under the uncontrolled scenario. For the 100-year peak flows, the pattern is similar as there is an increase of up to 12% compared to existing conditions. None of the flow nodes at Lower Morrison Creek show any increases under the uncontrolled scenario.

Under the future-uncontrolled scenario, peak flows are often lower than existing conditions, which can be attributed to differences in modeling approaches between the PCSWMM model and earlier models, including the regulatory model (R.V. Andreson,1993). The PCSWMM framework employs more detailed catchment delineation, creating smaller, discretized drainage areas that explicitly connect the storm sewer system to the proposed roadway network. In contrast, the regulatory model relied on lumped catchments, either directly linked to Lower Morrison Creek or assumed to transfer runoff through overrun drainage between catchments. This distinction in catchment representation and flow routing results in more distributed runoff in PCSWMM, thereby reducing peak flow estimates compared to the simplified assumptions of the regulatory model.

Analysis of peak flow results under the future-controlled scenario shows a considerable reduction in peak flows compared to the existing conditions for both the 5-year and 100-year design storm events, demonstrating that the proposed mitigation measures meet the post-to-pre-development control requirements. It should be noted that while Outfall 16 under existing conditions show slightly lower peak flows than in the controlled scenario, the increase is minimal, less than 3%, and not considered significant.

Table 9-5. Peak Flow Comparison at Subwatershed Outlets: 5-Year vs. 100-Year Design Storms

Outlet/Flow Node ID	Location	5-Year Peak Flow (m3/s)					100-Year Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
OF11_54	Lyons Ln - Sixteen Mile Creek	0.645	1%	0.645	0%	0.645	1.404	0%	1.404	0%	1.404
108	Lyons Ln - Sixteen Mile Creek	0.691	-44%	0.389	-44%	0.389	1.357	-43%	0.776	-43%	0.776
91	Cross Ave - Sixteen Mile Creek	4.119	8%	4.431	-35%	2.679	5.071	12%	5.677	-2%	4.98
97	Cross Ave - Sixteen Mile Creek	0.085	4%	0.088	-85%	0.013	0.135	10%	0.148	-6%	0.127
10	Cross Ave - Sixteen Mile Creek	0.503	-48%	0.261	-48%	0.261	1.747	-43%	0.995	-52%	0.84
92	Cross Ave - Sixteen Mile Creek	0.348	-1%	0.344	-51%	0.169	0.711	6%	0.757	-33%	0.477
204	Cross Ave - Sixteen Mile Creek	0	0%	0	0%	0	0.279	0%	0.324	-92%	0.022

Outlet/Flow Node ID	Location	5-Year Peak Flow (m3/s)					100-Year Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
16	Cross Ave - Sixteen Mile Creek	0.393	3%	0.404	3%	0.404	0.738	1%	0.746	1%	0.746
217	Cornwall Rd - Sixteen Mile Creek	0.012	0%	0.012	0%	0.012	0.021	0%	0.021	0%	0.021
149	Cornwall Rd - Sixteen Mile Creek	4.079	-1%	4.054	-4%	3.925	5.193	0%	5.202	-2%	5.095
OF2_37	Trafalgar Rd - Sixteen Mile Creek	0	0%	0	0%	0	0.159	0%	0.172	-40%	0.096
Tee15_LMC	West Tributary - LMC-W	10.438	-6%	9.799	-34%	6.935	20.234	-14%	17.426	-31%	13.9
J2353.323	West Tributary south of Maple - LMC-W	11.558	-6%	10.904	-30%	8.106	22.129	-11%	19.667	-31%	15.294
J165	East Tributary - LMC-E	11.435	0%	11.45	-27%	8.356	22.105	-4%	21.136	-25%	16.509
Tee8_LMC	Main Branch west of	23.707	-3%	23.035	-25%	17.879	42.3	-7%	39.327	-24%	32.081

Outlet/Flow Node ID	Location	5-Year Peak Flow (m3/s)					100-Year Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
	Morrison Heights Dr - LMC										
J867.2666	Main Branch at the Confluence (Morrison Rd) - LMC	24.433	-3%	23.779	-23%	18.83	44.339	-7%	41.376	-23%	34.267
J482.2199	Main Branch between Morrison Rd and Lakeshore Rd E - LMC	24.659	-3%	23.973	-23%	19.014	44.554	-6%	41.722	-22%	34.573
J74.93881	Main Branch between Lakeshore Rd E and Lake Ontario - LMC	24.931	-3%	24.278	-23%	19.303	44.208	-6%	41.629	-20%	35.275

Table 9-6. Peak Flow Comparison at Subwatershed Outlets: 100-Year Design Storm vs. Regional Storm (Controlled Scenario with 100-Year SWM Control Measures)

Outlet/Flow Node ID	Location	100-Year Peak Flow (m3/s)					Regional Storm Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
OF11_54	Lyons Ln - Sixteen Mile Creek	1.404	0%	1.403	0%	1.404	0.882	0%	0.882	0%	0.882
108	Lyons Ln - Sixteen Mile Creek	1.357	-43%	0.776	-43%	0.776	0.449	-40%	0.27	-40%	0.27
91	Cross Ave - Sixteen Mile Creek	5.071	12%	5.677	-2%	4.98	3.678	10%	4.063	2%	3.751
97	Cross Ave - Sixteen Mile Creek	0.135	10%	0.148	-6%	0.127	0.067	10%	0.074	101%	0.135
10	Cross Ave - Sixteen Mile Creek	1.747	-43%	0.995	-52%	0.84	0.261	-42%	0.152	-42%	0.152
92	Cross Ave - Sixteen Mile Creek	0.711	6%	0.757	-33%	0.477	0.241	11%	0.268	-59%	0.098
204	Cross Ave - Sixteen Mile Creek	0.279	0%	0.324	-92%	0.022	0	0%	0	0%	0

