Prepared for:

City of Peterborough

City of Peterborough Watershed Planning Study

Implementation Plan

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List of Terms, Definitions and Acronyms

AEM	Adaptive Environmental Management
ANSI	Area of Natural and Scientific Interest
AMA	Adaptive Management Approach
BMP	Best Management Practice
CLI	Consolidated Linear Infrastructure
Cms	Cubic Metres per Second
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
ECA	Environmental Compliance Approval
EMC	Event Mean Concentration
EOP	End-of-Pipe
ERA	Ecological Restoration Areas
ESPA	Environmentally Sensitive Policy Area
GI	Green 'Stormwater' Infrastructure
GIS	Geographical Information Systems
GWCS	Ground Water Collection Systems
ICA	Issue Contributing Area
ISW-MP	Integrated Stormwater Master Plan
LID	Low Impact Development
LOS	Level of Service
MEA	Municipal Class Environmental Assessment
MECP	Ministry of Environment, Conservation and Parks
NHS	Natural Heritage System
MMAH	Ministry of Municipal Affairs and Housing
MNRF	Ministry of Natural Resources and Forestry
NPS	Urban Non-point Source
OGS	Oil and Grit Separator
OWRA	Ontario Water Resources Act
OP	Official Plan
ORCA	Otonabee Region Conservation Authority

PEAC	Peterborough Environmental Advisory Committee
PICP	Permeable Interlock Concrete Paver
PPS	Provincial Policy Statement
PWQO	Provincial Water Quality Objectives
SARA	Species at Risk Act
SPP	Source Protection Plan
SWM	Stormwater Management
SWMPDM	Stormwater Planning and Design Manual (MOECC 2003)
SWS	Subwatershed Study
WHPA	Well Head Protection Area
WPS	Watershed Planning Study
WRS	Water Resource Sustainability
WWTP	Wastewater Treatment Plant

1 Introduction

Ontario's Provincial Policy Statement (MMAH, 2020) directs watershed planning and subwatershed planning. The PPS emphasizes using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development. Section 1.4 of MECP's Draft Subwatershed Planning Guide (MECP, Subwatershed Planning, 2022) describes the processes and interdependence of watershed and subwatershed planning:

> "Watershed plans may provide a comprehensive understanding of the ecological form and function in the watershed, the importance of different water resource and natural areas and features, factors that sustain them and indicators to monitor the long-term health of the watershed. Watershed planning may provide the "big picture" of how land use changes and the provisions of water, wastewater and stormwater infrastructure impact and interact with ecosystems and water resources within a watershed area.

Subwatershed planning is typically carried out for a sub-drainage area of a larger watershed. A subwatershed plan is triggered by a specific local issue requiring a higher level of details (i.e., development proposals, area-based water quantity and/or quality problems), or specific policy requirements […]. Watershed planning, where undertaken, may inform subwatershed planning. Watershed planning can enable the assessment and consideration of upstream, downstream, and cumulative effects of development throughout the entire watershed, provide additional context and information that supports, and expedite subwatershed planning. Watershed and subwatershed planning are intended to support land use and infrastructure planning, promote informed decision making, and lead to greater efficiency and effectiveness of the land use planning process." (MECP, Subwatershed Planning 2022)

Traditional watershed and subwatershed studies provide a framework to address cross-jurisdictional water resource and environmental issues and identify opportunities for projects and programs that improve watershed health. These studies differ in approach from municipal SWMPs, in that they predominately focus on issues directly associated with environmental processes and natural heritage features, such as hydrologic processes, ecological habitat, and large-scale environmental connectivity.

The City of Peterborough Watershed Plan summarized the investigations, inventories and analyses used to define existing environmental conditions, future impacts, and recommended management measures for the WPS Study Area. The recommended measures include actions to address stormwater management requirements, protection of the natural heritage system and associated ecological features together with groundwater resources.

The role of the City of Peterborough watershed Planning Study - Implementation Plan (the Implementation Plan) is to provide a framework and broad-scale guidance to the next level of planning and design study as the City of Peterborough grows and faces challenges related to climate change and intensification. As such, the focus of this chapter is to provide guidance for the future work required to implement the recommendations. This includes direction with respect to future studies, timing/phasing of the works, policy/design guidance, and approvals.

The Implementation Plan was developed with consideration for other Strategic Plans, Subwatershed Studies, Master Plans, Secondary Plans, Environmental Assessments and Policies. More specifically, the elements of the recommended approach represent potential synergies with other studies and plans and should be considered as such.

The City of Peterborough Watershed Planning Study Implementation focuses on the follow management strategies to ensure long-term health of the subwatershed that are contained within or flow through the City of Peterborough:

- Stormwater Policy (**Section 3**);
- Natural Heritage Policy (**Section 4**);
- Climate Change Policy (**Section 5**);
- Ecological Restoration in Urban and Urbanizing Subwatersheds **(Section 6**);
- Stormwater Management in Urban Subwatershed (**Section 6.10**);
- Flood Risk Mitigation (**Section 6.14**);
- Ecological Restoration and Enhancement in Rural Subwatersheds (**Section 7**); and
- Watershed Monitoring and Adaptive Management Strategies (**Section 8**)

Where applicable, the following implementation components are outlined with each management strategy.

Key Next Steps: Steps to be undertaken in order to continue an existing measure or to kick start a new program. This includes the identification of pilot project opportunities.

Future Studies: Future studies required in order to implement each type of measure which constitutes the recommended approach.

Policy, By-law or Design Standards Considerations: Existing or proposed policies and or standards that need to be reviewed or updated, have been recommended or developed as part of the Watershed Plan are also discussed. Specific policy discussion will include By-laws, OP and zoning, Monitoring and Enforcement. Operating cost recovery, Land acquisition priorities, easements and 'right-to enter'. From past projects, it is anticipated that this will include:

- SWM Targets Policy (including minimum volume controls) for the City of Peterborough
- Infiltration Policy for land-uses and road types based on a risk mitigation framework.

Facilitator & Contributors: Definition of the party responsible for implementing the measure or the agency(ies) or groups(s) that will assist in implementing the measure by providing support in any number of ways, e.g., funding, labour, materials, technical expertise.

Mechanisms for Implementation: Methods by which the recommended strategy will be implemented, whether voluntary or mandatory, incentive based or prescriptive.

Development Requirements: Outlines the requirements of future new development, infill-development and redevelopments, rehabilitations and infrastructure replacements.

Cost: Unit cost to implement recommended works and or life-cycle costs including staffing requirements, education & training requirements and technical resources both internal and external to the City.

Funding: General funding alternatives that were considered.

Timeframe: General timeframe for implementation of specific steps, projects, studies and the preferred strategy in general.

Integration: How the recommended approach integrates with existing municipal programs.

Prioritization: The order in which the recommended projects are to be implemented to best achieve goal, objectives and targets.

Asset Management: How the recommended strategy cost and implementation timeframes are integrated into a previously established City of Peterborough Asset Management Plan (2016).

O&M: Operation and maintenance activities, approaches and costs associated with the implementation of the proposed measures.

Monitoring & Verification Requirements: Mechanism by which the expected benefit can be quantified or assessed including the assessment interval, structure and adaptive management processes. Association monitoring costs will be identified.

2 Watershed Planning Policy Recommendations

At the planning-level, policies related to the protection of watershed features and function are critical to the long-term success of the City of Peterborough's WPS. Policies in this section are separated into three components.

1) **Stormwater Policy**: Stormwater policies are needed to ensure new urban development and urban intensification projects include approved strategies to mitigate hydromodification and associated impacts on the watershed (erosion, flooding, pollutant loading, changes in groundwater recharge and degradation of habitat and associated biota). These policy recommendations are associated with municipal water balance targets (i.e., infiltration targets) and water quality targets developed as part of the technical analysis undertaken for the cumulative effects analysis. New or updated stormwater policy will require these targets to be met under specific development and/or redevelopment scenarios. These targets are subwatershed specific where feasible.

2) **Natural Heritage Policy**: NHS policies are needed to ensure the form, function and connectivity of wetlands, woodlands, watercourses, valley lands and the ecosystems contained within are protected and/or enhanced where feasible. NHS policies include those within the City's OP as well as those developed and enforced at other levels of government (i.e. ORCA, MNRF, DFO)

3) **Climate Change Policy**: Climate change is defined as any significant change in long-term weather patterns. It can apply to any major variation in temperature, wind patterns or precipitation that occurs over time (Ontario Climate Change Strategy, 2015). The anticipated impacts of climate change caused by anthropogenic greenhouse gas accumulation are wide-ranging and will have impacts at the watershed-level, subwatershed-level and municipal level. Climate change policies relate to both climate change mitigation and climate change adaptation.

3 Stormwater Policy Recommendations

Panning-level policies related to the management of stormwater within the City of Peterborough are contained within the City's Official Plan (2023). Section 6.1.5 of the OP identifies the objectives of stormwater management including that it is informed by watershed planning. Policy direction includes the requirement for stormwater management practices including LIDs be implemented through the planning and development process. OP policies related to stormwater management are identified in **Appendix A**. Engineering standards including design targets, assumptions and analysis techniques related to stormwater management are described in City of Peterborough Engineering Design Standards (2022). These policy standards are summarized in **Appendix A**.

Section 6.3 of the Watershed Plan (January 2023) identifies the Runoff Volume Control (RVC_T) approach for Water Quality Treatment. This approach is consistent with the treatment train stormwater quality control approach identified in Section 6.1.5 of the City of Peterborough Official Plan and is also consistent with the requirements as outlined in **Section D.2.5.B** -stormwater quality control, and **Section D.2.5.D** -Low Impact Development within the City of Peterborough Engineering Design Standards.

To ensure a treatment-train approach to stormwater quality control approach that relies on infiltration-based LIDs provides maximum benefits to subwatershed health, the following recommendations should be applied to stormwater policy.

3.1 Risk-Based Approach to Stormwater Infiltration to preserve Groundwater Quality

This policy component defines where and how infiltration-based stormwater management controls, commonly referred to as Low Impact Development (LID) controls, can safely be planned and constructed in the context of protecting groundwater resources from undue contamination from pollutants that may be transported by stormwater runoff. Although, the vast majority of the population within the WPS study area does not rely on groundwater for potable usage, rural/unserviced development may be reliant on groundwater quality, as are NHS features supported by groundwater-surface water connections.

