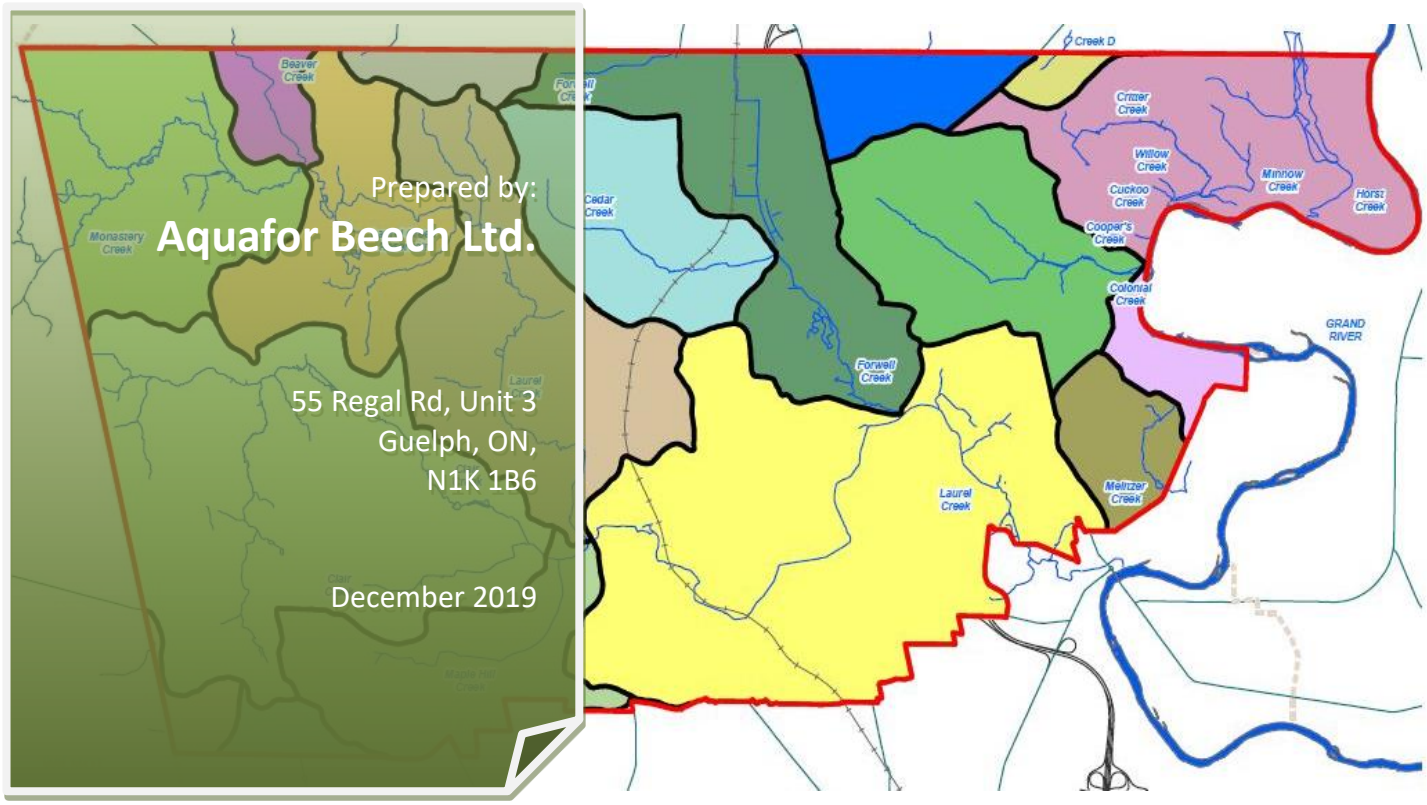
Prepared for:

City of Waterloo

STORMWATER MANAGEMENT MASTER PLAN (SWM-MP)

MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

FINAL REPORT



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EXECUTIVE SUMMARY

SWM-MP

MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

Final Report

1.0 INTRODUCTION AND PROBLEM IDENTIFICATION

The City of Waterloo's Stormwater Management Master Plan (SWM-MP) delivers a 'state-of-the-art' approach to managing stormwater and serves as a decision support tool, providing direction for the prioritization of municipal stormwater management (SWM) projects and programs. The SWM-MP was completed as a Master Plan, an approved process under the *Ontario Environmental Assessment Act*.

The study was initiated with the basic recognition that urban development can cause a number of environmental concerns, including:

- Degraded surface water and groundwater quality
- Warming of local creeks which can affect fish
- Increased sediment being delivered to local creeks
- Negative effects on human and animal health
- Loss of fish and wildlife habitat, and natural features
- Increased flooding and creek erosion
- Reduced groundwater recharge (our drinking water source)
- Overwhelming of the municipal storm sewer system resulting in flooding

The approach to SWM outlined in the SWM-MP focuses on runoff prevention, acknowledges the benefits provided by natural systems, recognizes rainwater as a resource to be managed rather than a waste and uses the principles of Green 'Stormwater' Infrastructure (GI) and Low Impact Development (LID) in combination with conventional SWM approaches to better and more efficiently manage stormwater.

The SWM-MP has six (6) elements which are detailed in a series of technical documents which make up the core of the plan. The six (6) elements which are described in additional detail below include:

1) Municipal Pollution Prevention, Operations & Maintenance Practices

This element focuses on pollution prevention and municipal practices that can help to prevent impacts before they occur.

2) Market Based Strategies for Private Property (source controls)

This element focuses on supporting and encouraging private property to 'take-action' to beautify their neighborhoods and business while managing stormwater at the same time.

3) Stormwater for the Capital Roads Program (conveyance controls)

This element focuses on improving the way municipal roads manage runoff by constructing SWM controls, including LID controls like bioswales or perforated pipes as part of routine road reconstruction programs to reduce stormwater volume and pollutant loading.

4) Stormwater Management Facilities

This element focuses on maintaining and improving existing SWM facilities as well as constructing new stormwater management facilities in uncontrolled stormwater catchments as part of park rehabilitations.

5) Watercourse and Erosion Restoration

This element focuses on opportunities for restoring local creeks suffering from erosion issues.

6) Urban Flood Management & Stormwater Infrastructure

This element focuses on managing urban flooding associated with storm sewer surcharging with focus on the predicted impacts of climate change.

The projects identified in the SWM-MP will be undertaken per the pending Implementation Plan (under separate cover). The plan will prioritize the works which make up the recommended approach on a subwatershed basis. Subwatersheds are the land area that contributes runoff to each individual watercourse in the City. Projects within subwatersheds will be prioritized based on the areas of greatest need.

2.0 STUDY PURPOSE

The preferred strategy outlined in the SWM-MP will identify, protect and enhance natural features, ecological function and biophysical integrity, and will appropriately manage risks through the establishment of environmental targets for water quality, water quantity, erosion and infiltration (water balance). The SWM-MP will also establish stormwater management policies and guidelines for the next 15 years, address stormwater infrastructure needs, identify and prioritize recommended works, and feed into the overall asset management plan for the City of Waterloo.

The SWM-MP primarily addresses the existing urban areas of the City and recommends remedial measures to improve overall environmental performance, increase efficiencies and reduce costs. The study focus is not new development; however, it does provide guidance in regards to future policies. It is understood that all new development must follow the established processes and required approval under the Planning Act and as such must comply with approved studies, plans, policies and guidelines as they relate to stormwater management and the natural environment.

3.0 STUDY OBJECTIVES

The SWM-MP considers flood and erosion control, groundwater and surface water quality management, natural heritage environment management and infrastructure in an integrated manner as part of an overall water sustainability plan. In addition, the SWM-MP integrates existing policies, regulations, acts and guidelines, and where appropriate, develops new policies to aid in implementation within a water resource sustainability context. The study's objectives include the following:

Water Quality

- Maintain or improve surface water and groundwater quality.
- Minimize sediment loading to surface water and groundwater.
- Maintain or enhance the quality of drinking water sources.
- Maintain existing thermal watercourse regimes and enhance cool/coldwater regimes where possible.
- Design and optimize a comprehensive water quality monitoring program.

Water Quantity

- Preserve and re-establish the natural hydrologic process to protect, restore and replenish surface water and groundwater resources.
- Minimize the threat to life and property from flooding and climate change.
- Maintain or enhance groundwater supplies through infiltration while minimizing the risks from future land uses and activities.

Erosion Control

- Reduce the impacts of excessive erosion on aquatic and terrestrial habitat and property.
- Integrate stream erosion within a master planning process.

Natural Environment

- Protect, enhance and restore natural features and functions such as wetlands, riparian and ecological corridors, as well as identified linkages.
- Improve warmwater, coolwater and coldwater fisheries where feasible.

Water Resource Sustainability

- Holistically integrate goals, objectives and targets for water resources (water, sanitary and storm).
- Improve stormwater infrastructure resiliency and adaptation in the context of climate change.

Infrastructure

- Provide a level of service for stormwater management which is consistent with municipal and agency standards. Develop ways to optimize infrastructure wherever feasible.

- Encourage the implementation of innovative solutions including Low Impact Development (LID) and Green 'Stormwater' Infrastructure (GI) to mitigate stormwater runoff as part of the development of sustainable infrastructure solutions.
- Develop a strategy to gain access to infrastructure which serves a communal function.

Policy and Implementation

- Reflect existing acts, policies and regulation.
- Integrate Asset Management Plans for Stormwater, which includes long-range forecast and planning direction for many of the specific policy items and recommendations (i.e. ponds, oil-grit separators and stream rehabilitation).
- Create a SWM Policy for integration into the Engineering Manual and for use on SWM initiatives.
- Review and integrate the SWM Quality Management System.

4.0 PUBLIC CONSULTATION

A consultation plan which was developed early in the study process focused on more engaging approaches to get enhanced public input and improve participation of residents to secure feedback. The three (3) Public Open Houses featured an "Interactive Zone" and "Ideas Zone" which offered an opportunity for the community stay up to date with the SWM-MP process and to share their "vision and ideas" as to how stormwater could be improved in their neighborhood, on their property and in their community.

5.0 EXISTING CONDITIONS

At present the City of Waterloo, a geographical area of 652 km^2, has a population of 134,600 with an expectation to increase by almost 40,000 residents by the year 2031. The City is composed of 23 subwatersheds with approximately 60 km of watercourses. The City of Waterloo is characterized by a mixture of land-uses. Generally, agricultural lands remain only along the periphery of the City, both along the Grand River, in the northwest and in the southwest. Lands that are zoned industrial are clustered primarily in the north and central area of the City between Weber Street North and Northfield Drive East but smaller clusters can be found further south. Approximately, 34% of the City is occupied by private residential property.

SWM facilities within the City provide some level of control to 2,049.0 ha (32.1%) of the City. Of this area, approximately 1,718.1 ha (26.3%) are controlled for both water quality and water quantity, and 375.9 ha (5.8%) are controlled for water quantity only. Accordingly, there is approximately 4,429.1 ha of the City that does not have water quality or quantity control provided by SWM facilities such as wet ponds, dry ponds, or engineered wetlands.

6.0 CLASS EA PROCESS

The SWM-MP was conducted in accordance with the requirements for Master Plans under **Section 4, Approach #2** of the Municipal Engineers Association Municipal Class Environmental Assessment Act (October 2000, as amended in 2007 & 2011), which is an approved process under the *Ontario Environmental Assessment Act*. As part of the Class EA process evaluation of

alternatives, assessment of the potential environmental effects and identification of mitigation measures for potential adverse impacts has been conducted and presented through public and agency consultations.

The SWM-MP fulfills all of the Class EA requirements for Schedule A, A+, and B projects which can then proceed directly to detailed design and implementation (as required) and identifies any Schedule C projects for future studies.

Master plans by definition are long range plans which integrate infrastructure for existing and future land use with environmental assessment planning principles. In the case of the City of Waterloo SWM-MP, implementation is projected to occur over a period of 15 years. The SWM-MP concludes with a set of preferred alternatives which make up the recommended approach and, therefore, by its nature, the SWM-MP will limit the scope of alternatives which can be considered at the implementation stage. It is proper to revisit Master Plans on a 5-year basis to ensure conditions (environmental, social, financial and technical) have remained unchanged. As such, if at the time of implementation, conditions have changed such that the preferred alternative cannot be implemented, an addendum may be prepared for the specific project. Amendments to the projects identified as part of the preferred alternatives can be made using the addendum procedures outlined in the Municipal Engineers Association Municipal Class Environmental Assessment Act (October 2000, as amended in 2007 & 2011) document and shall be posted for the required 30-day review period.

7.0 LONG LIST OF ALTERNATIVES

Following the Phase 2 requirements of the Municipal Class EA process and the Master Plan Study process, a series of alternative management options, processes, strategies and project types were identified within each of the six (6) categories of stormwater management measures outlined previously.

8.0 SUMMARY OF TECHNICAL STUDIES

For each of the six (6) categories of stormwater management measures and identified alternatives, a series of technical assessments were undertaken to confirm feasibility and provide direction as to which types of measures should be implemented. For those measures within each category which are subject to the Class EA process, the feasibility was determined through examination of the constraints and opportunities at physical, social and environmental levels.

A series of technical reports have been prepared and included within the technical appendices of the SWM-MP. The report title and purpose are summarized below:

8.1 Sediment Analysis Memo: SWM Facilities and OGS units (June, 2019)

The study assessed existing SWM facilities and OGS unit conditions and prioritized maintenance activities based on the effect of accumulate sediment on performance. The study identified 10 OGS units that are a high priority for maintenance and made recommendations for sediment accumulation surveys at facilities that lacked recent data. The study identified SWM facilities 36 and 8 as being dry facilities that should be prioritized for maintenance due to the high vegetation

within the facilities. Additionally, 4 dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits. Wet facilities 51, 42, 1, 27, 45, 49, 35, 59, 25, 15, 29, 57, 58, and 62 were identified as having significant decreases in performance due to sediment accumulation and should be prioritized for maintenance.

8.2 Market Research Report (January, 2019) & Residential Market Research Summary (January, 2018)

The City of Waterloo undertook an extensive market-based research study to explore and understand the "wants and needs" of residents and businesses in order to support and service those interested in improving stormwater management on their properties using source controls.

This research included a comprehensive review of leading jurisdictions in Canada and the USA, development of a demographic profile of the residents of the City and Waterloo as well as:

- Interviews with business property owners/managers, builders/developers and service providers (in the fields of landscape design and installation, roofing and building sciences, and porous/permeable surfacing).
- A research session with a demographically representative sample of single-detached dwelling in the City.

The study recommended that in addition to the existing residential credit program, the City would evaluate and determine the appropriateness of a variety of incentives and programs to support and service those interested in improving stormwater management on private properties.

8.3 Municipal ROW (Conveyance Control) Retrofit Assessment Opportunities Report (December, 2018)

This technical study assessed stormwater treatment options that can be incorporated into road reconstruction projects undertaken by the City. The study assessed all local, minor and major roads, as well as laneways identified for reconstruction between 2019 and 2025 based on the City of Waterloo's Capital Forecast.

To direct the implementation, a decision-making framework to select the appropriate SWM treatment options for all Capital ROW projects was developed. In consultation with the Region of Waterloo Hydrogeology and Source water Protection staff, a document was subsequently developed which defines where and how infiltration of roadway runoff can safely occur in the context of the approved source protection planning policy.

8.4 End-of-pipe SWM Facilities Opportunities Report (New Facilities) (December, 2019)

The study focused on identifying opportunities where new end-of-pipe facilities could be constructed to provide stormwater quality and quantity control within existing urbanized areas as part of park rehabilitations. The study identified nine (9) locations where either a surface facility (SWM Pond) or subsurface facility (underground storage facility) could be constructed in

combination with a park enhancement of rehabilitation. Three of these were deemed to be priority locations:

- Northwood Park
- Laurelwood Park
- Sandowne Park

8.5 Erosion Assessment Report (March, 2019)

The purpose of this technical study was to document the physical health of Waterloo's watercourses and to create an inventory of erosion sites that could potentially be addressed through creek-based restoration works. A technical field scoring methodology was used to assess the levels of risk and environmental opportunity, and to classify the erosion sites. A total of 36 erosion sites were identified in the field and eight (8) were identified as primary due to significance or associated risk. An evaluation of alternatives was conducted for each of these eight (8) sites and conceptual designs provided.

8.6 Storm Sewer Capacity Report (December, 2019)

This study included the development of a minor system or pipe network model (uncalibrated) using two storm sewer model resolution and extents:

1. All pipes larger than 300mm in diameter in the City core; and
2. Pipes greater than 600mm in diameter throughout the remainder of the City (referred to as a 'trunk sewer model')

The storm sewer system network model was used to complete preliminary assessments of various performance scenarios:

- Existing conditions,
- Development Intensification
- Predicted impacts of predicted Climate Change,
- Water Quality
- Low Impact Development (LID) effects on:
    a. Existing conditions
    b. Predicted Climate Change
    c. Water quality

The modelling exercise determined that climate change does increase the prevalence of flooding but this can largely be mitigated through the implementation of wide-spread source and conveyance controls to reduce runoff volumes into the storm sewer network.

9.0 EVALUTION OF ALTERNATIVES

To select a preferred alternative for each of the six (6) categories of stormwater management measures identified previously; evaluation criteria were developed, an evaluation process was applied and of the preferred alternatives selected in fulfillment of the Class EA process. Each individual preferred alternative forms a component of the preferred SWM strategy or recommended approach. The following details the process undertaken per the Class EA process.

- **Municipal Pollution Prevention, Operations & Maintenance Practices**, follows Schedule A/A+ of the Municipal Class EA process, and therefore, is pre-approved. As such, detailed evaluations were not required.

- **Market Based Strategies for Private Property (source controls)** fall outside of the Class EA process; however, the process for selecting the preferred Market-Based Instruments was documented.

- **Stormwater for the Capital Roads Program (conveyance controls)** also follows Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved. As such, detailed evaluations were not required.

- **Stormwater Management Facilities** were evaluated using the following two (2) Class EA Schedules according to the project nature:

    - **Sediment Removal for SWM Facilities** - follows Schedule A/A+ of the Municipal Class EA process, and therefore, is pre-approved. As such, detailed evaluations were not required.

    - **Park Rehabilitation and SWM Enhancements (New SWM Facilities)** – preferred alternatives were selected for each of the identified nine (9) locations using a series of evaluation criteria that were selected and include Physical/ Natural Environment, Social/ Cultural, Economic and Technical/Engineering criteria. A score was then established through a multidisciplinary evaluation process for each alternative design for each criterion established. This follows Schedule B of the Municipal Class EA process, and therefore can proceed directly to detailed design and implementation.

- **Watercourse and Erosion Restoration** - preferred alternatives were selected for each of eight (8) primary opportunities (erosion sites and restoration reaches) using a series of evaluation criteria that were selected and include Physical/ Natural Environment, Social/ Cultural, Economic and Technical/Engineering criteria. A score was then established through a multidisciplinary evaluation process for each alternative design for each criterion established. This follows Schedule B of the Municipal Class EA process, and therefore can proceed directly to detailed design and implementation.

- **The Urban Flood Management & Stormwater Infrastructure** - addresses only Phase 1 of the EA process (problem Identification and Opportunity). As will be outlined in the subsequent Implementation Plan component of the SWM-MP (under separate cover), Phase 2 works will be completed as part of separate studies which will further the technical work that was undertaken in this study, identify alternatives and select the preferred alternative(s).

10.0 RECOMMENDED APPROACHES

The following section summarizes the preferred alternatives for each of the six (6) stormwater management program elements which collectively make up the recommended approach. **Table E-1** provides an overall summary.

Table E-1: Summary of the Recommended Approach

SWM Element	Recommended Approach (major components)
Municipal Pollution Prevention, Operations & Maintenance Practices	• OGS Maintenance (High, Moderate & Low Priority) • Sediment removal from catch basins from priority areas
Market Based Strategies (source controls)	• Market-Based Instruments (MBIs) Scenario 2 – 20% uptake was selected as the preferred approach as part of the SWM-MP. Includes both broad-based and targeted marketing to non-residential customers, as well as site consultation and design guidance.
Stormwater for the Capital Roads Program (conveyance controls)	• Implementation of conveyance controls using a combination of traditional SWM controls (i.e. OGS units) and Low Impact Development (LID) approaches as part of planned road reconstruction projects identified within the Capital Forecast.
Stormwater Management (SWM) Facilities	• Sediment Removals (High, Moderate & Low Priority) Dry and Wet Ponds • Water Quality Retrofits at four dry SWM facilities and 3 wet ponds (planned and in design) • Park Rehabilitation and SWM Enhancements – 9 New SWM facilities
Watercourse and Erosion Restoration	• Eight (8) primary opportunities (erosion sites and restoration reaches)
Urban Flood Management & Stormwater Infrastructure	• Flow monitoring is recommended to allow for model calibration. Expansion of the existing sewer network model. The model expansion will permit the City to evaluate and select the preferred remedial approaches to improve the level of service.

10.1 Recommended Approach: Municipal Pollution Prevention, Operations & Maintenance Practices

The Recommended Plan for Municipal Pollution Prevention, Operations & Maintenance Practices involves sediment removal from OGS in order to maintain performance. The OGS units that were found to be high priority for sediment removal due to excessive accumulation are identified in **Table E-2**.

Table E-2: High, Moderate and Low Maintenance Priority OGS Units

Asset ID	Make and Model	Install Date	Maintenance Threshold Sediment Depth (mm)	Loss in Maintenance Threshold Sediment Storage Capacity (2016)	Maintenance Priority
10080695	STC-1500	01-Jan-99	400	292%	High Priority
10080622	STC6000	31-Mar-15	425	239%	High Priority
10080647	STC-1500	01-Jan-99	400	222%	High Priority
10080563	STC-3000	21-Mar-12	475	160%	High Priority
10080569	STC-1500	01-Jan-99	400	152%	High Priority
10080521	STC-2000	24-Apr-01	350	116%	High Priority
10080649	STC-1000	10-Dec-02	275	111%	High Priority
10080618	STC-1500	09-Sep-05	400	108%	High Priority
10080651	STC-6000	29-Sep-99	425	90%	High Priority
10080515	STC-2000	13-Jun-05	350	87%	High Priority

10.2 Recommended Approach: Market Based Strategies

Market based strategies are recommended to encourage uptake and implementation of source controls on private property, specifically among industrial, commercial and institutional (ICI) and multi-residential property owners to achieve twenty percent (20%) uptake over a five-year period.

As part of the Preferred Market Based Strategy (MBI Scenario 2), the City of Waterloo would undertake both broad-based and targeted marketing to non-residential and multi-residential customers. Targeted marketing would focus on non-residential and multi-residential customers in key watersheds/drainage sheds via direct marketing. Marketing approaches would include the following:

- Business associations such as the Kitchener-Waterloo Chamber of Commerce and Building Owners and Managers Association (BOMA);
- Direct communications (email, phone, mail);
- Advertising and articles in trade press;
- Peer-to-peer marketing; and,
- Relevant organizations and committees

As part of the preferred alternative, the City would establish an incentive program to be made available to builders/developers of non-residential and multi-residential new construction projects. The City would evaluate and determine the appropriateness of a variety of incentives and programs to support and service those interested in improving stormwater management on their non–residential and multi-residential properties. Approaches such as various financing options, 'bonusing' strategies, review enhancements, and service charge reductions will be evaluated and appropriate methods should be considered as part of the SWM-MP Implementation Plan.

10.3 Conveyance Control

As an element of the recommended approach, the City has identified stormwater management treatment options (conveyance controls) that can be incorporated into all local, minor and major roads, as well as laneways identified for reconstruction between 2019 and 2025.

The incorporation of a cost-effective ROW retrofit approach using a combination of traditional SWM controls (i.e. Oil and Grit Separator (OGS) and other treatment devices) and Low Impact Development (LID) approaches as part of planned road reconstruction and resurfacing projects presents a significant opportunity to improve SWM control (water quality, water quantity, erosion mitigation and water balance) in a cost effective manner within existing urban areas of the City built prior to the implementation of modern stormwater management practices. In addition, ROW retrofits have the added benefit of providing an opportunity to enhance street aesthetics, mitigate and adapt to climate change conditions and reduce urban heat island effects. Preferred stormwater alternatives were selected for 35 local roads, 6 minor collectors, 2 city arterials, 7 regional arterials, and 2 major collectors. Recommended LID measures included perforated pipe, bioswales, bioretention, and oil grit separators.

10.4 Stormwater Management (SWM) Facilities

The Recommended Plan for Stormwater Management (SWM) Facilities includes three (3) primary components:

1. **Sediment Removal** -maintenance requirements (i.e. sediment clean-outs) were prioritized based on bathometry and sediment loading data. Dry facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table E-3**. Wet facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table E-4**.

2. **Retrofit Opportunities** - Retrofits improve or enhance the water quality, quantity and erosion control performance of existing stormwater management facilities and bring them in-line with current standards. The recommended approach includes the retrofit of four (4) existing dry SWM facilities to improve their ability to capture and retain sediment and associated pollutants. In addition, the three (3) proposed retrofit facilities (48, 10 and 28) have satisfied the respective Class EA requirements per previous studies, or are not required to fulfill the EA process so further evaluation as part of the SWM-MP. These retrofit opportunities are summarized in **Table E-5.**

3. **New Facilities as Part of Park Rehabilitations** – the recommended approach includes the construction of three (3) new stormwater management facilities as part of park rehabilitations. The details of the preferred alternatives for the three (3) priority park opportunity sites, as well as an additional six (6) secondary park opportunity sites is summarized in **Table E-6.**

Table E-3: Sediment Removal Priorities for Dry Facilities

SWM Facility #	Year of Construction	Drainage Area (ha)	Volume of Sediment in 2016 (m^3)	Decrease in Storage Capacity	Maintenance Priority
36	1988	12.86	Vegetation	2%	High Priority
8*	1991	78.4	Vegetation	2%	High Priority
16	1994	2.94	75	7%	Moderate Priority
22	1997	1.18	0	12%	Low Priority
13	1995	5.5	95	5%	Low Priority
18*	1986	84	8	3%	Low Priority
6	2014	62.25	0	3%	Low Priority
2*	1987	37.9	0	3%	Low Priority
32	1992	4.3	19	2%	Low Priority
26	1989	17.91	0	2%	Low Priority
9*	1985[1]	81.5	65	1%	Low Priority
23	1992	4.3	11	0%	Low Priority

*Dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits

Table E-4: Sediment Removal Priorities for Wet Facilities

SWM Facility #	Type of Facility	Year of Construction	Drainage Area (ha)	Volume of Sediment in 2019 (m^3)	% of Maximum Allowable Sediment Accumulation	Maintenance Priority
51	Wet	2000	13.75	587	321%	High Priority
42	Wet	1998	34.9	1924	317%	High Priority
1	Wet	2000	9.707	516	266%	High Priority
27	Wet	2000	45.72	2064	254%	High Priority
45	Wet	1999	29.66	1327	232%	High Priority
49	Wet	2002	6.3	724.28	191%	Moderate Priority
35	Constructed Wetland	2002	8	258.4	162%	Moderate Priority
59	Constructed Wetland	2002	8.13	262.599	162%	Moderate Priority
25	Wet	1986	3.24	89	138%	Moderate Priority
15	Wet	1995	41.3	1203	135%	Moderate Priority
29	Wet	2000	8.21	386	131%	Moderate Priority
57	Wet	2001	5.18	122	120%	Moderate Priority
58	Wet	2003	5.83	383	119%	Moderate Priority
62	Wet	2000	7.4	499	107%	Moderate Priority
34	Wet	1997	24.9	855	95%	Low Priority
31	Wet	1995	50.66	826	83%	Low Priority
5	Wet	2006	80.2	1185	73%	Low Priority
50	Wet		12.3	306	68%	Low Priority
54	Constructed Wetland	2001	8.13	225	67%	Low Priority
19	Wet	2000	36.6	652	49%	Low Priority
41	Wet	1999	18.1	213	48%	Low Priority
56	Wet	1999	25.55	201	39%	Low Priority
46	Wet	2013	50.66	321	25%	Low Priority
24	Wet	1995	80	422	7%	Low Priority

Table E-5 - SWM Facility Retrofit Opportunities

SWM Facility #	Facility Type	Drainage Area (ha)	Est. Avg. TIMP%	Water Quality Volume Requirement (cu.m/ha) per MOE 2003	Permanent Pool Volume Requirement (Cu.m)	Year of Construction	Status
48	Wet Pond/ Quality*	76.7	58	194	14,881	1990	Class EA requirements completed per previous studies. Currently in detailed design.
10	Wet Pond/ Quality	10.4	57	192	1,995	1993	
28	Wet Pond/ Quality	4	64.5	115 (wetland due to DA < 5ha)	460 (wetland due to DA < 5ha)	1999	
SWM Facility #	**Control Type**	**Drainage Area (ha)**	**TIMP%**	**Water Quality Volume Requirement (cu.m/ha) per MOE 2003**	**Permanent Pool Volume Requirement (Cu.m)**	**Subwatershed Name and Priority**	**Status**
18	Quantity	84	51	180	15,120	Forwell Creek- 1	Schedule A/A+
9	Quantity	81.5	51	180	14,670	Clair Creek – 2	
8	Quantity	78.4	45	165	12,936	Clair Creek – 2	
2	Quantity	37.9	52	182.5	6,917	Maple Hill Creek – 2	

* Assumed - Unavailable data

Table E-6: Nine (9) New Facilities as Part of Park Rehabilitations

Location Type	Location Name	Recommended Facility Type (1 - Primary alternative; 2- Secondary alternative)	Drainage Area (ha)
Priority Site	Northfield Park	Subsurface Storage Facility	49
Secondary Site	Dunvegan Park	Subsurface Storage Facility	23
Secondary Site	Belgreen Park / Warrington Park	Subsurface Storage Facility	45.3
Secondary Site	Waterloo Park (by LRT)	Subsurface Storage Facility	32.7
Secondary Site	Waterloo Park (Seagram Drive)	Subsurface Storage Facility	31
Priority Site	Laurelwood Park	1) Surface Facility (bioswale) 2) Subsurface Storage Facility	9
Secondary Site	Bechtel Park	Subsurface Storage Facility	35.6
Priority Site	Sandowne Park	Subsurface Storage Facility	54.5
Secondary Site	Lexington Park	Subsurface Storage Facility	10.2

10.5 Watercourse and Erosion Restoration

The eight (8) primary opportunities (erosion sites and restoration reaches) represent the key watercourse and erosion restoration projects to be included as a component of the Recommended Plan. These projects include measures designed to address erosion and flooding problems and restore stream functions and stability. The primary erosion sites and restoration reaches are summarized in **Table E-7.**

Table E-7: Summary of Stream System Opportunities (In Alphabetical Order)

Watercourse	Reach ID	Erosion ID	Risk	Preferred Alternative(s)	Watercourse
Laurel Creek	R4 (Marshall St to Marsland Dr N)	LRL-E5	Sanitary maintenance holes	Removal of Risk (& Local Works)	Laurel Creek
Cedar Creek	R4 (Rec. trail to LRT crossing)	CDR-E4	Sanitary maintenance holes	Full Channel Restoration	Cedar Creek
Laurel Creek	R5 (Erb St to Marshall St)	LRL-E6	Sanitary sewer and maintenance hole	Full Channel Restoration	Laurel Creek
Forwell Creek	R2 (Blue Springs Dr to Forwell Creek Rd)	FRW-E2	Culverts and headwall	Local Works	Forwell Creek
Laurel Creek	R5 (Erb St to Marshall St)	LRL-E7	Recreation trail, sanitary sewer run, private property	Full Channel Restoration	Laurel Creek
Cedar Creek	R2 (Pedestrian crossing to drainage channel)	CDR-E3	Culvert and gabion weir	Local Works	Cedar Creek
Clair Creek Tributary 1	T1-R1 (Keats Way to confluence)	CLR-T1-E1	Gabion and private residence	Full Channel Restoration	Clair Creek Tributary 1
Clair Creek	R9 (Columbia St W to Craigleith Dr)	CLR-E4	Storm sewer outfalls, sanitary sewer, culvert	Full Channel Restoration	Clair Creek

10.6 Urban Flood Management & Stormwater Infrastructure

The uncalibrated model clearly demonstrates that climate change poses a risk to the level of service provided by the minor system. LIDs are recommended to mitigate this risk and build climate change resiliency into the City's storm sewer network. The recommended approach includes calibration of the existing sewer network model via monitoring to be identified for future study as part of the Implementation Plan. The model calibration will permit the City to more accurately evaluate and select the preferred remedial approaches to improve the level of service.

11.0 COST ESTIMATES

Estimated capital costs estimates for each element of the recommended approach are detailed in **Table E-10** below.

Table E-10- Recommended Approach - Capital Cost Estimate†

Recommended Approach Element	Capital Cost Estimate ($ millions)*
1) Municipal Pollution Prevention, Management, Operations & Maintenance Practices	
a. OGS Maintenance (High, Moderate & Low Priority)	$0.046
b. Sediment Removal from catch basins	$0.447
2) Market Based Strategies for Private Property (source controls): 5 year program costs	$3.663
3) Stormwater for the Capital Roads Program (conveyance controls)	$8.375
4) Stormwater Management (SWM) Facilities	
a. Sediment Removals (High, Moderate & Low Priority)	$3.51
b. Retrofits (Planned and Proposed)	$9.987
c. New SWM Facilities	$19.84 – $25.50
5) Watercourse and Erosion Restoration	$9.2 to 13.0
6) Urban Flood Management & Stormwater Infrastructure (Preliminary Estimated Cost Implications based on Uncalibrated model)	$83.6
Total	$138.67 – 148.13
Total Yearly Expenditure‡	**$9.24 – 9.88**

‡ expenditure time frame is 15-years
† Class 'C' cost estimate. Note: all values in 2019 CDN dollars
* Rounded to the nearest $100,000

12.0 NEXT STEPS: IMPLEMENTATION PLAN

A separate document titled **Stormwater Management Master Plan (SWM-MP) Implementation Plan (2020)** will be prepared and included under separate cover. The Implementation Plan (under separate cover) will prioritize all the works based on priority subwatershed as well as recommend funding allocation and policy development. Prioritization will be based on the watersheds in the most need and where there are opportunities to improve conditions through the elements of the recommended approach. The main purpose of the Implementation Plan will be:

- The prioritization of the works based on priority subwatersheds,
- The allocation of the existing and forecasted funding over the next 15 years, and
- The development of supporting policy.

Prioritization will be based on a hierarchical approach, beginning with the watersheds that have been designated Priority 1 and applying the identified opportunities (i.e. watercourse restoration and erosion repairs, source control programs, conveyance controls, O&M, SWM facilities, flooding, etc.) as detailed within the Recommended Approach in order to improve overall subwatershed conditions. Subwatersheds will be prioritized based on the areas of greatest need and opportunity to maximize the 'net-benefit' to the City, the environment and the community.

The implementation plan will detail:

- SWM Policies:
    - for integration into the Development Manual and for use on SWM initiatives
    - for an integrated city-wide approach for water quality, water quantity, erosion control, preservation of hydrologic processes through water budgets, and the preservation and enhancement of the natural environment
    - for the infiltration of runoff to protect groundwater within the Source Protection Policy (SPP) context
    - for alternative SWM financing approaches
    - for the completion of works within private properties

- The market-based approaches designed to increase participation the Stormwater Credit Policy taking into consideration all costs and resource requirements, including staffing, overhead expenses, consulting services, advertising and promotion, and miscellaneous program related expenses;

- The plan will explore the development of a market for the sale of accumulated 'credits' as a future stormwater funding source;

- A strategy to gain access to infrastructure which serves a communal function;

- Various incentives for property owners who implement private stormwater controls as part of the Stormwater Utility Credit Program within prioritized subwatersheds as part of a 'pilot program' with a focus on the Industrial, Commercial, Institutional (ICI) and multi-residential land uses within the City;

- Strategic alignments in regard to the operation and maintenance of City-owned stormwater management facilities, specifically, the development of a cost reconciliation mechanism and service level agreement between the Stormwater Utility and Operations to better track allocated O&M funds and direct the allocation of future O&M funding.

- Final staffing recommendations in order to implement the recommended approach for Market-based approach implementation, conveyance and End-of-pipe opportunities, and Operations and Maintenance.

In order to ensure the goals and objectives of the Master Plan are accomplished over time, a monitoring program will also be established as part of the Implementation Plan which will address the need for financial and staff resources required to:

- Design and optimize a comprehensive water quality monitoring program and creation of a shared water quality data base in partnership with the GRCA and neighboring municipalities;

- Stay current in the review of monitoring reports and data as required by subwatershed plans and other policies;

- undertake monitoring of select stormsewer outfalls, both uncontrolled and SWM facility outlets where stage discharge relationships are not available, in order to calibrate the storm sewer model developed as part of this study.

Analyze and complete Phase 4 of the adaptive environmental management (AEM) feedback loop of subwatershed plans, environmental studies and other policies. The four (4) phase AEM approach requires Characterization (Phase 1), Impact Assessment (Phase 2), Implementation (Phase 3) as well as Monitoring and Refinement of the management strategy (Phase 4). The analyzed data from the follow-up monitoring is used to test the assumptions made during earlier study phases to evaluate the performance of the selected management strategies and make necessary adjustments. When all four (4) phases of the AEM process are not completed the process cannot ensure project goals and objectives are being met.

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List of Terms, Definitions and Acronyms

AEM	Adaptive Environmental Management
ANSI	Area of Natural and Scientific Interest
AMA	Adaptive Management Approach
BMP	Best Management Practice
CofA	Certificate of Authorization
Cms	Cubic Metres per Second
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
ECA	Environmental Compliance Approval
EMC	Event Mean Concentration
EOP	End-of-Pipe
ERA	Ecological Restoration Areas
ESPA	Environmentally Sensitive Policy Area
GI	Green 'Stormwater' Infrastructure
GIS	Geographical Information Systems
GRCA	Grand River Conservation Authority
GRWMP	Grand River Water Management Plan
GWCS	Ground Water Collection Systems
ICA	Issue Contributing Area
SWM-MP	Stormwater Master Plan
LID	Low Impact Development
LOS	Level of Service
MEA	Municipal Class Environmental Assessment
NHS	Natural Heritage System
MNRF	Ministry of Natural Resources and Forestry
MECP	Ministry of the Environment, Conservation and Parks
MTCS	Ministry of Tourism, Culture and Sport
NPS	Urban Non-point Source
OGS	Oil and Grit Separator
OWRA	*Ontario Water Resources Act*
OP	Official Plan
PICP	Permeable Interlock Concrete Paver
PPS	Provincial Policy Statement
PWQO	Provincial Water Quality Objectives
ROP	Regional Official Plan
RMOW	Regional Municipality of Waterloo
SARA	*Species at Risk Act*
SFU	Single Family Unit
SPP	Source Protection Plan
STEP	Sustainable Technologies Erosion Assessment Program

SWM	Stormwater Management
SWMPDM	Stormwater Planning and Design Manual (MECP 2003)
SWS	Subwatershed Study
WEMP	Water Efficiency Master Plan
WHPA	Well Head Protection Area
WRS	Water Resource Sustainability
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1 Introduction

The City of Waterloo Stormwater Management Master Plan (SWM-MP) Environmental Assessment (EA) is a strategic document that provides direction for the management of stormwater runoff and related infrastructure. The SWM-MP identifies a preferred strategy to protect and enhance natural features, ecological function and biophysical integrity, and appropriately manage risks through the establishment of environmental targets.

The SWM-MP establishes the stormwater management policies and guidelines for the next 15 years, addresses stormwater infrastructure needs, identifies and prioritizes recommended works, and informs the overall asset management plan for the City of Waterloo.

1.1 Study Purpose

It is the intent of the SWM-MP to develop a preferred stormwater management strategy (Recommended Approach) for the City of Waterloo following a Master Planning approach. The SWM-MP addresses primarily the existing urban areas of the City and recommends remedial measures to improve overall environmental performance, increase efficiencies and reduce costs. The study focus is not new development; however, it does provide guidance in regards to future policies and identified intensification areas. It is understood that new development must follow the established processes and requiring approval under the Planning Act.

The purpose of the SWM-MP study is to update the City of Waterloo 2005 Master Drainage study and serve as a decision support tool, as well as a methodology for the prioritization of works. The SWM-MP also serves as a transparent community consultation process by which the City can establish stormwater management guidelines and policies.

When approved, the SWM-MP will provide direction for resource requirements and identified works relating to the following six (6) stormwater management program elements:

1) Municipal Pollution Prevention, Operations & Maintenance Practices,
2) Market Based Strategies for Private Property (source controls),
3) Stormwater for the Capital Roads Program (conveyance controls),
4) Stormwater Management Facilities,
5) Watercourse and Erosion Restoration, and
6) Urban Flood Management & Stormwater Infrastructure.

1.1.1 Study Context - SWM Master Plan

This study has been completed as an integrated Stormwater Master Pan (SWM-MP), a new approach to completing municipal stormwater master plans under *Section 4, Approach #2 of the Municipal Engineers Association Municipal Class Environmental Assessment Act (October 2000, as amended in 2007, 2011 & 2015)*. An integrated SWM-MP addresses watershed-based issues relating not only to stormwater but also water supply and wastewater in a holistic manner. In this way cost-effective and sustainable solutions can be identified and implemented. The SWM-MP has been completed in keeping with the Ontario Water Resources Act (OWRA) O.Reg 525/98

which is designed to conserve, protect and manage Ontario's water resources for efficient and sustainable use relating to both groundwater and surface water throughout the province.

The conventional SWM Master Plan approach looks only at the impact of stormwater at the local scale in isolation and neglects the effect of stormwater on water supply and waste water treatment. For example, consider the effects of stormwater on the municipal water supply which are: Lake based vs. River based vs. Groundwater based.

On a case by case basis, i.e. within an individual municipality, the challenges and impacts relating to stormwater on water supply and waste water treatment may seem easy to understand and manage. However, when considering that challenges and impacts do not end at political boundaries, but rather are shared across the watershed, within neighbouring communities and span semi-urban, urbanizing and established development areas, the different scenarios and impacts become harder to understand and manage (**Figure 1.1**).

It is precisely for these reasons, that the integration of stormwater, wastewater and water supply is needed.

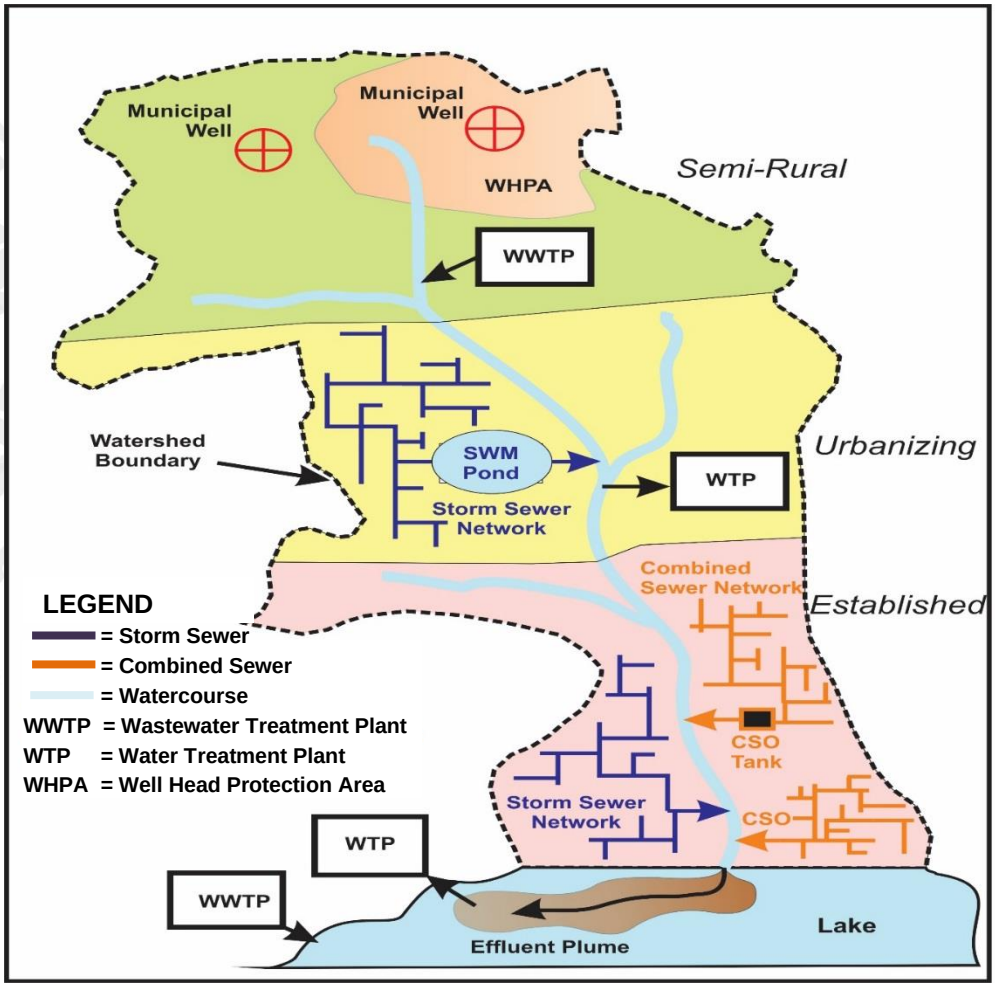

Figure 1.1: Conventional Approach to SWM

A integrated SWM-MP is a plan which strives for Water Resource Sustainability (WRS). WRS is defined as the planning, study and management of water resources that fundamentally recognizes the interdependencies of stormwater, wastewater and water supply relating to the geographical context of the study area within the watershed in combination with asset management approaches for stormwater infrastructure.

Water Resource Sustainability (WRS) is accomplished through the application of two key principles – Watershed Sustainability and Asset Management:

- Watershed Based Environmental Management – refers to ensuring that ecological attributes and functions are addressed in order to achieve environmental goals and objectives as identified within the Watershed Plan and/or environmental planning process.
- Asset Management – refers to the management of drainage infrastructure and functions within municipal boundaries

1.2 Study Goals & Objectives

The SWM-MP integrates water resources in the context of stormwater, water and wastewater, within a holistic approach to the natural environment and associated wildlife habitats, existing and future policies, land planning, concepts of open space & trails, operation and maintenance, asset management, climate change and community engagement and marketing.

The study goals and objectives for the City of Waterloo SWM-MP are informed by key documents, including:

1. The Grand River Water Management Plan (2014)
2. Best Practices Guide for Reducing Urban Non-point Source (NPS) Pollution in the Grand River Watershed (2014)
3. Previous watershed and subwatershed studies (various dates)

These documents have received support from City staff and Council and should be viewed as guiding documents, representing established commitments by the City of Waterloo for the management of surface and ground water resources in the Grand River Watershed to 2034. Additional detail is provided below.

The Grand River Water Management Plan (GRWMP)

Developed by the Grand River Conservation Authority (GRCA) and endorsed by the City of Waterloo on May 26th, 2014, the GRWMP (2014) is an integrated water management plan with four (4) main goals:

1. Ensure sustainable water supplies for communities, economies and ecosystems;
2. Improve water quality to improve river health and reduce the river's impact on Lake Erie (specifically phosphorous);
3. Reduce flood damage potential; and

4. Increase resiliency to deal with climate change.

Best Practices Guide for Reducing Urban Non-point Source (NPS) Pollution in the Grand River Watershed

The Best Practices Guide (2014) report builds on the recommendations of the GRWMP with three (3) main objectives and thirteen (13) recommendations. The three (3) main objectives include:

- Improve Stormwater Management Governance and Stewardship
- Secure Sustainable Funding to Implement Stormwater BMPs
- Improve Stormwater Management Education

1.2.1 SWM-MP Study Goals

The goals of City of Waterloo SWM-MP have been developed in keeping with the goals and objectives of the key guiding documents listed above and in compliance with existing guidance, acts and regulations. The study goals include:

- Direct infill and redevelopment requirements in regard to stormwater management criteria tied to the preferred Master Plan strategies,
- Fill gaps in existing subwatershed studies and stormwater master plans,
- Maintain existing funding and forecast future funding requirements to implement the preferred stormwater strategies,
- Improve community stormwater management education resources and programs,
- Develop an integrated city-wide approach for water quality, water quantity, erosion control, preservation of hydrologic processes through water budgets, and the preservation and enhancement of the natural environment,
- Aid in the development of a 'level of service' (LOS) for stormwater management with the City,
- Inventory and address stormwater infrastructure issues as part of the City's overall asset management program,
- Direct future SWM monitoring in compliance with the plan's goals, targets and objectives which acknowledges the adaptive environmental management (AEM) process,
- Evaluate the current Stormwater Utility Fee and Stormwater Credit Program,
- Enhance existing incentive programs, increase the uptake rate of credit applications, and examine the monetary value of rebates and the method by which the credits are given,
- Develop new SWM policies for the City,
- Develop an implementation plan to direct the safe and effective management of stormwater runoff from the City`s urban areas while improving the ecosystem health and ecological sustainability of the receiving watersheds. The implementation plan is designed to direct future actions, identify responsible parties, outline costs and environmental benefits and clearly define the operation and maintenance requirements and costs,
- Improve stormwater management governance and stewardship within the City and the Grand River Watershed.

1.2.2 SWM-MP Study Objectives

The City of Waterloo SWM-MP considers flood and erosion control, groundwater and surface water quality management, natural heritage environment management and infrastructure, all in an integrated manner as part of an overall water sustainability plan. In addition, the SWM-MP integrates existing policies, regulations, acts and guidelines, and where appropriate, develops new policies to aid in implementation and does so within a water resource sustainability (WRS) context. The objectives of the City of Waterloo SWM-MP include the following:

Water Quality

- Maintain or improve surface water and groundwater quality.
- Minimize sediment loading to surface water and groundwater.
- Maintain or enhance the quality of drinking water sources.
- Maintain existing thermal watercourse regimes and enhance cool/coldwater regimes where possible.
- Design and optimize a comprehensive water quality monitoring program.

Water Quantity

- Preserve and re-establish the natural hydrologic process to protect, restore and replenish surface water and groundwater resources.
- Minimize the threat to life and property from flooding and climate change.
- Maintain or enhance groundwater supplies through infiltration while minimizing the risks from future land uses and activities.

Erosion Control

- Reduce the impacts of excessive erosion on aquatic and terrestrial habitat and property.
- Integrate stream erosion within a master planning process.

Natural Environment

- Protect, enhance and restore natural features and functions such as wetlands, riparian and ecological corridors, as well as identified linkages.
- Improve warmwater, coolwater and coldwater fisheries where feasible.

Water Resource Sustainability

- Holistically integrate goals, objectives and targets for water resources (water, sanitary and storm).
- Improve stormwater infrastructure resiliency and adaptation related to climate change.

Infrastructure

- Provide a level of service for stormwater management which is consistent with municipal and agency standards. Develop ways to optimize infrastructure wherever feasible.
- Encourage the implementation of innovative solutions including Low Impact Development (LID) and Green 'Stormwater' Infrastructure (GI) to mitigate stormwater runoff as part of the development of sustainable infrastructure solutions.
- Develop a strategy to gain access to infrastructure which serves a communal function.

Policy and Implementation

- Reflect existing acts, policies and regulation.

- Integration of Asset Management Plans for Stormwater which includes long-range forecast and planning direction for many of the specific policy items and recommendations (i.e. ponds, OGS and stream rehabilitation).
- Create SWM Policies for integration into the Development Manual and for use on SWM initiatives.
- Review and integration of the SWM Quality Management System.

1.3 Background

In 2005, the City of Waterloo completed a Master Drainage Study to identify areas of the city where drainage deficiencies exist, the impact of future development on drainage infrastructure, and to provide mechanisms to mitigate these deficiencies. Since 2005, other studies have been completed to assess stormwater infrastructure requirements. However, the Master Drainage Study is now 14 years old, and is out of date due to new SWM technology and changes in key policies, acts, and regulation standards.

The field of stormwater management has evolved since the early 2000s (**Figure 1.2**) to include broader environmental objectives and targets for not only water quality, quantity and erosion control, but now include a greater focus on water budget (infiltration) considerations, as well as the protection of aquatic and terrestrial habitats and groundwater resources. In addition, climate change resiliency, adaptation and mitigation must now be considered as part of stormwater design and implementation.

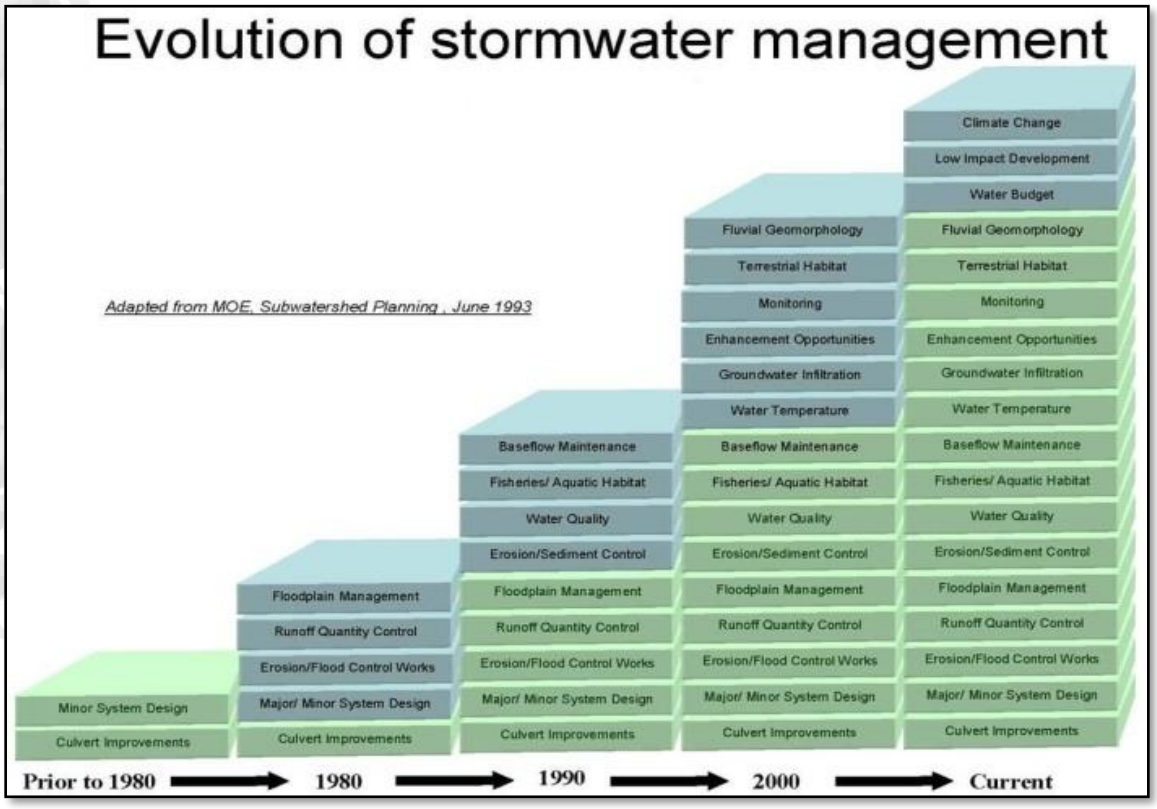

Figure 1.2: Evolution of Stormwater Management

1.4 Report Organization

Section 1.0 – Provides an introduction to the study, the study purpose, goals, objectives as well as an overview of the Class Environmental Assessment Process.

Section 2.0 – Describes the Problem statement, opportunity and constraints.

Section 3.0 – Summarizes key Federal, Provincial, Regional and Local legislations, policies, and guidelines for the management of water resources and stormwater management.

Section 4.0 – Summarizes the existing environmental conditions and stormwater assets within the City of Waterloo based on available information extracted from background reports, GIS mapping and databases, including the baseline subwatershed health score and ranking for Terrestrial Subwatershed Health, Stormwater Management, Water Quality, Stream Channel and Riparian Health, Aquatic Ecology, as well as the Overall Subwatershed Condition.

Section 5.0 – Details the various stormwater management options relating to each of the six (6) elements of stormwater management practices included with the SWM-MP and the development of the long list of alternatives.

Section 6.0 – Summarizes the study approach, analysis and recommendations relating to the SWM-MP program element 1) Municipal Pollution Prevention, Operations & Maintenance Practices.

Section 7.0 – Summarizes the study approach, analysis and recommendations relating to the SWM-MP program element 2) Market Based Strategies for Private Property (source controls).

Section 8.0 – Summarizes the study approach, analysis and recommendations relating to the SWM-MP program element 3) Stormwater for the Capital Roads Program (conveyance controls).

Section 9.0 – Summarizes the study approach, analysis and recommendations relating to the SWM-MP program element 4) Stormwater Management Facilities (end-of-pipe controls – existing, planned and proposed).

Section 10.0 – Summarizes the study approach, analysis and recommendations for the SWM-MP program element 6) Urban Flood Management and Storm Sewer Infrastructure.

Section 11.0 – Summarizes the study approach, analysis and recommendations for the SWM-MP program element 5) Watercourse and Erosion Restoration

Section 12.0 – Describes the evaluation criteria, evaluation process and selection of the preferred alternatives which will form the Recommended Approach in fulfillment of the Class Environmental Assessment process (Class EA).

Section 13.0 – Describes the Recommended Approach.

Section 14.0 – Summarizes the estimated costs of the Recommended Approach.

Section 15.0 – Details the study recommendations.

Section 16.0 – Describes the development of an Implementation Plan which is to follow the SWM-MP.

1.5 The Class Environmental Assessment Process

An approved Class Environmental Assessment (Class EA) document describes the process that a proponent must follow for a class or group of undertakings in order to satisfy the requirements of the *Environmental Assessment Act*, represents a method of obtaining an approval under the *Environmental Assessment Act* and provides an alternative to carrying out individual environmental assessments for each separate undertaking or project within the class.

The *Environmental Assessment Act* was legislated by the Province of Ontario in 1980 to ensure that an Environmental Assessment is conducted prior to the onset of development and development related (servicing) projects. Depending on the individual Class Environmental Assessments (Class EA) or Master Plan to be completed, there are different processes that municipalities must follow in order to meet Ontario's Environmental Assessment requirements.

These processes are defined within the Municipal Engineers Association (MEA) Class Environmental (Class EA) (2000, as amended 2007, 2011 & 2015)

Class EAs (see **Section 1.5.1**) or Master Plan (see **Section 1.5.2**) are prepared for approval by the minister of the environment and are approved planning document that defines: projects, groups of projects and / or activities and the environmental assessment (EA) process which the proponent commits to for each project undertaking. Provided the process is followed, projects and activities included do not require formal review and approval under the *Environmental Assessment Act*. In this fashion the process expedites the environmental assessment of smaller recurring projects.

The Environmental Assessment process to be followed is illustrated in **Figure 1.3**, and may involve up to five phases of assessment. These phases include:

- **Phase 1**: Establish the Problem or Opportunity
- **Phase 2**: Identify and Assess Alternative Solutions to the Problem, and Select a Preferred Alternative
- **Phase 3**: Identify and Assess Alternative Design Concepts for the Preferred Solution, and Select a Preferred Design Concept
- **Phase 4**: Prepare an Environmental Study Report
- **Phase 5**: Proceed with Design and Implementation

Public and agency consultation is also an important and necessary component of the five phases.

In partial fulfillment of Ontario's Environmental Assessment requirements, the process must satisfy at least the first two (2) phases of the Class Environmental Assessment process. Depending on the type of study to be completed, Phases 3 and 4 may also be required.

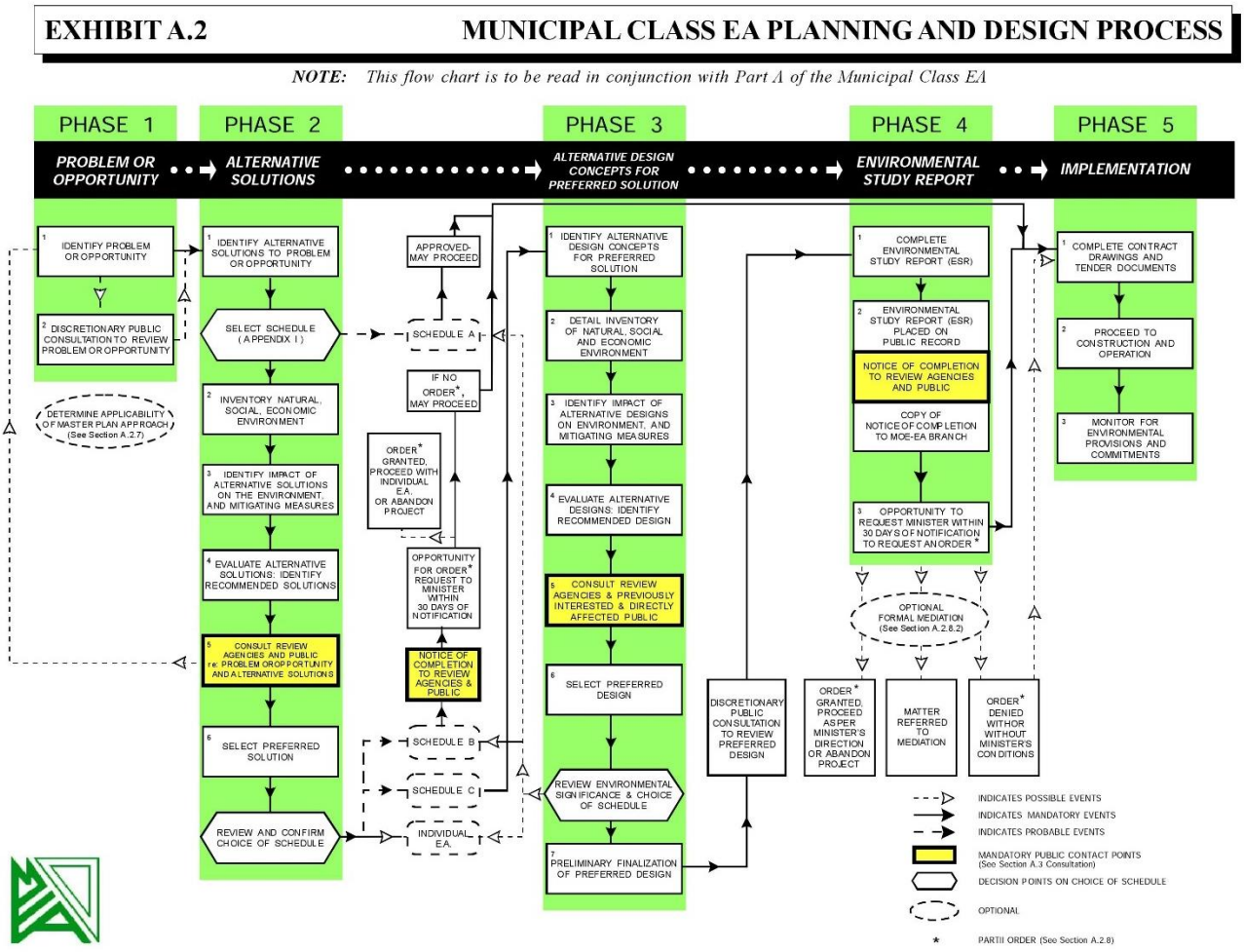

Figure 1.3: MEA Flow Chart

1.5.1 Class Environmental Assessment (Class EA)

The Municipal Engineers Association's Class EA document classifies individual projects as Schedule A, A+, B or C depending on their level of environmental impact and public concern. Any project identified must be classified as to their level of complexity and potential level of environmental impact, which will in turn decide which Schedule process needs to be followed.