Outlet/Flow Node ID	Location	100-Year Peak Flow (m3/s)					Regional Storm Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
16	Cross Ave - Sixteen Mile Creek	0.738	1%	0.746	1%	0.746	0.247	3%	0.254	3%	0.254
217	Cornwall Rd - Sixteen Mile Creek	0.021	0%	0.021	0%	0.021	0.008	0%	0.008	0%	0.008
149	Cornwall Rd - Sixteen Mile Creek	5.193	0%	5.202	-2%	5.095	3.782	-1%	3.734	-9%	3.431
OF2_37	Trafalgar Rd - Sixteen Mile Creek	0.159	0%	0.172	-40%	0.096	0	0%	0	0%	0
Tee15_LMC	West Tributary - LMC-W	20.234	-14%	17.426	-31%	13.9	16.488	-10%	14.871	-34%	10.824
J2353.323	West Tributary south of Maple - LMC-W	22.129	-11%	19.667	-31%	15.294	18.768	-9%	17.171	-31%	13.007
J165	East Tributary - LMC-E	22.105	-4%	21.136	-25%	16.509	16.482	-1%	16.334	-22%	12.83

Outlet/Flow Node ID	Location	100-Year Peak Flow (m3/s)					Regional Storm Peak Flow (m3/s)				
		Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled	Existing	Difference (Uncont vs Ext)	Future-Uncontrolled	Difference (Controlled vs Ext)	Future-Controlled
Tee8_LMC	Main Branch west of Morrison Heights Dr - LMC	42.3	-7%	39.327	-24%	32.081	36.532	6%	38.852	-21%	28.698
J867.2666	Main Branch at the Confluence (Morrison Rd) - LMC	44.339	-7%	41.376	-23%	34.267	39.139	-4%	37.479	-19%	31.632
J482.2199	Main Branch between Morrison Rd and Lakeshore Rd E - LMC	44.554	-6%	41.722	-22%	34.573	39.66	-4%	37.987	-19%	32.254
J74.93881	Main Branch between Lakeshore Rd E and Lake Ontario - LMC	44.208	-6%	41.629	-20%	35.275	40.499	-4%	39.013	-17%	33.631

9.5 Unitary Storage Rates Comparison with Previous Studies

The unitary storage rates required for the Sixteen Mile Creek and Lower Morrison Creek (east and west branches) as determined from the PCSWMM modeling were compared to those from the Midtown Oakville Class EA (Cole, 2014) and the Flood Mitigation Opportunities Study (WSP, 2024). The results are presented in Table 9-7.

Table 9-7. Comparison of Required Storage Volumes and Unitary Storage Rates between this Study and Previous Studies

<table>
<tr><th rowspan="2">Subwatershed</th><th colspan="3">Quantity Control Unitary Storage (m^3/Imp.ha)</th><th colspan="3">Total Storage (m^3)</th></tr>
<tr><th>Class EA 2014</th><th>Flood Mitigation 2024**</th><th>Midtown SWM Plan</th><th>Class EA 2014</th><th>Flood Mitigation 2024</th><th>Midtown SWM Plan</th></tr>
<tr><td>Lower Morrison Creek West</td><td rowspan="2">280.9</td><td>180</td><td>199.7</td><td rowspan="2">55552</td><td rowspan="2">35532</td><td>12213.8</td></tr>
<tr><td>Lower Morrison Creek East</td><td>210</td><td>211.8</td><td>11139.5</td></tr>
<tr><td>Sixteen Mile Creek</td><td>68.2</td><td>N/A</td><td>73.1</td><td>4980</td><td>N/A</td><td>3111.9</td></tr>
</table>

** Quantity control only scenario (WSP, 2024, Table 5-36)

9.6 Downstream Impact under Controlled Conditions

Following the review of the Lower Morrison Creek regulatory model (Appendix G) and as part of verifying and confirming stormwater management targets for the Midtown area, the peak flows from the PCSWMM future-controlled model under the 100-year storm conditions were compared with those from the regulatory model. Accordingly, the controlled peak flows will be significantly less than the regulatory model's numbers at all flow nodes, except at the confluence, at which the difference between the two flows is less than 1%.

It should be emphasized that the significantly lower peak flows under controlled conditions along the West Tributary (i.e. Lower Morrison West) are not a result of overcontrol, but because the VO model exaggerates the flows draining into Lower Morrison by assuming more flows from the area west of Trafalgar Road, which in reality drains into Sixteen Mile Creek.

Another key point to consider, is that the PCSWMM model employs more detailed catchment delineation, creating smaller, discretized drainage areas that explicitly connect the storm sewer system to the proposed roadway network. In contrast, the regulatory model relied on lumped catchments, either directly linked to Lower Morrison Creek or assumed to transfer runoff through overrun drainage between catchments. This distinction in catchment representation and flow routing results in more distributed runoff in PCSWMM, thereby reducing peak flow estimates compared to the simplified assumptions of the regulatory model.

Table 9-8. 100-Year Flow Comparison between PCSWMM and the regulatory VO Models (Controlled Scenario with 100-Year SWM Control Measures)

Flow Node	Flow Node Location	Proposed-controlled Condition Peak Flows (m3/s)	
		100-Year	
		Midtown SWM Plan	1993 MDP Study - VO
Tee15_LMC (**ADDHYD 14**)	West Tributary	**13.90**	**24.68**
J2353.323 (**ADDHYD 19**)	West Tributary south of Maple	**15.29**	**25.70**
J165 (**ADDHYD 20**)	East Tributary	**16.51**	**18.02**
J867.2666 Through M1 (**RouteChannel25**)	Main Branch at the Confluence	**34.26**	**34.04**

The regional storm was also simulated using the stormwater management (SWM) facilities originally proposed for the 100-year design storm event. This modeling scenario was requested by Conservation Halton with the intent of assessing the performance of the 100-year SWM infrastructure under the more extreme regional storm conditions. Modeling results indicate that twenty-three (23) out of thirty (30) proposed SWM facilities are predicted to experience flooding under the regional storm scenario.