The use of infiltration practices to reduce runoff, restore natural hydrologic processes and improve water quality is crucial to improving the City of Peterborough's Natural Heritage System and waterways, maintaining the viability of local stormwater infrastructure, and contributing to climate change adaptation & mitigation strategies. The City has a duty to protect local groundwater and surface water resources by implementing a risk-based stormwater infiltration policy which is developed based on a sound understanding of identified and future risks. A risk-based approach to stormwater infiltration policy can be undertaken at the **site plan review stage**, where internal catchments have been identified along with the ability to assess contamination risk at the site-level.

The risk-based infiltration policies outlined below are primarily intended to be used for retrofit opportunities and/or the redevelopment of land within the City's current built-up area. Where a stormwater strategy has been developed through a Subwatershed Study, Master Drainage Plan, or

Secondary Plan with consideration for infiltration of stormwater and groundwater pollution risk, these detailed studies will supersede the below infiltration policy recommendations.

The general goal of this risk-based approach is to provide an effective way of identifying infiltration opportunities to minimize ecological and hydrologic impacts of runoff while protecting local groundwater resources from contamination, specifically identified issues and threats, as well as emerging threats.

Infiltration practices should not accept runoff from catchment areas within the site which are associated with higher risks such as fueling stations, waste disposal areas, vehicle washing stations, salt storage areas, stockpiling areas and shipping and receiving areas. Instead of infiltration-based stormwater practices, pollution prevention practices in the form of administrative and engineering controls should be applied in these areas.

Table 3-1 identifies individual high-risk site activities based on O.Reg. 153/04 and O.Reg. 287/07. High-risk site activities are defined as those with the potential for high levels of contamination such as hydrocarbons, metals, organic and inorganic compounds, and sediments. At the watershed or subwatershed-level, it is impossible to predict the long-term site-specific activities of individual sites; however, **Table 3-1** can be used as a screening framework for identifying portions of each sites where additional focus and review is needed to identify where LIDs should be discouraged, due to risk associated with the specific uses.

Additional high-risk sites include brownfield sites, defined as undeveloped or previously developed properties that may be contaminated. They are usually, but not exclusively, former industrial or commercial properties that may be underutilized, derelict or vacant. An Environmental Site Assessment (ESA) is required to develop Brownfield sites. These sites are different from Greyfield sites, which are previously developed sites that are known or have been shown not to be contaminated.

Infiltration practices should be prohibited for sites with anthropogenically contaminated soils that have not been fully remediated due to the possibility and risk of mobilizing the contaminants. If remediation plans are developed and approved by the City of Peterborough, and remediation is to occur as part of the site development activities which will remove the contamination and/or reduce the risk to groundwater and/or mobilization of the contaminants off-site, then infiltration-based LID may be permitted.

Drainage areas containing a site with high-risk activities (**Table 3-1**) and/or contaminated soils will generally be discouraged from incorporating LID techniques that utilize infiltration as its primary function within the identified catchment because of the associated risk to groundwater contamination. However, high-risk site activities do not preclude the use of those LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes. Additionally, the infiltration of rainwater from catchments that are isolated from the respective high-risk site activities such as rainwater

emanating from rooftops, employee parking facilities or directly falling on permeable surfaces is generally considered relatively ‘clean’ and should not be excluded from infiltration.

Table 3-1: High-Risk Site Activities Which Preclude the Use of Infiltration-Based LID BMPs Within the Contributing Catchment Area

Potentially Contaminating Activities (O.Reg 153/04 Table 2)		
• Acid and Alkali Manufacturing, Processing and Bulk Storage • Adhesives and Resins Manufacturing, Processing and Bulk Storage • Airstrips and Hangars Operation • Antifreeze and De-icing Manufacturing and Bulk Storage • Asphalt and Bitumen Manufacturing • Battery Manufacturing, Recycling and Bulk Storage • Boat Manufacturing • Chemical Manufacturing, Processing and Bulk Storage • Coal Gasification • Commercial Autobody Shops • Commercial Trucking and Container Terminals • Concrete, Cement and Lime Manufacturing • Cosmetics Manufacturing, Processing and Bulk Storage • Crude Oil Refining, Processing and Bulk Storage • Discharge of Brine related to oil and gas production • Drum and Barrel and Tank Reconditioning and Recycling • Dye Manufacturing, Processing and Bulk Storage • Electricity Generation, Transformation and Power Stations • Electronic and Computer Equipment Manufacturing • Explosives and Ammunition Manufacturing, Production and Bulk Storage • Explosives and Firing Range • Fertilizer Manufacturing, Processing and Bulk Storage	• Fire Retardant Manufacturing, Processing and Bulk Storage • Fire Training • Flocculants Manufacturing, Processing and Bulk Storage • Foam and Expanded Foam Manufacturing and Processing • Garages and Maintenance and Repair of Railcars, Marine Vehicles and Aviation Vehicles • Gasoline and Associated Products Storage in Fixed Tanks • Glass Manufacturing • Importation of Fill Material of Unknown Quality • Ink Manufacturing, Processing and Bulk Storage • Iron and Steel Manufacturing and Processing • Metal Treatment, Coating, Plating and Finishing • Metal Fabrication • Mining, Smelting and Refining; Ore Processing; Tailings Storage • Oil Production • Operation of Dry-Cleaning Equipment (where chemicals are used) • Ordnance Use • Paints Manufacturing, Processing and Bulk Storage • Pesticides (including Herbicides, Fungicides and Anti-Fouling Agents) Manufacturing, Processing, Bulk Storage and Large-Scale Applications • Petroleum-derived Gas Refining, Manufacturing, Processing and Bulk Storage • Pharmaceutical Manufacturing and Processing	• Plastics (including Fiberglass) Manufacturing and Processing • Port Activities, including Operation and Maintenance of Wharves and Docks • Pulp, Paper and Paperboard Manufacturing and Processing • Rail Yards, Tracks and Spurs • Rubber Manufacturing and Processing • Salt Manufacturing, Processing and Bulk Storage • Salvage Yard, including automobile wrecking • Soap and Detergent Manufacturing, Processing and Bulk Storage • Solvent Manufacturing, Processing and Bulk Storage • Storage, maintenance, fueling and repair of equipment, vehicles, and material used to maintain transportation systems • Tannery • Textile Manufacturing and Processing • Transformer Manufacturing, Processing and Use • Sewage Treatment and Sewage Holding Facilities • Vehicles and Associated Parts Manufacturing • Waste Disposal and Waste Management, including thermal treatment, landfilling and transfer of waste, other than use of biosoils as soil conditioners • Wood Treating and Preservative Facility and Bulk Storage of Treated and Preserved Wood Products
Prescribed Drinking Water Threats (O.Reg. 287/07)		
• The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act. • The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage. • The application of agricultural source material to land. • The storage of agricultural source material. • The management of agricultural source material. • The application of non-agricultural source material to land. • The handling and storage of non-agricultural source material.	• The application of commercial fertilizer to land. • The handling and storage of commercial fertilizer. • The application of pesticide to land. • The handling and storage of pesticide. • The application of road salt.[1] • The handling and storage of road salt. • The storage of snow. • The handling and storage of fuel. • The handling and storage of a dense non-aqueous phase liquid. • The handling and storage of an organic solvent.	• The management of runoff that contains chemicals used in the de-icing of aircraft. • An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body. • An activity that reduces the recharge of an aquifer. • The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. • The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.
Other Threats		
• Anthropogenically contaminated soils that have not been fully remediated		

[1] Although salt is included as a Prescribed Drinking Water Threat, it is being managed through restrictions to infiltration in high-risk areas and through Salt Management Plans, and therefore does not automatically prohibit infiltration.

3.2 Subwatershed-Level Water Balance Targets

For all development including urban infill and greenfield development, it is recommended that the local water balance of the development area will be maintained at pre-development conditions by providing infiltration opportunities of source and/or conveyance control measures. Infiltration-based LIDs acceptable for water balance matching include, but are not limited to, bioretention, rain gardens, infiltration chambers, bioswales , and non-lined permeable pavements.

Water balance targets were determined for the study area on a subwatershed basis. The methodology for deriving water balance targets from annual infiltration rates is described in **Section 6.3.2** of the Watershed Plan. Mean annual infiltration depth for each subwatershed and associated stormwater infiltration targets to maintain or restore natural groundwater recharge are identified in Table 3-2.

Table 3-2: Mean Annual Infiltration and Infiltration Targets for Water Balance

Subwatershed	Mean Annual Infiltration (mm)	Stormwater Infiltration Target (mm)
Airport	429.5	9
Bears	495.8	12
Byersville	606.5	24
Cavan	542.7	16
Curtis	452.5	10
Fisher	463.0	11
Fleming	519.8	14
Harper	567.8	18
Jackson	473.4	11
North Thompson	460.7	11
Otonabee Catchments	514.6	14
Riverview	507.9	13
South Meade	459.5	11
South Thompson	569.9	19
Stewart Hall	531.5	15
Trent	515.8	14
Urban Subwatersheds	605.5	24
Whitlaw	506.8	13

It should be noted that the infiltration targets identified in **Table 3-2.** are averages taken across subwatershed areas of varying scale. Site specific constraints including but not limited to shallow

bedrock, high groundwater, unsuitable or contaminated soils, prohibitions or restriction as identified in source protection plans, and infiltration-prone wastewater systems may prevent complete infiltration of the subwatershed-level target. It is recommended that these infiltration targets be used for planning-level studies where stormwater infrastructure siting, sizing and general layout is required. During site evaluation for infrastructure design, it is recommended that in-situ infiltration testing (e.g. via Guelph Permeameter at invert elevation), laboratory hydraulic conductivity analysis, and groundwater/geotechnical characterization be undertaken to confirm target suitability.

