OCTOBER 21, 2015

Stormwater Quality Management Master Plan
FINAL PROJECT REPORT

Prepared for:

City ofPeterborough
Utility Services
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Prepared by:

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City of Peterborough
Stormwater Quality Management Master Plan

PROJECT REPORT

Updated October 21, 2015

FOREWORD

This document presents the Stormwater Quality Management Master Plan Report as made available for public comment from February 20, 2015 to April 9, 2015; along with additions and revisions that have been made to the report since April 9, 2015.

The changes made to the report are presented in a new appendix added to the report, denoted as "Appendix C.7: Notice of Completion and Related Correspondence". Appendix C.7 documents the project's Notice of Completion and its circulation, and comments received during the above-noted public review period.

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XCG File No.: 3-2087-12-01
October 21, 2015

Executive Summary

Stormwater Quality Management Master Plan Project Report - FINAL

Prepared for:

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Executive Summary

This report presents a recommended stormwater quality management plan (SWQMP) for the City of Peterborough (the City).

The SWQMP provides the City with a strategy to implement over the coming years, to help reduce the amount of pollution carried by the municipal storm drainage system to local creeks and the Otonabee River.

The project has included public consultation to help develop the recommended plan. There were two Public Information Centres, the first on November 1, 2011; and the second on June 13, 2013.

Needs and Issues

The City owns and operates an extensive municipal drainage system that serves local residents and businesses. The drainage system is an important part of the municipality's infrastructure. It helps to ensure efficient drainage of rain and snowmelt, and thereby helps to protect public safety, health and property.

The municipal drainage system is contained mostly within municipal roadways, and is comprised of ditches, catch-basins, culverts and storm sewer pipes, which convey drainage water (stormwater) to the Otonabee River and to local creeks such as Jackson Creek, Byersville Creek, Bears Creek, Riverview Creek, Curtis Creek, Thompson Creek and Meade Creek. The municipal system also currently includes 28 stormwater ponds. These ponds were constructed in conjunction with new urban development over the last 20 years or so. Many of these ponds have been designed to treat stormwater by holding it long enough to allow a variety of pollutants to settle out. Routine inspection, maintenance and clean-out of these ponds is needed to maintain compliance with regulations of the Ontario Ministry of Environment (MOE).

The project included a water sampling program within local creeks and at the storm ponds. Results indicate that stormwater discharges are partly or possibly wholly responsible for pollutant concentrations in local creeks rising above accepted objectives (e.g. MOE's Provincial Water Quality Objectives) during wet weather. The sampling data also indicate that the stormwater ponds are having the intended effect of reducing pollutant concentrations.

As in many municipalities, older portions of the City do not have any direct form of stormwater treatment built into the drainage system; stormwater discharges untreated into local creeks or the river. The project has addressed this issue by looking at various short-term and long-term options for reducing the volume and contamination of stormwater across the City. As well, the project has examined opportunities for retrofit improvement of existing drainage systems, to identify locations where it may be feasible to install new and innovative forms of stormwater treatment.

The Recommended Plan

The recommended plan is comprised of a range of measures to be undertaken by the City over time, as follows:

Infrastructure Operation and Improvement

- Improvements to maintenance and operation of existing stormwater ponds; including specific requirements for routine inspection, maintenance and record-keeping to maintain compliance with MOE regulations.
- Removal of accumulated sediment from existing stormwater ponds that require it to maintain performance and compliance with regulations.
- Proposed modifications to some of the existing stormwater ponds, to improve their performance.
- Update to City's sewer-use bylaw governing allowable discharges into the storm sewer system.

Public Awareness and Outreach

- Public awareness and outreach program to make local residents, businesses and property owners more aware of steps they can take to reduce stormwater volume and the amount of drainage pollution washed off their property.

Collaboration and Linkages

- Establish working group or forum for agencies, organizations and others with an interest in stormwater management that meets regularly (e.g. twice per year) to facilitate ongoing input, networking, discussion and action. This will help the City keep abreast of evolving information and research, including climate change and best practices for adaptation.

System surveillance.

- A program of routine monitoring of pollutant concentrations in selected storm-sewer pipes (the larger ones) and in local creeks, to help track water quality trends.

Land Development Planning and Design

- New policies to incorporate within the City's Official Plan, to promote better and innovative design in new land development projects to help reduce the environmental impact of urban drainage.
- Update to the City's engineering design standards to promote or require site design approaches such as "Low Impact Design" (LID) to minimize stormwater volume and pollutant runoff, while maintaining good property drainage. Updating the City's engineering standards will also assist with adaptation to climate change, by making use of information from ongoing research and experience in other jurisdictions.

Funding Mechanisms

- Storm system user fee: The plan recommends that the City implement a separate "storm system user fee" that would apply to all properties that contribute storm drainage into the municipal drainage system. This fee could be based on property characteristics (lot size and amount of impervious surface) and would be used to provide dedicated funding for operation of and

improvement to the municipal storm drainage system, and would thereby help the City meet the requirements of the Province's Water Opportunities Act (2010).

- Cash-in-lieu policy for small land development proposals: a policy that allows the City, in certain defined circumstances, to accept cash in lieu of installation of approved stormwater treatment systems on small development properties. This measure is intended to allow the City to develop a fund to pay for new stormwater facilities at strategic locations in the City, while minimizing the proliferation of small privately-owned stormwater treatment devices.

New Infrastructure

- The project included a City-wide review of potential locations where new stormwater treatment facilities might be installed, to improve stormwater treatment. A long list encompassing 16 locations was developed. Based on environmental and cost considerations, this was narrowed down to a short list of 4 candidate sites on City-owned properties identified as: R5 at Bears Creek Woods Park; R7 along the east side of Otonabee River between the river and Rotary Greenway Trail in the vicinity of Moir Street; R10 in James Stevenson Park; and R12 in Walker Avenue Park.
- These four sites including preliminary concept layouts for each site were presented at the second PIC held on June 13, 2013 at the Canadian Canoe Museum. During and after PIC #2, there were concerns about these proposed facilities clearly expressed by residents who live in the vicinity of the proposed sites. The public concerns included neighbourhood compatibility, loss of valuable parkland, public safety, loss of tree cover and potential for creation of mosquito breeding areas. The outcome was clear direction that further neighbourhood consultation and careful and considerate design analysis would be required to implement stormwater treatment facilities at any of these four selected locations.
- Accordingly, the final recommendation of the plan is that subject to further analysis and public consultation, new facilities could be implemented at each of these four sites if it can be demonstrated that the planned facility fits with current uses of the location; fits within the neighbourhood setting; and is designed in conjunction with neighbourhood consultation to address the local community concerns that were expressed during this study

Costs

The following tables summarize the costs of the recommended program elements.

Table ES-1: Existing infrastructure Renewal & Improvement

Facility restoration: Sediment removal from existing storm ponds and other corrective measures	$2.1M
Measures to improve pond performance	$2.0M
Total	**$4.1M**

Table ES-2: System Maintenance

Annual maintenance at existing SWM ponds: Structured program to include routine inspections, landscape maintenance and routine removal of accumulated grit and sediment; accompanied by record-keeping system to allow for reporting and tracking of deficiencies.	$349,000
Storm-sewer catch basin cleaning and sewer flushing program: Maintain existing CB clean-out program (increasing CB clean-out frequency is not a cost-effective means of pollution abatement)	$150,000
Street-sweeping program Maintain existing program (based on use of 4 mechanical sweepers). Switching to regenerative-air/vacuum sweepers cannot be justified based on available research on net effectiveness of such sweepers. Mechanical sweepers required to remove winter road sand/grit.	$700,000
Total	**$1,199,000 per year**

Table ES-3: Additional Measures

System Surveillance Program • Monitor major outfalls in dry weather for bacteria, metals, nutrients (20 outfalls, 6 times per year) • Monitor creeks in dry and wet weather (25 locations, 6 times per year)	**$120,000 per year**
Public Awareness Campaign: Designed to promote Source Control and compliment infrastructure solutions by raising awareness and support • Develop objectives and key messages; e.g. inform general public of pollution sources and issues. • Target a broad audience, primarily property owners. • Promote source-control measures on private properties, e.g. rain barrels, vehicle maintenance practices, lawn maintenance, etc. • Integrated effort across City departments. • Cross-connect with Peterborough's Urban Forest Strategic Plan (June 2011) and Sustainable Peterborough • COST: Estimate $ 80,000/year for one part-time staff and materials development.	**$80,000 per year**

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STORMWATER QUALITY MANAGEMENT MASTER PLAN PROJECT REPORT - FINAL

Prepared for:

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1. INTRODUCTION

This report presents a recommended stormwater quality management plan (SWQMP) for the City of Peterborough (the City).

The SWQMP provides the City with a strategy to implement over the coming years, to help reduce the amount of pollution carried by the municipal storm drainage system to local creeks and the Otonabee River.

The recommended SWQMP has been developed in accordance with the Municipal Engineers Class Environmental Assessment ("Class EA") as amended in 2007. The SWQMP has been developed as a "Master Plan" in accordance with the Class EA guidelines.

This report describes the information gathering and analysis that has been undertaken, to develop the recommendations which include:

Infrastructure Operation and Improvement

- Improvements to maintenance and operation of existing stormwater ponds.
- Removal of accumulated sediment from existing SWM ponds that require it to maintain performance and regulatory compliance.
- Proposed modifications to some of the existing stormwater ponds, to improve their performance.
- Update to City's sewer-use bylaw governing allowable discharges into the storm sewer system.

Collaboration and Linkages

- Establish working group or forum for agencies, organizations and others with an interest in stormwater management that meets regularly (e.g. twice per year) to facilitate ongoing input, networking, discussion and action. This will help the City keep abreast of evolving information and research, including climate change and best practices for adaptation.

Public Awareness and Outreach

- Public awareness and outreach program to make local residents, businesses and property owners more aware of steps they can take to reduce stormwater volume and the amount of drainage pollution washed off their property.
- System surveillance: a program of routine monitoring of pollutant concentrations in selected storm-sewer pipes (the larger ones) and in local creeks, to help track water quality trends and identify any problems as they arise.

Land Development Planning and Design

- New policies to incorporate within the City's Official Plan, to promote better and innovative design in new land development projects to help reduce the environmental impact of urban drainage.

- Update to the City's engineering design standards to promote or require site design approaches that reduce stormwater volume and pollutant runoff, while maintaining good property drainage.

Funding Mechanisms

- Storm system user fee: recommendation that the City implement a separate "storm system user fee" that would apply to all properties that contribute storm drainage into the municipal drainage system. This fee would be based on property characteristics (size and amount of impervious surface) and would be used to provide dedicated funding for operation of and improvement to the municipal storm drainage system, and would thereby help the City meet the requirements of the Province's Water Opportunities Act (2010).
- Cash-in-lieu policy for small land development proposals: a policy that allows the City, in certain defined circumstances, to accept cash in lieu of installation of approved stormwater treatment systems on small development properties. This measure is intended to allow the City to develop a fund to pay for new stormwater facilities at strategic locations in the City, while minimizing the proliferation of small privately-owned stormwater treatment devices.

These recommended measures and their rationale are described in this report.

The study also identified four candidate sites (existing municipal properties) where it may be feasible to construct innovative systems to treat existing stormwater discharges. Subject to further analysis and public consultation, new facilities could be implemented at each of these four sites if it can be demonstrated that the planned facility fits with current uses of the location; fits within the neighbourhood setting; and is designed in conjunction with neighbourhood consultation to address the local community concerns that were expressed during this study.

1.1 Background

The City owns and operates an extensive municipal drainage system that serves local residents and businesses. The drainage system is an important part of the municipality's infrastructure. It helps to ensure efficient drainage of rain and snowmelt, and thereby helps to protect public safety, health and property.

The municipal drainage system is contained mostly within municipal roadways, and is comprised of ditches, catch-basins, culverts and storm sewer pipes, which convey drainage water (stormwater) to the Otonabee River and to local creeks such as Jackson Creek, Byersville Creek, Bears Creek, Riverview Creek, Curtis Creek, Thompson Creek and Meade Creek.

Figure 1 depicts the existing municipal drainage system serving the urbanized portion of the City.

Table 1 provides summary statistics regarding the existing municipal drainage infrastructure.

Figure 1:
Overview of Municipal Storm Management System

Legend

SWM Ponds

- Ponds Owned and Operated by City
- Ponds Not Yet Assumed by City
- Privately Owned Ponds
- Dry Ponds
- Oil/grit separation chambers per City database
- Storm Sewers
- Pond Catchments
- Serviced Area
- City Limits
- Watercourses
- Municipal Boundaries
- Major Road
- Minor Road

MAP ID	DETENTION POND NAME
1	WATER STREET POND
2	HERITAGE PARK POND
3	CUNNINGHAM BOULEVARD
4	ELDON COURT POND
5	SUMMERHILL POND
6	TOWERHILL POND NORTH
7	HILLIARD STREET POND
8	FAIRHAVEN POND
9	CHEMONG PARK PLAZA POND
10	TOWERHILL POND SOUTH
11	HILLVIEW POND
12	HEMLOCK STREET POND
13	LEAHY'S LANE POND
14	NAISH POND
15	FOXMEADOW ROAD
16	THE MEADOWS POND
17	FAIRVIEW ESTATES POND
18	LOGGERHEAD POND 2
19	LOGGERHEAD POND 1
20	WOODGLADE POND
21	GLENFOREST POND
22	KAWARTHA HEIGHTS PARK
23	WENTWORTH STREET POND
24	LANSDOWNE PLACE PLAZA
25	STEWART DRIVE POND
26	DOBBIN ROAD POND
27	COLLEGE PARK POND
28	AIRPORT ROAD PLUNGE POOL
29	MAJOR BENNETT PARK

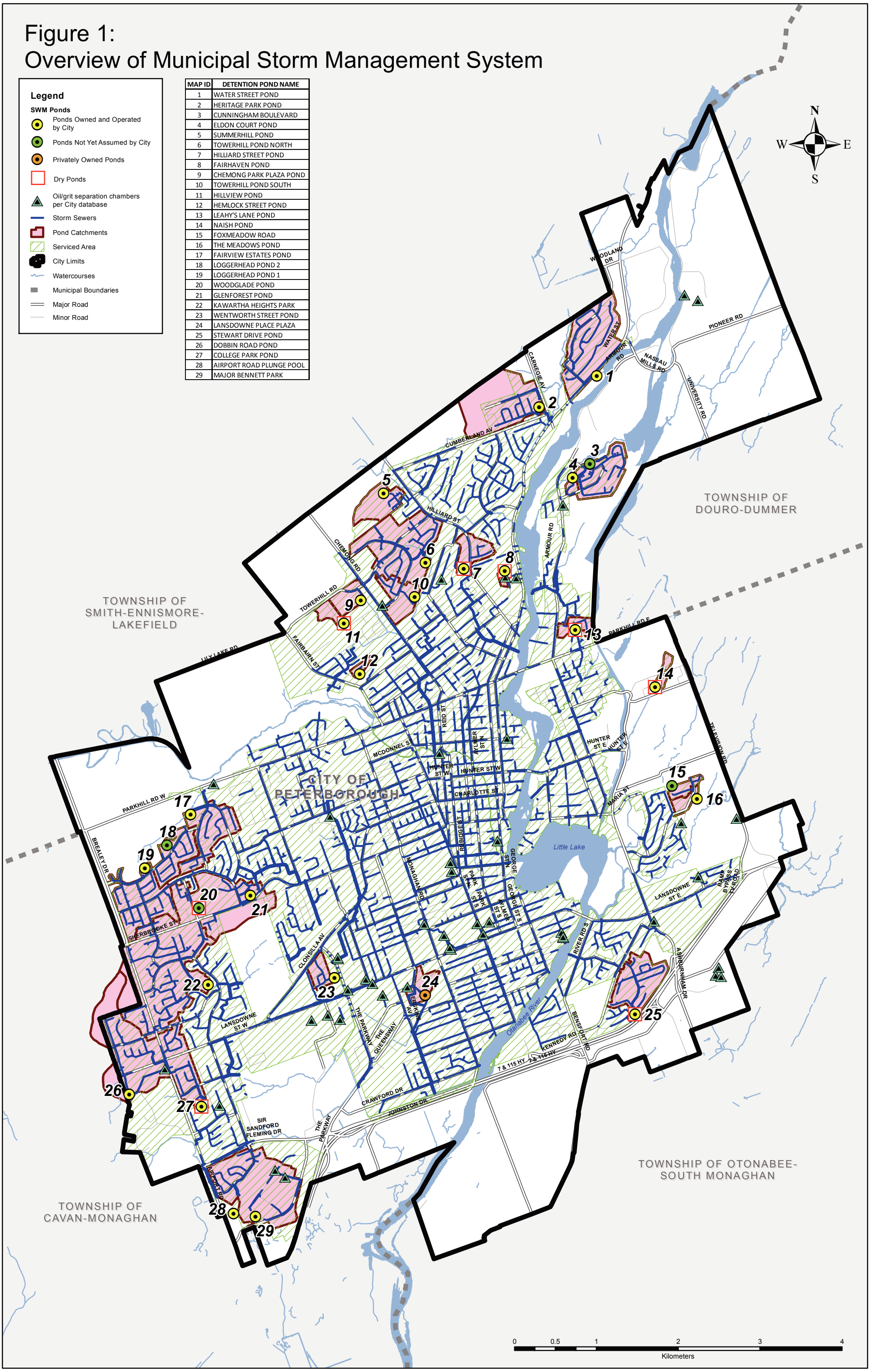


Table 1 Summary Statistics for Existing Municipal Drainage System

Total Area Served	3,600 ha
Total Length of Storm Sewer Pipe	317 km
Number of storm pipe outfalls	Total number = 299 Numbers by size category: Less than 300-mm diameter = 51 300 to 600 mm diameter = 139 600 to 900 mm diameter = 52 Larger than 900-mm diameter = 57
Number of Catchbasin Inlets	5,598 Catchbasins (CBs) 6,691 CB manholes (CBMHs) 12,289 total
Number of Municipal Stormwater Ponds	28 ponds
Area Served by Stormwater Ponds	Approximately 846 ha
Number of Private Storm Treatment Units (Oil/Grit Capture Chambers or ponds On Private Properties)	51
Estimated Area Served by Private Treatment Units	Approximately 83 ha

Note:

1. The estimated area served by private treatment units should be considered as a rough estimate. The number has been derived from the mapped location of each unit as provided by the City. The actual area draining to each of these units is unknown, but a rough estimate has been made for each unit by XCG Consultants Ltd. (XCG) by considering property parcel boundaries and parcel use.

It is now recognized that urban stormwater typically contains a range of contaminants that may contribute to pollution of our waterways and lakes. These contaminants can include sediment and grit; floating debris; oil, grease and hydrocarbon fuel residue; heavy metals; pathogenic bacteria; and residues from application of herbicides and pesticides; all of which are washed off the urban landscape into the municipal system.

Because of this concern, it is now a regulatory requirement under the Ontario Water Resources Act (administered by Ontario Ministry of Environment (MOE)) that new urban developments or property redevelopments incorporate measures or facilities to treat stormwater before it is discharged to the natural environment.

These requirements were formalized in 1994 when MOE first issued its "Stormwater Management Planning & Design Guidelines", which were subsequently updated in 2003. In some situations, development can be approved on the basis of the developer providing funding ("cash-in-lieu") towards compensatory measures implemented by the municipality at other locations where greater environmental benefit would be achieved.

As shown on Figure 1, the City's drainage infrastructure includes 29 stormwater pond facilities. The City is responsible for operating and maintaining 28 of these 29 ponds in accordance with the MOE approval that was issued at the time of facility design; one of the 29 (#24 Lansdowne Place pond) is privately owned and operated. Nineteen of the City-operated ponds were designed to provide stormwater quality treatment. The stormwater pond facilities are generally associated with newer development areas within Peterborough, and most were constructed within the last 20 years.

The Peterborough context is very similar to that faced by many municipalities in Ontario and other jurisdictions.

- The municipality owns and operates a system of drainage infrastructure (catchbasins, storm pipes, culverts, ditches, storm ponds) that has evolved over a number of decades.
- Only the more recently developed portions of the City have some form of stormwater treatment in place (typically end-of-pipe storm ponds) to help capture stormwater pollutants and thereby mitigate the impact of urban drainage on local waterways.
- A strategy is needed for maintaining the existing treatment ponds.
- A strategy is needed for reducing the amount of stormwater pollution originating from the "untreated" portions of the City, to help achieve long-term goals for sustaining and improving the local environment.

1.2 Project Scope and Method

The project has been undertaken to develop a strategy to guide the City's management of its storm drainage infrastructure, to assist with stormwater pollution control and environmental protection. One objective is to assist the City with defining and determining ongoing management requirements, and to quantify the associated costs. This will assist the City in addressing the requirements for infrastructure management that are set out in Ontario's recent Water Opportunities Act of 2010.

The project was initiated by the City in March 2011 when the City issued a Request for Proposals (RFP No. P-02-11) that described the intent and scope of the project. The City accepted the proposed project workplan submitted by XCG, and project execution began in July 2011.

As noted above, this project has proceeded as a "Master Plan" in accordance with Appendix 4 in the Municipal Class EA guidelines document.

1.2.1 Tasks

The project has been comprised by a number of tasks, per the City's RFP and XCG's workplan. In summary the project work program has included the following activities.

1.2.1.1 Information Gathering

- Acquisition of various information and data from the City, including mapping of the existing drainage system; reports related to design of existing stormwater ponds; data from previous water sampling programs; information regarding extent and cost of existing operation and maintenance programs related to roadway and drainage systems; and information on existing policies and procedures in place at the City related to review and approval of land development proposals and associated drainage infrastructure.
- Acquisition of historical local water quality data from Peterborough City-County Public Health Unit and MOE.

1.2.1.2 Stormwater Pond Investigations:

- Ground survey of all existing stormwater ponds (carried out by Elliott & Parr Surveyors) to confirm existing conditions at each pond and allow for preparation of engineering drawings depicting current status; accompanied by field inspection of the stormwater ponds to assist with preparation of engineering drawings.
- Installation of water-level monitors within the existing SWM ponds in the summer and fall of 2011, to assist with development of computer models of each pond (to facilitate future analysis of pond performance).
- Measurement of accumulated sediment depth in each pond, and chemical analysis of contaminant levels in the pond sediments, to help determine pond clean-out requirements.

1.2.1.3 Water Sampling Program

- Sampling of inflow to and outflow from each of the SWM ponds; sampling of discharges from a selected number of storm outfall pipes; and sampling of water in local creeks at various locations, to assist with examining the impact of municipal storm discharges. This work carried out in July-November 2011.
- Field inspection of 60 storm outfalls to assess general condition and potential surveillance or maintenance requirements.

1.2.1.4 Development and Evaluation of Alternatives

- Through the course of the project, four different alternatives for a long-term stormwater quality management strategy have been developed. These have been formulated by considering requirements maintaining regulatory compliance and improving system operation and maintenance, options for improving existing infrastructure, and options for revising or improving City

policies and guidelines for new land development. The alternatives have also been based on considering the need to get residents and business operators involved in helping reduce the amount of stormwater pollution that originates from private properties.

- The four alternatives have undergone an evaluation process that is intended to fulfill the intent and requirements of the Class EA process, to determine which alternative in best for the City to pursue.

1.2.1.5 Consultation

The project has included ongoing consultation between XCG and City staff, as well as consultation with government agencies and other organizations with an interest in stormwater management, through a Technical Advisory Committee (TAC). Three meetings of the TAC were held during the project; on October 18, 2011; June 19, 2012; and June 6, 2013. TAC members include:

- Otonabee Region Conservation Authority (ORCA);
- Trent University Dept. Of Biology (represented by Trent University Dept. Of Biology (represented by Dr. Jim Buttle);
- MOE (Peterborough District office);
- Peterborough County-City Health Unit;
- DFO (Peterborough office);
- Representatives of the Association for Canadian Educational Resources; and
- City's Utility Services Department.

The general public has also been advised of the project and given the opportunity to provide input and feedback. The Notice of Commencement was published in local newspapers on August 3, 2011; and the first Public Information Center (PIC) was held on November 1, 2011 at the McDonnel Street Activity Centre (577 McDonnel Street; formerly the Peterborough Lawn Bowling Club). The second PIC was held on June 13, 2013 at the Canadian Canoe Museum in Peterborough. Appendix C provides details on the information provided at and outcome of PIC # and PIC #2.

Additionally, direct consultation has taken place with representatives of First Nation communities. Refer to Appendix C.

1.2.2 Documentation of Information Gathering and Analysis

As the project progressed, project activities and outcomes were documented in a set of Technical Memoranda (TM) prepared by XCG and submitted to the City for review. Table 2 below, list the TMs that have been submitted during the course of the project:

Table 2 List of Technical Memoranda Submitted to the City During the Project

1.	Public Consultation Strategy	September 19, 2011; updated June 26, 2012
2.	Background Information Review	June 28, 2012
3.	Stormwater Pond Inventories	June 29, 2012
4.	Surface Water Quality Sampling and Analysis	June 27, 2012
5.	Pond Sediment Testing Results and Sediment Disposal Requirements	June 29,2012
6.	SWM Pond Level/Flow Monitoring	June 28, 2012
7.	SWM Pond Plan/Profile Drawings	
8.	SWM Pond Hydraulic Models	
9.	Problem, Alternatives and Evaluation Criteria	August 3, 2012
10.	Management Alternatives: Evaluation and Implementation	October 17, 2012
11.	Operation and Maintenance	November 23, 2012
12.	Recommended Stormwater Cash-In-Lieu program	November 29, 2012

This project report builds on the information and analysis presented in these TMs. This report incorporates the 12 TMs as follows:

- TM No.'s 1 to 8 are provided in Appendix L.
- The information and analysis presented in TM No. 9 and TM No. 10 has been directly incorporated within the main body of this report; and in Appendices A and B. These two TMs had been submitted to the City for review, and the comments received from the City are reflected in this project report.
- TM No. 11 (Operation & Maintenance) is provided in Appendix G.
- TM No. 12 (Recommended Stormwater Cash-In-Lieu Program) has been included as Appendix E.