Despite that the majority of the proposed SWM facilities would flood under the regional storm conditions, the predicted downstream peak flows from the PCSWMM model would be lower than those at the regulatory flow nodes, except for one node along Morrison Creek East. Node J165 (ADDHYD 20) would exhibit higher peak flows. This indicates that the downstream peak flow target for this section of the creek might not be met under the regional storm scenario when using SWM facilities designed for the 100-year event.

Table 9-9. Regional Flow Comparison between PCSWMM and the regulatory VO Models (Controlled Scenario with 100-Year SWM Control Measures)

Flow Node	Flow Node Location	Proposed-controlled Condition Peak Flows (m3/s)	
		Regional	
		Midtown SWM Plan	1993 MDP Study - VO
Tee15_LMC (**ADDHYD 14**)	West Tributary	**10.83**	**16.12**
J2353.323 (**ADDHYD 19**)	West Tributary south of Maple	**13.01**	**17.68**
J165 (**ADDHYD 20**)	East Tributary	**12.83**	**9.46**
J867.2666 Through M1 (**RouteChannel25**)	Main Branch at the Confluence	**31.63**	**32.17**

10. Midtown Stormwater Criteria and Strategies

The following sections provide stormwater management criteria and strategies for future development within Midtown Oakville.

10.1 Midtown Stormwater Criteria

As noted in Chapter 3 (Stormwater Planning Context), many studies and guidelines have shaped the stormwater management criteria for Midtown Oakville. This includes studies that covered subwatersheds containing Midtown and others that investigated the hydrological and hydraulic directly and indirectly impacting the Midtown area.

As the Midtown SWM Plan was developed following the requirements of the CLI ECA and its criteria (Appendix A), the SWM criteria for Midtown Oakville includes the following:

- Quantity Control:
  - Flood Control (Watershed Hydrology)
  - Water Quantity (Minor and Major System)
- Water Balance
- Erosion Control
- Water Quality

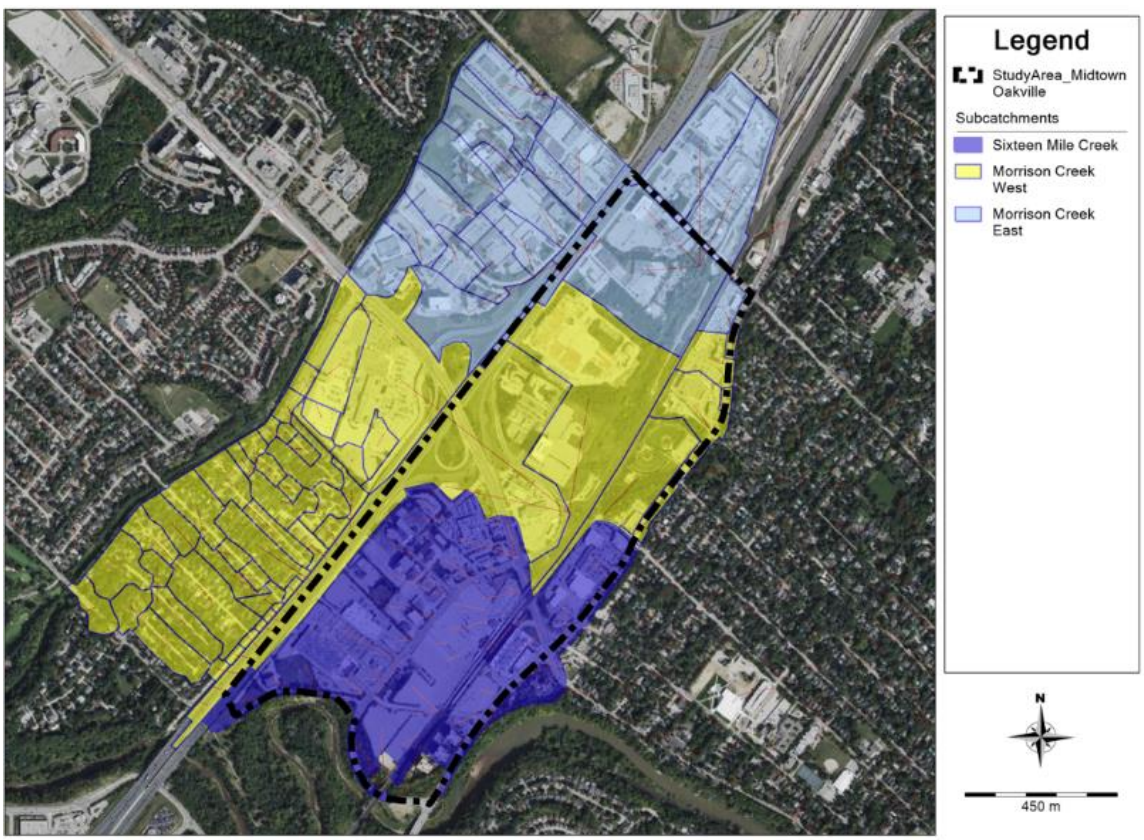

Figure 10-1 Midtown Oakville Subwatersheds and External Catchments

In the following sections, the process required to implement the proposed SWM criteria is described, and the necessary steps to achieve all required targets are explained.

10.1.1 Area Coverage - Subwatershed Context

The stormwater management criteria apply to Midtown Oakville in addition to the external catchments draining as part of the Lower Morrison Creek system. These include:

- Catchment areas located between the QEW and the Diversion Channel (Lower Morrison East: Blue and Lower Morrison West: Yellow)
- Catchments located east of Chartwell Road (Lower Morrison East: Blue)
- Catchment areas located within the Sixteen Mile Creek, in purple.

Areas north of the Diversion Channel and those located within the Wedgewood Creek subwatershed are not included in the proposed Midtown Stormwater criteria. The 2014 Midtown Class EA applies to those areas, unless specified otherwise by the Town.