- **Schedule 'A'** projects are generally routine maintenance and upgrade projects; they do not have the potential for significant environmental impacts or need public input. Schedule 'A' projects are pre-approved without any further public consultation.

- **Schedule 'A+'** was introduced in 2007 by the Municipal Engineers Association. These projects are pre-approved; however, the public is to be advised prior to the project implementation. Per Appendix 1 – Project Schedules of the Municipal Class Environmental Assessment (2000, as amended in 2007, 2011 & 2015), wastewater

management projects that are intended to "modify, retrofit, or improve a retention/detention facility including outfall or infiltration systems for the purpose of stormwater quality control" including "biological treatment through the establishment of constructed wetlands" are pre-approved under Schedule A+ of the MEA.

- **Schedule 'B'** projects have more environmental impact and do have public implications. Examples would be stormwater ponds, river crossings, expansion of water or sewage plants up to or beyond their rated capacity, new or expanded outfalls and intakes, and the like. Schedule 'B' projects require completion of Phases 1 and 2 of the Class EA process.

- **Schedule 'C'** projects have the most major public and environmental impacts. Examples would be storage tanks and tunnels with disinfection, anything involving chemical treatment or expansion beyond a water or sewage plants rated capacity. Schedule 'C' projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 implementation.

1.5.2 Master Plans

Master Plans are one form of Class EA document representing long range plans with environmental assessment planning principles. Master Plans provide a strategy for implementing a large number of projects of a similar nature where differences being primarily due to site specific conditions. The following characteristics distinguish the Master Planning Process from other processes:

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

b) Master Plans typically recommend a set of works which are distributed geographically throughout the study area and which are to be implemented over an extended period of time. Master Plans provide the context for the implementation of the specific projects which make up the plan and satisfy, as a minimum, Phases 1 and 2 of the Class EA process (**Figure 1.3**). Notwithstanding that these works may be implemented as separate projects, collectively these works are part of a larger management system. Master Plan studies in essence conclude with a set of preferred alternatives and, therefore, by their nature, Master Plans will limit the scope of alternatives which can be considered at the implementation stage.

The Municipal Engineers Association (MEA) Class Environmental Class EA document also identifies four different approaches to completing Master Plans corresponding to different levels of assessment. Regardless of the approach selected, all Master Plans must follow at least the first two phases of the Class Environmental Assessment process (**Figure 1.3**).

- **Approach 1**, the most common approach, is to follow Phases 1 and 2 as defined above, then use the Master Plan as a basis for future investigations of site-specific Schedule 'B' and 'C' projects. Any Schedule 'B' and 'C' projects that need specific Phase 2 work and Phase 3 and 4 work, usually have this Phase 2, 3 and 4 deferred until the actual project is implemented.

- **Approach 2** is to complete all of the work necessary for Schedule 'B' site specific projects at the time they are identified. Using this approach, a municipality would identify everything it needed in the first five years and would complete all the site-specific work required, including public consultation to meet Class EA requirements. The Master Plan in such cases has to be completed with enough detail so that the public in site-specific locations can be reasonably informed, and so that the approving government Agencies (Conservation Authorities, Ministry of Natural Resources and Forestry, Federal Department of Fisheries and Oceans, Transportation Canada, etc.) can be satisfied, in principal, that their concerns will be addressed before construction commences.

- **Approach 3** is to complete the requirements of Schedule 'B' and Schedule 'C' at the Master Plan stage.

- **Approach 4** is to integrate approvals under the EA and Planning Acts. For example, the preparation of new or amended Official Plans could be undertaken simultaneously with Master Plans for water, wastewater and transportation, and approval for both sought through the same process.

1.5.3 City of Waterloo Stormwater Management Master Plan

The City of Waterloo Stormwater Management Master Plan (SWM-MP) was conducted in accordance with the requirements for Master Plans under **Appendix 4, Approach #2** of the Municipal Engineers Association Municipal Class Environmental Assessment (October 2000, as amended in 2007, 2011 & 2015). As part of the Class EA process evaluation of alternatives, assessment of the potential environmental effects and identification of mitigation measures for potential adverse impacts has been conducted and presented through public and agency consultations.

This SWM-MP fulfills all of the Class EA requirements for Schedule A, A+, and B projects which can then proceed directly to detailed design and implementation (as required) and identifies any Schedule C projects for future studies.

Master plans by definition are long range plans. In the case of the City of Waterloo SWM-MP, implementation is projected to occur over a period of 15 years.

This SWM-MP concludes with a set of preferred alternatives which make up the Preferred SWM Approach (i.e. Recommended Approach) It is proper to revisit Master Plans on a 5-year basis to ensure conditions (environmental, social, financial and technical) have remained unchanged. As such, if at the time of implementation, conditions have changed such that the preferred

alternative cannot be implemented, an addendum may be prepared for the specific project. Amendments to the projects identified as part of the preferred alternatives can be made using the addendum procedures outlined in the Municipal Engineers Association Municipal Class Environmental Assessment (October 2000, as amended in 2007, 2011 & 2015) document and shall be posted for the required 30-day review period.

Prior to implementation, additional public consultation shall be undertaken in support of further work carried out in the future for specific Schedule B projects. In addition, integration across city departments is fundamental to a modern approach to stormwater management and is essential for the City of Waterloo in the implementation of the SWM-MP in order to meet the project goals and objectives. In this regard, potential synergies with other City Strategic Plans, Subwatershed Studies, Master Plans, Secondary Plans, Environmental Assessments and Policies are considered essential.

1.6 Study Process

The study process that has been followed in this study is illustrated in **Figure 1.4.** The study has been broken down into three (3) stages. Stages 1 and 2 represent the completion of the Stormwater Management Master Plan (SWM-MP) Municipal Class Environmental Assessment per the Municipal Class Environmental Assessment Master Planning process, as described By the Municipal Engineers Association (2000, as amended 2007, 2011 & 2015). The third stage is the Implementation Plan, which is to be submitted under a separate cover.

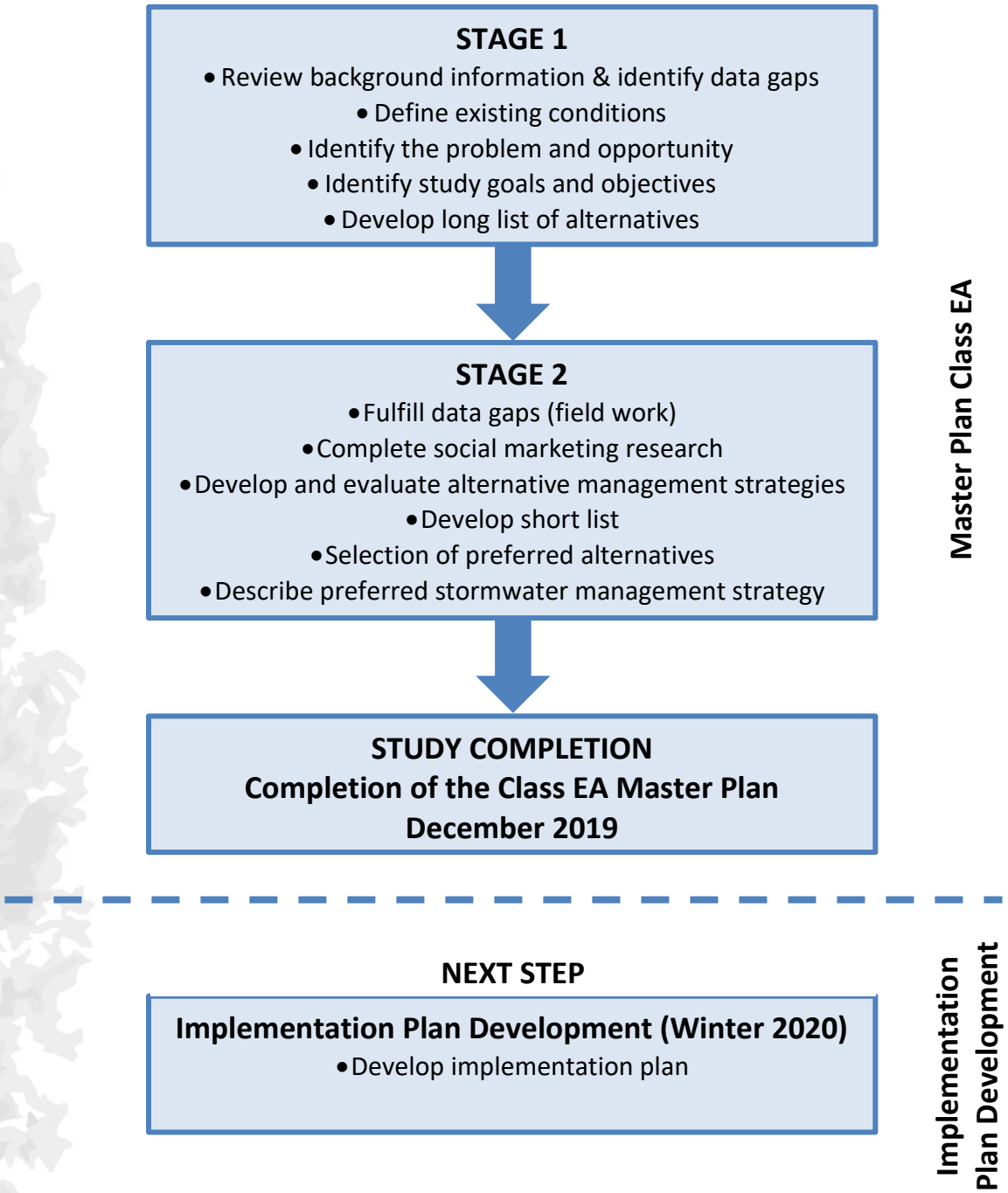

Figure 1.4: City of Waterloo Stormwater Master Plan Study Process

1.7 Public Consultation

This section summarizes the Public Consultation component of the study per the Consultation Plan. Recognizing the mandatory requirements for Public Consultation under the Municipal Class EA process, the Consultation Plan ensured all mandatory requirements were met while providing a more innovative approach that provides for enhanced public input and ultimately lays the foundation for improved participation of residents to secure feedback. It was the intent of the SWM-MP to move public consultation beyond a process of presentation and feedback to a community visioning opportunity and a chance to create excitement, secure valuable insights and ideas and encourage public support.

In advance of Public Open houses, key messaging was developed and advanced advertising was undertaken via newspaper, mail and website and throughout the City using mobile signs, and electronic signs at City facilities. At the public open houses, a relaxed 'coffee-house' atmosphere was created including a mobile coffee stand and separate areas were created, specifically:

1. **INFORMATION ZONE** - provided an opportunity for the public to review the study results related to environment, stormwater, and municipal infrastructure assets within the city's boundary
2. **INTERACTIVE ZONE** provides an opportunity for the public to: Share their knowledge and experience, provide their personal vision for the city, and identify any stormwater issues within their neighbourhood

To ensure full transparency and public involvement, the public consultation completed for the SWM-MP included:

1. **Notice of Study Commencement** (Notice was issued on June 29, 2017, and July 6, 2017)

2. **Public Open Houses**

   Public Open House No. 1 **-** was held on Tuesday November 14, 2017 from 5:30 to 8:00 pm in the Atrium of Waterloo City Hall, 100 Regina St. S., Waterloo.

   Public Open House No. 2 **-** was held on Tuesday November 13, 2018 from 5:30 to 8:00 pm in the Atrium of Waterloo City Hall, 100 Regina St. S, Waterloo.

   Public Open House No. 3 **-** was held on Tuesday October 8, 2019 from 5:00 to 8:00 pm in the Atrium of Waterloo City Hall, 100 Regina St. S, Waterloo.

3. **Project Team**
   A core project team was established which consisted of City staff from all departments.

4. **Stakeholders**
   A group of local stakeholders, community groups, agencies, and various levels of government were invited to participate in the Master Plan process. Legislative notices which included

updated project materials on the City's website as well as invitations were extended for all Public Information Centers to all Stakeholders. This group included:

- *Grand River Conservation Authority (GRCA)*
- *Chamber of Commerce, City of Cambridge, City of Waterloo, Township of North Dumfries, County of Wellington*
- *Region of Waterloo: Staff, Waterloo Regional Police Service Region of Waterloo Public Health and Emergency Services, Region of Waterloo LRT*
- *Members of Parliament and Members of Provincial Parliament*
- *Federal and Provincial Agencies: Department of Fisheries and Oceans, Aboriginal Affairs and Northern Development Canada, Ministry of Natural Resources and Forestry, Ministry of Tourism, Culture and Sport, Ministry of the Environment, Conservation and Parks, Infrastructure Ontario, Environment Canada, Ministry of Transportation, Ministry of Municipal Affairs and Housing COSEWIC – Secretariat, National Heritage Information Centre, Ministry of Agriculture, Food & Rural Affairs, Canadian Transportation Agency*
- *REEP Green Solutions and REEP House for Sustainable Living*
- *Industry Canada*
- *The Waterloo Region Home Builders Association*
- *Ontario Federation of Agriculture*
- *University of Waterloo, Wilfred Laurier University, Conestoga College – Waterloo Campus*
- *Local Utilities*
- *Waterloo Region District School Board and Waterloo Catholic District School Board*
- *First Nations – Six Nations of the Grand River, Mississauga of the New Credit First Nations, Huron-Wendat Nation Council, Six Nations Eco-Centre, Haudenosaunee Resource Centre, Haudeosaunee Confederacy Council, Haudenosaunee Development Institute, Mohawks of the Bay Quinte, Oneida Nation of the Thames, Métis Nation of Ontario*

5. Community and Market Engagement

As a component of the development of the Market Based Strategy (see **Section 7**), primary research was undertaken using 'key informant interviews' to identify and explore constraints and opportunities for uptake of on-site SWM measures amongst property owners including homeowners, industrial/commercial property owners, and builders/developers and to determine the potential influence of service providers (landscaping, roofing/building sciences, and porous/permeable surfacing) on the target sectors. They included (as detailed in **Appendix F**):

- Twenty-one (21) interviews with the business and/or trade sector
- Target consultation with residential homeowners via a focus research session comprised of thirty-four (34) Waterloo residents selected as a demographically representative sample of the City.

A complete record of public consultation is included as **Appendix M.**

2 Problem Statement and Opportunity Identification

2.1 General

In 2005, the City of Waterloo completed a Master Drainage Study to identify areas of the city where drainage deficiencies exist, the impact of future development on drainage infrastructure, and to provide mechanisms to mitigate these deficiencies. Since 2005, other studies have been completed to assess stormwater infrastructure requirements. However, the Master Drainage Study is now 14 years old, and is out of date due to new SWM technology and changes in key policies, acts, and regulation standards. A Stormwater Master Plan (SWM-MP) is thus being completed, following a Master Planning approach in accordance with the *Environmental Assessment Act as outlined by the Municipal Engineer's Association Municipal Class Environmental Assessment (MEA), October 2000, as amended in 2007, 2011 & 2015.*

2.2 Problem Statement

Areas of urban land use may degrade the environment in many ways. Degradation may occur at the onset as lands are stripped during the construction process. This may result in pollutants such as excessive sediment loads being discharged to the receiving bodies of water.

Sediment loading typically decreases as development of an area is completed, but different pollutants from the urban area can emerge at this stage. Common sources of pollutants include heavy metals from automobiles and air emissions, nutrients from fertilizers, bacterial contamination from animal wastes within stormwater runoff and toxic contaminants from a variety of residential, commercial and industrial sources.

The pollutants from developed urban areas, when conveyed to the receiving bodies of water, impact the environment in many ways. The particulate (settleable) and dissolved contaminants stress aquatic ecosystems by depleting oxygen, raising ambient water temperature, covering habitat or through the bioaccumulation or bioconcentration of contaminants in the tissues of various aquatic species. Similar to urban areas, rural areas may also degrade the environment as a result of increased bacterial, nutrient and suspended solids loadings from farms, golf courses and nurseries.

Urban development within the lands draining to streams also results in a transformation of the hydrologic characteristics within subwatersheds. Large amounts of previously permeable soils, which allowed rainwater to soak into the ground, are covered with impervious materials such as concrete and asphalt. Rainfall events that previously contributed little or no runoff to streams now cause flow to occur in the channels. Consequently, the amount of water draining to streams increases significantly in volume.

Commensurate with the increase in the volume of runoff is a decrease in the time it takes for the runoff to reach the channels. Storm sewers were constructed to rapidly convey the rainwater to streams resulting in higher peak flow rates in the receiving channels.

As a result of existing land uses, together with proposed changes in land use within the urban core, a number of potential environmental problems have been identified. These include:

- Degraded surface water and groundwater quality
- Thermal enrichment of surface water
- Increased sediment loads to surface water
- Adverse effects on human and animal health
- Loss and degradation of fish and wildlife habitat, natural features and processes
- Increased flooding and erosion
- Disruption of the pre-development hydrologic process (reduction in groundwater recharge and stream baseflow)
- Urban flooding (overwhelming of the municipal storm sewer system)

3 Policy Framework & Technical Direction

As a component of the SWM-MP, a Stormwater Policy Review was completed to identify existing policies, guidelines, and legislation that relate to stormwater management in the City of Waterloo.

In Canada, environmental issues including stormwater planning and management are predominantly regulated through a multi-level legislative framework. Under the legislative framework for stormwater planning and management within the City of Waterloo, there are several jurisdiction levels that interact and apply based on many factors including geographical scale, and administration role. These jurisdiction levels include:

- Local – Regional, Watershed or Municipal
- Provincial
- Federal

The reviewed documents are listed in **Table 3.1** below and are summarized in **Appendix A**.

Appendix A summarizes the relevant multi-level legislative framework in order to guide and direct future stormwater management activities in the City of Waterloo. It also is intended to inform this SWM-MP to ensure future municipal policy development is in full compliance with the necessary policies, statutes, regulations, plans and guidelines.

Table 3.1: Summary of Reviewed Federal, Provincial, Regional and Local Policies, Guidelines & Legislation

Federal Legislation	
• The Fisheries Act (1985, Amended 2016) • The Canada Water Act (1985, Amended 2014) • The Canadian Environmental Protection Act (1999, Amended 2019) • The Canadian Environmental Assessment Act (2012, Amended 2017) • The Migratory Birds Convention Act (1994, Amended 2017) • The Species at Risk Act (2002, Amended 2019) • Navigation Protection Act (1985, Amended 2017)	
Provincial Legislation, Policies and Guidelines	
Ministry of the Environment, Conservation and Parks (MECP)	• Water Management Policies, Guidelines and Provincial Water Quality Objectives (PWQO) - The Blue Book (1994, Reprinted 1999) • Water Resources Act (1990, Amended 2019) • Clean Water Act (2006, Amended 2019) • Environmental Protection Act (1990, Amended 2019) • Water Opportunities Act (2010, Amended 2019) • Safe Drinking Water Act (2002, Amended 2019) • Endangered Species Act (2007, Amended 2019) • Environmental Assessment Act (1990, Amended 2019) • Stormwater Management Planning and Design Manual (2003) • MECP Interpretation Bulletin (February 2015) • Low Impact Development Stormwater Management Guidance Manual (Draft 2017) • Management of Excess Soil – A Guide for Best Management Practices (2014, Updated 2019)
Ministry of Natural Resources & Forestry (MNRF)	• Lakes and Rivers Improvement Act (1990, Amended 2019) • Fish and Wildlife Conservation Act (1997, Amended 2019)
Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA)	• Drainage Act (1990, Amended 2019) • Nutrient Management Act (2002, Amended 2019)
Ministry of Municipal Affairs and Housing (MMAH)	• Planning Act (2010, Amended 2019) & the Provincial Policy Statement (Ministry of Municipal Affairs & Housing) (2014) • The Municipal Act (2001, Amended 2019) • A Place to Grow: Growth Plan for the Greater Golden Horseshoe (2019)
Ministry of Infrastructure	• The Places to Grow Act (2005, Amended 2012) • Policy Review of Municipal Stormwater Management in the Light of Climate Change (2011, Updated 2019)
Ministry of Tourism, Culture and Sport	• Ontario Heritage Act (1990, Amended 2019)
Local Legislation, Policies and Guidelines	
• Conservation Authorities Act, Ontario Regulation 150/06 (1990, Amended 2019) • Water Resources Protection Master Plan (2008) • Grand River Source Protection Plan (2016) • Region of Waterloo Official Plan (2015) • City of Waterloo Official Plan (2016) • Development Engineering Manual (2013)	

Local Plans, Strategies, and Guidelines
• Parkland Strategy (under development) • Waterloo Park Master Plan (2009) • City of Waterloo Transportation Master Plan (2011) • City of Waterloo Asset Management Plan (2016) • City of Waterloo Stormwater Utility and Credit Program By-Law (2012) • Region of Waterloo Greenlands Network Implementation Guideline (2016) • Grand River Water Management Plan (2014) • City of Waterloo Urban Design Manual (2010) • GRCA Fisheries Management Plan (2005) • Best Practices Guide for Reducing Urban Non-Point Source Pollution in the Grand River Watershed (2014) • Subwatershed Studies and Master Drainage Plans • Relevant Documents from External Jurisdictions (Various)

3.1 Cultural Heritage

The Ontario Ministry of Tourism, Culture and Sport (MTCS) mandates the conservation of Ontario's cultural heritage, including:

- Archaeological resources, including land-based and marine,
- Built heritage resources, including bridges and monuments, and
- Cultural heritage landscapes.

The MTCS notes that, while some cultural heritage resources may have already been formally identified, others may be identified through screening and evaluation. Furthermore, indigenous communities may have knowledge that can contribute to the identification of cultural heritage resources, and the MTCS suggest that any engagement with Indigenous communities includes a discussion about known or potential cultural heritage resources that are of value to these communities. The MTCS notes that Municipal Heritage Committees, historical societies and other local heritage organizations may also have knowledge that contributes to the identification of cultural heritage resources.

Under the Municipal Class Environmental Assessment (EA) process, the proponent is required to determine a project's potential impact on cultural heritage resources. The MTCS notes that developing and reviewing inventories of known and potential cultural heritage resources within the study area can identify specific resources that may play a significant role in guiding the evaluation of alternatives for subsequent project-driven EAs and/or on implementation.

3.1.1 Cultural Heritage: SWM-MP Implementation

Given that a Master Plan, such as the subject SWM-MP, is a high-level planning document, whose study area is the entirety of the City of Waterloo, it is not practical to carry out technical heritage studies for such a broad geographic scope the way an EA proponent would when the "study area" is the footprint of a single proposed undertaking. However, as part of subsequent EAs to the SWM-MP and /or prior to implementation, the more detailed processes stipulated by the archaeology and cultural heritage landscape shall be applied to the individual projects. In other

words, consideration based on such heritage screenings or technical studies as are required must be applied prior implementation and the approaches modified as required.

Prior to the implementation of individual projects which comprise the preferred stormwater management strategy of this SWM-MP, the City shall review each site-specific project for the potential to impact known or potential cultural heritage resources and complete heritage screenings or technical studies in compliance with the heritage policies of the Waterloo Official Plan as well as other policies and procedures using the resources below relating to:

- Archaeological resources, including land-based and marine,
- Built heritage resources, including bridges and monuments, and
- Cultural heritage landscapes.

3.1.2 Cultural Heritage Resources

Archeological Resources

The City of Waterloo does not map archaeological resources, as this is a Region of Waterloo responsibility. However, the Region does not release the specific locations of archaeological sites due to privacy and security concerns. Prior to the implementation of individual projects which comprise the preferred stormwater management strategy, the City shall complete a Stage 1 Archaeological Assessment. The Archaeological Assessment shall evaluate the potential for archaeological resources within or adjacent to the proposed site by completing the following:

- A review of pertinent provincial and federal government files, as well as other published and unpublished literature
- Evaluating the property's archaeological potential
- Reviewing site-sensitive factors
- Conducting a property inspection of the project area

Cultural Heritage Landscapes

The City of Waterloo finalized the Cultural Heritage Landscape Inventory Report in 2019, drawing on historical research, feedback from the community and guidance from the Region of Waterloo, the resulting inventory describes 27 significant landscapes.

Prior to the implementation of individual projects which comprise the preferred stormwater management strategy, the City shall review each site-specific project for the potential to impact the known 27 significant landscapes.

The MTCS Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes should be completed to help determine whether the project may impact cultural heritage resources.
www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/GetFileAttach/021-0500E%7E1/$File/0500E.pdf

Built Heritage

The City of Waterloo does not have a formal inventory of built heritage resources, although a recommendation has been put forward in the Cultural Heritage Landscapes Study to generate an inventory. For example, a list of resources in Waterloo Park is below:

- Waterloo Park contains many built heritage features, including Silver Lake, Eby Farmhouse, Cookhouses (2), Log School House, The Oval, Bandshell, Victorian Gates, Cannons, First Nations Grindstones (2), Park Inn concession stand, and Grist Mill replica.

Prior to the implementation of individual projects which comprise the preferred stormwater management strategy, the City shall complete a Stage 1 Built Heritage Assessment. The Built Heritage Assessment shall evaluate the potential for Built Heritage resources within or adjacent to the proposed site by completing the following:

- A review of pertinent provincial and federal government files, as well as other published and unpublished literature
- Evaluating the property's built heritage potential
- Reviewing site-sensitive factors
- Conducting a property inspection of the project area

The MTCS Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes should be completed to help determine whether the project may impact cultural heritage resources.
www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/GetFileAttach/021-0500E%7E1/$File/0500E.pdf

Note: The Built Heritage Assessment can be often be combined with the Cultural Heritage Landscapes Assessment.

4 Study Area Existing Conditions

In order to understand the existing environmental, surface and groundwater conditions as well as the relevant water, wastewater and stormwater conditions and assets within the City of Waterloo a report entitled "**SWM-MP Municipal Class EA - Existing Conditions Report (January 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix B.**

The following section provides a summary of the existing environmental and stormwater asset conditions in the City of Waterloo. The summary is based on available information extracted from background reports such as watershed studies and monitoring programs, GIS mapping and City databases.

4.1 Summary of Background Documents

In preparation of the existing conditions, the following background studies were reviewed and summarized wherever relevant information existed:

Region and Agency

1. Grand River Watershed Management Plan (GRCA, 2013)
2. Grand River Fisheries Management Plan (GRCA, 2005)
3. Grand River Watershed Characterization Report (2008)
4. Grand River Source Protection Area (Plan) – Approved Assessment Report (2012)
5. Grand River Source Protection Plan (SPP) (MECP Approved 2015)
6. Water Quality Targets to Support Healthy and Resilient Aquatic Ecosystems in the Grand River Watershed (2013)
7. Nutrient and Sediment Sources in The Grand River Watershed (2013)
8. Assessment of Future Water Quality Conditions in the Grand and Speed Rivers (2012)
9. Water Quality in the Grand River Watershed: Current Conditions & Trends (2003-2008)

Subwatershed Studies and Master Drainage Plans

1. North Waterloo Scoped Subwatershed Study (2013)
2. Forwell Creek Functional Drainage Study Class EA (2001)
3. Laurel Creek Flood Control Project Class EA (1990)
4. Eastbridge District North Master Drainage Plan (1997)
5. Albert/MacGregor Drainage Study (2008)
6. Northland Creek Drainage Study (1985)
7. Colonial Creek Rehabilitation Plan Functional Design Study (1995)
8. Scoped Subwatershed Study – Portions of Subwatersheds 307 and 314 Laurel Creek Watershed (2004)
9. Laurel Creek Watershed Study (1992)
10. Requirements for Subwatershed Plans in the Laurel Creek Watershed (1994)
11. Clair Creek Subwatershed Study (1977)
12. Melitzer Creek Master Drainage Plan (1989)
13. Colonial Creek Watershed and Basin A and B Maser Drainage Plan (1990)

14. Clair Creek Subwatershed 317 Drainage Study (2003)
15. Subwatershed Management Plans #313 and #309 (1999)
16. Subwatershed 311 Subwatershed Plan (1995)
17. Subwatershed 314 Management Plan (1996)

City of Waterloo – Master Plans and Technical Documents

1. Park Strategy, City of Waterloo (Under Development)
2. Waterloo Park Master Plan, City of Waterloo (2009)
3. Transportation Master Plan, City of Waterloo (2011)
4. Asset Management Plan, City of Waterloo (2016)
5. Stormwater Utility and Credit Program By-Law, City of Waterloo (By-Law No. 2012-125)
6. Greenlands Network Implementation Guideline, Region of Waterloo (2016)
7. Grand River Water Management Plan – Stormwater, GRCA (2014)
8. Urban Design Manual, City of Waterloo (2010)

4.2 Existing Conditions Executive Summary

The City of Waterloo covers 652 km^2 of land. At present the City of Waterloo has a population of 134,600[1] with an expectation to increase by almost 40,000 residents by the year 2031.[2] The City is composed of 23 subwatersheds with approximately 60 km of watercourses. Note: Watercourse length has been corrected from previous reports to reflect revised mapping per the conducted field studies. Watersheds are listed **Table 4.1** and shown on **Figure 4.1**.

[1] Region of Waterloo Estimate using 2016 Canadian Census data, includes students and other foreign/temporary residents.
[2] Region of Waterloo – Regional Official Plan, 2015.

Table 4.1: Watersheds in the City of Waterloo

Watershed	Drainage Area (ha) Within the Municipal Boundaries	Stream Length (km) Within the Municipal Boundaries
Alder Creek	46.06	0
Beaver Creek	85.81	1.49
Cedar Creek	356.88	2.95
Clair Creek	1033.22	9.95
Colonial Creek	436.70	4.38
Critter Creek	113.98	1.86
Cuckoo Creek	6.22	0.24
Conestogo River - Lower	35.13	0
Forwell Creek	508.49	6.13
Grand River Tributaries North	116.45	0.24
Grand River Tributaries South	82.70	0.04
Horst Creek	256.94	3.01
Laurel Creek Reservoir	358.18	1.34
Lower Laurel Creek	1211.81	8.97
Maple Hill Creek	326.60	0
Martin Creek East	142.00	0
Martin Creek West	74.25	0
Melitzer Creek	134.54	1.27
Middle Laurel Creek	609.70	8.22
Minnow Creek	43.31	1.16
Monastery Creek	488.78	8.29
Schneider Creek	51.10	0
Willow Creek	3.99	0.28
TOTAL	**6522**	**60**

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

THE CITY OF Waterloo

Figure 4.1
STUDY AREA & SUBWATERSHEDS

- Watercourse
- Roads
- Water Bodies
- Study Area

Subwatersheds:

- ALDER CREEK
- BEAVER CREEK
- CEDAR CREEK
- CLAIR CREEK
- COLONIAL CREEK
- CONESTOGO RIVER - LOWER
- FORWELL CREEK
- GRAND RIVER TRIBUTARIES NORTH
- GRAND RIVER TRIBUTARIES SOUTH
- LAUREL CREEK RESERVOIR
- LOWER LAUREL CREEK
- MAPLE HILL CREEK
- MARTIN CREEK EAST
- MARTIN CREEK WEST
- MELITZER CREEK
- MIDDLE LAUREL CREEK
- MONASTERY CREEK
- SCHNEIDER CREEK

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September, 2019

WELLESLEY
WOOLWICH
WILMOT
KITCHENER
GRAND RIVER
KRESSLER RD
OBSINGER LINE
KING ST N
ARTHUR ST S
WEBER ST N
SAWMILL RD
NORTHFIELD DR E
Creek D
ERBSVILLE RD
Beaver Creek
Forwell Creek
CONESTOGA PKY
NORTHFIELD DR W
Critter Creek
Willow Creek
Minnow Creek
Horst Creek
Cuckoo Creek
Cooper's Creek
Colonial Creek
Cedar Creek
Monastery Creek
Laurel Creek Reservoir
BEARINGER RD
Laurel Creek
BRIDGE ST W
Melitzer Creek
FISCHER-HALLMAN RD N
Clair Creek
UNIVERSITY AVE W
UNIVERSITY AVE E
KING ST N
WEBER ST N
BRIDGEPORT RD E
CAROLINE ST S
ERB'S RD
IRA NEEDLES BLVD
FISCHER-HALLMAN RD S
Maple Hill Creek
BLOOMINGDALE RD N
BRIDGE ST E
LANCASTER ST W
WESTMOUNT RD W
KING ST W
WEBER ST W
VICTORIA ST N
VICTORIA ST S
FREDERICK ST
BRUCE ST
SNYDER'S RD E
HIGHLAND RD W
QUEEN ST S
CHARLES ST E
LACKNER BLVD

The following section describes and summarizes environmental and infrastructural existing conditions within the City. The existing conditions inventory and analysis covers the following topics:

- Land-Use
- Physiography
- Geology
- Surficial Soils and Infiltration Potential
- Hydrogeology
- Hydrology
- Fluvial Geomorphology
- Aquatic Ecology
- Natural Heritage
- Stormwater Management Infrastructure
- Water Supply
- Wastewater

4.2.1 Land-Use

The City of Waterloo is characterized by a mixture of land-uses. Generally, agricultural lands remain only along the periphery of the City, both along the Grand River, in the northwest and in the southwest. Lands that are zoned industrial are clustered primarily in the north and central area of the City between Weber Street North and Northfield Drive East but smaller clusters can be found further south. Approximately, 34% of the City is occupied by private residential property (i.e. residential development areas excluding the municipal right-of-way).

The City is home to a large area of lands zoned as institutional, these are largely located east of Westmount Road North and South of Bearinger Road extending to University Avenue West in the South and the Laurel Trail in the East.

North of Columbia Street West the industrial lands extend west to Fischer-Hallman Road. The industrially zoned lands include the David Johnston Research & Technology Park, the University of Waterloo and Wilfred Laurier University. Waterloo's commercial lands are primarily located along King Street with other commercial hubs at major intersections and along major transitways.

Existing land-use as broken down by The City's Official Plan is illustrated in **Figure 4.2**. Mapping showing the distribution of land-use in the City of Waterloo as well as future development and intensification areas can be found in **Appendix B**.

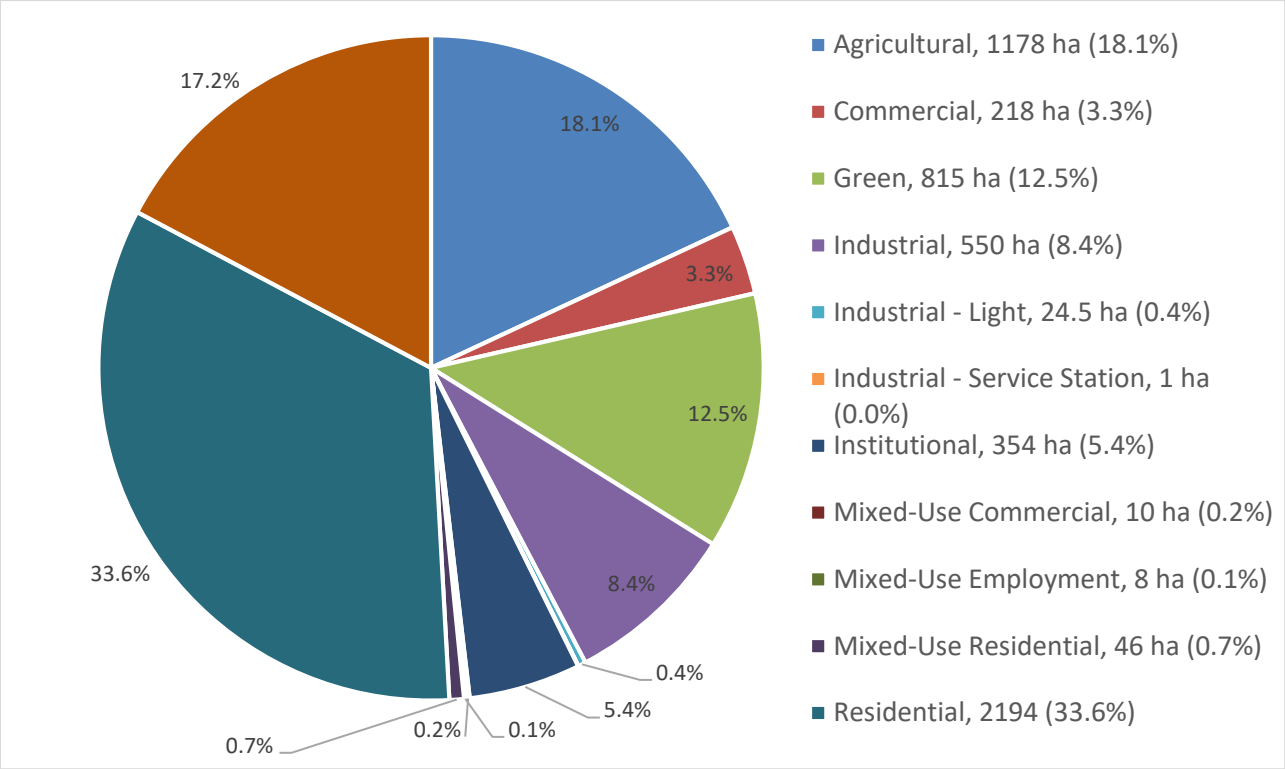


Figure 4.2: Existing City of Waterloo Land Use Designations Per Official Plan

4.2.2 Physiography

There are three (3) dominant physiographic regions within the City's municipal boundary per the Grand River Source Protection Area Assessment Report (2015). The City is bisected from northwest to southeast by the transition between a large Oxford Till deposit extending northeast and a large Waterloo Hills deposit extending southwest. Along the Grand River, fluvial deposits on the western periphery of the Guelph Drumlin Field dominate the landscape. Generally following the boundary of the Waterloo Hills Region within the City is a portion of the Waterloo Moraine. The Waterloo Moraine is located within the central area of the Grand River watershed and is approximately 400 km^2 in size. The Waterloo Moraine is the dominant topographic feature in the area, trending in a general northwest-southeast direction.

4.2.3 Geology

The primary moraine structure within the City of Waterloo is the Waterloo Moraine which is the largest moraine in the watershed and contains a series of large aquifers which discharge to and maintain the base flow for the Grand River, Nith River and many of their tributaries. These aquifers are also the source for approximately 50 percent of all the groundwater used within the Region of Waterloo water supply system. Surficial Quaternary geology mapping (**Figure 4.3)** shows the presence of a wide range of glacial outwash within the City boundaries. Dominant deposits include Maryhill Till in the southwest, Ice-contact Sand generally in the south and central subwatersheds of Laurel Creek and Clair Creek, Tavistock Till in the Cedar Creek and north Laurel Creek subwatersheds, and Port Stanley Till dominant in subwatersheds with their headwaters

closer to the Grand River including Colonial Creek, Critter Creek and other systems classified as part of the Grand River Tributaries North subwatershed.

4.2.4 Surficial Soils & Infiltration Potential

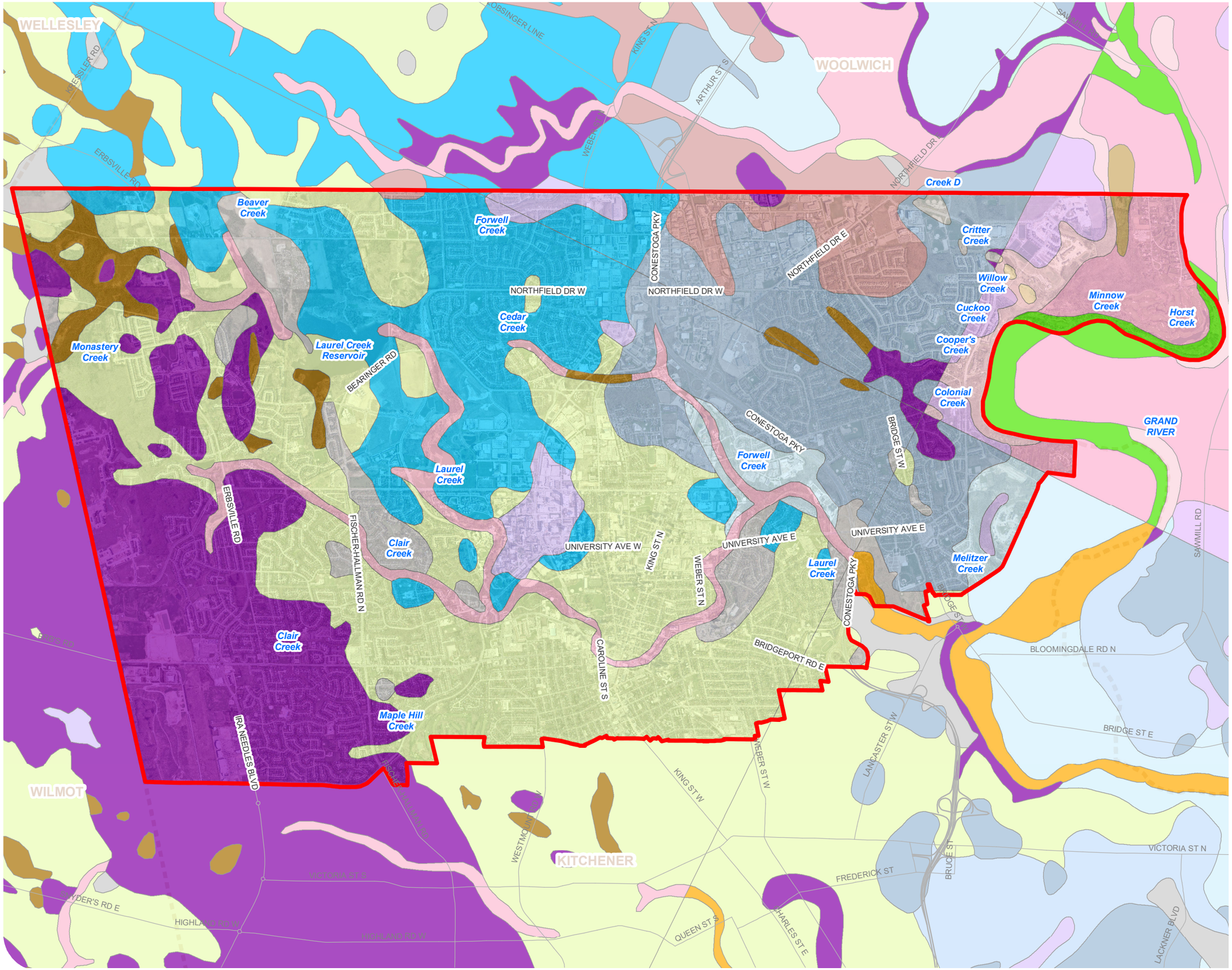
Areas of highest recharge tend to coincide with the moraine features within the watershed. For the City of Waterloo, this primarily applies to the Waterloo Moraine in the central and western area of the City. This moraine is comprised of permeable, coarse-grained deposits and consist of areas of hummocky topography (disconnected drainage), allowing for extensive infiltration and recharge. The moraine includes significant recharge zones for the watershed's major aquifers. Infiltration recommendations put forward in the context of this SWM-MP will have to consider the protection of groundwater resources and Source Protection Plan (SPP) Policies including Issue Contributing Areas (ICAs).

4.2.5 Hydrogeology

Within the City, the largest concentration of significant recharge areas can be found in the northwest (around the Laurel Creek reservoir, in the Beaver Creek subwatershed and in the Monastery Creek subwatershed) and in the Northeast (around the Martin Creek East subwatershed as well as Minnow Creek and Horst Creek in the Grand River Tributaries North subwatershed). Small clusters of significant recharge areas can be found along the municipal boundary to the southeast and in the southwest corner of the municipality. Significant recharge areas classified as high, medium and low capacity are illustrated on **Figure 4.4.**

In the Region of Waterloo most direct groundwater discharge to the Grand River occurs south of the Study Area. Within the City of Waterloo there are three (3) creeks that are classified as coldwater streams as a result of groundwater discharge, including:

1. Monastery Creek upstream of Wideman Road,
2. Beaver Creek in the northwest corner of the City, and
3. Melitzer Creek in the southeast.



MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.3
SURFICIAL GEOLOGY

- Roads
- Study Area

Geologic Deposit:

- Bog and swamp deposits
- Catfish Creek Till
- Glaciofluvial sand
- Ice-contact gravel
- Ice-contact sand
- Kames and eskers
- Lacustrine deposits
- Lacustrine, kame, and outwash
- Maryhill Till
- Middle Till
- Modern alluvium
- Outwash
- Outwash gravel
- Outwash sand
- Peat and muck
- Port Stanley Till
- Stream alluvium
- Stream deposits
- Swamps and bogs
- Tavistock Till
- Wentworth Till

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September 2019

THE CITY OF Waterloo

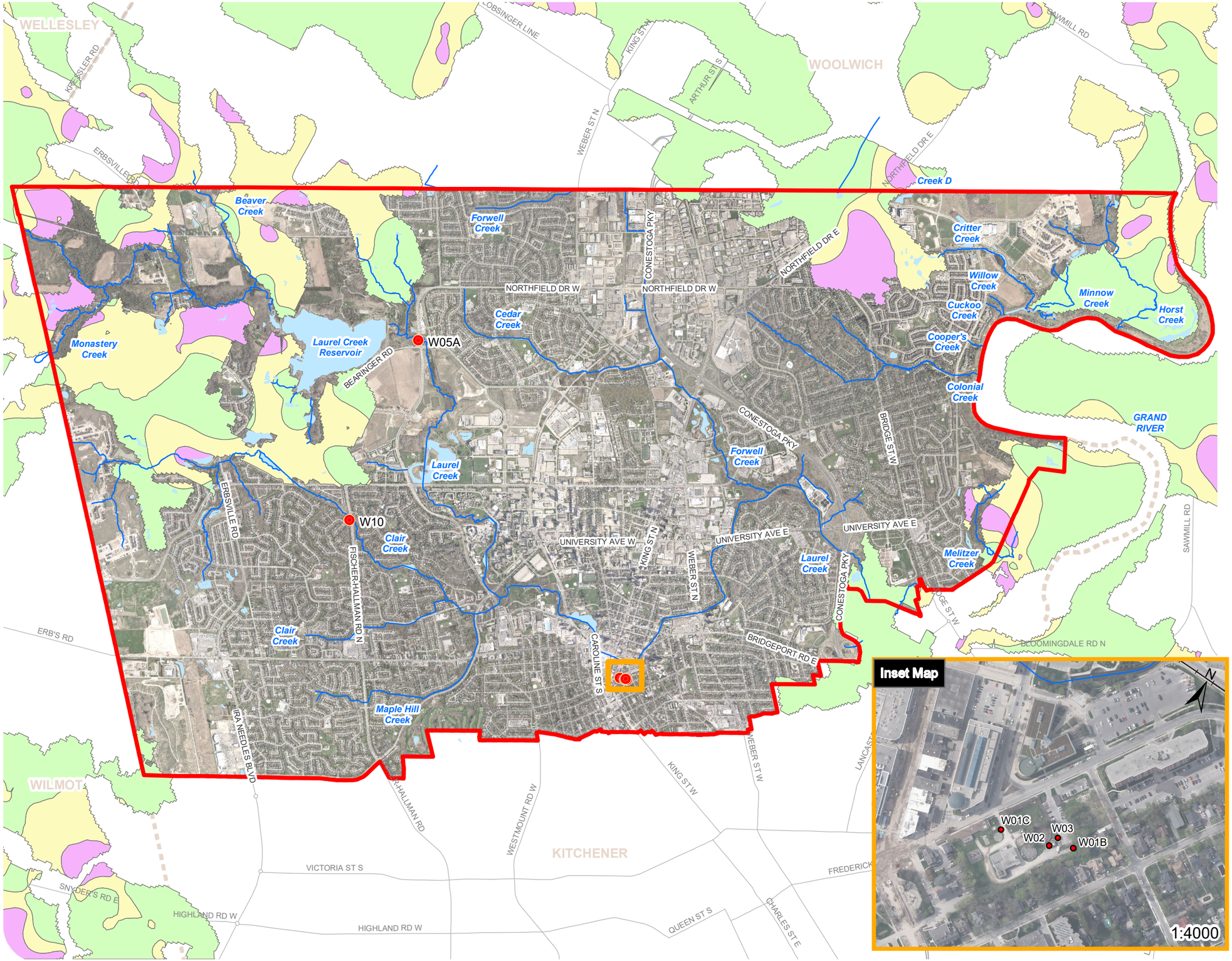
MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.4
SIGNIFICANT RECHARGE AREAS

- Regional Well
- Roads
- Watercourse
- Water Bodies
- Study Area

Recharge Area:

- High
- Medium
- Low



0 0.5 1 Kilometers

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Base data provided by The City of Waterloo, 2017.

Date: September 2019

4.2.6 Hydrology

The City of Waterloo's surface water system consists of several watercourses discharging into the Grand River. The most prominent watercourse draining through the City to the Grand River is Laurel Creek. The Laurel Creek subwatershed is approximately 75 square kilometers and includes the following tributaries before discharging into the Grand River at Bridgeport:

- Forwell Creek;
- Cedar Creek;
- Clair Creek;
- Beaver Creek; and
- Monastery Creek.

Significant watercourse systems that are not tributary to Laurel Creek include Melitzer Creek and Colonial Creek, both located on the east side of the City. On the northeast side, several small watercourses flow directly into the Grand River. These include Copper's Creek, Cuckoo Creek, Willow Creek, Critter Creek, Minnow Creek and Horst Creek. Along the periphery of City, several headwater areas drain to Grand River tributaries that are external of the municipal boundary.

4.2.6.1 Flow Control

Flow is regulated through the central portion of the Grand River from upstream reservoirs. Spring flows are greatly reduced by the reservoirs which capture the spring snow melt. In combination with local dyke systems, this has reduced average annual flood damages through the urban centers in Waterloo, Kitchener, and Cambridge by 75 percent. In addition, flow regulation provides for flow augmentation.

There are no flow control structures on the Grand River within the City of Waterloo. However, multi-purpose dams and reservoirs upstream of the City provide flow control targets at streamflow gauges within the City. Specifically, Shand and Conestogo Dams are operated to maintain minimum summer flows. Downstream of the City, the minimum summer flow target is 9.9 m^3/s at the Doon gauge. According to the Grand River Characterization Report, this minimum flow (**Table 4.2)** is critical to ensure adequate water supply and dilution of wastewater effluent along the main Grand River.

Table 4.2: Grand River: Minimum Flow Requirements for Water Supply and Wastewater Dilution

Hydrological Metric	Grand River Minimum Summer Targets (May 1 to Oct 31) (m^3/s)	Grand River Minimum Fall Targets (Nov 1 to Dec 31) (m^3/s)	Grand River Minimum Winter Targets (Jan 1 to Apr 30) (m^3/s)
Minimum Flow Target[1]	9.9	7.1	2.8
Reliability (occurrence)[2]	82.4%	88.2%	100%
Reliability (time)[3]	98.9%	94.5%	100%
Actual Min. Weekly Flow	8.5	5.5	3.9
Actual Min. Daily Flow	8.3 (Oct)	5.1	3.8

[1] Because of the 30 hour travel time from the reservoirs to Doon, the daily flows can vary approximately +/- 0.9 m^3/s from the target/ The travel time from the reservoirs to Brantford is 48 hours. The daily flows can vary +/- 1.4 m^3/s from the target.

[2] Reliability (occurrence) refers to the percentage of days target was met in 17 years of flow records.

[3] Reliability (time) refers to the percentage of days target was met within operating period for 17 years of flow records.

4.2.6.2 Flow Monitoring

There are four (4) hydrometric gauges to measure flow on the Laurel Creek system and one on the Grand River at Bridgeport. All gauges except on Laurel Creek at Weber Street North are operated by the GRCA. The Weber Street North gauge is operated by the Water Survey of Canada (WSC ID 02GA024). The remaining gauges are located on Monastery Creek at Erbsville Road, at the Laurel Creek Dam, on Clair Creek at Westmount Road.

4.2.6.3 Hydraulics

Within the City of Waterloo, several hydraulic studies have been conducted to delineate the limits of flooding. Floodplain mapping coverage is illustrated in **Figure 4.5**.

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.5
FLOODPLAIN & LAND REGULATED BY ONTARIO REGULATION 150/06

- Watercourse
- Roads
- Floodplain
- Water Bodies
- Study Area

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.2.7 Fluvial Geomorphology

In the City of Waterloo, approximately 60 km of stream systems flow through 18 distinct subwatersheds or catchment areas, all of which all drain into the central segment of the Grand River watershed. This segment of the Grand River includes all stream systems within Waterloo, Kitchener, and Cambridge, and is the most urbanized section of the watershed. Associated with urbanization are both direct and indirect factors of human activity on stream morphology. Direct impacts include changes of channel form, alignment, bank and bed materials, and instream structures (weirs, culverts, and dams), whereas indirect impacts relate primarily to changes in adjacent land use which can significantly influence the rate and method of water and sediment routing to a creek or river.

4.2.8 Aquatic Ecology

The Grand River watershed is incredibly diverse and is home to 80 confirmed, 12 probable, and 6 possible fish species, which represents 62% of all fish species found in Ontario. Six (6) fish species are classified as vulnerable or threatened in Canada (GRFMPIC, 2005).

The majority of the 60 km of streams in the City of Waterloo (not including the Grand River) are classified as warm water streams. Most watercourses in the City of Waterloo are highly urbanized with significant portions of them showing channelization and bank hardening. Channels lined with concrete, such as stretches of Forwell Creek, limit the burrowing depth of fish, having negative impacts on habitat, forage, and spawning. Three streams - Beaver Creek and Monastery Creek on the western edge of the City, and Melitzer Creek on the east, are classified as cold water streams.

Current stream thermal regime classification (commonly referred to as stream classification) was provided by the MNRF for each watercourse within the City of Waterloo and is illustrated in **Figure 4.6**. Each stream classification is related to Ministry of Natural Resources and Forestry (MNRF) aquatics/ fisheries timing windows for in-water works and is detailed below:

- Warm Water Timing Window – no in-water works should occur between March 31 and June 30 of any given year.
- Cold Water Timing Window – no in-water works should occur between October 1 and June 30 of any given year.

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.6
STREAM CLASSIFICATION

- Roads
- Water Bodies
- Study Area

Watercourse Thermal Regime:

- Coldwater
- Warmwater

0 0.5 1 Kilometers

N

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.2.9 Natural Heritage System

The City of Waterloo's Official Plan (OP) provides a framework to guide the development of lands so that ecological processes, functions and significant natural features are protected, maintained, restored, and enhanced management, and stewardship of the environment. Key objectives of the City's Natural System include:

a) Identify and protect elements of the Natural System through watershed-based analysis and planning.
b) Maintain, enhance, and restore *natural features* and functions.
c) Identify opportunities for ecological corridors and buffers.
d) Encourage community involvement in natural heritage maintenance, enhancement, and restoration.
e) Balance recreational opportunities and environmental protection.

The City of Waterloo's Natural Heritage System includes significant wetlands, significant woodlots, significant valleylands, and habitat of significant species, significant wildlife habitat, significant landforms, fish habitat, Regional Core Environmental Features and ecological restoration areas. The components of the City of Waterloo's Natural Heritage System are included in **Appendix B**.

4.2.9.1 Species at Risk

The City of Waterloo's NHS includes the Significant Habitat for Endangered and Threatened Species as well as Significant Wildlife Habitat. Based on information from the Guelph District MNRF, there are thirty-six (36) total species of Amphibian, Birds, Fish, Insect, Mammal, Mollusc, Plant and Reptile which are classified as a Species at Risk known or suspected to occur within the City of Waterloo. A table identifying SAR within the City of Waterloo is provided in **Appendix B**.

4.2.10 Stormwater Management Infrastructure

Municipal stormwater management infrastructure includes all SWM facilities (dry ponds, wet ponds, wetlands, and hybrid facilities), oil & grit separators and holding tanks, exfiltration systems, and storm pipe networks and associated appurtenances, such as manholes, catch basins, leads, and outfalls responsible for the capture, conveyance, and control (water quality and quantity) of stormwater runoff.

4.2.10.1 Stormwater Management Facilities

According to the City's database, there are a total of 81 active SWM facilities within the City of Waterloo. Note: 59 facilities are owned and operated by the City.

Of these 81 facilities, 61 provide both quality and quantity control and 20 provide only quantity control. These 81 SWM facilities provide some level of control to 2,049.0 ha (32.1%) of the City. Of this area, approximately 1,718.1 ha (26.3%) are controlled for both water quality and water quantity, and 375.9 ha (5.8%) are controlled for water quantity only.

Accordingly, there is approximately 4,429.1 ha of the City that does not have water quality or quantity control provided by SWM facilities such as wet ponds, dry ponds, engineered wetlands. **Figure 4.7** summarizes the urban coverage of SWM facilities and OGS units.

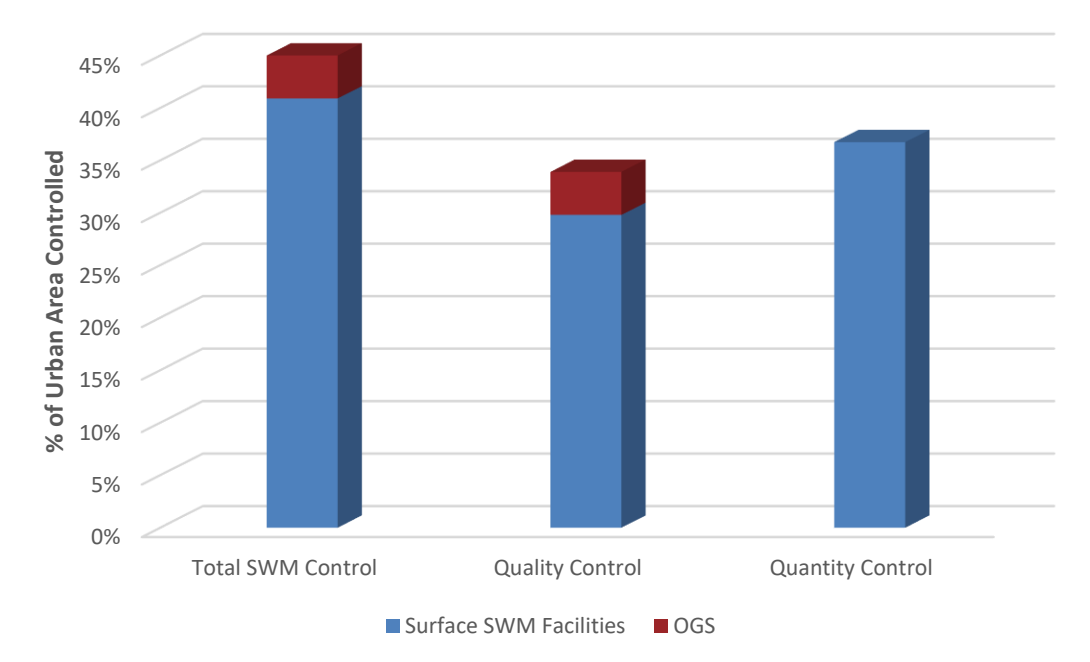

Figure 4.7: Percentage of City Controlled by SWM Assets

Figure 4.8 shows the location of the existing stormwater management facilities within the City of Waterloo. **Figure 4.9** shows the facility location and contributing drainage area for each of the existing facilities as determined through available background information. Within **Appendix B, Table 3.11.3** summarizes the existing SWM facilities including their ownership status, type, drainage areas, installation year and basic design features.

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.8
EXISTING STORMWATER FACILITIES

- Watercourse
- Roads
- Stormwater Management Ponds
- Study Area

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September 2019

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.9
STORMWATER QUANTITY & QUALITY CONTROL FACILITIES & DRAINAGE AREAS

- Watercourse
- Roads
- Water Bodies
- Rivers
- Stormwater Management Ponds
- SWM Facility Drainage Area
- Study Area

Existing OGS Structures:

- City of Waterloo
- Region of Waterloo
- Private
- University of Waterloo
- WCDSB
- WRDSB
- Null

0 0.5 1 Kilometers

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Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.2.10.2 Oil Grit Separators (OGS) & Ground Water Collection Systems (GWCS)

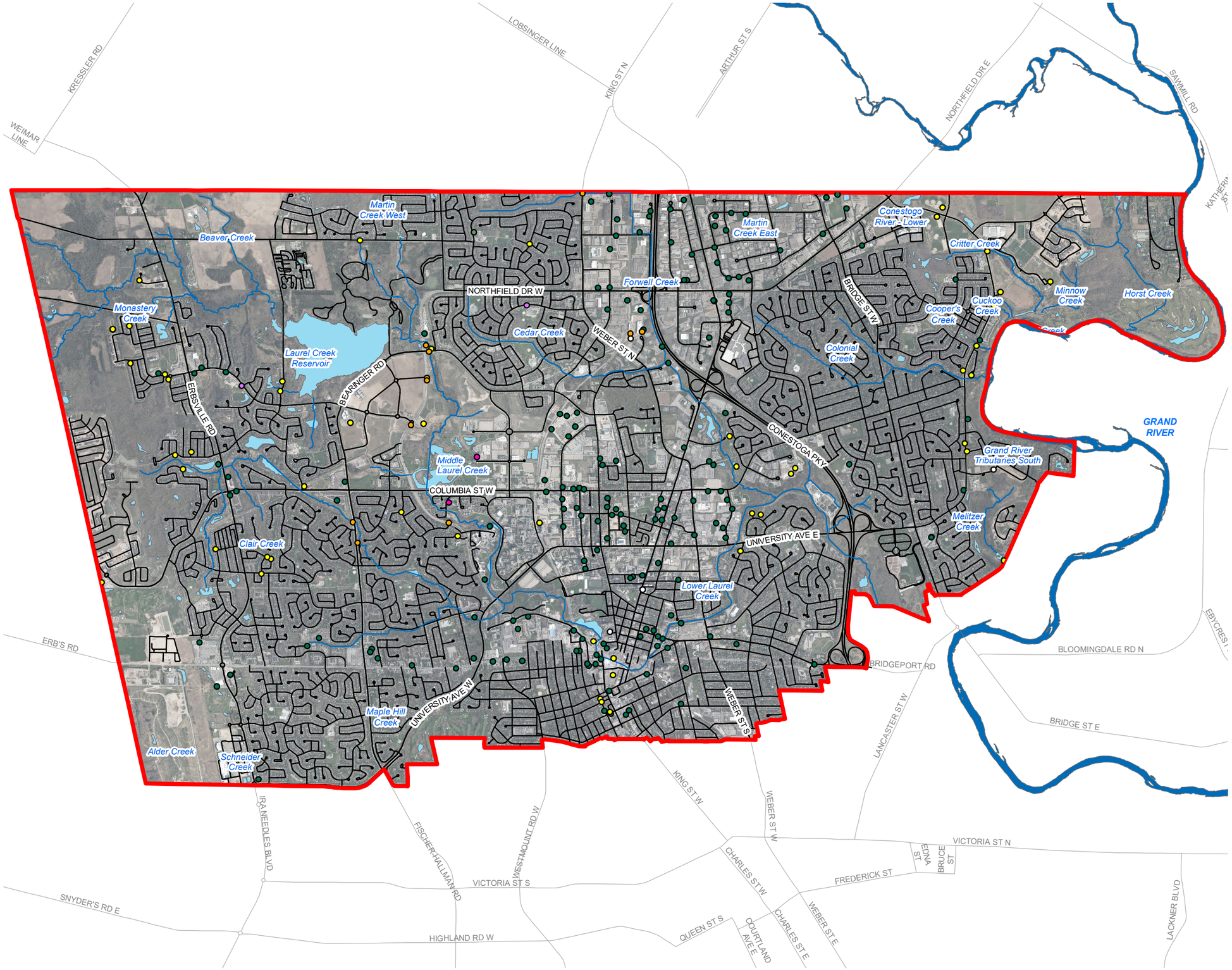
According to the City of Waterloo's GIS database, two hundred forty-one (241) Oil and Grit Separators exist within the City of Waterloo. The City is responsible for the operation and maintenance of sixty-one (61) of these units. One hundred fifty-six (156) OGS units are owned privately (156), seven (7) by the Region of Waterloo, and the remaining units have unknown ownership.