The main report is intended to fully document the project method and recommendations, and makes reference to the appended TMs as needed.

2. PROBLEM AND OPPORTUNITY STATEMENT

2.1 Measured Impact of Municipal Storm Discharges

To better describe and quantify the nature of the problem (i.e. the impact of stormwater), this project included a field sampling program carried out in the latter part of 2011.

In summary, the sampling program included the following components as shown in Table 3:

Table 3 Summary of 2011 Water Sampling Program

Local Creeks	Sampling of flow in local creeks that receive discharge from the municipal storm system. This included Riverview Creek, Bears Creek, Jackson Creek, Byersville Creek, Harper Creek, Meade Creek, Curtis Creek and Thompson Creek. On each creek, sampling was done near the outlet to the Otonabee River, as well at a location upstream of most of the urban stormwater discharges.
Storm Outfalls	At 25 selected storm outfalls.
Storm Ponds	At the inlet to and outlet from 28 existing stormwater management (SWM) ponds.

Sampling was carried out on three occasions:

- October 5 and 6, 2012: dry weather with some lingering impacts from rain in the preceding days.
- October 24, 2012: wet weather, but relatively small rainfall amount 3 to 6 mm.
- November 29, 2012: wet weather, total rainfall of 45 to 55 mm.

The samples were analyzed for:

- nutrients (total and dissolved phosphorus, and nitrogen compounds);
- indicator bacteria (E. coli);
- metals (Aluminum, Cadmium, Chromium, Copper, Iron, Lead, Zinc); and
- total dissolved solids, and total suspended solids (TSS).

As well, on-site measurements were made for pH, water temperature and conductivity.

This parameter set was intended to provide general characterization of surface water quality, and to allow some assessment of the impact of stormwater on parameters which are typically of concern: namely, TSS phosphorus, E. coli, and metals such as copper, zinc and lead. Further discussion on the rationale for selecting these parameters, their potential environmental impact and applicable water-quality guidelines (i.e. desirable maximum concentrations), is provided in TM No. 4 (See Appendix L).

2.1.1 Results from 2011 Sampling Program

The results of the sampling program were presented initially in TM No. 4. Appendix A of this report provides a review of the results.

The sampling results were compared to accepted objectives established for the protection of freshwater aquatic life, and for safe recreational use of waterbodies. For most parameters, the objective is Ontario Provincial Water Quality Objective (PWQO, 1994) set by MOE. For parameters with no established PWQO, reference has been made to the Canadian Water Quality Guidelines (CCME, 2012).

Table 4 provides an interpretation of the sampling data, with the details provided in Appendix A. The sampling data were gathered during three sampling runs; the analysis results indicated the following.

Dry Weather:

In dry weather, water quality in the local creeks generally meets the relevant objectives (i.e. pollutant concentrations less than PWQO or other relevant numerical target), with the following exceptions, as highlighted in Table 4:

- Jackson Creek: Iron and E. coli;
- Byersville Creek: Aluminum, Iron, total phosphorus (TP) and E. coli;
- North Meade Creek: Aluminum, Iron, total phosphorus and E. coli; and
- Curtis Creek: Iron.

In all cases, the dry-weather E. coli contamination was only marginally above the PWQO for safe recreational water contact of 100 CFU per 100 ml, with the highest dry-weather value being 224 CFU per 100 mL. Such relatively low levels of E. coli contamination could be attributable to wildlife activity such as waterfowl. The absence of any significant dry-weather E. coli contamination indicates that there likely is not any significant sewage contamination of the creeks occurring in dry weather.

In the case of total phosphorus, the higher-than-objective values in dry weather are slightly above the PWQO of 0.03 mg/l, being in the range of 0.04 to 0.05 mg/L in Jackson, Byersville and North Meade Creek.

In the case of iron exceedances, the worst case in dry weather in a value of 0.40 mg/L, as compared to the PWQO of 0.30 mg/L. Jackson Creek, Curtis Creek and Byersville Creek below Clonsilla Avenue appear to be characterized by iron concentration that is near or above the PWQO. The reasons for this are not known, but it is possible that it is attributable to local soil conditions. However, it is also noteworthy that all of these creeks are subject to high iron concentrations in wet weather (see below); dry-weather exceedances might be attributable to lingering impact of previous wet weather. Similarly, aluminum exceedances are limited in dry weather, and may reflect the lingering effect of wet weather.

Table 4 Interpretation of Sampling Results from Local Creeks, 2011 Sampling Program (See Appendix A for detailed results.)

Legend:

✗	Concentrations in WET WEATHER greater than (worse than) the objective
✗	Concentrations in DRY WEATHER greater than (worse than) the objective
✓	Concentrations generally lower (better than) than the objective
YES	Sample results indicate that stormwater discharges are causing or contributing to creek concentrations being higher than objective concentrations, as indicated by the combination of concentrations increasing along length of the creek, and objectives not being met in wet weather.

Creek name		Al	Cd	Cr	Cu	Fe	Pb	Zn	TP	E. Coli	TSS
Riverview	OK in dry weather?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	OK in wet weather?	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗
	Increases through urban area in WW?	YES	No	No	Yes	YES	No	No	YES	YES	YES
Bears	OK in dry weather?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	OK in wet weather?	✗	✓	✗	✓	✗	✓	✓	✗	✗	✗
	Increases through urban area in WW?	YES	No	YES	Yes	YES	No	No	YES	YES	YES
Jackson	OK in dry weather?	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓
	OK in wet weather?	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗
	Increases through urban area in WW?	YES	No	Yes	YES	YES	No	YES	YES	YES	YES
Byersville	OK in dry weather?	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓
	OK in wet weather?	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗
	Increases through urban area in WW?	YES	No	Yes	YES	YES	YES	YES	YES	YES	YES
South Meade	OK in dry weather?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	OK in wet weather?	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗
	Increases through urban area in WW?	YES	No	No	Yes	YES	No	Yes	YES	No	YES
North Meade	OK in dry weather?	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓
	OK in wet weather?	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗
	Increases through urban area in WW?	YES	No	No	Yes	YES	No	Yes	YES	YES	YES
Curtis	OK in dry weather?	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
	OK in wet weather?	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗
	Increases through urban area in WW?	YES	No	YES	YES	YES	No	YES	YES	YES	YES
Thompson	OK in dry weather?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	OK in wet weather?	✗	✓	✓	✓	✗	✓	✗	✗	✗	✗
	Increases through urban area in WW?	*Not sufficient data to determine if concentrations increase along length of Thompson Creek as there were data from only one sampling location along Thomspon Creek*									

Wet Weather

The data indicate that wet-weather storm discharges are having the following impacts:

- E. coli higher than PWQO in nearly all the creeks.
- TP higher than PWQO in all creeks.
- Iron and aluminum higher than PWQO in all creeks.
- Lead, zinc, copper and chromium higher than PWQO in some creeks.
- TSS higher than the general guideline of 25 mg/L in all creeks.

These impacts appear to be due to storm discharge from the urban area. However, it needs to be recognized that measured concentrations within the creeks may also have been affected by processes within the creek channel that are associated with higher flow conditions in wet weather; such as streambank soil erosion, or resuspension and transport of previously deposited bed materials.

Sampling results from individual storm pipe outfalls help to explain the wet-weather contamination seen in the creeks. Table 5 provides the data from the largest sampled wet-weather event of November 29, 2011; additional data are in Appendix A.

- Most outfalls showed significant E. coli contamination in wet weather. For example, for the wet-weather event of November 29, 2011, observed readings over all 25 outfalls had geometric mean of 563 CFU per 100mL, with values ranging from a low of 20 to a high of 6,100 CFU per 100mL (see Table 5).
- Nearly all outfalls showed TP concentrations well above the PWQO (0.03 mg/L) in wet weather.
- Nearly all outfalls showed Aluminum, Iron and Zinc concentrations well above respective PWQOs in wet weather.
- Most outfalls had copper concentrations above PWQO in wet weather.
- Some outfalls had Lead and Chromium concentrations above PWQO in wet weather.

Results of the SWM pond influent (inflow) monitoring are consistent with this picture, as indicated by the following average wet-weather pond influent concentrations:

- TP concentration well above PWQO, at 0.19 to 0.30 mg/L;
- TSS at 122 to 228 mg/L;
- E. coli above PWQO, with geometric mean at 242 to 525 CFU / 100 mL; and
- Aluminum, Iron, Zinc and Copper concentrations above PWQO.

The sampling results from 2011 indicate that stormwater discharges are partly or possibly wholly responsible for pollutant concentrations in local creeks rising above accepted objectives (e.g. PWQO) during wet weather. The parameters or indicators most affected are TP, E. coli, TSS and metals including Aluminum, Iron, Zinc and Copper.

In the case of E. coli, the level of observed contamination in wet weather is above the PWQO objective for safe recreational water use (100 CFU per 100 mL) but is not so high as to indicate that there is sewage contamination of the storm pipe system (e.g. from sanitary sewers overflowing into storm sewers). If such sewage contamination were happening, much higher E coli densities (i.e. well above 10,000 CFU per 100 mL) would be expected.

Water Temperature

The 2011 field program also included water level and water temperature monitoring within the City-owned storm ponds. Level and water temperature were measured between third week of July and early October.

Within the City's wet ponds, it was observed that maximum water temperatures on hot summer days approached the maximum recorded air temperature. For example, on the hottest day of the 2011 monitoring period, July 23, 2011, maximum air temperature at Peterborough was 32 deg.C, and maximum water temperature recorded in a number of the wet ponds approached 30 deg.C. Similarly on August 2, 2011, with maximum air temperature reaching 29 deg.C, wet pond water temperatures peaked at 28 deg.C. Figure A-2 in Appendix A provides temperature data plots for four of the wet ponds to illustrate representative results.

These results indicate that during warm summer periods, discharges from the storm ponds could be having a warming effect on local watercourses, and potentially on the ability of local watercourses to provide suitable habitat for fish species that are not tolerant of warm water.

Table 5 Results of Sampling Storm Outfalls Discharges, Rain Event of Nov. 29, 2011 (45 to 55 mm Rainfall in Peterborough)

					Al	Cd	Cr	Cu	Fe	Pb	Zn	NO_3-N	TP	*E.coli*	TSS
				Objective>>	0.075	0.0002	0.0089	0.005	0.3	0.005	0.02	2.93	0.03	100	25
OUTFALL ID	Location description	Creek / watershed	Pipe Size (mm)	Catchment land area											
D4	Water Street, 1/2 between University Heights Blvd. and Carnegie Ave.	Otonabee River	250	0.5 ha	0.861	<0.0002	0.002	0.0074	1.02	<0.003	0.037	0.22	0.06	24	43
D18	North of Marina Blvd. & Water St.	Otonabee River	750	34.4 ha	0.317	<0.0002	<0.001	0.0026	0.35	<0.003	0.018	0.16	0.07	80	11
D21	Otonabee River, Whitaker St. & Armory Rd.	Otonabee River	1500	36.1 ha	0.305	<0.0002	<0.001	0.0013	0.391	<0.003	0.009	1.55	0.06	20	12
D22	Otonabee River, Argyle St. & Water St.	Otonabee River	1300	81.5 ha	0.975	<0.0002	0.003	0.0041	1.11	<0.003	0.022	0.29	0.17	1,000	49
D24	Water St. & Edinburgh St.	Otonabee River	1050	15.0 ha	1.41	<0.0002	0.009	0.0162	1.9	0.021	0.082	<0.05	0.25	2,600	111
D27	Otonabee River, Douro St.	Otonabee River	1143 x 1067	28.4 ha	1.41	<0.0002	0.004	0.0087	1.61	0.007	0.057	0.36	0.21	320	67
D32	Otonabee River, James Stevenson Park	Otonabee River	1050	20.0 ha	2.14	<0.0002	0.005	0.0214	2.36	0.01	0.073	0.33	0.22	320	121
D60	Parkhill Rd. W. & Ravenwood Dr.	Jackson Creek	1200	34.7 ha	0.326	<0.0002	<0.001	0.0016	0.457	<0.003	0.005	0.44	0.07	600	11
D23	Jackson Creek tributary, Fairbairn St. & Parkview Dr.	Jackson Creek	1050	20.3 ha	0.701	<0.0002	0.001	0.0028	1.48	<0.003	0.024	0.62	0.12	200	36
D28	Jackson Creek, Murray St. & Downie St.	Jackson Creek	2133	132.5 ha	1.3	<0.0002	0.004	0.0083	1.7	<0.003	0.038	0.28	0.14	1,640	64
D29	Jackson Creek, Murray St. & Bethune St.	Jackson Creek	1067 x 1067	21.7 ha	2.03	0.0002	0.027	0.0318	2.98	0.012	0.115	0.2	ND	6,100	144
D34	Jackson Creek near Otonabee River, Townsend St. & George St. N.	Jackson Creek	1050	4.7 ha	1.55	<0.0002	0.004	0.0117	1.98	0.01	0.053	0.18	0.22	1,800	90
D36	Otonabee River, Rink St.	Otonabee River	1524 x 965	190.7 ha	1.71	<0.0002	0.004	0.0205	2.07	0.012	0.065	0.22	0.18	1,700	109
D37	Little Lake, Romain St. & Crescent St.	Otonabee River (Little Lake)	600	36.4 ha	1.32	<0.0002	0.004	0.0116	1.71	0.007	0.06	0.23	0.17	1,100	86
D38	North Meade Creek, Marsdale Dr.	North Meade Creek	1300	22.3 ha	2.86	<0.0002	0.007	0.0113	3.17	0.008	0.064	0.06	0.4	250	153
D39	Otonabee River, Lockside Dr.	Otonabee River	1200	24.7 ha	3.48	0.0003	0.013	0.0156	4.57	0.011	0.088	0.34	0.29	1,100	162
D40	Otonabee River, River Rd. S. & Southlawn Dr.	Otonabee River	900	37.8 ha	0.868	<0.0002	0.002	0.004	0.948	<0.003	0.025	0.23	0.13	96	47
D42	Otonabee River, Park St. S. & Cameron St.	Otonabee River	1929 x 1828	116.3 ha	0.999	<0.0002	0.003	0.0062	1.19	0.005	0.038	<0.05	0.13	270	60
D43	Otonabee River, Cameron St. & St. Catherine St.	Otonabee River	600	32.7 ha	0.664	<0.0002	0.002	0.0054	0.931	<0.003	0.031	0.05	0.11	740	38
D44	Otonabee River, Monaghan Rd & Crawford Dr.	Otonabee River	900	9.0 ha	0.973	<0.0002	0.007	0.0062	1.21	<0.003	0.043	0.05	0.13	650	56
D55	Byersville Creek, near Pond #22	Byersville Creek	1500	63.2 ha	0.827	<0.0002	0.002	0.0078	0.842	<0.003	0.022	0.47	0.11	2,900	51
D57	Byersville Creek main stem above Clonsilla Ave (Whitefield Park)	Byersville Creek	1800	195.2 ha	0.233	<0.0002	<0.001	0.0016	0.284	<0.003	0.008	0.7	0.06	2,400	12
D58	Byersville Creek main stem between Clonsilla Ave & Lansdowne St W	Byersville Creek	1800	159.8 ha	1.57	<0.0002	0.004	0.0104	1.96	0.004	0.056	0.38	0.17	820	85
D49	Creekwood Dr. & Spillsbury Dr.	Byersville Creek (Harper Creek)	1600	34.2 ha	1.63	<0.0002	0.003	0.0094	1.8	0.005	0.033	1.39	0.14	1,220	85
D45	Erskine Avenue storm sewer to Byersville Creek	Byersville Creek	1500	108.3 ha	2.39	<0.0002	0.006	0.0143	2.56	0.025	0.09	0.11	0.16	590	117

NOTES:

(1) Highlighted values indicate values that are numerically greater than the objective concentration.

(2) The noted objective concentrations are the Ontario Provincial Water Quality Objectives (MOE, 1994) for all parameters except NO_3-N and TSS

(3) For NO_3-N, the objective is per Canadian Water Quality Guidelines (CCME, 2012)

(4) For TSS, the value of 25 mg/L is based on general guidelines related to protecting aquatic habitat and water clarity.

2.1.2 City Data from 2005

The City had carried out a storm system sampling program in 2005. The data from the 2005 program were obtained and reviewed.

TM No. 4 presented the average measured concentrations from the 2005 sampling program. The 2005 program was comprised of sampling on four occasions at a total of 18 locations; 8 locations were within local creeks, and 10 locations were at storm outfalls. The results seen in 2005 are generally consistent with results from 2011:

- E. coli contamination higher than PWQO in all creeks and at all outfalls.
- TP above PWQO in most creeks and at most outfalls.
- Aluminum, Iron, Copper and Zinc above PWQO in all or some creeks; and at many of the outfalls.

The TSS concentrations measured in 2005 are on average lower than those measured in 2011, particularly at storm outfalls.

2.1.3 Public Health Unit Data

TM No. 4 included review of data obtained from the Peterborough County-City Public Health Unit, consisting of Bathing Beach Reports from 1994 - 2011. These reports identify E. coli concentrations (geometric mean), water temperature, bather load, presence of geese, and rainfall in the past 24 and 48 hours. Sampling was carried out during the summer season (late May to early September); if concentrations exceed 100 CFU/100 mL then the beach is posted as unsafe for swimming.

A summary of PWQO exceedance and stormwater linkage is shown in Table 6 for the Beavermead and Rogers Cove beaches. This table shows that there approximately one-third of the PWQO exceedances are caused mainly by stormwater discharges; and that stormwater is the main factor or a contributing factor in about 50% of the E. coli exceedances.

Table 6 Summary of E. coli Exceedances at Public Bathing Beaches in the City

Beach	PWQO Exceedances (E. coli > 100 CFU/100mL)	Stormwater Likely the Main Cause of Exceedance	Stormwater a Likely Contributor to Exceedance
Beavermead	210	72	24
Rogers Cove	168	67	21

Notes:
1. Above table based on review of data reports from Public Health Unit for 1994 to 2011.
2. Insufficient data to characterize 2006 for Rogers Cove.
3. Increase in geese use over time noted by Health Unit at both locations.
4. Linking stormwater discharges: If only rainfall was observed with minimal geese and bathers using the beach, then stormwater discharges were identified as the main cause of water quality degradation at the beach. In instances where rain and geese and/or bathers were identified, stormwater was identified as a contributing factor.
5. In some cases E. coli exceedances did not correspond with rainfall events and many rainfall events did not result in an E. coli exceedance.

2.1.4 Mitigating Effect of SWM Ponds

The 2011 sampling program included sampling of inflow (influent) and outflow (effluent) at the existing SWM ponds. Appendix A presents the results.

The results for the two wet events (October 24 and November 29) show that the existing ponds appear to be having a beneficial mitigating effect. There are favourable reductions in pollutant concentrations for TP, TSS, E. coli and metals.

In particular, comparison of average TSS concentration at pond inlets with average TSS concentration at pond outlets, indicates a reduction in average TSS concentration of approximately 80%. While this result is based on limited data from each pond facility, it does provide a favourable indication that the existing SWM ponds, considered as a system, may be providing a level of TSS reduction consistent with current MOE design guidelines.

The concentration reductions provided by the existing SWM ponds are generally consistent with what has been reported in the literature with respect to average reduction in total phosphorus, as well as for a number of the metals. These reductions may reflect what appears to be reasonably favourable removal of TSS, as a significant portion of phosphorus, metals and other contaminants are associated with suspended solids entering the pond facilities (Pitt, 1999).

2.1.5 Surface Water Quality Upstream and Downstream of Peterborough

To assist with describing the impact of municipal stormwater discharges on the environment, the available data were reviewed with respect to changes in surface quality between points upstream and downstream of Peterborough; in other words, to describe the difference between flow quality entering and exiting the City limits.

As noted in Table 3, the sampling program conducted in 2011 was designed to incorporate sampling locations along the local creeks at points that are at City limits or upstream of municipal storm discharges.

As well, data available from the Ministry of Environment's Provincial Water Quality Monitoring Network (PWQMN) for sampling stations along the Otonabee River, were obtained and reviewed. The PWQMN data were reviewed for three stations along the Otonabee River:

- Station 17002101302 located at Nassau Mills Road, for 1965 to 2006.
- Station 17002107002 located at Lock 19, for 1972 to 2011.
- Station 17002101102 located at the Highway 115 bridge, for 1964 to 2007.

The PWQMN data generally consists of monthly sampling results for these river stations. Sampling is not necessarily done in wet weather, and individual sample results may therefore not indicate any wet-weather effects such as municipal stormwater discharges. The PWQMN database nonetheless helps to indicate whether discharges from the Peterborough urban area are having an effect on water quality along the river.

Review of the PWQMN data has shown the following (See Appendix L for details):

- With respect to phosphorus, concentrations above and below the City are lower (better) than the Provincial Water Quality Objective of 0.03 mg/L.
- Mean suspended solids concentrations do not increase and are low (< 3 mg/L).
- Mean concentration of metals including Cadmium, Chromium, Copper, Iron, Lead and Zinc are lower (better) than PWQO upstream and downstream of (above and below) the City, and do not increase across the City. In the case of Aluminum, concentrations remain lower (better) than PWQO, but increase between Nassau Mills Road and the Lock 19 and Highway 115 locations.

The PWQMN data indicates that surface water quality in the river meets PWQO, and therefore the river conditions appear favourable for sustaining high-quality aquatic communities. It further implies that while municipal storm discharges may be having an impact on local creeks (per the 2011 sampling results), there may not be substantial benefits to the Otonabee River by reducing pollutant levels in municipal storm discharges from Peterborough. This in part reflects the fact that the Peterborough municipal area of approximately 64 square kilometres, represents less than 1% of the total watershed of the Otonabee River upstream

of Peterborough (being approximately 7,410 square kilometres to the Peterborough water plant intake).

With respect to changes that happen along the local creeks, the 2011 sampling program allows for assessment, as follows.

- For the following creeks, a substantial portion of the creek's drainage area lies outside (upstream of) the City limits: North and South Meade Creeks, Jackson Creek, Bear s Creek, Riverview Creek and Curtis Creek.
- For these creeks, the 2011 sampling program included sampling stations both near City limits or upstream of most of the Peterborough municipal storm drainage inputs to each creek, as well as near the creek outlet to Otonabee River.
- The results (see Table A-1 in Appendix A) show that:
  - In North and South Meade Creeks, E. coli and TP concentrations at the City limits were higher than PWQO in wet weather; and for Iron and Aluminum in the case of South Meade Creek.
  - In Jackson Creek, E. coli concentrations were slightly above PWQO at City limits, as was Aluminum in wet weather.
  - In Bears Creek and Riverview Creek, E. coli and TP concentration upstream of the municipal storm inputs were higher than PWQO in wet weather; and the same was true for Iron and Aluminum. In dry weather, concentrations were below (better than) PWQO, with exception of Aluminum in Bears Creek.
  - In Curtis Creek, E. coli and TP concentration upstream of the municipal storm inputs were higher than PWQO in wet weather; and the same was true for Iron, Aluminum and Copper. In dry weather, concentrations were below (better than) PWQO, with exception of Iron.

These results are therefore indicating that elevated levels of E .coli, TP and some metals observed within the local creeks in wet weather, are partially attributable to inputs from outside the City boundary.

2.2 Sources and Levels of Stormwater Pollution

In formulating alternatives to deal with the stormwater contamination, it is important to account for the most probable source of the issue.

2.2.1 Sources of Urban Stormwater Contamination

Reviews of research provided by Heaney et al. (1999) and Pitt (1999) provide useful overview, based on extensive research, primarily from US cities. The following points are excerpts from these publications:

- Various urban source areas all contribute different quantities of runoff and pollutants, depending on their characteristics.

- Impervious source areas may contribute most of the runoff during small rain events. Examples of these source areas include paved parking lots, streets, driveways, roofs, and sidewalks.
- Pervious source areas become important contributors for larger rain events. These pervious source areas include gardens, lawns, bare ground, unpaved parking areas and driveways, and undeveloped areas.
- The washoff of debris and soil during a rain is dependent on the energy of the rain and the properties of the material. Pollutants are also removed from source areas by winds, litter pickup, or other cleanup activities. The runoff and pollutants from the source areas flow directly into the drainage system, onto impervious areas that are directly connected to the drainage system, or onto pervious areas that will attenuate some of the flows and pollutants, before they discharge to the drainage system.
- Sources of pollutants on paved areas include on-site particulate storage that cannot be removed by usual processes such as rain, wind, and street cleaning.
- Atmospheric deposition, deposition from activities on these paved surfaces (e.g., auto traffic, material storage) and the erosion of material from upland areas that directly discharge flows onto these areas are the major sources of pollutants to the paved areas.
- Pervious areas contribute pollutants mainly through erosion processes where the rain energy dislodges soil from between vegetation. The runoff from these source areas enters the storm drainage system where sedimentation in catchbasins or in the sewerage may affect their ultimate discharge to the outfall. In-stream physical, biological, and chemical processes affect the pollutants after they are discharged to the ultimate receiving water.
- Stormwater runoff typically exceeds some water quality standards for practically every rain event (especially for bacteria and some heavy metals).