3.3 Environmentally Significant Groundwater Recharge Areas

Ecologically Significant Groundwater Recharge Areas (ESGRA) are pervious areas of land that are responsible for replenishing groundwater systems that directly support sensitive areas like cold water streams and wetlands. ESGRAs are not necessarily the areas of highest recharge rate, but water that enters groundwater pathways from these areas will end up in areas of ecological importance. Groundwater modelling has indicated that ESGRAs are abundant within the study area. Because ESGRAs support ecological areas including cold water streams and wetlands, maintaining this recharge is essential for sustaining ecological health. Where greenfield development is being proposed within an area that includes ESGRAs, it is recommended that site specific groundwater analysis be undertaken to determine the impact of development (including changes to imperviousness and re-grading) on groundwater contributions to connected ecology features. It is recommended that this type of analysis occur through **subwatershed-level studies** and/or **secondary plans** undertaken to determine ecological opportunities, constraints and greenfield development layout. In all ESGRAs, imperviousness should be maintained to the greatest extent possible and infiltration targets should correspond with the maintenance of pre-development infiltration, demonstrated via continuous modelling. Providing infiltration opportunities using source and/or conveyance control measures will be an essential component of any development in areas that include ESGRAs.

3.4 Enhanced Thermal Mitigation for Sensitive Subwatersheds

Urban impervious surfaces including pavements and rooftops heat up quickly during warm summer days. As a result, runoff discharged from these surfaces is significantly warmer than runoff from cooler green spaces. Stormwater management ponds used to treat urban runoff are also prone to excessive heating resulting from receiving warm urban runoff and their lack of shade.

The impacts of excessive thermal loading on receiving waters include aquatic habitat destruction and altered diversity of downstream aquatic communities. While cold water species like brook trout would be particularly vulnerable to this warming, its impacts extend beyond a particular thermal guild. It can result in ecological alterations that affect the aquatic community and ecosystem in a variety of ways (STEP, 2019).

In the City of Peterborough, there are four (4) major tributaries with existing thermal regimes or target historical regimes that have been classified as coolwater, coolwater-coldwater or coldwater. These systems have fisheries sensitive to thermal loading and should be protected from thermal pollution via enhanced SWM practices. These systems are:

a) Bears Creek (coolwater)
b) Byersville Creek (coolwater-coldwater)
c) Harper Creek (coldwater)
d) Riverview Creek (coolwater)

For any new development in these subwatersheds, including greenfield development, infill development or linear development it is recommended that:

1) Consistent with development in other subwatershed areas, site-specific infiltration targets be met via infiltration-based LID practices.
2) Consistent with development in other subwatershed areas, the 90th Percentile water quality target as identified in **Section 6.3** of the Watershed Plan be met with retention (i.e. Priority 1) practices to greatest extent possible.
3) Additional to the above, where stormwater management ponds are required to provide water quantity control, erosion mitigation and/or meet water quality objectives, that one or more thermal mitigation features as identified in **Table 3-3** be integrated with facility design.

Note: Subsurface infiltration chambers may be used in place of SWM ponds.

Within the WPS area, two additional subwatershed areas outside of the City of Peterborough have thermal regimes that are sensitive to thermal pollution. These are:

e) Cavan Creek headwaters (coolwater-coldwater)
f) Jackson Creek headwaters (coldwater)

Should significant urban development be planned in these areas, it recommended that a similar stormwater approach be used to mitigate thermal input into these coldwater or coolwater-coldwater systems.

Table 3-3: Design Considerations for Thermal Mitigation Measures

Mitigation Measure	General Function	Expected Performance	Performance Variability	O&M Level of Effort	Design Considerations	Implementation Opportunities
Subsurface Draw Outlet	Reverse sloped outlet pipe draws cooler water from below the Normal Water Level in the pond (NWL)	Relative to surface draw, 95th percentile temperature reduction of 3 to 5^{o}C for outlets 2.0 m or more below the NWL during years with similar air temperature. Outflows from a 2 m deep outlet meet 24^{o}C target most of the time during an average year.	Equivalent depth outlets may vary by ±1^{o}C depending on pond/outlet design. Higher outflow temperatures may be observed during warmer years and late summer heat waves.	Low. Periodic inspections and flush outs are necessary	• Pond must be ⩾ 1.0 m deeper than the subsurface outlet invert elevation to provide sufficient sediment storage capacity and avoid sediment re-suspension. • Outlets accessible from the pond bank for maintenance via a control manhole. • Outlet inverts in the pond should be well supported with a headwall.	Retrofit of existing facilities and new designs. Anywhere in the subwatersheds.
Primary Outlet Cooling Trench	Removes heat through shading and thermal transfer to trench contents (air, water, stone) and surrounding soils	Dependable 95th percentile temperature reduction of 1 to 3^{o}C for well-designed system with a storage volume ⩾ 5% of the runoff volume generated during a 25 mm storm	Cooling benefits vary widely with trench size, pond outlet temperature, trench design (e.g. shading, depth below surface, overflow trigger rate) and groundwater interaction.	Low. Periodic inspections and flush outs are necessary	• Trench storage volume designed as large as available space permits. • Can be combined with subsurface draw outlets to provide additional cooling. • Include high flow bypass and maintenance flush out ports. • Trench as deep as possible and shaded. • Including infiltration enhance thermal benefit.	Retrofit of existing facilities and new designs. Ponds draining directly to watercourses.
Secondary Outlet Cooling Trench	Same as primary outlet cooling trench, but only for orifice-controlled flows through a secondary outlet. System inlet may be located 0.5 m below permanent pool to reduce primary outlet dry weather flows and increase pond	Reductions of 95th percentile temperatures of 4 to 5^{o}C for continuous flows of 1 to 2 L/s through the system. Primary outlet flows require a different cooling measure.	Variability is expected based on the size of the trench and throughput flow rate. Infiltration can further enhance thermal load reductions.	Low. Periodic inspections and flush outs are necessary	• Well shaded trenches with maximized area of base and sides to enhance heat transfer with ground. • Outlet should be 0.5 m below permanent pool and drain to control manhole for pre-cooling. • Only low flows drain through the trench. • Install flush out ports for maintenance. • Subsurface draw on primary outlet to provide further cooling during high flows.	Retrofit of existing facilities and new designs. Ponds draining directly to watercourses.

Mitigation Measure	General Function	Expected Performance	Performance Variability	O&M Level of Effort	Design Considerations	Implementation Opportunities
	storage capacity prior to rain events.					
Outlet Channel or Swale	Provides vegetative shading of outflows and thermal heat transfer with underlying soils	Average temperature reduction of 1 to 2^{o}C in well shaded areas. Maximum and 95th percentile outlet temperatures may not change	Variability of ±1 - 2^{o}C is expected based on degree of shading and channel length	Low. Periodic inspections for erosion	• Maximize shading and spread flows as much as possible to enhance ground contact ratios and infiltration potential. • Avoid concentrated flows that cause erosion. • Large areas between the outlet and watercourse often needed for this practice to provide thermal benefits	Retrofit of existing facilities and new designs. Ponds draining directly to watercourses
Lined biofiltration trench	Removes heat through shading, evapotranspiration and heat transfer with filter media/gravel, surrounding soils and stored water	Effluent temperatures below 22^{o}C are common for systems greater than 1 m deep. Thermal load reductions of approx. 40%	Temperatures may vary depending on shading in catchment. Thermal loads vary in proportion to the volume of water evapotranspired	Low for trenches, medium for bioretention due to plant maintenance.	• Good plant coverage and shading will enhance thermal performance. • Deeper trenches will likely outperform shallower ones.	Retrofit of existing facilities and new designs. Ponds draining directly to watercourses
Unlined bioretention or infiltration trench/chamber	Removes heat through volume reduction and shading/heat transfer with filter media/gravel and surrounding soils	Effluent temperatures below 22^{o}C are common. Thermal load reductions above 80% are common	Temperatures may vary depending on shading in catchment. Thermal loads vary in direct proportion to the volume of water infiltrated and evapotranspired	Low for trenches, medium for bioretention due to plant maintenance.	• Good plant coverage and underdrain configurations that maximize infiltration will enhance thermal load performance. • Deeper trenches will likely outperform shallower ones. • May be used to infiltrate a portion of storm pond outflows	Retrofit of existing facilities and new designs. Ponds draining directly to watercourses

Note: Table modified from Sustainable Technologies Evaluation Program (STEP) 2019 Paper titled *Data Synthesis and Design Considerations for Stormwater Thermal Mitigation Measures*.

Additional measures that may be considered for thermal mitigation include:

1. A timed-release outlet that discharges during cooler water periods (3am-10am). This measure requires automation and does not consider impact on downstream hydrograph.
2. Floating vegetation mats for shading in SWM detention area. This measure requires additional maintenance and bird prevention.

4 Natural Heritage Policy

4.1 Existing Natural Heritage Policies

Section 2.1.2 of the 2020 Provincial Policy Statement (PPS) states that:

> The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features (Ministry of Municipal Affairs and Housing, 2020).

Accordingly, Ontario municipalities (including the City of Peterborough) have developed Natural Heritage Systems (NHS) within their planning processes and identified polices related to the NHS to guide the future development of lands.

The PPS defines an NHS as:

> A system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. (Ministry of Municipal Affairs and Housing, 2020).

The PPS provides policy to protect NHS at the provincial level that supersedes municipal official plans including but not limited to 2.1.4, 2.1.5, 2.1.6, and 2.1.7 which state development or site alteration is not permitted in PSWs, significant woodlands, significant valleylands, Significant Wildlife Habitat (SWH), ANSIs, coastal wetlands, fish habitat, and habitat of endangered species and threatened species with few exceptions. Development and site alteration is also not permitted on adjacent lands of the above listed features unless it can be demonstrated that there will be no negative impacts to the natural feature or its functions (PPS Section 2.1.8). The PPS also strives to protect, improve or restore the quality and quantity of water through:

a) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development;
b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;

c) evaluating and preparing for the impacts of a changing climate to water resource systems at the watershed level;

d) identifying water resource systems consisting of ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas, which are necessary for the ecological and hydrological integrity of the watershed;

e) maintaining linkages and related functions among ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas;

f) implementing necessary restrictions on development and site alteration to: 1. protect all municipal drinking water supplies and designated vulnerable areas; and 2. protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ground water features, and their hydrologic functions;

g) planning for efficient and sustainable use of water resources, through practices for water conservation and sustaining water quality;

h) ensuring consideration of environmental lake capacity, where applicable; and

i) ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces (Ministry of Municipal Affairs and Housing, 2020).