The 241 OGS units within the City treat runoff from drainage areas totaling approximately 75 ha. In addition to the 32.1% of the City's urban areas controlled by SWM facilities that provide water quality improvement (i.e. wet ponds, wetlands and hybrid facilities), at minimum, an additional 4.1% of the City's urban areas are controlled by OGS units.

During the 2016 inspection of 50 of the 61 OGS units owned and operated by the City, 20 were found to have a sediment depth greater than the cleanout depth, and 12 of these were cleaned out after the inspection.

Section 6.1 of this report summarizes a sediment loading analyses conducted on these OGS units while further details are presented in **Appendix D**.

Figure 4.10 shows the location of the existing OGS units with ownership information. Within **Appendix B**, **Table 3.11.1** summarizes the existing OGS ownership status, type, drainage areas, installation year and basic design features (make/model).



THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.10
OIL & GRIT SEPARATOR LOCATIONS

- Watercourse
- Roads
- Water Bodies
- Rivers
- Study Area

Existing OGS Structures:

- City of Waterloo
- Region of Waterloo
- Private
- University of Waterloo
- WCDSB
- WRDSB
- Ownership Information Unavailable

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.2.10.3 Source Control Facilities

Since its establishment in 2013, the City of Waterloo has issued over 2,300 credits as part of its stormwater credit program for rain barrels, cisterns, rain gardens, permeable pavement and infiltration basins. Currently, the majority of credits issued by the City have occurred within residential areas whereas very few credits have been issued within commercial and industrial areas. In terms of stormwater management, the control of runoff from commercial and industrial areas generally provides much greater benefits compared to residential areas on a per hectare basis for two reasons:

Residential Rain Garden at Roof Downspout

1. Commercial and industrial areas are generally the greatest contributors to stormwater runoff since land use impervious levels may be as high as 80-100%, compared to residential land uses which typically range from 30-50%.

2. BMPs implemented by residential landowners are often limited to the most cost-effective, small scale practices which provide less stormwater control compared to commercial and industrial landowners who may undertake larger-scale projects with greater benefits (e.g. permeable pavement parking lots) in order to achieve maximum credits.

4.2.10 Water Supply

The Region of Waterloo is served by a combination of twenty-four (24) groundwater wells predominantly within the Waterloo moraine, and the production from the Manheim recharge facility as well as the surface water intake at the Grand River (Hidden Valley Intake). Within the City of Waterloo are six (6) Regional wells within the Waterloo moraine. The wells are grouped according into two (2) Well Fields.

Wellheads and associated Wellhead Protection Areas within or partially within the City are illustrated on **Figure 4.11.** The Hidden Valley Intake Protection Zone is illustrated on **Figure 4.12.** An Issue Contributing Area (ICA) has been developed through Grand River Source Protection Planning in response to the identified levels and/or water quality trends associated with Sodium, Chloride and trichloroethylene (TCE). This ICA is shown on **Figure 4.13.**

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.11
WELLHEAD PROTECTION AREAS (WHPA)

- Regional Well
- Roads
- Study Area

Wellfield:

- Erb Street
- Greenbrook
- Lancaster
- Mannheim
- Mannheim West
- Pompeii Forwell
- Strange Street
- Waterloo North W05
- Waterloo North W10
- William Street
- Woolner

Wellhead Travel Zones:

- A (0 to 2 years)
- B (2 to 5 years)
- C (5 to 10 years)
- D (10 to 25 years)
- E (25+ years)

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.12
INTAKE PROTECTION ZONES

- Waterloo North Well Under the Direct Influence of Surface Water (GUDI)
- Watercourse
- Roads
- Water Bodies
- Intake Protection Zones
- Study Area

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September, 2019

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MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.13
ISSUE CONTRIBUTING AREAS

- Roads
- Watercourse
- Water Bodies
- Issue Contributing Area - Chloride, Sodium, TCE
- Study Area

0 0.5 1 Kilometers

N

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Date: September, 2019

4.2.11 Wastewater

The Region of Waterloo is responsible for treating all wastewater in the Region. The three (3) largest waste water treatment plants in the Region of Waterloo are the Kitchener WWTP, Waterloo WWTP and Hespeler WWTP. The City of Waterloo has one wastewater treatment plant located at 340 University Avenue East. The City's Wastewater Collection Network is illustrated on **Figure 4.14.**

The Waterloo WWTP is a conventional activated sludge plant that provides carbonaceous BOD removal, chemical phosphorus removal, disinfection (sodium hypochlorite) and anaerobic digestion. The Waterloo WWTP has a rated capacity of 72,730 m^3/d, although it operates at a self-imposed operational capacity of 54,600 m^3/d due to the difficulty in meeting the more stringent water quality criteria at these flows. Future WWTP effluent quality and flows as assessed in the Assessment of Future Water Quality Conditions in the Grand and Speed Rivers (2012) are included in **Appendix B**.

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MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.14
EXISTING SANITARY NETWORK

- Sanitary Gravity Main
- Roads
- Watercourse
- Water Bodies
- Study Area

0 0.5 1 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.3 Subwatershed Summaries

As part of the **Existing Conditions Report**, Subwatershed Fact Sheets were created for each of the twenty-three (23) subwatersheds. The goal of each Fact Sheet is to aid in the identification of issues and opportunities. Each Fact Sheet includes a summary of general Watershed Characteristics, Water Resources Sustainability Metrics, Infrastructure, Ecology, Water Quality and Management Strategies. The summaries were used during the development of the SWM-MP to identify 'target' subwatersheds to be prioritized for restoration and or enhancement. Subwatershed Fact Sheets are included with the Existing Conditions Report in **Appendix B**.

4.4 Existing Subwatershed Health

From the information gathered and synthetized through the preparation of the **Existing Conditions Report**, baseline subwatershed health has been developed for each of the twenty-three (23) subwatersheds within the City of Waterloo relating to:

- Terrestrial Subwatershed Health,
- Stormwater Management,
- Water Quality,
- Stream Channel and Riparian Health,
- Aquatic Ecology.

Following approval of the SWW-MP following the required thirty (30) day public review period, an Implementation Plan will be developed. The prioritization of the works based on priority subwatersheds as well as allocating funding and policy development will be the main purpose of the Implementation Plan. As such, the baseline subwatershed conditions, and specifically the Overall Subwatershed Conditions will be a key element in prioritizing the identified works as part of the SWM-MP.

The prioritization will be based on the existing condition of the subwatersheds as well as the physical locations of the identified opportunities of the recommended approach (i.e. watercourse restoration and erosion repairs, source control pilot programs, conveyance controls, O&M, SWM facilities, flooding, etc.).

The following section provides a summary of the evaluation and ranking process undertaken as part of the SWM-MP to develop each of the respective baseline subwatershed conditions for Terrestrial Subwatershed Health, Stormwater, Water Quality, Stream Channel and Riparian Health, and Aquatic Ecology.

4.4.1 Terrestrial Subwatershed Health

The Southwestern Ontario landscape has experienced significant, possibly irreversible, ecological change following European settlement. Lands which were once covered in forest, wetland, savannah, grasslands and watercourses have been removed or altered in favor of widespread agricultural and urban development. Many of the ecological processes the aforementioned natural heritage features supported have also been altered or eliminated. Accordingly, it is of vital importance to the natural heritage system as a whole to conserve, and protect the form and

function of remaining natural areas, or restore areas back to natural conditions where possible. This preservation and restoration of natural areas is also beneficial to assist in the proper functioning of the City's SWM system by providing benefits to surface water quality, watershed health, and flood mitigation among others.

In recognition of the significant landscape scale change in the country, Environment Canada has published an updated science-based guide which addresses common terrestrial vegetation community types and their roles in watershed health. The *How Much Habitat is Enough?* (Environment Canada 2013) guideline is widely used by governments, NGOs, and citizen's groups as an ecology reference, and is especially valuable for watershed planning. The watershed health criteria within the Environment Canada guidelines was selected in the development of terrestrial watershed health metrics for the City of Waterloo's SWM-MP because of the guideline's science-based holistic approach to land use planning and management. Terrestrial watershed health metrics are not only interrelated, they often correspond with metrics from other disciplines such as hydrology and aquatic ecology. As such, it is recommended that the metrics discussed below are interpreted and applied in a holistic manner.

The terrestrial subwatershed health metrics used in this analysis were:

1) **Wetland Habitat**: A measure of the total subwatershed area covered by wetland (includes local wetlands, regionally significant wetlands and provincially significant wetlands)
2) **Riparian Habitat**: A measure of riparian areas which have been maintained in a vegetated state.
3) **Forest Habitat**: A measure of woodland within the subwatershed
4) **Natural Cover**: A measure of total natural heritage features within the watershed (includes wetlands, forest, woodlots, and stream corridors)
5) **Connectivity**: A measure of the level of connectivity between natural features in the subwatershed

The natural cover metric references minimum vegetation coverage guidelines within the How Much Habitat is Enough (HMHE) document by Environment Canada, and are not intended to justify reduction of habitat types that are present in excess of the guideline minimums. In the case of a highly urbanized landscape like the City of Waterloo, it may not be possible to meet the guideline minimums.

The connectivity metric is based upon the level of isolation of a given natural area in relation to surrounding natural areas. The natural heritage resources within the City of Waterloo are largely situated within an urban matrix, meaning there are many disjointed patches of natural habitat that have poor connectivity due to the urban areas that isolate them. Disjunct habitat patches are generally less valuable to wildlife than connected patches; a connected matrix of natural heritage features will exhibit greater ecological function than a fragmented system and will likely be more adaptable to stressors such as climate change.

The following section provides a summary of the scoring system with which terrestrial watershed health metrics were assessed. Each component's scale range (s given a score from one (1) to five (5), with 1 representing a "very good" score and 5 representing a "poor" score (**Figure 4.15**).

Figure 4.15: Terrestrial Scoring System

A summary of the scoring methodology for each of the scale ranges for terrestrial watershed health is presented below in **Table 4.3.** Each metric under terrestrial watershed health was given a score between one and five within which scale ranges were assigned. Ranges of values in the same row as "1 (v. good)" represent the suggested minimum described previously under each metric.

In recognition of the interrelationship between all metrics, the average score across all five metrics is considered the overall terrestrial health score for each of the subwatersheds included in the analysis. The results of the analysis are presented in the preceding section.

Table 4.3: Terrestrial Watershed Health Thresholds and Scoring Scheme

Score	Terrestrial Watershed Health Metrics Thresholds				
	Wetland Habitat	Riparian Habitat	Forest Habitat	Natural Cover	Connectivity
1 (v. good)	≥ 6%	≥ 75%	≥ 30%	≥ 50%	≥ 75%
2 (good)	4.4% - 5.9%	60% - 74.9%	21.5% - 29%	37.4% - 49.9%	60% - 74.9%
3 (fair)	2.9% - 4.3%	45% - 59.9%	14% - 21.4%	24.9% - 37.3%	45% - 59.9%
4 (marginal)	1.4% - 2.8%	30% - 44.9%	6.5% - 13.9%	12.4% - 24.8%	30% - 44.9%
5 (poor)	<1.4%	< 30%	< 6.5%	> 12.4%	< 30%

Appendix C presents a detailed assessment of the watershed health within the City of Waterloo as it relates to the parameters described above. As mentioned above, in recognition of the interrelationship between the terrestrial watershed health metrics, it is recommended that the metrics are interpreted and applied in a holistic manner where averaging of scores to obtain the overall terrestrial watershed health, for example, may fail to recognize the effects of a poor score in one metric on the overall watershed health. The information contained in **Appendix C** can be used as a guideline for prioritizing restoration initiatives in the City of Waterloo as a whole and in each of the subwatersheds listed.

The City of Waterloo is encouraged to consider prioritizing the restoration of vegetation types which may address multiple metrics. For example, treed swamp vegetation community types address both forest and wetland coverage targets and depending on their location, could also address riparian habitat targets. The City is also encouraged to look within and beyond their urban and geographical boundaries to neighbouring lands and consider how increasing landscape connectivity and representation of a diversity of ecological communities can provide an overall benefit for the ecology of the City of Waterloo. Furthermore, it is recommended that metrics from other disciplines (e.g. aquatic ecology, water quality, etc.) also be considered when evaluating priorities for overall subwatershed improvement.

Figure 4.21 illustrates the Terrestrial Ecology Health Score. Overall, subwatersheds that have not yet been subject to development scored better than those that were fully developed. Terrestrial Health scores, which represent a combined average of the scores for individual metrics, varied from 1.6 (very good – good) to 4.2 (marginal), and are generally in line with the overall scores for each watershed.

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.16
SUBWATERSHED HEALTH - TERRESTRIAL

- Roads
- Water Bodies
- Study Area

Terrestrial Ranking:

- Excellent
- Good
- Fair
- Marginal
- Poor

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.4.2 Stormwater Management

The age of the neighbourhood generally reflects the type of SWM practices implemented, with older developments tending to lack SWM infrastructure entirely while newer developments have SWM infrastructure that reflects more current practices. As a consequence, areas of older development may lack stormwater quality and/or stormwater quantity infrastructure. To provide an existing conditions SWM scores, three (3) metrics were used. SWM metrics used for this analysis are:

1. Stormwater Quality Control
2. Stormwater Quantity Control
3. Impervious Percentage

Data sources included Ministry approvals, City GIS layers, design drawings and report.

4.4.2.1 Stormwater Quality Control Metric

The scoring for the stormwater quality control metric is based on the percentage of the total subwatershed area that is served by (or drains to) water quality control SWM facilities (wet SWM facilities, constructed wetlands and OGS), regardless of the level of quality control provided. Open space areas and agricultural areas have been excluded from the calculation of this metric, as these areas are not required to be provided with SWM controls.

The scoring system for the stormwater quality control metric is presented in **Table 4.4.**

Table 4.4: Stormwater Quality Scoring System

% Quality Control	Quality Control Rating	Evaluation Score
% Control ≥ 60	Excellent	1
40 ≤ **% Control** < 60	Good	2
20 ≤ **% Control** < 40	Fair	3
10 ≤ **% Control** < 20	Marginal	4
0 ≤ **% Control** < 10	Poor	5

The percent area of subwatershed that is served by water quality SWM facilities ranges between 12% to 98%. **Table 3.4** of **Appendix C** provides a summary of stormwater quality control within the City by subwatershed.

4.4.2.2 Stormwater Quantity Control Metric

The scoring for the stormwater quantity control metric is based on the percentage of the total subwatershed area that is served by (or drains to) water quantity control SWM facilities (wet and dry SWM facilities), regardless of the level of quantity control provided. Open space areas and agricultural areas have been excluded from the calculation of this metric, as these areas are not required to be provided with SWM controls.

The scoring system for the stormwater quantity control metric is presented in **Table 4.5.**

Table 4.5: Stormwater Quantity Scoring System

% Quantity Control	Quantity Control Rating	Evaluation Score
% Control ≥ 60	Excellent	1
40 ≤ **% Control** < 60	Good	2
20 ≤ **% Control** < 40	Fair	3
10 ≤ **% Control** < 20	Marginal	4
0 ≤ **% Control** < 10	Poor	5

The percent of subwatershed area provided with stormwater quantity control ranges from 13% to 98%. **Table 3.5** of **Appendix C** provides a summary of stormwater quantity control within the City by subwatershed.

4.4.2.3 Impervious Percentage Metric

The scoring for the stormwater impervious percentage metric is, as the name suggests, based on the percent of impervious area for each subwatershed. Impervious areas used in this calculation include buildings, parking areas, roads and sidewalks. Impervious surfaces are the main source of excess runoff volume and pollutant loading when compared to pre-urbanized conditions.

The scoring system for impervious metric is presented in **Table 4.6**.

Table 4.6: Impervious Percentage Scoring System

% Quality Control	Quality Control Rating	Evaluation Score
0 ≤ **Impervious %** < 10	Excellent	1
10 ≤ **Impervious %** < 20	Good	2
20 ≤ **Impervious %** < 30	Fair	3
30 ≤ **Impervious %** < 40	Marginal	4
Impervious % ≥ 40	Poor	5

The subwatershed percent impervious ranged from 0% to 78%. **Table 3.6** of **Appendix C** provides a summary of impervious percentage within the City by subwatershed.

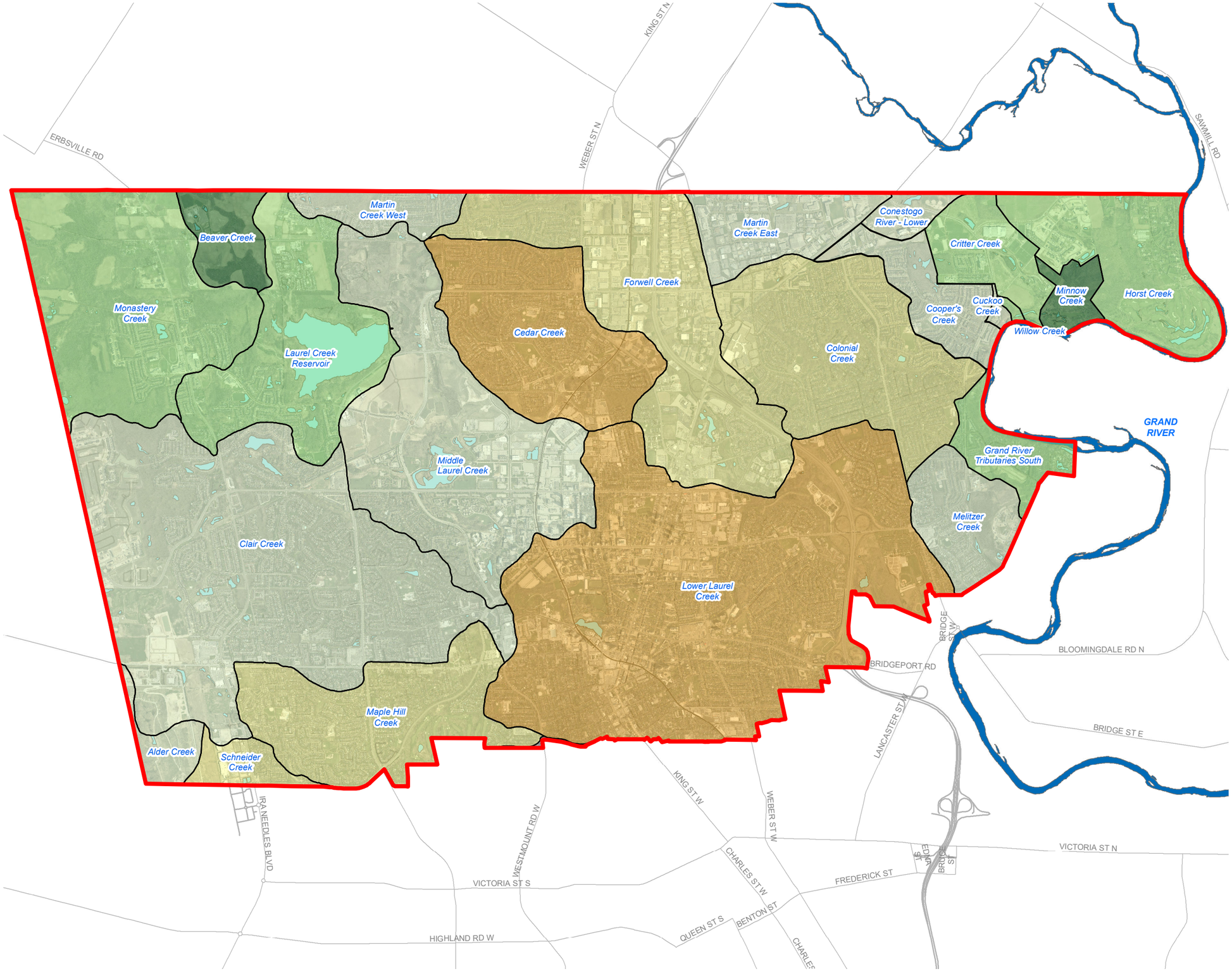
4.4.2.4 Overall Subwatershed Scoring of Stormwater Management

An overall stormwater evaluation score was calculated for each subwatershed by averaging the stormwater quality control, stormwater quantity control, and impervious percentage metrics. **Figure 4.21** illustrates the overall Stormwater Watershed Health score.

Table 3.7 of **Appendix C** provides a summary of SWM evaluation scores for each subwatershed.

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.17
SUBWATERSHED HEALTH - STORMWATER



- Roads
- Water Bodies
- Study Area

Stormwater Management Ranking:

- Excellent
- Good
- Fair
- Marginal
- Poor

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.4.3 Water Quality

Water quality is a critical indicator of subwatershed health. Poor water quality can result in a loss of biodiversity and impact the way Waterloo residents interact with local streams and rivers. By monitoring long-term trends and changes to the concentration of pollutants in local watercourses, it is possible to assess the impact of land use and stormwater management measures implemented within subwatershed areas.

The most comprehensive source of water quality data within the City is a long-term water quality study of Laurel Creek spanning a period of 1996 through 2015 undertaken by the University of Waterloo Department of Geography and Resource Management (Stone, 2016). Note: the Laurel Creek subwatershed represents approximately 30% of the total rrainage Area (ha) within City of Waterloo). The program was implemented to measure the effects of urban development on water quality and water quantity. Standard methods were used to measure total phosphorus, suspended solids, pH, dissolved oxygen and water temperature at ten sites reflecting a range of land uses. Also included in this program is the monitoring and assessment of benthic macroinvertebrate communities, of which can help identify trends in water quality and aquatic habitat. Each monitoring site was sampled from the beginning of May through to the end of August consecutively for 20 years (1996 to 2015).

Eighteen (18) subwatersheds did not have sufficient water quality data to assign a water quality classification. They include:

- Alder Creek
- Colonial Creek
- Conestogo River - Lower
- Cooper's Creek
- Critter Creek
- Cuckoo Creek
- Forwell Creek
- Grand River Tributaries South
- Horst Creek
- Laurel Creek Reservoir
- Lower Laurel Creek
- Maple Hill Creek
- Martin Creek East
- Martin Creek West
- Melitzer Creek
- Minnow Creek
- Schneider Creek
- Willow Creek

4.4.3.1 Water Quality Parameters

For this analysis, three (3) key water quality parameters were used as a reference for watershed health. These three (3) parameters are:

1. Total Phosphorus (TP)
    - Phosphorus is a nutrient that is essential for plant growth in aquatic environments. Excess phosphorus can lead to eutrophication and anoxia. Enhancing water quality (specifically reducing phosphorous) to improve river health and reduce the Grand River's impact on Lake Erie is a primary goal of the 2014 Grand River Water Management Plan (GRWMP) (see **Section 1.2**).

2. Total Suspended Sediment (TSS)
    - Suspended sediment is the standard surrogate parameter for water quality used in the Province of Ontario by regulators and is a primary water quality parameter of concern for urban catchments. Sediment is washed off of paved surfaces during rainfall events. Large volumes of sediment deposited in watercourses can destroy aquatic habitat and can reduce the flow capacity of hydraulic structures. Other contaminants of concern including metals and pathogens typically become attached to suspended sediments resulting in further risk to aquatic life and human water users when released without treatment.

3. Dissolved Oxygen (DO)
    - Refers to the concentration of oxygen dissolved in water. Sufficient DO is essential to growth and reproduction of aerobic aquatic life

4.4.3.2 Overall Subwatershed Scoring of Water Quality

Scoring for each water quality paraments was assigned based on the percentage of water quality results at each the water quality stations which fell within the Provincial Water Quality Objective (PWQO). The scoring for each parameter is outlined in **Table 4.7**.

Table 4.7: Water Quality Scoring System

Evaluation Score	Description
Total Phosphorus	
1	Water quality samples were not within these categories
2	
3	Greater than 65% through 75% sample exceedance of 0.03 mg/L objective
4	Greater than 75% through 85% sample exceedance of 0.03 mg/L objective
5	Greater than 85% sample exceedance of 0.03 mg/L objective
Suspended Solids	
1	Less than 20% exceedance of 25 mg/L objective
2	Greater than 20% through 30% sample exceedance of 25 mg/L objective
3	Greater than 30% through 40% sample exceedance of 25 mg/L objective
4	Greater than 40% through 50% sample exceedance of 25 mg/L objective
5	Water quality samples were not within this category
Dissolved Oxygen	
1	Water quality samples were not within this category
2	DO averages from 7.5 mg/L but less than 8.0 mg/L
3	DO averages from 7.0 mg/L but less than 7.5 mg/L
4	DO averages from 6.5 mg/L but less than 7.0 mg/L
5	Water quality samples were not within this category

Table 4.8 provides a summary of water quality evaluation scores for subwatersheds in which water quality samples were taken in reference to data provided in the Laurel Creek water quality study.

For the eighteen (18) subwatersheds which did not have sufficient water quality data to assign a water quality classification; because there is a strong correlation between the other subwatershed metrics indicating subwatershed urbanization and water quality, the average subwatershed metric score was used for subwatersheds were there are no water quality data. This was preferable to neutral scores which would result in clustering of overall subwatershed health scores.

It is recommended that the City undertake additional water quality monitoring to address the identified data gaps.

Figure 4.22 illustrates water quality scores for each subwatershed.

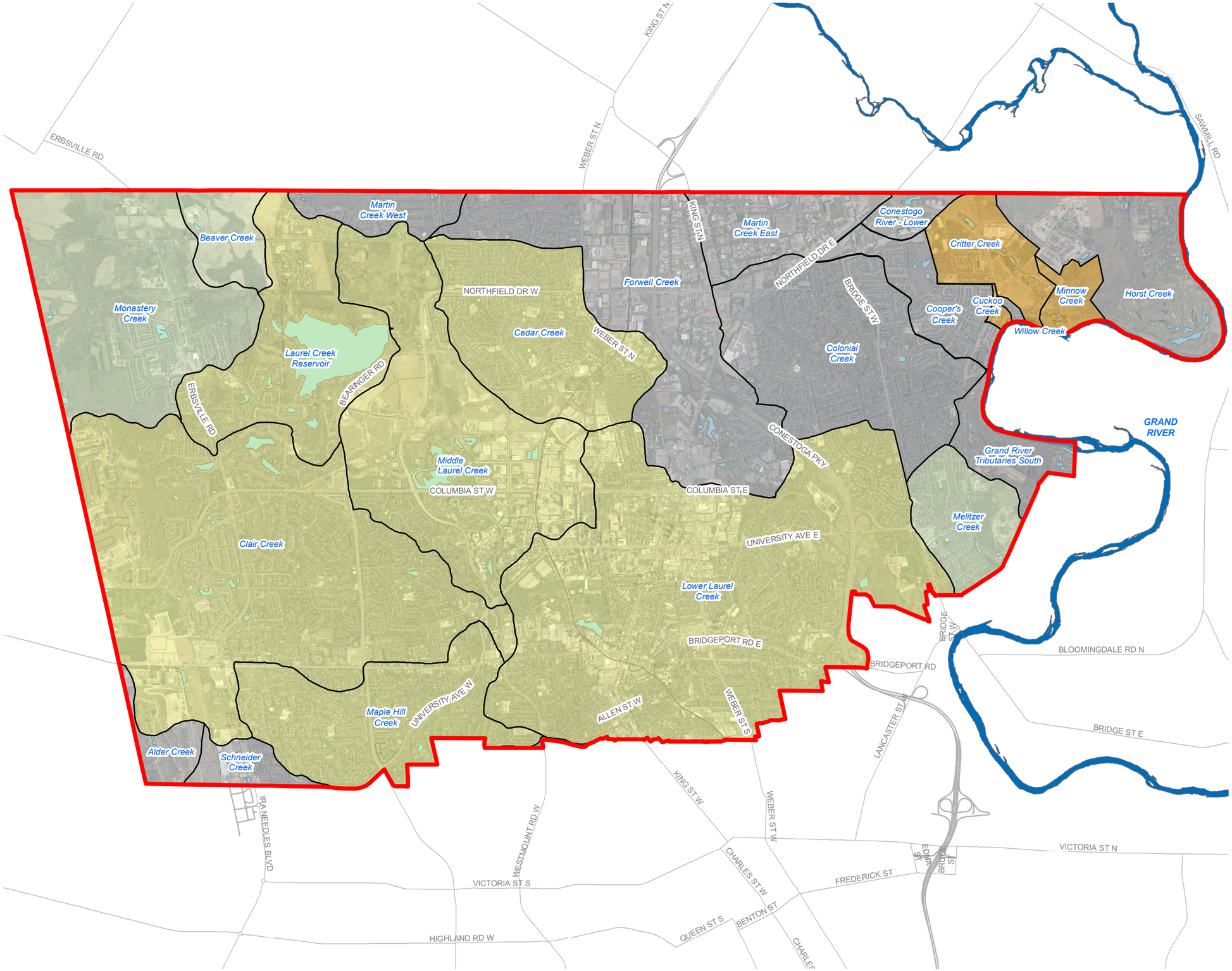
Table 4.8: Subwatershed Water Quality Evaluation Scoring

Subwatershed	Total Phosphorus Score	Suspended Sediment Score	Dissolved Oxygen Score	Average Water Quality Score	Water Quality Ranking
Cedar Creek	5	4	4	4.3	Poor
Middle Laurel Creek	3	3	3	3.0	Fair
Beaver Creek	4	2	2	2.7	Fair
Clair Creek	4	3	3	3.3	Marginal
Monastery Creek	3	2	2	2.3	Fair

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.18
SUBWATERSHED HEALTH - WATER QUALITY



- Roads
- Water Bodies
- Study Area

Water Quality Rank:

- Fair
- Marginal
- Poor
- Insufficient Data

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.4.4 Stream Channel and Riparian Health

A separate EA, **"Municipal Class Environmental Assessment: Watercourse Erosion Master Plan (October 2018)"** was prepared in advance of the SWM-MP at the request of the City to permit identified watercourse projects to proceed in concert with planned capital works ahead of the completion of the SWM-MP. The separate EA included in-field channel assessments for each subwatershed. In order to provide an existing conditions evaluation score for stream health on a subwatershed basis, three (3) metrics were used. Stream health metrics used for this analysis are:

1. Erosion Stream Health
2. Aquatic Stream Health
3. Riparian Stream Health

4.4.4.1 Erosion Stream Health Metric

A comprehensive inventory of erosion was documented at both the site and reach level within each of the subwatersheds. For this analysis, general subwatershed scores were assigned based on the average condition of the subwatershed and the severity of identified erosion issues. Scoring for this metric is presented in **Table 4.9**.

Table 4.9: Erosion Stream Health Scoring System

Evaluation Score	Description
1	No significant erosion issues for most watercourses
2	Low to moderate natural erosion rates and/or minor erosion issues
3	Moderate natural erosion rates, erosion issues, and/or degradation of engineered structures
4	Significant erosion issues on about 50% of the watercourses, including degradation of engineered structures
5	Significant erosion issues on most watercourses, including degradation of engineered structures

4.4.4.2 Overall Subwatershed Aquatic Stream Health Metric

During channel assessments, physical aquatic conditions were assessed for each subwatershed. Those channels with natural substrate and sediment depositions patterns minimally influenced by urbanization were given lower evaluation scores. Evaluation scores were increased for reaches with concrete channelization, piped sections, fish barriers and sediment deposition regimes heavily influenced by subwatershed urbanization. For this analysis, general subwatershed scores were assigned based on the average condition of the subwatershed and the severity of identified aquatic issues. Scoring for this metric is presented in **Table 4.10.**

Table 4.10: Aquatic Stream Health Scoring System

Evaluation Score	Description
1	Excellent physical aquatic habitat conditions for most watercourses, and/or contributing habitat
2	Good physical aquatic habitat conditions for most watercourses, and/or contributing habitat
3	Fair physical aquatic habitat conditions for most watercourses, and/or only locally poor habitat
4	Marginal physical aquatic habitat conditions for most watercourses, and/or only locally fair to good habitat
5	Poor physical aquatic habitat conditions for most watercourses

4.4.4.3 Riparian Stream Health Metric

During channel assessments, riparian conditions were assessed for each subwatershed. Mature trees and wetland vegetation in riparian areas were the primary indicators of good riparian stream health. Subwatersheds lacking these qualities scored as marginal or poor in the riparian stream health metric. For this analysis, general subwatershed scores were assigned based on the average condition of the subwatershed. Scoring for this metric is presented in **Table 4.11.**

Table 4.11: Riparian Stream Health Scoring System

Evaluation Score	Description
1	Excellent riparian habitat conditions for most watercourses, including mature trees and/or wetland vegetation; no significant erosion issues for most watercourses
2	Good riparian habitat conditions for most watercourses, including mature trees and/or wetland vegetation; low to moderate natural erosion rates and/or minor erosion issues
3	Moderate natural erosion rates, erosion issues, and/or degradation of engineered structures; fair riparian habitat conditions for most watercourses, and/or only locally poor habitat
4	Marginal riparian habitat conditions for most watercourses, and/or only locally fair to good habitat; significant erosion issues including degradation of engineered structures
5	Poor riparian habitat conditions for most watercourses; significant erosion issues on most watercourses, including degradation of engineered structures

4.4.4.4 Scoring of Stream Health Metric

An overall stream health evaluation score was calculated for each subwatershed by averaging the erosion, aquatic and riparian metrics. Each subwatershed was assigned a score between one (1) and five (5). A score of one (1) given to a watercourse indicates that the riparian zone has not been altered and there is no evidence of erosion or sedimentation beyond what can be expected within a natural system. A score of five (5) given to a watercourse indicates excessive erosion resulting in channel widening to the extent that property or infrastructure is at risk of failure. Encroachment, erosion or sedimentation that are not visibly resulting in immediate risk to property or infrastructure will fall between one (1) and five (5) depending on severity. **Figure 4.19** illustrates stream health evaluation scores for each subwatershed as indicated in **Table 5.4** of **Appendix C.**

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.19
SUBWATERSHED HEALTH - STREAM HEALTH

- Roads
- Water Bodies
- Study Area

Stream Health Ranking:

- Good
- Fair
- Marginal
- Poor
- Insufficient Data

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.4.5 Aquatic Ecology

The presence of healthy fish communities is a good indicator of subwatershed health.

Three (3) metrics were used for each subwatershed to determine an overall aquatics evaluation score. Metrics used for an aquatics evaluation score were:

- Species Richness
  - In general, a diverse, high quality habitat is able to support a variety of species. Therefore, higher species richness is indicative of a higher quality habitat.
- Species Intolerant of Disturbance
  - The presence of species that are intolerant to disturbance is indicative of higher quality habitat. Therefore, habitats with a greater number of intolerant species are higher quality than habitats with fewer intolerant species.
- Habitat Sensitivity
  - In general, coldwater habitat and the species which reside in them are more sensitive to disturbance than warmwater habitat and warmwater species. Scores were applied so that coldwater habitats are the most sensitive, followed by coolwater and then warmwater.

Scores of 0-20 were divided among the five categories as shown in **Table 4.12** to develop the ranges used in the evaluation score.

4.4.5.1 Scoring of Overall Aquatic Metric

Table 4.12 below summarizes the scoring system adopted in assessing the aquatic ecologic health of each subwatershed.

Table 4.12: Aquatics Scoring System

Species Richness	**1**	**2**	**3**	**4**	**5**
	16-20	12-15	8-11	4-7	0-3
Species Intolerant of Disturbance	**1**	**2**	**3**	**4**	**5**
	4	3	2	1	0
Habitat Sensitivity	**1**	**2**	**3**	**4**	**5**
	Coldwater	Coolwater	Warmwater		

An overall aquatic ecology score was calculated for each subwatershed by averaging the species richness, species intolerant of disturbance and species tolerant of disturbance scores.

A score of one (1) given to a watercourse would indicate that the watercourse is expected to currently support a wide diversity of aquatic life consistent with natural conditions. Watercourses that have historically supported coldwater species but are at risk of diminished coldwater habitat due to thermal pollution or lack of baseflow received a score of one (1).

A score of 5 (five) given to a watercourse would indicate that biodiversity within the watercourse is expected to be severely degraded.

The scoring applied to each subwatershed is shown in **Table 6.1** of **Appendix C** and is based on:

- Available data which was compiled and analyzed for existing trends
- Scores which were established based on available data and expected conditions within each subwatershed
- A test run performed to see if the average scores reflected the inferences of expected conditions within each subwatershed

Figure 4.20 illustrates aquatic health evaluation scores for each subwatershed.

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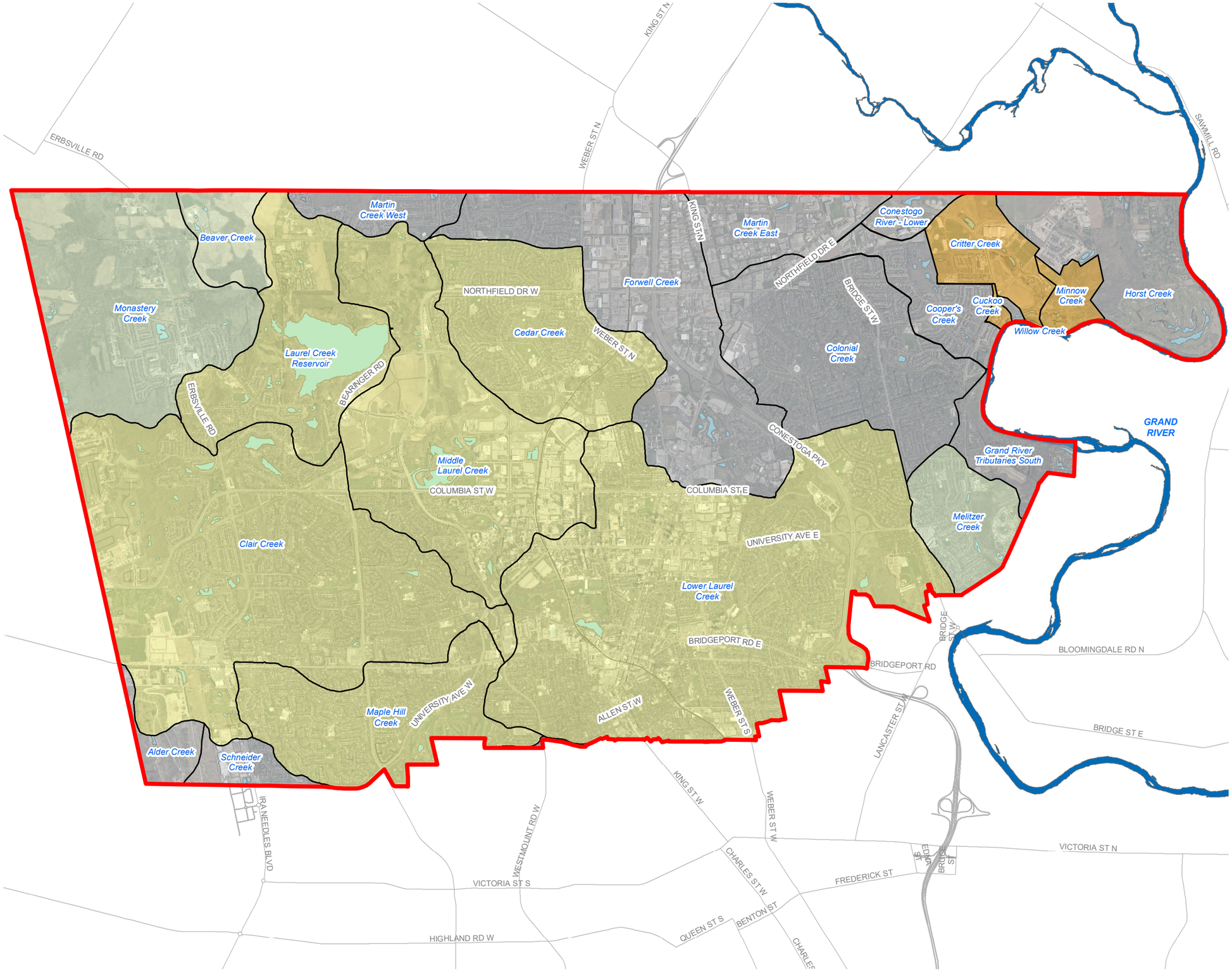
MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.20
SUBWATERSHED HEALTH - AQUATIC RANK



Roads
Water Bodies
Study Area

Aquatic Ranking:

Fair
Marginal
Poor
Insufficient Data

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.5 Overall Existing Conditions Subwatershed Scores

Existing conditions subwatershed scores were calculated by adding evaluation scores for each of the categories:

1. Terrestrial Subwatershed Health (**Section 4.4.1**)
2. Stormwater Management (**Section 4.4.2**)
3. Water Quality (**Section 4.4.3**)
4. Stream Channel and Riparian Health (**Section 4.4.4**)
5. Aquatics Ecology (**Section 4.4.5**)

A maximum score of five (5) was achievable for each of the subwatershed health metrics. The maximum score achievable, indicating the worst possible existing conditions for any subwatershed, was 25. The minimum score achievable, indicting the best possible existing conditions for any subwatershed, was 5.

Upon evaluating the existing conditions subwatershed scores, Forwell Creek and Schneider Creek subwatersheds were determined to have the highest score, indicating the worst subwatershed conditions in the City. The existing conditions subwatershed scores of 21 resulted from scores of 4.0 (marginal) or higher in all evaluation categories where data was available. Cedar Creek, Lower Laurel Creek, and Martin Creek East, also received scores of 20.

Willow Creek subwatershed was determined to have the lowest score, indicating the best subwatershed conditions in the City. Within this creek, the existing conditions subwatershed score of 9 resulted from scores between 2.0 (good) and 3.0 (fair) in three (3) of the metrics.

On average, subwatersheds within the City of Waterloo received an existing conditions subwatershed score of 15.5. When this value is normalized for varying subwatershed areas, the average for the City of Waterloo was 17. Individual evaluation scores and overall existing conditions subwatershed scores are shown for each subwatershed in **Table 4.13.**

4.6 Subwatershed Prioritization

Existing conditions subwatershed scores are used to establish potential prioritization hierarchy to be confirmed through further assessment as part of the Implementation Plan (see **Section 16.0**). Four (4) potential levels of subwatershed priority have been proposed.

1. **Priority 1 Subwatersheds**
   Those subwatersheds with scores of 20 or greater are classified as **Priority 1 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including source control initiatives, conveyance control works, end-of-pipe retrofits and in stream/riparian rehabilitation are proposed to receive a high priority. Five (5) Priority 1 subwatersheds were identified.

2. **Priority 2 Subwatersheds**
   Those subwatersheds with scores greater than 15 and less than or equal to 19 are classified as **Priority 2 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including source control initiatives, conveyance control works, end-of-pipe retrofits and in stream/riparian rehabilitation are proposed to receive a moderate priority. Five (5) Priority 2 subwatersheds were identified.

3. **Priority 3 Subwatersheds**
   Those subwatersheds with scores greater than 11 and less than or equal to 15 are classified as **Priority 3 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including source control initiatives, conveyance control works, end-of-pipe retrofits and in stream/riparian rehabilitation are proposed to receive a low priority. Eight (8) Priority 3 were identified.

4. **Priority 4 Subwatersheds**
   Those subwatersheds with scores less than or equal to 11 are classified as **Priority 4 Subwatersheds**. These subwatersheds are the closest to natural environmental conditions of the subwatersheds in the City of Waterloo. In order to sustain the environmental conditions in these subwatersheds, development and intensification are proposed to focus on providing sufficient buffers and maintaining the natural hydrologic cycle through source control initiatives, conveyance control works, and end-of-pipe facilities. Five (5) **Priority 4** subwatersheds were identified.

The proposed Priority Subwatersheds 1 to 4 with associated scoring are graphically presented in **Figure 4.21. Figure 4.22** presents the proposed prioritization of subwatersheds in the City of Waterloo. Subwatershed prioritization has been developed as a tool to guide the prioritization of works as part of the Implementation Plan which is discussed in **Section 16.0.**

Table 4.13: Evaluation of Existing Conditions Priority Rating

Subwatershed	SWM Score	Water Quality Score	Stream Channel and Riparian Score	Aquatics Score	Terrestrial Score	Total Score	Existing Conditions Priority Rating
Cedar Creek	4.33	4.33	3.33	4	3.75	20	1
Forwell Creek	4.00	-	4.33	-	4.25	21	1
Lower Laurel Creek	4.33	-	3.33	3.67	4	20	1
Martin Creek East	2.67	-	-	-	5	20	1
Schneider Creek	3.33	-	-	-	5	21	1
Clair Creek	3.00	3.33	3.33	4	3.5	18	2
Colonial Creek	3.33	-	3.33	-	4.25	18	2
Conestogo River - Lower	2.33	-	-	-	5	19	2
Maple Hill Creek	3.33	-	-	4	4	19	2
Middle Laurel Creek	3.00	3	3.33	3.67	3	16	2
Alder Creek	3.00	-	-	-	2.75	15	3
Cooper's Creek	2.33	-	3.33	-	2.5	14	3
Critter Creek	1.33	-	2	4.33	2.75	14	3
Cuckoo Creek	2.67	-	3	4.33	2	15	3
Grand River Tributaries South	2.00	-	-	-	3.25	14	3
Laurel Creek Reservoir	1.33	-	3.33	3.67	1.75	13	3
Martin Creek West	2.33	-	-	-	3	14	3
Melitzer Creek	2.33	-	-	3	2.25	13	3
Beaver Creek	1.00	2.66	-	2.67	1.75	11	4
Horst Creek	2.00	-	-	-	1.75	10	4
Minnow Creek	1.00	-	-	4.33	1	11	4
Monastery Creek	1.33	2.33	-	3	1.25	10	4
Willow Creek	1.33	-	2.66	-	1.25	9	4

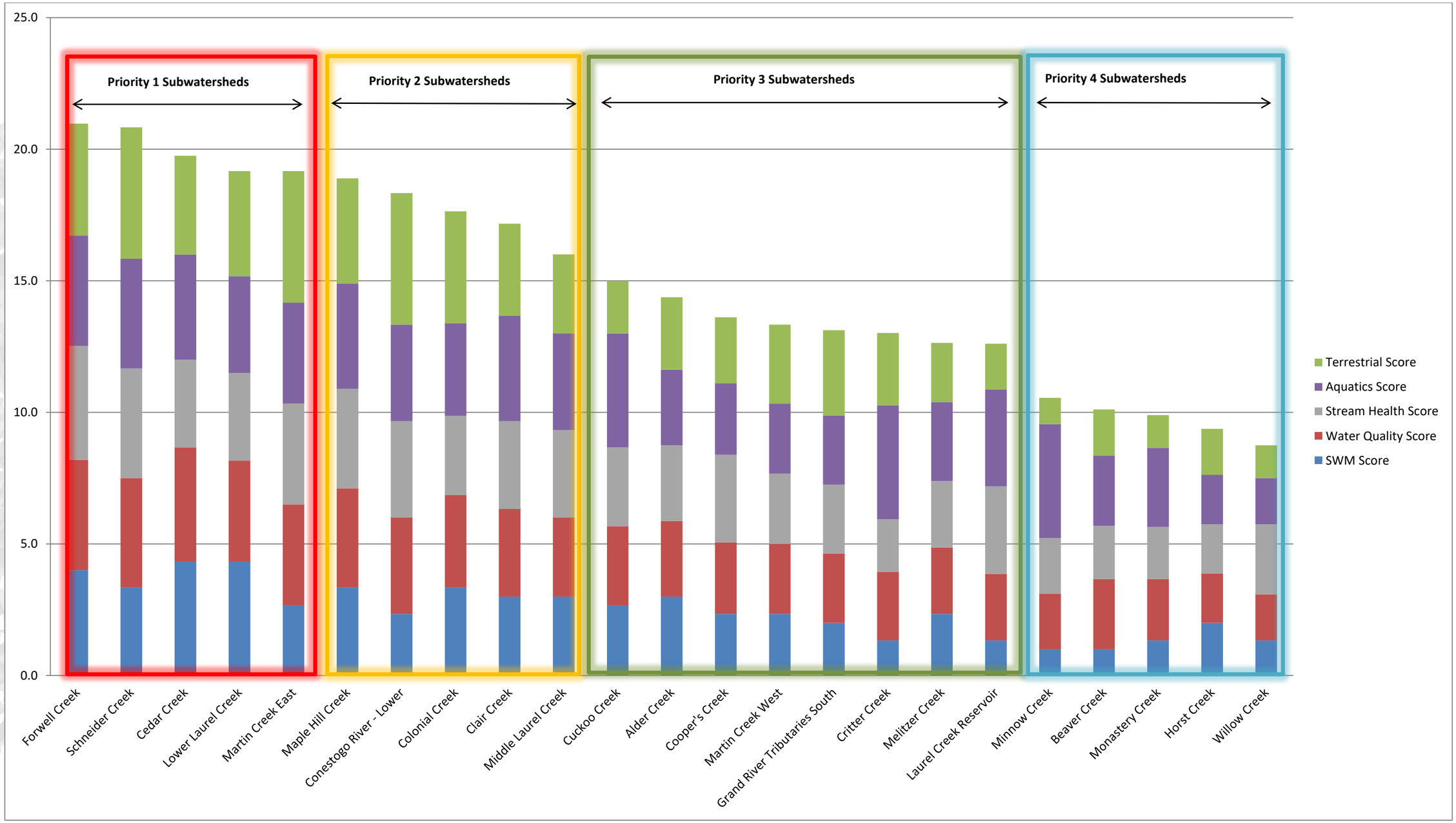


Figure 4.21: Evaluation of Existing Conditions Priority Rating

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

Figure 4.22
SUBWATERSHED HEALTH - PRIORITY RANK

- Roads
- Water Bodies
- Study Area

Priority Ranking:

- Priority 1
- Priority 2
- Priority 3
- Priority 4

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

4.6.1 Priority Subwatersheds Synergies with City Plans and Policies

Priority subwatersheds are not intended to be addressed in isolation as part of the SWM-MP. In fact, the SWM-MP has been developed with full consideration for other Strategic Plans, Subwatershed Studies, Master Plans, Secondary Plans, Environmental Assessments and Policies. More specifically, many of the proposed SWM opportunities represent potential synergies with other studies and plans and should be considered as such. Implementation of SWM approaches should have regard for the following:

- **Development Engineering Manual (2013)** which outlines policies, procedures and standards governing the development process. Of relevance to the SWM-MP are the requirements for grading, stormwater management, maintenance and acceptance of SWM facilities, SWM monitoring, and site servicing.

- **Park Strategy (under development)** will establish a vision for the park system for the next ten years and develop the action plans needed to achieve the vision. In developing the City of Waterloo's Park Strategy, it will be crucial to recognize the opportunity for stormwater retrofits that parks can present. Stormwater management can be incorporated into existing and future parks via subsurface stormwater chambers, bioswales and bioretention facilities, and dry stormwater management facilities. The SWM-MP considers opportunities to install new stormwater management facilities in existing parks.

- **Waterloo Park Master Plan (2009)** describes the conceptual context of the WPMP that will be used to guide the future development of Waterloo Park over the next 20 years and beyond. Of particular relevance to the SWM-MP is the objective developed by the Waterloo Park Master Plan Special Project Task Force to incorporate stormwater management facilities to treat and control surface water discharge from the Park to the receiving waters in the Park (Laurel Creek/Silver Lake). Three proposed stormwater management facilities are identified in the Plan, although the exact form and configuration of the stormwater facilities and associated conveyance methods will need to be addressed during the detail design.

- **Transportation Master Plan (2011)** provides direction for local transportation planning and decision-making. Integrating stormwater management functions is crucial to properly functioning transportation networks. Of relevance to the SWM-MP is the integration of Complete Streets with a complementary Linked Greenways or Trail Corridors policy that supports active transportation in a variety of non-street corridors such as parkland, natural areas, woodlands, river and creek corridors, stormwater management facilities, utility corridors, transit and rail corridors as well as the integration of trail and access roads around stormwater management facilities.

- **Asset Management Plan (2016)** contains corporate asset inventories and allows for illustration of how planned expenditures to renew assets effects the performance of the

asset through 2042. Stormwater Management (SWM Facilities) and storm collection (storm sewers) are each identified as asset groups in the AMP. The AMP identifies that the SWM-MP will result in an increase in maturity level of stormwater management data which will be above average with respect to similar municipalities in Canada.

- **Stormwater Utility and Credit Program By-Law (2012)** imposes a stormwater charge on property owners within the City and provides an opportunity for property owners to reduce their stormwater charge by applying best management practices. This stormwater utility funds stormwater projects at a rate of approximately $10 million annually.

- **Ecological Restoration Areas and Policies** – lands and waters that have the potential to be enhanced, improved or restored to a more natural state, contributing to the overall diversity and connectivity of the Natural Heritage System per Chapter 8 and Schedule A4 of the City of Waterloo Official Plan. The approaches of the SWM-MP represent an opportunity in regard to areas designated for restoration.

- **Grand River Source Protection Plan (Effective July 1, 2016)** – Drinking water source protection plans identify the risks to municipal water quality and water supplies, and the policies and programs that will reduce the risks. Volume II of the Grand River Source Protection Plan covers the Region of Waterloo including the City of Waterloo. Specific policies relating to Stormwater Management within Wellhead Protection Areas (WHPA) and Intake Protection Zones (IPZs) can be found from policy **RW-MC-15** through **RW-CW-20.1**. In 2000, the WHPAs were incorporated in the Regional Official Policies Plan (ROPP).

- **Grand River Water Management Plan (2014)** - addresses the issues faced by the Grand River watershed. The goals of the plan are to: improve water quality to maintain river health and reduce the impact of the Grand River on Lake Erie; ensure water supplies for communities and ecosystems, reduce flood damage potential, and increase resiliency to deal with climate change. Many agencies share the responsibility for managing water resources. In 2009, they agreed to develop a new plan to address today's most important issues: population growth, climate change and the impacts of extensive agriculture. The plan was developed through a collaborative process.

- **Wastewater** – As part of the study entitled **Assessment of Future Water Quality Conditions in the Grand and Speed Rivers (Water Management Plan Assimilative Capacity Working Group, January 2012)**, a number of water management scenarios were developed which incorporated wastewater treatment plant upgrades in current municipal wastewater master plans, wastewater treatment plant optimized performance targets and, most relevant to the City of Waterloo SWM-MP, rural / agricultural and urban non-point source load reductions ranging from 20% to 40%. The report notes the need for integration of watershed resources as it relates to wastewater and stormwater. The SWM-MP provides insight, options and management approaches to address the above noted needs and deficiencies.

Throughout the SWM-MP and supporting technical documents (**Appendix A to M**), the potential synergies with the above noted plans and policies are noted and the methods and approaches for integration with the objectives of this master plan are discussed.

Integration across city departments is the corner stone of a modern approach to stormwater management and will be essential for the City of Waterloo in the implementation of the SWM-MP in order to maintain and improve the condition and health of the City's subwatersheds.

5 Development of Stormwater Management Options

The approach for developing and evaluating alternatives is consistent with the requirements of the planning process for Master Planning projects as outlined by the Municipal Engineer's Association Municipal Class Environmental Assessment (MEA), October 2000, as amended in 2007, 2011 & 2015. That is, any problems or opportunities identified during the Master Planning process will have alternatives prepared to address them and a preferred alternative, strategic or approach selected for each deficiency.

The EA involves reviewing Phase 1 work (i.e. Identification of the Problem) and undertaking Phase 2 (i.e. Establishing Existing Conditions, Identification of a Long List of Alternatives, Development and Assessment of Alternative Management Strategies and Selection of a Preferred Strategy). Consultation with stakeholders is also a necessary and important component of this process.

When looking to address the problem statement and any identified deficiency, there are six (6) categories of stormwater management practices and options that can be used to:

- Improve surface water and groundwater quality,
- Prevent thermal enrichment of surface water,
- Decrease sediment loads to surface water,
- Reduce adverse effects on human and animal health,
- Prevent the loss and degradation of fish and wildlife habitat, natural features and processes
- Reduce flooding and erosion
- Prevent disruption of the pre-development hydrologic process (reduction in groundwater recharge and stream baseflow)
- Reduce the occurrence of Urban flooding (overwhelming of the municipal storm sewer system)

The six (6) categories of stormwater management practices and options are:

1) Municipal Pollution Prevention, Operations & Maintenance Practices,
2) Market Based Strategies for Private Property (source controls),
3) Stormwater for the Capital Roads Program (conveyance controls),
4) Stormwater Management Facilities,
5) Watercourse and Erosion Restoration, and
6) Urban Flood Management & Stormwater Infrastructure.

Section 5.1 describes each of the six (6) categories of stormwater management practices and options.

When a problem is identified, the first step undertaken in the development and evaluation of alternative management strategies and the ultimate selection of a recommended approach, is the development of a long list of alternatives. The long list of alternatives must be all encompassing, and consistent with the study principle, goals and objectives. Furthermore, the development of the long list of alternatives must consider both existing and proposed conditions within the study area.

The long list also considered agency and provincial direction, specifically the use of a Treatment Train Approach to stormwater management as prescribed in the Stormwater Planning and Design Guide (MECP, 2003) and the MECP Interpretation Bulletin (February 2015) which outlined:

- That "going forward the Ministry expects that stormwater management plans will reflect the findings of the watershed, subwatershed, and environmental management plans, and will employ Low Impact Development (LID) in order to maintain the natural hydrologic cycle to the greatest extent possible."
- "Too often, preservation of the natural hydrologic cycle is not sufficiently addressed in stormwater management plans submitted to the Ministry for an Environmental Compliance Approval (ECA)."
- "Low Impact Development (LID) is relevant for all forms of development, including urban intensification and retrofit."

5.1 The Long list of Alternative Methods

The following section describes each of the six (6) categories of stormwater management practices which comprise the long list of alternatives as part of the SWM-MP. The long list of alternatives represents a series of approaches, strategies, practices or actions that can be applied to address the identified problem statement and satisfy the study goals and objectives.

5.1.1 Municipal Pollution Prevention, Operations & Maintenance Practices

Municipal Pollution Prevention Measures, Management and Operational Practices are methods that have the intent to improve operation and maintenance of privately and publicly owned land, buildings, and infrastructure that will reduce pollution generation. Certain municipal and regional programs such road salt management, street sweeping and parks maintenance activities (elimination of the broad use of herbicides and pesticides) are known to improve water quality.

Applying Municipal Pollution Prevention Measures, Management and Operational Practices measures often include changing behavior, altering current practices and providing educational programs. These measures and practices are not site-specific and can be generally applied over a subwatershed or municipal boundary to prevent sources of pollution from entering the drainage system. Several Municipal Pollution Prevention Measure, Management and Operational Practices are described below.

Pollution Prevention Plans - Promote pollution prevention techniques that are applied in collaboration with the GRCA and the MECP to minimize the potential for spills and contaminated runoff from entering the storm drainage network, and ultimately to local watercourses, the Grand River and/or groundwater, the primary source of Waterloo's drinking water.

Control of De-icers - Sensible and conservative use of de-icing compounds, e.g. reducing de-icing chemical application rates to minimum amounts necessary to perform the job and use of alternative de-icing materials (to sodium chloride) that can be more effective and can be used in lesser amounts. This includes the development and use of Salt Management Plans and applicator training through such programs as the Region of Waterloo's smart about salt™ program. It should be noted

that pursuant to Region of Waterloo SPP Policy RW-CW-38, Smart about Salt accreditation is required for medium (200m^2 to 2000m^2) and large (in excess of 2000m^2) parking lots.

Control of Pesticides and Fertilizers – Can include alternatives for pest and weed control, including the use of beneficial insects, companion plantings, alternative spray compounds and non-toxic substances. In regard to existing laws:

- Per O.Reg 63/09 and the *Pesticides Act* (R.S.O 1990, C. P.11), it is illegal in Ontario to use Class 9 pesticides to kill weeds and insects on lawns, vegetable and ornamental gardens, patios, driveways, parks and schoolyards. Class 9 pesticides ingredients include 2,4-D, Diazinon and glyphosate. Class 9 pesticides are banned for cosmetic purposes because they may pose an unnecessary risk to human health, particularly children's health.
- A provincial fertilizer ban currently does not exist, however several nutrient limited watersheds in North America, including the Lake Simcoe watershed, have implemented or are considering fertilizer bans for non-agricultural purposes.

Enforcement of By-Laws - Prevents impact to the quality of water resources through enforcement of municipal by-law such as: City of Waterloo property standards, weed control, and garbage. They can also include: Debris and Anti-Litter policies to prohibit, for example, the illegal throwing of refuse and debris; Storm Sewer By-Laws to prevent the discharge of harmful substances to municipal and private storm sewer systems which ends up in our creeks and rivers; and Erosion and Sediment Control By-laws to prevent sediment from entering a body of water.

Household Hazardous Waste Collection & Used Oil Recycling - Collection of deleterious chemicals such that they are disposed of in a manner that does not threaten stormwater quality and the environment. Used oil recycling is a responsible alternative to improper disposal practices. Arrangement must be made for collection and delivering wasted oil to a recycling facility.

Safer Alternative Products – Promotes the use of less harmful and environmentally damaging products which can reduce the amount of toxic and deleterious substances entering stormwater and reaching receiving waters.

Materials Storage Controls - Concerns material delivery and storage for municipal and commercial operations. This can include reducing the storage of hazardous materials on site, storing materials in designated areas, installing secondary containment, conducting regular inspections and training employees and subcontractors.

Pool Drainage - Drawdown of pools prior to winter may release a large volume of water, chlorine and salt (with the increase in the use of salt water pools) that may be toxic to aquatic life. Actions can include providing advice or requiring pool drainage to be undertaken in an environmentally acceptable ways (e.g. emptying pool at least 3 days after the last chemical application).

Modifying Engineering Standards - Reduces pollutant loading near the source through filtering or absorbing of pollutants, and reduces runoff by encouraging infiltration. Changes to engineering

standards can serve to promote the use of Low Impact Development (LID) techniques which include provisions for surface storage and directing drainage through vegetated areas.

Municipal Management & Operational Practices

The following details municipal management and operation practices.

Storm Sewer Flushing - a storm drain is "flushed" with water to suspend and remove deposited materials. Flushing helps ensure pipes convey design flows and removes pollutants from the storm sewer system.

Catch Basin Cleaning - catch basin and stormwater inlet maintenance is typically done on a regular basis to remove pollutants, reduce high pollutant concentrations during the first flush of storms, prevent clogging of the downstream conveyance system and restore the catch basin's sediment-trapping capacity. Maintenance program can reduce loadings to existing stormwater management ponds and surface water. The City of Waterloo currently undertakes catch basin cleaning on an as-needed-basis.

Sediment Removal – involves the regular removal of sediment from municipal stormwater infrastructure such as oil and grit separators (OGS) and SWM facilities. The City of Waterloo is obligated to perform regular inspection and maintenance, including sediment removals, of all city owned OGS and SWM facilities, per the conditions of the respective MECP Environmental Compliance Approval (ECA).