As noted by Pitt (1999), “years of study reveal that the vast majority of stormwater toxicants and much of the conventional pollutants are associated with automobile use and maintenance activities, and that these pollutants are strongly associated with the particulates suspended in the stormwater (the non-filterable components or suspended solids). Reducing or modifying automobile use to reduce the use of these compounds, has been difficult with the notable exception of the phasing out of leaded gasoline”.

Pitt (1999) further notes that “the effectiveness of most stormwater control practices is, therefore, dependent on their ability to remove these particles from the water, or possibly from intermediate accumulating locations (such as streets or other surfaces) and not through source reduction. The removal of these particles from stormwater is dependent on various characteristics of these particles, especially their size and settling rates. Some source area controls (most notably street cleaning) affect the particles before they are washed off and

transported by the runoff, while others remove the particles from the flowing water".

In other words, the problem of stormwater contamination is endemic to our urban areas by virtue of the very nature of urban design and use, especially automobile activity. True source control, meaning the elimination of the primary source, is difficult and may be impractical. As a consequence, we need to consider available opportunities to implement retrofit stormwater treatment within the existing municipal system, to help control pollutant load released to local watercourses.

2.2.2 Levels of Contamination in Peterborough

It is worthwhile to compare the measured stormwater pollutant concentrations from the 2011 Peterborough sampling program, with statistics developed from research and studies in other North American cities.

The most comprehensive source of information is the U.S. National Stormwater Quality Database (Pitt et al., 2004). As of 2004, this database included data from 3,770 separate storm events from 66 agencies and municipalities. The data are from the U.S., but data review reported by Heaney et al. (1999) includes consideration of data from some Ontario cities including Toronto and Ottawa.

Table 7 compares median pollutant concentration values from the U.S. National Stormwater Quality Base, with the values obtained from the 2011 sampling program in Peterborough.

The Peterborough data indicate that local stormwater has levels of contamination that can be considered as generally consistent with what has been measured in many other North American urban areas. The median concentrations for Peterborough listed above are mostly lower than the US NSQD values, perhaps indicating that pollutant levels in Peterborough stormwater are somewhat lower than average.

Table 7 Comparison of Peterborough Stormwater Quality to U.S. National Stormwater Quality Database

Parameter	Units	US NSQD Medians (Jan. 2004)	Peterborough 2011 medians	
			Outfalls (25 Outfalls, 2 Events = 50 Samples)	Stormwater pond influent (33 Inlets, 2 Events = 66 Samples)
Total phosphorus	mg/L	0.27	0.13	0.15
Nitrite + Nitrate	mg/L	0.6	0.49	0.84
Total Suspended Solids	mg/L	58	37	56
Fecal coliform	CFU/100mL	5,081	n.r	n.r
E. coli	CFU/100mL	n.r.	635	530
Cadmium	mg/L	0.001	0.0003	0.0004
Copper	mg/L	0.016	0.0076	0.0059
Lead	mg/L	0.016	0.010	0.006
Zinc	mg/L	0.116	0.031	0.027

Notes:
"n.r." = not reported.
E. coli densities typically 0.7 to 0.9 that of fecal coliform.

2.3 Potential Impact of Urban Development

New urban developments such as residential subdivisions or commercial/ industrial property development present the potential to increase stormwater runoff volumes and associated pollutant loadings.

New land development projects are now subject to requirements imposed by MOE, as set out in MOE's 2003 Stormwater Management Planning & Design Manual. The MOE requirements are echoed in the City's own engineering design guidelines that apply to design of infrastructure to service new development.

From this standpoint, the potential impact of new development on stormwater pollution is being addressed through the development approval process and regulatory review.

However, stormwater management for new urban development is an area of significant ongoing research and innovation, throughout North America. New

urban design approaches are being explored, to help address a wide range of issues including flood control, watercourse erosion control, groundwater protection and local water-budget maintenance. In many jurisdictions, there are initiatives to move towards an integrated "Low Impact Design" (LID) approach that, in part, helps to minimize surface runoff through use of creative site design approaches.

In this context, it is appropriate for the City of Peterborough SWQMP to consider the emerging ideas and approaches, and find ways to have the new techniques and technologies considered and implemented where appropriate as new development or property redevelopments happen over the coming years in the City.

2.4 Regulatory Requirements

2.4.1 Compliance at Existing SWM Ponds

The City owns and operates 28 existing stormwater management ponds. Typically, each of these facilities is provided with a Certificate of Approval ("C of A") under the Ontario Water Resources Act, issued by the Ontario Ministry of Environment (MOE).

Each facility C of A may contain requirements related to ongoing operation and maintenance. These requirements need to be met for the City to remain in compliance with the MOE approval. The SWQMP therefore needs to address these requirements, in order to define what actions the City needs to carry out in future to ensure continued compliance.

2.4.2 Implications of Water Opportunities Act

The Province of Ontario recently enacted the Water Opportunities Act (2010). This legislation effectively requires municipalities to develop management and funding strategies for existing water-related infrastructure systems, including municipal stormwater drainage and management infrastructure.

The SWQMP therefore needs to assist the City in this regard, by defining system management requirements and cost associated with the components of the system that relate to stormwater quality control, particularly requirements and cost associated with the many stormwater treatment ponds.

2.5 Summary of Problems and Needs

2.5.1 Problem: Stormwater Contamination

The problem of stormwater contamination is City-wide in nature, and varies across the City. The municipal drainage system is extensive. It is located primarily within the municipal road rights-of-way, and consists of a system of pipes, catchbasins, culverts and ditches. This system collects drainage water (stormwater) from numerous private properties, as well as properties owned by a number of government agencies that own parcels within Peterborough. There are 299 separate storm pipe outlets to local creeks and the Otonabee River.

The available data from Peterborough, including the 2011 sampling results indicate that local stormwater has levels of contamination (metals including aluminum, copper, lead, zinc, iron, cadmium and chromium; phosphorus; and indicator bacteria E. coli) that can be considered as generally consistent with what has been measured in many other North American urban areas.

2.5.1.1 Impact on Local Creeks

- Wet-weather discharges from the municipal storm drainage system affect surface water quality in local creeks as they pass through the City and flow into the Otonabee River.
- The wet-weather impact along local creeks is to the degree that concentrations of some pollutants rise to values higher than the relevant Provincial Water Quality Objective. The 2011 sampling program has shown that this is generally the case for total phosphorus, E. coli, Aluminum, Iron, Copper and Zinc; and occasionally for Lead and Chromium. The implication is that stormwater discharges may be having an impact on aquatic life and aquatic habitat within local creeks.

2.5.1.2 Impacts on Municipal Swimming Beaches

- Wet-weather discharges from the municipal storm system appear to be causing or contributing to bacterial contamination at public swimming beaches at Beavermead Park and at Roger's Cove Park. The level of bacterial contamination within local creeks in wet weather means that there is a potential risk to public health from any body contact with the flow in those creeks.

2.5.2 Need: Maintain Existing SWM Ponds

- Stormwater treatment ponds that have been constructed in recent years as part of new urban developments are helping to mitigate the impact. These pond facilities are providing stormwater treatment for roughly 25% of the urban area.
- Based on the influent and effluent data collected at the ponds in 2011, it appears that these ponds are having a positive effect by reducing pollutant concentrations in the stormwater discharged to local watercourses.
- A strategy for maintenance of these facilities is needed. Maintenance activities such as removal of accumulated sediment are needed to ensure that each existing facility performs as designed and stays in compliance with its existing regulatory approval.
- As well, defining the costs and funding sources for the ongoing system maintenance requirements will help the City address the requirements of the Water Opportunities Act.

2.5.3 Need: Address Untreated Areas

- Much of the existing urban area (roughly 75% of it) and its municipal drainage system were designed before current standards came into place. These areas were designed and built without specific measures or facilities to minimize stormwater pollution.
- A strategy for minimizing stormwater pollution from these areas is needed.
- Defining associated costs is required, to assist City with infrastructure planning and addressing requirements of the Water Opportunities Act.

2.5.4 Need: Promote Innovative and Progressive Approaches

- With respect to stormwater management, design of new urban developments or property redevelopments, is subject to the requirements of the City's Official Plan, zoning by-law and engineering design standards, as well as applicable regulatory requirements of approval authorities such as MOE and ORCA. In this context, innovation needs to be strongly encouraged, promoted and supported through the land-use planning and site design approval process. Innovative approaches to urban SWM can help support local initiatives towards urban sustainability.

3. DEVELOPING ALTERNATIVE SOLUTIONS

3.1 General Approaches to Developing Alternatives

The Class Environmental Assessment (EA) Master Plan process involves the formulation and evaluation of "alternative solutions" for addressing the defined problem or need.

In this case, the environmental impact issue (water pollution by stormwater) is associated with an infrastructure system owned and operated by the City. The source of the problem lies within not only the municipal rights-of-way and properties in which the system is contained, but also originates within the numerous private properties that the system serves.

The strategy for reducing impacts of urban drainage on water quality must be a long-term plan that includes improving the maintenance, operation and design of the system. The final plan will consist of measures and actions to be undertaken by the City over a number of decades to fully implement. The components of the plan need to be well integrated with other City initiatives, such as the on-going flood-reduction plan implementation and land-use planning.

In this context, it also needs to be noted that as described above, some of the water pollution seen along local creeks within the City, is partly attributable to sources within portions of the creek watersheds that lie outside City limits. This is the case for Jackson Creek, Bears Creek, North and South Meade Creeks, Riverview Creek and Curtis Creek. This means that to completely solve existing water pollution issues, actions would be needed not only within the City limits, but also in areas outside the City by agencies or parties other than the City of Peterborough.

To help address the identified problems and needs, the alternative approaches that the City could consider encompass a wide spectrum.

At one end of the spectrum, the City could contemplate an engineered "technical" solution that involves only physical modifications and enhancements to the drainage collection infrastructure that the City itself owns and operates. Such an approach could involve, for example, installation of numerous individual stormwater treatment facilities within the existing urban area, to adequately treat stormwater before it is discharged to the natural environment. This approach would be very costly. And, as discussed below, it is very difficult to justify from a benefit-cost perspective. As well, it may provide little incentive and encouragement for dealing with the source of the problem through better pollution management and innovative design approaches on individual properties and within the urban area as a whole.

At the other end of the spectrum would be an approach that relies on property owners to control the quality of stormwater discharged to the municipal collection system. This broad-based "source control" approach would effectively require all property owners (including the City) to implement necessary measures. While

this general approach may have some appeal, its implications and requirements likely make it impractical and infeasible. At a minimum, the City would need to monitor discharges from numerous properties to ensure continued compliance. Because of the diffuse nature of inflows to the system, and the extent of the system, this alone could make this approach impractical. And property owners could be faced with having to implement expensive measures that could represent an onerous burden. As well, to provide a complete solution, the municipality would also need to implement measures to address the stormwater contamination that results from wash-off processes within the municipal road allowance.

A practical long-term strategy will most likely consist of some combination: a program of various source control measures, combined with some set of modifications and enhancements to the existing municipal collection system that can be justified with respect to cost and other environmental impacts.

3.2 Long-term Perspective

The plan should be based on a long-term perspective in which, over time, the true source of the problem is dealt with.

This means that the final strategy should place some emphasis on source control. Source control could encompass many types of actions and measures. This could range from programs and incentives to encourage beneficial actions by private home-owners and business operators, to changes to the design requirements for new property developments. Public outreach and education is an important part of any source-control initiative.

The drainage system and infrastructure is an integral part of the overall urban environment. The design of every streetscape, as well as the layout and design of individual properties, is directly influenced by the need to ensure proper surface drainage.

The urban environment is continually being renewed, rebuilt and improved. At the City-wide scale, this may happen gradually as individual properties are rebuilt, rehabilitated or redeveloped. This ongoing process is incremental, but it presents opportunity. Design approaches, methods and materials are continually improving, with an ever-increasing emphasis on environmental impacts, maintenance cost and long-term affordability, these factors all falling within the general notion of building in “sustainability”.

On the stormwater issue, a long-term plan that seeks to emphasize source control needs to take advantage of this opportunity. The plan needs to include practical and meaningful measures that promote or require innovative site design measures to control, reduce or eliminate stormwater discharges.

This long-term approach also takes advantage of what hopefully may be longer-term trends in the true source of the stormwater pollution problem. Much of the source is continual deposition of contaminants on hard urban surfaces, especially automotive vehicle surfaces – roads and parking areas. The source of this

continual deposition is in part, local automotive traffic, but it is also in part due to larger-scale atmospheric transport and deposition processes. As well, some contaminant deposition and wash-off results from local use of chemicals (pesticides, herbicides, etc.).

There may be hopeful trends towards reduction over time in these primary sources. As an example, there has been reduction in recent years in application of chemicals for landscape maintenance on public and private properties. On the automotive side, elimination of lead as an additive in gasoline fuels has reportedly helped to reduce lead concentrations in urban stormwater (Heaney et al., 1999). As well, the automotive industry has been adapting by modifying components such a brake pads to reduce the amount of metals such as copper released into the environment. Locally, the City has supported and committed to an aggressive plan to increase use of public transit as well as pedestrian/cycling commuting, to help reduce reliance on private automobile use. In general, improvements in technology, reduced air pollution, reduced local chemical application and improved land management practices are likely over time to bring about reduction in local pollution sources and in the larger-scale atmospheric transport and deposition of a range of contaminants.

3.3 Demonstrating Benefit

There are various benefits that can result from the City having in place and implementing a SWQMP.

A main objective in reducing the amount of pollutants carried to local waterways by the urban drainage system is to lessen any impacts on the natural environment and aquatic ecosystem. Reducing the amount of phosphorus, metals, suspended solids and associated contaminants that are discharged to local creek and the Otonabee River will be of benefit. However, it may be difficult to identify or quantify specific benefits that could justify significant immediate expenditures on better stormwater control.

3.3.1 Aquatic Environment in Otonabee River

In the case of the Otonabee River, available water quality data indicates that with respect to phosphorus and metals, concentrations in the river within Peterborough are lower (better) than the Provincial Water Quality Objectives. This means that surface water quality in the river appears to be generally favourable to sustaining high-quality aquatic communities. It further implies that any improvement in the quality of stormwater discharged to the river from the City may not have a demonstrable benefit in the river, with respect to improving conditions for aquatic life. A further consideration is that available municipal resources might be better allocated to dealing within the issue of excessive inflow and infiltration into the sanitary sewage collection system which contributes to high inflows to the City's wastewater treatment plant.

3.3.2 Recreational Use along Otonabee River

There is intermittent bacterial contamination in the river at public bathing beaches at Beavermead Park and at Roger's Cove Park. The Public Health Unit data indicate that stormwater discharges contribute to this problem. There are a number of other contributing factors such as waterfowl activity, that make it difficult to determine how much reduction in this problem would occur if stormwater discharges were not contaminated by E. coli to the degree that they are. Furthermore, bacteriological contamination by stormwater at the two public beaches may generally be quite short-lived after wet weather. From this standpoint, it is difficult to attribute or quantify the benefit in recreational-use opportunity and public safety that would result from reducing E. coli levels in storm system discharges.

3.3.3 Aquatic Environment in Local Creeks

In the case of the locals creeks (e.g. Byersville, Jackson, Curtis, Bears et al.), the 2011 sampling has shown that there are definite wet-weather impacts, with pollutant concentrations rising above PWQO consistently. The exceedances of the PWQO mean that probably there is impact on local aquatic communities, but the impact may be limited because of the limited duration of wet-weather events.

Figure 2 shows the general aquatic habitat classification of the local creeks that receive discharge from the municipal drainage system; this stream habitat classification map is based on information provided by Otonabee Region Conservation Authority (ORCA) as well as information contained in various reports provided by the City that are related to each of the creeks (e.g. the study reports prepared as part of the City's flood-reduction program).

Aquatic communities within the local creeks have presumably adapted to the intermittent pollution caused by stormwater discharges. Reduction in stormwater pollution could over time help to support an increase in the diversity of aquatic species along the creeks as they pass through the urban area.

While such an outcome would obviously represent an environmental benefit, it again becomes difficult to quantify it in a way that might help to justify significant immediate expenditures.

3.4 Municipal Responsibilities

Based on the above, it is difficult to quantify the direct environmental or recreational benefits of any program of stormwater pollution reduction in Peterborough.

Furthermore, with respect to existing municipal storm pipe systems that discharge without treatment to local creeks or the Otonabee River, the City does not have any known legal or regulatory obligations with respect to control of the concentrations of specific contaminants in those discharges.

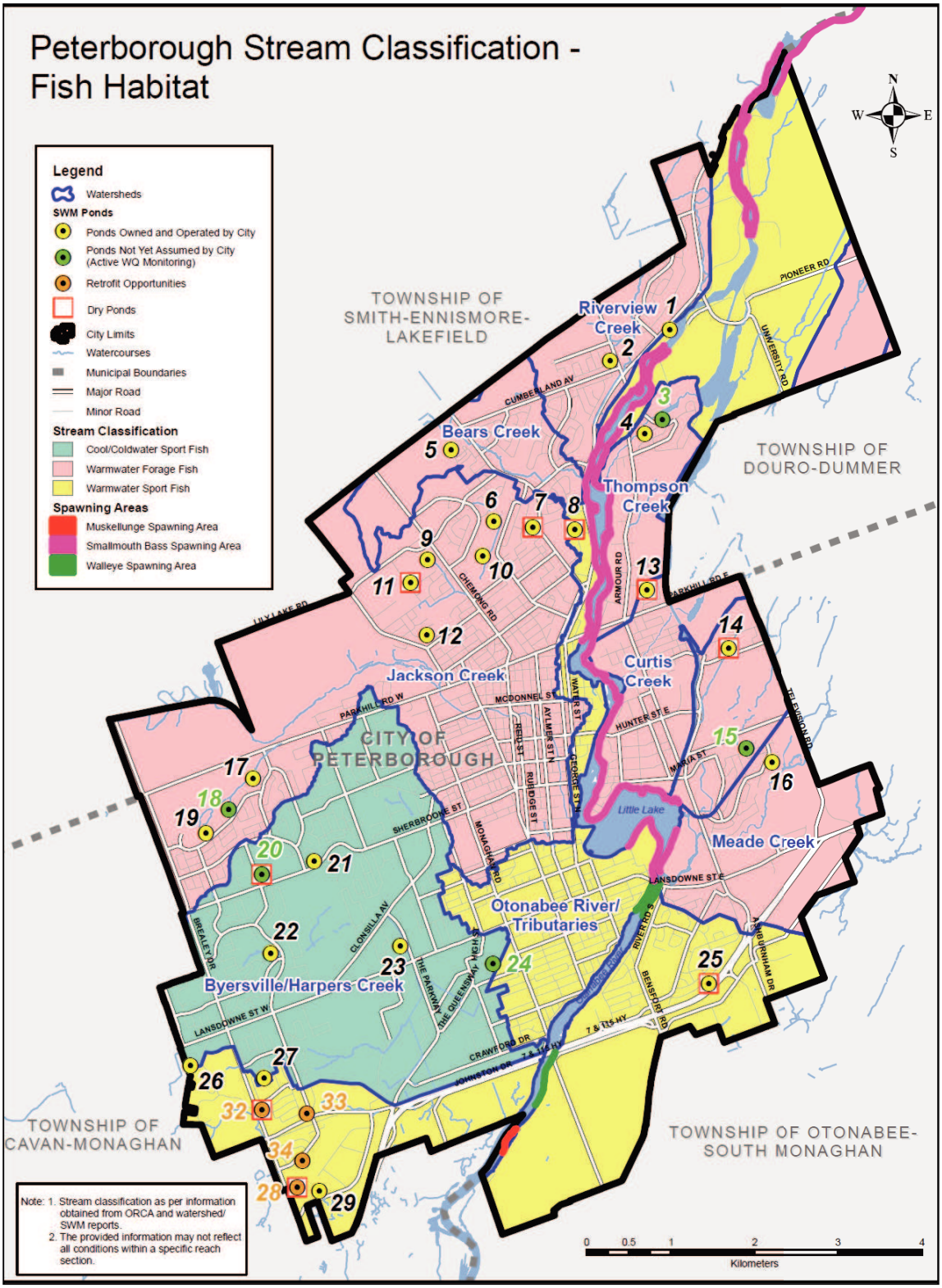


Figure 2 Local Creeks, Stream Classification by Fish Habitat

3.4.1 System Operation & Maintenance

This situation could change if specific problems and impacts become apparent through further investigations or monitoring. There is potential that the Federal Fisheries Act (administered by Department of Fisheries and Oceans) or Ontario's Environmental Protection Act or Water Resources Act (Ontario Ministry of Environment) could be used to require the City to address specific water pollution problems that are found to be attributable to discharges from the municipal system.

It is therefore in the City's interest to be able to demonstrate that it is using best practices and due diligence in the operation & maintenance of the existing municipal drainage infrastructure system; and that the City is monitoring the impact of the system on local waterways.

From this point of view, there will be direct benefit to the City in having a SWQMP in place.

3.4.2 Municipal Role in Otonabee-Peterborough Source Protection Plan

The City has contributed to the proposed Source Protection Plan recently developed for the Otonabee-Peterborough Source Protection Area through the Trent Conservation Coalition (TCC). The proposed Source Protection Plan (SPP) was released on June 27, 2012 by TCC. It includes a number of policies that pertain to municipal stormwater management systems and facilities.

With respect to municipal responsibilities for operation and maintenance of storm facilities, proposed SPP policy S-8 is the most relevant. This policy set out the following requirements that are to be the responsibility of the municipality:

- Proposed SPP Policy S-8(4): Develop and implement a stormwater management facility maintenance program within two years. The program will require regular inspection of stormwater management facilities to ensure that they are being sufficiently maintained such that the facility is not a significant drinking water threat.
- Proposed SPP Policy S-8(5): Provide an annual summary of activities undertaken as part of the maintenance program to the applicable source protection authority by February 1 for the preceding calendar year.

These specific SPP policies are relevant within the Policy Applicability Area that is presented on mapping in the Proposed SPP document, and therefore may apply only to a subset of the City's existing facilities.

Development of the Stormwater Quality Management Master Plan will assist the City with directly addressing these requirements, by helping to define operation and maintenance requirements at all of the City's existing stormwater pond facilities.

3.5 Municipal Capabilities and Opportunities

A basic challenge is the fact that a significant portion of stormwater/drainage pollution originates from the numerous private properties that are connected to the system. Also, the urban area is subject to continuous deposition of contaminants that can include airborne material transported from well beyond the City limits. These physical conditions and circumstances place some constraints on the City's direct ability to manage and control the amount of pollutants washed into and carried by the municipal drainage network.

3.5.1 Available Municipal Actions and Tools

In terms of opportunities, the City has various tools available that can potentially be used to help address the stormwater pollution issue:

- Improvements to current municipal operations related to maintenance of roadway and drainage systems, and maintenance of stormwater ponds.
- Improvements to existing storm ponds through expansion or other physical modifications.
- Installation of new stormwater treatment facilities where there are feasible opportunities.
- Using the City's Official Plan and the City's engineering design standards to require property redevelopment or new property development to incorporate innovative approaches to site design that help minimize runoff volume and pollutant wash-off.
- Improving and enforcing the City's sewer-use bylaw, particularly to address properties that may pose particular potential for stormwater pollution, such as industrial or materials-handling properties.
- Public outreach, awareness and incentive programs, including assisting with or engaging in cooperative programs with other governmental agencies or non-governmental organizations that are promoting water resources protection and environmental stewardship through public action, and promotion of source controls that can be taken on individual properties.

Use of these opportunities is included in each of the four alternatives presented in this report

3.5.2 Municipal Funding Opportunities

- The long-term strategy will require funding to allow implementation.
- Currently, funding for routine system operation and maintenance is part of overall budgeting by the Utility Services Department, with funding coming from general revenue sources.
- Ontario's Water Opportunities Act requires that the City develop long-term financial management plans for maintaining all of the City's water infrastructure including the stormwater drainage and management system.

- Going forward, there are funding options that can be considered to specifically address the needs of the stormwater quality management program.
- As discussed below, the City could develop dedicated sources of funding for maintaining and improving municipal stormwater infrastructure through measures such as storm-system user rates applied to properties that drain to the municipal system. This is one approach would could meet the Water Opportunities Act's requirements for a sustainable long-term financial management plan.

3.5.2.1 Cash-In-Lieu Program:

A stormwater “cash-in-lieu” program has been considered as a potential action for the City to implement. It would allow for property development proponents, in certain prescribed circumstances, to make a cash payment to the City, in lieu of installing some form of direct stormwater treatment facility on the development site.

Typically, smaller sites are currently meeting regulatory requirements by installing oil-grit separator chambers on site, with the property owner entering into a maintenance agreement with the City. This approach is expensive for small properties, and places some responsibility on the City for approving and administering an ever-increasing number of individual devices.

A more strategic and cost-efficient approach would be to use cash-in-lieu contributions to help fund centralized stormwater retrofits that would ultimately provide greater pollutant load reduction and more environmental benefit. Such a program could simplify and reduce costs of approval for small property development or redevelopments, especially smaller infill redevelopments where installing an on-site oil/grit separator or similar technology may be difficult because of site constraints. As well, it could help to avoid the City becoming party to an increasing number of individual agreements related to ensuring maintenance of individual site devices.

Stormwater cash-in-lieu policies have been implemented in other Ontario municipalities such as Belleville, Quinte West and Hamilton. During this project, the MOE's District and Regional offices were asked to review whether a cash-in-lieu policy could potentially be adopted in Peterborough. Correspondence received from the MOE in April 2013 (copy in Appendix C) states that MOE does not have any concerns with the proposed policy.

Because of the significant advantages its presents, Cash-in-Lieu as a funding mechanisms for strategic system retrofits has been carried forward as a potential component of the final strategy.