The Province of Ontario provides technical guidance to implement the natural heritage policies of the PPS through the Natural Heritage Reference Manual (NHRM). The first edition of the NHRM, issued by the Ministry of Natural Resources and Forestry (MNRF) in 1999, recognizes the development of a natural heritage system as a comprehensive approach to defining and protecting natural heritage features and areas. The most recent edition of the NHRM, issued in 2010, places greater emphasis on planning for natural heritage systems and providing connectivity among natural heritage features and areas (MNRF, 2010). The NHS is divided into components including core areas and linkages/corridors. Core areas include significant features (significant habitat of endangered and threatened species, significant wetlands and significant coastal wetlands, significant woodlands, significant valleylands, significant wildlife habitat, areas of natural and scientific interest, and fish habitat) and their associated adjacent lands.

In 2023, the Ontario government released a proposed update to the PPS and A Place to Grow: Growth plan for the Greater Golden Horseshoe and associated documents. Any recommendations can and will be modified to align with new Provincial Policy.

There are a series of Acts and policy documents that define and regulate natural heritage at the federal, provincial, and municipal level including the document described above. Additional policy documents applicable to this watershed are described in the Appendix A.

4.2 Natural Heritage Policy Recommendations

4.2.1 Within the City of Peterborough

Terrestrial Ecology

The City of Peterborough's Official Plan defines the components of the NHS and how they are to be delineated and protected. Under the More Homes Built Faster Act (2022), the responsibility of wetland evaluation and boundary delineation is now the responsibility of the municipalities. It is recommended that policy to clearly state on-site confirmation of natural heritage features boundaries by a qualified City or ORCA representative, and/or an objective third party prior to application approval. Additionally, it is recommended that the City retains an objective third-party reviewer to peer review EIS and similar reports to confirm all applications are complete and sufficiently addresses all sensitivities present.

The City should develop policies around the enhancement and protection of corridors and linkages. The OP highlights important locations for Regional Connections and Proximity Linkages but does not elaborate what is required as a part of a development or site alteration application. A policy document should be developed and implemented for every project, including road maintenance and road upgrades, located within the adjacent lands of a Regional Connection or Proximity Linkage to provide guidance on how to evaluate the ecological functions provided by both Proximity Linkages and Regional Connections. This document should provide a long list of potential avoidance alternatives and mitigation measures that must be considered. It should be noted that novel avoidance alternatives and mitigation measures can be proposed where applicable.

The City of Peterborough is currently completing a subwatershed study for Harper Creek with the intention to create a detailed inventory of the NHS and water resources including the natural heritage features, functions, and cultural values. The project will culminate in a land use plan, detailed management strategy, and stormwater management strategy that satisfies the policy direction of the Provincial Policy Statement (PPS), the Growth Plan for the Greater Golden Horseshoe, and the City of Peterborough Official Plan. The City should set a target to complete similar projects for subwatersheds containing designated greenfield areas to develop targeted policies and guidelines specific for greenfield areas. These projects should consider not only future land use and density targets but also future climate change conditions.

Urban Forestry recommendations align with those stated in the Urban Forest Strategic Plan (2011) and the follow up progress report in 2016. Further efforts are required to document the existing urban forest and determine where planting efforts are best allocated. A guidance document should be developed under By-law 21-074 (A By-law to Regulate the Destruction of Trees on Private Property in the City of Peterborough) to encompass all municipal directions for tree removals, replacement, and construction near trees should be developed. Currently, the bylaw requires a minimum of 1:1 replacement ratio with a minimum of 2cm diameter replacement tree (By-law 21-074) which is insufficient ratio to maintain the current urban forest canopy as there is a significant lag time between planting and a mature tree with equivalent canopy cover, therefore a larger replacement ratio is highly

recommended. The city has released an approved tree species list as well as species diversity percentages to increase diversity in the urban forest. This list should be a part of a guidance document and should be amended as to include only native species and highlight species that are either drought and/or flood tolerant. Planting plans must no more than 10% of the same species, 20% of the same genera, or 30% of the same family. Guidance document should be descriptive on how tree protection measures including but not limited to compaction control measures and tree protection fencing should be implemented. It should also include a list of activities allowed and prohibited within tree protection zones.

The city has developed an Emerald Ash Borer (EAB) management plan and further considerations should be made for other problematic species such as Common Reed (*Phragmites australis ssp. australis*) and Common Buckthorn (*Rhamnus cathartica*). Additional studies may be required to highlight other non-native invasive species that pose a threat to the natural communities present and suggest appropriate management.

Aquatic Ecology

Policy amendments should be made to better represent the aquatic ecology and fisheries biology of the study area and should aim at preserving and enhancing the remaining aquatic components of the Natural Heritage System as defined by the Official Plan. This includes fish habitat as defined by the Natural Heritage Reference Manual and in turn as defined by the federal *Fisheries Act* as, "spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes" (Ontario Ministry of Natural Resources, 2005). Currently, the Peterborough Official Plan (City of Peterborough, 2021) does not permit development applications within 30 metres of the high water mark in the case of fish habitat, unless subject to an Environmental Study. This is consistent with the Provincial Policy Statement and many regional Official Plans. In an attempt to guide future Environmental Studies within the study area, Fish and Fish Habitat Management Plans should be developed on a subwatershed scale to better define fish habitat as it related to the federal *Fisheries Act* and other relevant guidance documents.

These Plans should identify target species, key habitat features, thermal regimes, headwaters and drainage features, contributing wetlands and benthic assemblages. Plans such as these could better direct decision makers in development applications and could prove as a baseline for Environmental Studies in the future. In order to develop these Plans, extensive studies would be required to characterize each subwatershed, including fish community studies, thermal regime monitoring, benthic community studies, and habitat assessments. While extensive in nature, these Plans would identify healthy fish communities, sensitive fish species and habitats, and would serve to be monitored as barometers of watershed health. Consultation with local authorities and indigenous peoples should also be pursued such that the Plans will benefit all of those in the individual subwatersheds, while providing the greatest benefit to the aquatic resources on a subwatershed scale. From these Plans, policy could be further refined to include monitoring considerations for development activities including water quality, temperature and quantity monitoring as it relates to specific fish communities

and habitats. Sensitive fish species and habitats may require more rigorous monitoring and more robust mitigation measures during development activities.

Development activities should also be refined in that aquatic ecology is better represented in future works, which could refer to individual Fish and Fish Habitat Plans for specific mitigation measures and targets. Examples could include:

- **Crossings:** Open bottom box culverts or clear span bridges to accommodate natural processes and ensure long-lasting fish passage. Where this is not feasible, culverts are to accommodate baffles and/or other passage mitigation to both slow velocity and reduce downstream erosive powers and encourage fish passage through all flow conditions. Aquatic culvert and bridge crossing locations should also be considered regarding the potential for and appropriateness of terrestrial wildlife movement opportunities.
- **SWM Facilities:** Offline facilities with proper outlet design to create isolated infrastructure such that regularly scheduled maintenance activities do not interfere with the *Fisheries Act* and that additional permitting is not required. Encourage water quality and thermal mitigation from pre-treatment to outlet treatments.
- **SWM Outfalls:** Installed outside of the high water mark of any water feature, including headwaters and drainage features and wetlands, to ensure armouring and infrastructure does not exacerbate erosive forces in high flow events. Encourage water quality and thermal mitigation from pre-treatment to outlet treatments. Outlet treatments could include OGS unites, plunge pools with boulder treatments, wetland pockets, vegetation and plantings.
- **Private Ponds:** Do not permit private, online ponds. Where offline ponds are permitted, ensure bottom-draw dams and other cooling and thermal mitigation is incorporated into the pond permitting.
- **Dams and Liftlocks:** Where dams and locks are to be developed and/or maintained, ensure fish passage is incorporated where feasible and where fish communities would benefit from connectivity between up- and downstream habitats. Encourage the use of bottom draw dams to ensure downstream warming does not occur.

4.2.2 Outside of the City of Peterborough

Terrestrial Ecology

The County of Peterborough plans to develop a Watershed Management Plan with the goal of managing the water, land/water interactions, aquatic life and aquatic resources within a particular watershed (County of Peterborough, 1994). This document should also consider land use compatibility and overall landscape connectivity across subwatersheds and adjacent watersheds. A monitoring plan should be developed to characterize existing sensitive features such as ANSIs, PSWs, SWH, and significant woodlands to establish baseline conditions. Monitoring should occur at a regular interval to detect impacts before features and functions are lost from the landscape.

Development applications and secondary plans should consider implications to adjacent natural features as well as potential impacts to surrounding areas and landscape connectivity. Any development within or adjacent to large-scale terrestrial corridor and/or riparian linkage as identified by Kawartha Naturally Connected should confirm that there will be no net negative impacts to connectivity as a result of the development. Future climate change implications should also be considered when evaluating potential impacts from development.

Roads pose one of the greatest risks to wildlife. Collisions between wildlife and vehicles are more likely with larger, busier roads that are adjacent to natural heritage areas. This effect can create a partial or complete barrier to wildlife movement at the road, limiting or blocking access by wildlife to required resources and/or fragmenting populations which increases the risk of local extirpation[2].

A regional scale review of wildlife crossing hotspots should build upon the movement corridor work completed by KNC. This data set should be used when considering new road locations as well as road upgrades along existing roads through alterations to road management, rules, and retrofits. The Region should consider developing a guidance document to evaluate the risk to wildlife along roadways and the potential mitigation options available. This should consider that some species such as frogs, snakes, and turtles have a peak migration window where targeted road closures can dramatically improve the survival rates. Traffic calming measures and reduced speed limits can also decrease the likelihood of direct collisions. Exclusion fencing, ecopassages, curb design, road surface selection, and improved line of sight through targeted lighting and vegetation management can also reduce the risk of direct collisions.

In addition to roads, agriculture can be a source of indirect impacts to natural features through contamination from pesticides and fertilizers as well as soil erosion causing increased sedimentation. Pesticides can have a negative effect on non-target species and causes pollinator decline as well as can bioaccumulate impacting larger wildlife. Fertilizers can run off and enter watercourses causing eutrophication. Better farming practices to reduce erosion and run off can be encouraged through stewardship programs.