Street Sweeping - Regular street sweeping can reduce the build-up of pollutants on street surfaces and prevent mobilization during rainfall events. The City of Waterloo currently has a street sweeping program.

Erosion and Sediment Control - For construction sites where erosion and sedimentation rates are usually very high, this approach aims at the prevention of erosion and containment of sediment from leaving the site boundary. The City of Waterloo currently has an erosion and sediment controls program as part of the normal development process.

Leaf Pick-up and Removal – Reduces the discharge of nutrients and pollutants to stormwater from street surfaces by leaf clearing and removal during the fall and/or spring periods. This municipal action reduces the nutrient load in the storm sewers, stormwater ponds, and the creek system, which enhances overall water quality. The City of Waterloo currently has a leaf pick-up and removal program.

Cross Connection Control Program - Preventing unwarranted physical connections to the storm drain system from the sanitary and floor drains through regulation, regular inspection, testing and education. The City of Waterloo currently has a cross connection control program as part of building inspection, permitting and normal development process.

Public Education - Informs the public about pollution prevention and stormwater management issues, solutions, regulations and related financial incentives such as the SWM Utility Credit program using methods appropriate to the target audience and the specific issue. This approach involves the public in remedial actions to achieve cost savings though volunteerism, and increase political support. The City of Waterloo participates in the Waterloo-Wellington Children's Groundwater Festival to educate elementary school age children on the importance of water conservation, protection, technology, and ecology, among other educational initiatives. In addition, the City offers public education through REEP Green Solutions and the RAIN program (a stormwater education and action program created by Green Communities Canada). The City also distributes educational materials on a variety of stormwater related topics as part of regular bill inserts.

Business Education and Awareness - promotes education of the business and industrial community as to the impact of pollution on the environment and the runoff pathways of pollution in an industrialized watershed. This approach fosters an environment where expertise and information can be shared on pollution prevention at source.

Yellow Fish Road Program - Stenciling of storm drain system with warnings/advisories and graphic icons discourages the illegal dumping of unwanted materials. The City of Waterloo currently participates in the Yellow Fish Road Program in partnership with Trout Unlimited Canada.

Snow Plowing and Storage – The City is responsible for removing snow when accumulated snow exceeds the onsite storage capacity of road rights-of-way and municipal properties. Snow can be contaminated with salt, oil, grease, and heavy metals so it must be handled and stored in ways that protect water sources.

5.1.1.1 Summary

The Municipal Pollution Prevention Measures, Management and Operational Practices listed above have been included here to promote better housekeeping. Many measures and practices listed above are part of existing municipal programs by the City of Waterloo and/or are preventative rather than treatment measures and therefore are not considered further for the purposes of the Class Environmental process followed in this report.

Specific measure and practices which are discussed further within the SWM-MP include:

- Sediment removal (OGS and SWM facilities);
- Catch basin cleaning;
- Leaf removal and street sweeping;
- Public awareness and business awareness and education (discussed as a component of source controls);
- Erosion and sediment control; and
- Snow storage.

5.1.2 Source Control Measures

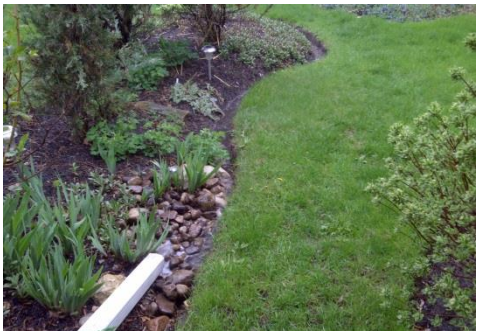
Source control measures are small-scale stormwater management techniques located at the beginning of a drainage system where stormwater is captured and treated on-site or close to where the rainfall lands. Due to the relatively small area treated by an individual measure, source controls must be well distributed to treat stormwater runoff effectively.

These measures are generally installed on private property within residential, commercial, industrial and institutional land uses, but can also be installed within municipal lands such as parks, trails, municipal buildings and facilities. Source control measures provide treatment for the stormwater generated by roof, driveway, landscape and parking areas.

Source control measures remove pollutants from stormwater through a variety of mechanisms, including mechanical filtration, biological uptake, adsorption, infiltration and settling. These measures can exhibit a wide variability in their ability to remove pollutants, generally ranging between 60% and 80% in efficiency depending on the particular measure and the type of pollutant being analyzed.

Despite the emphasis on source control in most recent stormwater policy and guidelines documents, systematic implementation of these measures throughout a municipality has not yet occurred in Canada. The implementation of a variety of source control measures has however become more common in the last decade as is exemplified in the City of Waterloo through the SWM Utility Credit program. Acceptance and promotion of this approach to stormwater management offers considerable promise in achieving the goals and objectives of the SWM-MP.
Source control measures include:

Disconnection of Roof Leader - Roof leader (eavestrough) connections from residential and commercial buildings can vary within different areas of the City depending on when the site was constructed and the standards of the day. Typically, if connected, the roof leaders flow into the municipal storm sewer system, however it is also possible that the roof leader is connected to the sanitary sewer system which is not generally permitted today. These conditions, known as 'directly connected', promote a significant inflow of stormwater runoff directly into these systems during a rainfall event.



Disconnected roof leader

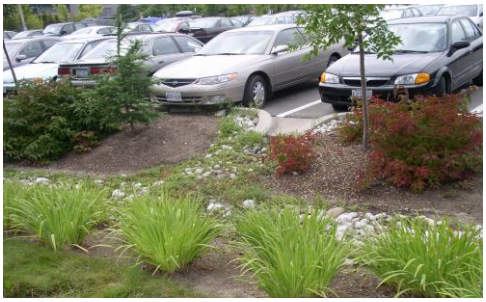
A relatively simple source control measure is to disconnect the roof leader from the municipal sewer so that the relatively clean rooftop drainage can be treated on a permeable ground surface and/or used as a resource for on-site purposes. The simplest forms of roof leader disconnection are to the lawn, to a depressed area in the lawn or to another SWM practice such as a rain barrel. More advanced systems direct the roof leader to absorptive or naturalized gardens and bioretention techniques as discussed below.

Landscaping to capture rooftop and yard drainage

Absorptive Landscapes - In residential and commercial land uses, absorptive landscape areas can be placed in the front or back of building where they will capture 'disconnected' rooftop and yard drainage and in doing so will prevent relatively clean stormwater from entering the conventional stormwater infrastructure system and mixing with more contaminated stormwater. Absorptive landscapes are an alternative to conventional turf areas and can be planted with a variety of perennials, grasses, trees and shrubs.

Bioretention Areas - Bioretention areas (also commonly referred to as rain gardens) are a specialized form of the more generic engineered sand filter class of stormwater control. Bioretention facilities capture, temporarily store, and treat stormwater runoff by passing it through an engineered filter media. The primary component of a bioretention practice is the filter media bed, composed of a mixture of sand, soil, and organic material as filtering medium. Bioretention can be applied in most soils or topography, since underdrains which collect and return filtered water to the surface or sub-surface system may be used when full infiltration into native soils is not feasible. Snow storage can be provided by bioretention, especially those located adjacent to parking lots. Plant material must be salt-tolerant, perennial, and tolerant of periodic inundation. In commercial land uses, bioretention areas can be used at the base of buildings, in parking lot islands, or at the edge of a parking lot where stormwater is directed. Bioretention areas are relatively inexpensive to build, easy to maintain, and can add aesthetic value to a site, without consuming large amounts of valuable land area. Bioretention is often popular in developments with a higher urban design standard as it can meet local landscaping requirements and provide improved site aesthetics.

Bioretention cell in a residential area



Bioretention cell in a commercial parking area

Reduced Lot Grading - The grading in manicured yards or other green space areas can be reduced from the standard 2% or can incorporate micro-grading (creation of small depressions or circuitous drainage pathways) to encourage infiltration.

Permeable Pavements – Driveways, parking lots, trails and sidewalks can be designed using permeable pavements to allow rain water to drain through the pavement and into the ground. Common materials include permeable interlocking concrete pavers (PICP), porous concrete and permeable asphalt as well as grass-pavers and permeable grid systems.

Permeable driveway

PICP parking lot

Soakaway Pits/Infiltration Trenches - These techniques provide for infiltration of roof drainage into the ground by directing the rain water from roof leaders to an underground infiltration trench referred to as a 'soakaway pit'. These underground units are typically filled with clear stone or pre-manufactured drainage materials (generally plastic grids or arched systems which increase the available storage).

Infiltration trench

Soakaway pit

Green Rooftop Technology - Are constructed on top of buildings to reduce runoff volume (via increased evapotranspiration), improve water quality and reduce energy usage. Green roofs are most applicable to the industrial and commercial land uses due to the prevalence of large flat roof areas. Generally, retrofitting green roofs onto an existing building is uncommon as it can be expensive and require structural reinforcements.

Green roofs treat stormwater landing on rooftops in commercial areas

Oil & Grit Separators (OGS) – OGS units are used to trap and retain oil and/or sediment in detention chambers. These units are located either at the beginning of a storm sewer (pre-treatment or source control) or at the end of a storm sewer (end-of-pipe control).

Rainwater Harvesting (RWH) Rainwater harvesting (RWH) is the practice of intercepting, diverting and storing rainfall in an above- or below-ground storage tank for future use. The captured rainwater is then pumped into the building where it can be used for non-potable water uses such as to serve toilets, to be used in building cooling processes or for outdoor irrigation applications such as underground sprinkler systems for landscaped elements. This capture and re-use of rainwater can, in turn, significantly reduce stormwater runoff volumes and pollutant loads.

Urban cistern (Employment Building) St. Paul, Minnesota

Soil Amendments – Compost amendments are tilled or mixed into existing soils thereby enhancing or restoring soil properties by reversing the loss of organic matter and compaction. They also are used to make Hydrologic Group C and D soils suitable for on-site source controls such as downspout disconnection, filter strips, and grass channels. Soil amendments benefits include increased infiltration, stormwater storage in the soil matrix, survival rate of new plantings, root growth and stabilization against erosion, improved overall plant health and decreased need for irrigation and fertilization of landscaping. Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process. While soil amendments will never be used solely to meet stormwater management objectives, they are effective in reducing the overall runoff volume, will contribute to a lower peak discharge, and can help reduce the size of total runoff storage needed.

Park soil amendments

Tree Conservation and Urban Canopy - Tree conservation at development sites should be given priority as a technique to maintain a natural hydrologic regime. Similarly, the urban tree canopy plays an important role in managing stormwater. A mature tree canopy can reduce stormwater runoff volume, peak flows, improve water quality, generate organic soils, absorb greenhouse gases, create wildlife habitat, and provide shading to mitigate temperature increases at development sites.

Tree conservation accompanied by soakaway pit design

5.1.3 Conveyance Control Measures

Conveyance control measures are measures that are designed to treat stormwater as it travels overland or through pipes to the downstream outlet.

Bioswales in Mississauga

Traditional conveyance systems are typically comprised of curbs, gutters and buried concrete (or other) piping systems that carry stormwater away from a development area to a water body generally along the road network. In appropriate applications, alternative conveyance control measures can be used to improve water quality conditions at lower cost to the municipality. Because the municipal right-of-way (ROW) account for a significant share of a community's impervious surfaces, conveyance control measures present an important opportunity to improve downstream water quality conditions (e.g. sediment, nutrient, bacteria, oil/grit, thermal impact reduction, etc.), promote groundwater recharge and minimize watercourse erosion.

Non-traditional conveyance control such as Low Impact Development (LID) measures can provide stormwater treatment for the collected drainage concentrated within the ROW of a municipal road (or regional road). LID conveyance controls are linear stormwater transport systems that are generally located within the road right-of-way (ROW) of private and public roads where they encourage infiltration of water into the ground, improve water quality and reduce runoff. The suitability of LID conveyance controls depends on many environmental and planning considerations, including soil conditions, ROW size and characteristics, and implementation considerations.

Traditional conveyance controls are well understood, are regularly applied within the City of Waterloo and are part of the existing City standards. LID conveyance control measures, however have had limited application in the City. LID conveyance controls are described in the following sections which include:

Bioretention - As a stormwater filtration and infiltration practice, bioretention temporarily stores, treats and infiltrates runoff. The primary component of the practice is the bioretention soil media. This component is comprised of a specific ratio of sand, fines and organic material. Another important element of bioretention practices is vegetation, which can be either grass or a more elaborate planting arrangement. Depending on the native soil infiltration rate and site constraints, bioretention practices may be designed without an underdrain for full infiltration or with an underdrain for partial infiltration. Bioretention can be further separated into:

- Bioretention Bump Outs (Curb Extensions)
- Boulevard Bioretention
- Bioretention Planters

These bioretention variants are described below.

***Bioretention Bump Outs (Curb Extensions)* –** Bump outs are bioretention areas that extend into the roadway and are separated from the paved ROW by perimeter curbing. Bioretention bump outs can be used for traffic calming and can be arranged to allow for adjacent on street parking. Bioretention bump outs are a very flexible and can be constructed during road resurfacing, road construction, or road reduction projects. The location, size and spacing of bioretention bump outs can be adjusted as needed to meet existing roadway conditions. It is possible to design these practices so the existing curb and inlets remain in place or are repurposed.

Bioretention bump out

***Boulevard Bioretention* -** Boulevard bioretention consists of shallow vegetated depressions located immediately behind the curb. For streetscapes with sidewalks, these units are located between the curb and inside sidewalk edge. In residential areas that do not have sidewalks, these cells are located on the municipally owned portion of the boulevard. Curb cuts typically direct road drainage to a bioretention cell, though other inlet types, such as side inlets, can be configured to meet site needs. The size and shape of boulevard bioretention units is flexible to accommodate site specific constraints.

Boulevard bioretention

Bioretention Planters **-** Bioretention planters have vertical sidewalls and are often narrow and rectangular in shape. The walls allow bioretention planters to maximize the amount of stormwater retention within a small footprint.

Bioretention planter –King Street, Kitchener

The self-contained structure of bioretention planters permits them to be installed in close proximity to utilities, driveways, trees, light standards and other urban features. Bioretention planters can be constructed immediately adjacent to the roadway, in the boulevard, or as a green feature within the pedestrian area (i.e. sidewalks and pathways). Given these characteristics, bioretention planters are ideal for integrating within highly urbanized streetscapes or within other road ROWs with tight space constraints. Planters are an ideal means to address multiple objectives in urban streetscapes, including street greening and improved aesthetics along with stormwater management benefits.

Bioswales - Bioswales are vegetated open channels designed to convey, filter, and attenuate stormwater runoff. Applying the same technology as bioretention units, bioswales also promote infiltration to the native soil reducing stormwater contributions to the municipal storm sewer. A unique feature of bioswales when compared to conventional vegetated swales is the bioretention soil media, granular storage layer, and optional underdrain components (which can replace a traditional storm sewer). Depending on the desired neighbourhood aesthetic, bioswales can be vegetated with grass to blend in with the traditional streetscape or can be planted with a wide variety of shrubs, grasses and flowers for a garden-like visual.

Bioswale

Perforated Pipe - Perforated pipe systems are long infiltration trenches that are designed for both conveyance and infiltration of stormwater runoff. These stormwater conveyance systems are composed of perforated pipes installed in gently sloping granular stone beds lined with geotextile fabric that allows infiltration of runoff into the gravel bed and underlying native soil. Perforated pipe systems can be used in place of conventional storm sewer pipes where topography, water table depth, and runoff quality conditions are suitable. Perforated pipe systems can be installed as a single larger diameter perforated pipe beneath the roadway surface or as two (2) parallel smaller diameter perforated pipes beneath a shallow swale beneath the boulevard area. With most perforated pipe designs, the streetscape

Perforated pipe

remains largely the same as conventional curb-and-gutter. Due to their simple design, perforated pipe systems require very little maintenance and have a proven track record in Ontario.

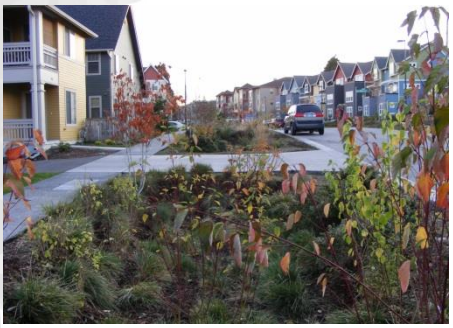
Permeable Pavements - Permeable pavement includes pervious concrete, porous asphalt and permeable interlocking concrete pavers (PICP). Permeable pavement can be used in place of conventional asphalt or concrete pavement. These alternatives contain pore spaces or joints that allow stormwater to pass through to a stone base for infiltration into underlying native soil or temporarily detained.

Permeable pavement used in a laneway

For best results in ROW applications, permeable pavement should be limited to areas subject to light vehicle traffic, including parking lay-bys, shoulders, cycle paths, sidewalks and pedestrian areas as well as laneways. Use in heavy traffic areas is not recommended—these materials currently don't wear as well as conventional asphalt or concrete.

PICP lay-by and sidewalk, Mississauga, ON

Vegetated and Enhanced Swales - Vegetated and enhanced swales have long been used for conveyance, particularly as roadway drainage. More recently, their benefits as a stormwater best management practice have been recognized. Vegetated and enhanced swales are closer in hydrologic properties to natural zero order channels than drainage systems composed of curb and gutter, inlets, and pipes. Grass channels allow infiltration, discharge at a lower rate, and reduce pollutant loads. Swales are most frequently applied for drainage alongside roads, highways, and parking lots however they are also well suited for use in conjunction with drive-lanes and rooftop drainage as well as within pervious surfaces, such as parks and landscaped areas.



Vegetated Swale – Seattle, WA

Proprietary Stormwater Quality Treatment Devices - Proprietary stormwater quality treatment devices cover a broad range of technologies that can be used to treat runoff from the municipal ROW. These devices are typically prefabricated enclosures into which proprietary technologies are added to treat stormwater runoff. Some of the treatment approaches include:

- Hydrodynamic systems, commonly called oil grit separators (OGS) devices;
- Media filters;
- Membrane filters; and
- Selected modular tree pits and bioretention units etc.

The pollutant removal characteristics of proprietary stormwater treatment devices can vary widely. Like all best management practices, their performance depends upon regular inspection and maintenance.

Oil grit separator

5.1.4 End-of-Pipe Measures (SWM Facilities)

End-of-pipe measures are the most commonly used stormwater management measure in most municipalities. These measures provide treatment for the collected drainage at the end of conveyance system prior to the discharge of stormwater to a watercourse. End-of-pipe measures are typically implemented in urbanizing areas as a requirement of development. Typical end-of-pipe measures used to treat stormwater include stormwater ponds (dry or wet), wetlands, hybrid facilities and/or subsurface storage facilities.

In end-of-pipe measures which have wet component, a permanent pool of water provides the water quality treatment. This permanent pool promotes the settling of sediments and pollutants to the bottom of the facility as stormwater travels through the facility. Provided the facility is functioning properly and is well maintained, sediments and pollutants will not be transported downstream of the facility. To optimize pollutant removal capacities, design engineers usually aim to maximize the distance that stormwater must travel through these facilities so that a larger percentage of the suspended solids will fall out of suspension. In general, a larger volume of water utilized for water quality storage will enhance performance; however, suspended solids removal performance becomes asymptotic with increasing design storage (there is a limit to storage beyond which there are negligible increases in suspended solids settling).

It is ideal if end-of-pipe measures are designed as large centralized facilities that treat the collected drainage from as much upstream development area as is realistically possible. This will reduce construction, operations and maintenance costs. It should be noted that this approach is not always feasible in existing urban areas.

End-of-pipe (SWM facilities) measures include:

Wet Ponds - The facilities comprise the most common form of end-of-pipe stormwater management facilities. Wet ponds contain a permanent pool of water and store a specific volume of water to provide water quality treatment and also address issues related to erosion and flooding.

Wet ponds are not limited in the size of the contributing catchment and can control drainage areas ranging from 10ha to over 100ha.

Wet stormwater quality pond

Constructed Wetlands – Typically comprise one of the least common end-of-pipe facilities in most municipalities due to the large land requirements. These facilities may be effective in improving water quality and reducing downstream erosion potential, but their role in water quantity control is limited because of their limited storage volume and shallow water depth. As compared with other end-of-pipe systems, construction costs for wetland systems are typically higher. Limited by the size of the catchment they can service, wetlands are common for small drainage areas, typically less than 10ha.

Constructed wetlands

Hybrid Wet Ponds / Wetlands - A system design using a combination of wet ponds and constructed wetlands. Hybrid facilities require a wet pond to be constructed in series with a wetland. The required permanent pool volume is approximately 50% for each element respective element. Hybrid facilities combine the best performance attributes of each technique; the wetland component provides improved water quality performance and the wet pond provides the added water quantity and erosion control benefits. Hybrid facilities typically require additional land to construct to accommodate the shallow wetland features.

Hybrid wet pond/ wetland

Dry Ponds - Stormwater dry ponds, which are dry except during rainfall events, are designed for erosion and flood control. These facilities may not provide water quality control. Dry facilities are often retrofitted so that a permanent pool of water is incorporated into the design to provide water quality treatment.

Dry stormwater pond

Subsurface Storage Facilities – Subsurface storage facilities capture and store stormwater collected from surrounding impervious areas. Storm sewers direct runoff to subsurface vaults or systems of large-diameter interconnected storage pipes or chambers. Stored water is then released directly through an outlet pipe back into the storm sewer network or to natural waters at rates designed to reduce peak water flows during storms or to mimic pre-development conditions. In some cases, stored water can be allowed to infiltrate to recharge groundwater (if soil types are suitable and the groundwater table is located sufficiently below the water storage units). Underground stormwater storage facilities can provide water quality benefits when designed with a permanent water volume or when pre-treatment or baffle designs are incorporated.

Subsurface HDPE arched chamber system

The addition of pre-treatment features at the system inlet can facilitate improvements to water quality by removing floatables, skimming of oils and grease and trap some level of sediments through deposition. Pre-treatment is most important if runoff is intended to be infiltrated, otherwise rapid clogging of the system could occur. Pre-treatment features can be designed and built into the system or commercially available, prefabricated units can be incorporated within the system during initial planning and design. Subsurface storage facilities can also significantly improve water quantity and erosion control.

Subsurface concrete arched chamber system

Oil and Grit Separators (OGS) - Discussed previously in **Section 5.1.3**, when located upstream of a storm sewer outfall at the terminus of the storm sewer network, OGS units can be considered an end-of-pipe treatment facility. These mechanical devices are used for the capture of spills and removal of coarse sediment from stormwater. OGS units are intended to remove floatables (debris, gasoline, oil, grease, light petroleum products and other floating liquids) from stormwater runoff. These systems are typically used for contributing drainage area less than four (4) ha but can accommodate larger drainage areas when used off-line, in parallel or in series. Generally, these devices are used for commercial and industrial land use but can also be used for redevelopment and infill areas (where available space is constrained, and traditional forms of water quality treatment cannot be implemented).

5.1.5 Watercourse and Erosion Restoration

Watercourse and erosion restoration measures are designed to address erosion and flooding problems and restore stream functions and stability. They are generally applied on a stream reach basis and include stream rehabilitation using natural or engineered channel design principles and naturalization of stream riparian zones using native materials. They may also include individual approaches such as streambank re-grading, gradient controls and floodplain contouring to address specific erosion and flooding problems. This approach can also include in-stream practices, such as outfall restoration, riparian plantings, and open space re-vegetation to improve the function of stream corridors. These approaches improve water quality, slow runoff, moderate stream temperatures, reduce erosion and improve aquatic and terrestrial habitat conditions.

Stream restoration examples

Ecological restoration measures enhance the ability of the natural environment to improve water quality and to prevent watercourse erosion from further degrading water quality. Existing natural areas provide valuable ecological services, such as quality and quantity treatment of stormwater at no cost. If an existing natural area is degraded, it may be possible to restore the area and regain lost ecological services. Restoration of degraded habitats may be done in a number of ways. Representative restoration / enhancement programs are summarized below.

Watercourse and erosion restoration measures include:

Stream Restoration Programs - These include measures designed to address erosion and flooding problems and restore stream functions and stability. They are applied on a stream reach basis. Stream restoration programs include stream rehabilitation using Natural Channel Design (NCD) and Geomorphic Referenced River Engineering (GRRE) generally referred to as a hybrid type design. An important component of these projects is naturalization of stream riparian zones using native materials. They may also include individual structures, such as streambank re-grading, gradient controls and floodplain contouring to address specific erosion and flooding problems. These programs are often integrated with components for aquatic habitat enhancement such as spawning habitat creation, refuge pool construction, undercut bank structures, boulder placements, half log cover structures, and flow deflectors.

Local Bank or Slope Stabilization Works - Local works reduce the level of risk by applying local bank or slope stabilization treatments using either hardened (engineered) type treatments, or more

natural (vegetation and biotechnical engineered) type treatments. The intent of these works is to protect the adjacent features at risk (i.e., residential properties and infrastructure), both now and in the future, by anticipating channel activity that may occur in the vicinity of the at-risk areas.

Realignment - These measures involve the realignment of risk (i.e., infrastructure) away from the channel. This alternative addresses the reoccurring issues associated with infrastructure and watercourse interactions, and looks at possible approaches of removing the interaction to provide the creek with sufficient space to naturally adjust and migrate without posing risks to municipal infrastructure or private property.

Opportunities for watercourse and erosion restoration measures in the City of Waterloo are outlined in a separate EA: **"Municipal Class Environmental Assessment: Watercourse Erosion Master Plan (October 2018)".**

5.1.6 Urban Flood Management & Stormwater Infrastructure

These include a variety of structural and non-structural measures associated with the storm sewer system to alleviate urban flooding resulting from capacity issues within the existing storm sewer network. Structural and non-structural approaches include:

Local Remedial Measures - These measures, if properly implemented, can be highly effective in reducing urban flooding and can provide a high level of protection for individual properties. They are typically recommended for isolated cases of urban flooding. They include but are not limited to:

- Backflow Prevention with or without Sump Pump – is an effective solution for individual properties to prevent basement flooding due to sewer surcharge. They require installation within individual properties and also require sporadic maintenance by home owners. Implementation can require financial assistance.
- Sump Pump for Foundation Drains – involves the disconnection of foundation drains from the sewer system to prevent hydrostatic pressure due to sewer surcharge. Also reduces inflow and infiltration (I/I) in cases of drain connections to sanitary sewer. They require installation within individual properties and also require electrical backup supply to work under power failure.
- Lot Regrading – effective in reducing local flooding and high inflow and infiltration (I/I) to foundation drains. Care must be taken due to the potential increase in overland flow and potential flooding to adjacent properties.
- Rain Barrel – reduces storm runoff by promoting re-use of roof runoff (also thus reduces municipal water consumption). Requires co-operation of home owner, so implementation may require financial assistance.

System Storage (in-line/off-line sewers) – involves the construction of off-line sewers parallel to the existing storm sewer to provide additional storage and flood relief. Effective in regulating/moderating peak flows at locations where the capacity of a storm sewer is inadequate. This approach allows some flexibility regarding location of construction, which is generally less

extensive than a full storm sewer replacement. Operations and maintenance requirements are less than for underground storage tanks. This approach does not require open space for implementation but does require favorable hydraulic conditions of the existing sewer for optimal operation and minimal maintenance.

Inlet Control Devices – are used to control flow into the storm sewer during peak flow events. They are designed to allow a specified flow volume out of an individual catch basin at a specified head and cause the excess stormwater to be temporarily stored above ground. This approach is effective in controlling the storm water entering the storm system provided an adequate major system exists.

Pipe Upgrade (pipe replacement/ twinning) – highly effective in preventing surcharge of existing combined sewer system, however often represents the highest capital cost due to significant construction requirements.

Internal Diversion – this approach focuses on balancing flows within the existing storm sewer system by utilizing spare capacity in other parts of system to accommodate more intensive storms. Internal diversion typically requires minimal construction.

6 Municipal Pollution Prevention/ Management/Operational Practices

The following section outlines the key pollution management practices which make up the preferred stormwater management strategy of this SWM-MP.

Municipal Pollution Prevention, Management and Operational Practices are important to ensure pollutants are prevented from impacting the environment and to ensure stormwater infrastructure maintain their effectiveness. In order to understand and assess the existing and future Municipal Pollution Prevention, Management and Operational Practices, a series of technical reports have been prepared in support of the SWM-MP. These technical reports are included within the report's appendices and are summarized in the following sections.

The SWM-MP explored approaches to manage pollutants and sediment within the City's stormwater management infrastructure in the most cost-effective manner. The following studies and resulting recommended works have been completed following Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved.

6.1 Sediment Removal OGS Units

In order to understand the impact of sediment accumulation within City of Waterloo OGS units, a report titled "**SWM-MP Municipal Class EA - Sediment Analysis Memo: SWM Facilities and OGS Units (April 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix D.**

The following section describes and summarizes the condition and maintenance priorities for oil and grit separators (OGS) units within the City of Waterloo. The SWM-MP explored approaches to manage pollutants and sediment within the City's OGS units in the most cost-effective manner. The following study and resulting recommended works have been completed following Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved.

6.1.1 Problem Identification

OGS units use hydrodynamic separation to remove sediment and hydrocarbons from urban runoff. These units require regular inspection and maintenance in order to function as designed. According to the City of Waterloo's GIS database, two hundred forty-one (241) OGS units have been installed within the City of Waterloo. The City is responsible for the operation and maintenance of sixty-one (61) of these units per the conditions of the respective MECP Environmental Compliance Approval (ECA). It is therefore important for the City to effectively prioritize necessary maintenance work for OGS units to ensure continued performance. **Figure 6.1** identifies all OGS units in the City of Waterloo.

6.1.2 Sources of Information

In 2016 the City of Waterloo undertook an inspection of forty-seven (47) OGS units, examining their existing operational conditions and structural aspects. The 2016 survey identified immediate service requirements for six (6) and categorized eight (8) additional units under 'Try to Clean'. Following this inspection, maintenance was undertaken for twelve (12) of the most critical units.

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 6.1
STORMWATER MANAGEMENT FACILITIES & OGS UNITS

- Watercourse
- Roads
- Water Bodies
- Rivers
- Stormwater Management Ponds
- SWM Facility Drainage Area
- Study Area

OGS Structures

- City of Waterloo
- Region of Waterloo
- Private
- University of Waterloo
- WCDSB
- WRDSB
- Ownership Information Unavailable

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

6.1.3 OGS Units – Analysis and Results

6.1.3.1 OGS Analysis

OGS units were analyzed based solely on their loss in storage capacity, based on the manufacturers' specifications. The effect of sediment accumulation was determined in terms of loss of total storage capacity, calculated as shown in **Equation 1**.

$$\textbf{\textit{Storage Loss}}\ (\%) = \frac{\textbf{\textit{Volume of Sediment in 2015}}\ (m^3)}{\textbf{\textit{Total Storage Capacity}}\ (m^3)} . \mathbf{100} \qquad \textbf{(1)}$$

Maintenance costs were estimated for the facilities currently operating at less than acceptable efficiency. Extra expenses were assumed considering the potential need of soil management for contaminated materials in three (3) different levels. In addition, provisional costs were added to consider other services such as traffic control, implementation of a health a safety plan, removal of contaminated water, removal and replacement of existing damaged structures, supply of materials and other potential construction needs. Refer to **Section 14.0** for estimated program costs.

6.1.3.2 OGS Analysis Results

Within the City of Waterloo there are sixty-one (61) city-maintained OGS units. Adequate information for analysis were available for thirty-five (35) of these units, excluding the twelve (12) units tendered for clean-out in 2016. OGS maintenance guidelines recommend cleaning OGS units once 15% of the total storage volume is filled with sediment. Based on this criterion, ten (10) structures currently need maintenance. **Table 6.1** summarizes the results of the OGS analysis including the ranking criteria utilized in **Appendix D**. City of Waterloo OGS units identified as requiring maintenance are identified in **Table 6.2** and in **Figure 6.2.**

Table 6.1: OGS Units Summary

Number of OGS Units	**61**
Number of OGS Units Removed from Analysis	26
Number of OGS Units with Lack of Information	14
Number of OGS Units Tendered for Clean-Out in 2016	12
Number of OGS Units with Accumulated Sediment	35
<15% Loss of Storage (Maintenance Not Required)	25
Assumed >15% (Requires Maintenance)	2
>15% (Requires Maintenance)	8

Table 6.2: OGS Units Sediment Analysis and Maintenance Requirements

Asset ID	Make and Model	Install Date	Loss in Maintenance Threshold Sediment Storage Capacity (2016)	Maintenance Priority
10080695	STC-1500	01-Jan-99	292%	High Priority
10080622	STC6000	31-Mar-15	239%	High Priority
10080647	STC-1500	01-Jan-99	222%	High Priority
10080563	STC-3000	21-Mar-12	160%	High Priority
10080569	STC-1500	01-Jan-99	152%	High Priority
10080521	STC-2000	24-Apr-01	116%	High Priority
10080649	STC-1000	10-Dec-02	111%	High Priority
10080618	STC-1500	09-Sep-05	108%	High Priority
10080651	STC-6000	29-Sep-99	90%	High Priority
10080515	STC-2000	13-Jun-05	87%	High Priority
10080568	STC-1500	21-Sep-09	76%	Medium Priority
10080561	STC-2000	06-Sep-00	73%	Medium Priority
10080585	STC-2000	15-Sep-00	73%	Medium Priority
10080578	STC-4000	15-Sep-00	64%	Medium Priority
10080646	STC-1500	03-Sep-98	57%	Medium Priority
10080551	STC-6000	29-Sep-99	54%	Low Priority
10080524	STC-2000	13-Jul-04	29%	Low Priority
10080514	STC-1000	13-Jun-05	28%	Low Priority
10080579	STC-4000	21-Mar-12	25%	Low Priority
10080619	STC-4000	27-May-04	19%	Low Priority
10131824	STC-2000	08-Dec-14	15%	Low Priority
10080648	STC-6000	20-Nov-02	12%	Low Priority
10080660	STC-6000	20-Nov-02	12%	Low Priority
10080566	STC-750	15-Jul-10	11%	Low Priority

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 6.2
OGS UNITS WITH MAINTENANCE PRIORITY

- Watercourse
- Roads
- Water Bodies
- Rivers
- Subwatershed Boundary
- Study Area

Maintenance Priority:

- High Priority
- Moderate Priority
- Low Priority
- Maintenance Required
- No Maintenance Required

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: March 2019

6.1.4 Conclusions and Recommendations

The follow summarizes the study findings and recommendations based on the OGS results. For full details regarding the study and results refer to **Appendix D**.

- The OGS Inspection report provided by the City of Waterloo did not contain fourteen (14) OGS units, which should be inspected to determine the depth of sediment and whether a cleanout is required.
- Ten (10) OGS units were identified with high priority maintenance needs, and are ranked in **Table 6.3** in **Appendix D**.

Refer to **Section 14.0** for financial considerations and cost estimates.

6.2 Erosion and Sediment Control

As previously discussed, the City of Waterloo currently has an erosion and sediment controls program as part of the normal development process. However, to promote better housekeeping, enhanced protection of the environment and recognizing the agency and provincial direction to move towards the use of a Treatment Train Approach to stormwater management which utilizes LID approaches, it is recommended that the City of Waterloo review the existing erosion and sediment controls program as part of the normal development process. This review is recommended such that new policies and standards capture the evolution in erosion and Sediment Controls (ESC), from a single approach for sediment management to ESC control methodologies and approaches that utilizes a hierarchical strategy of:

Step 1 – Eliminate or reduce erosion
Step 2 – Control sediment releases

This stepped approach is supported by national certification boards including the CISEC program (Certified Inspector of Erosions and Sediment Control program - www.cisec.org).

6.2.1 Recommendations

Using the hierarchical strategy, the development of subject site eliminates the erosion of soils during construction, reduces the reliance on sediment controls to reduce releases, and thereby more completely protects the receiving watercourse from sediment releases. The previous focus on sediment control fails to deal with the root cause of the problem - the erosion. In this regard, it is important to note the following:

- Sediment control does not control erosion, but erosion control does minimize sediment; and
- Sediment control BMPs do not removal all suspended sediment found runoff water.

The basic principles of any ESC plan strategy should include:

- A multi-barrier approach which begins with erosion controls, followed by sediment controls, and avoids reliance on a single control point for sediment
- Retains existing vegetation to the greatest extent possible for as long as possible
- Minimizes land disturbance areas
- Reduces runoff velocities and detains runoff to promote settling
- Diverts runoff from problem area
- Minimizes slope length and gradient of disturbed areas
- Maintains overland sheets flow and avoids concentrated flows
- Stores and stockpiles soils away from watercourse, drainage features and top-of-slope
- The acknowledgment that ESC plans are dynamic and require application of the Adaptive Management Approach (AMA) whereby the ESC plan is continually updated as a result of site inspections

In addition to the typical ESC control BMPs listed above within the *Erosion and Sediment Control Guidelines for Urban Development*, the following erosion control BMPs and sediment control BMPs listed in **Table 6.3** are recommended for consideration as part of the City review.

Table 6.3: Summary of Erosion Control BMPs and Sediment Control BMPs

Erosion Control BMPs	Sediment Control BMPs

Diversion Structures
• Slope drains
• Diversion berms
• Conveyance channels
 	
Erosion Control Methods (ECMs)
• Soil roughening
• Seeding or turf establishment – sprayed, drilled or spread
• Turf Reinforced Mats (TRMs)
  ○ For drainage channels/ conveyance
• Soil binders - tackifier or polymers
• Rolled Erosion Control Products (RECP)
  ○ For hillsides
• Mulch application (wet or dry)
  ○ Dry mulches such as straw, hay, compost, RECPs or rock
  ○ Wet mulches such as shredded wood, corn stalk fiber with or without tackifier or polymers
	Perimeter Controls
	• Silt fence barrier
	• Fiber log/ roll
	• Compost socks
	• Compost berms
	
	Check Structures
	• Straw bale barrier- check dam
	• Rock check dam
	• Geosynthetic check structure
	
	Inlet barriers
	• Rock bags
	• Curb inlet "sump barriers'
	• Curb opening to vegetated areas
	• Area bale/ rock barrier
	• Inlet inserts (i.e. Silt Sacks or equivalent)
	
	Stabilized Construction Access controls
	• Vehicle tracking pad/ mud mat
	• Entrance Grates or ridge systems
	• Tire washing

Specific items for consideration as part of the recommended City review include:

1. Typical ESC Plans currently require the placement of topsoil and seed for all areas not scheduled for immediate development following site grading (by June 1 of the following year) for winter conditions. It is suggested that "immediate development" be clarified as "immediate development within 30 days following the completion of site grading" and that "where winter grading prevents the use of topsoil and seed, that alternative *Erosion Control Methods (ECMs)* listed in **Table 6.3** be utilized".

2. All ESC plans focus on Erosion Control using the Erosion Control BMPs and ECMs listed in **Table 6.3** in addition to those listed in within the *Erosion and Sediment Control Guidelines for Urban Development*.

3. All ESC plans implement a multi-barrier approach which begins with erosion controls, followed by sediment controls and avoid reliance on a single control point for sediment.

4. That all development areas retain a full-time certified Inspector of Sediment and Erosion Control (CISEC) who has completed and is accredited through the CISEC program. To qualify

for admission into the CISEC certification program, applicant must meet the following minimum criteria:

- 2+ years of construction site field experience involving erosion and sediment
- Through understanding of erosion and sedimentation process and how they impact the environment
- Complete understanding of key federal, provincial and local regulations
- Ability to read and interpret ESC plans

5. Complete site inspections be completed according to the following frequency:

i. On a weekly basis
ii. After every rainfall event
iii. After significant snowfall event
iv. Daily during extended rain or snowmelt periods
v. During inactive construction periods where the site is left unattended for 30-days or longer, a monthly inspection should be conducted.

6. The site inspector shall maintain an inspection log-book.

7. ESC reports be prepared for submission to the contractor/ developer in advance of each meeting and that all records be kept for period of 2 year following construction. Reports should be provided to the City of Waterloo on a weekly. Reports should detail a minimum of:

- Site location and boundaries
- Permitting or approval information
- Inspector name and qualification
- Rational for inspection (see inspection frequency; i.e. weekly, following precipitation, etc.)
- Observations/ findings relating to the inspection (both positive and negative) including:
  - Written observations
  - Annotated ESC plans
  - Photographic using a GIS/ coordinate enabled camera (date stamped)
- Person(s) informed/ notified of findings and or observations
- Actions required
- Follow up on 'actions required' from previous reports.

8. All sediment releases and spills outside the designated control area (development limits) be recorded and reported to the City and GRCA within 24 hours.

9. The acknowledgment that ESC plans are dynamic and require application of the Adaptive Management Approach (AMA) whereby the ESC plan is continually updated as a result of site inspections.

6.3 Snow Storage

The City of Waterloo is responsible for clearing snow from roads, sidewalks and trails according to the provincial standards and municipal by-laws. When accumulated snow exceeds the onsite storage capacity of the road rights-of-way and municipal properties, snow must be removed and hauled to the City's snow storage facility. The City's existing snow storage facility is 0.59 ha, and its capacity has been exceeded in excessively snowy winters. A secondary snow storage facility is therefore necessary, and a report was prepared to assess potential locations, titled: **"SWM-MP Municipal Class EA – Snow Storage Memo (February 2019)" (Appendix E).**

The Source Protection Plan for the Grand River Source Protection Area (2016) has identified the "Storage of Snow" as a threat to drinking water sources, as "snow can be contaminated with salt, oil, grease and heavy metals from vehicles, litter, and airborne pollutants, it must be handled and stored in ways that protect water sources." Central storage locations (e.g. snow disposal sites) are considered to be drinking water threats.

A GIS analysis was therefore conducted to identify potential locations for a new secondary snow storage facility. The search criteria are listed in **Table 1** in **Appendix E** and consider proximity to Inlet Protection Zones, Issue Contributing areas, floodplains, woodlots, and wetlands. A total of eight (8) potential locations were identified, all of which would require site grading and drainage works to accommodate snow storage. These locations are shown in **Figure 6.3** and include:

1. Woolwich Street and University Avenue East
2. Woolwich Street and Park Road
3. North of University Avenue East and Country Squire Lane
4. South of University Avenue East and RIM Park Fields Lane
5. RIM Park Fields 1
6. RIM Park Fields 2
7. Lexington Park
8. Hydro Corridor at Ladyslipper Drive

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 6.3
POTENTIAL SNOW STORAGE AREAS

- Watercourse
- Roads
- Water Bodies
- Recommended Snow Storage Areas
- Study Area

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

7 Source Controls & Market Based Strategies

To increase uptake of SWM and pollution prevention practices as part of the SWM-MP, market-based research was undertaken with residential as well as business property owners/managers, builders/developers and service providers to develop enhancements to current SWM programming within City of Waterloo. Results of the market-based research are detailed within a series of three (3) reports were prepared, entitled:

- **SWM-MP Municipal Class EA – Market Research – Interview Summary: Industrial, Commercial and Builder/Developer Key Informants (January 2019)**
- **SWM-MP Municipal Class EA - Residential Market Research Analysis (January 2018)**
- **SWM-MP Municipal Class EA - Leading Jurisdictions Report (January 2019)**

These three (3) supporting technical documents to the SWM-MP are included as **Appendix F.**

Source control measures fall outside of the Municipal Class EA process, since they are to be constructed on private property, often by the individual land owner as a retrofit or during development/ redevelopment (i.e. the City is not the proponent). This precludes source control measures from the requirements of the Class EA process. The following study and resulting recommendations are intended to provide direction to the City of Waterloo as approaches which can be undertaken to increase uptake of SWM and pollution prevention practices by property owners and builders/developers.

7.1 Background and Context

Securing at-source control of stormwater and pollution prevention requires the participation of private property owners in the residential and business sectors. Toward this end, with the approval of council in 2010, the City established a stormwater utility fee based on actual contributions or load to the stormwater system and a credit program of up to 45% of the fee to encourage land-owners to implement on-site stormwater mitigation and pollution prevention measures. Implementation of the stormwater utility fee began in January 2011 with the issuance of the first utility invoices to residents.

To support landowners implementing stormwater mitigation measures such as rain gardens, bioswales, redirecting downspouts, etc., the City of Waterloo in partnership with REEP Green Solutions provides information, resources and direct expert guidance to residential and industrial, commercial and institutional (ICI) property owners.

Efforts to assist landowners with implementation of on-site SWM resulted in reasonable uptake over the early years of the program, but recently uptake has been leveling off. According to the "Stormwater Utility and Credit Program Review" (2016), there was a 7.5% uptake of the stormwater credits among residential customers, with a total of 1927 customers successfully receiving the credit. From 2013 to 2016, the percent of applications where residents had recently adopted the stormwater controls increased from 23.2% to 42.3%. Among non-residential customers, by October 2016 a total of 117 had implemented some on-site measures to reduce stormwater runoff and pollutant loadings. It should be noted that very few of these on-site measures can be directly

attributed to the credit program, as the majority of the credits claimed were for sites which already had on-site measures in place as part of other approvals (i.e., development requirement for infiltration galleries). 2019 Stormwater Account data is summarized in **Table 7.1.**

Table 7.1: 2019 Stormwater Account and Stormwater Credit Data

Account Type		Number of Stormwater Accounts	Number of Accounts with Stormwater Credits	Uptake of Credits
Non-Residential	Commercial	799	237	7.2%
	Industrial	421		
	Institutional	278		
	Multi-Res	1808		
Residential		28,576	2594	9.1%

Securing greater uptake in both customer sectors is a significant goal for stormwater programming moving forward. With this goal in mind, the City has undertaken market and best in class research to develop strategies for securing greater uptake of at-source SWM and pollution prevention measures by residential and non-residential customers. Primary research with property owners and senior managers, and secondary research into leading jurisdictions in SWM has been undertaken to determine mechanisms and approaches to drive uptake of on-site stormwater management measures. The research and findings are discussed herein and form the basis for the recommendations set out in this strategy.

7.2 Study Description

To increase uptake of SWM and pollution prevention practices by property owners and builders/developers, market-based research was undertaken to determine viable alternatives to current SWM programming. Market-based research involves market segmentation and analysis to determine constraints and opportunities in each market segment and across market segments or sectors.

Single-detached dwellings and industrial and commercial property owners/managers were the target sectors for the primary market research. Leading jurisdictions best practices research and a review of City policies and programs enabled an examination of constraints and opportunities vis-à-vis current SWM programming in Waterloo.

7.2.1 Study Considerations

In meeting the City's SWM-MP objectives, two primary considerations will inform the strategic direction of municipal actions to drive uptake of at-source SWM and pollution prevention by private property owners, specifically:

1. The creation of drivers for at-source actions by private landowners and new construction through the development or modification of City policies and practices via enhanced integrated decision-making and programming across City departments and portfolios.

2. The strategic engagement of the marketplace to drive uptake of at-source actions by property owners and builders/developers and create the impetus for market transformation.

These considerations informed the research methodology and the recommendations set out in this strategy.

7.2.2 Research Methodology

Primary research was undertaken to identify and explore constraints and opportunities for uptake of on-site SWM measures amongst property owners in the target sectors – homeowners and industrial/commercial property owners. A fulsome discussion of the methodologies for research with property owners/managers in the industrial/commercial sectors and with single-family homeowners are addressed separately in **Appendix F.**

Secondary research involving an extensive web-based search and on-line literature review was carried out to identify best practices employed by leading jurisdictions in SWM and sustainability (water and energy conservation, pollution prevention, alternative energy, etc.).

7.2.3 Research Goal and Objectives

Research objectives were based on the overall goal of determining constraints and opportunities to drive uptake of SWM and pollution prevention practices by single-family homeowners and business property owners/managers.

Research objectives drawn from the overarching SWM-MP project objectives were developed and guided the research process. Objectives specific to each area of research – single-family homeowners and industrial/commercial property owners – were developed to ensure the research was targeted and necessary insights and data would be captured. (See **Appendix F** for the sector-specific research objectives).

7.3 Business Sector Research

Industrial/commercial/institutional property owners/managers were targeted via City and third-party outreach and marketing, including the provision of a stormwater utility credit for implementation of on-site SWM measures, and access to audits and expert advice via REEP Green Solutions' RAIN Business Visits. These programs and initiatives encourage business property owners/managers to implement SWM and pollution prevention practices on their properties. In addition to these practices, City personnel engage builders/developers to achieve SWM objectives in new construction.

Uptake of on-site SWM measures amongst property owners/managers in the business sector has slowed recently, while adoption of enhanced SWM and pollution prevention practices by builders/developers remains challenging and is negotiated on a case-by-case basis. Primary research via key informant interviews with business property owners/managers and builders/developers was undertaken to determine the reasons behind the limited uptake of SWM measures in these target business sectors.

7.3.1 Business Sector Research Methodology

Through discussions with the project team, target sectors were identified, and research objectives were developed. The objective of fifteen interviews with key informants was established with the proviso that should there be significant inconsistencies in the information collected through the interviews, supplemental interviews with additional businesses would be undertaken.

A combination of thirty (30) industrial, commercial, and institutional businesses were selected based on location (hydrology issues) and/or capacity (space and resources) to implement source controls. Twenty-one (21) of these businesses responded to the survey.

Guiding questions were developed for the key informant interviews with industrial/commercial property owners/managers, builders/developers and service providers. A copy of the guiding questions used for the business sector key informant interviews is included in **Appendix F**.

Interview summaries capturing key informants' responses were generated upon completion the interviews (a copy of the interview summaries is included in **Appendix F**). Themes or consistencies in responses were identified and noted as these are indicative of significant constraints or opportunities requiring more detailed analysis. Information collected through the leading jurisdictions best practices research and the City policy and program research were cross-referenced with the findings from the interviews with key informants in the business sector.

7.3.2 Business Research Sample

Interviews were conducted with business owners/managers in the industrial / commercial / institutional sectors. Key informants included various Waterloo institutions, developers, retailers, manufacturers, and representatives from the construction and landscaping industry.

7.3.3 Business Research Findings

Consistencies or themes in responses from key informants were identified and categorized as a constraint or opportunity. The most common constraint or hurdle to the uptake of at-source SWM practices identified by key informants across all groups was the high upfront cost and long payback period associated with such investments. The primary motivators behind environmental investments were found to be operational expenses, liabilities, environmental performance, and flooding damage, in that order. The most significant opportunity identified through interviews with key informants is the willingness to address and/or promote at-source SWM and pollution prevention, especially through Corporate Social Responsibility, provided their efforts not involve significant investments with poor returns, undermine competitiveness, create delays, or long term maintenance costs/efforts.

A more fulsome discussion of the thematic constraints and opportunities as well as a summary table of findings from the key informant interviews with the businesses is included in **Appendix F.**

7.3.4 Integrated Analysis – Business Sector

The research themes from the business sector interviews have been analyzed separately and in combination with the findings from the residential and leading jurisdictions research discussed below. Recommendations as developed as part of this strategy are based on this integrated analysis and are informed by the City's SWM-MP goals and objectives.

7.4 Residential Homeowner Research

As discussed, uptake of stormwater mitigation measures by property owners in the residential sector is slowing. To identify opportunities and constraints for on-site SWM and pollution prevention on residential properties, a research session was held on October 25, 2017 with a demographically representative sample of single-family homeowners in the City.

7.4.1 Homeowner Research Methodology

A demographic profile of single-family home-owners in the City of Waterloo was developed using a combination of Statistics Canada census data (2016). A recruitment screener was developed from the demographic profile. A recruitment screener is a series of questions asked of potential participants for the homeowner research such as age, gender, income level, education, number of children living at home, country of origin, etc., which ensures the research sample closely mirrors the demographic of single-family homeowners for the entire City. A research sample of thirty-four homeowners (n=34) were recruited for the research session. The demographic make-up of the research sample in comparison with Statistics Canada 2016 Census data for Waterloo residents and recruitment quotas for the research session are included in **Appendix F.**

Participants were provided with a blank questionnaire and a facilitator guided them through a series of more than 70 closed- and open-ended questions (Refer to **Appendix F** for a copy of the homeowner research questionnaire). Participants provided written answers to verbally asked questions within a limited timeframe. This approach ensured top-of-mind, non-rationalized responses which is critical to securing insights into the intrinsic values and beliefs of homeowner respondents. Intrinsic values are at the root of all decisions and perceptions individuals hold and therefore are the key to determining constraints and opportunities amongst similar demographic groups. Respondents are also asked to draw pictures, a right brain, creative exercise which provided quality data about homeowners' perceptions and visions for their home and home landscape.

Resident respondents also identified trusted sources of information and supplies associated with stormwater mitigation on their properties and described the meaning of terminology and program identifiers used by the City and REEP Green Solutions in communication about SWM, landscapes, salt management and pollution prevention.

Homeowner responses were entered verbatim into a database and were subsequently grouped and categorized based on similarities and consistencies (e.g., "beautiful, "pretty", "attractive", etc. would be grouped together). A copy of the Verbatim Report is included in **Appendix F**.

7.4.2 Homeowner Research Findings

Early in the questionnaire, participants were asked: "What does the City of Waterloo mean to you?" Seventy-seven percent of responses indicated that the City of Waterloo means "home, and a safe and friendly community." Respondents were asked to describe the two things they most like about living in Waterloo. Respondents identified the sense of community and the easy access to amenities as the primary things they liked about living in the City. The next answers most frequently provided by respondents were all eqally represented at 15%, taken collectively and using respondents own words, a "clean", "safe" community with "beautiful parks."

7.4.2.1 Meaning of Home and Landscape

When homeowners were asked, "what does your home mean to you", the majority respondents describe their homes as a safe, secure and peaceful place for family and friends. A number of respondents also identified their homes as their largest financial investment. Home also represents freedom and fun and a comfortable atmosphere, "where I can be me" (30%).

Respondents were asked a series of questions about their home's landscape. **The single most important motivation for homeowners regarding their home's surrounding landscape is its "curb appeal."** The home's landscape is seen as a reflection of the respondent and a source of pride. This motivation is repeated throughout the responses, including the reasons why landscape design, landscape maintenance, lawns and trees are important. Aesthetics was identified as the primary reason why lawns are important to respondents as they, "add curb appeal." Ninety percent of respondents rated lawns as important to their home landscape. Only three responses stated "lawns are not important." Trees were identified as providing many benefits: Beauty, shade, privacy, and environment. Homeowners also have "pride" in their homes and landscapes and "enjoy" them.

When homeowners were asked to rate on a scale of 1 to 10 – with 1 being low and 10 being high – the importance of landscape maintenance to their home landscape, they gave a high average rating of 8.0 out of 10. Again, was the main reason why 80% of respondents gave high rating of importance. The most important practices for maintaining the home landscape were identified by respondents as: cutting the grass (77%), weeding (35%), trimming trees and shrubs (18%), and tending gardens (18%).

7.4.2.2 Importance of Gardens, Lawns & Trees

Gardens also rated highly (8.3 out of 10) as an important aspect of these homeowners' landscapes. Eighty percent of homeowners have gardens. These homeowners identified the following three primary motivations for having gardens:

- 50% Love gardening and flowers
- 44% Beauty, looks, appearance and colour
- 25% Providing food, flowers and supporting bees

The importance of lawns to the home's landscape rated highly at 8.2 out of 10. The overwhelming reasons why respondents provided the high rating were **"looks"** and **"curb appeal".** In addition, for eighty-two percent of these homeowners, lawn comprises more than half of their home's landscape.

Respondents rated the importance of trees to the home landscape highly with a mean rating of 8.0 out of 10. While trees provide shade (56%), they also provide environmental and wildlife benefits (38%) and are also seen as an important ingredient for beautiful landscapes (29%). In addition, many people said they "like the privacy and feeling of comfort" trees provide.

7.4.2.3 Ideal Landscape & Ideal Naturescape

Homeowner respondents were asked to draw an "ideal" landscape and an "ideal Naturescape" landscape for their home. As previously identified, "Naturescape" is the name of the Region of Waterloo's water efficient landscaping program. The drawing exercise is a right brain, creative endeavor which secures data about the visual perceptions homeowners' hold. After each drawing by respondents, they were asked a number of questions regarding their "ideal landscape" and "ideal Naturescape" drawings, such as "provide up to three words to describe your drawing" and "what feelings or emotions are evoked by your drawing?"

The two types of landscapes elicited some similar responses from homeowners when asked to identify the most important elements or aspects of both landscapes, as indicated below:

- Trees (their beauty and shade) are seen as the most important element for the ideal landscape (50%) and Naturescape (60%).
- Flowers and colour are the second most important element for ideal landscapes (47%), while a variety of flowers and plants, including native plants are chosen for the Naturescape (53%).
- Clean, weed-free grass is the third response (29%) for ideal landscapes, while stone and rock, water features, native plants, tall grasses and mulch (in other words a variety of natural design elements) are important aspects for Naturescapes, collectively totalling 65% of responses.

The feelings and emotions evoked by homeowners' drawings of their ideal front yard landscape and Naturescape have some overlap and some significant differences. Homeowners feel relaxed and calm about both types of front yards, but the Naturescape evokes two times the frequency of this emotion (76% versus 38%), while the ideal landscape evokes twice the incidence of feelings of happiness (35% versus 18%) and beauty (21% versus 9%). And, there are a number of emotions and feelings evoked by their ideal landscape – pride, neat and tidy, comfort, colour, and satisfaction – that are not mentioned for Naturescapes. Instead, the Naturescape drawings evoke "good feelings about clean air and a healthy, natural landscape" (44%). However, a quarter of the emotions expressed by respondents regarding Naturescapes are negative: "sadness", "lazy", "ugly", "cold", and "disorganized".

Homeowners were asked "what constraints or reasons might prevent you from having an ideal front yard landscape or Naturescape?" Lack of money and time, and not having enough space or design knowledge were the primary constraints for both types of front yard landscapes.

Respondents were provided with three sets of photos: four front yard landscapes, four flower/rain gardens, and four drainage options (research photos are included in **Appendix F**). They were asked to consider the images in the photos and then to rank them on a scale of 1 to 10, with 1 being low and 10 being high. They were subsequently asked to provide reasons for the lowest and highest ratings they gave for each set of photos.

For the front yard landscape, the highest-ranking image was described as clean and tidy (47%), it looks good (21%), and it has nice trees (18%), lawn (9%) and flowers (12%). Respondents articulated significantly negative views of the other three pictures, such as looks messy and wild, too busy, unkempt, too crowded, cluttered, ugly, no grass, no curb appeal, stark and chaotic.

For the images of gardens, residents preferred one image over the others since it had: balance of design elements, attractive, clean and tidy, colour and easy to maintain. The negatives responses given by homeowners for the remaining three pictures include: ugly, crowded, not enough variety or colour, too busy, and cluttered.

For the drainage and downspouts photographs, none of them rated highly and were all grouped in the middle of the pack (5.8 to 7.0). The picture of the rain barrel was rated slightly higher because it was somewhat hidden and reflected reuse of rainwater. On the negative side, the rain barrel is an "eye sore", provides no benefit to the grass or garden, and the water will have to be used.

The pattern in the responses indicates that images that look "clean with appealing designs" rated the highest. The lower rated images are those identified by respondents as "messy, ugly, or crowded."

Keeping in mind the importance of friends and neighbours to homeowner respondents, and the strong connection they have to their neighbourhoods as a "safe place for their family and children", one should consider the links between aesthetic motivations and family, friends and neighbours. Considering these personnel connections of homeowners coupled with both their strong preference for traditional landscape design and tendency to seek landscape and garden design advice from their *friends, neighbours* and *family*, one can appreciate how homeowners would self-reinforce their current home landscape aesthetic. Nevertheless, this relationship in residents' motivations for aesthetically beautiful landscapes and their trust of friends, neighbours and family when seeking landscape and garden design advice represents an opportunity for using peer assimilation or belonging as a motivator for change. The tendency to conform to neighbour and friends can serve as a barrier to transitional and sustainable landscapes, but positioned correctly, this same tendency to conform can be a driver for uptake of sustainable residential landscapes.

7.4.2.4 Understanding Terminology

A number stormwater related terms (watershed, City of Waterloo Stormwater Utility, Stormwater Credit, and rain garden) were presented to the homeowners and they were asked what the terms meant to them. Most of the terms were not known by the homeowners, and the most frequent response was "no answer."

7.4.3 Constraints and Opportunities: Single-Family Homeowners

An analysis of the results from the market research with single-family homeowners identified constraints and opportunities associated with residents' willingness or inclination to adopt lot-level stormwater control Best Management Practices (BMPs). Themes, as evidenced by the high consistency in responses amongst homeowners, emerged from the research and are summarized based on their influence as a constraint or an opportunity in **Table 7.2.**

Table 7.2: Constraint & Opportunity Themes: Single-Family Homeowners

THEMES	
CONSTRAINTS	Residential information and education-based outreach has not resonated with homeowners.
	Homeowners have a deeply held aesthetic of a beautiful home landscape that is entrenched and does not include rain gardens, permeable driveways, cisterns or rain barrels.
	Investment in landscaping improvement projects is limited to projects under $5,000 with only 3/34 homeowners investing more than that amount in the past five years.
	Region of Waterloo's "Naturescape" water efficient landscaping program is not well recognized by homeowners in Waterloo.
	Although homeowners hold a positive view of a Naturescape landscape, their view runs contrary to the intent of the program.
	Homeowner respondents have little or no understanding of the term "watershed".
	Ninety-one percent (91%) of respondents could not accurately answer the question; "*What is a rain garden*?"
	Images (rain gardens) and wording used on City and REEP Green Solutions web sites to communicate information about SWM to residents do not resonate with the intended audience.
THEMES	
OPPORTUNITIES	The City of Waterloo and the community it represents, and homeowners' neighbourhoods are very important to respondents.
	Homeowners are highly motivated to have beautiful landscapes and are willing to invest in them.
	Homeowners seek and trust advice about their landscape design from "friends" and "neighbours" (38%), the Internet (35%), garden centres (24%), and family (21%).
	Majority of homeowners purchase plants from nurseries (59%) and garden centres (18%)
	The front yard image and garden image rated the highest by homeowners, although traditional in their design, include the potential for rain gardens and measures to enhance the infiltration of stormwater.
	The highest rated downspout/drainage image by homeowner respondents depict a rain barrel mostly concealed by garden.

7.4.4 Integrated Analysis – Residential Homeowners

Constraint and opportunity themes or consistencies found through the research with single-family homeowners are indicative of priority areas of focus for this strategy. As discussed, integrated analysis of the findings from research with homeowners and key informants in the business sector,

and on-line research of leading jurisdictions informed the development of the recommendations in this strategy.

7.5 Leading Jurisdictions

Research into leading jurisdictions with successful initiatives to drive uptake of on-site SWM measures by private property owners identified several best practices for consideration for future SWM programming by the City.

A complete summary of leading jurisdictions research can be found within the report entitled "*Leading Jurisdictions Summary* (January 2019)" within **Appendix F.** The best practices outlined in **Table 7.3** have been selected for inclusion in this strategy as they address specific constraints or capitalize on specific opportunities identified through the primary market research. It is important to note that stormwater credits or 'feebates' alone are not sufficient to drive uptake of at-source SWM on private property. Even where the credits have been in excess of 90%, such as Philadelphia, uptake is low (single digit or lower participation). In the case of Philadelphia, the low uptake was a key reason for the implementation of a grant program available to ICI property owners for the implementation of stormwater measures.