3.5.2.2 Storm System User Rate:

The City has the capability to implement a separate service rate for storm system users. This is understood to be within the City’s legal capabilities, with such a

service rate being analogous to rates charged to property owners for sewage system use or water use.

A storm system user rate would be applied to all properties that contribute flow to the municipally owned drainage collection and conveyance system. Various approaches or methods can be considered for determining the rates, but generally the rate applied to each property would be based on some consideration of physical property characteristics including land area and surface imperviousness.

The clear advantage of this approach is that it provides a clear and dedicated funding mechanism based on a “user pay” principle. Funding can be used for system operation, maintenance, surveillance and upgrades, including installation of system retrofits to improve stormwater quality control.

Another advantage of a user-rate system is that it can be structured to provide private property owners with direct incentive to implement beneficial measures on their properties. The user rate program can be structured to account for measures that property owners implement to reduce the amount of storm drainage runoff from their individual properties. This is an important advantage to the user-rate approach, as it presents the potential for long-term gains.

City staff has indicated that the City has given some previous consideration to the concept of a storm system user charge. It has been implemented to date in similar Ontario municipalities such as Kitchener, Waterloo and Newmarket, and is being considered by a number of other municipalities. On this basis, the potential for implementing a storm system user rate in Peterborough has been carried forward as a potential component in specific alternatives for evaluation.

3.6 SWQMP Alternatives

Based on the above considerations, four alternatives have been formulated. They are summarized in Figures 3 to 6.

Each alternative is intended to form an overall strategy for managing the City’s storm drainage infrastructure, with respect to the objective of reducing and minimizing the pollutant load delivered to local creeks and the Otonabee River.

Alternative No. 1 "Maintain Current Effort"

- This alternative is based on maintaining current programs, and proceeding with SWM pond sediment clean-outs that are required to maintain compliance and performance. This alternative does not include retrofit end-of-pipe installations. In the Class EA context, this alternative is effectively the "do nothing" option.

Alternative No. 2 "Opportunistic Source Reduction" (Conveyance Control Added)

- This alternative is based on using relatively straightforward approaches to improve source and conveyance controls through improvements to municipal system maintenance operations, and through policy advancement to promote better design, and public outreach to promote source control on private

property. As with Alternative No. 1, this alternative does not include new end-of-pipe facility installations.

Alternative No. 3 "Aggressive System Retrofit"

- Alternative No. 3 is based on implementing an aggressive approach to end-of-pipe retrofits (i.e. new end-of-pipe facilities for untreated outfalls), along with the source- and conveyance control measures, policy advancement and public outreach included in Alternative No. 2.

Alternative No. 4 "Progressive System Improvement"

- This alternative places considerable emphasis on improving policies and design standards to promote improved urban design practices and innovation, so that over time, stormwater control and pollutant reduction are achieved City wide. This alternative also includes those end-of-pipe retrofit facilities that are considered as cost efficient, in order to make use of the best opportunities.

All alternatives have been formulated to include actions or measures that the City must implement to meet or continue to meet current regulatory requirements.

The following sections describe the components of each alternative.

Figure 3: ALTERNATIVE No. 1 - MAINTAIN CURRENT EFFORT

REGULATORY COMPLIANCE

Sediment removal from existing SWM ponds that were designed and approved as stormwater treatment ponds, and which have measured sediment accumulation in excess of current MOE guidelines.

SYSTEM PERFORMANCE IMPROVEMENT

Do nothing. (No end-of-pipe retrofits)

SYSTEM SURVEILLANCE

Respond to complaints.

POLLUTION SOURCE CONTROL

Existing urban areas:

Maintain existing system operation & maintenance

- Street sweeping program
- Catchbasin cleaning
- Salt management program (winter road maintenance)

New urban development:

Designed in accordance with current MOE and City guidelines

CITY POLICIES / GUIDELINES

1. Maintain current engineering standards including conformance with MOE guidelines

FUNDING

1. Existing funding sources maintained to support existing O&M programs.
2. General revenues for regulatory pond clean-outs

Figure 4: ALTERNATIVE No. 2 - OPPORTUNISTIC SOURCE REDUCTION

REGULATORY COMPLIANCE

Sediment removal from existing SWM ponds that were designed and approved as stormwater treatment ponds, and which have measured sediment accumulation in excess of current MOE guidelines.

SYSTEM PERFORMANCE IMPROVEMENT

Do nothing. (No end-of-pipe retrofits)

SYSTEM SURVEILLANCE

Routine monitoring of major storm outfalls in dry weather; and investigate source of any exceptional contamination, especially bacteriological contamination.

POLLUTION SOURCE CONTROL

Existing urban areas:

Existing system operation & maintenance

- Street sweeping program: **intensify with new equipment**
- Catchbasin cleaning: maintain existing program
- Maintain Road Salt management program (winter road maintenance)

New urban development:

- Designed in accordance with current MOE and City guidelines.
- Promote innovative approaches through planning policies (OP policies)

Across City: Aggressive **public education/outreach program**, working with local environmental organizations (e.g. Peterborough Green Up) to promote actions on private properties such as rain gardens, green roofs, rainwater harvesting and similar measures.

CITY POLICIES / GUIDELINES

1. Maintain current engineering design standards including conformance with MOE guidelines

2. Use OP policies to promote "low-impact development" (LID) design approaches in new development areas or on redevelopment properties.

FUNDING

1. Increased annual funding (source is general revenue) to allow intensified street sweeping including new vacuum/regenerative-air sweeper machines.

2. General revenue for purchase of new equipment.

3. General revenues for regulatory pond clean-outs.

Figure 5: ALTERNATIVE No. 3 - AGGRESSIVE SYSTEM RETROFIT

REGULATORY COMPLIANCE

Sediment removal from existing SWM ponds that were designed and approved as stormwater treatment ponds, and which have measured sediment accumulation in excess of current MOE guidelines.

SYSTEM PERFORMANCE IMPROVEMENT

- **Comprehensive End-of-Pipe Retrofit Program**:
  - Construct new end-of-pipe treatment facilities at all feasible locations.
  - Modify existing SWM ponds to improve performance.

SYSTEM SURVEILLANCE

- Routine monitoring of major storm outfalls in dry weather and wet weather.
- Routine monitoring of conditions in local creeks to assess system impact and progress.

POLLUTION SOURCE CONTROL

Existing urban areas:

Existing system operation & maintenance

- Street sweeping program: maintain existing program
- Catchbasin cleaning: maintain existing program
- Maintain Road Salt management program (winter road maintenance)

New urban development:

- Designed in accordance with current MOE and City guidelines.
- Promote innovative approaches through planning policies (OP policies)

Across City: Aggressive **public education/outreach program**, working with local organizations to promote actions on private properties such as rain gardens, green roofs, rainwater harvesting and similar measures.

CITY POLICIES / GUIDELINES

1. Maintain current engineering design standards including conformance with MOE guidelines.

2. Use OP policies to promote "low-impact development" (LID) design approaches in new development areas or on redevelopment properties.

FUNDING

1. **Cash-in-lieu mechanism** to facilitate property redevelopment while funding new end-of-pipe treatment facilities in selected drainage areas.

2. **Storm sewer rate charge** to all property owners based on system usage, to fund regulatory pond clean-outs and long-term program of retrofit facility installation and system maintenance; including direct incentive (reduced rate) for implementing on source-control on individual properties. Also used to maintain funding for street sweeping and CB cleaning programs, including purchase of new equipment when required.

Figure 6: ALTERNATIVE No. 4 - PROGRESSIVE SYSTEM IMPROVEMENT

REGULATORY COMPLIANCE

Sediment removal from existing SWM ponds that were designed and approved as stormwater treatment ponds, and which have measured sediment accumulation in excess of current MOE guidelines.

SYSTEM PERFORMANCE IMPROVEMENT

- **Opportunistic End-of-Pipe Retrofit Program:**
  - Construct new end-of-pipe treatment facilities at feasible locations where cost efficiency is demonstrated (cost per hectare treated).
  - Modify existing SWM ponds to improve performance where cost efficiency demonstrated (cost per hectare treated).

SYSTEM SURVEILLANCE

- Routine monitoring of selected storm outfalls in dry weather and wet weather, with focus on catchments without designed treatment facilities
- Routine monitoring of conditions in local creeks to assess system impact and progress.

POLLUTION SOURCE CONTROL

Existing urban areas:

Existing system operation & maintenance

- Street sweeping program: maintain existing program
- Catchbasin cleaning: maintain existing program
- Maintain Road Salt management program (winter road maintenance)

New urban development:

Designed in accordance with current MOE and City guidelines

Across City: Aggressive **public education/outreach program**, working with local organizations to promote actions on private properties such as rain gardens, green roofs, rainwater harvesting and similar measures.

CITY POLICIES / GUIDELINES

1. **Encourage Innovative Design:**
   Review current engineering design standards including requirements for conformance with MOE guidelines, to ensure adequate incentive for on-site runoff reduction and source control through innovative design.
2. **Make it part of the Planning Process:**
   Use OP policies and other planning approval mechanisms (site plan approval guidelines, Secondary Plans) to explicitly require design measures to minimize stormwater runoff and ensure "low-impact development" (LID) design on all new development sites or on redevelopment properties.

FUNDING

1. **Cash-in-lieu mechanism** to facilitate property redevelopment while funding new end-of-pipe treatment facilities in appropriate drainage areas.

2. **Storm sewer rate charge** to all property owners based on system usage (property characteristics), to fund regulatory pond clean-outs and long-term program of retrofit facility installation and system maintenance; including direct incentive (reduced rate) for implementing source-control on individual properties. Also used to increase funding for intensified street sweeping and CB cleaning programs; and to fund purchase of new equipment when required.

4. COMPONENTS OF THE FOUR ALTERNATIVES

This section describes the components included in the four alternatives.

4.1 Regulatory Compliance at Existing Storm Ponds

Table 8 and Figure 7 indicate measures required at each of the City-owned facilities that have been assessed in this project. All of these measures are included in all four alternatives. Further details are provided in Appendix B.1.

Determination of what measures are required at each facility to maintain compliance has been based on review of the available information on the original design of the facility, including any available design report or record drawings that were supplied by the City. A review of the existing MOE Certificate of Approval for each facility is recommended to ensure that the recommendations listed is Table 8 will satisfy the Certificate of Approval requirements.

For this project, definition of the measures required to maintain compliance has been based on the following approach:

- Available documentation was reviewed to determine if the facility was designed to provide stormwater treatment; and if so, what MOE guidelines treatment level it was designed for (e.g. "Level 1" or "Level 2" prior to 2003; or "Enhanced" or "Normal" since 2003). This information is indicated on the pond map figures in Appendix B.1.
- In the case of facilities designed as wet ponds in accordance with the MOE guidelines of the day, need for facility clean-out has been based on the current MOE guideline that clean-out is needed once the permanent pool volume has decreased to the point at which expected TSS removal efficiency drops by 5 percentage points; and whether a forebay clean-out is needed by considering remaining forebay depth and the guideline that clean-out is required if the forebay is more than 50% full. Judgment has been applied by also considering the current MOE guidelines that forebay design depth should be at least 1.0 m, and that forebay pool volume should not exceed 20% of total facility permanent pool volume or one-third of water surface area. As well, field observations have been considered in assessing whether a forebay clean-out is required to maintain intended function (and by implication, maintain compliance).
- In the case of facilities that were designed as normally-dry ponds intended for stormwater treatment (e.g. Pond #27 College Park Pond), the determination has been based on what measures are needed to restore the facility to the approved design.

Table 8 includes estimated costs to implement the required measures. In cases where sediment removal is required, costing includes estimated costs to transport sediments to the City's Bensfort Road landfill site for disposal.

Routine facility inspections will be required to ensure ongoing facility performance. Table 9 provides estimates of annual operating & maintenance (O&M) costs for each of the existing storm ponds, including allowances for routine site visits by City staff as well as allowances for landscape maintenance. The annual O&M costs

also include the annualized cost of forebay sediment cleanout, based on average cleanout frequency of once in 10 years, per current MOE guidelines.

Table 8 Existing SWM Ponds: Required Measures

Ref.	Facility	Description of Works or Measures Required	Estimate of Capital or One-time Cost
PR.2.1	#2: Heritage Park Pond	Clean out accumulated sediment from both forebays. Estimated volume of material to remove is 1,000 m^3.	$280,000
PR.3.1	#3: Cunningham Pond	Clean out accumulated sediments from both forebays. Estimated volume of material to remove is 400 m^3.	$145,600
PR.3.2	#3: Cunningham Pond	Confirm with facility constructor that pond liner and under-drain system installed per facility design report.	No cost attributed
PR.3.3	#3: Cunningham Pond	Monitor liquid level during spring, summer and fall to determine if required normal water level and permanent pool volume are achieved and maintains	$8,750
PR.9.1	#9: Chemong Park Plaza Pond	Remove accumulated sediment from forebay to restore to original design. Estimated volume of material to remove is 150 m^3.	$79,450
PR.12.1	#12: Hemlock Street Pond	Confirm that C. Of A. 3-1040-95-006 applies. If so, the facility expansion required to achieve detention volume of 1,243 m^3.	$112,700
PR.15.1	#15: Foxmeadow Pond	Remove accumulated sediment from main pond cell and from forebay to restore to design volume and depth. Estimated volume of material to remove is 150 m^3.	$73,850
PR.15.2	#15: Foxmeadow Pond	Correct erosion problem along forebay berm to restore it and minimize further problems.	$51,660
PR.17.1	Fairview Estates Pond	Remove material from main pond to restore original design volume. Volume of material to remove estimated at 2,500 m^3.	$555,800
PR.19.1	#19: Loggerhead 1	Remove accumulated sediments from forebay within 2 years. Estimated volume of material to remove is 300 m^3.	$109,900

Table 8 Existing SWM Ponds: Required Measures

Ref.	Facility	Description of Works or Measures Required	Estimate of Capital or One-time Cost
PR.21.1	#21: Glenforest	Modify outlet control structure to raise NWL to design elevation of 236.00 m, to increased permanent pool volume from current 1,140 m^3 to design value of 3,200 m^3.	$134,960
PR.21.2	#21: Glenforest	Remove accumulated sediment from forebay to restore to original design depth of 1.5 m. Estimated volume of material to remove is 400 m^3.	$133,000
PR.23.1	#23: Wentworth Street	Remove accumulated sediment from forebay to achieve minimum depth of 1.0 m per original design. Estimate of volume of material to remove is 100 m^3.	$58,100
PR.25.1	#25: Stewart Drive	Confirm implementation status of facility inlet modification proposed in Feb. 2011 report by D.M. Wills.	Not cost attributed.
PR.27.1	#27: College Park Pond	Clean out accumulated sediment from the forebay. Estimated volume of material to remove is 400 m^3.	$138,600
PR.27.2	#27: College Park Pond	Clean extended detention outlet (perforated 1500-mm CSP riser pipe) to lower normal water level to design value.	$2,000
PR.28.1	#28: Airport Road Plunge Pool	Clean out accumulated material from the sediment trap. Estimated volume of material to remove is 10 m^3.	$20,160
PR.29.1	#29 Major Bennett Pond	Remove accumulated sediment from Forebay No. 1. Estimated volume of material to remove is 50 m^3.	$27,650
PR.29.2	#29 Major Bennett Pond	Remove accumulated sediment from Forebay No. 3. Estimated volume of material to remove is 600 m^3.	$172,200
PR.29.3	#29 Major Bennett Pond	Inspect 2400-mm manhole on 900-mm outlet pipe just north of Fisher Drive, and check steel weir plate for blockage of 290-mm orifice (to restore normal water level).	No cost attributed.
Total of Above Items			**$2,104,380**

Table 9 Estimated Annualized O & M Costs For Existing Storm Ponds

Pond Name	Number of Forebays	Service Area (ha)	Catchment Imperviousness %	Annualized Cost of Sediment Removal from Forebays of Wet Ponds, Once per 10 Years	Annualized Cost of Sediment Removal from Main cell of Wet Ponds, Once per 30 Years	Annualized Cost for Sediment/Grit Removal from Dry-Pond Facilities	Allowance for Routine Inspection	Allowance for Landscape Maintenance	Total Annual O&M Cost
2 Heritage Park	2	56.1	34.5	$10,300.00	$6,300.00		$1,800.00	$2,200	$20,600
3 Cunningham	2	27.4	43.3	$9,800.00	$6,000.00		$1,800.00	$2,200	$19,800
4 Eldon Court	0	2.9	36.2			$400.00	$1,200.00	$1,400	$3,000
5 Summerhill	2	51.3	50.0	$19,000.00	$11,700.00		$1,800.00	$2,200	$34,700
6 Towerhill North (Northridge)	1	59.0	34.6	$10,400.00	$6,400.00		$1,200.00	$1,800	$19,800
7 Hilliard Street	0	13.5	38.3			$2,000.00	$1,200.00	$1,800	$5,000
8 Fairhaven	0	2.3	45.0			$300.00	$600.00	$1,000	$1,900
9 Chemong Park Plaza	1	10.6	40.6	$4,200.00	$2,700.00		$1,200.00	$1,800	$9,900
10 Towerhill South	1	17.8	51.7	$9,400.00	$5,800.00		$1,200.00	$1,800	$18,200
11 Hillview	0	5.9	28.1			$900.00	$600.00	$1,200	$2,700
12 Hemlock Street	0	2.7	45.0			$400.00	$600.00	$1,200	$2,200
13 Leahy's Lane	0	0.9	35.0			$1,100.00	$1,200.00	$1,800	$4,100
14 Naish						$600.00	$600.00	$1,800	$3,000
15 Foxmeadow	1	6.1	43.5	$3,400.00	$2,000.00		$1,200.00	$1,800	$8,400
16 Meadows	1	6.1	55.1	$4,600.00	$3,000.00		$1,200.00	$1,800	$10,600
17 Fairvew Estates (Pond 107 LLMP)	1	31.5	43.3	$10,800.00	$6,600.00		$1,200.00	$1,800	$20,400
18 Loggerhead 2 (Pond 105 LMMP)	2	22.1	41.0	$7,600.00	$4,400.00		$1,800.00	$2,200	$16,000
19 Loggerhead 1 (Pond 102 LMMP)	1	41.1	43.9	$13,400.00	$8,100.00		$1,200.00	$2,200	$24,900
20 Woodglade	0	11.3	55.5			$1,700.00	$1,200.00	$1,800	$4,700
21 Glenforest	1	63.1	22.5	$11,200.00	$6,900.00		$1,200.00	$3,000	$22,300
22 Kawartha Heights Park	0	115.0	38.2			$17,200.00	$1,200.00	$3,000	$21,400
23 Wentworth Street	1	8.1	45.0	$4,200.00	$2,700.00		$1,200.00	$1,400	$9,500
25 Stewart Drive	0	31.6	40.6			$4,700.00	$1,200.00	$1,400	$7,300

Table 9 Estimated Annualized O & M Costs For Existing Storm Ponds

Pond Name	Number of Forebays	Service Area (ha)	Catchment Imperviousness %	Annualized Cost of Sediment Removal from Forebays of Wet Ponds, Once per 10 Years	Annualized Cost of Sediment Removal from Main cell of Wet Ponds, Once per 30 Years	Annualized Cost for Sediment/Grit Removal from Dry-Pond Facilities	Allowance for Routine Inspection	Allowance for Landscape Maintenance	Total Annual O&M Cost
26 Dobbin Road	0	39.9	28.2			$6,000.00	$1,200.00	$1,800	$9,000
27 College Park	1	103.0	29.7			$15,400.00	$1,200.00	$2,200	$18,800
28 Airport Road Plunge Pool	0	30.7	35				$1,200.00	$600	$1,800
29 Major Bennett	3	74.9	38.2	$15,600.00	$9,500.00		$1,800.00	$2,200	$29,100
Totals				$133,900	$82,100	$50,700	$33,000	$49,400	$349,100

Notes:
1. Annualized cost for forebay sediment clean-out is based on 10-year cycle, with amount of material removed based on assumed 80% capture of annual sediment loading per MOE 2003 design manual's Table 6.3; and includes cost of transport and disposal at City landfill site.
2. Annualized cost for sediment clean-out for main cell of wet pond facilities is based on a 30-year cycle, with volume of material removal conservatively estimated at 50% of annual sediment loading per MOE 2003 design manual's Table 6.3; and includes cost of transport and disposal at City landfill site.
3. Allowance for routine inspections is based on inspection 4 to 6 times per year by City work crew, to review facility status and address minor issues such as debris accumulation.
4. Allowance for landscape maintenance allows for two trips per year to conduct landscape maintenance including grass-cutting or brush removal as needed.

Figure 7:
Measures Required at Existing SWM Ponds

Legend

- SWM Ponds
- City Limits
- Watercourses
- Municipal Boundaries
- Major Road
- Minor Road
- Ponds Requiring Action

N W E S

#2: Heritage Park Pond	$280,000
Clean out accumulated sediment from both forebays. Estimated volume of material to remove is 1,000 m3.	

#9: Chemong Park Plaza Pond	$80,000
Remove accumulated sediment from forebay to restore to original design. Estimated volume of material to remove is 150 m3.	

#3: Cunningham pond	$160,000
Clean out accumulated sediments from both forebays. Estimated volume of material to remove is 400 m3.	
Confirm with facility constructor that pond liner and under-drain system installed per facility design report.	
Monitor liquid level during spring, summer and fall 2013 to determine if required normal water level and permanent pool volume are achieved and maintains	

#12: Hemlock Street pond	$120,000
Confirm that C. Of A. 3-1040-95-006 applies. If so, the facility expansion required to achieve detention volume of 1,243 m3.	

#15: Foxmeadow pond	$130,000
Remove accumulated sediment from main pond cell and from forebay to restore to design volume and depth. Estimated volume of material to remove is 150	
Correct erosion problem along forebay berm to restore it and minimize further problems.	

#17: Fairview Estates Pond	$560,000
Remove material from main pond to restore original design volume. Volume of material to remove estimated at 2,500 m3.	

#19: Loggerhead 1	$110,000
Remove accumulated sediments from forebay within 2 years. Estimated volume of material to remove is 300 m3.	

#23: Wentworth Street	$60,000
Remove accumulated sediment from forebay to achieve minimum depth of 1.0 m per original design. Estimate of volume of material to remove is 100 m3.	

#21: Glenforest	$270,000
Remove accumulated sediments from forebay within 2 years. Estimated volume of material to remove is 300 m3.	
Remove accumulated sediment from forebay to restore to original design depth of 1.5 m. Estimated volume of material to remove is 400 m3.	
Meet the above requirements through development of an integrated facility redesign that also addresses recommendation of Byersville Creek Flood Reduction EA to increase live storage by approximately 10,000 m3.	

#25: Stewart Drive	N/A
Confirm implementation status of facility inlet modification proposed in Feb. 2011 report by D.M. Wills.	

#27: College Park Pond	$140,000
Clean out accumulated sediment from the forebay. Estimated volume of material to remove is 400 m3.	
Clean extended detention outlet (perforated 1500-mm CSP riser pipe) to lower normal water level to design value.	

#28: Airport Road plunge pool	$20,000
Clean out accumulated material from the sediment trap. Estimated volume of material to remove is 10 m3.	

#29 Major Bennett Pond	$200,000
Remove accumulated sediment from Forebay No. 1. Estimated volume of material to remove is 50 m3.	
Remove accumulated sediment from Forebay No. 3. Estimated volume of material to remove is 600 m3.	
Inspect 2400-mm manhole on 900-mm outlet pipe just north of Fisher Drive, and check steel weir plate for blockage of 290-mm orifice (to restore normal water level).	

TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD

TOWNSHIP OF DOURO-DUMMER

CITY OF PETERBOROUGH

TOWNSHIP OF CAVAN-MONAGHAN

TOWNSHIP OF OTONABEE-SOUTH MONAGHAN

Little Lake

Otonabee River

0 0.5 1 2 3 4
Kilometers

4.2 Measures To Enhance Pond Performance

Table 10 summarizes measures suggested at each facility, to enhance treatment performance.

These measures are included in Alternatives #3 and #4. Refer to Figure 8. Further information is shown on the facility map figures in Appendix B.1.

These suggested measures have been developed as follows:

- For wet pond facilities, if the current facility design does not meet the primary requirements of the current MOE guidelines for permanent pool volume or forebay geometry and depth, then facility modifications (e.g. deepening) have been suggested to get the facility closer to the current guidelines.
- For ponds designed for stormwater treatment, detention times were checked using level monitoring data and hydraulic models developed for each pond, as documented in Appendix L (refer to Table 2 in Technical Memorandums #6, 7 and 8, on page L-278).
- For all ponds that from field inspection appear to be subject to significant inputs of coarse sediments (sand and grit), and where facility location and layout make it feasible, installation of a grit-capture chamber on the inlet sewer has been included as a suggested enhancement. The concept is that a grit-capture chamber would be located on the inlet sewer at a location easily accessible by vacuum truck, to allow for routine clean-out and thereby extend the service life of the facility forebay.
- For dry ponds, consideration has been given to the possibility of retrofitting as wet ponds to provide treatment benefits; or to modifying the outlet control device to provide longer detention time.

Each facility is unique in design, and is located in a unique setting. The suggested improvements are concepts that are considered to likely be feasible and acceptable, based on available information. However, the potential for conflicts with underground utilities such as water mains, gas mains, sanitary sewers and electrical services has not been examined, so that further design analysis is required to confirm each concept.