10.1.2 Quantity Control

Due to the large scale of this SWM Plan, uncertainty in timing of developments and lack of block-by-block grading information for the future development, the PCSWMM model adopted a centralized SWM strategy, as opposed to a block-by-block approach. The total storage volume provided across all proposed measures was normalized for the coverage area. Accordingly, unitary storage rates were developed (Table 10-1).

Table 10-1. Required Unitary Storage Rates

Subwatershed	Total Storage (m^3)	Quantity Control Unitary Storage (m^3/Impervious ha)
Lower Morrison Creek West	12213.8	199.7
Lower Morrison Creek East	11139.5	211.8
Sixteen Mile Creek	3111.9	73.1

While Table 10-1 presents the total storage needed at the subwatershed scale (Watershed hydrology) and while the results downstream of the study area are expected to meet the regulatory requirements as shown in previous sections, the unitary storage (m3/impervious hectare) may not be sufficient to achieve quantity control objectives at the block level. More specifically, individual developments may require more or less storage than the normalized unitary rate suggests.

To confirm the validity of the unitary storage rates at the block level, a sensitivity analysis was conducted using the Rational Method. Two blocks per each subwatershed were examined, using one block with significant change in imperviousness and another with slight or no change. Unitary storage volumes were applied and release rates estimated for the 100-year storm event under post and pre-development conditions. Downstream peak flows were estimated.

Similar to the results from the Lower Morrison/Wedgewood Creeks Flood, Erosion and MDP (1993) and the Midtown Oakville Class EA (2014), estimated peak flows under post and pre-development conditions showed that applying the post-to-pre control criteria to the undeveloped sites would result in higher than existing downstream peak flow rates at the downstream end of the study area for the three subwatersheds.

When a more conservative SWM approach, namely controlling the 100-year to 5-year was investigated at the block level, the downstream peak flow rates showed results that are lower than existing downstream peak flow rates.

10.1.2.1 Block Level Implementation- Quantity Control Criteria

The following process is proposed for implementing quantity control criteria at the development block level across the study area:

1. Modelling Requirements:

- Future development within the Midtown area, including the proposed roads, is to utilize the PCSWMM model to simulate proposed development and size required storage facilities
- Initial storage sizing shall be based on the unitary storage rates in Table 10-1.

2. Demonstrating Compliance with Quantity Control Criteria:

- After applying the minimum storage from Table 10-1, each development application must demonstrate the following:
    - o Flood Control (Watershed Hydrology): Post-development ultimate discharge to the receiving water body must not exceed allowable flow targets (Refer to Table 9-5: Peak Flow Comparison at Subwatershed Outlets).
    - o Water Quantity Control (Minor and Major Systems): The proposed design must ensure no flooding or surcharge occurs in either the minor or major conveyance systems. Design storm requirements are 1:5-year return period for the minor system and1:100-year return period for the major system.

3. Requirements if Non-Compliance Is Identified:

If PCSWMM modelling shows downstream impacts or failure to meet any criteria:

a. A more conservative approach shall be applied, such that
    i. Post-development 100-year peak flows must be controlled to the 5-year pre-development peak flow rate, or
    ii. Storage volume must be increased until all criteria in Section 2 are met.

b. Revised conditions must be verified again using PCSWMM.

4. Alternative to PCSWMM:

If a proponent chooses not to use PCSWMM:

a. They must complete a downstream capacity assessment using acceptable engineering tools (e.g., storm sewer design sheets or equivalent).

b. This assessment must confirm compliance with the Town's ECA-CLI requirements for:
    i. Flood Control (Watershed Hydrology)
    ii. Water Quantity (Minor and Major System)

10.1.3 Water Balance and Erosion Control

Future development within the Midtown area, including the proposed roads, is to provide retention of 25 mm, applied to the impervious area. Proponents are to utilize the Midtown Stormwater Plan's findings, which demonstrate that the retained runoff volumes could mitigate the impact of frequent flows and improve downstream conveyance. The 25-mm storm, which is commonly cited for both water balance and erosion control target setting, was evaluated earlier (Section 9.4.3) to identify the impact of this storm event on existing and future conditions.

It has been determined that future development must provide the following to satisfy the water balance and erosion control criteria:

- 122.6 m^3/Imp.ha for Sixteen Mile Creek
- 93.1 m^3/Imp.ha for Lower Morrison West and
- 104.2 m^3/Imp.ha for Lower Morrison East

To accommodate site constraints and conform to provincial and municipal guidelines, including the Environmental Compliance Approval for a Municipal Stormwater Management System (ECA Number: 314-S701), the 25 mm runoff volume reduction target shall follow the hierarchical order as per Appendix A of the ECA:

1. Retention (Infiltration, reuse, or evapotranspiration)
2. Filtration (Absorption and increased depression storage)
3. Conventional stormwater management (Detention and attenuation)

Step 3 should proceed only once Maximum Extent Possible has been attained for Steps 1 and 2 for retention and filtration.

10.1.4 Quality Control

Future development within the Midtown area, including the proposed roads, is to achieve Enhanced Level 1 Protection (80% long-term removal of TSS) as per the Stormwater Management Planning and Design Manual (MECP, 2003). Following the guidelines of Conservation Halton and the Town of Oakville Development Manual, a Treatment Train approach is recommended for quality control along the proposed roads. These may include oil/grit separators (OGS) units, CB Shields and feasible Green Infrastructure/LID measures.

10.2 Midtown Stormwater Management Strategies

In general terms, it is the responsibility of all proponents to follow the Town's policies and procedures for drainage and stormwater management, apply stormwater criteria and targets established by the Midtown Stormwater Plan, confirm drainage capacity and functionality, and develop drainage plans.

SWM Strategies that are necessary for future development include but are not limited to the following as noted below.

10.2.1 Strategies within Private Properties

It is the responsibility of the proponent to design and construct stormwater management facilities in compliance with the Stormwater Management Planning and Design Manual (MECP, 2003), stipulations of the Town's Environmental Compliance Approval (ECA Number: 314-S701), and Conservation Halton's policies and guidelines for the administration of Part VI of the Conservation Authorities Act and Ontario Regulation 41/24 and Land Use Policy Document (last amended, April 17, 2025) and Conservation Halton Guidelines for Stormwater Management Engineering Submissions.. The final location and connection to municipal infrastructure shall be subject to the approval of the Town in consultation with Conservation Halton.