Table 7.3: Applicable SWM Best Practices

LEADING JURISDICTION	BEST PRACTICE DESCRIPTION
York & Peel Regions, ON	**Market-based Incentive program for alternative "Fusion" Landscapes**: • Implemented a landscape designer/contactor incentive and training & certification program in co-operation with Landscape Ontario (LO) – the professional association representing the landscaping industry – for the designing and installing fusion landscapes. • The goal of the Fusion Landscaping program is to drive uptake of SWM measures, including rain gardens, bioswales, and increased permeable area, and the use of water efficient designs via the landscaping industry.
Philadelphia, PA	**Green Acre Retrofit Program (GARP):** • Provision of grants to contractors, companies or project "aggregators" who can build large-scale stormwater retrofit projects across multiple properties. • The intent of GARP is "to reduce the price for qualified non-residential PWD [Philadelphia Water Department] customers and contractors to design and install stormwater best management practices". **Community Engagement** • Provision of grants to Philadelphia-based non-profit organizations to engage citizen participation in the management of green infrastructure.
Portland, OR	**Green Street Policy & Program:** • A program requiring infrastructure projects in the right-of-way to incorporate green street facilities into all City funded development, re-development or enhancements. • Any City of Portland funded development, redevelopment or enhancement project, that "does not trigger the Stormwater Manual but requires a street opening permit or occurs in the right of way", pays into a "% for Green" street fund. The amount is 1% of the construction costs for the project.
New York City, NY	**Green Roof Policy and Tax Abatement** • NYC offered a property tax abatement to building owners to install green roofs. The one-time abatement was initially \$4.50/ft^2 but then in 2013 was increased to \$5.23/ft^2 and is limited to the lesser of \$200,000 or the building's annual tax. The program was suspended in 2018; the size of the tax abatement was too low to achieve desired uptake rates.
Onondaga County, Syracuse, NY	**Save the Rain Green Improvement Fund** • Grant funding offers assistance to applicants installing GI technologies as an aspect of the development, redevelopment, and/or retrofitting of certain classes of privately-owned properties (commercial, business, and not-for-profit owned properties) in specific geographical locations.

7.5.1 Leading Jurisdictions: Applicable Generic Best Practices

Given the constraints and opportunities identified through the primary market research, best practices not directly tied to SWM, but with potential to advance SWM in the City of Waterloo, were identified and are summarized in **Table 7.4.**

Table 7.4: Applicable Non-SWM Best Practices

JURISDICTION(S)	BEST PRACTICE DESCRIPTION
Chicago, IL	City Works Global Hub for Urban Infrastructure: • The prime focus of this hub is the use of information technology (IT) to advance the state of urban infrastructure with emphasis on energy conservation and GHG emissions reduction via transportation and building innovations
Melbourne, AU Minneapolis, MO Halifax, NS	Integrated Water Management Planning: • Several leading jurisdictions and agencies are employing and/or recommending whole system water management or *Integrated Water Resource Management* (IWRM) planning processes that consider impacts of given measures across water management portfolios. • This approach addresses a major challenge in water management; 'siloization' and provides the basis to deliver integrated water management programming.
San Francisco, CA Berkeley, CA Seattle, WA Chicago, IL Boston, MA	Green Permitting: • Green building/permitting programs in leading jurisdictions are part of municipal-level sustainable growth plans and address individual new green building/development projects, eco-neighbourhoods or districts, brown field and re-development projects and cover both the residential and commercial construction sectors.
Sydney, AU	Performance Indicators & Scorecard: • Sydney Water has produced an integrated Annual Report using a sustainability reporting framework. The utility's Sustainability Scorecard reports on corporate performance measured against sustainability indicators.

7.5.2 Integrated Analysis – Leading Jurisdiction

The leading jurisdictions research has been analyzed in conjunction with the findings from both the homeowner and business sector key informant research with consideration of the City's and related third party SWM policies and programs. Based on this analysis, recommendations for policies, programs and initiatives to drive uptake of at-source/on-site SWM practices and measures have been developed.

7.6 Summary & Recommendations

Creating a "made in Waterloo" market-strategy to generate uptake of at-source SWM and pollution prevention practices and measures by residential and industrial/commercial property owners, and enhanced SWM best practices in new development and re-development projects was a goal of the market research. Governance, programming, policy, economic, joint venture, and metrics and reporting recommendations have been developed based on the findings from the research and an analysis of potential options applicable to the City stormwater utility model and the achievement of the City's ambitious SWM-MP objectives.

The City of Waterloo has taken a progressive approach to SWM programming. This market-strategy continues this progressive approach and positions the City as a leader and innovator in stormwater management.

For ease of reference, recommendations are divided into the following three categories: Governance & Administration, Municipal Functions & Operations, and Market-based Programming. The following provides a summary of the recommendations. A detailed discussion of the recommendations summarized below is included in **Appendix F.**

Governance & Administration:

- As SWM program moves forward with the SWM-MP, it is recommended that the City undertake an IWM planning process to develop implementation plans.
- It is recommended that the City apply a market-based approach to planning and decision-making processes pertaining to, or impacting, SWM practices by private property owners.
- It is recommended the City, in conjunction with the City of Kitchener, Region of Waterloo and the Grand River Conservation Authority (GRCA), establish an IWM Steering Committee and /or utilize the existing Grand River Water Management Plan working groups.
- It is recommended that a Water Innovation Hub be established with the City of Kitchener or that the City participate in existing 'Hubs".

Municipal Functions & Operations:

- It is recommended that the City review the current stormwater utility fee structure and evaluate the potential to modify the structure for non-residential and multi-residential property owners.
- It is recommended that the City establish incentive and administrative mechanisms to enable the aggregation of non-residential and multi-residential privately-owned properties for a SWM utility credit.
- Based on the results of the market-based research, it is recommended that the City evaluate the opportunity to determine the appropriateness of a variety of incentives and programs to support and service those interested in improving stormwater management on their non–residential properties. Approaches such as various: financing options, 'bonusing' strategies, review enhancements, and service charge reductions will be evaluated and appropriate methods should be considered as part of the SWM-MP Implementation Plan. Various financing approaches are detailed in the "Innovative Financing Approaches for Municipal Stormwater Management" memorandum included as **Appendix F4**.
- It is recommended the City establish a SWM infrastructure right-of-way policy and program.
- It is recommended that the City utilize neighbourhood design charrettes at the earliest possible stage of planning for SWM in the municipal ROW and public parks. Note: As part of the residential research, were asked to describe the two things they most like about living in Waterloo, and responded with "easy access to amenities" and "beautiful parks". Early and on-going participation of residents in the design and planning of SWM projects on public lands results in projects that reflect the values and aesthetics of local neighbourhoods and builds support amongst area residents and businesses.

- It is recommended the City implement a SWM reporting framework involving a performance indicators and scorecard management mechanism.

Market-Based Programming

- It is recommended that City staff responsible for SWM investigate the opportunity for strategic joint ventures with the Region and energy utilities to deliver a comprehensive energy-water-stormwater demand side management (DSM) program.
- It is recommended the City establish a service provider incentive program for landscape design and/or installation contractors.
- It is recommended that the City undertake a targeted promotional initiative to re-position SWM and SWM-related programming in the marketplace.
- It is recommended that City SWM staff undertake a marketing and promotional initiative targeting single detached dwellings and focused on transitional landscapes for lot-level SWM.

8 Conveyance Controls & the Municipal ROW

In order investigate the opportunities and constraints of ROW retrofits and determine an integration strategy within the City of Waterloo, two technical reports have been prepared in support of the SWM-MP. These technical reports are included within the SWM-MP appendices and are summarized in the following sections and include:

- **"SWM-MP Municipal Class EA - Municipal ROW (Conveyance Control) Retrofit Assessment Opportunities Report (December 2018)" (Appendix G)**
- **"SWM-MP Municipal Class EA – Stormwater Infiltration Policy Recommendations (June 2018)" (Appendix H)**

The main deliverables of these reports were to identify site specific opportunities, constraints, and approaches to infiltration and a list of preferred retrofit alternatives and retrofit costs for all road reconstruction projects identified in the City's capital works schedule (2019-2025).

The following section summarizes the policy considerations, decision framework, integration with municipal programs, and opportunities associated with conveyance controls within Waterloo's municipal ROWs. A more detailed analysis including process charts for each road-type found within the City can be found in **Appendix G**.

8.1 Background

Targeting roads for municipal SWM improvements is an important method of mitigating the stormwater impact of urban development. The incorporation of a cost-effective ROW retrofit approach using a combination of traditional SWM controls (OGS and proprietary stormwater treatment devices) and Low Impact Development (LID) approaches as part of road reconstruction and resurfacing projects presents a significant opportunity to improve SWM control (water quality, water quantity, erosion mitigation, water balance).

ROW retrofits using traditional SWM controls and LID has the ability to most significantly improve stormwater quality by reducing the pollutant loading from uncontrolled urban catchments because of the large volume of sediment and other pollutants that wash off of these surfaces on an annual basis, as well reducing runoff volumes and reducing thermal impacts to receiving waters. In addition, ROW retrofits have the added benefit of providing an opportunity to enhance street aesthetics, mitigate and adapt to climate change and reduce heat island effects.

8.2 Policy Considerations & Decision Framework

To protect local groundwater resources from contamination, constraints have been placed on the use of infiltration-based practices to treat runoff from road ROWs within Issue Contributing Areas (ICAs) and Wellhead Protection Areas (WHPAs). Based on the Infiltration Policies, the permitted use of infiltration-based practices relates directly to the City of Waterloo's road classification system. The City of Waterloo's road classification system identifies the following road categories based on vehicle traffic counts:

1. **Local Roads:** Includes all Alleyways/Laneways, Cul-de-Sacs, and Local Streets.
2. **Minor Roads:** Includes less frequently used collector roads. Examples are Regina Street and Marshall Street.
3. **Major Roads:** Includes frequently used collector roads and all arterial roads. Examples are Albert Street (Collector), Lincoln Road (Collector), Keats Way (Collector), Columbia Street (Arterial), and University Avenue East (Arterial).

The proposed ROW cross-section also plays a significant role in determining what type of LID practice can be most efficiently implemented during the reconstruction project. Cross-section can be "rural" or "urban"

- **Urban cross-sections** typically include curbs, gutters, catch-basins and storm sewers.
- **Rural cross-sections** typically do not have curbs, gutters, catch-basins storm sewers and instead rely on roadside swales or ditches for conveyance of runoff. Alternatively, rural cross-sections can also have an informal edge of pavement and shoulder without a designed conveyance system.

The permitted use of infiltration practices within the municipal ROW is dependent on whether the potential infiltration practice location is within a Wellhead Protection Area (WHPA), the Adjusted Vulnerability Rating of the WHPA within the project area, and/or whether the potential infiltration practice location is within an Issue Contributing Area (ICA).

8.2.1 Wellhead Protection Areas

WHPAs have been designated around all municipal wells by the Drinking Water Source Protection Assessment Reports. Vulnerability scores have been established within WHPAs based on technical analysis to support the Drinking Water Source Protection Plan. Travel times to the wellhead from areas with vulnerability scores of 8 or greater are short and it is within the best interest of the City of Waterloo to avoid the implementation of infiltration practices from paved surfaces within these areas in order to protect drinking water sources. While some infiltration is acceptable within WHPAs having vulnerability scores less than 8, the infiltration of runoff from roads that are heavily salted should be avoided in these areas in order to protect local drinking water sources. WHPAs and adjusted vulnerability scores are shown on **Figure 8.1.**

- Where the Adjusted Vulnerability Rating is 8 to 10, infiltration practices are not recommended for any road-type.
- Within a WHPA where there the Adjusted Vulnerability Rating is less than 8 (i.e. the Vulnerability Rating is 2 to 6, inclusive), infiltration practices are recommended for Local Roads only.

Outside of the WHPAs, infiltration practices are recommended for Local Roads and Minor Roads. These practices are only recommended for Major Roads provided a project specific Groundwater Impact Analysis study is undertaken to demonstrate that groundwater contamination (especially from salt loading) is minimal, not likely, or can be mitigated.

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MUNICIPAL CLASS EA STORMWATER MANAGMENT MASTER PLAN

FIGURE 8.1
STORMWATER INFILTRATION CONSTRAINTS

- Watercourses
- Roads
- Water Bodies
- Waterloo Boundary
- Issue Contributing Area - Chloride / Sodium / TCE
- WHPA Vulnerability Score 8 - 10
- WHPA Vulnerability Score 2 - 6.3
- Intake Protection Zone 3

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

8.2.2 Issue Contributing Areas

ICAs have been developed in response to the identified issues for each well or well field within the City of Waterloo. The corresponding ICAs are illustrated in **Figure 8.1**.

Per the **SWM-MP Municipal Class EA – Stormwater Infiltration Policy Recommendations (June 2018) (Appendix H)**, to avoid contamination from road de-icers, runoff from all road segments within ICAs should not be conveyed to infiltration practices. This prohibition includes the use of flexible liners and or gated/ closeable inlets to prevent infiltration of runoff due to the potential for punctures and or winter by-pass, respectively. Should 'permanent' or 'hardened' impermeable closed bottom structures (i.e. plastic or concrete tanks, vaults, or chambers) be proposed, explicit approval from the Region of Waterloo shall be obtained. Note: a formal approval process in this regard has not been established, as such, consultation is required.

One exception for roads within ICAs is for local roads with existing rural-cross-sections. These roads already contribute to chloride loading (though significantly less than minor and major roads per unit length) and it is unlikely that directing runoff from existing grassed ditches to infiltration practices will exacerbate the issue or increase the threat, provided:

a) The proposed infiltration facility footprint is no larger than the existing ditch footprint and dead storage (storage below the invert) is not incorporated into the design;

or

b) The proposed annual infiltration volume is not increased as compared to the existing condition (ditch) annual infiltration volume based on the characterization of the limiting in-situ native soils (i.e. infiltration rate(s) per the LID SWM Planning and Design Guide (https://wiki.sustainabletechnologies.ca).

The infiltration policy is summarized in **Table 4.1** of **Appendix H.** Runoff from road segments that service high risk activities, especially those where spills of hazardous materials are more likely, should include a spill capture plan and/or structures, or should not be conveyed to infiltration practices.

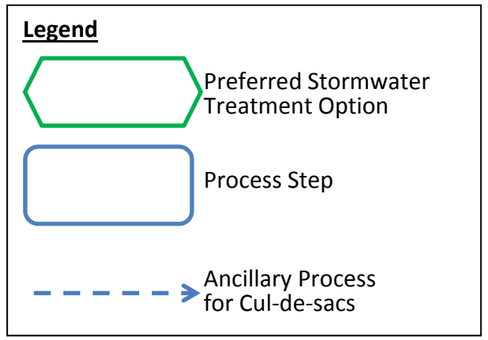
8.2.3 ROW Retrofit Decision Process

For each road type, a retrofit decision processes has been developed. These processes take a hierarchical approach, first considering infiltration policy screening before using the proposed cross-section type and physical characteristics of the proposed ROW to determine the preferred retrofit alternative. Factors that play a role in the decision process include the need for lane reduction, traffic calming and on-street parking, as well as the aesthetic and maintenance preferences of the designer.

Due to the highly customizable nature of the proposed retrofit practices (conventional and LID), many of the ROWs have more than one feasible option. In these cases, options were selected based on overall integration into the existing neighbourhood aesthetic.

An example of the decision process for Local Roads is presented in **Figure 8.2**. The decision processes for other road-types can be found in **Appendix G**. It should be noted that prior to detailed design, pre-design activities such as infiltration testing, geotechnical and groundwater investigations are typically required as detailed in the Grey to Green Road Retrofit Guide (CVC, 2013) and the LID SWM Planning and Design Guide (https://wiki.sustainabletechnologies.ca).

Figure 8.2: Local Road Retrofit Decision Making Process



Infiltration Policy Screening

STEP 1: Inside WHPA with a Vulnerability Score ≥ 8 ?

Yes → **Infiltration Not Permitted** → **Proprietary Stormwater Quality Treatment Device**

No → **STEP 2:** Inside Issue Contributing Area?

Yes → **Step 3:** Existing Rural Cross-Section?

No → Go to **Step 5**

Yes → **Step 4:** Can condition 5.1.1a) or 5.1.1b) can be met ? (See **Note 1**)

No → **Infiltration Not Permitted** → **Proprietary Stormwater Quality Treatment Device** → Oil Grit Separators / Media Filtration / Membrane Filtration

Yes → **Step 5:** Proposed Road to be Rural Cross-Section (Ditches)?

No → **Infiltration Not Permitted** → **Proprietary Stormwater Quality Treatment Device** → Oil Grit Separators / Media Filtration / Membrane Filtration

Oil Grit Separators

Media Filtration

Membrane Filtration

NOTE 1) ***5.1.1 Local Rural Cross-section Roads within ICAs – Exemption***

Local roads with existing rural-cross-sections already contribute to chloride loading (though significantly less than minor and major roads per unit length) and it is unlikely that directing runoff from existing grassed ditches to infiltration practices will exacerbate the issue or increase the threat, provided:

a) The proposed infiltration facility footprint is no larger than the existing ditch footprint;

or

b) The proposed annual infiltration volume is not increased as compared to the existing condition (ditch) annual infiltration volume based on the characterization of the limiting in-situ native soils (i.e. infiltration rate(s) per the LID Stormwater Planning and Design Guide (2010 V1.0 or most recent).

Proposed Rural Cross-Section

Yes → **Step 6A:** Shallow ditch profiles prefered?

Yes → **Step 7A:** Are Vegetated Streetscapes (Flowering Perennials and Shrubs) desired and can Maintenance of Plantings be provided?

Yes → **Bioswales**

No → **Low Maintenance Bioswales (Turf or stone mulch)**

No → **Enhanced Swale**

Bioswale

Low Maintenance Bioswale

Enhanced Swale

Proposed Urban Cross-Section

No → **Step 6B:** Are boulevard areas ≥ 3 meters without significant mature tree growth?

Cul-de-sac → **Island Bioretention**

Yes → **Step 7B:** Are Lane Reductions, Traffic Calming, or Onstreet Parking planned or desired?

LIDs in Boulevard

Yes → **Step 8A:** Are Vegetated Streetscapes (Flowering Perennials and Shrubs) desired and can Maintenance of Plantings be provided?

Yes → **Boulevard Bioretention** or **Bioretention Bump Outs** or **Bioswales**

No → **Permeable Pavement Parking Laybys** or **Perforated Pipe**

No → **Step 8B:** Are Vegetated Streetscapes (Flowering Perennials and Shrubs) desired and can Maintenance of Plantings be provided?

Yes → **Boulevard Bioretention** or **Bioswales**

No → **Perforated Pipe**

Boulevard Bioretention

Low Maintenance Bioswale

Bioswale

LIDs in Roadway

No → **Step 7C:** Are Lane Reductions, Traffic Calming, or Onstreet Parking planned or desired?

Yes → **Step 8C:** Are Vegetated Streetscapes (Flowering Perennials and Shrubs) desired and can Maintenance of Plantings be provided?

Yes → **Bioretention Bump Outs**

No → **Permeable Pavement Parking Laybys** or **Perforated Pipe**

No → **Perforated Pipe**

Permeable Parking Layby

Perforated Pipe

Bioretention Bump Out

8.3 Integration with Municipal Programs

Public transportation, active transportation, and the urban forest are all components of the municipal ROW. Road reconstruction projects, including those that incorporate LID features into the ROW, should be designed with consideration of these systems.

8.3.1 Public Transportation

Public transit within the City of Waterloo is a regional responsibility and is provided by Grand River Transit (GRT). Due to the flexible nature of conveyance control measures, they can be integrated with transportation infrastructure during the design phase. These may include permeable pavements, bioretention, bioswales etc. A series of examples where conveyance control measures have been integrated into Public Transit projects are depicted below.

Left to Right: Bioswale are part of a surface LRT, Bioretention Planters as are part of a surface LRT and bioretention bump outs as part of bus lay-bys

8.3.2 Active Transportation

Active transportation tends to focus on a reduced demand for car use in favour of alternative modes of travel, especially walking and cycling within the municipal right-of-way. The development of a city-wide active transportation network has gained momentum as a result of the development of the City's Transportation Master Plan. While active transportation components such as bikes lanes are competing for the same space within the ROW as conveyance control features, there are several ways that LID practices can be integrated into active transportation systems, these include:

- Using permeable pavement for sidewalks, multi-use pathways, trails and to distinguish on-road bikeways from driving lanes
- Using bioretention units or bioswales to create a separation between on-road bikeways and driving lanes
- Enhancing pedestrian features with highly aesthetic vegetated LID facilities.

8.3.3 Urban Forestry

Trees provide many benefits to communities, such as improving water quality, reducing stormwater runoff, lowering summer temperatures, reducing energy use in buildings, reducing air pollution, enhancing property values, improving human health, and providing wildlife habitat and aesthetic benefits. It is recommended that where possible, road retrofits maintain or improve the long-term sustainability of the City of Waterloo's tree canopy. This can be done by avoiding disturbance to the

critical root zone of mature trees during ROW projects and encouraging the planting of trees within the ROW in neighbourhoods with a canopy deficit. Where a need is identified it is recommended that the LID design be modified to include the ability for tree plantings during construction or in the future as part of City initiatives.

8.4 ROW Opportunities

During 2018 field investigations were conducted on 52 roads. All roads investigated were identified as being slated for road reconstruction between 2019 and 2030 based on the City of Waterloo's Capital Forecast as provided by the Infrastructure Services Department. Of these 52 roads:

- 35 are local roads,
- 6 are minor collectors,
- 2 are city arterials,
- 7 are regional arterials, and
- 2 are major collectors.

The field investigations were conducted to develop a comprehensive understanding of the function of adjoining land uses and nearby human activity as well as to confirm the results of the background review, determine the technical feasibility of implementing LID practices within the ROW, and identify and confirm any existing constraints or opportunities.

For each of the following ROW types, a decision was used to determine a preferred alternative(s) based on policy and desired roadway characteristics:

- Local Roads
- Minor Roads
- Major Roads
- Laneways
- Sidewalks

Preferred alternatives include Bioretention Bump Outs (curb extensions), Boulevard Bioretention, Bioretention Planters, Bioswales, Perforated Pipe, Permeable Pavement and Proprietary Stormwater Quality Treatment Devices. **Tables 8.1-8.8** of **Appendix G** identify the preferred alternatives and associated cost for each of the roads slated for road reconstruction between 2019 and 2025, including over target projects, based on the City of Waterloo's Capital Forecast.

8.5 Summary & Recommendations

Targeting roads for municipal stormwater management (SWM) improvement is an important method of improving municipal SWM practices and the percentage of the urban area that currently has SWM control. Recommendations within the **SWM-MP Municipal Class - Municipal ROW (Conveyance Control) Retrofit Assessment Opportunities Report (December 2018)** include:

1. Update municipal road cross-section drawings as well as relevant sections in the Development Manual to reflect LID opportunities as identified in this report;

2. Investigate whether access agreements with other utilities (i.e., Bell, Rogers, etc.) may need to be altered to ensure that the installed LIDs are restored or consider implementing enhanced road cut permits which include rectification bonds.

3. Ensure proper oversight during construction and warranty periods by trained and experienced professionals in LID design and construction.

4. Establish a maintenance period for all ROW LID in the context of standard City of Waterloo tender and special provisions, specifically the requirement for extended contractor maintenance periods and enhanced guarantees;

5. Proceed with 'multiple objectives' at the detailed design stage for each capital roads project such that the project can incorporate new SWM infrastructure to achieve SWM objectives as well as achieving objectives relating to Urban Forestry, transit, cycling, trails etc.

9 Stormwater Management Facilities (End-of-Pipe Controls)

Stormwater management (SWM) facilities are an important component of the City of Waterloo's current stormwater assets. The management of existing facilities and the construction of new SWM facilities remains a central course of action to ensure stormwater infrastructure maintain their effectiveness and that pollutants are prevented from impacting the environment.

In order to assess sediment accumulation within existing SWM facilities and identify opportunities for new SWM facilities a series of two (2) technical reports have been prepared in support of the SWM-MP. These technical reports are included within the SWM-MP appendices and are summarized in the following sections and include:

- **SWM-MP Municipal Class EA - Sediment Analysis Memo: SWM Facilities and OGS Units (April 2019) (Appendix D)**
- **SWM-MP Municipal Class EA - End-of-Pipe SWM Facility Opportunities Report (May 2019 (Appendix I)**

Based on the analysis undertaken in the above reports and described in **Sections 9.1** through **9.3**, there are four (4) general approaches to improving the City of Waterloo's end-of-pipe stormwater treatment network, these are:

1. Retrofit existing ponds (previously identified retrofits and those identified in this report) to improve water quality treatment where feasible.
2. Remove sediment from existing facilities that have water quality and water quality control significantly impacted by sediment accumulation.
3. Construct new SWM facilities in urban areas of opportunity which are typically associated with public parks and trails.
4. Enhance SWM catchment areas with conveyance and source controls to mitigate the impact of infill development and intensification on existing end-of-pipe facilities and the natural environment.

Note: the management of Sediment within City owned OGS unit is discussed in **Section 6.1.**

9.1 Sediment Removals for Ponds

In order to understand the impact of sediment accumulation within City of Waterloo SWM facilities a report titled "**SWM-MP Municipal Class EA - Sediment Analysis Memo: SWM Facilities and OGS Units (April 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix D.**

The following section describes and summarizes the condition and maintenance priorities of SWM facilities including Wet Facilities, Dry Facilities and Wetlands within the City of Waterloo.

The SWM-MP explored approaches to manage pollutants and sediment within the City's SWM facilities in the most cost-effective manner. The following study and resulting recommended works have been completed following Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved.

9.1.1 Problem Identification

In order to ensure long-term operational effectiveness of SWM facilities, it is crucial to remove accumulated sediment periodically per the conditions of the respective MECP Environmental Compliance Approval (ECA). The maintenance frequency depends on several aspects, such as type of facility, design storage volume, characteristics of the catchment area and municipal practices. Sediment accumulation compromises the effective storage volume and the long-term efficiency of suspended solids retention.

There are a total of 59 active SWM facilities owned and operated by the City of Waterloo, including 45 wet pond facilities and 14 dry pond facilities. Both wet and dry ponds accumulate sediment, which reduce the capacity of the facility. **Figure 4.8** identifies all SWM facilities in the City of Waterloo.

9.1.2 Sources of Information

The City of Waterloo provided digital copies of the original design briefs and drawings corresponding to most of the existing SWM Facilities. Full GIS mapping and data was also provided by the City of Waterloo. Supplemental reports reviewed and included as part of this study included:

- City of Waterloo Stormwater Management Facility Assessment (Ecosystem Recovery, 2015)
- City of Waterloo Stormwater Management Facility Assessment – Fifteen Facilities (Ecosystem Recovery, 2017)

The above studies, addressed forty-six (46) SWM facilities, examining their existing operational conditions. This information was used to determine the current capacity of each of these ponds and the corresponding maintenance requirements. Four (4) ponds (35, 46, 47, and 59) were not inspected in 2015 or 2016; these ponds should be surveyed and inspected to confirm their current condition. In cases where information such as control type of the facility, level of protection, drainage area, impervious area and storage volumes were undefined or unclear, data gaps were covered with data gathered using GIS or other studies.

9.1.3 SWM Facility Analysis Methodology

The methodology applied as part of this study was designed to determine the effect of sediment accumulation in City owned and operated SWM facilities. The SWM facilities were grouped according to the facility type. In order to calculate the sediment accumulation within SWM facilities, an analysis of the volumetric stage-storage profile of each facility was required. All facilities not containing a permanent pool were categorized as dry facilities. This classification was selected in order to remove uncertainty relating to changes in facility type over time (i.e. facilities that were

designed as dry ponds which now appear and have been inappropriately classified as wetlands. It is likely that these facilities are retaining water due to clogging of outlets due to sedimentation or have been misclassified due to the associated colonization by wetland species).

Wet Facilities are defined as those facilities with a permanent pool (per the original design brief), which includes wetlands. Dry facilities are defined as facilities without a permanent pool. The primary purpose of wet facilities is sediment retention.

Dry ponds were analyzed based on the loss of storage capacity, whereas the wet facilities were evaluated based on the drop-in sediment removal efficiency in accordance with the provincial guidelines. This approach aims to identify which facilities currently operate under inappropriate conditions.

As part of this analysis, the following should be noted:

- Nine (9) facilities were recently cleaned-out or retrofit. These facilities were excluded from the analysis. Additional detail can be found in **Appendix D.**
- Six (6) facilities are currently scheduled for full or partial retrofit. These were also excluded from this analysis but are discussed in **Section 9.2**. Additional detail can be found in **Appendix D.**
- Twelve (12) dry facilities were identified as providing mainly quantity control. In some cases, these facilities also provided an extended detention volume for quality control purposes.
- Twenty-four (24) wet facilities were identified as providing both quality and quantity control (1 provides only quality control and three provide only quantity control), however fourteen (14) of them currently exceed the maximum allowable sediment accumulation as per Sustainable Technologies Evaluation Program (STEP) Inspection and Maintenance Guide for Stormwater Management Ponds and Constructed Wetlands. In many cases, the permanent pool is almost or completely full of sediment, directly affecting the effectiveness of the facility in terms of water quality.
- Facility 47 was removed from analysis due to insufficient data
- Facilities 21 and 64 were removed from analysis due to their tiered drainage system.

9.1.3.1 Dry SWM Facilities

All facilities not containing a permanent pool were categorized as dry facilities and providing mainly quantity control, although some of these are described as also providing quality control due to the inclusion of extended detention storage in the original design. Since the main purpose of these facilities is not the retention of sediment, the effect of sediment accumulation was determined in terms of loss of total storage capacity, calculated as shown in **Equation 2.**

$$\textbf{\textit{Storage Loss}}\ (\%) = \frac{\textbf{\textit{Volume of Sediment in 2015}}\ (m^3)}{\textbf{\textit{Total Storage Capacity}}\ (m^3)} . \mathbf{100} \qquad \textbf{(2)}$$

In some cases, the design brief reports did not present sufficient information to base the study solely on original data. For these facilities, GIS data had to be introduced so that the calculations could be conducted. Similarly, sediment loads had to be estimated for the facilities that did not have sediment data from the studies by Ecosystem Recovery in 2015 and 2017. **Table 9.1** consists of a summary of the dry SWM facility conditions, including the ranking criteria utilized in **Appendix D**.

Table 9.1: Dry SWM Facilities Summary

Number of dry SWM facilities analyzed	12
Number of dry SWM facilities with no loss in storage	1
Number of dry SWM facilities with loss in storage	11
1% - 5% loss (small loss)	9
6% - 10% loss (moderate loss) (Low Priority)	1
11% - 20% loss (large loss) (Moderate Priority)	1
>20% loss (extreme loss) (High Priority)	0

9.1.3.2 Dry Facility Results

Table 9.2 present the results of the sediment analysis for existing dry SWM facilities, including a priority ranking for maintenance. In addition, **Table 9.2** also notes those dry facilities which are recommended for retrofit.

Table 9.2: Dry SWM Facilities Sediment Analysis and Maintenance Requirements

SWM Facility #	Year of Construction	Type of Facility	Storage Capacity (m^3)	Volume of Sediment in 2016 (m^3)	Decrease in Storage Capacity	Maintenance Priority
36	1988	Dry Pond	3,800	Vegetation	2%	High Priority
8*	1991	Dry Pond	13,900	Vegetation	2%	High Priority*
16	1994	Dry Pond	1,231	75	7%	Moderate Priority
22	1997	Dry Pond	61	0	12%	Low Priority
13	1995	Dry Pond	2,501	95	5%	Low Priority
18*	1986	Dry Pond	12,660	8	3%	Low Priority*
6	2014	Dry Pond	8,867	0	3%	Low Priority
2*	1987	Dry Pond	7,000	0	3%	Low Priority*
32	1992	Dry Pond	2,400	19	2%	Low Priority
26	1989	Dry Pond	4,700	0	2%	Low Priority
9*	1985[1]	Dry Pond	48,535	65	1%	Low Priority*
23	1992	Dry Pond	11,000	11	0%	Low Priority

*Dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits under Schedule A/A+

Figure 9.1 shows the locations of the dry facilities prioritized according to their maintenance priority. Additional detail regarding prioritized dry facilities can be found in **Appendix D.**

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MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 9.1
DRY SWM FACILITY MAINTENANCE PRIORITY

- Roads
- Water Bodies
- Rivers
- SWM Facility Drainage Area

SWM Facility Maintenance Priority:

- High Priority
- Moderate Priority
- Low Priority

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

9.1.3.3 Dry Facility Conclusions and Recommendations

The follow summarizes the study findings and recommendations relating to Dry Facilities. For full details regarding the study and results refer to **Appendix D**.

- For maintenance purposes, facility number 36 and 8 should be prioritized due to high vegetation within these facilities. This thick vegetation can reduce the facility capacity and clean-outs are recommended for these facilities.

- Although dry facilities provide mainly quantity control, some of these facilities were also designed to provide quality control per the included extended detention. Accumulation of high loads of sediment not only affects the peak runoff control, but may also invalidate the contribution of the extended detention volume. Facility 23 is currently operating with full capacity, and the remaining facilities operate at small to moderate loss.

- Using the sediment loading rate obtained from the 2003 Stormwater Management Planning and Design Manual, Facility 22 has a decrease in storage capacity of 12% indicating it was operating at a large loss. However, in 2016 Ecosystem Recovery observations indicate that facility 22 has not accumulated sediment, and remains in the state it was installed in in 1997. Therefore, this facility has been prioritized as a low priority for maintenance.

- The Subwatershed Health Analysis completed for the City of Waterloo prioritized subwatersheds based on the current health of the subwatershed. Using the results from this report, quantity control facilities with large drainage areas located in priority subwatershed are ideal retrofit locations. These retrofits would include dry facilities: 18, 9, 8, and 2.

9.1.3.4 Wet SWM Facilities

The permanent pool component of wet facilities is the most important contributor for suspended solids removal, therefore any substantial loss in storage capacity due to sediment accumulation and lack of maintenance compromises the overall performance in terms of quality control. The analysis of the wet facilities consisted of an estimate of their current operational efficiencies based on the volumetric water quality criteria considering the influence of the accumulated sediment.

Appendix D presents the volumetric water quality design criteria as recommended by the 2003 Stormwater Management Planning and Design Manual. The values are based on a 24-hours drawdown time and a design pursuant the guidance provided in the manual. Requirements differ with facility type to reflect differences in removal efficiencies.

An efficiency profile can be created for each facility based on the results obtained from the calculations stated in **Appendix D**. These performance-storage curves exhibit how sediment retention performance of each facility varies with the volume, depending also on the type of the facility, level of imperviousness and the total drainage area. The current TSS removal efficiency can then be determined based on the obtained profile and the remaining permanent pool volume.

Only the volumes required to provide 60%, 70% and 80% TSS removal efficiencies are obtained from the linear regression equations shown in **Appendix D**, thus all values beyond this region of the graph are estimates. The volume estimates for efficiencies under 60% were considered as decreasing linearly until the point of zero volume and efficiency. All facilities with storage volumes above the required for 80% TSS removal were analyzed according to the excess in storage. In reality, the facility's performance becomes asymptotic with increasing design storage; hence there is a limit to storage beyond which the increase in performance will be negligible.

Similar to the analysis developed for the dry facilities, GIS data was used in order to fill data gaps from the original design brief reports. Sediment load estimates were necessary whenever there was no data available in the Ecosystem Recovery reports from 2015 and 2017. **Table 9.3** includes the summary of the wet SWM facility conditions, including the ranking criteria utilized. The decrease in performance considered in **Table 9.3** represents the loss when compared to the initial efficiency (estimated based on the original features of each facility according to the design brief reports), so only the influence of sediment accumulation is considered.

Table 9.3: Wet SWM Facilities Summary

Number of Wet SWM facilities Analyzed	24
Number of Wet Facilities with No Decrease in TSS Removal Performance	0
Number of Wet Facilities with Decrease in TSS Removal Performance	24
1% - 5% loss of performance (small loss)	10
6% - 10% loss of performance (moderate loss)	9
11% - 20% loss of performance (large loss)	5
>20% loss of performance (extreme loss)	0

9.1.3.5 Wet Facility Results

Table 9.4 present the results of the sediment analysis for wet SWM facilities, including a priority ranking for maintenance. **Figure** 9.2 shows the locations of the wet facilities prioritized according to their maintenance priority. See **Appendix D** for additional detail.

Table 9.4: Wet SWM Facilities Sediment Analysis and Maintenance Requirements

SWM Facility #	Year of Construction	Type of Facility	Permanent Pool Volume (m^3)	Volume of Sediment in 2019 (m^3)	% of Maximum Allowable Sediment Accumulation	Maintenance Priority
51	2000	Wet	689	587	321%	High Priority
42	1998	Wet	1350	1924	317%	High Priority
1	2000	Wet	300	516	266%	High Priority
27	2000	Wet	1377	2064	254%	High Priority
45	1999	Wet	6925	1327	232%	High Priority
49	2002	Wet	751	724	191%	Moderate Priority
35	2002	Constructed Wetland	432	258	162%	Moderate Priority
59	2002	Constructed Wetland	8825	263	162%	Moderate Priority
25	1986	Wet	104	89	138%	Moderate Priority
15	1995	Wet		1203	135%	Moderate Priority
29	2000	Wet	804	386	131%	Moderate Priority
57	2001	Wet	400	122	120%	Moderate Priority
58	2003	Wet	380	383	119%	Moderate Priority
62	2000	Wet	468	499	107%	Moderate Priority
34	1997	Wet	2740	855	95%	Low Priority
31	1995	Wet		826	83%	Low Priority
5	2006	Wet	4679	1185	73%	Low Priority
50		Wet		306	68%	Low Priority
54	2001	Constructed Wetland	334	225	67%	Low Priority
19	2000	Wet	1500	652	49%	Low Priority
41	1999	Wet	460	213	48%	Low Priority
56	1999	Wet	2245	201	39%	Low Priority
46	2013	Wet	1266	321	25%	Low Priority
24	1995	Wet	1600	422	7%	Low Priority

9.1.3.6 Wet Facility Conclusions and Recommendations

The follow summarizes the study findings and recommendations relating to Wet Facilities. For full details regarding the study and results refer to **Appendix D**.

- Among the identified problems, the most critical is the lack of a permanent pool volume as a result of sediment accumulation. Fourteen (14) wet facilities currently require maintenance due to sediment accumulation. Wet facilities 51, 42, 1, 27, 45, 49, 35, 59, 25, 15, 29, 57, 58, and 62 have exceeded the 5% reduction in sediment removal efficiency and require sediment removal to provide the design level of water quality treatment. These high and moderate priority facilities should be prioritized for maintenance.

- Facilities 62, 46, and 54 provide quantity control for drainage areas that have additional water quality controls including ponds designed for water quality and OGS units. These units were analyzed based on loss in storage capacity using the same methodology as the dry facilities in the previous section.

- Facility 62 was originally designed to function as a dry pond. However, as confirmed with City of Waterloo staff by Ecosystem Recovery (2015), this pond functions as a wet pond with a permanent pool volume. As concluded in the previous study, further analysis is required to determine if a retrofit is possible/necessary in addition to sediment clean-out.

- The 2003 design guidelines state a 5% loss of performance as the indication point of maintenance needs. Using this maintenance criterion, only ten (10) of the twenty-four (24) facilities analyzed currently do not require maintenance.

- While currently a low priority facility, facility 34 is predicted transition to a moderate priority facility and require maintenance within the next year.

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 9.2
WET SWM FACILITY MAINTENANCE PRIORITY

- Roads
- Water Bodies
- Rivers
- SWM Facility Drainage Area

SWM Facility Maintenance Priority:

- High Priority
- Moderate Priority
- Low Priority
- No Maintenance Required

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

9.2 Planned SWM Facility Retrofits

As part of the analysis of existing SWM facilities, an inventory has been established of SWM facilities that have been previously identified for retrofit. This inventory is detailed within a report titled "**SWM-MP Municipal Class EA - Sediment Analysis Memo: SWM Facilities and OGS Units (April 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix D.**

The following section summarizes the twelve (12) completed SWM facility retrofits completed by the City between 2017 and 2019 as well as the three (3) facilities which are currently scheduled for full or partial retrofit (**Figure 9.3**).

9.2.1 Completed Retrofits

Of the fifty-four (54) facilities listed in the analyzed datasets, twelve (12) have received maintenance recently. Retrofits improve or enhance the water quality, quantity and erosion control performance of existing stormwater management facilities and bring them in-line with current standards. **Table 9.5** presents the list of completed retrofits.

Table 9.5: Completed Retrofit SWM Facilities

SWM Pond #	Year of Construction	Facility Type	Control Type	Drainage Area (ha)	Year Completed
20	1989	Wet Pond	*	75	2017
30	1996	Wet Pond	Quality / Quantity	7.4	2017
33	1997	Wet Pond	Quality / Quantity	30.9	2017
38	1999/2008	Wetland	Quality / Quantity	54.9	2017
12	1994	Wet Pond	Quality	19.3	2017
52	2002	Wet Pond	Quality / Quantity	6.1	2017
7	2004	Wet Pond	Quality / Quantity	22.1	2017
14	1996	Wet Pond	Quality / Quantity	10.2	2017
55	2000	Wet Pond	Quality / Quantity	4.27	2018
53	2003	Wet Pond	Quality / Quantity	19.4	2019
3	1992	Wet Pond	*	69.8	2019
4	1979	Dry Pond	Quantity	142.9	2019

* - Unavailable data

9.2.2 Planned Retrofits

The three (3) remaining SWM facilities currently scheduled for retrofit are listed in **Table 9.6**. These facilities have satisfied the respective Class EA requirements per previous studies, or are not required to fulfill the EA process so further evaluation as part of the SWM-MP is therefore not warranted.

Table 9.6: SWM Facilities Scheduled for Retrofit

SWM Facility #	Facility Type	Drainage Area (ha)	Est. Avg. TIMP%	Water Quality Volume Requirement (cu.m/ha) per MOE 2003	Permanent Pool Volume Requirement (Cu.m)	Year of Construction
48	Wet Pond/ Quality*	76.7	58	194	14,881	1990
10	Wet Pond/ Quality	10.4	57	192	1,995	1993
28	Wet Pond/ Quality	4	64.5	115 (wetland due to DA < 5ha)	460 (wetland due to DA < 5ha)	1999

* Assumed - Unavailable data

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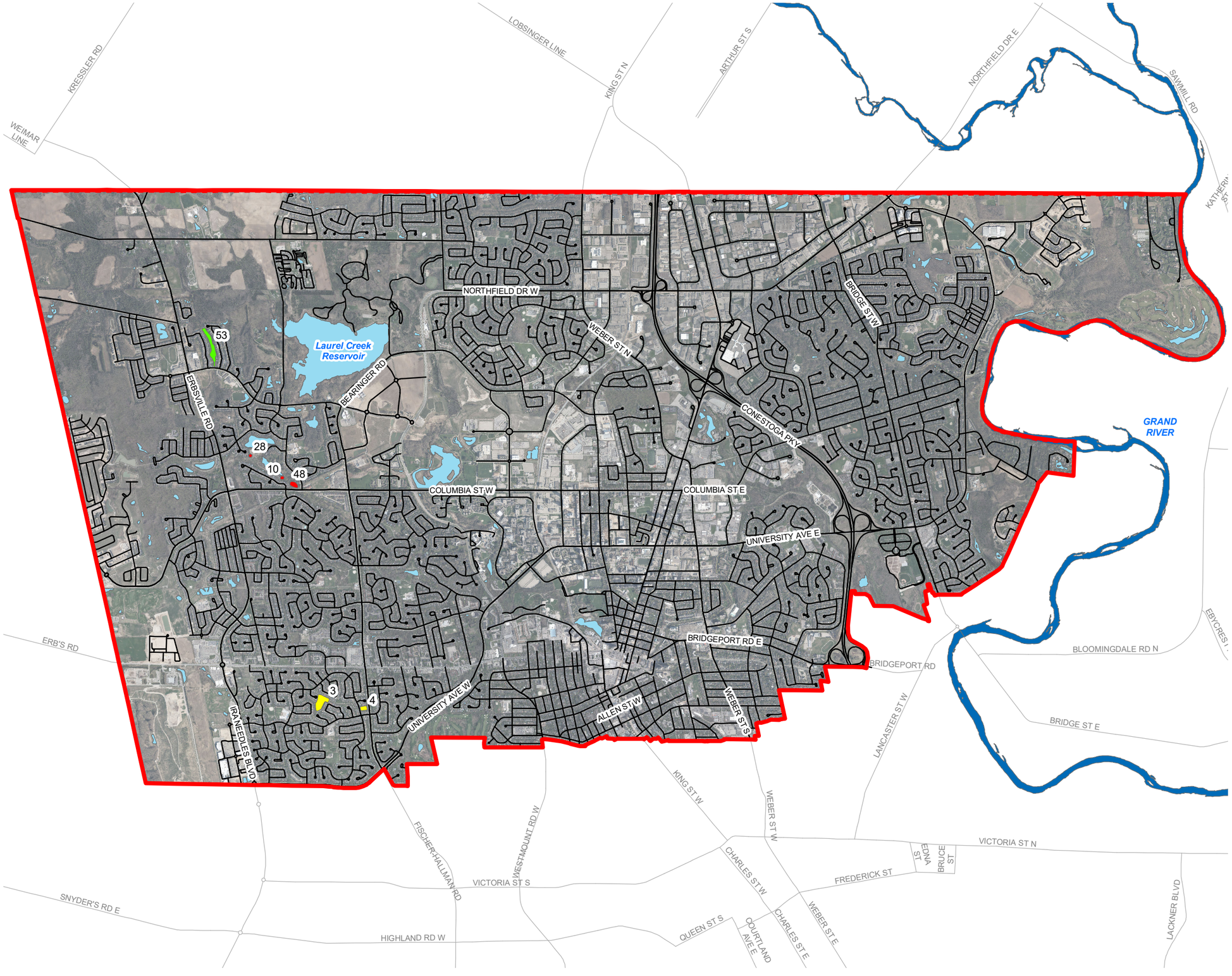

FIGURE 9.3
SWM FACILITY RETROFITS

- Roads
- Water Bodies
- Rivers

Status:

- Completed 2019
- Completed Winter 2019
- Not Completed

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

9.3 Park Rehabilitation and SWM Enhancements (New SWM Facilities)

The following end-of-pipe (EOP) facility opportunities study was initiated to provide a framework for a long-term strategy to implement stormwater quality and quantity control within the existing urbanized areas of the City of Waterloo as part of the Stormwater Management Master Plan (SWM-MP). Central to this framework is the recognition and importance of potential synergies with existing City plans, policies and programs (refer to **Section 4.6.1**). This synergy results in a two-fold benefit:

1. It provides an opportunity for establishment of new stormwater management facilities in areas where there is currently none, thereby providing increased flood control in flood prone areas and increased water quality control for degraded creeks, etc.
2. It introduces a park amenity that may be desired as part of a park rehabilitation.

To most effectively identify and construct new stormwater management facilities within an existing urban area, it is necessary to achieve multiple objectives beyond stormwater management to include community enhancement, transit planning and active transportation (trails and cycling infrastructure), urban forestry and, most relevant to this element of the SWM-MP, is the potential synergy with parks rehabilitation and enhancements within under-serviced areas or within parks scheduled for improvements. It has been shown through previous Master Plans for other Ontario municipalities that 'broader community benefits' are required when implementing new SWM facilities in established neighbourhoods in order to gain community support and ensure the project success.

The SWM-MP explored and assessed the feasibility of constructing new stormwater management facilities as part of park rehabilitations. The following study and resulting recommended works have been completed following Schedule B of the Municipal Class EA process and therefore can proceed directly to detailed design and implementation.

9.3.1 Background

A significant portion of the City of Waterloo was developed prior to the development of current stormwater management (SWM) criteria. As such, there are areas within the city where uncontrolled and untreated stormwater runoff is directly discharged to the receiving streams. Industry experience has shown that these uncontrolled discharges are responsible for a significant portion of the contaminant loadings to receiving streams as well as increasing the potential for downstream erosion and flooding.

Figure 4.9 shows the location of the existing stormwater management facilities and their respective drainage areas within the City of Waterloo and accentuates the lack of SWM control within the majority of the existing urban area.

9.3.2 Purpose and Objective

The principle objective of this report is to identify locations where new end-of-pipe stormwater management facilities could be implemented within existing urban areas of the City without

stormwater control to increase the proportion of SWM controlled drainage areas in the City to improve:

- Water quality control
- Water quantity control
- Erosion control

As such a list of potential sites which represent opportunities for new end-of-pipe stormwater management (SWM) facilities has been developed as a component of the City of Waterloo's SWM Master Plan were identified. Sites were identified and assessed using a four (4) phase process as input into the Municipal Class Environmental Assessment Master Planning process. The four (4) phase process is detailed in the subsequent section.

9.3.3 Study Process

Potential sites were identified and evaluated using a four (4) phase approach; each phase subject to a unique set of evaluation criteria and considerations. The following four (4) evaluation phases establish the framework of the evaluation process:

1) Phase 1 – Geographic Information Systems (GIS)/Land Assessment
2) Phase 2 – Field Reconnaissance and Impact Assessment
3) Phase 3 – Performance Assessment
4) Phase 4 – Consultation with City Staff

The methodology used to assess potential site locations is outlined in **Figure 9.4**. **Appendix I** describe the process outlined in **Figure 9.4** and the methods by which the various criteria for evaluating potential facility locations were obtained.

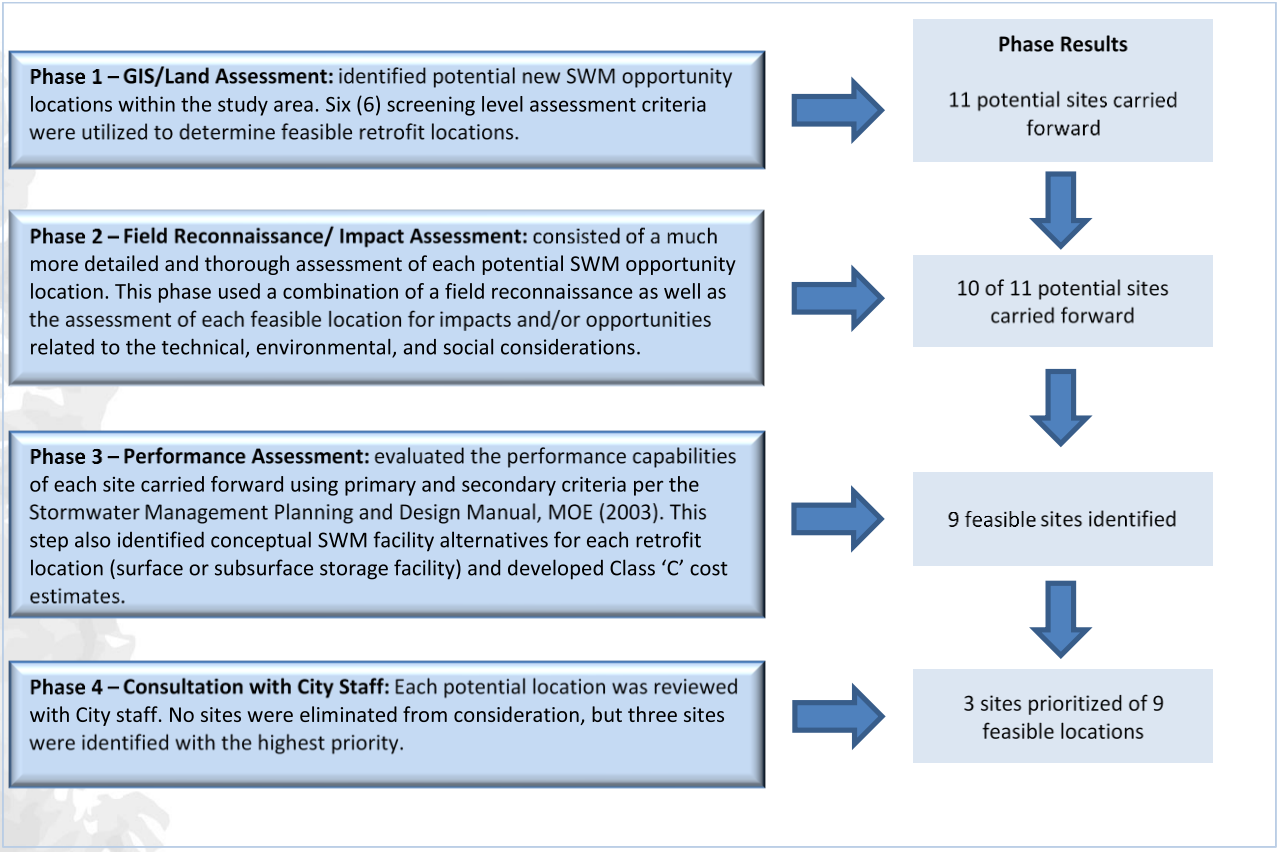

Figure 9.4: Four (4) Phase Process Summary

Prior to initiating the four (4) phase process, the Grand River Source Protection Plan (LERSPC 2012, Approved 2015, effective July 1, 2016) was reviewed as it relates to new end-of-pipe SWM opportunities, or more specifically the planning, design and construction of new SWM Ponds, per policies RW-MC-16 and RW-MC-17. These policies do not preclude the implementation of the identified new SWM opportunities, although consideration of the policies will be required during the design of the new facilities (e.g. lined subsurface facility).

9.3.4 Phase 1 - GIS/Land Assessment

The Phase 1 assessment involved analyzing available GIS databases to locate potential table and valley land SWM opportunities. Potential new SWM opportunity sites were evaluated using the following eight (8) technical evaluation criteria:

1. Available area;
2. Floodplain limit
3. Land Ownership: Municipal (M), Conservation Area (C), Provincial (P) including transportation corridors, Hydro Corridor (HC), and Unknown land ownership (Unk), Vacant lands (V) and existing site use. Private lands were not considered due to the requirement and cost to purchase lands;
4. Stormwater Infrastructure
    - Pipe Size;
    - Pipe Depth;

- Drainage Area;
- Drainage area (sewershed);
- Total Impervious Area Percentage (TIMP);

5. Topographic Constraints;
6. Significant Vegetation & Wetlands;
7. Preliminary Water Quality Estimates (note: a minimum target of 80% TSS removal (Level 1) water quality was applied a the most limiting and stringent criteria to ensure cost efficiency as part of implementation and future operation and maintenance. Erosion and flood control are achieved as by-product of meeting the level minimum water quality target);
8. Planned use or active park elements present;

Each potential SWM opportunity site was determined as feasible, possible or not feasible based on the land assessment performed. Sites were deemed possible in the situation where all not feasible criteria were surpassed, but some criteria for feasible were only partially met, some information for criteria was unavailable, or site characteristics created potential but difficult implementation. The land assessment criteria are outlined below in **Table 9.7**.

Table 9.7: Geographic Information Systems (GIS)/Land Assessment

Feasible	Possible	Not Feasible
• Available area greater than 1 ha • Available area does not intrude on floodplain limit • Ownership: Conservation (C), Municipal (M), Provincial (P), Hydro Corridor (HC), and Vacant land • No topographic constraints • No planned use/ active park elements present • No vegetation constraints or wetlands • No Additional sewer infrastructure required • Sufficient water quality provided	• Available area less than 1 ha • Unknown land ownership • Planned use/ active park elements present • Additional sewer infrastructure required i.e. diversion sewers, flow splitters etc. • Moderate vegetation constraints and or partial wetlands present • Some water quality provided • Minor topographic limitations •	• Available area intrudes on floodplain limit • All remaining types of land ownership • Major topographic limitations • Pipe size <450mm • Pipe size <900mm (Valley Lands within 200m of City parcel boundary) • High vegetation constraints and or significant portion of the area is dominated by wetlands • No water quality provided
Note: Consideration was made for proposed facilities within park areas where existing planned uses could be identified (i.e. active park elements) such as sports fields, play structures etc. such that it did not directly interfere with the existing land usage or its intrinsic value.		

Concluding the Phase 1 assessment, eleven (11) sites were classified as feasible or possible and were carried forward to the Phase 2 assessment. The results of the Phase 1 assessment are presented in **Appendix I** which also includes additional detail regarding the six (6) technical evaluation criteria.

9.3.5 Phase 2 - Field Reconnaissance/Impact Assessment

Phase 2 included completion of field reconnaissance of the eleven (11) potential SWM opportunity locations carried forward from Phase 1. The field assessment involved identifying site specific constraints and opportunities and potential impacts related to any future SWM opportunities proposed for each site location. The field assessment evaluated each feasible/ possible location for impacts and/or opportunities related to the general site characteristics, technical, environmental, and social considerations. The field assessments were also used to verify site conditions and identify site features at greater detail. **Appendix I** includes additional detail regarding the results of the field reconnaissance activities.

Concluding the Phase 2 assessment, ten (10) of the eleven (11) sites were carried forward to the Phase 3 assessment.

9.3.6 Phase 3 – Performance Assessment

The performance assessment was intended to develop conceptual SWM facility alternatives for each of the feasible or possible SWM opportunity locations carried forward from Phases 1 and 2 using a set of primary and secondary technical evaluation criteria. The conceptual alternatives identify details such as SWM facility type, size, configuration and function for each potential location.

For the purpose of the Phase 3 assessment, the types of end-of-pipe controls have been grouped into:

- **Surface Facilities** (wet pond, wetland and hybrid facilities)
- **Subsurface Storage Facilities**

The use of surface facilities such as wet pond, wetland and hybrid facilities becomes impractical from an economic and social perspective as installation depths increase. Therefore, the use of subsurface storage facilities was introduced as an alternative for servicing storm sewers at depths greater than 5m. As a preliminary cut-off, a depth of 5m was used to select surface facilities versus subsurface storage facilities. subsurface storage facilities were also recommended for site which have an identified surface constraint which cannot be mitigated. **Table 9.8** demonstrates the criteria for each EOP control.

Table 9.8: EOP Criteria

EOP Type	Criteria
Surface Facility	1. Pipe depth <5m
Subsurface Storage Facility	1. Pipe depth >5m, 2. Site has surface constraints which cannot be mitigated

The following primary and secondary technical evaluation criteria were used to develop the conceptual alternatives for each potential SWM facility and determine the feasibility of each SWM facility.

Primary Criteria

1) **Available areas with SWM pipe depths <5m were evaluated as Surface facilities (wet pond, wetland and hybrid facilities) with the following exemptions:**

- Where surface constraints exist, due to impacts to active and passive use of parks and park features, sport fields and trails, subsurface storage facilities may be considered regardless of pipe depth criteria.
- In addition, for site within the regulatory floodplain, subsurface storage facilities may also be considered regardless of pipe depth criteria.

2) Available areas with SWM pipe depths >5m were evaluated as Subsurface Storage facilities (due to excess excavation and disposal requirements for surface facilities).

3) In reference to the 2003 Stormwater Management Planning and Design Manual:

- Provide at minimum half the volume of enhanced (80% long –term suspended solid removal) water quality control without exceeding available areas
- Conceptual alternatives possess the ability to adhere to all other applicable design guidelines of this document to insure proper function and safety requirements

Secondary Criteria

4) Ability to Provide Erosion Control (25mm Storm Event)

According to the Stormwater Management Planning and Design Manual (MOE, 2003), the larger of the erosion control active storage and the water quality active storage should be provided. The volume of water from the 25mm rain event was used for all remaining potential sites in the assessment, as it was larger than the active storage volume criteria ($40m^3$/ha) in each scenario.

5) Ability to Provide Quantity Control

In addition to quality and erosion control, any remaining storage available for quantity control was identified as an overall net benefit and ensured increased consideration of the applicable SWM opportunity. Additional flood control was not allocated to subsurface storage facilities as this would increase facility size and costs (Note: additional flood storage maybe accommodated based on available area and allocated budgets).

The performance assessment was intended to develop conceptual SWM facility alternatives for each of the feasible or possible SWM opportunity locations carried forward from Phases 1 and 2 using a set of primary and secondary technical evaluation criteria. One of the remaining ten (10) sites was eliminated as the drainage area for the proposed inlet was too small. Further detail on the phase 3 performance assessment are provided in **Appendix I**. The results from the performance assessment yielded eight (8) sites viable for subsurface facilities and one (1) site where a combination of surface (bioswale) facility and subsurface facility could viably treat runoff from the catchment. **Appendix I** includes additional detail of the results of the performance assessment.

9.3.7 Phase 4 – Consultation with Project Team

Phase 4 of the study process included consultation with various departments of City of Waterloo in order to identify constraints, opportunities and synergies with other City plans, policies and programs in regards to the identified SWM Pond Opportunities carried forward from Phase 1, 2 and 3. As such, all SWM opportunity locations carried forward from Phases 1, 2 and 3 were presented to members of project team from various departments to solicit feedback and provide an opportunity for City staff to review and discuss each location in detail.

Non-feasible SWM Opportunities

Following the discussion with City staff, no sites were deemed not feasible.

Feasible SWM Opportunities

Following the review, nine (9) SWM opportunities (**Figure 9.5**) were confirmed by City staff. Three sites were identified as being priority locations, including:

- Northfield Park (Site 1)
- Laurelwood Park (Site 8)
- Sandowne Park (Site 10)

The remaining feasible sites include:

- Dunvegan Park (Site 3)
- Belgreen Park / Warrington Park (Site 4)
- Waterloo Park by LRT (Site 6) – If the proposed design in the Waterloo Park Master Plan is implemented in its current form, Site 6 will be the location of the Ecological/Education Area with a building and parking lot in place of the existing sports field.
- Waterloo Park near Seagram Drive (Site 7)
- Bechtel Park (Site 9)
- Lexington Park (Site 11)

Table 9.9 summarizes the priority and feasible SWM opportunities, the respective contributing drainage area as well as the recommended primary and secondary facility types (surface or subsurface) based on the technical criteria detailed in **Table 9.8** relating to existing sewer depth. The recommended facility type was developed as part of the technical evaluation process detailed above but does not supersede the evaluation process undertaken to select the preferred alternatives for each site is detailed in **Section 11.0.**

Table 9.9: Park Rehabilitation 9 Feasible SWM Facility Opportunities

Map & Site ID	Location Name	Recommended Facility Type (1- Primary alternative; 2- Secondary alternative)	Drainage Area (ha)
Priority Sites			
01	Northfield Park	Subsurface Storage Facility	49
08	Laurelwood Park	1) Surface Facility† 2) Subsurface Storage Facility	9
10	Sandowne Park	Subsurface Storage Facility	54.5
Feasible Sites			
03	Dunvegan Park	Subsurface Storage Facility	25.3
04	Belgreen Park / Warrington Park	Subsurface Storage Facility	45.3
06	Waterloo Park (by LRT)	Subsurface Storage Facility	32.7
07	Waterloo Park (Seagram Drive)	Subsurface Storage Facility	31
09	Bechtel Park	Subsurface Storage Facility	35.6
11	Lexington Park	Subsurface Storage Facility	10.2
† Bioswale is proposed to fully treat the park runoff and a portion of the catchment runoff, however the majority of the catchment runoff would have to be managed by the subsurface facility.			

Appendix I highlights relevant discussion points in regard to each of the nine (9) SWM opportunity locations. **Section 11.0** presents figures detailing each site's existing conditions and summarizes the selection of the preferred alternatives with accompanying conceptual designs. **Section 14.0** provides cost estimates.