In examining potential pond enhancements, for the Byersville Creek/Harper Creek watersheds, the conversion of existing "dry pond" facilities including Pond #26 (Dobbin Road), #27 (College Park) and #22 (Kawartha Heights Park), to "wet pond" facilities, has not been considered as an acceptable option, due to concerns about summer warming of water temperature and the potential negative impact on the cold-water fish habitat that is known to be present along Harper Creek and along portions of Byersville Creek.

Table 10 Existing SWM Ponds: Enhancements to Improve Treatment Performance

Ref	Facility	Description of Proposed Modifications	Estimated Cost
PE.7.1	#7: Hilliard Street	Retrofit to create wet pond: • Deepen to create a permanent pool. • Maintain live storage through grading and excavation. • Install grit-capture chamber at inlet, or a forebay, to facilitate grit clean-out. • Retrofit will also require a new outlet structure. • Potentially feasible to create perm. Pool that meets MOE "Enhanced" guideline by designing perm pool with surface area of approx. 1,500 m^2 and average depth of 1.0 m, with NWL at approximately 215.0 m.	$214,200
PE.8.1	#8: Fairhaven dry Pond	Improve the existing facility (currently a small normally-dry detention pond) by retrofitting as an "Enhanced Swale" using underdrain piping and Hickenbottom outlet.	$51,590
PE.9.1	#9 Chemong Park	Install oil/grit capture chamber at easily accessible location on inlet pipe to facilitate routine maintenance.	$92,400
PE.9.2	#9 Chemong Park	Deepen forebay to increase its depth to 1.0 m, and thereby achieve MOE "Enhanced" treatment volume. Estimated volume of material to remove is 500 m^3.	$105,000
PE.11.1	#11: Hillview Dry Pond	Improve stormwater treatment by installing a "Hickenbottom" outlet control device including granular surround to assist with filtration.	$42,980

Table 10 Existing SWM Ponds: Enhancements to Improve Treatment Performance

Ref	Facility	Description of Proposed Modifications	Estimated Cost
PE.18.1	#18: Loggerhead 2	Install grit-capture chambers at easily accessible locations on the two 900-mm inlet sewers (e.g. on Ireland Drive) to facilitate routine grit removal.	$329,000
PE.19.1	#19: Loggerhead 1	Install grit-capture chamber at easily accessible locations on the 1050-mm inlet sewer (e.g. on Ireland Drive) to facilitate routine grit removal.	$175,000
PE.22.1	#22: Kawartha Heights Park	Install grit-capture facility on the 1050-mm storm sewer that enters the site from the north (from Kawartha Hts. Blvd.).	
PE.22.1a		Option A: Underground oil/grit capture tanks located for easy access by vacuum truck.	$590,800
PE.22.1b		Option B: Sedimentation basin (dry forebay).	$402,500
PE.23.1	#23: Wentworth Street	Install grit-capture chamber at easily accessible location on the 675-mm inlet storm sewer (e.g. on facility access lane) to facilitate routine grit removal.	$161,000
PE.26.1	#26: Dobbin Road	Install grit-capture chamber on existing 900-mm inlet sewer to facilitate routine clean-out; including clean out of accumulated sediments from existing pond inlet (900-mm sewer).	$196,000
Total Of Above Items:			
		With Option A at Pond #22	$1,957,970
		With Option B at Pond #22	$1,769,670

Figure 8: SWM Ponds Performance Enhancements (Included in Alternatives No. 3 and No. 4)

Legend

- SWM Ponds
- City Limits
- Watercourses
- Municipal Boundaries
- Major Road
- Minor Road
- Enhancements

#7 Hilliard Street	$220,000

Retrofit to create wet pond:

- Deepen to create a permanent pool;
- maintain live storage through grading and excavation;
- install grit-capture chamber at inlet, or a forebay, to facilitate grit clean-out;
- Retrofit will also require a new outlet structure.
- Potentially feasible to create perm. Pool that meets MOE "Enhanced" guideline by designing perm pool with surface area of approx 1,500 m2 and average depth of 1.0 m, with NWL at approximately 215.0 m.

#9 Chemong Park	$200,000

Install oil/grit capture chamber at easily accessible location on inlet pipe to facilitate routine maintenance

Deepen forebay to increase its depth to 1.0 m, and thereby achieve MOE "Enhanced" treatment volume. Estimated volume of material to remove is 500 m3.

#8: Fairhaven dry pond	$60,000

Improve the existing facility (currently a small normally-dry detention pond) by retrofitting as an "Enhanced Swale" using underdrain piping and Hickenbottom outlet.

#11 Hillview Dry Pond	$43,000

Improve stormwater treatment by installing a "Hickenbottom" outlet control device including granular surround to assist with filtration.

#18 Loggerhead 2	$330,000

Install grit-capture chambers at easily accessible locations on the two 900-mm inlet sewers (e.g. on Ireland Drive) to facilitate routine grit removal.

#19 Loggerhead 1	$180,000

Install grit-capture chamber at easily accessible locations on the 1050-mm inlet sewer (e.g. on Ireland Drive) to facilitate routine grit removal.

#22 Kawartha Heights Park	$590,000

Install grit-capture facility on the 1050-mm storm sewer that enters the site from the north (from Kawartha Hts. Blvd.)

Preferred Option: Underground oil/grit capture tanks located for easy access by vacuum truck

#26 Dobbin Road	$200,000

Install grit-capture chamber on existing 900-mm inlet sewer to facilitate routine clean-out; including clean out of accumulated sediments from existing pond inlet (900-mm sewer)

#23 Wentworth Street	$160,000

Install grit-capture chamber at easily accessible location on the 675-mm inlet storm sewer (e.g. on facility access lane) to facilitate routine grit removal

TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD

TOWNSHIP OF DOURO-DUMMER

CITY OF PETERBOROUGH

TOWNSHIP OF CAVAN-MONAGHAN

TOWNSHIP OF OTONABEE-SOUTH MONAGHAN

Little Lake

Otonabee River

0 0.5 1 2 3 4 Kilometers

4.3 Source Control through City Operations

Each of the four alternatives includes either maintain or improving current source-control programs, or implementing additional programs.

The current operations are summarized in Figure 9.

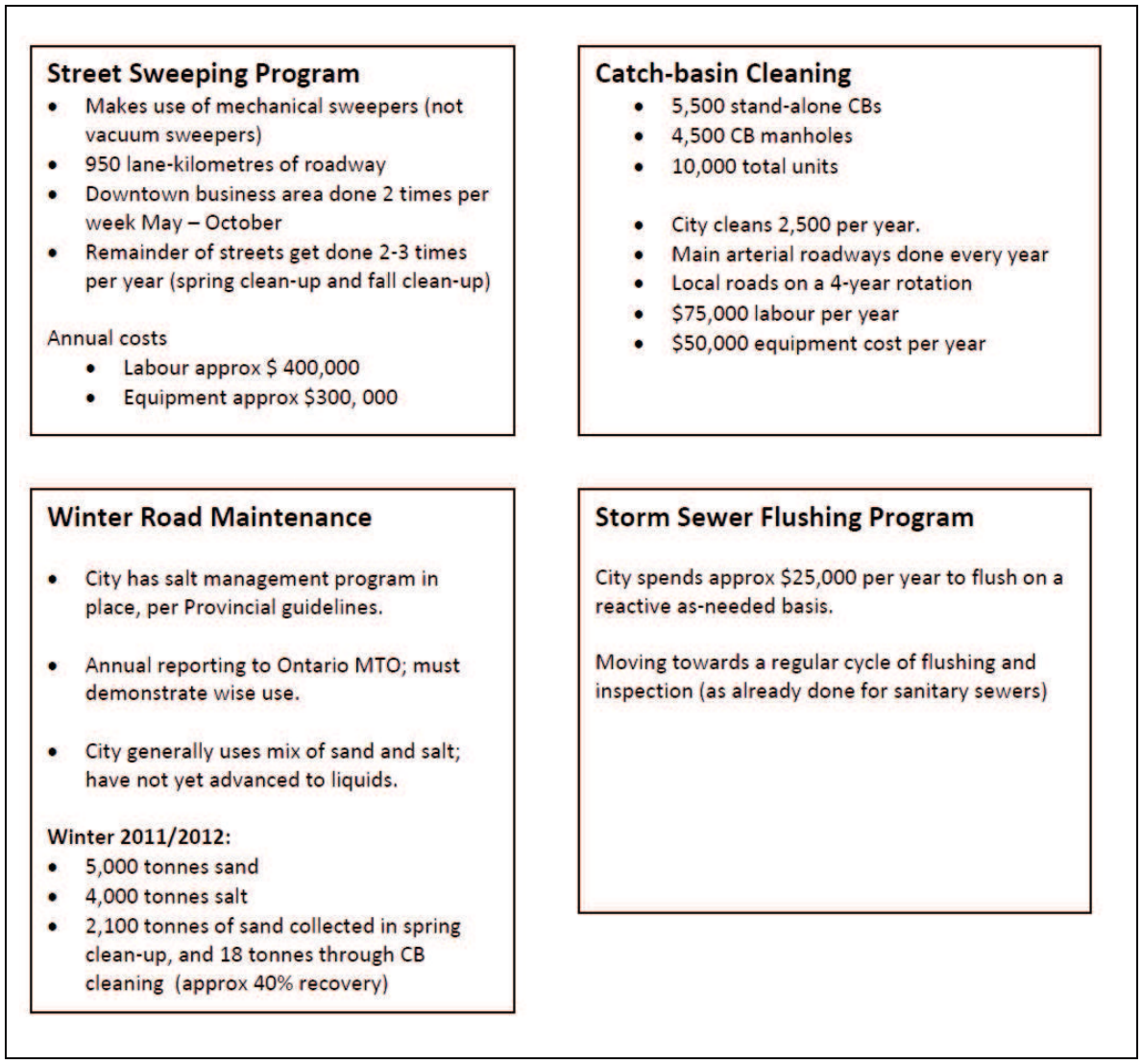


Figure 9 City's Current Roadway and Drainage System Maintenance Programs (Existing Programs at 2012)

4.3.1 Street Sweeping

In defining the alternatives, Table 11 provides two options that have been considered.

Table 11 Street Sweeping Program Options

Ref.	Summary	Estimated Annualized Cost	Which Alternatives Applied To
SS.1	Maintain current program: • Makes use of 4 mechanical sweepers (no vacuum-assist)	Labour $400,000 Equipment $300,000 Total $700,000	ALT #1, ALT #3 and ALT #4
SS.2	Intensify and acquire better equipment: • Acquire regenerative-air/ vacuum-assisted sweepers; and double sweep frequency for areas outside of downtown business area.	Labour $800,000 Equipment $500,000 Total $1,300,000 (86% increase)	ALTs #2

Under SS.1, the City is currently recovering approximately 40% of the sand/grit laid down as part of winter road operations. This is considered a good recovery rate, based on review of available literature that indicates that conventional mechanical sweepers typically recover 10% to 50% of total solids on paved roadway surfaces.

Under SS.2, the use of more modern vacuum-assisted equipment is intended to increase the amount of finer particles removed from roadways, as it is the finer particles (e.g. smaller than 100 um) that contain or carry a significant portion of contaminants including metals and nutrients (Tetra Tech, 2001; Pitt, 2002). Research results indicate that regenerative-air/vacuum-assisted equipment can improve pickup of fine material from paved areas, although there is not conclusive evidence of reduction in stormwater pollution at the outfall (e.g. Pitt et al., 2004; Rochfort et al., 2009).

The issue becomes one of benefit versus cost. While research results indicate that regenerative-air/vacuum-assisted equipment can improve pickup of fine material from paved areas, the available literature is ambiguous or inconclusive on the expected benefits of this newer equipment on stormwater quality (e.g. Pitt et al., 2004; Rochfort et al., 2009).

Note that under the current program, the cost of material removal by street sweeping is approximately $350 per tonne. This is a reasonably cost-effective unit cost for material removal, when compared against estimated costs for removal of accumulated sediments from forebays of existing stormwater treatment ponds; per Table 2 above, pond forebay cleanout costs generally range from approximately $200 to $400 per tonne.

Option SS.2 has been included in only Alternative #2 - Opportunistic Source Reduction.

4.3.2 Catch-basin Cleaning

Catch-basins capture and hold coarser sediments that are washed off of roadway surfaces. Routine clean-out is carried out by the City per Figure 5 above.

Literature indicates that the sediments held within catchbasins can contain various contaminants, including nutrients (e.g. phosphorus), metals and indicator bacteria such as E. coli. Routine clean-out of CBs may therefore assist with reducing the contaminant load that is transported through the system to final outfall; however, the net reduction in pollutant load through CB cleaning may be marginal, as CBs tend to trap only coarser sediment particles, as opposed to the more pollutant-laden fines.

As with street sweeping, Table 12 shows two options that have been considered.

Table 12 CB Cleaning Program Options

Ref.	Summary	Estimated Annualized Cost
CC.1	Maintain current program: • Main arterials once per year; • Local roads on 4-year cycle; and, • Total of 2,500 CBs/year.	Labour $75,000 Equipment $50,000 Total $125,000
CC.2	Intensify program: • All CB's once per year; and, • Total of 10,000 CBs/yr.	Labour $300,000 Equipment $200,000 Total $500,000 (300% increase)

Routine clean-out helps reduce the amount of material transported through the pipe system to storm ponds. CB clean-out can therefore help with reducing the frequency of pond forebay clean-outs.

- The unit-cost associated with CB clean-out, per current City operations, is approximately $7,000 per tonne of material removed from the system.
- The cost for removal of accumulated sediment from the forebay of a conventional stormwater pond is estimated to be between $200 and $400 per tonne, depending on facility size and ease of equipment access.

From this point of view, CB clean-out as a means of stormwater pollution control is significantly more costly than centralized removal at storm pond forebays.

Therefore, intensifying CB clean-out beyond the current level is not cost-effective for stormwater pollution control within those catchments that are currently served by stormwater ponds.

For catchments not currently served by storm ponds (i.e. "untreated" areas), increased CB cleanout could be considered. However, because of its high cost and its likely minimal effect on stormwater pollution (as CBs tend to accumulate coarser grit as opposed to more pollution-laden fines), increasing CB clean-out frequency in untreated areas is difficult to justify.

Therefore, increasing CB cleanout, as a means of stormwater pollution reduction, has not been included as part of any of the alternatives. However, the existing CB clean-out program needs to be maintained to ensure that CB function (i.e. drainage capture) is maintained.

4.3.3 Winter Road Salt Management

The City's current winter road maintenance program is based on meeting required standards and public expectations regarding winter driving conditions and road safety.

The City is currently adhering to regulatory requirements by having developed a road salt management program per guidelines developed by the Ontario Ministry of Transportation (MTO). The City submits annually to the MTO a report on the winter road maintenance program that include information to document efforts made by the City to minimize the use of road salt.

In other words, the City is currently using a "best practice" approach to managing road salt, and is having its efforts reviewed on an on-going basis by the Province to ensure continuous improvement. The program is therefore one in which all reasonable efforts are being made to minimize cost and negative environmental impact associated with runoff of road salt.

For this reason, none of the alternatives includes any modifications to the winter road maintenance program.

4.4 System Surveillance

System surveillance has been incorporated as part of the management alternatives. System surveillance is needed to help document system conditions and impacts. It can assist with identifying any unusual or significant pollution problems that occur with the storm system as they arise. As well, an ongoing surveillance program will mean that the City is applying and can demonstrate a "due diligence" approach to the operation and maintenance of the City's drainage infrastructure.

Table 13 shows the three different levels of effort that have been identified as options.

Table 13 System Surveillance Program Options

Ref.	Summary	Estimated Annualized Cost	Which Alternatives ?
SU.1	Maintain current program: • Respond as needed to complaints.	Not available.	ALT #1
SU.2	Monitor Outfalls In Dry Weather, Focus on Bacterial Contamination: • Routine monitoring of major storm outfalls in dry weather; followed by investigation of source of any high level of bacterial contamination that could indicate sewage cross-contamination.	Approx. $60,000	ALT #2
SU.3	SU.2 plus following: • Monitor Creeks in Dry and Wet Weather. • Monitoring in local creeks and the Otonabee River to assess system impact, potentially in collaboration with ORCA and MOE, and local environmental organizations. This would provide direct information on the apparent impact of the municipal drainage system, and could better help to demonstrate progress over time.	Approx. $120,000	ALT #3 and ALT #4

Notes:

Above cost estimates based on:

- In SU.2, sampling from 20 outfalls approx. 6 times per year, with samples analyzed for E. coli, metals and nutrients; along with allowance for follow-up investigations within tributary sewers and allowance for data compilation and reporting.
- In SU.3, add sampling at 25 creek/receiver locations approximately 6 times per year.

4.5 New Treatment Facilities for Untreated Areas

One general option for addressing "untreated" portions of the City is to install new end-of-pipe treatment facilities. For larger storm catchment areas (e.g. larger than 5 hectares), depending on location and space availability, such facilities could be storm ponds, constructed wetlands or underground settling tanks. For smaller catchments, use of treatment devices such as vortex separators or oil/grit

chambers can be considered, although these are less effective than ponds, being generally capable of removing only coarse sediment and grit.

4.5.1 Long List of Potential Sites

The study area has been reviewed to identify potentially feasible locations where new end-of-pipe treatment could be installed. This analysis was carried out using the following information:

- Mapping of the storm pipe system and property boundaries;
- Identification of which property parcels are owned by the City; and
- General information on current use of City-owned properties as obtained from available aerial photography and site reconnaissance by XCG staff.

The result was a "long list" of 15 potential sites for installation of new stormwater treatment facilities (i.e. new facilities at untreated outfalls).

The locations are shown on Figure 10. Map figures of each site showing approximate size and construction cost for a new end-of-pipe facility at each of these locations, are presented on map figures in Appendix B.2. Table 14 summarizes the long list.

The long list presented in Table 14 was developed without full consideration of all site constraints and potential impact on local environment that would be caused by constructing the proposed facility. This approach was taken so that this project, through this Class EA evaluation, would give consideration to all potentially feasible measures, with the potential site impacts of each retrofit concept being evaluated as part of this Class EA.

During the course of the project, the long list of potential retrofit sites was reviewed by Otonabee Conservation with respect to potential acceptability of each concept from a policy and regulatory standpoint. Comments were received by the City and XCG in August 2012 (copied in Appendix C); these are summarized within Table 14.

4.5.2 Subsets Applied in Alternatives 3 and 4

Of the four management alternatives, only Alternative No. 3 ("Aggressive System Retrofit) and Alternative No. 4 ("Progressive System Improvement") include new end-of-pipe treatment facilities.

- Alternative No. 3 includes all those new facilities on the long list, which are considered to be potentially feasible and acceptable from a policy and regulatory standpoint.
- Alternative No. 4 includes the subset of the potentially feasible and "approvable" proposed facilities that are also considered to be "cost effective".

Table 14 lists the impact and feasibility issues identified from the input received from Otonabee Region Conservation Authority (ORCA). In a number of cases, ORCA indicated that it does not support the retrofit concept, based on the potential impacts as summarized in Table 14. In a number of these cases, it is XCG's opinion that it may be possible to satisfactorily minimize or eliminate the potential impacts through the design process. These instances are indicated in Table 14. Whether or not each of the facility concepts identified in Table 14 is potentially feasible is subject to design analysis, and can only be determined by advancing the design concept and having further review by ORCA or other affected regulatory agencies.

For Alternative No. 4, the benchmark of cost effectiveness has been taken as the typical or average capital cost for design, approval and construction of a wet pond facility within a "greenfield" property development site. This approach to defining cost-effectiveness benchmark has been applied since constructing a new "greenfield" pond is the conventional method of meeting current regulatory requirements, with well-established costs that can be expected to be relatively low compared to most retrofit situations in existing built-up areas.

The most promising retrofit sites in terms of feasibility and regulatory acceptability have service area in the range of 20 to 40 hectares. The cost estimation for "greenfield" development presented in Appendix H indicates that for this range of drainage service area, estimated capital costs for new stormwater treatment ponds (including design and regulatory approvals) would typically be in the range of $20,000 to $30,000 per hectare. On this basis, a threshold of $30,000 per hectare has been used to assess whether a proposed retrofit facility can be considered as cost-effective and therefore would be included in Alternative No. 4.

For Alternative No. 3 ("Aggressive Retrofit"), all of the potentially feasible retrofit projects are included, encompassing 10 sites, with total estimated capital cost of $41 million to $54 million.

As indicated in Table 14, four retrofit site concepts (R5, R7, R10 option 1, and R12) are considered both potentially feasible and cost-effective; these four constitute the proposed retrofit facilities in Alternative 4. The total estimated capital cost is $2.3 Million.

There is therefore a clear differentiation between Alternative 3 and Alternative 4 with regard to the level of effort and cost applied to installing new end-of-pipe retrofits to address "untreated" portions of the existing municipal drainage network.

The costs for Alternative No. 3 are an order of magnitude higher than those for Alternative No. 4.

On the benefit side, Alternative No. 3 results in treatment for an additional 580 to 661 ha of service area, in contrast to only 110 ha for Alternative 4.

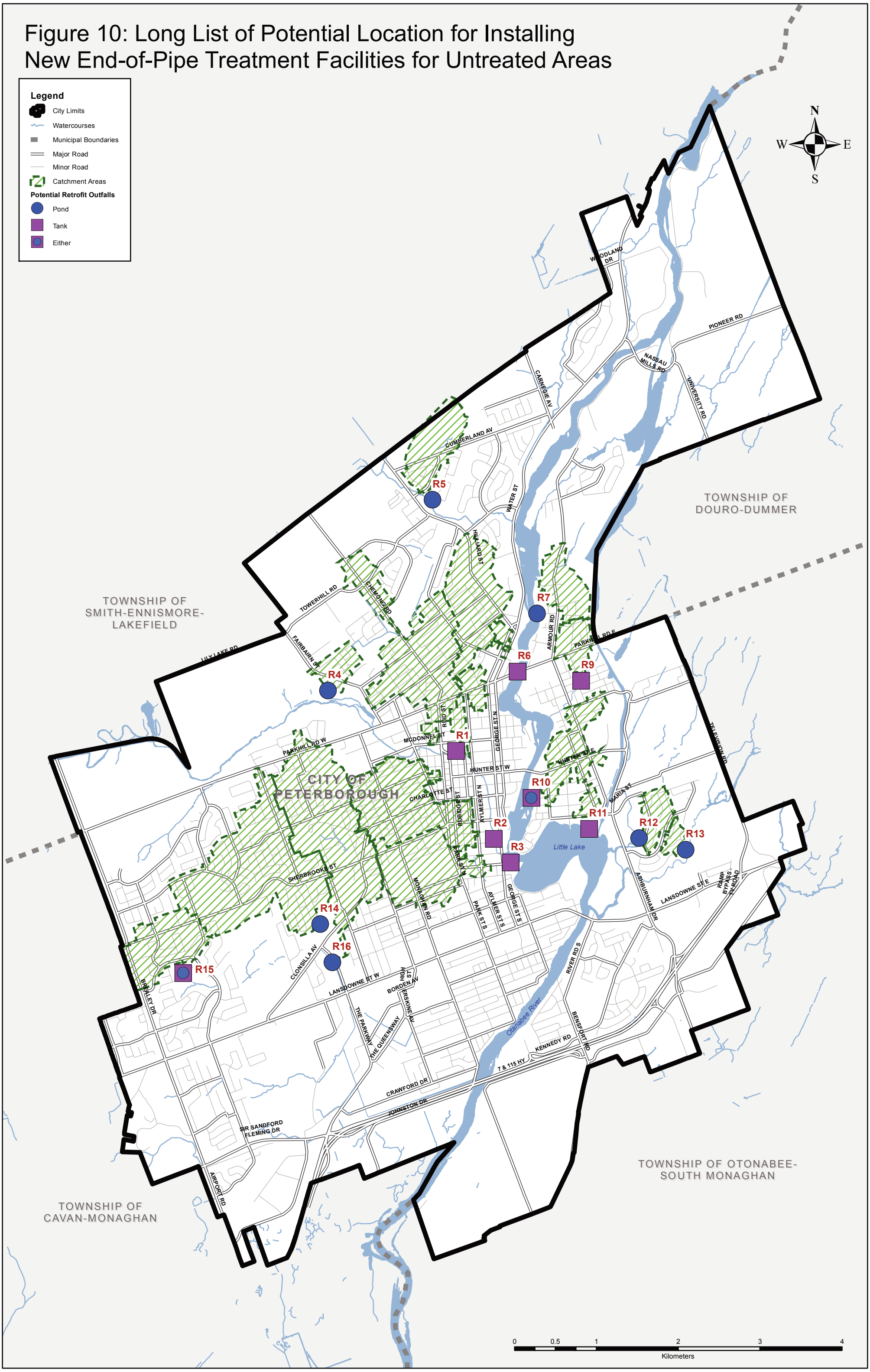
These factors are significant to the final evaluation of alternatives.