For water balance and erosion control, water reuse can be considered an option only after all retention measures have been investigated, including infiltration-based measures.

For quality control, new development is required to meet Enhanced Level 1 Protection as per the Ministry of Environment's Stormwater Management Planning and Design Manual (2003).

Long-term perpetual groundwater discharges are not permitted (e.g. bathtub or added storage for groundwater). The proponent should also demonstrate that there is no negative impact to the local groundwater condition and ensure the accumulated impact is considered in their proposed groundwater management strategy.

10.2.2 Strategies along Local Roads

It is the responsibility of the proponent to design and construct stormwater quantity and quality measures along local roads to achieve unitary storage targets stipulated in the Midtown SWM Plan.

A Treatment Train approach is encouraged to achieve water quality and runoff volume reduction targets. This approach should align with the CLI-ECA agreement and related SWM criteria, including peak flow control, water quality control, water balance and erosion control.

10.2.3 Strategies along Major Roads

These include upsized pipes, super pipes to control peak flows, green infrastructure to retain and infiltrate surface runoff and MTDs to control water quality to Enhanced Levels.

The location, depth and connectivity of the new storm sewers to the municipal drainage system shall be subject to the approval of the Town in consultation with Conservation Halton.

The capacity and functionality of proposed storm sewer pipes and superpipes shall be demonstrated. Hydraulic modelling using appropriate software shall be completed to quantify peak flows, required storage volumes, and determine Hydraulic Grade Line (HGL).

10.2.4 Strategies within Parks

Parks shall be designed to support a broader stormwater management system across Midtown and as part of a Treatment Train approach to achieve stormwater quantity and quality targets.

As shown in Figure 10-2, stormwater management measures have been proposed within three public parks. Their footprints were estimated as follows:

- Sixteen Mile subwatershed: SWM8: 850m^2 and SWM13: 564m^2
- Lower Morisson West subwatershed: SWM12: 1341 m^2

To allow for space and functional integration with parks' programming and recreational uses, the three SWM measures have been assumed to take the form of underground storm tanks, providing detention and retention and serving quantity control, water balance and erosion control.

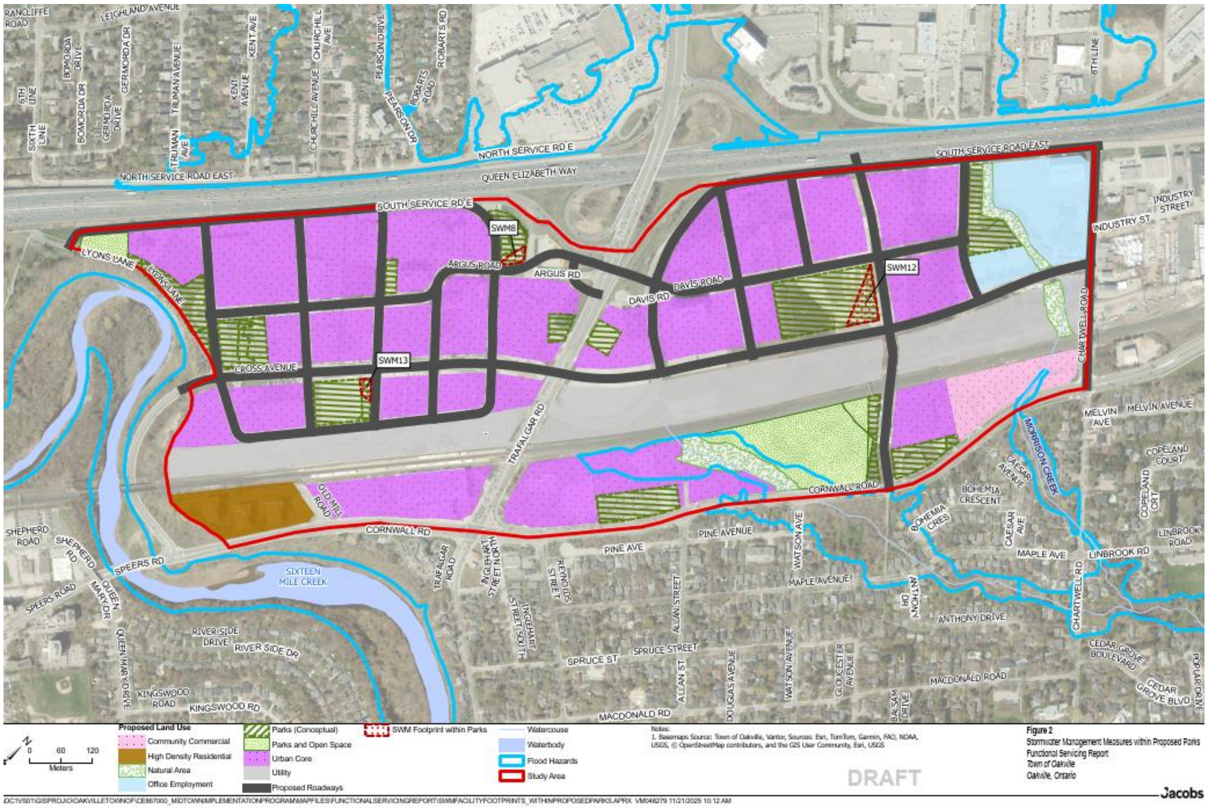

Figure 10-2. Stormwater Measures Proposed for Implementation within Public Parks

11. Implementation Plan

The following sections provide general considerations for the implementation of the proposed SWM criteria and strategies. Further details will be provided as part of the Midtown Functional Servicing Report (Midtown FSR) and subsequent phases of the Midtown Oakville project.