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FIGURE 9.5
POTENTIAL SWM FACILITY LOCATIONS

- Roads
- Potential SWM Facility Locations
- Potential SWM Facility Drainage Area
- Stormwater Management Ponds
- Water Bodies
- Rivers

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

10 Urban Flood Management & Storm Sewer Infrastructure

As part of the SWM-MP, in order to understand and assess the capacity of the existing municipal storm sewers and stormwater management ponds, the environmental benefits, as well as technical and financial implications relating to urban flooding within the City of Waterloo a report entitled "**SWM-MP Municipal Class EA - Sewer Capacity Report (December 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix J.**

10.1 Introduction and Problem Identification

As part of the SWM-MP, a City-wide storm sewer model for the City of Waterloo was developed to assess the existing level of service of the City's stormwater infrastructure. The assessment of the existing stormwater conveyance systems including individual SWM facilities considers the effectiveness of the City's infrastructure at reducing the impacts of urban runoff on infrastructure, property and the environment including the:

- ability to more closely match pre-development hydrologic conditions by reducing urban peak flows at storm sewer outfalls, maintaining groundwater recharge, and mitigating in-stream and overland erosion;
- ability to provide conveyance of a 1:5-year precipitation event within the minor system per the City standard level-of-service; and
- ability to improve water quality of stormwater runoff so it more closely matches water quality in a natural landscape.

10.2 Study Purpose and Objective

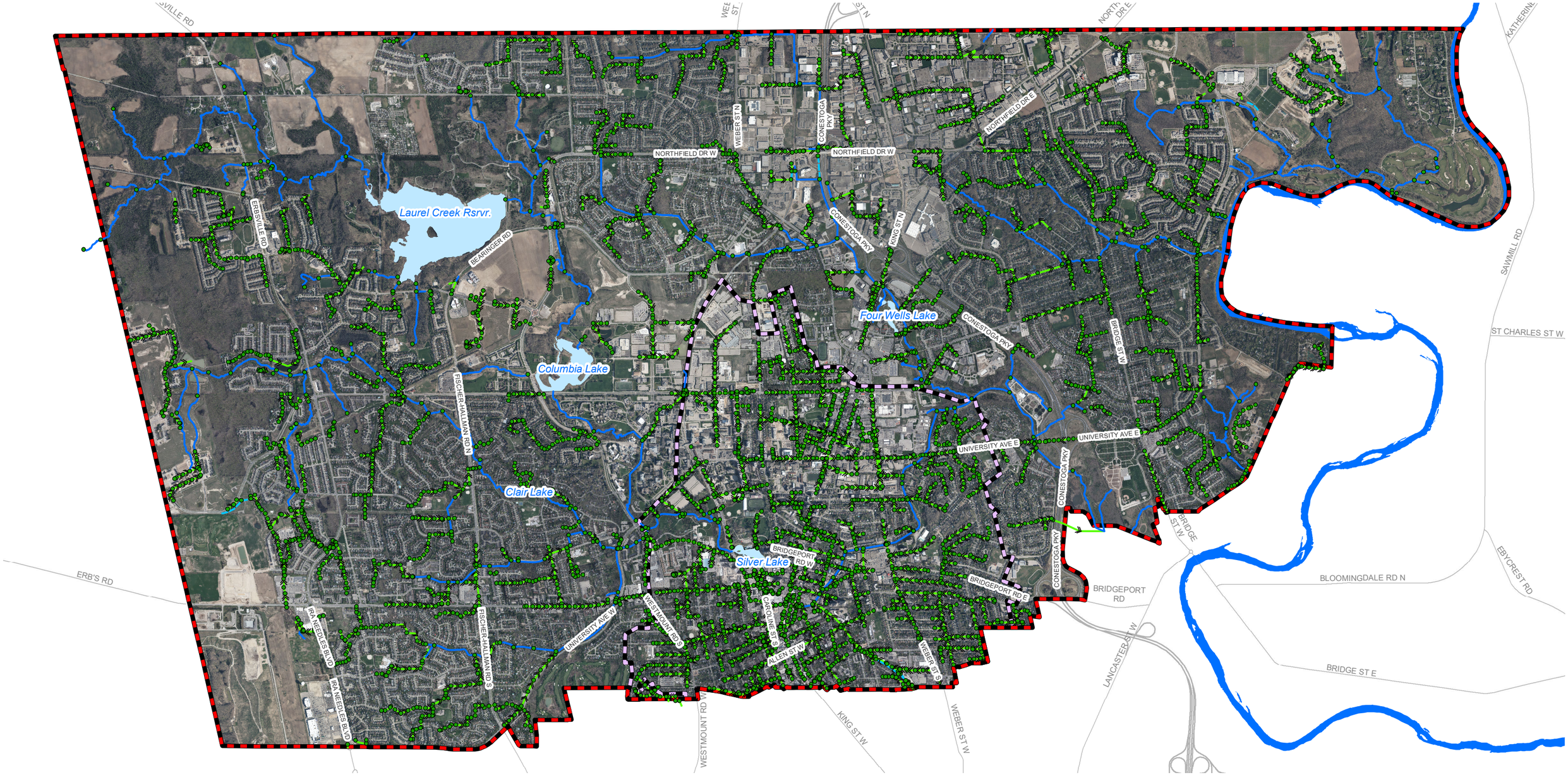
The model will help City staff anticipate needs regarding infrastructure capacity upgrades or capital improvements as well as to provide direction as to where spare capacity for future development may exist. Along with the existing conditions assessment, the City's existing infrastructure was run against various performance scenarios including:

1. Climate change,
2. Intensification (urban infill development and increased impervious surfaces), and
3. the implementation of Low Impact Development (LID)SWM controls as part of volume retention strategy.
4. Pollutant loading under existing and LID scenarios.

The model was constructed as a minor system model using two storm sewer model resolution and extents per the City request (See **Figure 10.1**):

1. All pipes larger than 300mm in diameter in the City core; and
2. Pipes greater than 600mm in diameter throughout the remainder of the City (referred to as a 'trunk sewer model')

The trunk sewer system represents approximately 183 km (35%) of the total 524 km storm sewer network in the City of Waterloo. While the trunk sewer system is made of the largest diameter sewers and the sewers in the most urbanized area of the City, there remains to be approximately 341 km (65%) sewers which were not part of the project scope and were not modelled.



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MUNICIPAL CLASS EA STORMWATER MANAGMENT MASTER PLAN

FIGURE 10.1 MODELED STORM NETWORK

Legend

- Junctions
- Pipes
- Creek
- Ditch
- Roads
- Rivers
- Waterbody
- Study Area
- Core Area

N W E S

0 1 2
Kilometers

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.
Date: December, 2019

10.3 Approach and Methodology

The hydrologic model selected for application in this study was PCSWMM 2019. PCSWMM 2019 has the capacity of using a number of versions of EPA SWMM5 for performing the hydrologic and hydraulic calculations. For the existing condition model, SWMM 5.1.013 was selected, as it is the latest official version of SWMM currently available. The parameters used to develop the model are further detailed in **Section 2.0** in **Appendix J.**

Input information for the conduits, junctions, and natural channels for the PCSWMM model was derived from storm sewer network data received from the City of Waterloo. An extensive data gap analysis was conducted on the information received, with additional information gathered from as-built drawings and documentation where possible. When data was still unavailable, Aquafor Beech staff conducted extensive field surveys to measure storm sewer inverts, conduit pipe sizes, material, cross sections, etc., of the existing storm sewer and natural channel networks in order to fill in the data gaps. If a new storm sewer network configuration was identified in the field which disagreed with the City's existing data, the new configuration was measured and redrawn according to the field survey.

Detailed stage-storage-discharge relationships were input for the City's stormwater management facilities. The stage-storage-discharge relationships were established through from the review of background information including design briefs and Environmental Compliance Approvals (ECAs), formerly known as Certificates of Authorization (CofA). In the case of the 40 stormwater facilities where information was found to be partially or completely missing, a reasonable functional relationship was assumed based on professional judgement and available information. **Section 2.3** in **Appendix J** provides further detail on how these relationships were developed.

10.4 Assessment of Model Results

The existing conditions baseline model for the City was simulated along with a total of four (4) scenarios:

1. Development Intensification
2. Climate Change
3. Water Quality
4. Low Impact Development (LID)

The four (4) scenarios were evaluated using the PCSWMM model and then compared to the existing conditions.

The fourth scenario represent the application of Low Impact Development (LID). In the LID scenario, a volume retention target of 12.5 mm was applied to simulate the City-wide implementation of source and conveyance controls and was evaluated in the context of:

a) Development intensification,
b) Climate change and
c) Water quality.

The model results were assessed in terms of length of sewers which reached full capacity or became surcharged. 'Full capacity' was defined as sewers which reached a flow capacity of 1 in the model, and

'surcharged' sewers were defined as sewers which reached a flow capacity greater than 1 in the model. Detailed figures discussing the results of each model scenario can be found in **Section 3.0** in **Appendix J**.

10.4.1 Existing Conditions

Based on the parameters discussed in **Section 2.4** and **Section 2.5** in **Appendix J**, storm sewers in Waterloo are required to accommodate a 1:5-year storm event without surcharging. In order to assess whether the City's existing sewers are currently reaching their target level of service, the model was run for a 1:5-year, 4-hour storm event and assessed for sewers which were at full capacity or surcharged.

The system performance analysis indicates that some portions of the City's minor storm system network are deficient with respect to the stated level of service criteria, which is leading to a total of 71.9 km of surcharged storm sewers within the City for a 1:5-year storm event.

10.4.2 Scenario 1 – Development Intensification

The intensification scenario is intended to provide an indication of how future development will impact the existing storm sewer network, assuming capacity upgrades do not occur concurrently with intensification. Two areas in the City are expected to undergo significant urban intensification and increased density, Schedule B2 Uptown Waterloo Urban Growth Centre and Schedule I Industrial Transition Area of the City's Official Plan. The urban intensification was modelled by updating the projected land use imperviousness parameters in the projected areas, as detailed in **Section 3.2** of **Appendix J.** The development intensification scenario was run on the existing conditions model using the 1:5-year, 4-hour storm event.

Table 10.1 identifies the change in the level of service provided during the 1:5-year event from the existing conditions model to the intensification scenario. An increase of 1,288m of sewers reach capacity or become surcharged during the intensification scenario compared to the existing conditions model. This suggests that minor system upgrades may be required to accommodate the proposed intensification.

Table 10.1: Comparison of Existing Conditions and Intensification Scenarios during 1:5-year Storm Event

Scenario	Sewers at Capacity or Surcharged	
	Total Length (m)	% of Storm Sewers
Existing Conditions	71,870	39.3%
Intensification Scenario	73,158	40.0%
Change in Service	**+ 1,288 m**	**+0.7%**

10.4.3 Scenario 2 – Climate Change Scenario

Climate change resilience, adaptation and mitigation is now considered an integral part of stormwater design and implementation. The climate change scenario was run in the model to assess the potential risks, vulnerabilities, and liabilities involved in the long-term maintenance of infrastructure due to climate change. For the purposes of the model for this report, the IDF_CC Tool 4.0 was used to generate a local IDF curve that accounts for the possible impacts of climate change, for a projection range of 50 years. The methodology for the climate change model scenario is detailed further in **Section 3.3** of

Appendix J. With the use of the IDF_CC Tool 4.0, the climate change scenario was developed by rerunning the existing conditions baseline model with the Climate Change IDF curve for a 1:5-year 4-hour storm event under the RCP 8.5 pathway.

Table 10.2 identifies the change in the level of service provided during the 1:5-year event from the existing conditions model to the climate change scenario. An increase of 11,028m of sewers reach capacity or become surcharged during the climate change scenario compared to the existing conditions model. This suggests that minor system upgrades may be required to accommodate the impacts of climate change.

Table 10.2: Comparison of Existing Conditions and Climate Change Scenarios during 1:5-year Storm Event

Scenario	Sewers at Capacity or Surcharged	
	Total Length (m)	% of Storm Sewers
Existing Conditions	71,870	39.3%
Climate Change Scenario	82,898	45.3%
Change in Service	**11,028**	**+6.0%**

10.4.4 Scenario 3 – Water Quality Scenario

Water quality, including the pollutant levels found in surface runoff, can impact both human and ecological well-being. There are a variety of pollutants as well as other physical, chemical and biological characteristics used to measure water quality. The water quality scenario was run on the existing conditions model using the 1:5-year, 4-hour storm event to assess how the City of Waterloo stormwater performs to the standard water quality parameters. The assessment was completed for nitrate, phosphorus, and TSS, for the subcatchment within the City of Waterloo limits. The methodology for the water quality model scenario is detailed further in **Section 3.4** of **Appendix J.**

The impacts of the water quality scenario on the existing storm sewer network is displayed in **Table 10.3**. The assessment was completed for the subcatchments within the City of Waterloo limits; Grand River Central South, Laurel Creek, Martin Creek, and Schneider Creek.

Table 10.3: Summary of Water Quality Scenario

Subcatchments	Scenario 3 - Water Quality		
	Total Nitrate (kg)	*Total Phosphorus (kg)*	*Total TSS (kg)*
Grand River Central South	109.8	33.2	8011.8
Laurel Creek	69.8	19.4	4669.9
Martin Creek	18.5	4.3	687.9
Schneider Creek	4.2	1.1	222.3

10.4.5 Scenario 4 – Low Impact Development (Volume Control)

Non-traditional source and conveyance control such as Low Impact Development (LID) measures can provide stormwater treatment for individual properties and the collected drainage concentrated within the ROW of a municipal road (or regional road). For the purposes of this model, a moderate interim

target of 12.5 mm volume retention is proposed for the Volume Control scenario. The 12.5 mm volume target corresponds to a future scenario in which all catchments are provided with some form of source and/or conveyance control reducing runoff volume significantly. The 12.5 mm volume retention target was also selected as it generally offsets the predicted effects of climate change.

The LID scenarios assume the application of the 12.5 mm volume retention across all of the City's subcatchments over an extended time period. This time period has been assumed to be in the projection range of 50 years (i.e. 2070) to coincide with the projected range of the climate change scenario.

The impacts of introducing LIDs was observed in three scenarios, Existing Conditions, Climate Change, and Water Quality, as described below.

10.4.5.1 Scenario 4a - Existing Conditions (Volume Control)

The impacts of the existing conditions scenario with volume control was modelled as an input of 12.5mm depression storage across all of the City's subcatchments, using the existing IDF curve for a 1:5-year, 4-hour storm event. **Table 10.4** identifies the change in the level of service provided during the 1:5-year event from the existing conditions model with the addition of LIDs. A decrease of 15,568m of sewers reach capacity or become surcharged during the volume control scenario compared to the existing conditions model.

Table 10.4: Comparison of Existing Conditions and Volume Control Scenarios during 1:5-year Storm Event

Scenario	Sewers at Capacity or Surcharged	
	Total Length (m)	% of Storm Sewers
Existing Conditions	71,870	39.3%
Volume Control Scenario	56,303	30.8%
Change in Service	**-15,568**	**-8.5%**

10.4.5.2 Scenario 4b - Climate Change (Volume Control)

The effects of climate change on existing infrastructure can be reduced through the use of low impact development (LIDs) volume control options. The impacts of the climate change scenario with volume control was modelled as an input of 12.5mm depression storage across all of the City's subcatchments, using the modified climate change IDF curve for a 1:5-year, 4-hour storm event.

Table 10.5 compares the change in the level of service provided during the 1:5-year event between the climate change scenario and the climate change scenario with the addition of LIDs. The length of sewers which reach full capacity or become surcharged decreases by 10,234m with the addition of volume control.

Table 10.5: Comparison of Climate Change and Climate Change (Volume Control) Scenarios during 1:5-year Storm Event

Scenario	Sewers at Capacity or Surcharged	
	Total Length (m)	% of Storm Sewers
Climate Change Scenario	82,898	45.3%
Climate Change (Volume Control) Scenario	72,664	39.7%
Change in Service	-10,234	-5.6%

10.4.5.3 Scenario 4c - Water Quality (Volume Control)

The impacts of the water quality scenario with volume control on the existing storm sewer is displayed in **Table 10.6.** This is modelled as an input of 12.5mm depression storage across all of the City's subcatchments, using the City's existing IDF curve for a 1:5-year, 4-hour storm event. As in Scenario 4 - Water Quality, the Water Quality (Volume Control) assessment was separated into four major subcatchments, representing 100% of the subcatchments within the City of Waterloo limits.

Table 10.6: Summary of Water Quality (Volume Control) Scenario

Subcatchments	Scenario 4c - Water Quality (Volume Control)		
	Total Nitrate (kg)	*Total Phosphorus (kg)*	*Total TSS (kg)*
Grand River Central South	75.0	22.2	5345.8
Laurel Creek	41.2	11.9	3009.6
Martin Creek	14.3	3.2	493.0
Schneider Creek	2.4	0.6	138.6

10.5 Preferred Model Scenario

Intensification and climate change scenarios demonstrate an increased risk of sewers which are at full capacity or surcharged. It can be determined that the preferred modelling scenario recommended for adoption is Scenario 4b, LID Volume Control (Climate Change). Scenario 4b takes into account the predicted impacts of climate change as well as the application of a mitigation strategy through the use of a 12.5mm volume control.

Based on the cost implications of storm sewer replacement associated with Scenario 1 through 4, it is evident that the implementation of City-wide volume targets is beneficial. The implementation of LIDs in the form of source and conveyance controls on a City-wide scale can mitigate the affects of climate change and intensification. Volume targets associated with LID practices will reduce the length of storm sewers which are at full capacity or surcharging during the 5-year storm event.

11 Stream System Understanding

In order to understand the existing stream conditions, as well as the relevant conditions of past river engineering and stream rehabilitation projects within the City of Waterloo, a separate EA was conducted entitled "Municipal Class Environmental Assessment Watercourse Erosion Master Plan (March 2019)". This document is included as **Appendix L.**

The following section provides a summary of the existing stream and watercourse conditions within the City of Waterloo. The summary is based on available information documented from field work in 2017 and extracted from background reports such as watershed studies and monitoring programs, GIS mapping and City databases.

11.1 Background

Within the City of Waterloo over 60 km of stream systems extend through at least 18 of the 23 distinct sub-watersheds or catchment areas, all of which ultimately all drain into the central segment of the Grand River **(Figure 4.1)**. Regionally, the Grand River includes stream systems within Kitchener, Cambridge and Waterloo, and is the most urbanized section of the watershed. Associated with urbanization are both direct and indirect factors of human activity on stream geomorphology. Direct impacts include changes of channel form, alignment, bank and bed materials; as well as in-stream structures including weirs, culverts, and dams. Indirect impacts relate primarily to changes in catchment land use which significantly influences the pathways and rates of water and sediment routing through the drainage networks.

The stream drainage networks within the City of Waterloo are centred around the main branch of the Grand River. The most significant tributary of the Grand River within Waterloo is Laurel Creek with a drainage area of about 2400 ha. Laurel Creek tributaries include the Clair, Monastery, Beaver, Forwell, and Cedar Creeks. There are numerous other smaller tributaries of the Grand River within Waterloo, with the most notable being Colonial Creek. Areas at the north end of the City drain to the lower Conestogo River watershed which is, itself, a tributary of the Grand River.

Stream reaches had previously been identified by the City as part of the inspections of municipal watercourses in 2002 (Parish Geomorphic Ltd. and Planning & Engineering Initiatives Ltd.) and 2013 (City of Waterloo). Watercourse reaches are lengths of channel that display similar channel characteristics, functions, and processes and can be used as a guide for management objectives and restoration opportunities. Stream reaches are delineated by key factors that include hydrology, channel gradient, geology, valley setting, sinuosity, and riparian vegetation. The reach delineations were updated to better represent geomorphically significant changes in channel conditions. The reaches are shown in **Figure 11.1**.

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 11.1
STUDY AREA DRAINAGE NETWORK AND STREAM REACHES

- Reach Breaks
- Roads
- Water Bodies
- Study Area

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

11.2 Methods

To complete the erosion inventory and assessment for watercourses within the City of Waterloo, all creeks were walked and visually assessed over the period of April to June 2017. Of the estimated 74 km of watercourses measured from the City's GIS mapping database, about 40 km were walked continuously. The balance of the watercourses was assessed by walking in-and-out from road crossings or were not accessed as they were on private property.

During the creek field-walks, a number of tasks were completed by two staff members:

1. Geomorphic reach assessments, channel observations, and Rapid Geomorphic Assessments (RGAs)
2. Erosion site identification, characterization, and technical scoring
3. Maintenance sites identification, characterization, and technical scoring
4. Stormwater outfalls identification, assessment, with cross-referencing of erosion/maintenance sites
5. Photographic inventory collection for watercourse reach conditions, erosion sites, maintenance sites, and stormwater outfalls

Further details of the methods used can be found in **Appendix L**.

11.3 Geomorphic and Erosion Assessment

During the field walks, the geomorphology of each watercourse was analyzed to characterize the stream system within the context of the erosion assessment. Erosion is a natural process and natural streams and rivers should be considered dynamic allowing for gradual and long-term channel adjustments that may occasionally include more dramatic changes due to high magnitude flood events.

Sediment aggradation and degradation are processes that create and maintain geomorphic features within a river. However, changes within a watershed (such as deforestation or urbanization) can create an imbalance within these processes resulting in erosion that is unnatural, or unhealthy for the system. Therefore, completing a geomorphic assessment is important in order to identify the natural processes and areas of excessive erosion or sedimentation.

The geomorphic assessment consisted of field investigations for a total of 14 watercourses. The Grand River was not included within the field investigation. A total of 36 erosion sites were identified during the field walks. Each site was evaluated using the erosion site assessment field scoring described in **Appendix L**. A summary of all the erosion sites inventoried is presented in **Figure 11.2** and **Table 11.1**. The table describes the watercourse common name, the section investigated, the date of the investigation, the observed total length of channel where erosion was deemed present, and the risks associated with the erosion noted at each site. Sites falling above the bold line indicate sites with primary erosion issues and those below with secondary erosion issues. A description of the criteria for delineating between these two categories can be found in **Appendix L**.

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

THE CITY OF Waterloo

FIGURE 11.2
LOCATIONS OF PRIMARY EROSION SITES

- Erosion Sites
- Watercourse
- Roads
- Water Bodies
- Study Area

0 0.5 1 Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: September, 2019

Table 11.1: List of Erosion Sites Identified during the 2017 Field Investigation

	Watercourse	Site	Date	Erosion Length	Risk
Primary Erosion Sites	Laurel Creek	LRL-E5	18-May-17	150 m	Sanitary maintenance holes
	Cedar Creek	CDR-E4	16-May-17	70 m	Sanitary maintenance holes
	Laurel Creek	LRL-E6	18-May-17	70 m	Sanitary sewer and maintenance hole
	Forwell Creek	FRW-E2	17-May-17	20 m	Culverts and headwall
	Laurel Creek	LRL-E7	19-May-17	350 m	Recreation trail, sanitary sewer run, private property
	Cedar Creek	CDR-E3	16-May-17	10 m	Culvert and gabion weir
	Clair Creek	CLR-T1-E1	16-Jun-17	50 m	Gabion and private residence
	Clair Creek	CLR-E4	14-Jun-17	40 m	Storm sewer outfalls, sanitary sewer, culvert
Secondary Erosion Sites	Laurel Creek	LRL-E3	31-May-17	70 m	Storm outfalls, sanitary sewers, leaning concrete wall
	Clair Creek	CLR-E1	16-Jun-17	30 m	Sanitary sewer, bank erosion
	Laurel Creek	LRL-E10	30-May-17	30 m	Gabion slumping, sanitary sewer, fire hydrant
	Cedar Creek	CDR-E1	16-May-17	-	Sanitary sewer, gabion failure
	Cedar Creek	CDR-E2	16-May-17	30 m	Sanitary sewer, bank erosion
	Forwell Creek	FRW-E4	17-May-17	170 m	Sanitary sewer, SWM facility
	Forwell Creek	FRW-E1	17-May-17	60 m	Sanitary sewer, SWM facility
	Colonial Creek	CLN-E1	15-May-17	20 m	Sanitary sewer, manhole
	Forwell Creek	FRW-E5	17-May-17	>75 m	Hydro pole, fence, sanitary sewer
	Forwell Creek	FRW-E3	17-May-17	70 m	Sanitary sewer
	Laurel Creek	LRL-E9	30-May-17	15 m	Sanitary sewer
	Laurel Creek	LRL-E11	30-May-17	5 m	Conduits
	Laurel Creek	LRL-E2	31-May-17	70 m	Sanitary sewer, undermined abutments
	Clair Creek	CLR-T1-E2	15-Jun-17	25 m	Gabions failing
	Laurel Creek	LRL-E4	18-May-17	15 m	Gabion slumping
	Forwell Creek	FRW-E6	17-May-17	125 m	Debris dumping, encroachment
	Forwell Creek	FRW-E7	17-May-17	40 m	Parking lot
	Forwell Creek	FRW-E8	17-May-17	100 m	Fence, gabion failure, private property
	Clair Creek	CLR-E6	14-Jun-17	long	Widening and entrenchment
	Cedar Creek	CDR-E5	16-May-17	5 m	Gabions failing
	Laurel Creek	LRL-E1	31-May-17	15 m	Gabions failing
	Clair Creek	CLR-E3	14-Jun-17	80 m	Failing bank treatments
	Clair Creek	CLR-E5	14-Jun-17	50 m	Bank slumping and erosion
	Clair Creek	CLR-E2	16-Jun-17	100 m	Failed bank treatments
	Laurel Creek	LRL-E8	30-May-17	10 m	Private property
	Cuckoo Creek	CCK-E1	16-May-17	-	Storm outfall
	Colonial Creek	CLN-E2	15-May-17	50 m	Bank erosion
	Clair Creek	CLR-T3-E1	15-Jun-17	15 m	Slope erosion

11.4 Erosion Assessment Classifications

As discussed previously in this section, erosion sites were clustered into primary opportunities and secondary opportunities based generally on field interpretations and the technical scoring, then separated by a bold line within **Table 11.2**. The primary opportunities represent the key projects to be considered within system-wide prioritization and implementation plan of the SWM-MP. Most primary opportunities do not require immediate action and can be monitored and addressed in fullness of time. In a few cases, projects may be implemented immediately where the level of risk is high and the City can easily proceed with erosion mitigation works. Secondary opportunities have lower levels of risk (and/or may be complicated by land ownership), but have been documented for the City to monitor and may still be considered for integration into other projects as they arise.

Table 11.2: Erosion Assessment Opportunities

Erosion Category	Prioritized Ranking	Date	Watercourse	Site	Public Health & Safety Index	Erosion Index					Riparian Buffer Index	Aquatic Habitat Index	Total Score
					Type of Risk	Distance	Extent	Stream Energy & Flow Regime	Erodibility	TOTAL			
Primary Erosion Issue	1	18-May-17	Laurel Creek	LRL-E5	35	15	10	4	3	32	15	10	92
	2	16-May-17	Cedar Creek	CDR-E4	35	15	8	3	5	31	15	10	91
	3	18-May-17	Laurel Creek	LRL-E6	35	15	6	4	3	28	10	15	88
	4	17-May-17	Forwell Creek	FRW-E2	35	15	8	5	5	33	10	10	88
	5	19-May-17	Laurel Creek	LRL-E7	25	12	10	5	5	32	15	15	87
	6	16-May-17	Cedar Creek	CDR-E3	35	15	6	3	3	27	15	10	87
	7	16-Jun-17	Clair Creek	CLR-T1-E1	35	12	4	4	1	21	15	15	86
	8	14-Jun-17	Clair Creek	CLR-E4	35	12	6	4	3	25	10	15	85
Secondary Erosion Issue		31-May-17	Laurel Creek	LRL-E3	35	12	8	5	3	28	10	10	83
		16-Jun-17	Clair Creek	CLR-E1	35	12	4	4	3	23	15	10	83
		30-May-17	Laurel Creek	LRL-E10	35	12	2	4	3	21	15	10	81
		16-May-17	Cedar Creek	CDR-E1	35	12	8	3	3	26	10	10	81
		16-May-17	Cedar Creek	CDR-E2	35	12	4	3	5	24	15	5	79
		17-May-17	Forwell Creek	FRW-E4	25	12	8	4	5	29	10	15	79
		17-May-17	Forwell Creek	FRW-E1	35	12	4	4	3	23	10	10	78
		15-May-17	Colonial Creek	CLN-E1	35	12	2	5	3	22	10	10	77
		17-May-17	Forwell Creek	FRW-E5	15	15	4	4	5	28	15	15	73
		17-May-17	Forwell Creek	FRW-E3	35	5	4	4	3	16	10	10	71
		30-May-17	Laurel Creek	LRL-E9	35	15	2	4	5	26	5	5	71
		30-May-17	Laurel Creek	LRL-E11	35	15	2	2	5	24	5	5	69
		31-May-17	Laurel Creek	LRL-E2	35	5	4	4	5	18	5	10	68
		15-Jun-17	Clair Creek	CLR-T1-E2	15	15	4	4	5	28	10	15	68
		18-May-17	Laurel Creek	LRL-E4	15	12	4	4	3	23	15	15	68
		17-May-17	Forwell Creek	FRW-E6	10	10	8	4	5	27	15	15	67
		17-May-17	Forwell Creek	FRW-E7	10	12	2	3	5	22	15	15	62
		17-May-17	Forwell Creek	FRW-E8	10	12	6	3	5	26	15	10	61
		14-Jun-17	Clair Creek	CLR-E6	15	12	10	4	5	31	5	10	61
		16-May-17	Cedar Creek	CDR-E5	15	12	2	5	1	20	15	10	60
		31-May-17	Laurel Creek	LRL-E1	25	12	2	4	1	19	5	10	59
		14-Jun-17	Clair Creek	CLR-E3	10	15	2	4	3	24	15	10	59
		14-Jun-17	Clair Creek	CLR-E5	10	10	4	4	5	23	15	10	58
		16-Jun-17	Clair Creek	CLR-E2	10	12	6	4	3	25	10	10	55
		30-May-17	Laurel Creek	LRL-E8	10	12	2	5	3	22	10	10	52
		16-May-17	Cuckoo Creek	CCK-E1	10	5	10	5	3	23	5	10	48
		15-May-17	Colonial Creek	CLN-E2	10	12	4	4	5	25	5	5	45
		15-Jun-17	Clair Creek	CLR-T3-E1	0	5	2	4	3	14	10	5	29

11.5 Land ownership of Watercourses

In consideration of preliminary alternative solutions for the primary erosion site opportunities, many of the identified works cannot be completed or fully completed without addressing land rights and channel encroachment within the watercourse corridors. While generally it has been recommended that creek-based works not be completed by the City on private property, land rights will be a critical component of many of the identified projects, and thus permanent easements and/or property acquisition may be necessary to address the existing erosion issues and to achieve the long-term environmental and economic benefits. The accompanying cost of land rights negotiations and acquisitions are not included in project cost estimates outlined in the current EA report.

11.6 Summary & Recommendations

The erosion assessment report (**Appendix L**) presents the results of the 2017 creek field-walks and erosion inventory completed for the City of Waterloo in order to identify potential creek-based stream restoration works as a component of the SWM-MP. This component is an additional management layer to address the overall ecological health of watercourses within the City of Waterloo. While the erosion site opportunities may themselves be identified as stream restoration projects, the intention of the SWM MP is to integrated multiple management layers to develop a system-wide prioritization and implementation plan.

The study specifically contributes a list of eight (8) primary erosion site and reach restoration opportunities that are to be considered in a city wide comprehensive and integrated stormwater master plan. As part of the Watercourse Erosion Master Plan, this list of primary erosion sites was evaluated to determine the preliminary preferred solution. In general, it is recommended that the erosion at these primary sites be reduced using engineering methods to improve function, water quality, and habitat of the watercourse. A summary of the evaluation of the preliminary alternatives, the selection of the recommended solution, and the development of the preliminary conceptual designs (including cost estimates) for each of the primary erosion site opportunities are presented in **Section 12.4**. This list of eight (8) primary erosion sites and stream restoration opportunities will be prioritized within a system-wide prioritization as part of the SWM-MP, and some number of them may be included in the implementation plan developed in the final stages of the EA study. Given the lower level of risk associated with identified secondary opportunities, they are not recommended for direct consideration in the SWM-MP prioritization and implementation plan.

12 Evaluation of Alternatives

Section 5 of this SWM-MP details the development of a long list of alternative measures, while **Sections 6** through to **Section 11** describe in detail, the feasibility of the six (6) stormwater management program elements in the context of the different opportunities/constraints within the City. The following section describes the evaluation criteria, evaluation process and selection of the preferred alternatives which will form the recommended approach in fulfillment of the Class Environmental Assessment process (Class EA).

The SWM-MP was conducted in accordance with the requirements for Master Plans under **Appendix 4, Approach #2** of the *Municipal Engineers Association Municipal Class Environmental Assessment (October 2000, as amended in 2007, 2011 & 2015)*, which is an approved process under the *Ontario Environmental Assessment Act*. As part of the Class EA process evaluation of alternatives, assessment of the potential environmental effects, analysis of problems or opportunities, and identification of mitigation measures for potential adverse impacts has been conducted and presented through public and agency consultations. The SWM-MP fulfills all of the Class EA requirements for Schedule A, A+, and B projects which can then proceed directly to detailed design and implementation and identifies any Schedule C projects for future studies. Schedule C projects would have to fulfill Phases 3 and 4 prior to filing an Environmental Study Report (ESR) for public review.

A key component of the SWM-MP is to define and describe each type of proposed measure, followed by an evaluation in the context of identified evaluation criteria in order to develop a preferred strategy. This chapter will explain this process in detail.

12.1 Categories of Alternatives

As detailed previously, the six (6) stormwater management program elements include:

1) Municipal Pollution Prevention, Operations & Maintenance Practices,
2) Market Based Strategies for Private Property (source controls),
3) Stormwater for the Capital Roads Program (conveyance controls),
4) Stormwater Management Facilities,
5) Watercourse and Erosion Restoration, and
6) Urban Flood Management & Stormwater Infrastructure.

A summary of the six (6) stormwater management program elements and the relevant Class EA Schedule associated is detailed below. Detailed descriptions are provided in **Section 5.1** of this report.

1. **Municipal Pollution Prevention, Operations & Maintenance Practices**, follows Schedule A/A+ of the Municipal Class EA process, and therefore, is pre-approved. As such, detailed evaluations were not required.

2. **Market Based Strategies for Private Property (source controls)** fall outside of the Class EA process since they are to be constructed on private property, by the individual land

owner as a retrofit or during development/ redevelopment (i.e. the City is not the proponent).

3. **Stormwater for the Capital Roads Program (conveyance controls)** also follows Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved. As such, detailed evaluations were not required.

4. **Stormwater Management Facilities** were evaluated using the following two (2) Class EA Schedules according to the project nature:

    a. **Sediment Removal for SWM Facilities** - follows Schedule A/A+ of the Municipal Class EA process, and therefore, is pre-approved. As such, detailed evaluations were not required.

    b. **Planned SWM Facility Retrofits** – identified by the City as part of previously completed studies. Pond 48 will satisfy Class EA requirement following Schedule B of the Municipal Class EA process. Ponds 10 and 28 are currently undergoing design work.

    c. **Park Rehabilitation and SWM Enhancements (New SWM Facilities)** – follows Schedule B of the Municipal Class EA process, and therefore can proceed directly to detailed design and implementation. Selection of the preferred alternative in fulfillment of Phase 2 of the Class EA process is detailed in **Section 12.3.**

5. **Watercourse and Erosion Restoration** – follows Schedule B of the Municipal Class EA process, and therefore can proceed directly to detailed design and implementation. Selection of the preferred alternative in fulfillment of Phase 2 of the Class EA process is detailed in **Section 12.4.**

6. **The Urban Flood Management & Stormwater Infrastructure** - addresses only Phase 1 of the EA process (Problem Identification and Opportunity). As will be outlined in the subsequent Implementation Plan component of the SWM-MP (under separate cover), Phase 2 works will be completed as part of separate studies which will further the technical work that was undertaken in this study, identify alternatives and select the preferred alternative(s).

The following sections will therefore focus primarily on the documentation of the selection of the preferred approach for **Market Based Strategies for Private Property (source controls)** and fulfillment of Phase 2 of the Class EA process for elements:

- Stormwater Management Facilities (Element 4c above), and
- Watercourse and Erosion Restoration, (Element 5 above)

12.2 Selection of the Preferred Market Based Strategy (Source Control)

As discussed previously, source control measures fall outside of the Municipal Class EA process, since they are to be constructed on private property, often by the individual land owner as a retrofit or during development/ redevelopment (i.e. the City is not the proponent). This precludes source control measures from the requirements of the Class EA process.

However, in keeping with the purpose of the SWM-MP as a transparent community process by which the City can establish stormwater management guidelines and policies for the next 15 years, the following section describes the three (3) potential Market-Based Instruments scenarios and the selection of the preferred approach.

Three (3) potential scenarios involving the use of Market-Based Instruments (MBIs) to secure at-source SWM measures and practices by non-residential and multi-residential property owners were developed as part of the SWM-MP. Non-residential and multi-residential properties have been specifically targeted as they represent the greatest potential to meet identified SWM objectives as part of the SWM-MP. The residential credit program would remain unchanged from the current program, as residential source controls are a valuable component of the overall approach to SWM in the City of Waterloo. The scenarios do not include construction costs, as these costs would be the responsibility of the individual land owner as a retrofit or during development/ redevelopment.

A summary of the projected resource requirements and the associated program costs to develop and implement each scenario is discussed below. It is important to note that the scenarios assume a three-year implementation period with year one representing the design and development of the program. Three (3) potential scenarios involving the use of MBIs to secure at-source SWM measures and practices by non-residential and multi-residential property owners are summarized below.

12.2.1 MBI Scenario 1 – 10% Uptake

MBI Scenario 1 would be expected to generate uptake of at-source SWM measures by an additional 10% or 30 non-residential and multi-residential customers over a 5-year period, above existing uptake levels.

Under scenario 1, the City of Waterloo would provide “on-bill” financing at a zero (“0”) interest rate to non-residential and multi-residential customers for installation of qualifying[3] on-site SWM measures and associated design and engineering costs. Repayment would be made through the stormwater utility fee. Once the on-bill loan is repaid, the appropriate stormwater credit would be applied. With a 10% uptake over 5 years the City would secure creditable at-source SWM measures at just over 57% of all non-residential and multi-residential customers by 2025. The program would be made available to all non-residential and multi-residential customers in Waterloo. The City would provide preliminary site consultations to interested customers. These

[3] Qualifying measures to be determined and defined by the City of Waterloo.

preliminary consultations would provide customers with a general understanding of the SWM measures required, design considerations and ballpark costs.

The City would undertake both broad-based and targeted marketing of the at-source SWM zero interest loan program to non-residential and multi-residential customers. Target marketing would focus on non-residential and multi-residential customers in key watersheds/drainage sheds via direct marketing. Marketing approaches would include the following:

- Business associations such as the Kitchener-Waterloo Chamber of Commerce and Building Owners and Managers Association (BOMA);
- Direct communications (email, phone, mail);
- Advertising and articles in trade press;
- Peer-to-peer marketing; and,
- Relevant organizations and committees

Significant and on-going marketing efforts would be required to drive uptake to 10% of the non-residential and multi-residential customer base. MBI Scenario 1 is estimated to cost $1.5 million over a 5-year period, including the required 16,000 person hours as summarized in **Table 12.1.**

Table 12.1: MBI Scenario 1 Elements and Required Person Hours

DESCRIPTION	PERSON HOURS
Set up and administration of financing program[4]	10,400
On-line application process	715
Set up and administration of site consultation visit program	3,120
Site visits	1,464
Advertising and promotional materials	n/a
Advertising and promotion	n/a
Miscellaneous	n/a
Total	***15,696***

[4] Cost estimate does not include cost of debt financing.

12.2.2 MBI Scenario2 – 20% Uptake

Under MBI Scenario 2, the City of Waterloo would offer "on-bill" financing at a zero ("0") interest rate to non-residential and multi-residential customers as described in Scenario 1. In addition to the zero-interest loan program for installation of at-source SWM measures, the City would establish an incentive program to be made available to builders/developers of non-residential and multi-residential new construction projects. The City would evaluate the opportunity to determine the appropriateness of a variety of incentives and programs to support and service those interested in improving stormwater management on their non–residential properties. Approaches such as various: financing options, 'bonusing' strategies, review enhancements, and service charge reductions will be evaluated, and appropriate methods should be considered as part of the SWM-MP Implementation Plan.

With twenty percent (20%) uptake over a five-year period, the City would secure source-level SWM measures at just over 68% of non-residential and multi-residential properties by 2025.

Site consultation and design guidance with support from the City (or City-contracted third party) for existing non-residential and multi-residential SWM and new construction projects would be provided until project completion. This support function would involve guidance only and it would be the responsibility of the property owner/builder to secure a contractor or contractors.

Advertising and promotion of the programs (zero interest loan and new construction incentive) would be undertaken as described in Scenario 1. MBI Scenario 2 is estimated to cost $3.6 million over a 5-year period, including the required 40,000 person hours as summarized in **Table 12.2.**

Table 12.2: MBI Scenario 2 Elements and Required Person Hours

DESCRIPTION	PERSON HOURS
Set up and administration of financing program[5]	10,400
On-line application process	715
Set-up of incentive program for new ICI development	10,400
Administration of incentive program	9,360
Set up and administration of site consultation visits and support	6,240
Site visits and support for both programs	2,928
Advertising and promotional materials for both programs	n/a
Advertising and promotion for both programs	n/a
Miscellaneous	n/a
Total	***40,043***

[5] Cost estimate does not include cost of debt financing.

12.2.3 MBI Scenario 3 – 60+% Uptake

MBI Scenario 3 includes zero interest on bill financing for installation of qualifying at-source SWM measures as described in Scenario 1, plus a stormwater credit trading program available to non-residential and multi-residential customers. The value[6] of credits available for trading would be based on the off-set to the City's SWM infrastructure. The stormwater credit trading program would be open to all non-residential and multi-residential customers in the City. The credit trading program would be designed to facilitate implementation of at-source SWM across multiple properties, with the goal of securing drainage-shed scale SWM. By enabling aggregation of non-residential properties via stormwater credit trading, cost effective reduction in stormwater flows and non-point source contaminant loadings is achievable.

As described in Scenario 2, the City (directly or via a third-party provider) would provide preliminary site consultation and design guidance and on-going support throughout the duration of the project(s). The City would provide consultative support only and it would be the responsibility of the property owners to secure a contractor or contractors for all aspects of the SWM project.

Advertising and promotion of the zero-interest loan and stormwater credit trading programs would be undertaken as described in Scenario 1. MBI Scenario 3 is estimated to cost $38.6 million over a 10-year period, including the required 46,000 person hours as summarized in Table 12.3**.** Note: MBI Scenario 3 is implemented over a 10-year period vs. 5 years for MBI Scenarios 1 and 2).

Table 12.3: MBI Scenario 3 Elements and Required Person Hours

DESCRIPTION	PERSON HOURS (Note: 10 year implementation period)
Set-up and administration of financing & credit trading program	18,720
"Off-set" value of tradable stormwater credits[7]	n/a
On-line application process for both programs	4,160
Set up and administration of site consultation visits for both programs	12,480
Site visits and support for both programs	10,400
Advertising and promotional materials for both programs	n/a
Advertising and promotion for both programs	n/a
Miscellaneous	n/a
Total	***45,760***

12.2.3.1 Scenario 3 - Off-set Value Determination

To achieve 100% control of the urban area, a significant investment would be required to purchase additional lands in order to construct municipally owned SWM facilities. Applying a cash-in-lieu (CiL) SWM charge of $97,500/ ha (per the neighboring municipality - City of Kitchener- standard rate), which represents the rate to purchase lands and construct centralized

[6] Value assessments based on off-set of City SWM infrastructure investments (capital, asset management and operations) and ancillary cost savings (reduced liability, source water protection, I & I reduction, etc.)

[7] Assumes year 1 program set up with deferral of 100 percent of year 1 off-sets or $3.4M

municipally owned SWM facilities, a significant investment would be required over a 55 to 65-year time horizon.

Downscaling theses costs over a shorter to medium range time horizon which more accurately represents the implementation time frame of the SWM-MP, an additional investment of $76 million dollars per year would be required over a corresponding 10-year implementation period and would net approximately 786 ha of additional urban area with SWM control.

As such, the "Off-set" value of tradable stormwater credits is estimated to be equivalent to 60% of the potential municipal expenditure over the 10-year period, as detailed above (assumes a 60% uptake of source controls on non-residential and multi-residential private property). A reduction of 25% is then applied and represents the 'cost-savings' for the City of Waterloo. This places an initial value "Off-set" value of tradable stormwater credits at approximately $3.4 million/ year over the 10-year period and would translate into a savings of more than $37 million dollars over 10 years.

12.2.4 Preferred Market Based Strategy Scenario

Following a review of the three (3) Market-Based Instruments (MBIs) Scenarios, and consideration for staffing and funding requirements, a moderate approach was determined to be most in-line with the goals and objectives of the SWM-MP as well as other City programs, initiatives and strategic plans. As such, MBI Scenario 2 – 20% uptake was selected as the preferred approach as part of the SWM-MP.

With twenty percent (20%) uptake over a five-year period, the City would secure source-level SWM measures at just over 68% of non-residential and multi-residential properties by 2025.
As the SWM-MP will serve as a decision support tool as well as a methodology for the prioritization of works, and a means by which the City can establish stormwater management guidelines and policies for the next 15 years, the selection of MBI Scenario 2 as the preferred approach does not preclude the City from making enhancements over the course of time such that ultimately a combination of MBI Scenario 2 and 3 may be implemented.

Cost estimates for the preferred approach are presented in **Section 14.0**.

12.3 Evaluation of New Pond Opportunities

As discussed in **Section 9.3,** nine (9) SWM opportunities were identified as feasible for the construction of new stormwater management facilities as part of park rehabilitations based on the four (4) phase technical assessment. The SWM opportunities include:

1. Northfield Park (Site 1)
2. Laurelwood Park (Site 8)
3. Sandowne Park (Site 10)
4. Dunvegan Park (Site 3)
5. Belgreen Park / Warrington Park (Site 4)
6. Waterloo Park by LRT (Site 6)
7. Waterloo Park near Seagram Drive (Site 7)
8. Bechtel Park (Site 9)
9. Lexington Park (Site 11)

For each of the nine (9) SWM opportunity sites, six (6) alternative solutions were evaluated using baseline information collected as part of the four (4) phase technical evaluation process and a list of evaluation criteria. Scoring of the criteria produced a preferred alternative based on the highest score, which was then developed into a conceptual design.

12.3.1 Description of Evaluation Criteria

Following the EA procedure, each of the nine (9) SWM opportunity sites was evaluated for different SWM facility alternatives. For this report, the following six (6) different SWM facility alternatives were evaluated:

- Alternative 1 – "Do Nothing"
- Alternative 2 – Wet Pond
- Alternative 3 – Constructed Wetland
- Alternative 4 – Hybrid SWM Facility
- Alternative 5 – Subsurface Storage System
- Alternative 6 – Subsurface Storage System in combination with Wet Pond

Regarding the above and the preferred alternative, the following should be noted:

- Oil and Grit separators (OGS) were not evaluated as the drainage areas far exceed the maximum contributing drainage area for an OGS.

- Low impact development (LID) solutions were not evaluated independently, as the drainage areas exceed the maximum contributing drainage area for these facilities.

- A subsurface storage system in combination with wetlands and hybrid facilities was not evaluated. Typically, where a combination approach is recommended, the underlying assumption is that the site does not have sufficient area to accommodate a stand-alone practice. Therefore, due to the land requirements of hybrid and wetland facilities, it is impractical to combine them with subsurface storage facilities.

- To mitigate impacts as part of detailed design, to obtain necessary approvals and/or to mitigate impacts identified through community consultation, surface facilities may substitute for sub-surface facilities which provide equivalent function.

- Prior to implementation as part of detailed design of the preferred alternative, further consultation is required with all affected city departments, as well as the public.

Each of the alternatives is evaluated ranked using a list of relevant environmental, social, economic, and technical criteria, considering how the project will affect the environment and the surrounding community.

The following subsections provide general descriptions for each of these preliminary alternatives, followed by the evaluation of each preliminary alternative for each of the nine (9) SWM opportunity sites.

12.3.1.1 Alternative 1 – "Do Nothing"

The "Do-Nothing" option is a mandatory concept that must be considered in the Class EA process, as it helps to justify the need to undertake construction of new stormwater management facility as part of park rehabilitations. It forms the basis of comparison against all other alternatives to determine whether the solutions provide better outcomes than just leaving the site alone, by identifying the existing and long-term environmental, social, economic, and technical outcomes associated with the current condition. The 'Do Nothing' alternative would, as the name implies, involve no action, thereby leaving each site in its present state.

12.3.1.2 Alternative 2 – Wet Pond

The 'Wet Pond' alternative would involve the construction of a stormwater quality control pond at each site. The wet pond is a stormwater control facility that utilizes a permanent body of water to efficiently provide water quality, erosion and quantity control. The wet pond is constructed with a forebay (typically 1.5 to 3m in depth) designed to remove suspended sediment and a permanent pool (typically 1.5 to 3.5m in depth) to provide extended detention and continued pollutant removal. Wet ponds can be designed with extensive landscaping and associated recreational amenities, contributing to the character of the community and enhancing its potential for integration with the surrounding area. Wet ponds are particularly suitable for park settings and can be combined with adjacent trails, play structure, seating areas and lookouts as shown in the example below.

Wet Pond and Park Rehabilitation (Terraview Park, Toronto, ON)

The wet pond alternative would provide water quality benefits, has the ability to integrate well with the existing environment and also offers an aesthetic and recreation benefit to the community. This option, however, requires a moderate investment through construction costs and comes with a high operation and maintenance burden, but is less land intensive than the wetland and or hybrid systems system, and requires a moderate investment through construction costs.

12.3.1.3 Alternative 3 – Constructed Wetland

The wetland alternative would involve the construction of a large constructed wetland. Wetlands are one of the preferred stormwater management facilities for water quality enhancements, utilizing a shallow pool (0.15-0.3m) and a variety of aquatic and fringe vegetation to provide biological impacts and enhancements. The benefits of constructed wetlands include:

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

Constructed Wetlands

This alternative would provide improved water quality, habitat benefits and would satisfy safety objectives, however integration of this a wetland feature within and existing urban area can be difficult and result in poor community support. The wetland alternative also represents a high cost option as wetlands are normally more land-intensive than wet ponds because of their

shallower depth (both in the permanent pool and in the active storage zone) and due to the larger vegetation requirements.

12.3.1.4 Alternative 4 – Hybrid SWM Facility

The 'Hybrid' wet pond/ wetland option alternative, as the name implies, is a combination of wet pond element and a wetland element, connected in series. The system provides for the deep water component which will be least impacted by winter/spring conditions and the wetland component which provides enhanced biological removal during the summer months. In terms of land requirements, it falls between the amounts needed for wet ponds and wetlands.

Hybrid Wet Pond/ Wetland

The hybrid alternative has the potential to provide a more diverse range of opportunities to achieve recreational, aesthetic and ecological objectives in the context of the open space system within a community as it affords greater design flexibility and a diversity of landscape elements. The hybrid alternative would provide improved water quality, aquatic habitat potential, and would integrate well with existing infrastructure, environment and the adjacent land-use. The hybrid alternative is less costly than the wetland option and more expensive than the wet pond option, as it does require considerable land area.

12.3.1.5 Alternative 5 – Subsurface Storage Facility

Subsurface storage facilities capture and store stormwater collected from surrounding impervious areas. Storm sewers direct runoff to subsurface vaults or systems of large diameter interconnected storage pipes or chambers. Stored water is then released directly through an outlet pipe back into the storm sewer network or to natural waters at rates designed to reduce peak water flows during storms or to mimic pre-development conditions. In some cases, stored water can be allowed to infiltrate to recharge groundwater (if soil types are suitable, the groundwater table is located sufficiently below the water storage units, and no infiltration restrictions exist). Subsurface storage facilities are typically employed where pipe depths exceed 5m, due to the excess excavation and facility footprint requirements for surface facilities (wet ponds, wetlands and hybrid facilities) at that depth; where surface facilities would impact existing park uses or community spaces; or where surface facilities would impact the floodplain.

Subsurface Concrete Arched Chamber System

Underground stormwater storage facilities can provide water quality benefits when designed with a permanent water volume or when pre-treatment or baffle designs are incorporated. The addition of pre-treatment features at the system inlet can facilitate improvements to water quality by removing floatables, skimming of oils and grease and trap some level of sediments through deposition. Pre-treatment is most important if runoff is intended to be infiltrated, otherwise rapid clogging of the system could occur. Pre-treatment features can be designed and built into the system or there are commercially available, prefabricated units that can be incorporated within the system during initial planning and design. Subsurface storage facilities can also significantly improve water quantity and erosion control.

The subsurface storage alternative would provide improved water quality, would integrate well with existing infrastructure, and allow the existing park uses as park elements to be re-instated on top of the completed subsurface storage facility. This is the most expensive alternative.

12.3.1.6 Alternative 6 – Subsurface Storage Facility in combination with a Wet Pond

Alternative six (6) is a combination of alternatives 2 and alternative 5 and would consist of wet pond in combination with a subsurface storage facility. This combination allows for the most efficient use of available area, particularly with sites with space limitations and still permits the use of extensive landscaping and associated recreational amenities, contributing to the character and enhancing its potential for integration with the surrounding community.

12.3.2 Description of Evaluation Criteria

Evaluation of alternatives involves establishing alternative solutions based on the study objectives, technical considerations and criterion. The evaluation criteria considered in assessing overall applicability of each alternative are shown in **Table 12.4** and they include Physical/ Natural Environment, Social/ Cultural, Economic, and Technical/Engineering criteria. A score was then established through a multidisciplinary evaluation process for each alternative design for each criterion established. The score for each individual design option ranged from 1 to 10. A score of 1 indicates that the alternative solution scored low in relation to the criteria. Alternatively, a score of 10 indicated that the alternative solution scored high in satisfying the respective design criteria. The overall preferred design was then based on an aggregate score from all the design criteria, normalized such that each category represented 25% of the total possible score. The intent was to identify the preferred alternative to be carried forward to detailed design **Table 12.4** to **Table 12.8** provide further information with respect to description of the criteria and the method uses in assigning a score to each criterion.

Table 12.4: Criteria used in Evaluation Process for selecting the Preferred Retrofit Options

Environmental Assessment Categories	Criteria
Physical/ Natural Environment (6)	• Potential Aquatic Habitat Benefit • Potential Water Quality Benefit • Potential to Reduce Erosion • Potential to Reduce Flooding • Potential to Improve Terrestrial Habitat • Integration with Existing Environment
Social/ Cultural (6)	• Aesthetic / Recreation • Integration with other City plans, policies and initiatives (programs) • Compatibility with Adjacent Land Use • Community Disruption • Public Health and Safety Objectives • Potential to Provide Public Safety Objectives – Physical Characteristics
Economic (4)	• Construction Costs • Long term Operation Maintenance Costs • Life Cycle Costs (Capital and O&M costs) • Infrastructure Protection
Technical/Engineering (4)	• Ease of Implementation • Agency Acceptance • Technical Feasibility • Integration with Existing Infrastructure

Table 12.5: Description of Physical/ Natural Environment Criteria used for Selection of the Preferred Alternative

Criteria	Description of Criteria	Measures for Assigning Scores
Potential Aquatic Habitat Benefit	Potential to improve aquatic habitats or systems. Scoring considers sensitivity of local receiving stream (fish type), stream order (size of stream) as well as quality and type of potential habitat created.	Scoring ranges from 10 if the SWM facility alternative provides reduced flows and improved thermal mitigation; to 1 if the alternative does not reduce flows and improve thermal mitigation.
Potential Water Quality Benefit	Potential for the SWM facility alternative to improve water quality based on existing water quality conditions and ability to provide enhanced water quality control (to the maximum extent possible based on available area) per the MECP requirements.	Scoring ranges from 10 if the SWM facility alternative provides an estimated 100% of the required enhanced water quality control volume; to 1 if the alternative provides less than an estimated 50% of the required enhanced water quality control volume. In this manner, each 5% increment between 50% and 100% is equal to an additional score of plus 1.
Potential to Reduce Erosion	Potential to reduce erosion in local receiving streams based on the potential ability to provide the required erosion control volumes (to the maximum extent possible based on available area) per the MECP requirements.	Scoring ranges from 10 if the SWM facility alternative has a high potential to provide the required 25mm of extended detention volume over 24 hours per the MECP; to 1 if the SWM facility alternative has a low potential to provide the required erosion control benefits.
Potential to Reduce Flooding	Potential to reduce the potential for flooding for properties adjacent to and / or downstream properties. Proposed alternative must maintain or improve existing flood control (if any).	Scoring ranges from 10 if the SWM facility alternative has a high potential to reduce flooding on adjacent and downstream properties; to 1 if the SWM facility alternative has the potential to increase flooding.
Potential to Improve Terrestrial Habitat	Potential for the SWM facility alternative to improve terrestrial habitat conditions for native species and/or to create new habitat	Scoring ranges from 10 if the proposed SWM facility alternative has a high potential to improve terrestrial habitat conditions and/or to create new habitat to 1 if there is limited or no potential.
Integration with Existing Environment	Potential to integrate the SWM facility alternative into the existing natural landscape. Scoring based on the potential impact to existing vegetation, watercourses, wetlands and associated habitats	Scoring ranges from 10 if the proposed SWM facility alternative does not impact existing vegetation, watercourses, wetlands and associated habitats; to 1 is significant impacts and loss of existing vegetation, watercourses, wetlands and associated habitats are anticipated.

Table 12.6: Description of Social/ Cultural Criteria used for Selection of the Preferred Alternative

Criteria	Description of Criteria	Measures for Assigning Scores
Aesthetic / Recreation	Potential for SWM facility alternative to become an asset to the community by integrating and improving the existing site activities (walking, jogging, cycling biking and hiking) and/or improve the site aesthetics.	Scoring ranges from 10 if the proposed SWM facility alternative has a high potential to integrate the facility into existing activities and/or improve aesthetics; to 1 if there is minimal potential and/or existing site uses will be lost to the community.
Integration with other City plans, policies and initiatives (programs)	Potential for SWM facility alternative to integrate with other City plans, policies and initiatives (programs) including but limited to: The Parks Master Plan (park planning, park rehabilitations and service levels), urban forestry objectives, PARTS planning, cycling and trails master plans etc.	Scoring ranges from 10 if the proposed SWM facility alternative has a high potential to complement existing City plans, policies and initiatives (programs); to 1 if the proposed SWM facility alternative impedes existing City plans, policies and initiatives.
Compatibility with Adjacent Land Use	Potential for SWM facility alternative to integrate with the adjacent land uses in regards to aesthetics, community expectations. It includes consideration for existing site uses and the expectation that adjacent residents have in maintaining these uses.	Scoring ranges from 10 if the proposed SWM facility alternative has a high potential to integrate with land uses in regards to aesthetics, community expectations; to 1 if the proposed SWM facility alternative does not integrate well and as such would require a change to how the site is perceived and therefore used by adjacent land owners.
Community Disruption	The potential of the alternative to disrupt the community and or site uses (including businesses) during, or after the construction process.	Scoring ranges from 10 if the proposed SWM facility alternative has a low potential for community disruption or disruption to the site uses during, or after the construction process; to 1 if the potential for community disruption is high.
Public Health and Safety Objectives	Public health and safety include risks to the community including: west nile virus, algae blooms, impacts to roads, footbridges, public trails, and existing critical infrastructure.	Scoring ranges from 10 if there is no health & safety risks associated with the proposed SWM facility alternative or risk can be appropriately mitigated to 1 if significant public health and safety risks exist or could exist. .
Potential to Provide Public Safety Objectives – Physical Characteristics	Potential to meet public safety objectives. Scoring based on physical characteristics if the proposed SWM facility alternative and can be implemented with appropriate side slopes, open water depths, proximity to adjacent properties etc. to ensure agency, City and industry safety standards can be accommodated.	Scoring ranges from 10 if the proposed SWM facility alternative does not increase current safety considerations and all agency, City and industry safety standards can be accommodated; to 1 if the proposed SWM facility alternative cannot meet standards.

Table 12.7: Description of Economic Criteria used for Selection of the Preferred Alternative

Criteria	Description of Criteria	Measures for Assigning Scores
Construction Costs	The relative estimated cost as compared to the other alternatives of the proposed SWM facility alternative based on factors such as location, access/egress and disposal of excavated material based on most current O.Reg. and environmental policies	Scoring ranges from 10 if the relative capital cost, based on the identified factors, is low; to 1 if the relative capital cost is high.
Long term Operation Maintenance Costs	The relative cost of operating and maintaining the proposed SWM facility alternative based on factors such as access/ egress, sediment drying capability, ongoing cost, future permit requirements, maintenance access overall maintenance frequency and intensity.	Scoring ranges from 10 if the relative operation and maintenance cost, based on based on factors such as access/ egress, sediment drying capability, ongoing cost, future permit requirements, maintenance access overall maintenance frequency and intensity is low; to 1 if the relative operation and maintenance cost is high.
Life Cycle Costs (Capital and O&M costs)	The relative estimated life cycle cost as compared to the other alternatives of the SWM facility alternative based on the capital costs and operation and maintenance costs over the facility lifespan, including rehabilitation, refurbishment and or replacement at the end of the facility life expectancy.	Scoring ranges from 10 if the relative life cycle cost based on the capital costs and operation and maintenance costs over the facility lifespan, including rehabilitation, refurbishment and or replacement at the end of the facility life expectancy is low; to 1 if the relative life cycle cost is high.
Infrastructure Protection	Potential for the proposed SWM facility alternative to protect existing or future infrastructure including storm sewers and outfalls; as well as the protection of the facility function itself into the future (includes potential for damage based on proximity to erosion sites, migrating channels and or floodplains)	Scoring ranges from 10 if the alternative protects existing/proposed infrastructure thereby reducing risk; to 1 if existing/proposed infrastructure is left unprotected and represents a risk over the long term.

Table 12.8: Description of Technical/Engineering Considerations Criteria used for Selection of the Preferred Alternative

Criteria	Description of Criteria	Measures for Assigning Scores
Ease of Implementation	The relative ease with which the proposed SWM facility alternative can be implemented taking into consideration approvals, public consultation requirements (adjacent landowner acceptance) and length of time to implement (construction time).	Scoring ranges from 10 if the proposed SWM facility alternative can be implemented easily; to 1 if there are potential major hurdles associated with implementation.
Agency Acceptance	The willingness of representative agencies (City of Waterloo, GRCA, DFO, MNRF, RMOW) to accept the proposed SWM facility alternative based on relevant policy constraints.	Scoring ranges from 10 if the proposed SWM facility alternative agrees all with existing policies; to 1 if the alternative contravenes all existing policies.
Technical Feasibility	The proposed SWM facility alternative is practical and can be feasibly implemented based on the existing infrastructure and available area etc. per the four (4) phase process.	Scoring ranges from 10 if the proposed SWM facility alternative is technically feasible based on the four (4) phase process; to 1 if the implementation of the alternative is faced with mounting difficulties.
Integration with Existing Infrastructure	Potential for the SWM facility alternative to be integrated into existing site infrastructure. Scoring based on integration with nearby watercourses, and infrastructure, pumping station, storm and sanitary sewers, roadways, park elements, surface walkways, trails and pedestrian bridges.	Scoring ranges from 10 if the proposed SWM facility alternative has the ability to integrate with the existing infrastructure including park infrastructure without removals; to 1 if the proposed SWM facility alternative would require removals or significant relocation of existing infrastructure.