Table 14 New End-of-Pipe Treatment Facilities – Long List of Potential Sites

END-of-PIPE RETROFIT SITES FOR UNTREATED CATCHMENTS: long list of potential sites							Review of feasibility and cost-effectiveness			
Site ID	**Outfall pipe size**	**Catchment area**	**Property location description**	**Proposed facility type**	EST. CAPITAL COST	Capital Cost / ha	Site supported by ORCA per comments memo of July 24, 2012	Feasibility and Impact Issues based on ORCA review	Considered potentially feasible based on resolving impact issues through design?	Cost effective??
R1	2130 mm and 914 mm	154.1 ha	Reid-Rubidge Park, Rubidge Street on north side of Jackson Creek	Underground tank with pump out	$13,300,000	$ 86,000 /ha	No.	Natural area and corridor, parkland with mature trees, impacts to recreational infrastructure, riparian habitat affected.	Yes	No
R2	1066 mm	110.2 ha	West side of Jackson Creek, between Wolfe St and Dalhousie St	Underground tank with pump out	$10,700,000	$ 97,000 /ha	Yes	No concerns.	Yes	No
R3	1066 mm	191.1 ha	Parking lot and park area (Del Crary Park) at Little Lake between Rink St and Perry St	Underground tank with pump out	$21,900,000	$ 115,000 /ha	Yes	Floodplain areas within Del Crary Park.	Yes	No
R4	1066 mm	20.3 ha	Jackson Park, just north of The Parkway corridor and TCT, south of Parkview Dr	Wet pond	$600,000	$ 29,600 /ha	No.	Steep slopes may rule out feasibility. Site is wooded area, and proposed facility may conflict with recreational trail usage and Natural Area and Corridor designation.	No.	Yes
R5	990 mm & 533 mm	27.7 ha	Bears Creek Woods Park (Bears Creek south of Franklin Dr.)	Wet pond	$600,000	$ 22,000 /ha	No.	May have impacts (loss of tree cover) on Bears Creek riparian buffer. Ravine has steep slopes. Pond's spillway to the creek could be problematic due to natural hazards.	Yes	Yes
R6	1370 mm & 380 mm	91.1 ha	Inverlea Park (west side of river) between Argyle St and Parkhill Road)	Underground tank with pump out	$8,900,000	$ 98,000 /ha	Yes	May be loss of mature trees, but can be replanted.	Yes	No
R7	1520 mm & 610 mm	39.7 ha	Meadowvale Park (east side of river) between Whitaker St and Moir Street	Wet pond	$700,000	$ 18,000 /ha	Yes	Limited concerns. Wetland design could provide interpretive opportunities along Rotary Trail.	Yes	Yes
R9	914 mm	22.8 ha	Small parcel fronting on Euclid Ave at Trent St	Underground tank with pump out, within road allowance	$1,900,000	$ 83,000 /ha	Yes	Tank with road right-of-way considered ideal siting.	Yes	No
R10 option 1	1066 mm	19.9 ha	James Stevenson Park (south of Hunter St, east of Otonabee River)	Wet pond	$400,000	$ 20,000 /ha	Yes	Mature trees; also floodplain area.	Yes	Yes
R10 option 2	1066 mm	19.9 ha	James Stevenson Park (south of Hunter St, east of Otonabee River)	Underground tank with pump-out.	$2,100,000	$ 105,000 /ha	Yes	Tank would have less natural heritage impact than pond.	Yes	No
R11	610 mm, 457 mm & 610 mm	31.1 ha	Rogers Cove Park: North side Little Lake between Mark Street and the Trent Canal channel	Underground tank with pump-out.	$3,700,000	$ 119,000 /ha	Yes	No concerns.	Yes	No
R12	914 mm or 1066 mm	22.3 ha	Walker Park	Wet pond	$600,000	$ 27,000 /ha	No.	Wooded location is riparian buffer for Meade Creek, and may have wetland habitat. Maintained grassy area to north is better suited.	Yes, if located within existing grassed park area, assuming loss of play field can be accepted	Yes
R13	685 mm	9.0 ha	Alongside S. Meade Creek through Farmcrest Park	Wet pond	$500,000	$ 55,000 /ha	No.	Site is within Provincially Significant Wetland.	No.	
R14	1830 mm	195.2 ha	Whitefield Park (Whitefield at The Parkway)	Off-line wetland area between The Parkway and south-east property lines	$1,100,000	$ 5,600 /ha	No.	Impoundments allowing thermal increases are not recommended in the Byersville/Harper watershed	No.	Yes
R16	1830-mm	174.4 ha	East of The Parkway, north of CPR (Private Property)	Wet pond	$6,000,000	$ 34,400 /ha	No.	Floodplain area and natural wetland vegetation may not be suitable for infrastructure	No. Floodplain location and wetland features, plus site is currently private property	No
TOTAL AREA		1198.4 ha								

SUMMARY FROM ABOVE:		Est. Capital cost	Total service area	Average cost per ha	Notes
Total for all potentially feasible sites: (ALT #3)	Low: using R2 and R10 Option 1	**$40,800,000**	580.0 ha	$ 70,346 /ha	Includes R2 but excludes R3
	High: using R3 and R10 Option 2	**$53,700,000**	660.9 ha	$ 81,248 /ha	Includes R3 but excludes R2 (R2 is within R3 area)
Total for all sites that are potentially feasible AND cost-effective (ALT #4)	using R10 Option 1	**$2,300,000**	109.6 ha	$ 20,978 /ha	

Figure 10: Long List of Potential Location for Installing New End-of-Pipe Treatment Facilities for Untreated Areas



4.6 City Policies and Guidelines

This component is focused on using existing municipal capabilities in the form of the Official Plan (OP) and Engineering Design Standards, to promote innovation in site development.

The differences between the alternatives in this regard, relate to the extent and specificity of new policies incorporated within the OP; as well as how specific or prescriptive would be any updates or revisions to the City Engineering Design Standards.

4.6.1 Official Plan Policies

The City's existing OP is currently under review. There is therefore an opportunity now for the City to incorporate new policies in the OP that relate directly to stormwater management and stormwater pollution control within new property development area, or on property redevelopment sites.

These new policies could reflect or be related to existing strategic documents such as the Urban Forest Strategic Plan and Sustainable Peterborough (See below).

Examples from other Ontario municipalities were reviewed during this project. There are various considerations that may affect the best approach:

- An overly specific or prescriptive set of OP stormwater policies could prove to be difficult to work with, and may not allow enough flexibility within the planning process, and could even work against innovation. On the other hand, a too generic approach to OP policy could serve to simply maintain the status quo.
- In any case, any proposed new policies for incorporation into the City's emerging OP would most likely need to be subject to public consultation through the current OP update process being administered by the City's Planning Department, since any such policies can have direct implications for property developers

From the standpoint of overall structure and clarity, the Town of Richmond Hill OP (S. 3.1.9.2) provides a good example of the current best practices regarding stormwater management policies at the Official Plan level.

It is suggested that the City include a clear statement of stormwater management related goals, including direct reference to requirements for stormwater pollutant load control, application of the "treatment train" approach, innovation and incorporation of Low Impact Development (LIDs). Municipalities such as Caledon and Mississauga, along with Credit Valley Conservation are good resources where LIDs have been successfully implemented. See the list of resources below in Table 15.

By having this level of specificity within the OP, the requirements are enshrined in a document that has formal approval of City Council. This provides City staff with a firm basis for promoting sound and innovative approaches on new development properties or redevelopment sites that are subject to OP approval or amendment.

Table 15 Low Impact Development Resource List

Credit Valley Conservation	Credit Valley Conservation - Low Impact Development - Showcasing Water Innovation webpage Credit Valley Conservation Stormwater Criteria August, 2012 webpage
Town of Caledon	"Our Green Legacy" - Town of Caledon's Environment webpage Green Development Program Town of Caledon's Green Development Program webpage.
City of Mississauga	Living Green Master Plan (Mississauga's Livinggreen Masterplan webpage)

Table 16 presents the three options that have been considered:

- Option OP.1 is essentially a "do nothing" approach to the OP. Applies in ALT #1.
- Option OP.2 is based on making some modifications to the existing relevant OP policies in a manner that is meant to "promote and encourage" low impact development approaches to property development or site redevelopment, and innovative solutions. Applies in ALT #2 and #3.
- Option OP.3 represents a more aggressive approach to incorporating stormwater management. In addition to "promoting and encouraging" LIDs and innovation, a specific set of "must do" requirements would also be included. Applies in ALT #4.

Table 16 Options for New Stormwater Policies in the City's Official Plan

Ref	Summary	Implementation	Which Alt's?
OP.1	No change to current OP requirements related to stormwater management. Current OP does not contain explicit or well-defined requirements related to SWM.	Current OP has general policies related to environmental protection (e.g. 2.4.12.1.b.iii related to sewage and water infrastructure to be provided such that they protect human health and the natural environment) and subsection 2.4.13.1, the most relevant being 2.4.13.1.f and .g. Also section 3.5.2 related regarding review of any proposed development with respect to impact on quality of the environment.	ALT #1
OP.2	New OP policies to promote "low impact development" (LID) practices and LID site design with respect to stormwater management	Modify existing policies provided in subsection 2.4.13.1 to state that design of new developments or property redevelopment should be based on "Low Impact Development" design approaches. Modify section 7.5 to state that LID approaches should be assessed for feasibility and applicability on the development site, with the design objective of minimizing runoff volume and associated pollutant wash-off and transport. Add policy statements: Applicants are also encouraged to: Propose innovative stormwater management works to control the quantity and quality of stormwater runoff, erosion control, sedimentation control and temperature control subject to the City's approval. Create wetland areas as part of the design of new stormwater management works, where feasible. Undertake local demonstration projects on public land and private land to increase public understanding of alternative stormwater management works and to test their performance.	ALT #2 and #3

Table 16 Options for New Stormwater Policies in the City's Official Plan

Ref	Summary	Implementation	Which Alt's?
OP.3	New OP policy section related directly to stormwater management requirements for draft plans of subdivision or site plan approvals, which require design measures to minimize stormwater volume and ensure "low impact" design approaches are considered and implemented to the extent practical on all property development or property redevelopments, with reference to City's new "cash-in-lieu" policy for smaller property developments.	Include in the new OP in sections addressing infrastructure planning and design, a separate section addressing stormwater management using examples from City of Barrie and Town of Richmond Hill as examples. The section should require that applications to the City for approval of draft plan of subdivision or site plan are to include technical submissions that demonstrate that low-impact stormwater design approaches and measures have been reviewed and integrated into the proposed development. (This would provide better definition of submissions needed from development proponents to address the general policy set out in existing OP section 3.5.2; and section 9.1.3.d). This section can refer to technical guidance documents such as the recent TRCA/CVC document on LID design; and the City's Engineering Design Standards documents. See proposed structure in Table 17.	ALT #4

Table 17 Proposed OP Stormwater Policy Framework for Option OP.3 (Applies to Alternative 4)

SW.1	**LOW-IMPACT DEVELOPMENT DESIGN APPROACH REQUIRED:** Applicants MUST meet following policy requirements: 1. Design of new development sites shall consider the potential and feasibility to incorporate appropriate low impact development (LID) techniques to help maintain the water balance on the development site, provide appropriate quality and quantity control of runoff at source, maintain the long-term recharge function to underground aquifers and protect groundwater quality. 2. Development shall adhere to or exceed Provincial guidelines for stormwater management best management practices (BMPs). 3. In areas where soil types, water-table levels and site size would permit, the City shall require consideration of on-site infiltration measures such as permeable surfaces, bioswales, and other innovative techniques. 4. Design of new development sites should consider the potential for incorporating feasible and appropriate LID techniques to help maintain the water balance on the development site, provide control of the quantity and quality of runoff from the development site; and must also consider the need to maintain long-term recharge of local groundwater aquifers and protect groundwater quality function to underground aquifers. 5. Low impact development quantity controls should focus on reducing peak flow and reducing runoff volumes; and providing appropriate quality control of runoff at source. 6. Development design should consider low impact development techniques that allow smaller rainfall events to be retained at source on the development site, and provide appropriate groundwater recharge at source. 7. The City shall require the preparation of comprehensive Master Environmental Servicing Plans (MESPs), and Stormwater Management Plans to minimize stormwater volume and contaminant loads, and maximize infiltration through an integrated treatment approach, which may include techniques such as rainwater harvesting, runoff reduction of solids and materials at source, phosphorus reduction, constructed wetlands, bioretention swales, green roofs, permeable surfaces, clean water collection systems, and the preservation and enhancement of native vegetation cover. 8. Stormwater Management Plans shall be prepared prior to the approval of development to the satisfaction of the City. Where an MESP applies, the content of Stormwater Management Plans shall be in conformity with and implement the provisions of the relevant MESP, Watershed Plan and other relevant policies of this Plan. 9. Rapid infiltration technologies can be considered, where soil, geotechnical and hydrogeological conditions are favourable, and where all regulatory and policy requirements for groundwater quality protection can be met, including any requirements of the relevant Source Protection Plan. 10. Development may be required to create and implement an Erosion and Sedimentation Control Plan consistent with City and Conservation Authority requirements. The Erosion and Sedimentation Control Plan must list the BMPs employed and describe how they accomplish the following objectives: 11. Prevent erosion of soil during construction by stormwater runoff and/or wind erosion, including but not limited to stockpiling of topsoil for reuse; 12. Prevent sedimentation of any affected stormwater conveyance systems or receiving streams; and 13. Prevent polluting the air with dust and particulate matter. 14. Stormwater management works shall be oriented, designed and constructed in accordance with any relevant City Plans in mind in order to create and enhance new public views, and integrate stormwater management works as destinations within the community. Opportunities for pedestrian pathways combined with other passive recreational opportunities to compliment and connect to the surrounding area will be encouraged. 15. Stormwater management works for watersheds that extend beyond the municipal boundary shall be developed in conjunction with adjacent municipalities. 16. The City shall pursue opportunities to implement quantity and quality controls for stormwater management works and/or source control programs within the settlement area where current controls do not exist or are not adequate. **(Note: Town of Richmond Hill Official Plan, 2012 was heavily sourced in developing these points.)**
SW.2	**CONFORM TO ENGINEERING DESIGN STANDARDS** Technical submissions for draft plan of subdivision approval or for site plan approval must meet all requirements set of in the City of Peterborough Engineering Design Standards for Municipal Infrastructure, as updated from time to time by the City.
SW.3	**CASH-IN-LIEU POLICY REGARDING STORMWATER:** The OP stormwater policy section can also make reference to City's "Cash-In-Lieu" policy/program. City needs to review whether this is appropriate within the OP, or should be part of the City's Engineering Design Standards only. If included in the OP, the Cash-In-Lieu policy would be to the effect that the City will allow for cash-in-lieu contributions in specific instances determined to be acceptable by the City in a manner consistent with the City's Engineering Design Standards, which can spell out the specific circumstances under which C-I-L would be considered by the City, and how the C-I-L would be calculated.

4.6.2 Engineering Design Standards

In the case of the City's Engineering Design Standards, they are currently based on well-established and recognized approaches to the details of drainage design, that are intended to ensure good drainage efficiency. This basic requirement needs to be maintained.

The City's Engineering Design Standards ("CEDS") specify the following requirements related to stormwater management design for proposed developments or property redevelopment sites:

- Specify design requirements for stormwater management systems in terms of required degree of flow control (quantity control).
- Specify that stormwater treatment (quality control) is required in accordance with current MOE guidelines.
- Specify site drainage design requirements such as lot grading, pipe sizing requirements, catchbasin location requirements and other related details, as needed to ensure efficient and safe property drainage.
- Define specific technical submission requirements that development proponents must submit with applications for approval of Draft Plan of Subdivision or Site Plan.

The CEDS are intended to clearly define the City's technical requirements. With regard to stormwater pollution control, the CEDS effectively defer to the MOE guidelines of 2003.

The CEDS provides the "operational" way to implement OP policies related to stormwater management and development servicing. The CEDS in effect describe how an individual property development needs to be designed to fulfill the intent of OP policies such as Policies 2.4.13.1.g and 3.5.2 of the current OP. Any future revision to the CEDS needs to reflect and support any new OP policies.

Revisions to the CEDS should focus on promoting innovative approaches to minimizing stormwater runoff volume and pollutant loading. From a practical standpoint, this could best be accomplished by including within the standards document a set of illustrative site design examples that demonstrate the specific type of approaches that the City is willing to accept within residential subdivisions or on commercial property developments.

The recent document "Low Impact Development Stormwater Management Planning and Design Guide" prepared by Credit Valley Conservation and Toronto and Region Conservation Authority (2010) provides an Ontario-based source of technical information that is valuable input. Also, the Toronto Region Conservation Authority's "Stormwater Management Criteria" document (August 2012) is a potentially useful reference example.

Table 18 lists the two options that have been considered.

- ED.1 is the "do nothing" approach that is based on finalizing the current internal City document to allow for its general circulation.
- ED.2 is based on modifying the current document to better promote, encourage and require "low impact" design approaches, and to implement a "Cash-In-Lieu" policy.

Option ED.1 applies in ALT #1; ED.2 in ALTs #2, #3 and #4.

Table 18 Options for City's Engineering Design Standards

Ref	Summary	Implementation	Which Alt's?
ED.1	Maintain current CEDS	Finalize current CEDS for general release	ALTs #1, #2 and #3
ED.2	Revise the CEDS to aggressively encourage and promote innovation in development/site design. • Structure the CEDS section related to drainage/stormwater design to start with statement of overall design goal and required approach: assess all reasonable measures minimize property runoff. • Set reasonable design target for assisting with maintaining local hydrology and minimizing volume from frequent rain events: example – zero runoff for all events up to 10 mm rainfall in one day (which accounts for about 70% of annual rain). • List the specific types of LID measures that each site design should consider, and require submission to indicate what measures have been selected and why others excluded. • Include in the standards document a set of illustrative site design examples that demonstrate the specific type of approaches that the City is willing to accept within residential subdivisions or on commercial property developments. • Continue to require compliance with the intent of the MOE guidelines regarding stormwater quality control. • Clarify under what circumstances end-of-pipe wet ponds will be acceptable to regulatory agencies that have a mandated role in protecting aquatic habitat, including Otonabee Region Conservation Authority and the Department of Fisheries and Oceans; and where this type of treatment is not desirable or acceptable due to concerns about impacts on water temperature during summer months on cool-water or cold-water aquatic habitats (e.g. Harper Creek and Byersville Creek below Clonsilla Avenue).	Make use of and make direct reference to recent technical guidelines such as the 2010 TRCA/CVC guideline for LID design. (See source references in Table 9). Revise guidelines as needed to indicate how "credit" can be achieved for implementing LID, such as reductions in storm runoff coefficient used in pipe sizing calculations. Set out circumstances in which proposal for Cash-In-Lieu will be considered by the City, with details including: • Type, size and location of applicable properties. • Calculation of Cash-In-Lieu amount based on property characteristics. • City objective for use of Cash-In-Lieu contribution from the subject property (i.e. what works will the C-I-L be used to fund or support).	ALT #4

4.6.3 Sewer Use By-Law (By-Law 05-104)

Section 3 of By-law 05-104 specifies what can be discharged into the municipal storm drainage system.

The sewer-use bylaw requires that no discharge into the municipal drainage system impair the quality of the water in any waters. Section 3(1)2 of the sewer-use bylaw effectively requires a high degree of control over the concentrations of pollutants in any water discharged to the storm system; for a number of parameters, the numerical limit in Table 2 of Schedule H of the sewer-use bylaw appears to be stricter than PWQO.

Enforcement of the sewer-use bylaw with respect to stormwater discharges from private property into the municipal system, is very likely impractical to source control. The City would need to monitor discharges from many individual properties, and this in itself may pose significant logistical challenges because of the physical extent of the system, the number of separate connections and the intermittent nature of storm flows. A further practical consideration is that a significant amount of drainage water enters the municipal system via diffuse overland flow (e.g. from driveways onto roadways), a source which is very difficult to monitor and difficult to attribute to specific properties. Furthermore, property owners would very likely be faced with having to implement measures that could include on-site stormwater treatment systems; this could place an unusual and onerous burden on many property owners.

For these reasons, an approach that would involve City-wide enforcement for strict compliance with the sewer-use bylaw requirements has not been considered as a viable part of the final SWQMP.

However, the intent and focus of Section 3 of the sewer-use bylaw is on discharges from industrial properties. This focus is appropriate, since industrial properties may present potential for stormwater contamination, and monitoring of discharges from such properties to ensure compliance with the by-law is a reasonable proposition.

It is recommended that the final stormwater quality management strategy should include review of Section 3 of the sewer-use bylaw, to address the following:

- Review scope of its application. Currently, it appears to focus on "industrial process areas" (Section 3((3)), while also having general requirements (Section 3(1)) that apply to discharges from all properties. Review should include consideration of whether the current scope is clear, and whether it is broad enough to include all industrial or commercial properties that may pose specific risks of stormwater contamination (e.g. bulk fuel handling facilities, materials storage facilities, etc.).
- Review the requirements of Section 3(1)1, specifically the requirement that no discharge shall impair the quality of the water in any waters, to ensure that this is a reasonable, practical and enforceable target.

- Review the numerical parameter concentration limits listed in Table 2 of Schedule H to ensure they are appropriate when compared with current Provincial Water Quality Objectives and the Canadian Water Quality Guidelines.

The above recommendation is carried forward as part of all the Alternatives. No direct cost has been attributed to this recommendation.

4.7 Public Awareness and Community Outreach

Issues caused by polluted stormwater and its management are common to municipalities across the Province and other jurisdictions. Many have taken steps, through public attitude research, awareness campaigns, and policies, to encourage actions by individual property owners to manage stormwater on their property. Often these "source controls" are married with engineered structural measures, such as new or improved treatment facilities, to provide an overall solution approach.

This section outlines a number of measures that could be undertaken by the City to raise public awareness and to encourage property owners to take action on their properties.

These actions describe what is intended to be a pro-active approach to public engagement and outreach that would go beyond current efforts and be components of Alternatives 2, 3 and 4.

4.7.1 Public Awareness of Stormwater Management

As a starting point for any public education campaign, it is useful to understand the level of knowledge and interest that exists in the community. This information can be used to shape the message content and delivery mechanisms.

Recently, Ehl Harrison Consulting Inc. was involved in stormwater related research for the Cities of Kitchener and Waterloo. After conducting a series of four focus groups with businesses, residents and not for profit agencies, it was concluded that:

- Many people have limited understanding of what stormwater is, the connection to the natural environment and how it is managed.
- Similarly, people are not aware of the current stormwater management-related issues currently being faced in municipalities.
- There is a willingness to investigate and possibly implement on-site SWM controls. However, education, incentives and credits are critical to success.
- In most cases, people placed it as a low to mid-level priority item among City services. However, after receiving information, most people have a greater interest in and would give SWM higher priority. This presents some important opportunities to gain support for SWM though public education.

Participants encouraged the Cities to develop clear, concise messaging about the issues, implications and solutions and deliver these messages through a variety of vehicles such as radio and television, bill inserts, and in schools. Local examples of the best SWM practices should also be highlighted. (Source: Ehl Harrison Consulting, TSH, January 2008). This information was utilized to develop the storm water management rate program.

Similar research was carried out by the City of Toronto in developing its Wet Weather Flow Master Plan, which was approved in 2003. In general, residents indicated a willingness to implement lot-level initiatives on their properties. Low cost, easily implemented solutions such as planting a tree or disconnecting a downspout were considered more desirable than complicated or costly projects. In all cases, additional information and incentives were requested.

Peterborough has a slightly different scenario in that knowledge of stormwater management and flooding is likely higher due to heavy rainfall events within the last decade that caused widespread flooding and property damage.

4.7.2 Source Control on Private Properties

There are a number of actions property owners can take to decrease the quantity of stormwater at the lot level, including disconnecting roof leaders/downspouts and diverting the flow onto grassed areas; and by planting trees and rain gardens to help absorb stormwater. Depending on individual lot characteristics, these measures can help reduce stormwater pollution by reducing the amount of surface runoff conveyed from individual properties to municipal road surfaces and then into the storm pipe system.

The City can promote one or all of these through its policies and programs such as public education programs, incentives, mandatory programs or some combination. Many municipalities have implemented these programs. A sample of these programs has been included in Appendix D.

4.7.3 Implementing a Public Awareness Strategy

As noted, stormwater management does not enjoy the broad understanding or support of some other municipal environmental programs, such as blue box recycling. The challenge then becomes one of raising awareness of the basics (stormwater management, infiltration and inflow, lot level controls), identifying any barriers to participation and gaining support for action. A multi-faceted approach is suggested.

Typically, information about program objectives, key messages, target audience, strategy, tactics, timelines, responsibility, and costs are included in a Public Education Plan. Timelines, responsibilities and costs can be identified at a later date when the results of the Master Plan are known, specific policy and program approaches have been chosen and community partners identified.

Appendix D presents information and suggestions on approaches that could be implemented by the City.

4.7.4 Linking to Activities and Programs within the Community

It is suggested that in conjunction with a public awareness campaign, the City should consider and make use of strategic partnerships and linkages with existing organizations or community groups, to disseminate key messages throughout the community and explore the possibility of actions such as pilot projects. These linkage opportunities and efforts can include:

- Integrating efforts and communication within the City Departments (Planning, Utility Services, Parks and Recreation).
- Designating resources / develop a protocol to form meaningful partnerships with other organizations/Groups; e.g. to establish a Task Force to collaborate on selected stormwater projects, programs, initiatives; establish a Round Table Discussion Group(s).
- Establishing relationships with existing environmental groups will extend the current reach and help to reinforce stormwater related messaging.

Appendix D provides additional information on opportunities for local collaborations that have been identified through the course of this project.

5. EVALUATING THE ALTERNATIVES

5.1 Overview

In this section, a comparison of the alternatives is presented. As described in Section 4, alternatives are "packages" of activities that represent various philosophies on how to address the problem and opportunity identified. The four alternatives being evaluated have been given the following names.

- Alternative 1: Status Quo
- Alternative 2: Opportunistic Source Reduction
- Alternative 3: Aggressive System Retrofit
- Alternative 4: Progressive System Improvement

5.2 Evaluation Criteria

In a Class EA process, it is necessary to develop a set of criteria by which the alternatives can evaluated in a systematic way, with the aim of identifying alternatives that are best suited to addressing the problem or opportunity of the study (i.e. the reason the study was undertaken).