11.1 Coordination with Midtown Oakville Transportation Plan

11.1.1 Opportunities to Integrated SWM Measures

The Midtown Transportation Plan proposes a “Complete Streets” approach, which involves designing streets in a way that enables safe access for all people who need to use them within the context of the road function and adjacent land uses, including the needs of pedestrians, bicyclists, motorists and transit riders of all ages and abilities. Included in this vision is the accommodation of SWM measures, including quantity control, quality control and water balance measures within the proposed Right of Way.

Cross-sections were developed to cover most major roads in Midtown through a context-sensitive design to ensure that the roadway network can balance capacity, safety, and sustainability. An example of a conceptual streetscape developed for the Cross Avenue is shown in Figure 11-1.

The design showcases how a road can support and enhance the adjacent land uses by integrating landscaping, lighting, and pedestrian-scale elements.

The proposed cross sections range in width between 16 and 20 metres for local roads and between 26 and 36 metres for major roads. Our preliminary analysis for the application of soil cells and permeable pavements show that there is an ample space along sidewalk areas and biking lanes for GI and LID measures to be implemented.

Figure 11-1. Conceptual Streetscape for the Cross Avenue - Source: Designing Midtown (2025)

11.1.2 Crossings

There are two proposed crossings that will be addressed as follows:

- Cross Avenue extension to be investigated under a Class EA Addendum

- North-south crossing over the QEW highway, under the 2014 Class EA criteria

11.2 SWM Measures on Private Properties

11.2.1 Underground Storage Facilities

Underground storage systems may be implemented on private properties, subject to the approval of the Town, and shall be designed and constructed in accordance with the manufacturer's specifications and with recognition of the specific conditions on the site and shall be operated and maintained by the owner according to manufacturer and/or designer specifications / requirements.

11.2.2 Green Infrastructure / LID Measures

Private property owners should consult with the Town to determine the municipal requirements to maintain long-term effectiveness of LIDs on private property, to obtain any credits toward the sizing of end-of-pipe facilities for erosion and stormwater quality control. Notwithstanding, the application of SWM measures to maintain water balance targets on private properties shall not be considered in the sizing of end-of-pipe facilities to provide flood control.

The Control Hierarchy for water balance should be aligned with the hierarchy outlined by the MECP Consolidated Linear Infrastructure Environmental Compliance Approvals Appendix A.

To accommodate site constraints and conform to provincial and municipal guidelines, a 25 mm runoff volume reduction target shall follow the hierarchical order as per the approach proposed MECP CLI ECA:

1. Retention (Infiltration, reuse, or evapotranspiration)
2. Filtration (Absorption and increased depression storage)
3. Conventional stormwater management (Detention and attenuation)

Step 3 (in conjunction with potential water reuse considerations) should proceed only once Maximum Extent Possible has been attained for Steps 1 and 2 for retention and filtration.

Water balance controls shall be recognized as providing benefits to water quantity control (detention and/or peak flow requirement), water quality impacts, and erosion control requirements, as long as the volume control facilities are maintained for their function as designed. Qualified Practitioners shall be required to demonstrate through calculations or hydrologic modelling the storage quantity and/or the peak flow reductions associated with incorporating the required volume controls

11.2.3 Manufactured Treatment Units

As per the Town's Development Engineering Procedures and Guidelines Manual (2023), specific manufacturers shall provide certification of the performance of these devices. The private site owner shall be responsible for the long-term operation and maintenance of this type of device.

11.3 Implementation of Green Infrastructure / LID Measures

The implementation of Green Infrastructure and LID measures has been encouraged by the Town and Conservation Halton (Chapter 3). However, constraints at various scales may limit the implementation of these measures across Midtown Oakville. Along the Right of Way, the Town is amenable to the use of soil cells (e.g. silva cells) and stormwater planters which can be worked into the streetscape but require curb cuts. These measures can be designed and constructed in partial compliance with the CLI-ECA requirements.

It is understood that the Town is amenable to the use of LID measures in parks, where groundwater levels permit and where it does not impact the programming. The use of LID along publicly owned frontage and around the park may be integrated as part of the street scaping.

The Town is not supportive of implementing LID measures within the Natural Heritage System. Development blocks adjacent to NHS are required to maintain certain buffer widths that are determined through an EIA and may vary based on feature sensitivity. Drainage from and into NHS features need to be assessed in appropriate detail.

11.3.1 LID Design Considerations

Guidance on Green Infrastructure and LID design can be found in many provincial documents, including the following:

- Low Impact Development Stormwater Management Guidance Manual (Draft 2022, MECP)
- LID Stormwater Management Planning and Design Guide (2017 Update, by Sustainable Technologies Evaluation Program (STEP) and TRCA)
- Low Impact Development Stormwater Management Planning and Design Guide (TRCA, 2010)
- Stormwater Management Planning and Design Manual (MECP, 2003)

The following LID measures, including design considerations, resources and limitations, are examples of what can be implemented within the private properties and along the proposed roads' Right of Ways within the Midtown area.

11.3.1.1 Soil Cells:

Soil Cells consist of modular frames (or cells) that provide structural support for paved surfaces without the need for a compacted soil base within the tree root zone.

Key design guidelines:

- Suitable for high and medium density streets
- Common constrains include geotechnical and hydrogeological constraints, including soil type, permeability and seasonal groundwater levels are important design factors
- Size considerations (For specific design guidelines, Silva Cells have been considered): Each Silva Cell can hold a specified volume of soil and can be spread across a wide surface area and stacked on top of each other to a specified depth (varies by Module Type from 729 to 1397mm), creating large tree root zones and infiltration areas beneath sidewalks. Any number of Silva Cells can be configured to form a system, provided a storm drain is proximate unless the underlying soils can support full infiltration of stored water. Generally, the system has a minimum of 10 but can extend to hundreds.
- Tree selection: Street tree palate and the Town's guidelines should be consulted when selecting a tree for a Soil Cells system. Consultations with a landscape architect may be needed to ensure climate and irrigation needs are met. In general, every 1 cubic foot to 3 cubic feet of soil results in a square foot of projected tree canopy diameter.