12.3.3 Selection of Preferred Alternatives

As discussed previously, **Section 9.3** describes the identification process for each of the nine (9) SWM opportunities which were identified as feasible for the construction of new stormwater management facilities as part of park rehabilitations based on the four (4) phase technical assessment. This process which describes each site in full, is document within a report titled "**SWM-MP Municipal Class EA - End-of-Pipe SWM Facility Opportunities Report (May 2019)"** was prepared. This supporting technical document to the SWM-MP is included as **Appendix I.**

The following sections details the evaluation process for each site, identifies the preferred alternative and presents a conceptual design based on the preferred alternatives. **Table 12.9** summarizes the preferred alternative for each of the nine (9) SWM opportunities.

Table 12.9: Preferred Alternative (Evaluation Process Summary)

Location	Preferred Alternative
Northfield Park (Site 1)	Subsurface Storage Facility
Laurelwood Park (Site 8)	Subsurface Storage Facility with Bioswale
Sandowne Park (Site 10)	Subsurface Storage Facility
Dunvegan Park (Site 3)	Subsurface Storage Facility
Belgreen Park / Warrington Park (Site 4)	Subsurface Storage Facility
Waterloo Park (by LRT) (Site 6)	Subsurface Storage Facility
Waterloo Park (Seagram Drive) (Site 7)	Subsurface Storage Facility
Bechtel Park (Site 9)	Subsurface Storage Facility
Lexington Park (Site 11)	Subsurface Storage Facility

The following sections present the existing conditions, evaluation results, preferred alternative, and accompanying conceptual design. The following should be noted:

- A score of 10 indicates that the retrofit design alternative score high in satisfying the respective design criteria
- A score of 1 indicates the retrofit design option scored low in relation to the criteria.
- The score for each of the six (6) alternatives has been normalized such that each category represented 25% of the total possible score.
- The accompanying conceptual design of each preferred alternative is a concept only and is intended to demonstrate 'feasibility' of the preferred option. At the detailed design stage, alternative SWM facility configurations and features, park feature and locations, trails integration, associated planting and forestry etc. must be considered and addressed appropriately.

12.3.3.1 Construction Cost Estimates Summary

The total cost of implementation for all nine (9) SWM opportunities is estimated between $19.8 and $25.5 million. Individual facilities range in price from $0.72 million up to $4.59 million. Specific cost estimates for each preferred approach can be found under in **Table 14.8** under **Section 14.0**.

12.3.3.2 Northfield Park (Site 1)

Owned by the City of Waterloo, Northfield Park is located on Northfield Dr. W., east of the intersection with Westmount Road, and is a 0.8 ha park characterised by a sports field. **Figure 12.1** presents the existing condition. The preferred alternative for Northfield Park is Alternative 5 - Subsurface Storage Facility (**Table 12.10**). A conceptual design is presented as **Figure 12.2.**

Table 12.10: Northfield Park Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**18**	**18**	**18**	**20**	**21**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	5	3	4	9	10
Potential to Reduce Erosion	1	9	7	8	10	10
Potential to Reduce Flooding	1	8	6	7	9	9
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**23**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	5	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	10	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Charact.	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**16**	**13**	**15**	**12**	**15**
Construction Costs	10	6	4	5	2	3
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	4	5	3	5
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**11**	**11**	**11**	**23**	**11**
Ease of Implementation	10	3	3	3	7	3
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	1	1	1	10	1
Total Normalized Score (1+2+3+4: Score out of 100)	**73**	**54**	**51**	**52**	**79**	**59**

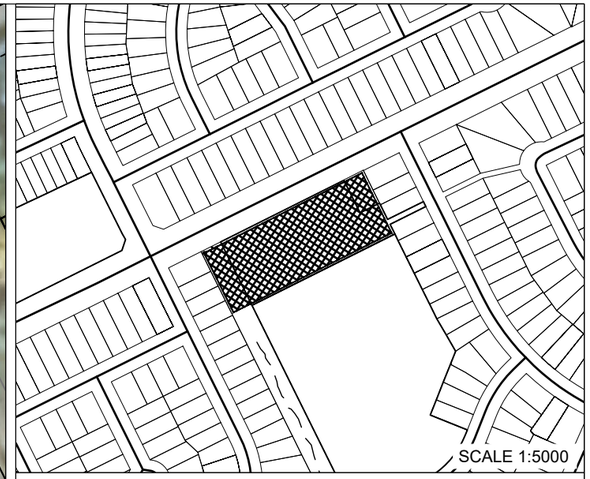
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 1: Northfield Park

Ownership: City of Waterloo
Current Use: Sports Field (Soccer Field)
Total Area: 1.3ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.8ha
Drainage Area: 49ha
TIMP %: 57%
Inlets at: 1350mm Ø stormsewer
Depth to Pipe Invert at Inlet: 2.9m
Outlets to: Existing Stream
Depth to Pipe Invert at Outlet: N/A
Floodplain Present: No
Mature Trees: No
Identified Conflicts:
•None Identified

Notes:
•Asphalt pedestrian walkway along western side of park; outlet would have to pass beneath.
•School grounds immediately adjacent to the south.
•Priority Location.

Meters
0 10 20 40

Figure 12.2: Northfield Park Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: SPORTS FIELD (SOCCER)
TOTAL SITE AREA: 1.3ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 0.8ha
DRAINAGE AREA: 49ha
TIMP % : 57%
FLOODPLAIN PRESENT : NO
MATURE TREES: NO
INLETS AT: 1350mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 2.9m
OUTLETS TO: EXISTING STREAM
DEPTH TO PIPE INVERT AT OUTLET: N/A
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 7,840m^2
TOTAL FACILITY STORAGE: 7,170m^3
TARGET WATER QUALITY STORAGE:9,400m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 76%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 4,000

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12.3.3.3 Dunvegan Park (Site 3)

Owned by the City of Waterloo, Dunvegan Park is located on Dunvegan Dr., near Bridge St. W. The site is characterized by an existing playground, tennis courts, and green space. **Figure 12.3** presents the existing condition. The preferred alternative for Dunvegan Park is Alternative 5 - Subsurface Storage Facility (**Table 12.11**). A conceptual design is presented as **Figure 12.4.**

Table 12.11: Dunvegan Park Preferred Alternative Evaluation

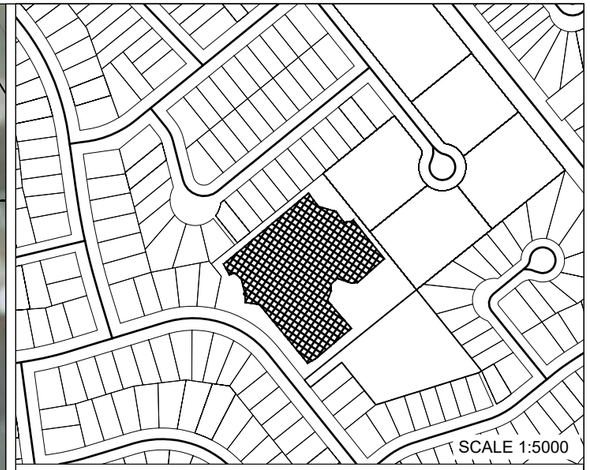
Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**22**	**24**	**23**	**21**	**22**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	10	10	10	10
Potential to Reduce Erosion	1	10	10	10	10	10
Potential to Reduce Flooding	1	10	10	10	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**25**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	10	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	10	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**16**	**15**	**16**	**14**	**17**
Construction Costs	10	6	6	6	4	5
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	5	5	4	6
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**13**	**11**	**12**	**24**	**13**
Ease of Implementation	10	4	3	3	8	4
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	4	2	3	10	3
Total Normalized Score (1+2+3+4: Score out of 100)	**75**	**60**	**59**	**59**	**82**	**64**

City of Waterloo Integrated SWM MP - Possible SWM Facility Location 3: Dunvegan Park

Ownership: City of Waterloo
Current Use: Park
Total Area: 2.2ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.8ha
Drainage Area: 56ha
TIMP %: 56%
Inlets at: 3A - 675mm Ø stormsewer,
3B - 1050mm Ø stormsewer
Depth to Pipe Invert at Inlet: 3.3m
Outlets to: 1200mm Ø stormsewer
Depth to Pipe Invert at Outlet: Unknown
Floodplain Present: No
Mature Trees: Yes (Can be protected)
Identified Conflicts:
•None Identified

Notes:
•Tennis courts adjacent to 3B have lighting, likely with buried electrical conduits that may intersect the site.
•Catchbasin and stormsewer identified in 3C but not on mapping, appearing to discharge to Dunvegan Drive.
•Available area already significant bowl shape, so potential for surface pond. Constrained by limited inlet/outlet opportunities.

Figure 12.4: Dunvegan Park Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: PARK
TOTAL SITE AREA: 2.2ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 0.9ha
DRAINAGE AREA: 23ha
TIMP % : 56%
FLOODPLAIN PRESENT : NO
MATURE TREES: YES
INLETS AT: 1050mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 3.9m
OUTLETS TO: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 3.6m
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 4,770m^2
TOTAL FACILITY STORAGE: 4,390m^3
TARGET WATER QUALITY STORAGE: 4,360m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 100%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 2,432

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12.3.3.4 Belgreen Park / Warrington Park (Site 4)

Owned by the City of Waterloo, Belgreen Park / Warrington Park is located between Belgreen Way and Warrington Dr. The site is characterized by existing tennis courts and green space. **Figure 12.5** presents the existing condition. The preferred alternative for Belgreen Park / Warrington Park is Alternative 5 - Subsurface Storage Facility (**Table 12.12**). A conceptual design is presented as **Figure 12.6.**

Table 12.12: Belgreen Park / Warrington Park Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**17**	**17**	**17**	**20**	**20**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	4	2	3	8	9
Potential to Reduce Erosion	1	8	6	7	10	10
Potential to Reduce Flooding	1	7	5	6	8	8
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**25**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	10	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	10	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**16**	**13**	**15**	**12**	**15**
Construction Costs	10	6	4	5	2	3
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	4	5	3	5
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**11**	**11**	**11**	**23**	**11**
Ease of Implementation	10	4	3	3	7	4
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	1	1	1	10	1
Total Normalized Score (1+2+3+4: Score out of 100)	**75**	**54**	**49**	**51**	**78**	**59**

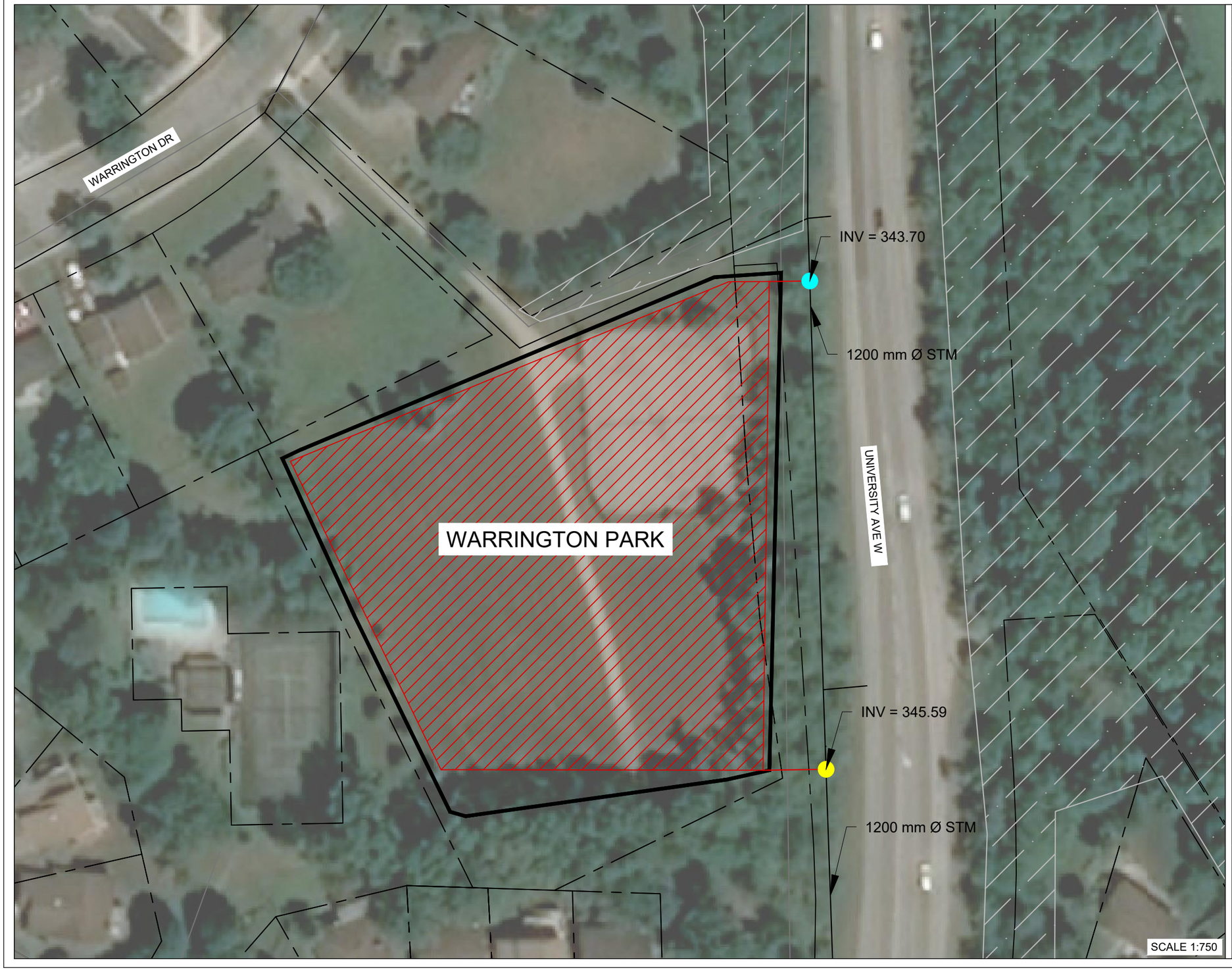
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 4: Belgreen Park / Warrington Park

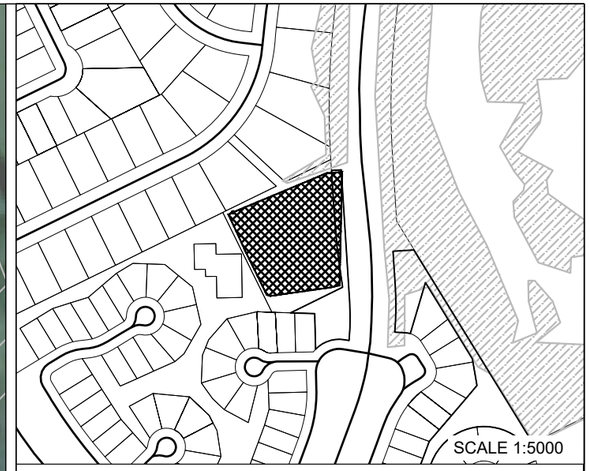
Ownership: City of Waterloo
Current Use: Park
Total Area: 0.85ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.7ha
Drainage Area: 45ha
TIMP %: 60%
Inlets at: 1200mm Ø stormsewer
Depth to Pipe Invert at Inlet: 2.8m
Outlets to: 1200mm Ø stormsewer
Depth to Pipe Invert at Outlet: 2.5m
Floodplain Present: No
Mature Trees: Yes
Identified Conflicts:
•None Identified

Notes:
•Tennis courts currently undergoing upgrade. Lights are present likely with buried electrical conduits that may intersect the site.
•Vegetated berm present between site and University Ave, but existing catch basin and stormsewer connection present.
•Stormsewer along University Ave located in the boulevard, reducing traffic disruptions during construction.

0 15 30 60 Meters

Figure 12.6: Belgreen Park/Warrington Park Conceptual Design





LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: PARK
TOTAL SITE AREA: 0.85ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 0.7ha
DRAINAGE AREA: 45ha
TIMP % : 60%
FLOODPLAIN PRESENT : NO
MATURE TREES: YES
INLETS AT: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 2.8m
OUTLETS TO: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 2.5m
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 6,110m^2
TOTAL FACILITY STORAGE: 5,620m^3
TARGET WATER QUALITY STORAGE: 8,990m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 63%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 3,116

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12.3.3.5 Waterloo Park (by LRT) (Site 6)

Owned by the City of Waterloo, Waterloo Park is a 45 ha park in the centre of the City. Site 6 is located near the Laurier-Waterloo Park Station of the LRT. The site is characterized by an existing multi-use sports field. If the Waterloo Park Master Plan (2009) is implemented in its current design, the sports field at Site 6 will be replaced by the Ecological/Education Area with a building and parking lot. **Figure 12.7** presents the existing condition. The preferred alternative for Waterloo Park (by LRT) takes into account this future design scenario, and as such is Alternative 1 – Do Nothing (**Table 12.13**). A conceptual design is presented as **Figure 12.8.**

Table 12.13: Waterloo Park (by LRT) Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	6	23	22	21	21	23
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	8	10	10	10
Potential to Reduce Erosion	1	10	7	8	9	10
Potential to Reduce Flooding	1	10	7	7	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	10	10	10	10	10
2. Social/Cultural Environment (Score out of 25)	25	8	8	7	13	9
Aesthetic / Recreation	10	1	1	1	3	1
Integration with other City plans, policies and initiatives (programs)	10	1	1	1	2	1
Compatibility with Adjacent Land Use	10	1	1	1	2	1
Community Disruption	10	1	1	1	3	1
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	24	16	13	14	13	15
Construction Costs	10	6	4	4	3	3
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	4	4	4	5
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	21	13	13	13	15	12
Ease of Implementation	10	4	4	4	6	4
Agency Acceptance	4	3	3	3	6	3
Technical Feasibility	10	10	10	10	8	8
Integration with Existing Infrastructure	10	3	3	3	4	4
Total Normalized Score (1+2+3+4: Score out of 100)	**76**	**58**	**54**	**55**	**61**	**58**

Note: A contributing factor for the "Do Nothing" alternative scoring the highest was the proposed development plan for this area identified in the Waterloo Park Master Plan. The timetable of development and extent to which this development would be compatible with a subsurface SWM facility is unknown. The subsurface facility alternative has been provided as a conceptual design in light of the unknowns associated with this development.

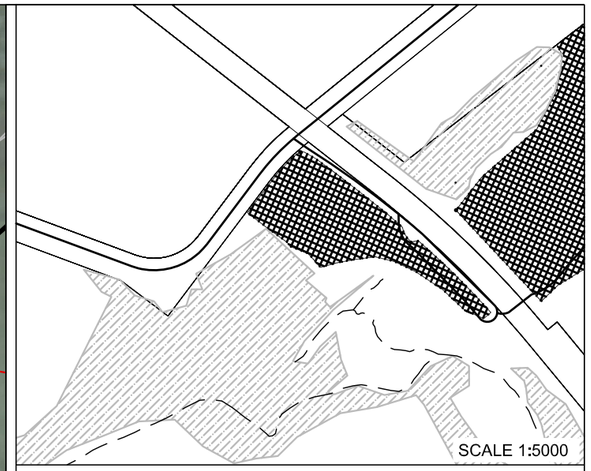
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 6: Waterloo Park (by LRT)

Ownership: City of Waterloo
Current Use: Sports Field (Soccer)
Total Area: 1.1ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.88ha
Drainage Area: 33ha
TIMP %: 63%
Inlets at: 1200mm Ø stormsewer
Depth to Pipe Invert at Inlet: 2.3m
Outlets to: Daylights to creek
Depth to Pipe Invert at Outlet: N/A
Floodplain Present: Yes
Mature Trees: No
Identified Conflicts:
•Sanitary sewer crosses field along northern edge

Notes:
•Low elevation of soccer field surface compared to outlet may be a constraint.
•Inlet from stormsewer will be within 40m of active LRT track.
•Stormsewer daylights to creek near the soccer field; proposed outlet to the creek.
•Captures drainage area of Location 7.

0 10 20 40 Meters

Figure 12.8: Waterloo Park (LRT) Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: SPORTS FIELD (SOCCER)
TOTAL SITE AREA: 1.1ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 0.88ha
DRAINAGE AREA: 33ha
TIMP % : 63%
FLOODPLAIN PRESENT : YES
MATURE TREES: NO
INLETS AT: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 2.3m
OUTLETS TO: DAYLIGHTS TO CREEK
DEPTH TO PIPE INVERT AT OUTLET: N/A
IDENTIFIED CONFLICTS: SANITARY SEWER CROSSES FIELD ALONG NORTHERN EDGE

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 3,340m^2
TOTAL FACILITY STORAGE: 3,080m^3
TARGET WATER QUALITY STORAGE: 6,710m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 46%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 1,704

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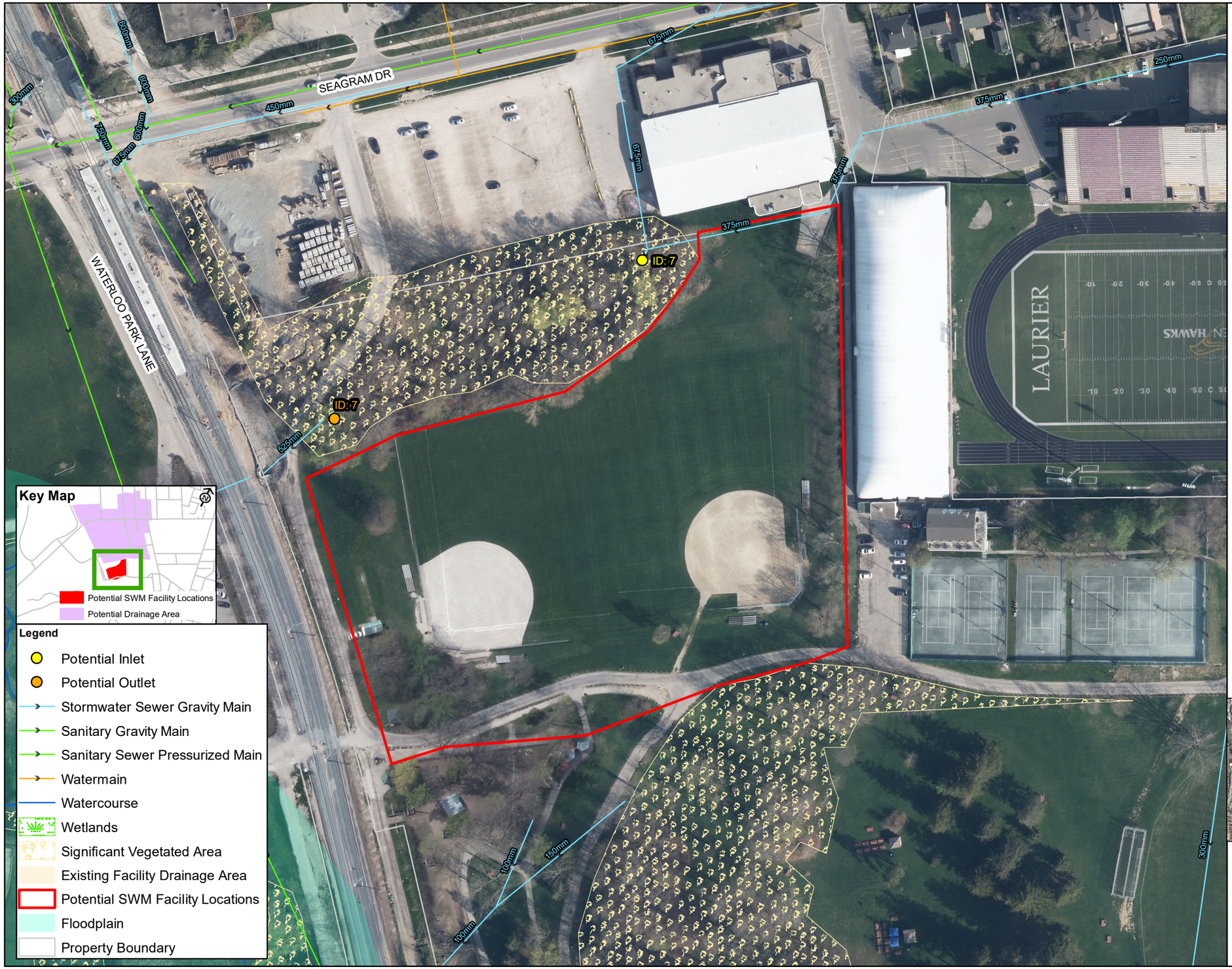
12.3.3.6 Waterloo Park (Seagram Drive) (Site 7)

Owned by the City of Waterloo, Waterloo Park is a 45 ha park in the centre of the City. Site 7 is located near Central Dr. and Seagram Dr. The site is characterized by two existing baseball diamonds. **Figure 12.9** presents the existing condition. The preferred alternative for Waterloo Park (Seagram Drive) is Alternative 5 - Subsurface Storage Facility (**Table 12.14**). A conceptual design is presented as **Figure 12.10.**

Table 12.14: Waterloo Park (Seagram Drive) Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**22**	**24**	**23**	**21**	**22**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	10	10	10	10
Potential to Reduce Erosion	1	10	10	10	10	10
Potential to Reduce Flooding	1	10	10	10	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**23**	**8**	**8**	**7**	**24**	**10**
Aesthetic / Recreation	8	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	6	1	1	1	10	1
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**16**	**15**	**16**	**14**	**17**
Construction Costs	10	6	6	6	4	5
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	5	5	4	6
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**12**	**11**	**11**	**23**	**12**
Ease of Implementation	10	4	4	4	6	4
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	2	1	1	10	2
Total Normalized Score (1+2+3+4: Score out of 100)	**73**	**57**	**58**	**56**	**82**	**61**

City of Waterloo Integrated SWM MP - Possible SWM Facility Location 7: Waterloo Park (Seagram Drive)



Ownership: City of Waterloo
Current Use: Park, Sports Field (Baseball)
Total Area: 13.5ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 2.3ha
Drainage Area: 31ha
TIMP %: 64%
Inlets at: 600mm Ø stormsewer
Depth to Pipe Invert at Inlet: 1.7m
Outlets to: Daylights to creek
Depth to Pipe Invert at Outlet: N/A
Floodplain Present: Yes
Mature Trees: Yes
Identified Conflicts:
•None identified

Notes:
•Erosion and sediment build-up noted at proposed outlet in creek channel before it enters the culvert beneath the LRT tracks. Opportunity for concurrent stream restoration.
•Proposed inlet and outlet located in Supporting Natural Feature as identified in Schedule A4 of the City of Waterloo Official Plan.
•Located in drainage area of Location 6.

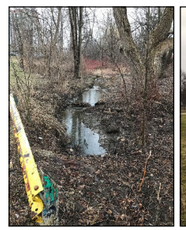
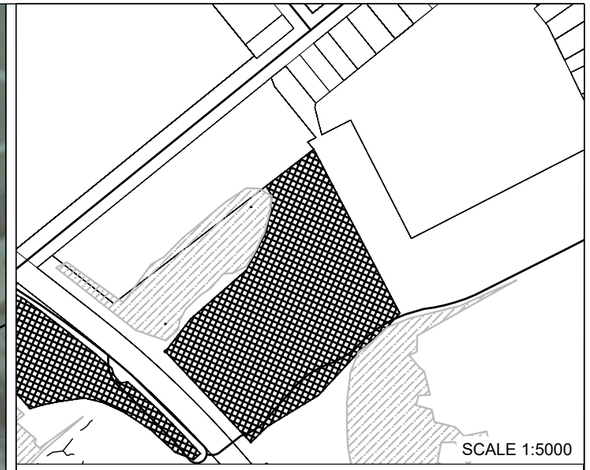


Figure 12.10: Waterloo Park (Seagram Drive) Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: PARK, SPORTS FIELD (BASEBALL)
TOTAL SITE AREA: 13.5ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 2.3ha
DRAINAGE AREA: 31ha
TIMP % : 64%
FLOODPLAIN PRESENT : YES
MATURE TREES: YES
INLETS AT: 600mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 1.7m
OUTLETS TO: DAYLIGHTS TO CREEK
DEPTH TO PIPE INVERT AT OUTLET: N/A
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 7,250m^2
TOTAL FACILITY STORAGE: 6,720m^3
TARGET WATER QUALITY STORAGE: 6,710m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 100%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 3,696

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12.3.3.7 Laurelwood Park (Site 8)

Owned by the City of Waterloo, Laurelwood Park is located on Gatestone Blvd, near Fischer-Hallman Rd. N. The site is characterized by an existing playground, baseball diamond, and trails that serve the adjacent school and community. **Figure 12.11** presents the existing condition. The preferred alternative for Laurelwood Park is Alternative 5 - Subsurface Storage Facility (**Table 12.15**). A conceptual design is presented as **Figure 12.12.**

Table 12.15: Laurelwood Park Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**22**	**24**	**23**	**21**	**22**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	10	10	10	10
Potential to Reduce Erosion	1	10	10	10	10	10
Potential to Reduce Flooding	1	10	10	10	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**22**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	7	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	6	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**18**	**15**	**16**	**14**	**17**
Construction Costs	10	8	6	6	4	5
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	6	5	5	4	6
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**10**	**10**	**10**	**23**	**10**
Ease of Implementation	10	2	2	2	6	2
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	1	1	1	10	1
Total Normalized Score (1+2+3+4: Score out of 100)	**72**	**59**	**58**	**57**	**81**	**61**

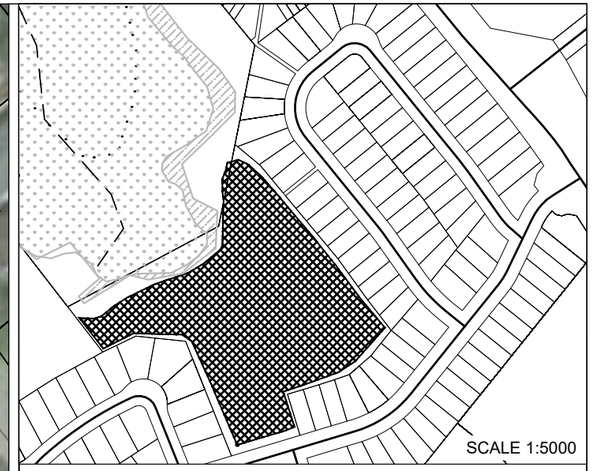
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 8: Laurelwood Park

Ownership: City of Waterloo
Current Use: Park, Sports Field (Baseball)
Total Area: 13.5ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 2.4ha
Drainage Area: 9ha
TIMP %: 56%
Inlets at: 900mm Ø stormsewer
Depth to Pipe Invert at Inlet: 1.8m
Outlets to: 900mm Ø stormsewer
Depth to Pipe Invert at Outlet: 1.7m
Floodplain Present: Yes
Mature Trees: Yes
Identified Conflicts:
•None identified

Notes:
•Many Ash trees along path painted with red spray paint and display signs of insect damage.
•Existing swale drains park to the north.

0 15 30 60 Meters

Figure 12.12 Laurelwood Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: PARK, SPORTS FIELD (BASEBALL)
TOTAL SITE AREA: 13.5ha
FORESTED AREA: 0ha
WETLAND AREA: 0ha
AVAILABLE AREA: 2.6ha
DRAINAGE AREA: 9ha
TIMP % : 56%
FLOODPLAIN PRESENT : YES
MATURE TREES: YES
INLETS AT: 900mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 1.8m
OUTLETS TO: 900mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 1.5m
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 1,835m^2
TOTAL FACILITY STORAGE: 1,720m^3
TARGET WATER QUALITY STORAGE: 1,710m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 100%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 936

TYPICAL BIOSWALE CROSS SECTION

NOT TO SCALE

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12.3.3.8 Bechtel Park (Site 9)

Partially owned by the City of Waterloo and partially by the City of Kitchener, Bechtel Park is a large park on the east side of the City. Site 9 is located in an undeveloped part of the park owned by the City of Kitchener adjacent to Conestoga Parkway. The site is adjacent to a City of Kitchener Core Natural Heritage Feature and a Region Core Environmental Feature. **Figure 12.13** presents the existing condition. The preferred alternative for Bechtel Park is Alternative 5 - Subsurface Storage Facility (**Table 12.16**). A conceptual design is presented as **Figure 12.14.**

Table 12.16: Bechtel Park Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**22**	**23**	**22**	**21**	**22**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	10	10	10	10
Potential to Reduce Erosion	1	10	10	10	10	10
Potential to Reduce Flooding	1	10	10	10	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	6	7	9	8
2. Social/Cultural Environment (Score out of 25)	**24**	**22**	**22**	**22**	**23**	**23**
Aesthetic / Recreation	10	10	10	10	10	10
Integration with other City plans, policies and initiatives (programs)	8	5	4	5	8	7
Compatibility with Adjacent Land Use	10	8	8	8	8	8
Community Disruption	10	10	10	10	10	10
Public Health and Safety Objectives	10	10	10	10	10	10
Potential to Provide Public Safety Objectives – Physical Character	10	10	10	10	10	10
3. Economic Environment (Score out of 25)	**24**	**14**	**11**	**14**	**11**	**14**
Construction Costs	10	4	2	4	1	2
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	4	3	4	3	4
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**17**	**17**	**17**	**23**	**18**
Ease of Implementation	10	4	4	4	6	5
Agency Acceptance	2	10	10	10	10	10
Technical Feasibility	10	3	3	3	10	3
Integration with Existing Infrastructure	10	10	10	10	10	10
Total Normalized Score (1+2+3+4: Score out of 100)	**74**	**74**	**73**	**75**	**78**	**76**

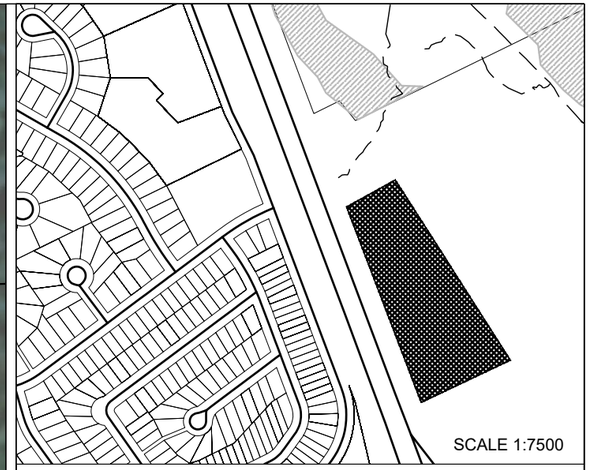
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 9: Bechtel Park

Ownership: City of Kitchener
Current Use: Park, Trails
Total Area: 8.6ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 3.1ha
Drainage Area: 36ha
TIMP %: 56%
Inlets at: 1200mm Ø stormsewer
Depth to Pipe Invert at Inlet: 6m
Outlets to: 1200mm Ø stormsewer
Depth to Pipe Invert at Outlet: Unknown
Floodplain Present: Yes
Mature Trees: Yes
Identified Conflicts:
•None identified

Notes:
•Property is owned by City of Kitchener and is adjacent to City of Kitchener Core Natural Heritage Feature and Region Core Environmental Feature.
•Vehicular access to site is limited.
•Photo below obtained from Google Street View (October 2018).

0 20 40 80 Meters

Figure 12.14: Bechtel Park Conceptual Design



LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF KITCHENER
CURRENT USE: PARK, TRAILS
TOTAL SITE AREA: 8.6ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 3.1ha
DRAINAGE AREA: 36ha
TIMP % : 56%
FLOODPLAIN PRESENT : YES
MATURE TREES: YES
INLETS AT: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 6.0m
OUTLETS TO: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 5.9m
IDENTIFIED CONFLICTS: NONE IDENTIFIED

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 7,420m^2
TOTAL FACILITY STORAGE: 6,815m^3
TARGET WATER QUALITY STORAGE: 6,750m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 100%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 3,784

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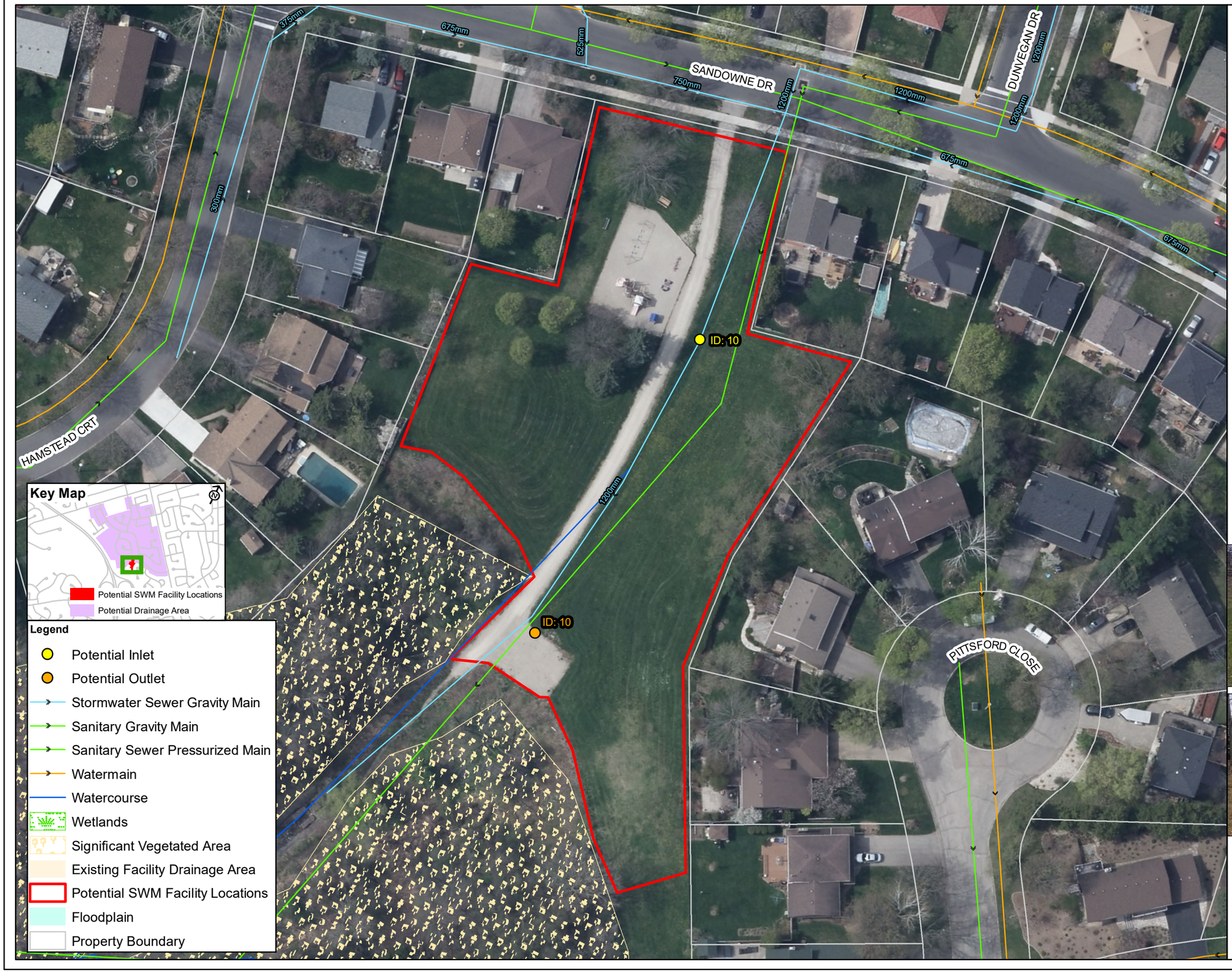
12.3.3.9 Sandowne Park (Site 10)

Owned by the City of Waterloo, Sandowne Park is located on Sandowne Dr., near Bridge St. W. The site is characterized by an existing playground and green space, which backs onto a significant vegetated area. **Figure 12.15** presents the existing condition. The preferred alternative for Sandowne Park is Alternative 5 - Subsurface Storage Facility (**Table 12.17**). A conceptual design is presented as **Figure 12.16.**

Table 12.17: Sandowne Park Preferred Alternative Evaluation

Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**15**	**15**	**14**	**18**	**19**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	3	1	2	8	9
Potential to Reduce Erosion	1	3	1	2	7	7
Potential to Reduce Flooding	1	7	5	6	8	8
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**25**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	10	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	10	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**22**	**16**	**13**	**15**	**12**	**15**
Construction Costs	10	6	4	5	2	3
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	5	4	5	3	5
Infrastructure Protection	5	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**11**	**11**	**11**	**23**	**11**
Ease of Implementation	10	4	3	3	7	4
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	1	1	1	10	1
Total Normalized Score (1+2+3+4: Score out of 100)	**73**	**51**	**47**	**48**	**77**	**58**

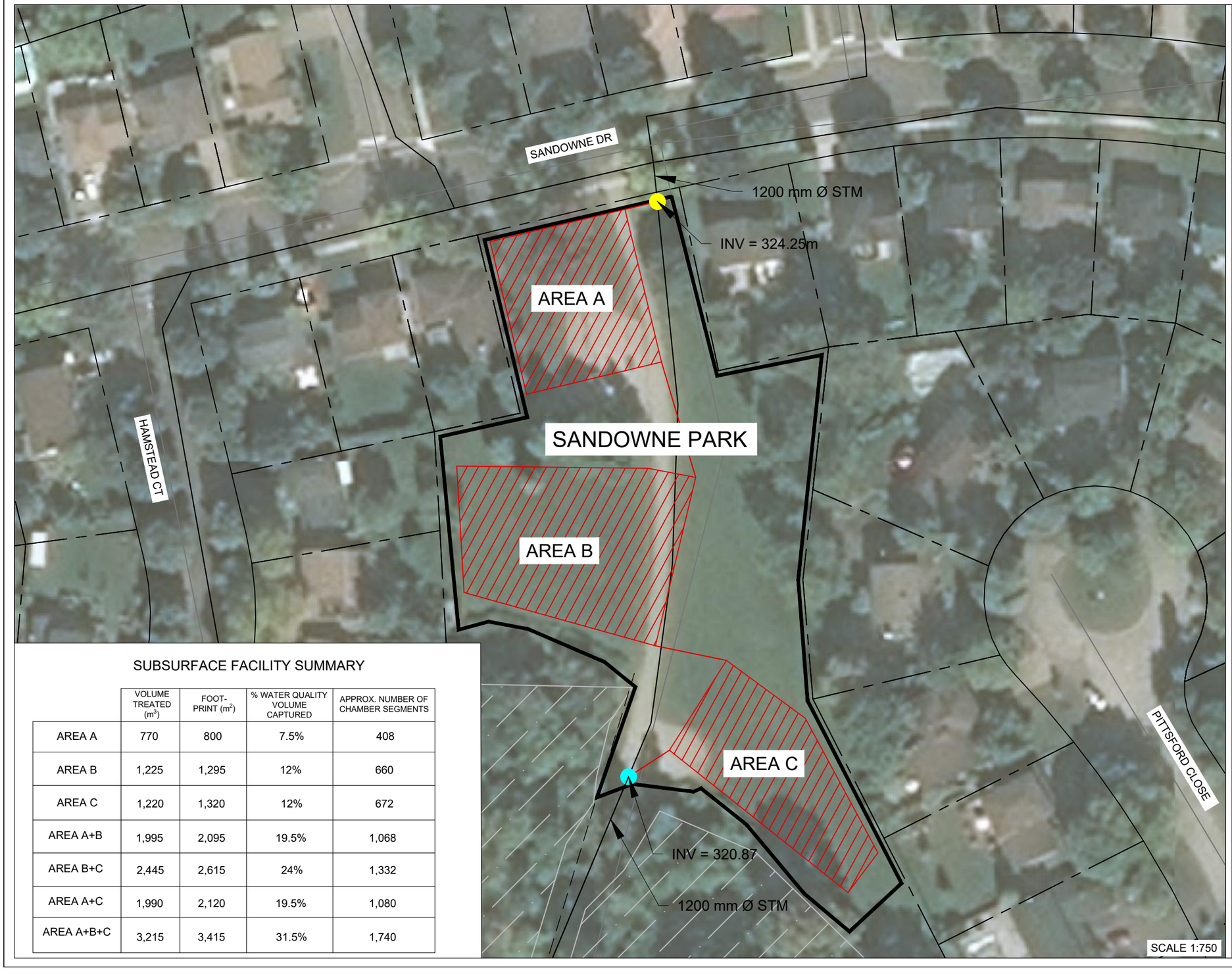
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 10: Sandowne Park

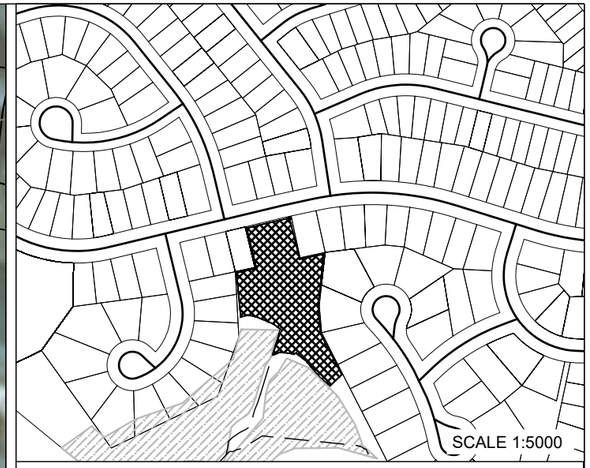


Ownership: City of Waterloo
Current Use: Park, Trails
Total Area: 1.8ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.6ha
Drainage Area: 54ha
TIMP %: 55%
Inlets at: 1200mm Ø stormsewer
Depth to Pipe Invert at Inlet: 2.8m
Outlets to: 1200mm Ø stormsewer
Depth to Pipe Invert at Outlet: Unknown
Floodplain Present: No
Mature Trees: Yes
Identified Conflicts:
•Sanitary sewer runs parallel to storm sewer

Notes:
•Ground surface slopes away from residential backyards.
•Catchbasin and manhole identified east of inlet, but not shown on mapping.
•1200mm stormsewer daylights to creek through gabion basket headwall just downstream of the proposed outlet.
•Captures drainage area of Location 3.
•Priority Location.

Figure 12.16: Sandowne Park Conceptual Design





LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: PARK, TRAILS
TOTAL SITE AREA: 1.8ha
FORESTED AREA: 0ha
WETLAND AREA: 0ha
AVAILABLE AREA: 0.6ha
DRAINAGE AREA: 54ha
TIMP %: 55%
FLOODPLAIN PRESENT: NO
MATURE TREES: YES
INLETS AT: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 3.2m
OUTLETS TO: 1200mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 3.1m
IDENTIFIED CONFLICTS: SANITARY SEWER RUNS PARALLEL TO STORM SEWER

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TARGET WATER QUALITY STORAGE: 10,211m^3
SEE TABLE FOR PERFORMANCE BREAKDOWN OF IDENTIFIED SUBSURFACE LOCATION OPTIONS

SUBSURFACE FACILITY SUMMARY

	VOLUME TREATED (m^3)	FOOT-PRINT (m^2)	% WATER QUALITY VOLUME CAPTURED	APPROX. NUMBER OF CHAMBER SEGMENTS
AREA A	770	800	7.5%	408
AREA B	1,225	1,295	12%	660
AREA C	1,220	1,320	12%	672
AREA A+B	1,995	2,095	19.5%	1,068
AREA B+C	2,445	2,615	24%	1,332
AREA A+C	1,990	2,120	19.5%	1,080
AREA A+B+C	3,215	3,415	31.5%	1,740

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12.3.3.10 Lexington Park (Site 11)

Owned by the City of Waterloo, Lexington Park is located on Lexington Rd. near Bridge St. W. The site is characterized as a baseball diamond and parking lot. **Figure 12.17** presents the existing condition. The preferred alternative for Lexington Park is Alternative 5 - Subsurface Storage Facility (**Table 12.18**). A conceptual design is presented as **Figure 12.18.**

Table 12.18: Lexington Park Preferred Alternative Evaluation

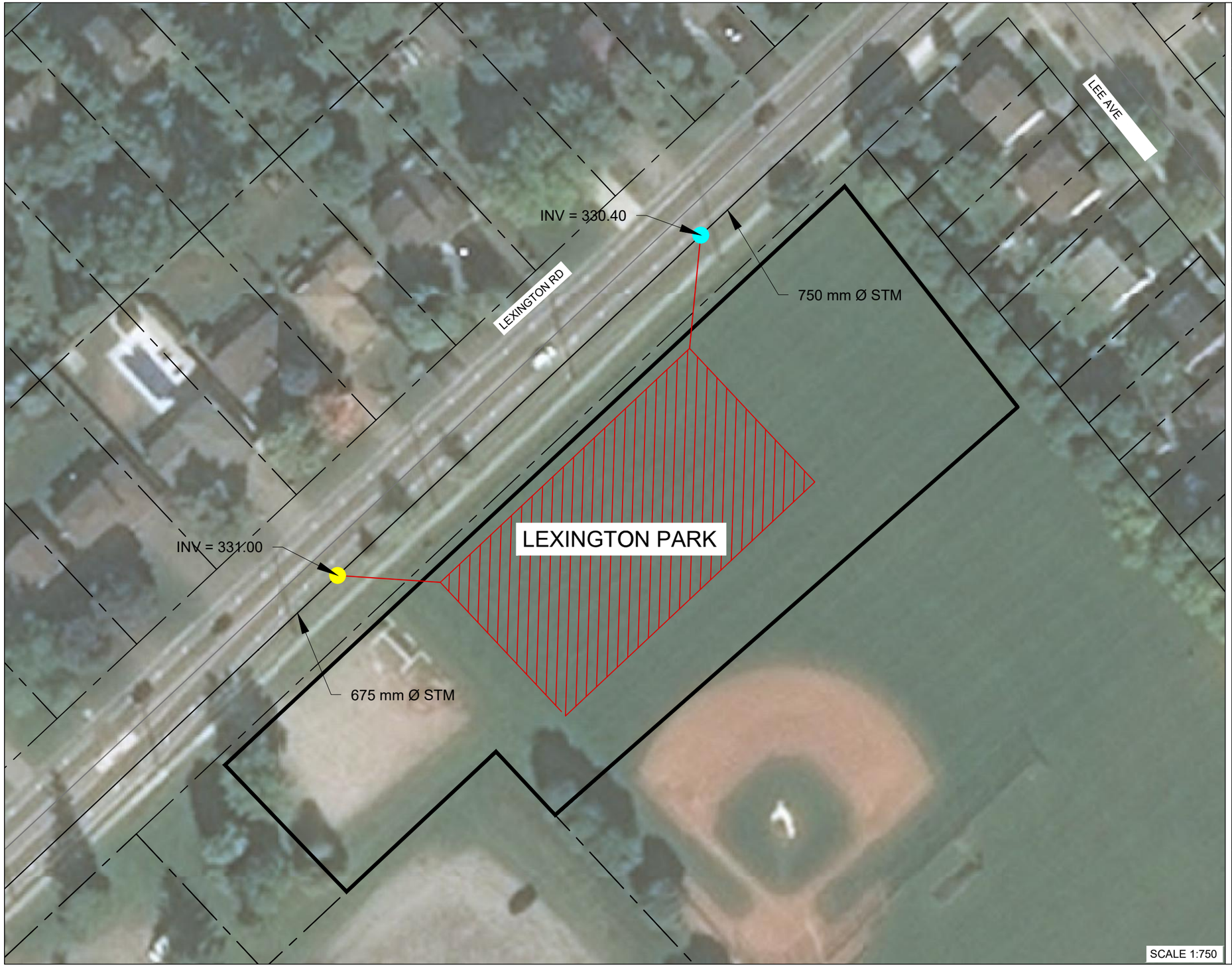
Evaluation Criteria	DO NOTHING	WET POND	CONSTRUCTED WETLAND	HYBRID FACILITY	SUBSURFACE STORAGE	SUBSURFACE STORAGE WITH WETPOND
1. Physical/Natural Environment (Score out of 25)	**6**	**22**	**24**	**23**	**21**	**22**
Potential Aquatic Habitat Benefit	1	7	10	8	8	9
Potential Water Quality Benefit	1	10	10	10	10	10
Potential to Reduce Erosion	1	10	10	10	10	10
Potential to Reduce Flooding	1	10	10	10	10	10
Potential to Improve Terrestrial Habitat	1	7	10	8	3	5
Integration with Existing Environment	10	8	8	8	10	8
2. Social/Cultural Environment (Score out of 25)	**23**	**10**	**9**	**9**	**23**	**13**
Aesthetic / Recreation	10	1	1	1	10	1
Integration with other City plans, policies and initiatives (programs)	6	5	4	5	8	7
Compatibility with Adjacent Land Use	10	1	1	1	10	1
Community Disruption	10	2	1	1	8	5
Public Health and Safety Objectives	10	6	4	5	10	8
Potential to Provide Public Safety Objectives – Physical Character	10	8	10	8	10	9
3. Economic Environment (Score out of 25)	**24**	**18**	**15**	**16**	**14**	**17**
Construction Costs	10	8	6	6	4	5
Long term O&M Costs	10	4	3	4	4	6
Life Cycle Costs	10	6	5	5	4	6
Infrastructure Protection	8	10	10	10	10	10
4. Technical/Engineering Considerations (Score out of 25)	**20**	**14**	**14**	**14**	**24**	**16**
Ease of Implementation	10	7	6	6	8	7
Agency Acceptance	2	3	3	3	10	3
Technical Feasibility	10	10	10	10	10	10
Integration with Existing Infrastructure	10	3	3	3	10	5
Total Normalized Score (1+2+3+4: Score out of 100)	**73**	**63**	**61**	**61**	**82**	**67**

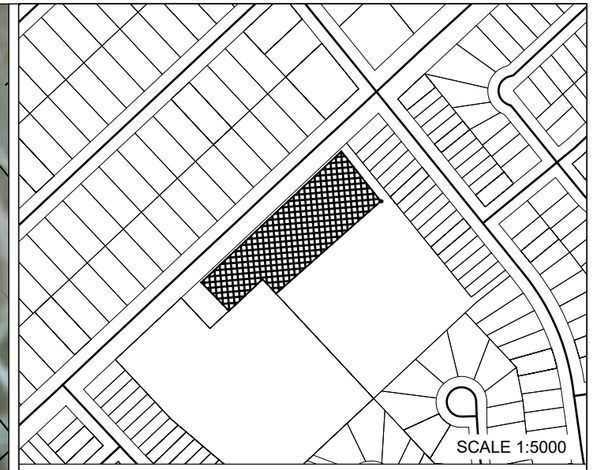
City of Waterloo Integrated SWM MP - Possible SWM Facility Location 11: Lexington Park

Ownership: City of Waterloo/ Unknown
Current Use: Gravel Parking Lot, Sports Field (Baseball)
Total Area: 2.3ha
Forested Area: 0ha
Wetland Area: 0ha
Available Area: 0.75ha
Drainage Area: 10ha
TIMP %: 61%
Inlets at: 675mm Ø stormsewer
Depth to Pipe Invert at Inlet: 1.4m
Outlets to: 750mm Ø stormsewer
Depth to Pipe Invert at Outlet: 1.5m
Floodplain Present: No
Mature Trees: No
Identified Conflicts:
Washrooms located between parking lot and baseball diamond, but no servicing marked on maps.

Notes:
•Three monitoring wells located adjacent to washrooms.

Figure 12.18: Lexington Park Conceptual Design





LEGEND

- PROPOSED SUBSURFACE STORAGE FACILITY
- PROPOSED SITE LOCATION
- PROPOSED SITE BOUNDARY
- SIGNIFICANT VEGETATED AREA
- WETLANDS
- EXISTING WATERCOURSE
- EXISTING PROPERTY LINE
- PROPOSED STORM PIPE EXTENTION
- EXISTING STORM SEWER
- EXISTING SANITARY SEWER
- EXISTING FLOODPLAIN BOUNDARY
- PROPOSED INLET LOCATION
- PROPOSED OUTLET LOCATION

CURRENT CONDITIONS:

OWNERSHIP: CITY OF WATERLOO
CURRENT USE: SPORTS FIELD (BASEBALL), GRAVEL PARKING LOT
TOTAL SITE AREA: 2.3ha
FORESTED AREA: 0ha
WETLAND AREA: 0 ha
AVAILABLE AREA: 0.75ha
DRAINAGE AREA: 10ha
TIMP %: 61%
FLOODPLAIN PRESENT: NO
MATURE TREES: NO
INLETS AT: 675mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT INLET: 1.4m
OUTLETS TO: 750mm Ø STORMSEWER
DEPTH TO PIPE INVERT AT OUTLET: 1.5m
IDENTIFIED CONFLICTS: WASHROOMS LOCATED BETWEEN PARKING LOT AND BASEBALL DIAMOND, BUT NO SERVICING MARKED ON MAPS

PROPOSED FACILITY DESIGN:

SYSTEM: SUB-SURFACE INFILTRATION GALLERY
TOTAL FACILITY AREA: 2,120m^2
TOTAL FACILITY STORAGE: 2,070m^3
TARGET WATER QUALITY STORAGE: 2,050m^3
PROPORTION OF WATER QUALITY VOLUME CAPTURED: 100%
APPROXIMATE NUMBER OF MODULAR CHAMBER SEGMENTS: 1,116

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12.4 Evaluation of Stream System Alternatives

As explained in Chapter 11, the thirty-six (36) erosion sites identified during the field walks were classified as first-order groupings of primary and secondary opportunities. The eight (8) primary opportunities represent the key projects to be considered within system-wide prioritization and implementation plan of the SWM-MP. The evaluation of alternative solutions was completed for the eight (8) primary opportunities.

For each of the sites, four (4) preliminary alternative solutions were evaluated using baseline information and a list of evaluation criteria. A series of alternatives was developed to address erosion concerns for the primary erosion issues. These alternatives are described below with specifics dependant on each particular site:

- **Alternative 1: Do Nothing** – This alternative involves leaving the site as it is and allowing erosive processes to continue within the watercourse corridor. Maintenance will have to be undertaken to address damage to infrastructure caused by the continued erosion as the damage occurs.
- **Alternative 2: Local Works** – This alternative consists of localized channel bank and/or bed work to address erosion issues at the site.
- **Alternative 3: Full Channel Restoration** – This alternative consists of a reach-based approach to address erosion issues at the site.
- **Alternative 4: Removal of Risk** – This alternative consists of moving the infrastructure at risk and allowing channel processes to continue at the site.

Scoring of the criteria produced a preferred alternative based on the highest score, which was then developed into a conceptual design. Cost estimates for engineering services (i.e., design, background studies such as geotechnical investigations) and construction costs for each of the preferred alternatives was estimated for each of the preferred alternatives for each site.

12.4.1 Description of Evaluation Criteria

As part of the Municipal Class Environmental Assessment process, each alternative must be evaluated based on a set of environmental/physical, social, and economic criteria. A set of criteria was developed specific to erosion issues. These evaluation criteria are described in **Table 12.19**.

Table 12.19: Evaluation Criteria

Evaluation Criteria	Description
Physical/Natural Environment	
Impacts to Aquatic Habitat	Ranks how the changes impact fish habitat including substrate, overhanging vegetation, turbidity, and passage/connectivity

Evaluation Criteria	Description
Impacts to Terrestrial Habitat	Ranks how the changes impact terrestrial habitat including loss of vegetation and corridor connectivity
Potential to Reduce Erosion of Public Lands	Ranks how the alternative impacts erosion risks to public lands
Potential to Reduce Erosion of Private Lands	Ranks how the alternative impacts erosion risks to private lands
Potential to Reduce Stream Bank and Stream Bed Erosion	Ranks how the alternative impacts erosion or stream bed and banks
Integration with Existing Infrastructure	Ranks how the alternative impacts existing infrastructure in the vicinity of the site
Integration with Existing Environment	Ranks how the alternatives impact the existing environment around the site
Social/Cultural Environment	
Aesthetics / Recreation	Ranks how the alternative impacts the aesthetics of the creek corridor and how the alternative impacts recreational use of the corridor
Compatibility with Adjacent Land Use	Ranks the impacts of the alternative on the adjacent properties
Community Disruption	Ranks the degree to which the surrounding community will be impacted by the alternative
Public Health and Safety	Ranks the degree to which the alternative protects public health and safety
Economic Environment	
Construction Costs	Ranks the construction cost associated with the alternative relative to other alternatives
Operation and Maintenance Costs	Ranks the upkeep costs associated with the alternative relative to other alternatives
Technical/Engineering Considerations	
Ease of Implementation	Ranks ease of implementing the alternative
Agency Acceptance	Ranks the likelihood that regulation authorities will support the alternative
Technical Feasibility	Ranks the degree of difficulty for the detailed design for the alternative

Detailed evaluation matrices for choosing the preferred alternatives are included in **Appendix L.** A summary of the evaluation of the primary opportunities is presented below in **Table 12.20**.

Table 12.20: Summary of Preferred Alternatives

Primary Erosion Issue Site Number	Preferred Remediation Alternative
LRL-E5	Removal of risk
CDR-E4	Full channel restoration
LRL-E6	Full channel restoration
FRW-E2	Local works
LRL-E7	Full channel restoration
CDR-E3	Local works
CLR-T1-E1	Full channel restoration
CLR-E4	Full channel restoration

12.4.2 Preferred Alternatives

For each of the primary erosion concerns, conceptual design was developed for the preferred alternative. The conceptual designs are described below and figures are presented in **Appendix L**.

Refer to **Section 14.0** for estimated implementation costs. **Table 14.9** of **Section 14.5** presents cost estimates for each of the identified primary erosion sites.

12.4.2.1 Laurel Creek, Site LRL-E5

The City of Waterloo completed an extensive review of record drawings and consultation with technical staff. The reason for the concrete conduit within the channel was not determined. An Ontario One Call planning locates request was also completed and none of the infrastructure identified from this request matched the location of the concrete conduit in the channel. Prior to removing the concrete conduit, exploratory field tests should be conducted to determine what it is and whether it is still in use.

Assuming that the concrete conduit is no longer in use, the preferred alternative at this site is the removal of the risk. The concrete conduit would be removed from the channel and bed and bank restoration works would be completed. Aquatic and terrestrial habitat features should be included where feasible. A geotechnical investigation may be required at the detailed design stage.

The private bridge structure should be assessed for structural condition and replaced as required. At a minimum, the failing gabion basket abutments should be replaced as part of the above channel bank restoration works.

12.4.2.2 Cedar Creek, Site CDR-E4

The preferred alternative at this site is full channel restoration. A geomorphic assessment should be completed at the onset of the detailed design to inform the restoration works. Consideration

to channel sediment transport processes should be given to assess the impacts of potential bank treatments. During the detailed design, consideration should be given to moving the trail away from the creek, where possible, and using vegetated treatments where space is available. The detailed design must also provide protection to buried sanitary sewer infrastructure.

A geotechnical investigation should be undertaken at the onset of the project to inform the design of armourstone walls, where required by space constraints.