Table 19 lists the criteria categories and sub criteria (representing positive or negative impacts) that have been utilized for this study. These criteria have been drawn from common practice with some additions that are specific to this study, such as the "Sustainability Considerations" criteria, which are of importance to the proponent and stakeholders.

Table 19 Evaluation Criteria

Natural Environment	
N.1	Expected benefit to aquatic habitat conditions in local creeks
N.2	Expected benefit to water quality and aquatic habitat conditions in Otonabee River and downstream environment
N.3	Potential to improve local hydrology and water balance
N.4	Loss of terrestrial habitat due to loss of tree cover or other terrestrial features; or disruption or alteration to wildlife corridors
N.5	Potential impact to any species at risk or species of concern.
N.6	Potential for groundwater contamination
Financial Environment	
F.1	Capital cost for recommended modifications to existing SWM ponds and for new end-of-pipe treatment facilities
F.2	Annual costs for operation and maintenance of recommended new facilities, including annual costs for system monitoring and surveillance program.
F.3	Funding feasibility: ability of City to fund program

Table 19 Evaluation Criteria

Socio-Cultural Environment	
C.1	Tree loss within public park lands
C.2	Loss of useable space within public parklands
C.3	Public health and safety: Potential for health/safety concerns about open water and mosquito breeding
C.4	Potential impact on archaeological resources as determined from study area review
C.5	Potential for impact on cultural resources (e.g. historical buildings)
C.6	Level of benefit to recreational water use through reduction in wet-weather bacteriological contamination along Otonabee River especially public bathing beaches
C.7	Temporary impacts due to construction, including traffic, noise, dust generation
Sustainability Considerations	
S.1	Comparative ability to make the Peterborough municipal drainage system more adaptable to expected increases in rainstorm intensity (e.g. through provision of additional storage volume, maximizing rainwater infiltration)
S.2	Potential reduction in local warming through improvement to tree cover or to green space
S.3	Comparative energy use and GHG emissions
S.4	Integrated watershed management: Long-term improvement to local and downstream surface water quality for sustaining water sources for beneficial uses such as drinking water supply
Technical Considerations	
T.1	Integration with Flood Reduction Program
T.2	Potential for conflicts with existing underground infrastructure
T.3	Potential for negative effects on wet-weather inflow to sanitary system
T.4	Flexibility to accommodate future urban growth
T.5	Acceptability of proposed works to regulatory agencies including ORCA and DFO
T.6	Practical applicability of proposed OP policies
T.7	Practical applicability of proposed Engineering Design Standards modifications
T.8	Time required for implementation
T.9	Implementation time: duration for implementation, and ability to implement in phases over time

5.3 Evaluation Methodology

For this study, a graphic, narrative evaluation style has been utilized to select the preferred alternative.

Each alternative has been considered/ compared to each of the five criteria categories. Tables have been prepared for each criterion, containing information focused on the key factors when considering that criterion category. Colours have also been assigned to indicate how well each alternative does with respect to that criteria category. (green = favourable; yellow = somewhat favourable/ unfavourable/ neutral; red=not favourable). Table 20 shows the general table format.

Table 20 General Table Format for Alternative Comparison

Criteria Category Name: Natural Environment					
Alternative 1 Status Quo	Discussion of pro's and con's with respect to the Natural Environment criteria.				
Alternative 2 Opportunistic Source Reduction	As above.				
Alternative 3 Aggressive System Retrofit	As above.				
Alternative 4 Progressive System Improvement	As above.				
	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

A narrative description of the evaluation outcome follows the individual criterion tables. Then, a summary table is provided, along with a narrative describing the rationale for selecting the most favoured alternative.

This method was adopted recognizing that all evaluation methodologies are somewhat subjective in nature and that in order to foster meaningful input, the results need to be clearly presented. For the purpose of this study, all criteria categories are considered to be of equal importance.

5.4 Evaluation

5.4.1 Criterion Category: Natural Environment

For the purpose of this study, the natural environment impact evaluation includes the following considerations:

- Effects to aquatic habitat conditions in local creeks.
- Effects on water quality and aquatic habitat conditions in Otonabee River and downstream environment.
- Effects on local hydrology and water balance.
- Effects on terrestrial habitat due to loss of tree cover or other terrestrial features; or disruption or alteration to wildlife corridors.
- Potential impact to any species at risk or species of concern.
- Potential for groundwater contamination.

The key consideration differentiating the alternatives is the degree to which each reduces stormwater pollution conveyed to local creeks and the Otonabee River, and resulting benefit to aquatic habitat and communities in those watercourses. Table 21 compares the alternatives with respect to the key considerations related to natural environment.

Table 21 Alternatives Comparison - Natural Environment

Natural Environment	
Alternative 1 Status Quo	• Will not provide any benefit to local creeks or Otonabee River. • Does not address existing impacts. • Does not address the problem statement.
Alternative 2 Opportunistic Source Reduction	• Minimal reduction in stormwater pollution and therefore minimal expected improvement in local water quality in creeks and Otonabee River. • Presents potential for local groundwater contamination by stormwater infiltration measures
Alternative 3 Aggressive System Retrofit	• Largest reduction in stormwater pollution and therefore most benefit to water quality in local creeks and Otonabee River • Larger negative effects than other alternatives, related to loss of tree cover, wildlife habitat and parkland area due to facility construction, and potential for groundwater contamination.
Alternative 4 Progressive System Improvement	• Moderate stormwater pollution reduction and resulting benefits to local surface water quality.

	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

Based on this information, Alternative 3 and Alternative 4 are the most favourable in terms of effects on natural environment. While Alternative 3 presents greatest reduction over the long term in stormwater pollution, this alternative also poses potential for larger negative effects due to loss of tree cover, parklands areas and wildlife habitat (possibly including effects on species at risk) that is caused by construction of new end-of-pipe stormwater treatment facilities. There may also be higher potential for groundwater contamination. Alternative 4 may present a more favourable compromise.

5.4.2 Criterion Category: Financial Environment

The financial impacts of each alternative are an important consideration in the evaluation process.

For the purpose of this study, the financial environment impact evaluation includes the following considerations:

- Capital cost for recommended modifications to existing SWM ponds and for new end-of-pipe treatment facilities.
- Annual costs for operation and maintenance of stormwater treatment facilities, including annual costs for source-control measures such as street-sweeping program; as well as annual costs for system surveillance and monitoring.
- Funding feasibility: ability of City to fund program.

5.4.2.1 Cost Summaries

Table 22 presents a summary comparison of the one-time or capital construction costs associated with each alternative; previous Tables 8 and 10 provide detail on the basis of the costs, with further detail in Appendix C.

Table 23 summarizes the estimated annual O&M costs for each of the four alternatives.

There is clear differentiation between the alternatives with regards to one-time or capital costs. Alternative 3, which includes construction of all end-of-pipe retrofits that are considered at this stage to be potentially feasible, has total estimated capital cost that is over 6 times the next alternative, Alternative 4.

Table 22 Cost Analysis Summary: Capital Costs

Component	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Existing Storm Ponds				
Required Measures	$2.1M	$2.1M	$2.1M	$2.1M
Enhancements			$2.0M	$2.0M
New Treatment Facilities				
All Potentially Feasible End-of-Pipe Retrofits			$40.8M to $53.7M	

Table 22 Cost Analysis Summary: Capital Costs

Component	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Potentially feasible and Cost-Effective End-of-Pipe Retrofits				$2.3 M
Totals for Above Components	$2.1 M	$2.1 M	$44.8 to $57.8M	$6.4M

Table 23 Cost Analysis Summary: Annual O&M Costs

Component	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Existing Storm Ponds:				
Annual O&M	$349,000	$349,000	$393,000	$393,000
New Treatment Facilities:				
Annual O&M			$450,000 to $570,000	$59,000
Municipal Source Control Measures:				
Street Sweeping Program				
SS.1: Existing Program	$700,000		$700,000	$700,000
SS.2: Enhanced Program		$1,300,000		
CB Cleaning Program				
Maintain Existing	$125,000	$125,000	$125,000	$125,000
System Surveillance Program by City:				
SU.1: Maintain Existing	Minimal			
SU.2: Major Outfalls Sampling		$60,000		
SU.3: Major Outfalls and Creek Sampling			$120,000	$120,000
Public Education and Outreach Program	Minimal	$80,000	$80,000	$80,000
Totals for Above Components	$1.2 M	$1.9 M	$1.9 to $2.0 M	$1.5 M

Table 24 compares the alternatives with respect to the key considerations related to financial environment.

Table 24 Alternatives Comparison – Financial Environment

Financial Environment					
Alternative 1 Status Quo	• Lowest capital cost • Lowest annual costs				
Alternative 2 Opportunistic Source Reduction	• Same capital cost as Alternative #1 • Approx. 60% increase ($0.7 M) in annual costs				
Alternative 3 Aggressive System Retrofit	• Very high capital cost ($45 M to $58 M) may not be affordable • Highest annual costs				
Alternative 4 Progressive System Improvement	• Modest capital cost ($6.4M) is approx. $4.3M than Alternatives 1 and 2 • Relative low increase in annual costs of approx. 30% ($0.3 M)				
	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

In the financial category, Alternative 1 is most favourable simply because it minimizes future costs; however, this is in the face of providing minimal benefits.

Alternative 3 has such a high capital cost that it likely must be considered unaffordable.

Alternatives 2 and 4 provide more modest increases in capital and annual costs. These two alternatives therefore may present potential for giving the most favourable benefit-to-cost ratio, given that Alternative No. 1 provides no benefits beyond the status quo and does not address the problem of this study.

5.4.3 Criterion Category: Socio-Cultural Environment

The socio-cultural considerations are:

- Tree loss within public park lands.
- Loss of useable space within public parklands.
- Public health and safety: Potential for health/safety concerns about open water and mosquito breeding.
- Potential impact on archaeological resources.
- Potential for impact on cultural resources (e.g. historical buildings).
- Level of benefit to recreational water use through reduction in wet-weather bacteriological contamination along Otonabee River especially public bathing beaches.
- Temporary impacts due to construction, including traffic, noise, dust generation.

Table 25 compares the alternatives with respect to the key considerations related to financial environment.

Table 25 Alternatives Comparison - Socio-Cultural Environment

Socio-Cultural Environment	
Alternative 1 Status Quo	• No impacts because it is the "do nothing" approach
Alternative 2 Opportunistic Source Reduction	• Has minimal impacts because it avoids construction of any new stormwater treatment facilities
Alternative 3 Aggressive System Retrofit	• Has the largest and most significant impacts on public parklands • Largest impacts due to construction activity • Has best potential benefit on reducing bacterial contamination at public beaches, although would not fully solve this problem. • Some potential public health/safety concerns with having many additional pond facilities
Alternative 4 Progressive System Improvement	• Has substantially less impact on parklands and less construction activity impacts than Alternative No. 3, but more potential impacts than Alternative No. 2. • Significant concerns about neighbourhood compatibility and loss of parkland have been expressed by residents in the vicinity of the four proposed new end-of-pipe pond facilities (see Appendix C for full description of the public concerns expressed at PIC #2 in June 2013)

	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

In the socio-cultural category, Alternative 1 is most favourable, simply because "do nothing" has no impacts.

Alternative 3 has high potential for undesirable impacts on public parklands during the construction of new facilities; and afterwards due to loss of useable parkland area. Alternatives 2 and 4 provide significantly lower potential for undesirable impacts. Alternative No. 4, because it includes construction of new pond facilities in selected park areas, does present higher potential impact that Alternative No. 2. It should be noted though that some of these impacts will largely be short-term, construction related.

5.4.4 Criterion Category: Sustainability Considerations

The Sustainability considerations are:

- Comparative ability to make the Peterborough municipal drainage system more adaptable to expected increases in rainstorm intensity (e.g. through provision of additional storage volume, maximizing rainwater infiltration).
- Comparative energy use and GHG emissions.
- Potential reduction in local warming through improvement to tree cover or to green space.
- Integrated watershed management: Long-term improvement to local and downstream surface water quality for sustaining water sources for beneficial uses such as drinking water supply.

Table 26 compares the alternatives with respect to the key considerations related to sustainability.

Table 26 Alternatives Comparison – Sustainability

Sustainability Considerations	
Alternative 1 Status Quo	• Lowest improvement in the adaptability and sustainability of the municipal drainage system.
Alternative 2 Opportunistic Source Reduction	• Provides only marginal benefits in terms of the above sustainability considerations because of inherent limits of a distributed source-control approach and practical limits on how widely source control can be implemented.
Alternative 3 Aggressive System Retrofit	• Provides the greatest increase in the adaptability of the system to projected climate change and sustainability of downstream surface water quality, because this alternative includes the largest number of new stormwater retention and treatment facilities to address existing untreated storm discharges. • Negative effects include loss of greenspace and tree cover due to new facility construction.
Alternative 4 Progressive System Improvement	• Provides modest gains in the adaptability of the system to projected climate change, and helps with sustaining surface water quality, but to a lesser degree than Alternative No. 3.

	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

In the sustainability category, Alternative 3 is the most favourable, primarily because the aggressive approach to providing additional end-of-pipe stormwater facilities provides greater sustainability of good water quality conditions by

providing greater reduction in water pollution from urban drainage. However, this advantage is partly offset by loss of greenspace and tree cover that would result from construction of end-of-pipe treatment facilities.

5.4.5 Criterion Category: Technical Considerations

The Technical considerations are:

- Integration with Flood Reduction Program.
- Treated service area: amount of system service area that receives direct stormwater treatment.
- Potential for conflicts with existing underground infrastructure.
- Potential for negative effects on wet-weather inflow to sanitary system.
- Flexibility to accommodate future urban growth.
- Acceptability of proposed works to regulatory agencies including ORCA and DFO.
- Practical applicability of proposed OP policies.
- Practical applicability of proposed Engineering Design Standards modifications.
- Time required for implementation.
- Implementation phasing: ability to implement in phases over time.

Table 27 compares the alternatives with respect to the key technical considerations.

Table 27 Alternatives Comparison – Technical Considerations

Technical Considerations	
Alternative 1 Status Quo	• Minimal negative impacts because the “do nothing” approach does not involve construction of new works or other system modifications. • No technical advantages such as better adaptability to future growth or improvement in development design standards.
Alternative 2 Opportunistic Source Reduction	• Provides the advantages of better design standards coupled to better OP policies, so that new development is better designed. • Has advantage of easier than some of the other alternatives implementation. • Avoids any technical issues involved in construction of new treatment facilities. • Practical and feasible extent of implementing source control may be very limited • Presents some potential for worsening water infiltration into sanitary sewers if stormwater infiltration applied as source control
Alternative 3 Aggressive System Retrofit	• Presents the largest technical challenges because it includes the implementation of many (14 or more) new end-of-pipe stormwater treatment projects. By far the longest implementation time requirement.

Table 27 Alternatives Comparison – Technical Considerations

Technical Considerations	
Alternative 4 Progressive System Improvement	• Provides the advantages of better design standards coupled to better Official Plan policies, so that new development is better designed • Relatively low technical challenges associated with proposed new treatment works; and substantially less implementation time than needed by Alternative No. 3.

	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

In the Technical category, Alternatives 2 and 4 are favourable, with Alternative 4 being considered the most favourable. Alternative 4 provides the technical advantages of Alternative 2, while avoiding some of its technical drawbacks.

Table 28 Alternatives Comparison Summary Table

Criteria Category	Alternative 1 Status Quo	Alternative 2 Opportunistic Source Reduction	Alternative 3 Aggressive System Retrofit	Alternative 4 Progressive System Improvement
Natural Environment				
Financial Environment				
Socio-cultural Environment				
Sustainability Considerations				
Technical Considerations				

	Favourable		Somewhat favourable, unfavourable or neutral		Not favourable

5.4.6 Additional Narrative Information

5.4.6.1 Alternative 1: Must Consider Problem/Opportunity Statement

At the outset of the study, the problem/opportunity statement was identified as "The recommended SWQMP should provide the City with a long-term strategy that leads to reduction in stormwater pollution and advancement of the City's role in helping to protect and improve the natural environment."

From this standpoint, Alternative No. 1, the “do nothing” alternative, can be ruled out as a viable approach. Alternative No. 1 is the status quo, and staying with Alternative No. 1 would mean that the need for long-term improvement would not be met, and that the City would not be doing its part in helping to improve pollution abatement and advancing environmental protection.

5.4.6.2 Alternative 3: Must Consider Costs and Benefits

Because there is such clear and significant cost difference between this and the other alternatives, a central issue is whether the resulting benefits are worth the cost. The most aggressive and ambitious alternative, Alternative 3, presents very high capital cost (over $40 million) that may make it less affordable than the other alternatives and/or unaffordable to the municipality. Such high cost is very difficult to justify partly because it is difficult to quantify what the demonstrable benefits would be from installing this system of end-of-pipe retrofit stormwater treatment facilities. Beyond intermittent bacterial pollution at public swimming beaches at Beavermead Park and Roger's Cove Park, there are no known, significant water pollution problems directly attributable or solvable by improving municipal stormwater treatment in Peterborough. Furthermore, the bacteriological contamination at the public swimming beaches would not be entirely solved by Alternative 3.

While the data collected in 2011 indicate that stormwater discharges are causing elevated levels of some contaminants (metals, phosphorus, indicator bacteria) along local creeks, the demonstrable benefit to eliminating these effects is difficult to quantify in a manner that would clearly justify significant expenditures by the City. It should also be noted that for some creeks (e.g. North and South Meade, Jackson, Curtis and Bears Creeks), the 2011 sampling data show that for some of these parameters, there are elevated levels at the City limits, indicating that part of the problem is originating from outside the City.

Furthermore, Alternative 3 includes a number of costly system retrofits that may not all be feasible due to concerns about environmental impacts at each site.

The more general principle that does support spending money on measures to improve stormwater pollution reduction is that the City should continue to help with stewardship of the local water environment, by improving system performance and impact mitigation over the long-term, especially through control and reduction of the source(s) of the pollution.

On this basis, Alternative 3 should not be considered as a preferred alternative.

5.4.6.3 Alternatives 2 and 4: Top Choices

The evaluation results indicate that Alternative 2 ("Opportunistic Source Reduction") and Alternative No. 4 (“Progressive System Improvement”) are nearly equal.

To arrive at a conclusion, the following points should be considered.

- In the case of Alternative 2, benefits are largely attributable to effects of increased public education and outreach, as well as direct improvements in municipal operations related to road maintenance. The gains that will be provided by Alternative 2 are likely to be modest and take a long period of time.
- Alternative 4 captures all of the benefits of Alternative 2. Alternative 4, with capital cost for SWM pond enhancements and new end-of-pipe retrofit projects of approximately $4.3 million and annual O&M costs approximately $300,000 higher than the "do nothing" alternative, appears to be an affordable approach. This alternative would also see the highest percentage of lands positively affected through implementation.
- Alternative 4 is based on working towards long-term improvement by incorporating specific stormwater policies within the new Official Plan, and promoting Low Impact Development design approaches through updated City Engineering Design Standards. As well, it incorporates a Cash-In-Lieu program that would be used to fund a well-defined set of projects that includes four new end-of-pipe facilities as well as enhancements at a number of the existing ponds.

5.4.7 Public Feedback on Potential New Facilities

Through the public consultation process, the consulting team became apprised of significant public concerns about the proposed new pond facilities that are a component of Alternative 4. The locations of these four proposed facilities are shown in Figure 11.

Concept layouts for each site were presented at the second PIC held on June 13, 2013 at the Canadian Canoe Museum. Appendix C provides the information panels and site maps that were presented to the public during PIC #2.

There were concerns about these proposed facilities clearly expressed by residents who live in the vicinity of the proposed sites. The public concerns included neighbourhood compatibility, loss of valuable parkland, public safety, loss of tree cover and potential for creation of mosquito breeding areas. Refer to Appendix C for full details on the information that was presented to the public at PIC #2, and for the feedback and comments that were received at the meeting and subsequent to the meeting.

The outcome was clear direction that further neighbourhood consultation and careful and considerate design analysis would be required to implement stormwater treatment facilities at any of these four selected locations. This important outcome has been reflected in the final recommendations on the preferred approach, as discussed in the following section of this report.

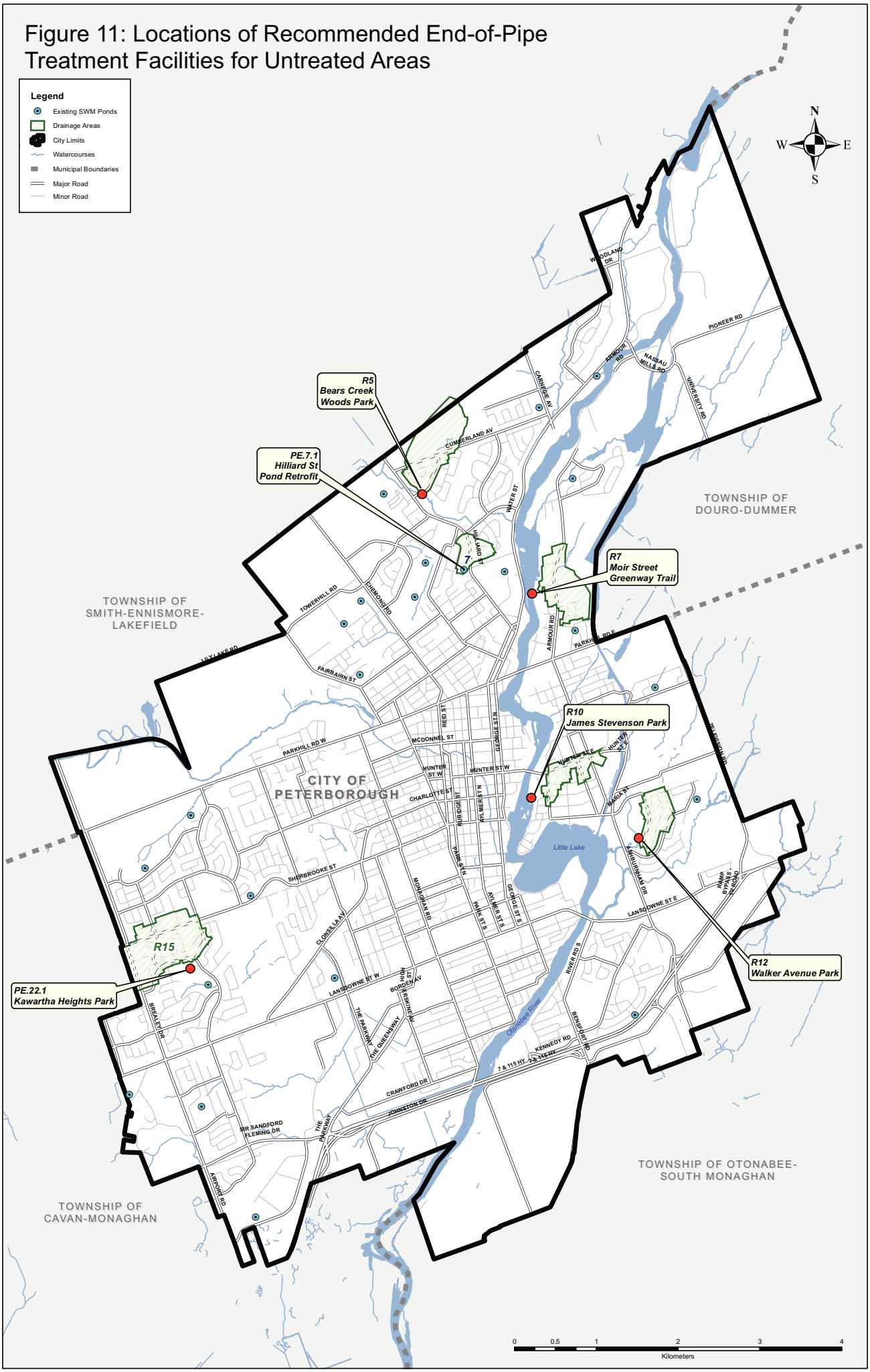
5.4.8 Preferred Alternative

Based on the preceding evaluation and the public input received during the course of this study, it has been determined that a revised version of Alternative

4 is preferred plan. This conclusion has been reached recognizing the significant public concerns about the four proposed new end-of-pipe stormwater treatment facilities that are a component of Alternative 4. The consulting team's judgement is that as an overall long-term strategy, the best approach for the City to pursue is a revised version of Alternative 4 in which the City recognizes that any specific proposal to construct new end-of-pipe stormwater treatment facilities at any of the four suggested sites, must be subject to further public and neighbourhood consultation as part of subsequent Class EA and design studies. This revision provides assurance to the public that this component of Alternative 4, will and must advance with due consideration to public concerns that have been expressed during this project.

It is therefore recommended that this revised version of Alternative 4 be put forward as the recommended alternative for final public review and adoption by City Council.

Figure 11: Locations of Recommended End-of-Pipe Treatment Facilities for Untreated Areas



6. THE RECOMMENDED STRATEGY

6.1 Summary Diagram

Figure 12 presents a diagram that summarizes the recommended strategy.

6.2 Implementation of Funding Mechanisms

The recommended strategy includes implementation of two specific funding mechanisms:

- Stormwater Cash-In-Lieu Policy.
- A new "Storm System User rate" that would apply to all properties that are served by the municipal drainage system.

6.2.1 Implementing Cash-In-Lieu Policy

Appendix E provides a recommended approach for defining the Cash-In-Lieu policy, including recommendations regarding which specific proposed stormwater treatment works could be implemented using by C-I-L funding. The rationale for the C-I-L policy is as follows:

- It is a means to fund strategic system retrofits (i.e. installation of new stormwater treatment facilities to service catchments that are currently "untreated"), while also minimizing the proliferation of small on-site treatment devices.
- It would thereby help the City fund stormwater retrofits that would ultimately provide greater pollutant load reduction and more environmental benefit.
- It could simplify design and approvals, and reduce costs, for small property developments or site redevelopments.
- It could help to avoid the City becoming party to an increasing number of individual agreements with property owners related to ensuring maintenance of individual private site devices.