Design guidelines resources:

- Silva Cell Fact Sheet
- Low Impact Development Road Retrofits – From Grey to Green (CVC, 2017)

11.3.1.2 Permeable Pavement:

Permeable pavement is an alternative to traditional impervious pavement, allowing surface runoff to drain through them into a stone reservoir and then into underlying native soil or subdrain.

Key design guidelines:

- Permeable pavement types include permeable interlocking pavers, grid pavers, pervious concrete and porous asphalt
- Common constrains include geotechnical and hydrogeological constraints, clogging, structural stability and heavy traffic
- Suitable for sites with limited space for other LID measures, such as rain gardens, planters and bioswales
- Setbacks from buildings: A minimum setback of four (4) metres downgradient from building foundations is recommended
- Pollution prevention: Should not be applied in pollution hot spots such as vehicle fueling, service or demolition sites, outdoor storage and handling areas for hazardous materials.

Design guidelines resources:

- Low Impact Development Stormwater Management Planning and Design Guide (2010)

11.3.1.3 Underground Storage Facilities:

The dual-use approach of underground stormwater management facilities involves above-ground uses, including passive and active parkland. This approach is supported by Conservation Authorities in Ontario as an effective means to address stormwater management requirements while maintaining and/or enhancing public realm benefits.

For parks, grass and shallow-rooted shrubs can be planted on top of underground storm tanks. Planting trees should be avoided on top of a facility's footprint unless root barriers or suspended systems are applied. Due consideration and review should address:

- Park programming and routine operation and maintenance
- Technical details such as soil depths, structure footings, tree canopy requirements
- Long term life cycle costs on park replacement due to structure renovations

Each underground facility will require a series of access points for maintenance and operations. These access locations can be planned together with the surface land use to minimize impact.

Underground stormwater management facilities typically have a pre-treatment methodology, such as an oil-grit separator or various low impact development techniques, which serve to reduce the sediment accumulation in the underground tank, and therefore reduce the required frequency and volume of sediment removal

Within private properties and along ROWs, underground storage facilities can be designed to accommodate highway loading and are therefore ideally utilized below private or public parking areas and/or driveways.

Design guidelines resources:

- Conservation Halton Guidelines for SWM Engineering Submissions – Section 3 (2021)
- Brentwood Design Guides (https://stormwater.brentwoodindustries.com/)
- StormTech – ADS Design Guides (https://www.adspipe.com/stormtech)

11.3.1.4 Green Roofs

Green roofs reduce runoff volume by intercepting and storing rainfall, in addition to evapotranspiration. Within private properties, this measure may present a feasible opportunity to provide runoff volume reduction, especially in presence of site constraints. Green roofs typically include the following:

- Vegetation
- Growing media (Engineered soil)
- Moisture retention mat
- Drainage panel and filter fabric
- Root barrier
- Waterproofing membrane

Green roofs are physically feasible in most development situations but should be planned at the time of building design. Some key constraints include load bearing capacity and roof slopes. According to the Low Impact Development SWM Planning and Design Guide (2010), Reported rates for runoff reduction have been shown to be a function of media depth, roof slope, annual rainfall and cold season effects. A conservative runoff reduction rate for green roofs of 45 to 55% is recommended for initial screening of LID practices.

11.3.1.5 Water Reuse

Water reuse may present a feasible water balance management option when onsite infiltration and filtration measures are not attainable. A water reuse feasibility study may need to be completed to determine non-potable reuse of stormwater for onsite or shared use

11.3.1.6 Manufactured Treatment Devices (MTDs):

MTDs to be located within private properties and along ROW for the removal of Total Suspended Solids (TSS).

- Within private properties: Jellyfish units may be most appropriate as it provides enhanced water quality benefits (80% TSS removal)
- Along ROWs, to achieve 80% TSS removal, a combination of OGS units (e.g. Stormceptors) and CB-Shields in conjunction with LID measures such as Soil Cells and permeable pavements will be needed.

Design guidelines resources:

- Imbrium (https://www.imbriumsystems.com/stormwater-treatment-solutions/jellyfish-filter)
- CB Shield (https://www.cbshield.com/)

11.3.2 LID Suitability and Feasibility Assessments

The suitability of various LID practices is evaluated to varying degrees at different planning stages based on the available information as well as the scale and level of detail of the study or plan.

Table A2 of the CLI- ECA (reproduced as Table 11-1) lists SWM practices constraints (also referred to as restrictions in the 2022 MECP Draft LID Manual) that may be used to justify deviations from the performance criteria in the ECA. These and any other applicable constraints (e.g., natural heritage features and tree retention areas) should be evaluated and documented for a site. As described in the following section, site constraints/restrictions factor into applying SWM objectives and criteria to a site.

Infrastructure feasibility and prioritization studies should comprehensively assess Stormwater site opportunities and constraints to improve cost effectiveness, environmental performance, and overall benefit to the receivers and the community. The studies include assessing and prioritizing municipal infrastructure for upgrades in a prudent and economically feasible manner.

Table 11-1. Site Constraints (source: MECP ECA, May 2022)

Site Constraints
Shallow bedrock, areas of blasted bedrock, and Karst; High groundwater or areas where increased infiltration will result in elevated groundwater levels which can be shown through an appropriate area specific study to impact critical utilities or property (e.g., susceptible to flooding);
Swelling clays or unstable sub-soils;
Contaminated soils (e.g., brownfields);
High Risk Site Activities including spill prone areas;
Prohibitions and or restrictions per the approved Source Protection Plans and where impacts to private drinking water wells and /or Vulnerable Domestic Well Supply Areas cannot be appropriately mitigated;
Flood risk prone areas or structures and/ or areas of high inflow and infiltration (I/I) where wastewater systems (storm and sanitary) have been shown through technical studies to be sensitive to groundwater conditions that contribute to extraneous flow rates that cause property flooding / Sewer back-ups

11.4 Phasing and Prioritization

The development of Midtown is expected to occur over the long-term and timing of growth will primarily be driven by the development community and market conditions. A prioritization of major roadways and road infrastructure is documented in the Midtown Transportation Plan; stormwater management will be required in alignment with these timelines.