Aquatic Ecology

Policies regarding aquatic resources in rural settings should, in general, match those discussed previously for urban areas. Regardless of the land use, fish habitat is and should be managed consistently across the study area as defined by the Official Plan, Natural Heritage Reference Manual, and federal *Fisheries Act*, such that development applications within 30 metres of the high water mark in the case of fish habitat are not permitted unless subject to an environmental study. As a

[2] Extirpation is the local extinction of a species but it continues to exist elsewhere.

continuation of recommendations made above, Fish and Fish Habitat Management Plans should be developed on a subwatershed scale to better define fish habitat as it relates to the federal *Fisheries Act* and other relevant guidance documents. In rural areas, focus should be drawn to headwaters and headwater drainage features (HDFs) which, depending on the form and function of the feature, could provide direct and/or indirect fish habitat as defined by aforementioned policies.

HDFs typically consist of shallow, seasonally-ephemeral drainage features which provide primary and secondary inputs into more defined watercourses. HDFs vary in both form and function and may provide direct (both permanent and seasonal) habitat for fish. Examples of aquatic habitat types present in HDFs include refuge pools, seasonal spawning and nursery areas, and thermal refugia in areas of groundwater discharge. HDFs also provide indirect habitat by transport of detritus/invertebrates to downstream reaches (Stanfield, 2017). Examples of HDFs include small streams, springs, wetlands, swales, and ditches (natural or human-modified). These features are also important sources, conveyors, or sinks of sediment, nutrients, and flow. Some HDFs may function as important habitat for terrestrial and wetland species as breeding areas or corridors for travel.

HDFs have not traditionally been a part of most aquatic monitoring efforts and have been overlooked during development applications. However, understanding of the importance of such features has been growing and HDFs are now protected features under certain local and provincial regulations, including the *Fisheries Act,* and could qualify for protection as Fish Habitat under municipal policy. Future studies should therefore include an assessment of HDFs to identify features and determine the appropriate level of management applicable to each. The most relevant set of guidelines and standards, at this time, The Evaluation, Classification, and Management of Headwater Drainage Features Guidelines (CVC & TRCA, 2014), should be used to classify HDFs within the study area, with the most conservative level of management used to protect the habitat in policy. At a point in time where a more locally sensitive or updated version of management guidelines be developed for HDFs, these should be adopted for the study area's features.

Policy should limit the clearing of vegetation within the riparian buffer of HDFs and should follow the same guidelines as those for other features identified as fish habitat. Where cattle crossing is required, crossings should be approved under the same recommendations as those listed above. Where existing features are identified and where historic clearing and or grazing has been noted, vegetated buffers should be reestablished and managed as fish habitat moving forward. Cattle should be discouraged from grazing within this buffer and should not be allowed to enter the buffer or the feature itself. Providing designated, fenced areas for grazing animals to access water sources for drinking avoids detrimental bank erosion, and prevents direct pollution through defecation. Application of fertilizer should not be permitted during rainfall and/or runoff events.

5 Climate Change Policy

Climate change is defined as any significant change in long-term weather patterns. It can apply to any major variation in temperature, wind patterns or precipitation that occurs over time (**Ontario Climate Change Strategy, 2015**). The anticipated impacts of climate change caused by anthropogenic greenhouse gas accumulation are wide-ranging and will have impacts at the watershed-level, subwatershed-level and municipal level. Climate Change Impacts are summarized in the City of Peterborough Watershed Planning Study Climate Change Memo.

Based on the information presented in the Climate Change Memo, the most significant climate change considerations that will need to be considered through implementation planning include, but are not limited to:

a) Broad-scale climate shifts including higher seasonal temperatures (averages and maximums) as well as greater precipitation in all seasons.

b) Decreases in winter snowpack water storage and associated reductions in spring freshet runoff response. A corresponding flashier runoff regime is expected throughout the winter as melt and intense rain-on-snow events become more frequent.

c) Ecological range shift as aquatic and terrestrial species are forced out of their current range as temperatures and other environmental factors shift beyond their adaptation capacity.

d) Changes to physical abiotic habitat characteristics including surficial flow, soil moisture, erosion and water table depth.

e) The intensification of storm events, including those short-duration events that are used in the design of stormwater management infrastructure and used to assess compliance with desired level of service frameworks.

Climate change policy recommendations outlined in this section are identified to;

1) Build climate resilience into our community;

2) Mitigate the risk associated with extreme weather events;

3) Preserve hydrologic functions that support watershed health; and

4) Prevent significant degradation of natural heritage features with urban and rural areas of the watershed.

Climate change mitigation and **climate change adaptation** strategies are a key component of the WPS. **Adaptation** is the process of adjustment in the built and natural environments in response to actual or expected climate change and its impacts. In the urban environment, adaptation seeks to mitigate risk to infrastructure and property and to exploit beneficial opportunities for building resiliency. In natural resources management, adaptation seeks to address the vulnerability of species or natural systems and processes by reducing threats, enhancing resilience, engaging people, and improving knowledge.

Climate change resilience is the capacity of a system to maintain function despite stresses applied by climate change factors. Climate change resilience can be built into existing systems through adaptation and learning from the resiliency of natural systems. **Mitigation** involves the use of measures or actions to avoid or reduce greenhouse gas emissions, to avoid or reduce impacts on carbon sinks, or to protect, enhance, or create carbon sinks. Where possible, **climate change co-benefits** will be prioritized. Co-benefits result from technologies or approaches that achieve some level of both climate change mitigation and climate change adaptation.

As identified through cumulative effects analysis, many of the impacts associated with climate change projections share impact pathways with land intensification. For example, the intensification of short-duration rainfall events resulting from climate change and the addition of impervious surfaces to a catchment both result in excessive runoff which can lead to flooding, erosion and aquatic habitat destruction. Similarly, both land development and climate change can results in warmer temperature profiles in watercourse, especially during the summer. While it is not possible to impact high-level climate parameters such as rainfall patterns and regional temperatures through watershed management strategies, using management alternatives that target cumulative impacts can both mitigate the impacts of land intensification and build climate resiliency into the watershed.

5.1 Existing Climate Change Policies

The City of Peterborough aims to develop projects, programs, and policies to reduce greenhouse gas (GHG) emissions and adapt to climate change. In 2016, the Climate Change Action Plan (CCAP) was approved by City Council after developing it in partnership with Sustainable Peterborough and ICLEI-Canada. The CCAP is Peterborough's foundational climate change strategy to mitigate corporate and community GHG emissions. The CCAP identified 21 strategies that would limit the growth of GHG emissions by 30% by 2031 from 2011 baseline levels.

The Peterborough Environmental Advisory Committee (PEAC) was founded in 2019 to advise Council and the City of Peterborough about sustainability, environment, and climate action matters. This committee was formed in response to City Council declaring a climate emergency with the goal of acceleration timelines of climate actions and new actions that could be propose to lower greenhouse gas emissions to reach the 45% reduction by 2030 (based on 2011 levels) and net zero by 2050. The City and PEAC are implementing several community and corporate actions including:

- Developing a Home Energy Efficiency Program to support homeowners reduce energy consumption and GHG emissions;
- Expanding the active travel network to facilitate mode share shift away from cars;
- Supporting the Green Economy Peterborough hub's mission to support local businesses becoming low-carbon;
- Increasing the number of community gardens to increase access to local food and improve food security for residents;
- Protecting the urban tree canopy from preventable felling;

- Proposing greenhouse gas decarbonization pathway study to develop a plan for reducing 80% if greenhouse gas emissions from high emitting corporate buildings,
- Installing electric vehicle charging stations in advance to enable the conversion of the light-duty fleet to electric or hybrid vehicles;
- Completed conversion of streetlighting with LED fixtures; and
- Planning the development of the city-wide composting program and construction of a composting facility.

The County of Peterborough established Sustainable Peterborough which has developed a Greater Peterborough Area Climate Change Action Plan (2016) also referred to as CCAP. Each municipality has an action plan and emissions reduction targets with the goals of reducing greenhouse gas emissions, reducing use of fossil fuels, lowering energy consumption, and adapting to climate change. The CCAP developed strategies to reduce greenhouse gases which include:

- L1: Strengthen land use policy and the development review process to better support climate change mitigation and adaptation;
- L2: Identify climate change risks and prepare for potential impacts;
- L3: Protect and enhance natural assets; and
- L4: Facilitate best management practices for low emission farming and climate change adaptation.

Annual reporting has been provided as a part of the Sustainable Peterborough report cards, and Sustainable Peterborough will be updating the Strategic plan to align with the United Nation's 17 Sustainable Development Goals.

5.2 Climate Change Policy Recommendations

5.2.1 Urban Strategy for Natural Heritage Resilience to Climate Change

To mitigate climate change impacts as much as possible, the City should consider any and every method to build resiliency into their natural heritage system with greatest efforts placed along watercourses. Much of the City's NHS is located on private lands and will require encouragement of the residents to plant trees, install rain gardens, and naturalize watercourse riparian zones through a more robust stewardship program. This can occur through local partnerships, fundraising, and tax benefits. Additionally, the City can look to purchase natural areas currently on privately owned land.

The City should develop a methodology to quantify natural features as a city asset. Natural features and their functions should be managed similarly to infrastructure and their functions to mitigate flooding and offset climate change through carbon sequestration, urban cooling, and other measurable functions should be quantified. Potential stressors and management plans could be developed for natural features that provide significant flood and climate change mitigation including invasive species management plans, forest health strategies, and water balance initiatives.

5.2.2 Urban Strategy for Enhancing Climate Change Resiliency Related to Rainfall Intensification

Intensification of rainfall events has the potential to reduce the level of stormwater service provided by conveyance systems and end-of-pipe infrastructure. While expected impacts to the storm sewer system include an increased frequency of surcharging, nuisance flooding and potential damage to private property, it is the impacts on end-of-pipe stormwater detention and treatment facilities that pose greater risk to watershed function. Stormwater management ponds are designed to reduce peak flows during extreme runoff events in order to mitigate erosive flows in downstream channels, mitigate flooding and provide settlement of suspended solids which are transported by urban runoff. These facilities are designed with specific design-event inflow hydrographs corresponding to storage and discharge relationships needed to provide an appropriate level of service. Changes to inflow volumes and flow rates results in changes to outflow hydrographs along urban tributaries which support aquatic communities susceptible to erosion, sedimentation and degraded water quality.