These are significant advantages that have led to the recommendation that Cash-In-Lieu should be implemented by the City.

To define how CIL would operate, the following requirements are addressed in some detail in Appendix E:

Which Properties are Eligible?

- Clear definition of which types and sizes of property developments may be eligible for using CIL. Refer to Table 1 in Appendix E.

What is the CIL Payment Amount?

- The suggested amount of cash contribution (one-time payment) required from an individual property, based on physical characteristics of the property, is set out in Table 3 of Appendix E. The amount ranges from $25,000 to $37,000 per hectare of site area, for site imperviousness ranging from 35% to 85%, based on rationale set out in Appendix E.

What Will the Money Be Used For?

Table 26 shows the set of designated target projects as set out in Appendix E:

Table 29 Set of Designated Target Projects

Site ID	Catchment Area	Proposed Facility Location	Estimated Capital Cost
R5	27.7 ha	Bears Creek Woods Park	$600,000
R7	39.7 ha	East side of Otonabee River in the vicinity of Moir Street (between the river and Rotary Greenway Trail)	$700,000
R10	19.9 ha	James Stevenson Park	$400,000
R12	22.3 ha	Walker Avenue Park	$600,000
PE.7.1	13.5 ha	Existing Hilliard Street dry pond: convert o wet pond	$220,000
PE.22.1	61.1 ha	Kawartha Heights Park: Install grit-capture chamber on 1050-mm storm outfall from Kawartha Heights Boulevard discharging to existing pond in Kawartha Heights Park	$600,000
Totals	184.2 ha		$3.1 million

To implement such a policy, the City will need to reach agreement with regulatory authorities who have a legislated mandate to review and approve property development with respect to stormwater drainage and specifically the regulatory requirements regarding stormwater treatment and water pollution abatement.

As noted above, during the course of this project, MOE was asked to review the proposed cash-in-lieu approach, and MOE has indicated that the Ministry does not have any concerns with it; refer to correspondence from April 2013 that is included in Appendix C.

It is recommended that the City also review the proposed C-I-L policy with ORCA so that ORCA is aware of the City's initiative, as ORCA is routinely involved in reviewing development applications with respect to stormwater management.

FIGURE 12: City of Peterborough Stormwater Quality Management Master Plan : Components of Recommended Strategy (Updated Oct. 20, 2014)

DEVELOPMENT PLANNING & DESIGN

OFFICIAL PLAN UPDATE

- Implement specific policy section (e.g. within OP section addressing infrastructure and servicing) related to stormwater management (SWM).
- SWM policy section to state clear goals, require "treatment train" approach and require Low Impact Design approach to the extent practical.
- Consider good recent examples such as Barrie and Richmond Hill.

No cost attributed

CITY DESIGN STANDARDS

- Update to promote, encourage and require Low Impact Design (LID) and Source Control while maintaining adequate property drainage.
- Make reference to recent and emerging technical guidance documents such as LID guidelines and design criteria recently developed by TRCA and CVC.
- New design standards document should include illustrative design examples to make the City's requirements and accepted design approaches clear to development proponents.

No cost attributed

COMMUNITY OUTREACH & COLLABORATION

Public Awareness Campaign

Designed to promote Source Control and compliment infrastructure solutions by raising awareness and support

- Develop objectives and key messages; e.g. inform general public of pollution sources and issues.
- Target a broad audience, primarily property owners.
- Promote source-control measures on private properties, e.g. rain barrels, vehicle maintenance practices, lawn maintenance, etc.
- Integrated effort across City departments.
- Cross-connect with ***Peterborough's Urban Forest Strategic Plan*** *(June 2011)* and ***Sustainable Peterborough***
- COST: Estimate **$ 80,000/year** for one part-time staff and materials development.

Collaboration and Linkages

Establish working group or forum for agencies, organizations and others with an interest in stormwater management that meets regularly (e.g. twice per year) to facilitate ongoing input, networking, discussion and action.

No cost attributed

FUNDING

STORM SEWER USER RATE

- Based on property characteristics (e.g. size & impervious area)
- Consistent with requirements of Water Opportunities Act
- Requires supporting consultative study to implement; estimated cost $80,000

CASH-IN-LIEU POLICY

- Intended to generally applicable to relatively small development parcels
- Consult with regulatory agencies to implement; est. cost $20,000

REGULAR REVIEW

- 5-year review cycle
- Assess implementation status
- Assess improvements in local conditions
- Advise public and stakeholders of status
- Adjust as needed to pursue continuous improvement

INFRASTRUCTURE

EXISTING INFRASTRUCTURE RENEWAL & IMPROVEMENT	
Facility restoration: Sediment removal from existing SWM ponds and other corrective measures	$ 2.1 M
Measures to improve pond performance	$ 2.0 M
Total	**$ 4.1 M**

SYSTEM MAINTENANCE	
Item	Est. annual cost
Annual maintenance at existing SWM ponds: Structured program to include routine inspections, landscape maintenance and routine removal of accumulated grit and sediment; accompanied by record-keeping system to allow for reporting and tracking of deficiencies.	$ 349,000
Storm-sewer catch basin cleaning and sewer flushing program: Maintain existing CB clean-out program (increasing CB clean-out frequency is not a cost-effective means of pollution abatement)	$ 150,000
Street-sweeping program Maintain existing program (based on use of 4 mechanical sweepers). Switching to regenerative-air/vacuum sweepers cannot be justified based on available research on net effectiveness of such sweepers. Mechanical sweepers required to remove winter road sand/grit.	$ 700,000
Total	**$ 1,199,000/year**

SYSTEM SURVEILLANCE PROGRAM	
• Monitor major outfalls in dry weather for bacteria, metals, nutrients (20 outfalls, 6 times per year) • Monitor creeks in dry and wet weather (25 locations, 6 times per year)	$ 120,000 per year

SEWER USE BYLAW	
Review and update to ensure enforceability for industrial, commercial and other applicable property uses	No cost attributed.

NEW INFRASTRUCTURE OPPORTUNITIES	
Construct new innovative storm facilities at untreated outfalls	
• At Bears Creek Woods Park to treat 27.7 ha	$ 0.6 M
• South of Meadowvale Park to treat 39.7 ha	$ 0.7 M
• At James Stevenson park, to treat 19.9 ha	$ 0.4 M
• At Walker Ave. Park to treat 22.3 ha	$ 0.6 M
Total	**$ 2.3 M**

At this time, the City is not seeking EA approval for these 4 projects. Approvals may be sought as opportunities arise, such as Federal/Provincial funding programs. Additional design analysis and consultation needed as part of a future planning exercise for each of these projects. Innovative design approaches to be pursued in each case.

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6.2.2 Implementing Storm-System User Rate

Implementation of a stormwater system user rate is recommended as a means of providing direct and dedicated funding for operation, maintenance and improvement of the municipal storm drainage infrastructure. Such a funding mechanism will help the City meets the intent and requirements of Ontario's recent Water Opportunities Act (2010).

Based on experience in other Ontario municipalities such as Kitchener and Waterloo, implementation of this user fee is feasible, provided it is accompanied by appropriate public awareness strategies to explain the need to the general public.

In Peterborough, as a result of significant flood events in 2002 and 2004, there is generally good public awareness of the need for maintaining and improving the City's drainage system. The City has undertaken a series of flood-reduction studies to define what is needed within each of the local creek watersheds. These studies have been subject to considerable public consultation and scrutiny. As a result, the public in Peterborough is believed to be aware that the City over the coming years needs to spend considerable money improving the drainage system, for the benefit of all residents and property owners.

The recommended strategy presented in this report with respect to what the City needs to do to maintain and improve existing stormwater ponds for purposes of water pollution abatement, involves additional costs for system operation and improvement beyond those already identified in the flood-reduction studies. The SWQMP therefore assists the City with better defining the full cost of maintaining, operating and improving the municipal drainage system.

At this stage, it is XCG understanding that the City's legislated authority would allow for the proposed storm-system user rate to provide future funding for all of the above requirements (i.e. flood-reduction works, plus measures related to stormwater quality control). To implement the proposed user rate, the following steps would be needed:

- Finalize total estimated capital and annualized cost for maintaining, operating and improving the municipal drainage system to an appropriate time horizon (e.g. 25 years).
- Prepare an inventory of properties that would be subject to the proposed user fee, and decide upon an objective basis for the fee calculation that would be applied to each property. Generally, the calculation would be based on using measurable property characteristics that affect the volume of stormwater runoff from the property: property size and impervious surface coverage.
- The calculation method should allow for adjustments or "credits" for beneficial measures implemented by individual property owners. For example, for home-owners who install rain barrels to capture roof runoff, then the impervious surface coverage amount could be reduced by as much as the roof area.

- Using the above information, determine what the typical annual or monthly user fee would be for various types and sizes of properties, to assist with describing the implications of the proposed fee to the public. Particular attention should be given to the possible effects that any new fees could have on various types of property owners (residential, business, institutions/tax exempt) and whether these effects warrant special considerations or approaches within the overall framework. One way to identify such effects would be to meet with the various types of property owners to discuss the program and seek input.
- Develop a consultation plan to develop the program and a communications plan to introduce to the community the proposed fee as a measure the City is considering implementing. The communications plan will need to make the public aware of why such funding is needed, and what the benefits to the community will be.

The successful implementation in other Ontario municipalities has shown that any challenges associated with introducing a storm system user rate can be overcome with a good communication strategy. There is a clearly defined need for the City to properly fund the municipal storm system, and the Water Opportunities Act requires the City to develop the necessary plan. The recommended storm system user rate directly addressed these needs.

6.2.3 Candidate Locations for New End-of-Pipe Facilities

The recommended strategy includes the possibility of constructing four new end-of-pipe stormwater treatment facilities, as listed below in Table 30.

Table 30 Four Candidate Sites for New End-of-Pipe Treatment Facilities

ID	Location Description	Estimated Cost	Comment
R5	Bears Creek Woods Park	$600,000	To treat 900-mm and 533mm storm outfalls (27.7 ha)
R7	Moir Street (between Otonabee River and Rotary Greenway Trail)	$700,000	To treat 1520-mm and 610mm outfall (39.7 ha)
R10	James Stevenson Park	$400,000	To treat 1066-mm outfall (19.9 ha)
R12	Eastgate Park (Walker Avenue Park)	$600,000	To treat 1066mm outfall (22.3 ha)

Review of natural environmental conditions and potential impact on natural environment of proposed facility construction, is provided in Appendix I.

As well, a Stage 1 archaeological assessment for these four sites is provided in Appendix J.

As noted above, there have been significant concerns expressed about these four proposed new facilities as a result of their presentation at PIC #2 in June 2013. Appendix C presents the information about the proposed concepts as presented at PIC #2, and also provides the details of the public concerns that were expressed during PIC #2 and subsequently in a number of written submissions that were received from members of the public. Primary concerns are loss of parkland, compatibility of open pond facilities with local neighbourhoods, associated concerns about public safety, and potential impact on property values; as well as concerns about loss of existing mature trees and potential for mosquito breeding. At PIC #2 and in subsequent response to written submissions, the consulting team made it clear to concerned members of the public that further consultation with local residents would be required to move any of these four projects forward, that alternative design approaches would be considered during that process (i.e. alternatives to conventional open stormwater ponds), and that the City would duly consider the concerns that have been expressed by those living near the proposed sites.

Design and implementation of new stormwater treatment facilities at any or all of these 4 sites, must be carried out in accordance with the Municipal Class Environmental process, and each new facility will likely be considered as a "Schedule B" project requiring further public consultation and opportunities for input into the design process. This process requirement provides assurance that the public will have a chance to become involved in design of proposed stormwater treatment facilities for these four sites.

As a result, the recommended plan does NOT include the design and construction of specific stormwater treatment facilities at any or all of these four sites. Rather, the recommended plan is identifying these four locations as potential opportunities (given that the existing stormwater outfall pipes will remain untreated) for new treatment facilities. Prior to implementation of any such systems, additional consultation with affected neighbourhoods should take place. Any plans for these locations should be developed such that they:

- Are designed and planned in conjunction with neighbourhood consultation; and,
- Remain sensitive and provide due consideration to the reasonable concerns of the community.

These locations may be ideal settings to test new community partnerships to develop innovative, context-sensitive and functional systems for addressing the stormwater quality issue.

6.3 Implementation Priorities

The priority is for the City to implement those measures that are needed to maintain regulatory compliance at the existing stormwater pond facilities. These recommended measures are the associated estimated costs are presented previously in Table 8 and Figure 7.

A concurrent priority is for the City to implement routine inspections of the existing stormwater pond facilities. Appendix G provides specific and detailed recommendations regarding methods and procedures.

6.3.1 Pond Sediment Cleanouts

The list of measures recommended to maintain compliance includes removal of sediment from a number of the existing stormwater ponds. The following ponds are considered to be top priorities for sediment clean-out:

- Chemong Park Plaza Pond (Pond 9): Forebay over 70% full, and land development proposals are understood to be pending within the pond's service area;
- Wentworth Street Pond (Pond 23): Forebay is approximately 70% full;
- Foxmeadow Pond (Pond 15): Forebay approximately 60% full; and,
- Major Bennett Pond: Forebay #1 (smallest of the three at this pond) is almost full.

It is expected that the pond sediment clean-out operation will be carried out by contractors hired by the City, as the City's Public Works Division does not have the required equipment, and there is no justification or rationale for the City to acquire the necessary equipment for this specialized and intermittent type of operation.

For each pond, the City will therefore need to develop a contract specifications document that describes how the contractor is to proceed with the operation. The following are considerations:

- In all cases, the pond sediment analyses carried out in the project have shown that the removed material will need to be disposed of at the City's Bensfort Road landfill site; refer to TM No. 5 for the sediment testing results and their interpretation.
- Estimated quantities of sediment to be removed are listed in this report, and estimated costs for clean-out operation have been provided above in this report.
- The plan/profile facility drawings that were prepared during this project (see Appendix L, TM No. 7) can be used as information for tenderers on the current status, dimensions, layout and features of each pond.
- The natural environmental features and conditions at each pond site have been investigated during this project, and are documented in Appendix L(TM No.3). This information can be used to help plan each sediment clean-out operation.

Where the information provided in TM No. 3 indicates that the pond may support aquatic life including fish or amphibians, it is recommended that the City consult with ORCA and/or Department of Fisheries & Oceans (DFO) to determine project-specific requirements for impact mitigation.

It is recommended that the City develop a standard procedure document to guide the planning and contract specification development for each pond sediment clean-out project.

As well, it is recommended that the City meet with local contractors who are potentially interested in doing these projects for the City, and discuss with them the most practical ways of designing and planning such projects. Contractor input in the planning stages will be helpful in ensuring a practical set of contract specifications and required procedures can be developed by the City.

6.3.2 Routine Pond Inspection and Reporting

Another important implementation priority is for the City's Public Work Division to undertake routine pond facility inspections and to document and report the inspection results. Appendix G sets out the recommended procedure and includes a standard pond inspection form example, with custom form for each existing facility.

Of significant importance is that the City implements internal systems to record and store the routine pond inspections, so that they can be made available on an as-needed basis. The Ontario Ministry of Environment is responsible for ensuring that the pond facilities are operated and maintained in accordance with each facility's C of A. These documents invariably include a general condition requiring routine inspection and document thereof.

The MOE has recently been stepping up enforcement activity with respect to municipal stormwater ponds, including random unannounced inspections in which MOE enforcement staff require that the municipality provide available documentation on operation and maintenance activities.

This is therefore a high priority action item, as it is needed to ensure that the City is taking a due-diligence approach.

6.4 Immediate Needs

6.4.1 Storm Sewer Investigations

The sampling program completed in 2011 identified a number of outfalls that showed what can be considered very high levels of bacterial contamination in dry weather or wet weather. See Table A-2 in Appendix A.

The following outfall shown in Table 31 should be subject to follow-up sampling to determine if the problem is persistent. If so, then investigations should be carried out to try to locate and eliminate the source of the contamination. It is recommended that initially these outfalls be sampled in dry weather to help determine if there is some continuous source of contamination.

Table 31 Storm Outfalls to Further Investigate

ID	Location description	Catchment Area	Pipe Size	Bacterial contamination from 2011 sampling program	
				Wet weather	Dry weather
D18	Outfall to Otonabee River, north of Marina Blvd at water Street.	34.4 ha	750 mm	E. coli of 98,000 CFU/100mL Oct. 24, 2011, but OK on Nov. 29, 2011.	OK in dry weather (Oct 5/11).
D24	Outfall to Otonabee River, Water Street at Edinburgh Street.	15.0 ha	1050 mm	E. coli of 35,000 CFU/100mL Oct 24, 2011; and E. coli 2,600 on Nov 29, 2011	OK in dry weather (no flow during dry weather)
D37	Outfall to Little Lake (Otonabee River), Romain Street & Crescent Street.	36.4 ha	600 mm	E. coli > 840,000 Oct 24, 2011; and at 1,100 on Nov 29, 2011	OK in dry weather (Oct 5, 2011).
D44	Outfall to Otonabee River from Monaghan Road at Crawford Drive.	9.0 ha	900 mm	E. coli of 900 CFU/100mL Oct 24, 2011; and E. coli 650 on Nov 29, 2011	E. coli at 4,000 CFU/100mL in dry weather (Oct 5, 2011).

Part of the recommended SWQMP is that the City initiates a program of routine surveillance and sampling of major storm outfalls. Appendix K sets out the recommended program.

6.4.2 Procedures for Municipal Assumption of New Pond Facilities

The City has developed a standard set of requirements regarding stormwater performance monitoring that are incorporated in subdivision agreements between the City and land developers. These standard requirements set out specific requirements for clean out of accumulated sediments from new storm ponds, and performance monitoring of new storm ponds, that must be met before the City assumes ownership of such ponds. The City's standard requirements ensure that at the time of assumption, the pond will not contain significant sediment accumulation and that pond performance will be in accordance with the MOE Environmental Compliance Approval (ECA).

Appendix F provides recommendations on specific submission requirements that the City should require at the time of City assumption of newly constructed stormwater management ponds. It is recommended that the City review current requirements and procedures in light of the fact that there are a number of recently constructed facilities that are pending municipal assumption.

6.5 Innovation during Implementation

6.5.1 Innovative Design of Proposed New End-of-Pipe Pond Facilities

The recommended strategy has identified four candidate sites where it may be feasible to construct new end-of-pipe treatment facilities subject to further public consultation and design analysis.

Each of these sites may present the opportunity for innovative design that could be accompanied by performance monitoring and research activities, in an effort to find better ways of mitigating the impact of urban stormwater.

Many Ontario municipalities have to come to grips with the proliferation of conventional pond facilities, with respect to the costs and complications involved in cleaning out and disposing of accumulated sediments.

From this standpoint, it makes sense to look at innovative ways to design outfall treatment facilities, possibly in conjunction with researchers in this field who may be looking for opportunities for pilot projects.

One potential design approach that could be considered and which would entirely avoid the use of a conventional wet pool, would be the use of engineering filtration beds. Such facilities could be designed based on use of subsurface perforated pipe bed systems, not unlike weeping tile beds, with use of appropriate granular filter material and inlet grit-capture chambers to ensure performance and minimize the required bed restoration frequency. The advantage of such a design approach is that instead of loss of parkland to a wet pond facility, there would be a maintained grassed area above the subsurface filtration bed system, meaning less loss of usable park area.

This is only one potentially innovative approach that could be applicable at some or all of the four sites that have been identified as potential opportunities for new end-of-pipe facilities. In general, the capital costs for innovative systems can be expected to be higher than conventional wet treatment ponds, but this will depend on local site conditions and site constraints; in some cases, capital costs may well be lower. And over the long term, well-designed systems that avoid the need for costly pond clean-outs may well present lower life-cycle costs. Such innovative projects could be undertaken in cooperation with, for example, researchers at Trent University who may have a particular interest in stormwater treatment systems. As well, the Provincial government may have funding programs available from time to time related to innovative infrastructure design that might assist the City.

6.5.2 Integration with Ongoing City Projects

In future there may be additional opportunities for innovative implementation of additional stormwater treatment facilities as part of ongoing City projects. Two examples are:

- Parkway Extension project: the potential site identified in Whitefield Park (identified as site R14 on Figure 10 and Table 14) may present an opportunity to implement innovative measures in conjunction with final design of the proposed Parkway extension. Within the current study, as indicated in Table 14, ORCA expressed its lack of support for a treatment facility at this location, because of concerns about warm stormwater discharges to Byersville Creek. For this reason, this opportunity has not been forward as a recommended candidate site. However, this site may present potential for stormwater treatment using an innovative approach if it can be demonstrated that it eliminates any thermal impacts on Byersville Creek.
- Byersville Creek flood reduction strategy: The City is pursuing the possibility of creating a flow detention facility at site R16 (Figure 10 and Table 14). Within the current study this site has not been brought forward as a recommended candidate site because of site constraints and concerns expressed by ORCA, as well as the potentially high cost of implementing stormwater treatment at this location. As well, the site is currently under private ownership, so that extent of works possible at this site remains unknown. However, as the proposed flood detention facility concept advances there may be opportunity to provide some stormwater treatment at this site. Potential thermal impact on Byersville Creek will also be a concern at this location.

6.5.3 Innovation in Urban Development Design

The recommended strategy includes new Official Plan policies to promote innovative approaches to design of new development or redevelopment properties. As well, the recommended strategy includes modification of the City`s Engineering Design Standards to better promote, encourage and require "low impact" design approaches, and to implement a "Cash-In-Lieu" policy.

Implementation of new OP policies and design standards can take advantage of the experience and approaches of other Ontario municipalities, and technical guidelines such as the recently published "Low Impact Development Stormwater Management Planning and Design Guide, Version 1.0" developed by Toronto Region Conservation and Credit Valley Conservation.

However, new policies and design standards that promote innovation, may not guarantee that innovation will in fact happen. There are many competing factors and considerations that affect the final design of new developments or redevelopment sites, and which can work against innovation in urban drainage management. These include:

- The desire or requirement for urban intensification;

- What private developers consider to be market preferences;
- Accepted approaches to site and roadway design that have evolved over decades and have proven efficacy, but which may inadvertently hinder true innovation;
- The need to meet regulatory requirements for stormwater treatment and flow control, and adhere to specific guidelines from regulatory agencies, that may also dictate or promote certain design approaches (approaches that have worked before and are known to be acceptable) at the expense of true innovation; and,
- The potential for higher cost to implement innovative design because of what may be requirements for new construction approaches, new materials or structures, or because of added complexity in obtaining necessary approvals.

These are ongoing challenges. Once new OP policies and revised design standards are in place significant progress will have been made by providing clear direction towards and foundation for innovative approaches.

The City in its role as planning approval authority could potentially take various actions to help ensure that innovation does happen.

The recommended stormwater Cash-In-Lieu policy (see Appendix E) could be developed to clearly define how the required cash payment amount from smaller development sites can be minimized using specific innovative site design approaches that minimize the "effective imperviousness" of the site. Techniques that could be promoted include:

- Use of grassed swales, soak-away areas and rain gardens to provide runoff filtration from roofs or paved surfaces.
- Installation of "green roof" systems to reduce direct runoff.
- Installation of rainwater harvesting systems (e.g. cistern systems) that provides water for landscape maintenance.

Such approaches are already being widely promoted. By having clear definition of how such measures would reduce the cash-in-lieu payment amount, there becomes financial incentive for innovation. The best way to do this, to make it meaningful to designers and developers, would be to incorporate detailed illustrative design examples within the City's revised design standards document.

Another pro-active approach that the City could take would be to play a more direct and active role in the design of specific development proposals that may present particular opportunity to incorporate innovation. The final design of individual private developments obviously remains in the hands of the developer, and most development proponents consult directly with City staff to ensure that what they bring forward in their development applications will in fact be accepted by City staffing, Planning Committee and Council.

Through this consultation process, there is opportunity for the City to promote and push for innovation from development proponents. This requires a cooperative and collaborative approach between City and developer and in many instances may also require direct involvement by staff from regulatory agencies that deal with drainage management, including ORCA and MOE.

While this is happening at present, there may be a need to create a more formalized consultation process that is directly targeted at finding opportunities for innovation. An innovative approach may be to form ad-hoc design review panels to deal with more significant or larger development proposals that by virtue of their size present some real potential for innovative urban design. Such a panel could consist of City staff from Utility Services and Planning Departments, as well as local regulatory agency staff, that would work directly with the development proponent to generate ideas.

To make this worthwhile for the developer, incentives would be needed. If cash-in-lieu is a possibility, then clearly there would be financial incentive. If not, then it would have to be made clear to the developer that such consultation would facilitate final approvals, and that some flexibility in interpreting design guidelines and regulatory requirements would be provided by City and regulators to allow for innovative approaches that may not be fully proven. In other words, the City and regulators would work collaboratively with the developer to help shape an innovative design.

7. GLOSSARY OF ABBREVIATIONS

Al	Aluminum
BMP	Best management practice
Cd	Cadmium
Cr	Chromium
Cu	Copper
DFO	Department of Fisheries & Oceans
E. coli	Escherichia coli (bacteria, indicator of public health risk)
LID	Low Impact Development or Low Impact Design
MOE	Ontario Ministry of Environment
ORCA	Otonabee Region Conservation Authority
PIC	Public Information Centre
PWQO	Provincial Water Quality Objectives, as established by MOE
SWM	Stormwater management
TP	Total phosphorus
TSS	Total suspended solids
Zn	Zinc

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