Consistent with the Oakville Transportation Plan, the SWM projects will be based on the following phasing timeframes (Figure 11-2):

- Short Term: 2026-2035 (within the 10-year Capital Plan)
- Medium Term: 2036-2041

- Long Term: 2041-2051

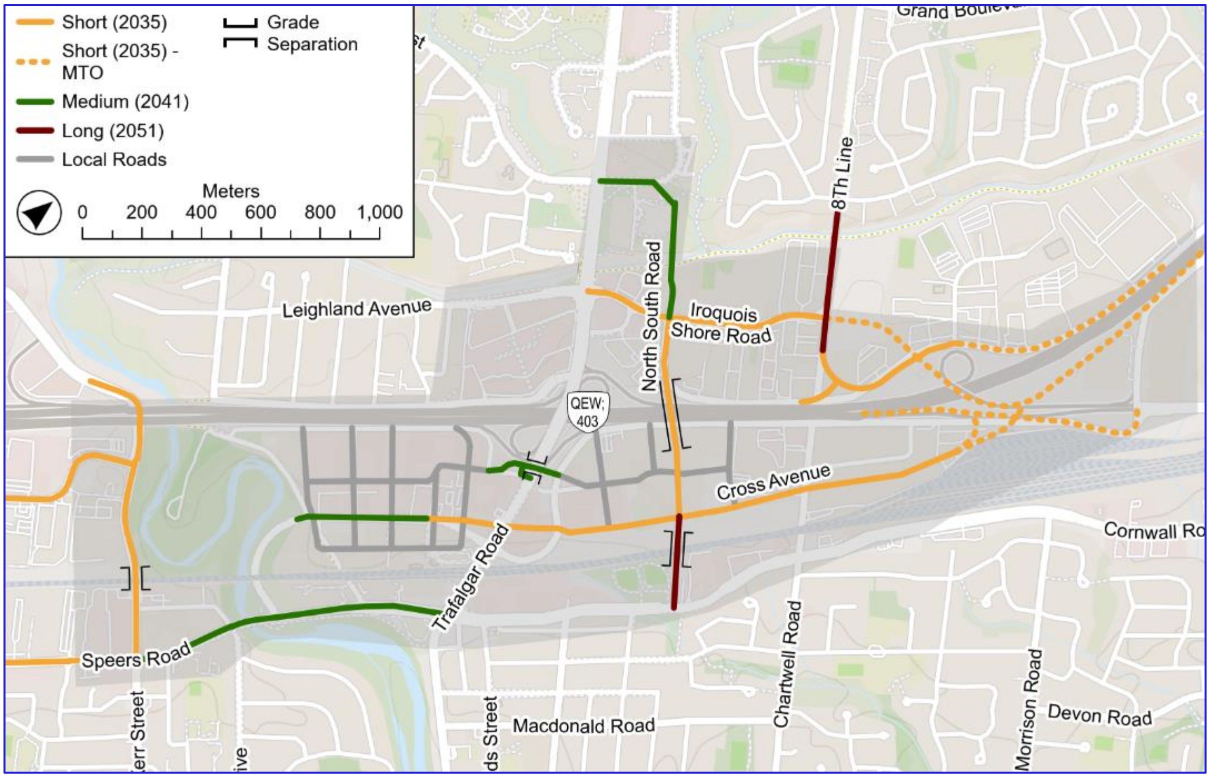

Figure 11-2. Recommended Phasing Plan for the Proposed Road Network

Based on the timing and phasing of development and road network improvements, as recommended by the Transportation Plan, additional stormwater management analysis may be required to demonstrate adherence to stormwater criteria and objectives.

11.5 Future Studies

The following future studies, including technical and policy direction, may be needed to expedite the implementation of the proposed SWM Plan and SWM strategies:

- Midtown Storm Asset Management Study: to address data gaps related to existing storm sewers, catch basins, manholes and outfalls.
- Hydrogeological Assessment with focus on groundwater elevations and infiltration rates: Sporadic information is currently present, hindering a clear and detailed understanding of constraints and opportunities for runoff volume reduction.
- Detailed MWDC Spill Mitigation Study: including identifying and analyzing the extent of spill flooding and feasible solutions to address mitigation within Midtown and at the receiving watercourses.
- Green Infrastructure / LID policy: It is recommended that the Town proceed with developing a Green Infrastructure / LID policy or guideline to address the requirements of the new SWM Criteria. The policy / guideline may include the following components: approvals process for private property, CLI-ECA considerations, assumption protocols, and operation and maintenance procedures.

11.6 Financial Implications

The high-level cost estimate for stormwater management infrastructure improvements (in 2025 dollars) is $16 million. This estimate encompasses the installation of new storm sewer pipes and the implementation of stormwater management measures for detention, retention and water quality purposes. The proposed drainage and SWM measures are planned along public rights-of-way and within proposed park spaces. The estimate will be further refined and validated through the forthcoming Functional Servicing Report and Design. The preliminary breakdown on Stormwater Management Table 11-2.

Table 11-2. Preliminary Stormwater Management Cost Estimate Breakdown

Conveyance	Quantity Control (Detention)	LIDs (Retention + Water Quality)	Parks (controlling drainage from ROW)	Total
$6,920,443	$2,210,325	$1,025,298	$5,922,150	$16,078,216

Appendix A. As-built Drawings

Appendix B. Catchment Delineation and Model Schematics

Appendix C. Catchment Parametrization and Modeling Results

Appendix D. Minor Drainage System - Hydraulic Profiles

Appendix E. Major Drainage System - Performance and Cross Sections

Appendix F. Stormwater Management Sizing

Appendix G. Downstream Impact Assessment

Appendix H. Regional Storm Analysis

Appendix I. Public and Agency Consultation