The risks associated with climate change impacts are not expected to be spread equally across the City of Peterborough. Several factors may limit the impact of rainfall and runoff intensification on stormwater infrastructure and local watercourses. Some examples of conditions that may limit risks associated with rainfall are listed below.

Conditions that may limit Climate Risk related to Rainfall Intensification

- The implementation of infiltration-based LIDs and/or removal of paved surfaces from existing urban areas will buffer flow and runoff volume increases.
- Those catchment with higher percentages of pervious, green spaces will better mitigate impacts of rainfall intensification via interception, retention, evapotranspiration, and infiltration.
- At the time of storm sewer design, the selection of standard pipe sizes that are larger than required for design flows may allow for conveyance of flows resulting from climate change scenarios.
- Existing stormwater management facilities may have capacity to provide some incremental flood control beyond design parameters.
- Channels that are hardened with erosion control features or naturally resilient to erosion will be less susceptible to increased incidents of erosive flows.

Conversely, the presence of certain climate change receptors may exacerbate the risks associated with rainfall and runoff intensification. Areas considered high-risk when considering the potential impacts of climate change are listed below.

Areas of High Risk related to Rainfall Intensification

- Areas lacking formal stormwater management control, specifically end-of-pipe detention systems.
- Areas within the flood damage centre or contributing drainage to the flood damage centre.
- Catchments draining directly to a receiver containing one or more of the following ecological conditions:
    - Coldwater fisheries
    - species at risk

- environmentally sensitive areas

It is recommended that, where feasible, the climate change approaches identified below are applied to:

1) Stormwater infrastructure renewal or retrofit projects within the "Areas of High Risk" identified above, where existing downstream conveyance infrastructure is not flow limiting.
2) The design of new end-of-pipe stormwater management infrastructure to service new development areas.
3) The design of new stormwater management conveyance infrastructure to service new development areas where existing downstream conveyance infrastructure is not flow limiting.

Intensity-Duration-Frequency Rainfall Relationships

The City of Peterborough uses Intensity-Duration-Frequency (IDF) statistical relationships to set design standards and evaluate level-of-service performance metrics associated with stormwater management infrastructure. The City uses the 6-hour SCS Type II design storm for municipal stormwater infrastructure standards and 10+ minute duration constant intensity rainfall events for conventional storm sewer designs.

Predictive climate change modelling technology has advanced significantly over the last 10 years, with more readily available climate data available on Environment Canada's Climate portal (https://climatedata.ca/). It is now possible for municipalities across Canada to use publicly available statistical models to predict the impacts of climate change on specific design storm events. The results of this IDF analysis produce a climate change scenario total event storm depth and average storm intensity, which can be calculated as an average intensity or used to produce hyetographs (i.e., using the SCS Type II distribution) for hydrologic modelling purposes. For the City's WPS the Western University / Institute of Catastrophic Loss Reduction developed IDF_CC Tool 6.5 was used to generate IDF curves for the Peterborough Airport rain gauge under three climate change scenarios from 2023-2100 using the CMIP6 GCMs selection default.

Three emission scenarios as defined by Shared Socio-economic Pathway (SSPs) from the ICPP's 6th Assessment Report (2021) were utilized in this analysis to demonstrate incremental change resulting from projected climate change at the Peterborough Airport climate gauge. SSPs have replaced Representative Concentration Pathways (RCPs) from the IPCC's 5th Assessment Report (2014) as the most comprehensive future climate projections used by climate modelers. **Table 5-1** demonstrates the general equivalency between various scenarios, and the degree of warming by 2100 as estimated by the most recent IPCC report (2021). In this table, emission scenarios from the Representative Concentration Pathways (RCPs) are identified in column 1 and equivalent Shared Socio-economic Pathway (SSPs) from the ICPP's 6th Assessment Report (2021) are identified in column 2.

Emission scenarios analyzed for the WPS are SSP 1-2.6, SSP 2-4.5, and SSP 5.8.5 which correspond to low, moderate, and severe climate change severity. The six-hour storm was analyzed for the 2-year, 5-year, and 100-year storm, while the 100-year storm was also analyzed for 12- and 24-hour durations. The total precipitation event depths projected by the IDF_CC Tool 6.5 are presented in **Table 5-2** and

compared to the total precipitation event depths provided by the City of Peterborough Engineering Design Standards (December 2022). Percentage changes from the design standards are identified in brackets.

Table 5-1: Climate Scenarios

IPCC 5th Assessment Report (2014)	IPCC 6th Assessment Report (2021)	Degree of Warming by 2100*	Emissions Assumptions†
RCP2.6	SSP 1-2.6	1.3°C – 2.4°C	Net zero emissions reached by 2080
RCP4.5	SSP 2-4.5	2.1°C – 3.5°C	Stable emissions begin to decline by 2050
RCP8.5	SSP 5-8.5	3.3°C – 5.7°C	Emissions double by 2050

* Based on the results from the IPCC 6th Assessment Report (2021), comparing average global surface temperature from 1850-1900 to 2081-2100

† Based on the results from the IPCC 6th Assessment Report (2021)

Table 5-2: Total precipitation event depths projected by the IDF_CC Tool 6.5

Duration	Frequency	City Design Standards (mm)	IDF_CC: Historical (mm)	IDF_CC Projection: SSP 1-2.6 (mm)	IDF_CC Projection: SSP 2-4.5 (mm)	IDF_CC Projection: SSP 5-8.5 (mm)
			Years: 1971-2006	Years: 2023-2100	Years: 2023-2100	Years: 2023-2100
6-hour	1:2-year	38.7	39.07 (+1.0%)	42.52 (+9.9%)	43.32 (+10.7%)	44.47 (+13.0%)
6-hour	1:5-year	52.48	53.17 (+1.3%)	57.54 (+9.6%)	59.34 (+11.6%)	62.46 (+16.0%)
6-hour	1:100-year	89.9	87.82 (-2.3%)	91.87 (+2.2%)	97.35 (+7.7%)	103.15 (+12.9%)
12-hour	1:100-year	98.4	99.98 (+1.6%)	104.36 (+6.1%)	111.12 (+11.5%)	117.56 (+16.3%)
24-hour	1:100-year	108.7	118.30 (+8.8%)	122.59 (+12.8%)	130.44 (+16.7%)	139.22 (+21.9%)

Model results from: Simonovic, S.P., A. Schardong, R. Srivastav, and D. Sandink (2015), IDF_CC Web-based Tool for Updating Intensity-Duration-Frequency Curves to Changing Climate – ver 6.5, Western University Facility for Intelligent Decision Support and Institute for Catastrophic Loss Reduction, open access https://www.idf-cc-uwo.ca.Changes

It is recommended that the climate change modified IDFs presented above be used in the design process of planned end-of-pipe stormwater management facilities and to stress test existing end-of-pipe stormwater management facilities.

New Stormwater Management Facilities

There is an opportunity to build climate resilience into new stormwater management systems by using quantifiable climate projections as design inputs. This design approach typically results in increased extended detention volumes. It should be noted that incremental increases in SWM facility detention volumes will also provide long-term resilience to incremental changes in catchment imperviousness. This long-term change in imperviousness is an issue that communities across Ontario are reacting to via end-of-pipe retrofit projects and source control strategies.

It is recommended that new end-of-pipe stormwater management facilities be designed using, at a minimum, IDF data from the SSP 2-4.5 climate scenario representing moderate climate change severity. This would be accomplished by using target release rates calculated using the existing design standard IDF in response to return events identified in the climate scenario IDF. Using this approach, rainfall events projected for future climate scenarios will be controlled to peak flow targets based on existing IDF relationships. This end-of-pipe design methodology would result in slightly larger extended detention volumes.

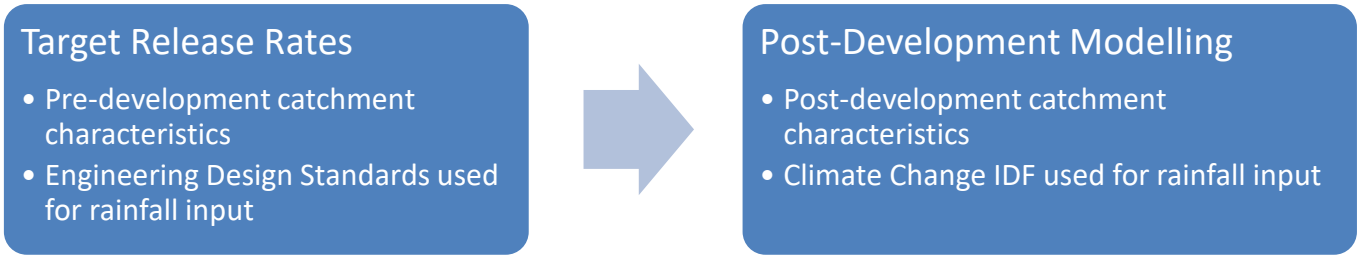

Figure 5-1: Target Release Rates and Post Development Modelling Diagram

Using a stormwater approach that focuses on matching pre-development water balance through Priority 1 volume capture (i.e. infiltration-based LIDs) as identified in **Section 3.2** will contribute significantly to mitigating peak flows from future climate change scenarios and should be quantified in post-development modelling.

Existing Stormwater Management Facilities

It is expected that the level of service provided by existing stormwater management facilities will be impacted by the intensification of short-duration rainfall events. To quantify the impacts of climate change on release rates from stormwater detention facilities into local receivers, it is recommended that all existing stormwater management facilities be stress tested with climate change modified IDFs. To undertake this analysis at the desktop-level, release rates from design storms derived from climate

modified IDFs are compared to target release rates as identified in design briefs and ECAs. This analsyis would be undertaken using modelling or design sheet methodology used at the time of facility design. Where these is a significant operational discrepancy from the original targets, monitoring programs and/or retrofits may be considered. During the stress test of SWM facilities for climate change, any changes to the contributing catchments should be considered, specifically:

- Changes in catchment area resulting from grade changes during the development process; and
- Changes in imperviousness resulting from new development or incremental changes across the catchment.