12.4.2.3 Laurel Creek, Site LRL-E6

The preferred alternative at this site is full channel restoration. Bank protection is required downstream of the existing armourstone wall to protect the sanitary sewer line and maintenance holes. The existing protruding outfall will be retrofitted into the bank protection. Bed restoration works (i.e. grade control) will be undertaken to protect the existing sanitary sewer crossing which is currently exposed. During the detailed design, implications of the bed works on the upstream flow gauging station must be identified and addressed. A geotechnical investigation will also be required at the detailed design stage.

12.4.2.4 Forwell Creek, Site FRW-E2

The preferred alternative at this site is local works. A hydraulic assessment should be undertaken to determine the appropriate sizing for the culvert replacement. Additionally, a geotechnical investigation should be undertaken at the onset of the project to inform the culvert replacement design. Since a recreational trail, a sanitary sewer, a natural gas pipeline, and hydro lines cross the creek in this location, the utility owners should be contacted at the start of the project. Utility requirements should be identified and incorporated into the design for the culvert replacement.

12.4.2.5 Laurel Creek, Site LRL-E7

The preferred alternative at this site is full channel restoration. Due to the confined nature of the channel at this site, it is expected that armourstone walls will be required. Grade control on the channel bed will be included at the sanitary sewer crossing and elsewhere, as required, to protect the base of the armourstone wall from undermining. Vegetation plantings at the top of the armourstone wall should be included where space permits.

To inform the detailed design, a geotechnical investigation will be required at the onset of the project.

12.4.2.6 Cedar Creek, Site CDR-E3

The preferred alternative at this site is local works. A hydraulic assessment of the culvert should be performed to determine the appropriate sizing for a new culvert. A geotechnical investigation should also be completed at the onset of the project to inform the culvert and bank treatment designs. The existing culvert and gabion baskets will be removed and replaced. It is expected that armourstone walls will be required to replace the gabion baskets given the confined nature of the creek corridor. The existing gabion weir will be replaced with riffle grade control which will incorporate fish passage.

12.4.2.7 Clair Creek Tributary 1, Site CLR-T1-E1

The preferred alternative at this site is full channel restoration. The existing gabion baskets will be removed and replaced with armourstone walls. Due to the confined nature of the corridor in this area, it is expected that softer channel restoration measures will not be feasible. A

geotechnical investigation will be required at the onset of the project to inform the armourstone wall design and assess the potential construction impacts to the adjacent building.

12.4.2.8 Clair Creek, Site CLR-E4

The preferred alternative at this site is full channel restoration. The existing gabion baskets would be removed and replaced with armourstone walls and/or vegetated buttresses depending on the space available. The storm sewer headwalls will be restored and grade control will be required on the channel bed to protect the sanitary sewer crossing. The culvert condition at Columbia Street West should be assessed and replaced if required.

To inform the detailed design, a geotechnical investigation will be required at the onset of the project.

13 Description of Recommended Approach

The following sections describe the recommended approaches for the six (6) stormwater management program elements of:

1) Municipal Pollution Prevention, Operations & Maintenance Practices
2) Market Based Strategies (source controls)
3) Stormwater for the Capital Roads Program (conveyance controls)
4) Stormwater Management (SWM) Facilities
5) Watercourse and Erosion Restoration
6) Urban Flood Management & Stormwater Infrastructure

Separate detailed reports were prepared for each of the program elements detailed above and are included as technical appendices to the SWM-MP Class EA document. A summary of the six (6) stormwater management program elements as well as a description of the EA Schedule for all proposed undertakings which make up the Recommended Approaches is provided in the subsequent section.

13.1 Municipal Pollution Prevention, Operations & Maintenance Practices

Municipal Pollution Prevention, Management and Operational Practices are important to ensure pollutants are prevented from impacting the environment and to ensure existing stormwater infrastructure maintain their effectiveness. The SWM-MP explored approaches to manage pollutants and sediment within the City's stormwater management infrastructure in the most cost-effective manner. The study and resulting recommended approaches have been completed following Schedule A/A+ of the Municipal Class EA process, and therefore, are pre-approved.

13.1.1 Catch Basin Clean-out, Street Sweeping and Leaf Pick-up Program

The City of Waterloo currently operates a street sweeping and leaf collection program. It is recommended that:

- The existing street sweeping and leaf collecting programs be further investigated to assess the potential to integrate catch-basin cleaning to increase efficiency and reduce cost.
- Sediment removal from catch-basins within uncontrolled areas (areas without existing stormwater ponds or OGS units) be completed within priority subwatersheds to be detailed in the Implementation Plan.
- That clean-outs occur once catch basins reach full capacity which can be forecasted by clean-out frequencies.
- That the City investigate the installation of CB Shield™ as a pilot project on catch basins in uncontrolled drainage areas where other opportunities do not exist.

13.1.2 Oil and Grit Separator (OGS) Cleanouts

OGS units are designed to capture sediment and oils from the storm sewer network prior to stormwater being discharged. The City of Waterloo is currently responsible for the operation and maintenance of sixty-one (61) OGS units in the City. Maintenance was completed for twelve (12)

of the units in 2016 and the remainder have been prioritized based operational status or recommended for additional study within the SWM-MP.

The SWM-MP evaluated thirty-five (35) units with available information and quantified their overall maintenance requirements and concluded that ten (10) OGS units required immediate maintenance and were classified as high priority. Ultimately, all of the units will require maintenance service at some point as a condition of the Environmental Compliance Approval for their installation. OGS units classified as high and low priority which are recommended for maintenance are detailed in **Table 13.1.**

Table 13.1: High and Low Maintenance Priority OGS Units

Priority Ranking	Asset ID	Make and Model	Install Date	Loss in Sediment Storage Capacity	Maintenance Priority	Class EA Schedule
1	10080695	STC-1500	1999	292%	High Priority	Schedule A/A+
2	10080622	STC6000	2015	239%	High Priority	Schedule A/A+
3	10080647	STC-1500	1999	222%	High Priority	Schedule A/A+
4	10080563	STC-3000	2012	160%	High Priority	Schedule A/A+
5	10080569	STC-1500	1999	152%	High Priority	Schedule A/A+
6	10080521	STC-2000	2001	116%	High Priority	Schedule A/A+
7	10080649	STC-1000	2002	111%	High Priority	Schedule A/A+
8	10080618	STC-1500	2005	108%	High Priority	Schedule A/A+
9	10080651	STC-6000	1999	90%	High Priority	Schedule A/A+
10	10080515	STC-2000	2005	87%	High Priority	Schedule A/A+
11	10080568	STC-1500	2009	76%	Low Priority	Schedule A/A+
12	10080561	STC-2000	2000	73%	Low Priority	Schedule A/A+
13	10080585	STC-2000	2000	73%	Low Priority	Schedule A/A+
14	10080578	STC-4000	2000	64%	Low Priority	Schedule A/A+
15	10080646	STC-1500	1998	57%	Low Priority	Schedule A/A+
16	10080551	STC-6000	1999	54%	Low Priority	Schedule A/A+
17	10080524	STC-2000	2004	29%	Low Priority	Schedule A/A+
18	10080514	STC-1000	2005	28%	Low Priority	Schedule A/A+
19	10080579	STC-4000	2012	25%	Low Priority	Schedule A/A+
20	10080619	STC-4000	2004	19%	Low Priority	Schedule A/A+
21	10131824	STC-2000	2014	15%	Low Priority	Schedule A/A+
22	10080648	STC-6000	2002	12%	Low Priority	Schedule A/A+
23	10080660	STC-6000	2002	12%	Low Priority	Schedule A/A+
24	10080566	STC-750	2010	11%	Low Priority	Schedule A/A+

The above has been completed following Schedule A/A+ of the Municipal Class EA process, and therefore all the recommended works as detailed above are considered pre-approved. Further, the maintenance of OGS units is a legislated requirement as a condition of the Environmental Compliance Approval issued for their construction.

Refer to **Section 14.0** for estimated implementation costs.

13.1.3 Snow Storage Facility

The City of Waterloo currently operates a 0.59 ha snow storage facility whose capacity is exceeded in excessively snowy winters. As snow storage is identified as a threat to drinking water sources, eight (8) potential locations were identified to act as secondary snow storage facilities, including:

1. Woolwich Street and University Avenue East

2. Woolwich Street and Park Road
3. North of University Avenue East and Country Squire Lane
4. South of University Avenue East and RIM Park Fields Lane
5. RIM Park Fields 1
6. RIM Park Fields 2
7. Lexington Park
8. Hydro Corridor at Ladyslipper Drive

If the preferred location meets criteria outlined in the *"Guidelines on Snow Disposal and De-icing Operations in Ontario"*, the snow storage facility can be completed following Schedule A of the Municipal Class EA process, and therefore the recommended works are considered pre-approved. The criteria include:

- Accessibility – access roads and site can bear heavy truck traffic;
- Noise – dump site on level ground should be at least 1,000 ft from a residential area; if in a hollow or a noise barrier is constructed, it may be located closer to residences;
- Alternate Use of Site – use of the site for other purposes may be restricted unless remedial measures are taken, due to contaminant loading of the soil;
- Visual Considerations – the site should be screened or buffered from public view;
- Drainage Factors – the site should be removed from surface watercourses, and should be assessed for runoff rates, dilution capacity of nearest watercourse, and downstream water uses; and
- Sub-surface Drainage – site should be located where an aquifer supplying potable water is not likely to be impaired.

It is unlikely that the proposed locations will meet all of the above criteria. However, the Guidelines do state that "A site which does not fully meet the criteria outlined above may be approved if disposal to this area will result in the least adverse environmental impact of all methods available." If not approved under Schedule A, the proposed snow storage facility will likely be completed following Schedule B, although depending on the final design decision, it may fall under Schedule C.

The costs of the new snow storage facility will be determined at the site design stage. No land acquisition costs are expected, as all potential sites are currently owned by the City.

13.2 Market Based Approach (Source Control)

In 2011, the City established a stormwater utility and credit program was started in 2013 for up to 45% of the fee to encourage private landowners to implement on-site stormwater mitigation and pollution prevention measures. To support landowners implementing SWM mitigation measures such as rain gardens, bioswales, redirecting downspouts, etc., the City of Waterloo in partnership with REEP Green Solutions, provides information, resources and direct expert guidance to residential and industrial, commercial and institutional (ICI) property owners.

However, the number of applications by residents and businesses received for participating in the Stormwater Utility Credit Policy has decreased in volume recently relative to when the program was introduced in 2013. As of 2017, overall uptake sat at approximately 7.8% of all residential and 46.8% of all non-residential properties. To increase uptake of SWM and pollution prevention practices, market-based research was undertaken to develop enhancements to current SWM programming. The City of Waterloo undertook an extensive market-based research study to explore and understand the "wants and needs" of residents and businesses in order to support and service those interested in improving stormwater management on their properties. This research included a comprehensive review of leading jurisdictions in Canada and the USA, development of a demographic profile of the residents of the City of Waterloo as well as:

- Interviews with owners and managers of large institutional, commercial and industrial properties.
- A research session (October 25, 2017) with a demographically representative sample of single-family homeowners in the City.

13.2.1 Preferred Market Based Strategy – MBI Scenario 2

Following a review of the three (3) Market-Based Instruments (MBIs) Scenarios, and consideration for staffing and funding requirements, a moderate approach was determined to be most in-line with the goals and objectives of the SWM-MP as well as other City programs, initiates and strategic plans. As such, MBI Scenario 2 – 20% uptake was selected as the preferred approach as part of the SWM-MP. With twenty percent (20%) uptake over a five-year period, the City would secure source-level SWM measures at just over 25% of non-residential and multi-residential properties by 2024.

As part of the Preferred Market Based Strategy (MBI Scenario 2), the City would undertake both broad-based and targeted marketing of the at-source SWM zero interest loan program to non-residential and multi-residential customers. Targeted marketing would focus on non-residential and multi-residential customers in key watersheds/drainage sheds via direct marketing. Marketing approaches would include the following:

- Business associations such as the Kitchener-Waterloo Chamber of Commerce and Building Owners and Managers Association (BOMA);
- Direct communications (email, phone, mail);
- Advertising and articles in trade press;
- Peer-to-peer marketing; and
- Relevant organizations and committees

In addition to the zero-interest loan program for installation of at-source SWM measures, the City would establish an incentive program to be made available to builders/developers of non-residential and multi-residential new construction projects. The City would evaluate the opportunity to determine the appropriateness of a variety of incentives and programs to support and service those interested in improving stormwater management on their non–residential properties. Approaches such as various: financing options, 'bonusing' strategies, review enhancements, and service charge reductions will be evaluated and appropriate methods should

be considered as part of the SWM-MP Implementation Plan. It is proposed that the City attempt selected methods on a pilot project basis and focus on priority watersheds.

Site consultation and design guidance with support from the City (or City-contracted third party) for existing non-residential and multi-residential SWM and new construction projects would be provided until project completion. This support function would involve guidance only and it would be the responsibility of the property owner/builder to secure a contractor or contractors.

The City would provide preliminary site consultations to interested customers. These preliminary consultations would provide customers with a general understanding of the SWM measures required, design considerations and ballpark costs.

As discussed previously, source control measures fall outside of the Municipal Class EA process, since they are to be constructed on private property, often by the individual land owner as a retrofit or during development/ redevelopment (i.e. the City is not the proponent). This precludes source control measures from the requirements of the Class EA process.

Refer to **Section 14.0** for estimated implementation costs of the Recommended Approach for Source Controls & Market Based Strategies.

13.3 Stormwater for the Capital Roads Program (conveyance controls)

Targeting roads for municipal stormwater management (SWM) improvement is an important method of improving municipal SWM practices and the percentage of the urban area that currently has SWM control. The SWM-MP explored approaches to manage pollutants and sediment within the City's existing municipal ROW network. The recommended approach for conveyance control is:

- That the City update road cross section drawings, relevant sections in the Development Engineering Manual, and any future updates to the Transportation Master Plan to reflect LID opportunities as identified in this report.

- That the City investigate whether access agreements with other utilities (i.e., Bell, Rogers, etc.) may need to be altered to ensure that the installed LIDs are restored or consider implementing enhanced road cut permits which include rectification bonds. Implementation of a "Green Streets Fund" would allow for application of a fee-based system on all road cut permits where fees are equal to a nominal percentage of total capital (actual or estimated) construction budget. Collected fees would be primarily allocated to verification of appropriate rectification post construction as well as to future municipal ROW retrofit projects and operation and maintenance activities.

- That the City review the maintenance period for all ROW LID in the context of standard City of Waterloo tender and special provisions, specifically the requirement for extended contractor maintenance periods and enhanced guarantees.

- That at the detailed design stage for each capital roads project, that the project proceeds with 'twin objectives' such that the project can incorporate new SWM infrastructure to achieve SWM objectives as well as achieving Urban Forestry objectives. These 'twin objectives' are one-in-the-same from a stormwater perspective, as trees reduce stormwater impacts, flows and volumes. The various LIDs which include soil media as outlined within this report are capable of supporting trees provided adequate soils volume and depth is provided as part of detailed design per Grey to Green Road Retrofit Guide (CVC, 2013) and the LID Stormwater Planning and Design Guide (https://wiki.sustainabletechnologies.ca) and City standards. Consideration during detailed design should also be given to situations where trees are proposed as part of the current project as well as the potential for future tree planning within the same area. Provisions for future tree plantings as part of ROW Retrofit design is also therefore recommended.

- That an assessment be completed for Archaeological, Built Heritage, and Cultural Heritage Landscapes prior to implementation of the proposed conveyance controls. At a minimum, this should entail the completion of the MTCS checklists (*Criteria for Evaluating Archaeological Potential, Criteria for Evaluating Marine Archaeological Potential*, and *Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes*). Refer to **Section 3.1** for additional assessment details.

Refer to **Section 14.0** for estimated implementation costs.

13.4 Stormwater Management Facilities

The Recommended Approach for Stormwater Management Facilities is comprised of three (3) individual elements of:

1. Sediment Removals from Existing SWM Facilities
2. Planned SWM Retrofits
3. Park Rehabilitation and SWM Enhancements

13.4.1 Sediment Removals

The City of Waterloo inventory includes fifty-nine (59) City-maintained SWM facilities that require regular maintenance (not including natural ponds). The SWM-MP determined the effect of sediment accumulation on existing SWM facilities and developed a prioritized list of those requiring maintenance based on the amount of sediment within each facility and the effect of this accumulation in terms of loss in storage or decrease in performance. The SWM facilities were grouped according to the facility type (i.e. Dry versus Wet Facilities).

Dry facilities (only have water in them during certain storm events) focus on quantity control and were assessed based on the loss in storage capacity. Wet Facilities are designed to provide quality control via a permanent water pool to allow the accumulation of sediment from stormwater.

The Dry versus Wet Facilities classification was selected in order to remove uncertainty relating to changes in facility type over time (e.g. Facility 62 originally designed as a dry pond but functions

as a wet pond). For this analysis all facilities that lacked a designed permanent pool based on their available design reports, were classified as 'dry facilities". Wet Facilities are defined as those facilities with a permanent pool (per the original design brief), which includes wetlands.

Wet facility sizing is based on the level of protection to be provided in terms of Total Suspended Solid Removal (TSS). A decrease in performance was represented as a loss in efficiency/level of protection due to sediment accumulation. Maintenance requirements (i.e. clean-outs) were prioritized accordingly. The SWM-MP recommendations included:

- Of the twelve (12) Dry facilities that were analyzed:
  - Two (2) were assessed as High Priority (highly vegetated)
  - One (1) were assessed as Moderate Priority (6-20% Loss)
  - Nine (9) were assessed as Low Priority (1 -5% Loss)

- Of the twenty-four (24) Wet facilities that were analyzed:
  - Five (5) were assessed as High Priority
  - Nine (9) were assessed as Moderate Priority
  - Ten (10) were assessed as Low Priority

Dry facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table 13.2.**

Wet facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table 13.3.**

Table 13.2: Dry Facilities - High, Moderate and Low Maintenance Priority Sediment Removals

Priority Ranking	SWM Facility #	Year of Construction	Type of Facility	Decrease in Storage Capacity	Maintenance Priority	Class EA Schedule
1	36	1988	Dry Pond	2%	High Priority	Schedule A/A+
2	8*	1991	Dry Pond	2%	High Priority*	Schedule A/A+
3	16	1994	Dry Pond	7%	Moderate Priority	Schedule A/A+
-	22	1997	Dry Pond	12%	Low Priority	Schedule A/A+
-	13	1995	Dry Pond	5%	Low Priority	Schedule A/A+
-	18*	1986	Dry Pond	3%	Low Priority*	Schedule A/A+
-	6	2014	Dry Pond	3%	Low Priority	Schedule A/A+
-	2*	1987	Dry Pond	3%	Low Priority*	Schedule A/A+
-	32	1992	Dry Pond	2%	Low Priority	Schedule A/A+
-	26	1989	Dry Pond	2%	Low Priority	Schedule A/A+
-	9*	1985	Dry Pond	1%	Low Priority*	Schedule A/A+
-	23	1992	Dry Pond	0%	Low Priority	Schedule A/A+

*Dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits under schedule A/A+

Table 13.3: Wet Facilities - High, Moderate and Low Maintenance Priority Sediment Removals

Priority Ranking	SWM Facility #	Year of Construction	Type of Facility	% of Maximum Allowable Sediment Accumulation	Maintenance Priority	Class EA Schedule
1	51	2000	Wet	321%	High Priority	Schedule A/A+
2	42	1998	Wet	317%	High Priority	Schedule A/A+
3	1	2000	Wet	266%	High Priority	Schedule A/A+
4	27	2000	Wet	254%	High Priority	Schedule A/A+
5	45	1999	Wet	232%	High Priority	Schedule A/A+
6	49	2002	Wet	191%	Moderate Priority	Schedule A/A+
7	35	2002	Constructed Wetland	162%	Moderate Priority	Schedule A/A+
8	59	2002	Constructed Wetland	162%	Moderate Priority	Schedule A/A+
9	25	1986	Wet	138%	Moderate Priority	Schedule A/A+
10	15	1995	Wet	135%	Moderate Priority	Schedule A/A+
11	29	2000	Wet	131%	Moderate Priority	Schedule A/A+
12	57	2001	Wet	120%	Moderate Priority	Schedule A/A+
13	58	2003	Wet	119%	Moderate Priority	Schedule A/A+
14	62	2000	Wet	107%	Moderate Priority	Schedule A/A+
-	34	1997	Wet	95%	Low Priority	Schedule A/A+
-	31	1995	Wet	83%	Low Priority	Schedule A/A+
-	5	2006	Wet	73%	Low Priority	Schedule A/A+
-	50		Wet	68%	Low Priority	Schedule A/A+
-	54	2001	Constructed Wetland	67%	Low Priority	Schedule A/A+
-	19	2000	Wet	49%	Low Priority	Schedule A/A+
-	41	1999	Wet	48%	Low Priority	Schedule A/A+
-	56	1999	Wet	39%	Low Priority	Schedule A/A+
-	46	2013	Wet	25%	Low Priority	Schedule A/A+
-	24	1995	Wet	7%	Low Priority	Schedule A/A+

The above has been completed following Schedule A/A+ of the Municipal Class EA process, and therefore all the recommended works as detailed above are considered pre-approved. Further, the maintenance of SWM facilities is a legislated requirement as a condition of the Environmental Compliance Approval issued for their construction.

Refer to **Section 14.0** for estimated implementation costs.

13.4.2 Retrofits

The three (3) proposed retrofit facilities have satisfied the respective Class EA requirements per previous studies (Facility numbers 48, 10 and 28), or are not required to fulfill the EA process so further evaluation as part of the SWM-MP is therefore not warranted. In addition, four (4) existing dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits

Table 13.4: SWM Facilities Scheduled for Retrofit

SWM Facility #	Facility Type	Drainage Area (ha)	Est. Avg. TIMP%	Water Quality Volume Requirement (cu.m/ha) per MOE 2003	Permanent Pool Volume Requirement (Cu.m)	Year of Construction	Class EA Schedule
48	Wet Pond/ Quality*	76.7	58	194	14,881	1990	Class EA requirements completed per previous studies. May proceed to implementation
10	Wet Pond/ Quality	10.4	57	192	1,995	1993	
28	Wet Pond/ Quality	4	64.5	115 (wetland due to DA < 5ha)	460 (wetland due to DA < 5ha)	1999	
SWM Facility #	**Control Type**	**Drainage Area (ha)**	**TIMP%**	**Water Quality Volume Requirement (cu.m/ha) per MOE 2003**	**Permanent Pool Volume Requirement (Cu.m)**	**Subwatershed Name and Priority**	**Class EA Schedule**
18	Quantity	84	51	180	15,120	Forwell Creek- 1	Schedule A/A+
9	Quantity	81.5	51	180	14,670	Clair Creek – 2	
8	Quantity	78.4	45	165	12,936	Clair Creek – 2	
2	Quantity	37.9	52	182.5	6,917	Maple Hill Creek – 2	

* Assumed - Unavailable data

Refer to **Section 14.0** for estimated implementation costs.

13.4.3 Park Rehabilitation and SWM Enhancements (New SWM Facilities)

The SWM-MP explored and assessed the feasibility of constructing new stormwater management facilities as part of park rehabilitations.

Nine (9) SWM opportunities were identified as feasible based on the four (4) phase approach, and preferred alternatives for each location were selected as part of the Recommended Approach.

The identification, evaluation and selection of preferred alternatives for the nine (9) SWM opportunities summarized in **Table 13.5** below, have been completed following Schedule B of the Municipal Class EA process and therefore can proceed directly to detailed design and implementation.

Table 13.5: Park Rehabilitation 9 Feasible SWM Facility Opportunities

Map & Site ID	Location Name	Drainage Area (ha)	Recommended Facility Type 1 - Primary alternative; 2- Secondary alternative)	Preferred Alternative	Class EA Schedule
1	Northfield Park	49	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
3	Dunvegan Park	25.3	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
4	Belgreen Park / Warrington Park	45.3	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
6	Waterloo Park (by LRT)	32.7	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
7	Waterloo Park (Seagram Drive)	31	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
8	Laurelwood Park	9	1) Surface Facility 2) Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
9	Bechtel Park	35.6	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
10	Sandowne Park	54.5	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B
11	Lexington Park	10.2	Subsurface Storage Facility	Subsurface Storage Facility	Schedule B

Prior to the construction of these new SWM facilities, an assessment will need to be completed for Archaeological, Built Heritage, and Cultural Heritage Landscapes. At a minimum, this should entail the completion of the MTCS checklists (*Criteria for Evaluating Archaeological Potential,*

Criteria for Evaluating Marine Archaeological Potential, and *Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes*). Sites 6 and 7 do not conflict with the known Built Heritage resources in Waterloo Park, however, Built Heritage information is not currently available for the remaining sites. No information is currently available regarding archaeology and Cultural Heritage Landscapes related to these sites. Refer to **Section 3.1** for additional assessment details.

Refer to **Section 14.0** for estimated implementation costs.

13.5 Watercourse and Erosion Restoration

The evaluation process resulted in preferred alternatives that address reach specific erosion concerns at each of the eight (8) primary erosion sites. Project types include;

- Removal of risk at one (1) location
- Local works at two (2) locations
- Full channel restoration at five (5) locations

Table 13.6 identifies the preferred alternative at each site. All projects identified in this table are classified as EA Schedule B projects.

Table 13.6: Preferred Alternatives for Primary Erosion Sites

Primary Erosion Issue Site Number	Preferred Remediation Alternative	Class EA Schedule
LRL-E5	Removal of risk	Schedule B
CDR-E4	Full channel restoration	Schedule B
LRL-E6	Full channel restoration	Schedule B
FRW-E2	Local works	Schedule B
LRL-E7	Full channel restoration	Schedule B
CDR-E3	Local works	Schedule B
CLR-T1-E1	Full channel restoration	Schedule B
CLR-E4	Full channel restoration	Schedule B

Prior to the construction of these new SWM facilities, an assessment will need to be completed for Archaeological, Built Heritage, and Cultural Heritage Landscapes. At a minimum, this should entail the completion of the MTCS checklists (*Criteria for Evaluating Archaeological Potential, Criteria for Evaluating Marine Archaeological Potential*, and *Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes*). Refer to **Section 3.1** for additional assessment details.

Refer to **Section 14.0** for estimated implementation costs.

13.6 Urban Flood Management & Stormwater Infrastructure

The following recommendations have been developed in support of next steps relating to the advancement of the PCSWMM model:

1. It is recommended that the City undertake monitoring of select stormsewer outfalls, both uncontrolled and SWM facility outlets where stage discharge relationships are not available, in order to calibrate the storm sewer model developed as part of this study. The development and implementation of a flow monitoring program is recommended to consisted of:
    a) Supply and installing flow monitors at a minimum of 12 locations within the storm system selected in consultation with the City for a period no less than 1-year. The

selection of the monitoring locations within the storm sewer system should be based on the characteristics of the study drainage areas, the service area for the sewer systems and discussions with City staff. Selection of the sites are recommended to be based on the following:

- Strategic locations within the study area where bottlenecks or flooding events have been previously identified;
- Locations with satisfactory hydraulic sewer conditions in order to allow for the highest accuracy and reliability;
- Strategic locations which are located in readily-accessible locations, preferably away from areas requiring high-traffic control or at locations of deep sewers;
- At representative homogenous catchment areas, such that the hydrologic component of the hydraulic model can be calibrated.

b) Completion of monthly field verification and calibration of flow monitors;
c) Collection and storage of data in a digital based format; and
d) Decommissioning of the flow monitoring equipment following the monitoring period.

2. It is recommended that the City calibrate the storm sewer model developed as part of this study. Calibration to 20% of peak flows and 20% of event volumes are recommended.

a. The rainfall data selected to calibrate and validate the drainage sewer system model is recommended to include at least three (3) reasonably-sized recorded events.
b. The events are to be preferably greater than 10mm at a majority of the rain gauges.
c. The rain gauges shall have suitable coverage of the City, per the recommendations of Precipitation Gauge Memo Final Report January 2019)

3. It is recommended that the City continue to expand the storm sewer model to include all pipes within the City boundaries. The model expansion will permit the City to evaluate and select the preferred remedial approaches to improve the level of service.

4. Furthermore, it is recommended that the Implementation Plan detail all resource and staffing requirements.

14 Estimated Costs: Recommended Approach

A summary of the estimated implementation costs for each element of the recommended strategy, as well as future Class EA requirements (Schedule C projects) is provided below and includes a summary of all assumptions.

All program costs as outline below are intended to be implemented within existing and or committed funding allocations per the City of Waterloo budget process. The Master Plan is intended to allow to the City to prioritize and more efficiently spend the existing and committed budgets to achieve the greatest environmental benefit.

Estimated capital costs estimates for each element of the Recommended Approach are detailed in **Table 14.1** below.

Table 14.1: Recommended Approach – Summary of Capital Cost Estimates†

Recommended Approach Element	Capital Cost Estimate ($ millions)*
7) Municipal Pollution Prevention, Management, Operations & Maintenance Practices	
a. OGS Maintenance (High, Moderate & Low Priority)	$0.046
b. Sediment Removal from catch basins	$0.447
8) Market Based Strategies for Private Property (source controls): 5 year program costs	$3.663
9) Stormwater for the Capital Roads Program (conveyance controls)	$8.375
10) Stormwater Management (SWM) Facilities	
a. Sediment Removals (High, Moderate & Low Priority)	$3.51
b. Retrofits (Planned and Proposed)	$9.987
c. New SWM Facilities	$19.84 – $25.50
11) Watercourse and Erosion Restoration	$9.2 to 13.0
12) Urban Flood Management & Stormwater Infrastructure (Preliminary Estimated Cost Implications based on Uncalibrated model)	$83.6
Total	$138.67 – 148.13
Total Yearly Expenditure‡	**$9.24 – 9.88**

‡ expenditure time frame is 15-years
† Class 'C' cost estimate. Note: all values in 2019 CDN dollars
* Rounded to the nearest $100,000

14.1 Estimated Costs - Municipal Pollution Prevention, Operations & Maintenance Practices

14.1.1 Estimated Costs: Catch Basin Sediment Removal

Although an analysis of catch basin clean-outs was not conducted in the City of Waterloo, a recent assessment in the City of Kitchener would be applicable to the City of Waterloo. Cost estimates included a Vac Truck at a unit cost of $58.00/hr, a staff cost of $84.29/hr for two operations staff (including Lead Hand premium), and sediment disposal costs of $41.24/Tonne of sediment material disposed. By applying these values, the average service unit costs for full catch basins were estimated to be $156.65/Tonne of sediment removed or $47.13/catch basin serviced.

By extrapolating the cost estimate to all 9485 catch basins owned by the City of Waterloo, an approximate total cost of $447,000 would be attributed to the service.

Assuming four representative areas in the City of Waterloo, **Table 14.2** indicates how frequently catch basins would need to be cleaned out in each area.

Table 14.2: Catch Basin Cleanout Frequency

Representative Area	Description	Cleanout Frequency
New Subdivision	Under construction or immediately after assumption	4.2 years
Mature Subdivision	Minimum 10 years post-assumption	9.1 years
Old Subdivision	Minimum 30 years post-assumption	5.0 years
Industrial/Commercial Area		3.1 years

Catch Basin versus EOP Facility Clean-outs

The SWM-MP Municipal Class EA: Sediment Analysis Memo (2019) indicates a unit cost of $180/m^3 of sediment for the removal and disposal of sediment from EOP facilities. Assuming a density of 1.3 tonnes/m^3, this would be $234/tonne to remove and dispose of sediment from EOP facilities. It is therefore cost effective to remove sediment from full catch basins ($156.65/tonne) even in areas where an EOP facility exists.

According to the City's GIS database, approximately 40% of the City's urban area currently has some level of SWM control, meaning the catch basins within these areas drain to downstream EOP facilities. The remaining catch basins are located in uncontrolled areas and are currently the sole sediment retention mechanism present in these areas. Therefore, sediment collection from catch basins located in uncontrolled areas is an important tool to provide some quality control for stormwater.

As the City already conducts street sweeping and leaf collecting, it is recommended that the City investigate potential efficiencies between the various programs.

14.1.2 Estimated Costs: OGS Units Sediment Removal

Ten (10) OGS units require maintenance and were classified as high priority (Estimated Cost: $20,300) and fourteen (14) OGS units were classified as low priority (Estimated Cost: $25,700)

Maintenance costs were estimated for the facilities currently operating at less than acceptable efficiency. The calculations were based on the costs of previous services, specifically the clean out costs for thirteen (13) OGS units in 2016 as provided by the City of Waterloo. A cost of cleanout was calculated as $\$69/m^3$ for the removal and disposal of non-impacted solid material based on a 13 OGS unit average. This value is the basis of developing cost estimates within this report.

Extra expenses were assumed considering the potential need of soil management for contaminated materials in three (3) different levels. In addition, 25% provisional cost was added to the final price in order to consider other services such as traffic control, implementation of the health a safety plan, removal of contaminated groundwater, removal and replacement of existing damaged structures, supply of materials and other potential construction needs. Estimated maintenance costs for the OGS units identified as requiring maintenance are outlined in **Table 14.3.**

Table 14.3: Priority OGS Maintenance Costs

Priority Ranking	Asset ID	Make and Model	Maintenance Priority	Estimated Maintenance Cost†
1	10080695	STC-1500	High Priority	$2,000
2	10080622	STC6000	High Priority	$2,700
3	10080647	STC-1500	High Priority	$2,000
4	10080563	STC-3000	High Priority	$2,100
5	10080569	STC-1500	High Priority	$1,900
6	10080521	STC-2000	High Priority	$1,900
7	10080649	STC-1000	High Priority	$1,800
8	10080618	STC-1500	High Priority	$1,900
9	10080651	STC-6000	High Priority	$2,100
10	10080515	STC-2000	High Priority	$1,900
11	10080568	STC-1500	Low Priority	$1,800
12	10080561	STC-2000	Low Priority	$1,900
13	10080585	STC-2000	Low Priority	$1,900
14	10080578	STC-4000	Low Priority	$1,900
15	10080646	STC-1500	Low Priority	$1,800
16	10080551	STC-6000	Low Priority	$2,000
17	10080524	STC-2000	Low Priority	$1,800
18	10080514	STC-1000	Low Priority	$1,800
19	10080579	STC-4000	Low Priority	$1,800
20	10080619	STC-4000	Low Priority	$1,800
21	10131824	STC-2000	Low Priority	$1,800
22	10080648	STC-6000	Low Priority	$1,800
23	10080660	STC-6000	Low Priority	$1,800
24	10080566	STC-750	Low Priority	$1,800
			Total	**$46,000**
			Total Yearly Expenditure‡	**$3,066**

‡ expenditure time frame is 15-years

† Based on estimated clean-out costs of $69/m^3, rounded to the nearest $100.

14.2 Estimated Costs: Market Based Strategies (source controls)

Table 14.4 below provides a cost estimate for a 5-year period for the Preferred Market Based Strategy (MBI Scenario 2). The estimated costs reflect resource requirements including staffing, overhead expenses, consulting services, advertising and promotion, and miscellaneous program related expenses. The dollar value used for "Person Hours" is $72.00. This amount reflects Statistics Canada's unadjusted average union salary for employees in Ontario at $32.18 per hour in 2019 plus an additional overhead cost of $39.34 per hour.

Table 14.4: Cost Estimate for Preferred Market Based Strategy (MBI Scenario 2)

DESCRIPTION	PERSON HOURS	COSTS ($) YEAR 1†	COSTS ($) YEARS 2 – 5†
Set up and administration of financing program[8]	10,400	337,000	412,000
On-line application process	715	26,000	25,000
Set-up of incentive program for new ICI development	10,400	309,000	440,000
Administration of incentive program	9,360	169,000	505,000
Set up and administration of site consultation visits and support	6,240	89,000	360,000
Site visits and support for both programs	2,928	42,000	169,000
Advertising and promotional materials for both programs	n/a	100,000	80,000
Advertising and promotion for both programs	n/a	150,000	225,000
Miscellaneous	n/a	75,000	150,000
Sub-Total	*40,043*	1,297,000	2,366,000
		Total	**$3,663,000**
		Total Yearly Expenditure‡	**$244,200**

‡ expenditure time frame is 15-years
† Class "C" Cost estimate, all values in 2019 CDN dollars.

14.3 Estimated Costs: SWM for the Capital Roads Program (conveyance controls)

Implementation of the preferred approach would require an additional $8.375 million to construct bioswales, permeable pavement, and OGS units based on the recommendations in **Tables 8.1-8.8** in **Appendix G**.

14.4 Estimated Costs: Stormwater Management (SWM) Facilities

The following section summarizes the estimated costs associated the three (3) individual elements which make up the Recommended Approach for Stormwater Management Facilities, specifically:

1. Sediment Removals from Existing SWM Facilities
2. Planned SWM Retrofits
3. Park Rehabilitation and SWM Enhancements

[8] Cost estimate does not include cost of debt financing.

14.4.1 Estimated Costs: Sediment Removals

Maintenance service costs for each SWM facility were estimated based the costs of previous sediment removal works completed in the City of Waterloo and surrounding area. Maintenance service costs for all facilities were determined using a value of $\$180/m^3$ of sediment.

As part of the Recommended Approach, eleven (11) Dry facilities and twenty-four (24) Wet facilities require maintenance activities in the form of sediment removal, specifically:

Of the eleven (11) Dry facilities that were analyzed:

- Two (2) High Priority
- One (1) Moderate Priority
- Eight (8) Low Priority

Of the twenty-four (24) Wet facilities that were analyzed:

- Five (5) High Priority
- Nine (9) Moderate Priority
- Ten (10) Low Priority

Cost estimates for Dry facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table 14.5.**

Cost estimates for Wet facilities classified as high, moderate and low priority for maintenance and sediment removals are detailed in **Table 14.6**.

Table 14.5: Dry Facilities - High, Moderate and Low Maintenance Priority Sediment Removals

Priority Ranking	SWM Facility #	Year of Construction	Control Type	Decrease in Storage Capacity	Maintenance Priority	Cost Estimate†
1	36	1988	Quantity	2%	High Priority	$16,000
2	8*	1991	Quantity	2%	High Priority*	$58,000
3	16	1994	Quantity/Quality	7%	Moderate Priority	$17,000
-	22	1997	Quantity	12%	Low Priority	$2,000
-	13	1995	Quantity/Quality	5%	Low Priority	$27,000
-	18*	1986	Quantity	3%	Low Priority*	$83,000
-	6	2014	Quantity/Quality	3%	Low Priority	$51,000
-	2*	1987	Quantity	3%	Low Priority*	$38,000
-	32	1992	Quantity	2%	Low Priority	$11,000
-	26	1989	Quantity	2%	Low Priority	$22,000
-	9*	1985	Quantity	1%	Low Priority*	$92,000
-	23	1992	Quantity	0%	Low Priority	$8,000
					Total	**$425,000**
					Total Yearly Expenditure‡	**$28,000**

*Dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits under Schedule A/A+

‡ expenditure time frame is 15-years

† Class "C" Cost estimate, all values in 2019 CDN dollars. Rounded to the nearest $1,000 plus 10% contingency.

Table 14.6: Wet Facilities - High, Moderate and Low Maintenance Priority Sediment Removals

Priority Ranking	SWM Facility #	Year of Construction	Type of Facility	% of Maximum Allowable Sediment Accumulation	Maintenance Priority	Cost Estimate†
1	51	2000	Wet	321%	High Priority	$117,000
2	42	1998	Wet	317%	High Priority	$381,000
3	1	2000	Wet	266%	High Priority	$102,000
4	27	2000	Wet	254%	High Priority	$409,000
5	45	1999	Wet	232%	High Priority	$263,000
6	49	2002	Wet	191%	Moderate Priority	$144,000
7	35	2002	Constructed Wetland	162%	Moderate Priority	$51,000
8	59	2002	Constructed Wetland	162%	Moderate Priority	$52,000
9	25	1986	Wet	138%	Moderate Priority	$18,000
10	15	1995	Wet	135%	Moderate Priority	$238,000
11	29	2000	Wet	131%	Moderate Priority	$77,000
12	57	2001	Wet	120%	Moderate Priority	$24,000
13	58	2003	Wet	119%	Moderate Priority	$76,000
14	62	2000	Wet	107%	Moderate Priority	$99,000
15	34	1997	Wet	95%	Low Priority	$170,000
-	31	1995	Wet	83%	Low Priority	$164,000
-	5	2006	Wet	73%	Low Priority	$235,000
-	50		Wet	68%	Low Priority	$61,000
-	54	2001	Constructed Wetland	67%	Low Priority	$45,000
-	19	2000	Wet	49%	Low Priority	$129,000
-	41	1999	Wet	48%	Low Priority	$42,000
-	56	1999	Wet	39%	Low Priority	$40,000
-	46	2013	Wet	25%	Low Priority	$64,000
-	24	1995	Wet	7%	Low Priority	$84,000
					TOTAL	**$3,085,000**
					Total Yearly Expenditure‡	**$206,000**

‡ expenditure time frame is 15-years

† Class "C" Cost estimate, all values in 2019 CDN dollars. Rounded to the nearest $1,000 plus 10% contingency.

14.4.2 Estimated Costs: Retrofits

The three (3) remaining planned retrofits awaiting implementation include Facilities 10, 48, and 28. Cost estimates developed as part of the previous Class EAs, estimate the implementation costs at $1.3million.

In addition, four (4) existing dry SWM facilities (Facility numbers 18, 9, 8 and 2) were identified as opportunities for water quality retrofits at a cost of $8.69 million.

Table 14.7: SWM Facilities Scheduled for Retrofit

SWM Facility #	Facility Type	Drainage Area (ha)	Est. Avg. TIMP%	Water Quality Volume Requirement (cu.m/ha) per MOE 2003	Permanent Pool Volume Requirement (Cu.m)	Year of Construction	Estimated Costs ($)†
48	Wet Pond/ Quality	76.7	58	194	14,881	1998	$650,000
10	Wet Pond/ Quality	10.4	57	192	1,995	1993	$325,000
28	Wet Pond/ Quality	4	64.5	115 (wetland due to DA < 5ha)	460 (wetland due to DA < 5ha)	1999	$325,000
SWM Facility #	**Facility Type**	**Drainage Area (ha)**	**TIMP%**	**Water Quality Volume Requirement (cu.m/ha) per MOE 2003**	**Permanent Pool Volume Requirement (Cu.m)**	**Subwatershed Name and Priority**	**Estimated Costs ($)†**
18	Dry Pond/ Quantity	84	51	180	15,120	Forwell Creek- 1	$ 2,646,000
9	Dry Pond/ Quantity	81.5	51	180	14,670	Clair Creek – 2	$ 2,567,000
8	Dry Pond/ Quantity	78.4	45	165	12,936	Clair Creek – 2	$ 2,263,000
2	Dry Pond/ Quantity	37.9	52	182.5	6,917	Maple Hill Creek – 2	$ 1,210,000
						Total	**$9,986,000**
						Total Yearly Expenditure‡	**$666,000**

* Assumed - Unavailable data
‡ expenditure time frame is 15-years
† Class "C" Cost estimate, all values in 2019 CDN dollars

14.4.3 Estimated Costs: Park Rehabilitation & SWM Enhancements (New SWM Facilities)

The implementation of the proposed SWM facility opportunities as part of park rehabilitations is estimated to cost $19.84 – 25.50 million. The capital construction cost estimates for the surface and subsurface storage facilities were based on the following:

Surface Facilities

1. Previous surface facility region had unit costs ranging from $150 to 215/$m^3$ (avg. of $190/$m^3$) of permanent pool volume created. Previous studies in the GTHA have utilized a rate of $100/$m^3$ for excavation required to excavate down to the proposed facility inlet (i.e. pipe depth) and a rate of $140.00/$m^3$ of permanent pool volume created thereafter. Analysis of this approach revealed an average total unit cost of $175/$m^3$ of permanent pool volume created. As such a range of $175/$m^3$ to $190/$m^3$ has been applied to account for unit cost variability and project uncertainty.
2. A minimum construction cost of $250,000 per facility was also used for smaller facilities to account for costs associated with mobilization, demobilization, bonding, erosion and sediment control and dewatering etc.
3. Bioswale construction cost is typically based on the linear distance of treated area. Previous projects have used $350/m for bioswales with a subdrain and $250/m for bioswales without a subdrain.

Sub-Surface Facilities

4. Costing for each subsurface storage unit has been based on unit costs of previously constructed facilities in the GTHA, through discussions with several municipalities and product distributors. The unit costs for subsurface facilities ranged from $350/$m^3$ to $450/$m^3$ per unit of water quality storage volume provided.
1. A minimum construction cost of $350,000 per facility was also used for smaller facilities to account for costs associated with mobilization, demobilization, bonding, erosion and sediment control and dewatering etc.

There is a good opportunity to coordinate park enhancements and or rehabilitations with proposed SWM facility construction. This is an opportunity to reduce overall project costs to the City as a result of economies of scale, the reduction in design costs and the avoidance of duplication of construction activities (bonding, insurance, mobilization and demobilization, general construction and restoration activities). As such it is recommended that opportunities to coordinate SWM facility construction with park rehabilitation, trail enhancements, and park facility upgrades be investigated as part of the SWM-MP Implementation Plan to be developed following the approval of the Environmental Assessment. Implementation costs for each feasible SWM facility opportunity are summarized in **Table 14.8** below.

Table 14.8: Estimated Cost ($) of the 12 Feasible SWM Facility Opportunities

Map & Site ID	Location Name	Recommended Facility Type (1 - Primary alternative; 2- Secondary alternative)	Drainage Area (ha)	Estimated Construction Cost ($) (millions)†
01	Northfield Park	Subsurface Storage Facility	49	$3.29 – 4.23
03	Dunvegan Park	Subsurface Storage Facility	23	$1.53 – 1.96
04	Belgreen Park / Warrington Park	Subsurface Storage Facility	45.3	$3.15 – 4.05
06	Waterloo Park (by LRT)	Subsurface Storage Facility	32.7	$2.35 – 3.02
07	Waterloo Park (Seagram Drive)	Subsurface Storage Facility	31	$2.25 – 2.89
08	Laurelwood Park	1) Surface Facility (bioswale) 2) Subsurface Storage Facility	9	1) $0.02 – 0.03 2) $0.60 – 0.77
09	Bechtel Park	Subsurface Storage Facility	35.6	$2.36 – 3.04
10	Sandowne Park	Subsurface Storage Facility	54.5	$3.57 – 4.59
11	Lexington Park	Subsurface Storage Facility	10.2	$0.72 – 0.92
		TOTALS	236.3◊	$19.84 – $25.50*
			Total Yearly Expenditure‡	**$1.32 – $1.7**

† Class 'C' cost estimate
‡ expenditure time frame is 15-years
◊ Total area does not include Sites 3 and 7 separately, as they are included in the drainage areas of Sites 10 and 6, respectively
* total cost includes both options 1 and 2 for Site 8

14.5 Estimated Costs – Watercourse and Erosion Restoration

Based on the primary list of erosion sites and restoration reach opportunities, $9.2 – $13.0 million in stream restoration projects have been considered within the Stormwater Master Plan.

The eight (8) primary opportunities represent the key projects to be considered within system-wide prioritization and implementation plan of the SWM-MP. The evaluation of alternative solutions was completed for the eight (8) primary opportunities. For each of the sites, four (4) preliminary alternative solutions were evaluated using baseline information and a list of evaluation criteria. Scoring of the criteria produced a preferred alternative based on the highest score, which was then developed into a conceptual design. Cost estimates for engineering services (i.e., design, background studies such as geotechnical investigations) and construction costs for each of the preferred alternatives was estimated for each of the preferred alternatives for each site.

The estimated range of costs for the conceptual designs discussed in **Section 12.4** are presents in **Table 14.9** which includes the costs for construction, engineering design and approval and contingency (15%). Cost estimates are exclusive of HST.

Table 14.9: Estimated Cost Summary of Stream System Opportunities

Watercourse	Reach ID	Erosion ID	Primary Classification	Risk	Preferred Alternative(s)	EA Schedule	Estimated Range in Costs for Preferred Alternative[1]
Laurel Creek	R4 (Marshall St to Marsland Dr N)	LRL-E5	Erosion Site	Sanitary maintenance holes	Removal of risk	B	$1,100,000 - $1,600,000[2]
Cedar Creek	R4 (Rec. trail to LRT crossing)	CDR-E4	Erosion Site	Sanitary maintenance holes	Full channel restoration	B	$1,600,000 - $2,200,000
Laurel Creek	R5 (Erb St to Marshall St)	LRL-E6	Erosion Site	Sanitary sewer and maintenance hole	Full channel restoration	B	$1,200,000 - $1,600,000
Forwell Creek	R2 (Blue Springs Dr to Forwell Creek Rd)	FRW-E2	Erosion Site	Culverts and headwall	Local works	B	$500,000 - $600,000[3]
Laurel Creek	R5 (Erb St to Marshall St)	LRL-E7	Erosion Site	Recreation trail, sanitary sewer run, private property	Full channel restoration	B	$2,500,000 - $3,800,000
Cedar Creek	R2 (Pedestrian crossing to drainage channel)	CDR-E3	Erosion Site	Culvert and gabion weir	Local works	B	$800,000 - $1,100,000[3]
Clair Creek Tributary 1	T1-R1 (Keats Way to confluence)	CLR-T1-E1	CLR-T1-E1	Gabion and private residence	Full channel restoration	B	$1,100,000 - $1,600,000[4]
Clair Creek	R9 (Columbia St W to Craigleith Dr)	CLR-E4	Erosion Site	Storm sewer outfalls, sanitary sewer, culvert	Full channel restoration	B	$400,000 - $500,000
						Total	$9.2 – $13.0
						Total Yearly Expenditure‡	$0.613 – 0.867

Notes:

1. Cost estimate range includes costs for construction, engineering design and approval (15%), and contingency (15%), but is exclusive of HST.
2. Bridge repair for a private crossing at LRL-E5 upstream of University Drive East is not included, estimated to be between $250 – 500 K.
3. Erosion sites FRW-E2 and CDR-E3 include culvert replacements and associated crossing repairs estimated in the range of $200 – 300 K.
4. City to consider additional hydraulic study at erosion site CLR-T1-E1 to investigate flow diversion options through storm sewer for alleviating future flood and erosion risks. Study costs are estimated at $50– 75K.

‡ expenditure time frame is 15-years

14.6 Estimated Costs - Urban Flood Management & Storm Sewer Infrastructure

The results of the existing conditions model and the three scenarios were used to establish the preliminary cost implications of the overall SWM-MP strategy. **Table 14.10** represents the preliminary cost implications associated with each of the modelling scenarios, assuming a unit cost of $1,150 per linear metre of surcharged sewer.

It must be noted that the cost implications below are based on the uncalibrated model results and as such may not represent the actual cost implications. It is recommended that this preliminary assessment be refined as part of next steps. Furthermore, it is therefore most appropriate at this stage to examine the % of cost change from existing conditions as a means to compare the scenario results. In this manner **Table 14.10** illustrates the effect of intensification (1.7% increase in cost) and climate change (15.2% increase in cost) on existing conditions, and most importantly demonstrates the effect of the application of LID via a 12.5mm volume retention target on improving the existing conditions (21.8% reduction in costs) and in mitigating the effects of climate change (1.1% increase in cost vs. 15.2% increase with no LID).

Table 14.10 - Summary of Model Results, Pipe Breakdown

Scenario #	Scenario Name	Total Length of Pipes at Capacity or Surcharged (m)	Total Volume (m^3)	Preliminary Cost Implications ($ millions)*	Preliminary Cost Implications (% Change from baseline*
Baseline	Existing Conditions	71,870	212,428	82.7	n/a
1	Development Intensification	73,158	238,103	84.1	1.7%
2	Climate Change	82,898	251,295	95.3	15.2%
4a	LID Volume Control (Existing Conditions)	56,303	155,661	64.7	-21.8%
4b	LID Volume Control (Climate Change)	72,664	187,093	83.6	1.1%

**Assumes a unit replacement cost of $1,150/linear metre*

The anticipated cost to replace the total length of surcharged pipes under Scenario 4b is estimated to be $83.6 million based on a unit cost of $1,150 per linear metre. This represents the estimated capital cost to replace only the sewers which were assessed as part of the storm sewer trunk system network model (300mm and larger in the Core, 600mm and larger in the remaining City).

The trunk sewer system represents approximately 183 km (35%) of the total 524 km storm sewer network in the City of Waterloo. While the trunk sewer system is made of the largest diameter sewers and the sewers in the most urbanized area of the City, there remains to be approximately 341 km (65%) sewers which were not part of the project scope and were not modelled.

In the areas where trunk sewers are shown as surcharging, there is a high probability that additional surcharged sewers may be identified as the model network is expanded to sewers beyond the trunk sewer network.

As stated previously, it must be noted that the cost implications are based on the uncalibrated model results and as such may not represent the actual cost implications. It is recommended that this preliminary assessment be refined as part of next steps.

15 Recommendations

Consistent with the recommended approach as outlined within this report, the final fifteen (15) study recommendations for consideration by the City of Waterloo are as follows:

1. That Council approve the City of Waterloo Stormwater Management Master Plan (SWM-MP) Class Environmental Assessment Report together with the Recommended Approach;

2. That City staff be directed to file the report with the Ministry of the Environment, Conservation and Parks (MECP) for the 30-day public review period as required by the *Environmental Assessment Act*;

3. That staff be directed to develop an Implementation Plan (as detailed in **Section 16**), with an operational and maintenance strategy, resource requirements, and supporting policies and by-laws permit the implementation of the Recommended Approach. This shall include, but is not limited to, policies to support the stormwater infiltration, works on private property, updated SWM design criteria, and SWM cash-in-lieu.

4. That the City of Waterloo conduct a comprehensive review of the current flat tier billing schedule per the Stormwater Utility Program for all land-uses and specifically within the ICI and multi-residential landuses. Alternative approaches, the number of tiers and tier structures should be reviewed to ensure equity amongst tiers and in the context of the Recommended Approach;

5. That the City of Waterloo apply a market-based approach to planning and decision-making processes pertaining to, or impacting, SWM practices by private property owners. The market-based approaches should be designed to increase participation the stormwater utility credit program taking into consideration all costs and resource requirements, including staffing, overhead expenses, consulting services, advertising and promotion, and miscellaneous program related expenses;

6. That the City further incentivize the implementation of private stormwater controls as part of the stormwater utility credit program within prioritized subwatersheds as part of a ‘pilot program’ and that a focus be paced upon the Industrial, Commercial and Institutional (ICI), as well as multi-residential land uses within the City;

7. That the City explore strategic alignments with neighboring municipalities and the GRCA in regard to the Recommended Approach, specifically the application of a market-based approach, such that resources and funding can be leveraged;

8. That the City explore strategic alignments in regard to the operation and maintenance of City-owned stormwater management facilities, specifically, the development of a cost reconciliation mechanism and service level agreement between the Stormwater Utility and Operations to better track allocated O&M funds and direct the allocation of future O&M funding. As well as the creation of an operations unit funded by the Stormwater Utility with a priority focus on the completion of stormwater related operation and maintenance tasks and associated projects as identified through the recommended approach;

9. That City staff undertake monitoring of select stormsewer outfalls, both uncontrolled and SWM facility outlets where stage discharge relationships are not available, in order to calibrate the storm sewer model developed as part of this study and that the City continue to expand the storm sewer model to include all pipes within the City boundaries. The model expansion will permit the City to evaluate and select the preferred remedial approaches to improve the level of service. Furthermore, the Implementation Plan will detail all resource and staffing requirements.

10. That City staff apply the Recommended Approaches of the SWM-MP as part of other city initiatives, plans, studies and programs to leverage potential synergies as the opportunities are identified in order to more efficiently achieve overall City goals to increase urban tree canopy, construct new trails and cycle lanes, improve transit and build transit capacity, rehabilitate parks, reconstruct roads as well as improve stormwater management.

11. That the City update/create LID road cross section drawings, relevant sections in the Development Engineering Manual, and any future updates to the Transportation Master Plan to reflect LID opportunities as identified in this report.

12. That City staff explore the development of a “Green Streets Fund” which would allow for the application of a fee-based system on all road cut permits where fees are equal to a nominal percentage of total capital (actual or estimated) construction budget. Collected fees would be primarily allocated to verification of appropriate rectification post-construction as well as to future municipal ROW retrofit projects and operation and maintenance activities.

13. That City staff explore collaborative funding partnerships with local municipalities, agencies and government to reduce urban non-point source pollution to achieve the specified reductions as part of wastewater treatment plant upgrades as specified in current municipal wastewater master plans. It is further recommended that City staff be directed to explore the development of a market for the collection and sale of urban non-point source pollution 'credits' as a future stormwater funding source.

14. That the City refine existing stormwater monitoring approaches as part of the Implementation Plan to reflect the recommended strategy, and address the lack of financial and staff resources required to:

    a) Address identified data gaps in regards to water quality

    b) Stay current in the review of monitoring reports and data as required by subwatershed plans and other policies;

    c) The creation of a shared water quality data base in partnership with the GRCA;

    d) Analyze and complete Phase 4 of the adaptive environmental management (AEM) feedback loop of subwatershed plans, environmental studies and other policies. The four (4) phase AEM approach requires Characterization (Phase 1), Impact Assessment (Phase 2), Implementation (Phase 3) as well as Monitoring and Refinement of the management strategy (Phase 4). The analyzed data from the follow-up monitoring is used to test the assumptions made during earlier studies phases to evaluate the performance of the selected management strategies and make necessary adjustments. When all four (4) phases of the AEM process are not completed the process cannot ensure project goals and objectives are being met.

15. Prior to undertaking any identified project, the City shall review each site-specific project for the potential to impact known or potential cultural heritage resources in compliance with the heritage policies of the Waterloo Official Plan as well as other policies and procedures using noted resources within **Section 3.1**. The City will complete the necessary heritage assessment and studies required to identify and mitigate potential impacts and share such studies with the appropriate officials as required.

16. It is recommended that the City of Waterloo review the existing erosion and sediment controls program as part of the normal development process. This review is recommended such that new policies and standards capture the evolution in erosion and Sediment Controls (ESC), from a single approach for sediment management to ESC control methodologies and approaches that utilizes a hierarchical strategy of: Step 1 – Eliminate or reduce erosion and Step 2 – Control sediment releases. This stepped

approach is supported by national certification boards including the CISEC program (Certified Inspector of Erosions and Sediment Control program - www.cisec.org).

16 Implementation Plan

A separate document entitled **Stormwater Management Master Plan (SWM-MP) Implementation Plan (2020)** is included under separate cover.

The implementation plan is intended to direct the safe and effective management of stormwater runoff from the City`s urban areas while improving the ecosystem health and ecological sustainability of the receiving watersheds. The implementation plan is designed to direct future actions, identify responsible parties, outline costs and environmental benefits and clearly define the operation and maintenance requirements and costs.

The implementation plan will prioritize all the works based on priority subwatershed as well as recommend funding allocation and policy development. Prioritization will be based on the watersheds in the most need and where there are opportunities to improve conditions through the elements of the recommended approach.

The implementation plan has been prepared to provide guidance with respect key next steps, future study considerations, facilitators and contributors, costs and funding considerations, operations and maintenance, integration with other studies, and the prioritization of works based on the identified priority subwatersheds within the City of Waterloo.

The main purpose of the Implementation Plan will be:

- The prioritization of the works based on priority subwatersheds,
- The allocation of the existing and forecasted funding over the next 15 years, and
- The development of supporting policy.

Prioritization will be based on a hierarchical approach, beginning with the watersheds that have been designated Priority 1 and applying the identified opportunities (i.e. watercourse restoration and erosion repairs, source control programs, conveyance controls, O&M, SWM facilities, flooding, etc.) as detailed within the Recommended Approach in order to improve overall subwatershed conditions. Subwatersheds will be prioritized based on the areas of greatest need and opportunity to maximize the 'net-benefit' to the City, the environment and the community.

The implementation plan will detail:

- SWM Policies:
    - for integration into the Development Manual and for use on SWM initiatives
    - for an integrated city-wide approach for water quality, water quantity, erosion control, preservation of hydrologic processes through water budgets, and the preservation and enhancement of the natural environment
    - for the infiltration of runoff to protect groundwater within the Source Protection Policy (SPP) context
    - for alternative SWM financing approaches
    - for the completion of works within private properties

- The market-based approaches designed to increase participation the Stormwater Credit Policy taking into consideration all costs and resource requirements, including staffing, overhead expenses, consulting services, advertising and promotion, and miscellaneous program related expenses;

- The plan will explore the development of a market for the sale of accumulated 'credits' as a future stormwater funding source;

- A strategy to gain access to infrastructure which serves a communal function;

- Various incentives for property owners who implement private stormwater controls as part of the Stormwater Utility Credit Program within prioritized subwatersheds as part of a 'pilot program' with a focus on the Industrial, Commercial, Institutional (ICI) and multi-residential land uses within the City;

- Strategic alignments in regard to the operation and maintenance of City-owned stormwater management facilities, specifically, the development of a cost reconciliation mechanism and service level agreement between the Stormwater Utility and Operations to better track allocated O&M funds and direct the allocation of future O&M funding.

- Final staffing recommendations in order to implement the recommended approach for Market-based approach implementation, conveyance and End-of-pipe opportunities, and Operations and Maintenance.

In order to ensure the goals and objectives of the Master Plan are accomplished over time, a monitoring program will also be established as part of the Implementation Plan which will address the need for financial and staff resources required to:

- Design and optimize a comprehensive water quality monitoring program and creation of a shared water quality data base in partnership with the GRCA and neighboring municipalities;

- Stay current in the review of monitoring reports and data as required by subwatershed plans and other policies;

- undertake monitoring of select stormsewer outfalls, both uncontrolled and SWM facility outlets where stage discharge relationships are not available, in order to calibrate the storm sewer model developed as part of this study.

- Analyze and complete Phase 4 of the adaptive environmental management (AEM) feedback loop of subwatershed plans, environmental studies and other policies. The four (4) phase AEM approach requires Characterization (Phase 1), Impact Assessment (Phase 2), Implementation (Phase 3) as well as Monitoring and Refinement of the

management strategy (Phase 4). The analyzed data from the follow-up monitoring is used to test the assumptions made during earlier study phases to evaluate the performance of the selected management strategies and make necessary adjustments. When all four (4) phases of the AEM process are not completed the process cannot ensure project goals and objectives are being met.

Appendix A – Stormwater Management Policy Review (Under Separate Cover)

Appendix B – Existing Conditions Report (Under Separate Cover)

Appendix C – Subwatershed Health Analysis (Under Separate Cover)

Appendix D – Sediment Analysis Memo: SWM Facilities and OGS Units (Under Separate Cover)

Appendix E – Snow Storage Memo (Under Separate Cover)

Appendix F – Market Research: Industrial, Commercial and Builder/Developer Key Informants; Residential Market Research Analysis; Leading Jurisdictions Summary (Under Separate Cover)

Appendix G – Municipal ROW Opportunities Report (Under Separate Cover)

Appendix H – Stormwater Infiltration Policy Recommendations (Under Separate Cover)

Appendix I – New End-of-Pipe SWM Opportunities (Under Separate Cover)

Appendix J – Storm Sewer Capacity Report (Under Separate Cover)

Appendix K – Rain Gauge Memo (Under Separate Cover)

Appendix L – Watercourse Erosion Master Plan (Under Separate Cover)

Appendix M – Record of Public Consultation (Under Separate Cover)

Appendix N – Implementation Plan Report (Under Separate Cover)

Appendix O – References

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