Existing Storm Sewers

The intensification of rainfall events resulting from climate change will decrease the overall level of service provided by conveyance systems including storm sewers. Under O.Reg. 588/17, storm sewer network level of service is to be evaluated using the follow two technical metrics:

4) Percentage of properties in municipality resilient to a 100-year storm.
5) Percentage of the municipal stormwater management system resilient to a 5-year storm.

It is recommended that a City-wide hydrologic and pipe hydraulics model be utilized to evaluate the impact of climate change on stormwater level of service technical metrics. Hydraulic modelling of stormwater conveyance using climate change modified IDFs can determine the impacts of climate change on the above technical metrics resulting in a future level of service comparison. It is anticipated that rainfall intensification will exacerbate existing conveyance issues and may create additional areas of the stormwater management system susceptible to surcharging during the 5-year event.

Erosion Control

Determining the impact of climate change on long-term creek erosion is difficult without detailed fluvial geomorphic data. Where continuous hydrologic models are available and infield geomorphic assessments can be undertaken to determine flow thresholds for erosion, a good method for assessing the impact of climate change on channel erosion is through modification of precipitation values input to continuous hydrologic models. Sources of regional climate data (e.g. Climate Atlas of Canada) often include average monthly changes to precipitation. These can be applied to historical precipitation data sets and used as climate change derived input for hydrologic models. The resulting flows must then be compared to thresholds identified through detailed geomorphic assessment. For channels that are less prone to erosion or geomorphological adjustment at lower flow rates, an approach to modifying historical precipitation data sets that meets projected average monthly changes while over-modifying larger runoff events may be preferred. This methodology does not take into consideration the impacts of changing free thaw cycles on channel erosion.

6 Recommended Approach for Urban and Urbanizing Subwatersheds

The degree to which these subwatersheds contain urban development impacts the management alternatives that are considered for improving or maintaining components of subwatershed health. Management alternatives suitable for an urban environment must consider opportunities and constraints related to land availability, integration with existing urban infrastructure and associated level-of-service frameworks as well as existing public uses of land. Additionally, unlike areas of new development where climate change resiliency can be considered during community design, existing urban areas must rely on building climate change resiliency into capital projects and opportunistic redevelopment opportunities. Climate change refers to the persistent, long-term change in the state of the global climate. This section identifies components of the Watershed Plan recommended for the City of Peterborough. Where feasible, the implementation components identified below are described for each management strategy.

6.1 Ecological Restoration

The City of Peterborough updated their Official Plan, approved April 2023, and it includes their updated NHS policies that define and protect NHS features and functions within the city. There are opportunities to refine recommendations further to strive to achieve the targets set out in the Watershed Plan. To improve ecosystem resiliency[3] within the urban environment, recommendations should consider the characteristics that lead to more resilient ecosystems, namely: connectivity; spatial heterogeneity; temporal variability; size of habitat; functional redundancy; and the feature's baseline sensitivity to change.

Connectivity

Within the urban landscape, natural features tend to be smaller and more isolated than those in neighboring rural areas, and this generalization holds true within the City of Peterborough. The subwatersheds that extend into the urban area can be generalized as having larger forest and wetland communities outside the city limit that drain into tributaries which flow directly to the Otonabee River. These tributaries tend to be narrow with little tree cover and represent an opportunity to improve both local and landscape scale connectivity. For example, there are two watercourses that flow from Jackson Creek East PSW into the urban area where the riparian habitat is either non-existent or less than 10 m wide with sections of creek piped underground. Harper Creek is also an ideal location for creek restoration as some sections of the creek have been significantly straightened with minimal natural cover or have been piped.

Local connectivity can also be improved through a robust and healthy urban forest. Street trees can provide a network of habitats through an urban center for small wildlife such as squirrels, birds, and insects. Urban forests provide several measurable benefits such as increased property value, improved air quality, reduction in erosion, reduced flashiness of storm events, reduced energy consumption,

[3] Ecosystem resilience is the capacity of an ecosystem to maintain its features and functions after being subject to disturbance.

reduced urban heat effect, as well as many other social benefits. The City of Peterborough published an Urban Forest Strategic Plan in 2011 with eight objectives towards strengthening the resiliency and functionality of the urban forest. A progress report was published in 2016 indicating that steps have been initiated towards a healthier urban forest. This report states that the urban canopy cover was approximately 29% in 2011, and has likely decreased since that time due to major city works and private developments. Additional loss to canopy cover can be associated with major weather events such as ice storms and windstorms. The City has enacted a new tree bylaw that regulates the removal of trees on both private and public property.

Recommendation:

- Where development or land use change is proposed adjacent to natural heritage, including watercourses, it should be ensured that VPZ distances are established sufficient to protect the adjacent features and functions. Minimum recommended VPZs are provided in the City's OP (Table A). VPZs should be planted with native vegetation or allowed to naturalize, and not be used for utilities or amenities unless it has been shown through an EIS or similar study that these uses will not limit the functionality of the VPZ for protecting the adjacent natural heritage features and functions for which they were established.
- Ensure land use changes and new developments are completed with all appropriate setbacks and protection measures for adjacent natural heritage. Due to changes to the Ontario Wetland Evaluation System (OWES) protocol that came into effect in January 2023, the MNRF is no longer required to approve new or updated wetland evaluations and wetland boundary delineation. Municipalities have instead been granted approval power over boundary changes and evaluation.
- Barriers to local habitat connectivity should be considered for removal or remediation. These include but are not limited to dams, roadways, and piped watercourses. Solutions could include wildlife road crossings, watercourse daylighting and restoration, and traffic calming measures.
- The City should work towards acquiring ownership of lands containing and directly adjacent to NHS features as well as land with a high restoration potential. The City can request all lands that are designated for environmental protection and their VPZs be transferred to the City as a part of a development or re-development application. Additionally, the city can target woodlots and wetlands on private property and request landowners to sell the land to the City. Generally, lands that should be considered for restoration include 'bays and inlets' along the edge of NHS features that are less than 60 m wide, interior gaps in features less than 0.5 ha; and gaps between features - < 60 m. Within City limits, these guides are not as useful and restoration should target areas where existing proximity linkages and regional connections are already highlighted in the OP, along watercourses, and directly adjacent to existing NHS features.
- As Peterborough undergoes densification, roadways might be expected to narrow and building setbacks to decrease. As a result, there would be less room for medium to large stature native trees. Efforts should be made to implement road cross-section designs that allow space for large trees, or to select species that can thrive in a smaller root zone where this is not possible. Additionally, as main arterial roads are being upgraded to accommodate both on- and off-road users, pre-existing trees should be compensated for accordingly.

- The City's on-going tree inventory has indicated that the urban forest consists of very little species diversity and predominantly mature declining trees (City of Peterborough, 2016). Inventory data should be used to guide where tree planting efforts should be targeted and what variety of tree species should be planted to build resiliency into the urban forest.

Spatial Heterogeneity

Spatial variety (heterogeneity) can be evaluated at a site-specific scale and a landscape scale. At a landscape scale, identification of which type of features are prevalent and which are rare in the landscape will better guide restoration efforts.

Larger natural features with a variety of habitats should be protected from encroachment and anthropogenic disturbances that could result in the loss of unique species and habitats. An example of this is the Harper Park area which contains the Harper Creek PSW and adjacent significant woodlands plus watercourses. This natural feature contains a diversity of habitats and a high species richness but is subject to increasing developmental pressures directly adjacent to its edges. Potential anthropogenic disturbances include but are not limited to informal trails, backyard encroachment, predation by pets, light and sound pollution, dumping, and introduction of non-native invasive species. Development projects in this area should have edge management plans that strive to minimize and monitor for signs of negative impacts.

Recommendation*:*

- Development projects adjacent to natural feature, such as Harper Creek PSW, should have edge management plans that strive to minimize and monitor for signs of negative impacts. Edge Management Plans should include buffer widths, planting plans, fencing requirements, educational material for home owners, and a monitoring plan.
- Within the city limits, wetlands are reasonably rare and should be protected in-situ where possible. Byersville Creek subwatershed, Riverview Creek subwatershed, Thompson Creek subwatershed, Trent Creek subwatershed, and Whitlaw Creek subwatershed are currently under the minimum target wetland percentage of 8.9% and should be considered for potential wetland restorations. The City's OP recommended evaluating all wetlands in the City, as part of this work the City could identify additional areas and preliminary scope to try and meet target 8.9% threshold.
- Within city limits, woodland cover is recommended to be a minimum of 30% and most subwatersheds are under this target with the exception of Curtis Creek. Airport Creek, Bears Creek, Byersville Creek, and Cavan Creek subwatershed are either not or hardly within the city limits and have not been considered. Woodland cover targets may not be attainable in all subwatersheds as many are completely developed with little opportunity for reforestation. These communities should be considered for a higher urban forest canopy coverage target to compensate. The canopy cover targets for land use classes (described within the Official Plan) are to be determined as a part of the recommendations made in the Urban Forest Strategic plan (2011).
- Opportunities such as stormwater maintenance facilities, parklands, and un-developed or underdeveloped locations should be considered for restoration and urban naturalization

projects such as pollinator gardens, rain gardens, larger specimen tree plantings, and habitat structures.

- Development and implementation of an Invasive Species Management Plan and a Standard Operating Procedure should be considered. Consideration for EAB underplanting should be included. An invasive species management plan should include at minimum the following: goals, targets and timelines; methods to prioritize resource allocation, funding opportunities and public engagement plan; costing and staffing requirements, species removal/management methodology, and a monitoring plan.

Temporal Variability

Climate change is predicted to shift timing and/or intensity of key weather events such as first and last frost, duration of snow pack, rainfall, snowmelt, etc. which will have biological impacts to the natural heritage system. It can be hard to compensate for these environmental shifts, but pre-emptive mitigation of predicted impacts can help reduce the strain on natural features.

Recommendation:

- Mitigating high storm surges through wetlands and watercourses can reduce erosion and temporary flooding of adjacent lands. This can be achieved through storm water management upgrades to capture flows before they reach the sensitive features, increased canopy cover in the urban area to intercept flows, targeted LID measures in areas of predicted high overland flows, and greater vegetated buffers around wetlands and watercourses.

Size of Habitat Area

Size of habitat area takes into account both connectivity and patch size. As discussed above, improvements to connectivity should be targeted along existing watercourses. Connected features can function as a larger patch.

Recommendation:

- Future restoration areas should be considered where they can make existing natural heritage features larger or connect two individual natural areas into a single larger overall area. Gaps around PSWs extending into the city limits including Peterborough Airport Wetland Complex, Dower's Corners PSW, Cold Springs and Yankee Bonnet PSW, Jackson Creek PSW, Jackson Creek East PSW, Loggerhead Marsh, and Harper Creek PSW should be considered for restoration efforts. These locations will not only create larger patches, but will also help buffer the impacts of future urban densification and climate change. Generally, lands that should be considered for restoration include 'bays and inlets' along the edge of NHS features that are less than 60 m wide, interior gaps in features less than 0.5 ha; and gaps between features - < 60 m. Within City limits, these guides are not as useful and restoration should target areas where existing proximity linkages and regional connections are already highlighted in the OP, along watercourses, and directly adjacent to existing NHS features. To compete this, the City first needs to identify opportunities to acquire land through development application or purchasing

land adjacent to existing natural heritage features with priority to parcels wither proximity linkages and regional connections are already identified. Then restoration projects can be prioritized based on opportunity and available budget.

Functional Redundancy

Complex communities with a wide variety of habitats and species tend to have greater functional redundancy[4]. Communities with higher functional redundancy are able to buffer environmental changes better before negative impacts start to cascade.

Recommendation:

- Within the context of the City of Peterborough, there are two methods to improve functional redundancy: plant a wide variety of species within restoration areas and within the urban forest; and protect areas where there is already high functional redundancy such as the PSWs. As a part of the Urban Forest Management Plan update, neighbourhoods should be evaluated for species diversity and strive for a maximum of 10% of the same species, 20% of the same genera, and 30% of the same family.

Features' Baseline Sensitivity to Change

Sensitive species are frequently reliant on narrow ranges of habitat conditions and may therefore be lost from communities when there is a shift in the physical environment such as increased water inputs or more frequent flooding and drought conditions. Loss of these species reduces the functional redundancy of communities and therefore reduces the overall resiliency of the community.

Recommendation:

- Monitoring for the distribution and abundancy of sensitive species is recommended to indicate where environmental affects are starting to impact the ecosystem; target species could include SAR and species with high coefficient of conservatism[5] (values of seven and higher) as well as cold/cool water fish species.

Planting species that are less sensitive to predicted environmental changes may help the urban forest and restoration areas buffer the environmental changes associated with climate change. For example, utilizing Carolinian species that are adapted to a warmer climate and therefore will have a greater survivorship as temperatures are expected to rise

[4] High functional redundancy is when there are many species that perform the same functional roles within the ecosystem, thus mitigating impacts to the whole system should one species be reduced or eliminated.

[5] Coefficient of Conservatism is a value between 0 and 10 assigned to native species based on the likelihood that that species is part of a stable and relatively undisturbed natural community. A value of 0 to 3 are assigned to species that can opportunistically occupy disturbed areas; 4 to 6 require some level of natural habitat; and 7 to 10 have a high fidelity to high quality stable natural communities.

6.1.1 Strategies to Achieve Ecological Restoration Recommendations

These recommendations can be integrated into a variety of key strategies:

- The City should either create a biologist/ecologist staff position or develop a third party peer review process for site alteration, developments, and re-development projects within or adjacent to NHS features;
- Secondary Plans for Greenfield areas;
- Riparian and shoreline restoration;
- Wetland and woodland restoration;
- An update report to the Urban Forest Strategic Plan with canopy cover targets specific to either neighborhood or subwatershed;
- City wide invasive species management plan;
- Land acquisition of areas within NHS and VPZs as well as potential restoration areas; and
- Community outreach and awareness.

Details of each strategy is expanded on in the following sections.

6.2 Third Party Peer Review Process

This strategy will result in a formal review process for any site alteration or development within or adjacent to NHS features including accurate evaluation of feature sensitivities and delineation of feature boundaries. This should include an evaluation of appropriate mitigation and compensation efforts. At this stage, projects can also be held accountable to consider local connectivity of the NHS extending outside of their study areas. If the City, deems there to be enough demand, it could be more economical to develop a biologist/ecologist staff position.

Key Next Steps

The *More Homes Built Faster Act* has shifted the development review roles in two key ways: conservation authorities are no longer permitted to comment on conservation and environmental issues during the *Planning Act* development review process with the exception of flooding and erosion issues; and the responsibility of wetland evaluation and delineation has shifted from the MNRF to municipalities. An internal review of how EIS and similar reports are reviewed should be considered to account for these changes as well as who is present and responsible for the accuracy of boundary delineations.

Approvals, Policy, By-law or Design Standards Considerations

ORCA has developed as comprehensive Environmental Impact Study (EIS) Terms of Reference & Submission Standards (2015) which should continue to be applied to all EIS reports.

Timeframe

As the *More Homes Built Faster Act* has received Royal Assent, it is imperative that all EIS and similar reports are reviewed by a qualified Ecologist to confirm that NHS features are evaluated and accounted for appropriately and that there will be no net negative impacts to the NHS.

Cost

The cost of each EIS peer review will vary greatly depending on the size and complexity of the proposed project as well as the type and complexity of natural heritage features affected. Some projects may not require a site visit or meetings where others may require multiple site visits, meetings, and iterative commenting. It is expected that peer review services could cost between to $3,000 to $20,000 but would need to be scoped to the specific project depending on complexity.

6.3 Secondary Plans for Greenfields

This strategy will result in a detailed inventory of the NHS and water resources including the natural heritage features, functions, and cultural values. The project will culminate in a land use plans, detailed management strategies, and stormwater management strategies that satisfies the policy direction of the Provincial Policy Statement (PPS, 2020), the Growth Plan for the Greater Golden Horseshoe, and the City of Peterborough Official Plan.

Future Studies

The Secondary Plan should feed into development designs, detailed management strategies, and stormwater management strategies that are tailored to the conditions and needs of each Greenfield. Secondary Plan studies should be used to guide on going monitoring, restoration and enhancement efforts, and invasive species management plans.

Approvals, Policy, By-law or Design Standards Considerations

Secondary Plans should consider all local, provincial, and federal policies listed in **Appendix A**. Recommendations may result in the creation of new by-laws or design considerations.

Facilitators and Contributors

Secondary Plans require coordination with many stakeholders including but not limited to ORCA, the County, adjacent lower-tier municipalities, indigenous communities, local interest groups such as Kawarthas Naturally Connected, and landowners.

Cost

Smaller-scale studies tend to cost around $300,000 but can extend up to $400,000 or more depending on study area size, level of detail, and complexity of the overall projects.

6.4 Watercourse Restoration Measures

Within the Study Area, sixteen significant tributaries and several smaller watercourses discharging into the Otonabee River which have been grouped as Otonabee Subwatersheds and Urban Catchments, contribute to the aquatic resources. Within the drainage area and these individual catchments, 14.8%

is designated as Commercial, Industrial, Institutional, Residential, ROW or Railway, with the majority of urban intensification centre to the Peterborough downtown core. Within the Municipal Boundary where urbanization is abundant, 5.45 km of watercourse across 16 catchments exists. These reaches have been or are anticipated to experience impacts typical of urban adapted aquatic systems. Site alteration and development can result in impacts to the form and function of these aquatic systems, both directly and indirectly. Direct impacts tend to be localized and mainly include outright removal of natural features from the landscape. Indirect impacts tend to spread further into the natural system and can include (but are not limited to) changes in water balance, sediment and/or contaminant loading, and habitat fragmentation. In general, urban and urbanizing watercourses would benefit from the restoration efforts in order to mitigate both the direct and indirect impacts associate with land use changes. Restoration efforts such as Reach Based Works, Buffer Enhancements and Plantings, Fish Barrier Mitigation, Enhanced Crossing Design and Improved SWM Mitigation and Design should be considered where appropriate.

Key Next Steps

Urban catchments should be assessed for potential restoration opportunities. In general, watercourses should be evaluated based on existing and historical catchment characteristics, and supported by fluvial geomorphological and aquatic ecology studies to prioritize watercourses and watercourse habitat for potential restoration. The City should develop an asset database for its watercourses, and integration of these assets in the asset management system as a form of "linear natural stormwater asset". Assessments should not only prioritize areas based on potential risks to infrastructure, but should consider target species within the catchment and evaluate the potential impact to the species from restoration measures. The evaluation of the preliminary alternatives, the selection of the preferred solution, and the development of the preliminary conceptual designs (including cost estimates) for each of the primary site opportunities can then be established.

Future Studies

In terms of watercourse restoration prioritization, a Fluvial Geomorphic Master Plan should be undertaken for individual catchments on an urban boundary scale. Through this study, watercourses will be evaluated based on geomorphic principles, identifying erosion risks and prioritizing restoration approaches. Additionally, Fisheries Management Plans should be considered for the catchments. In general, each catchment or watershed should have a plan which characterizes the rivers, major streams, and other features within the study area. Each Plan would describe the fishery, including the current state of fish and fish habitat, the historic or potential state of fish and fish habitat, and the factors that have resulted in a drift from the historic state and/or factors which are preventing it from reaching the potential state. The Plan should also detail the steps and recommendations that can be taken to reach the historic or potential state and should consider support from the MNRF. A Fisheries Assessment Project was completed by the Otonabee Region Conservation Authority which details fish communities and thermal regimes for the individual catchments in the City, including 11 of the 18 catchments detailed in this study (McGauley, Forrest, & Carter, 2015). This approach report should be updated to account for more recent land use changes, to assess additional catchments previously unassessed, and to identify target species for each catchment which can be used to refine watercourse restoration approaches. At the very least, the study should be updated to characterize those left unevaluated in the 2015 study, including the Airport, Cavan and Fisher Subwatersheds.

Approvals, Policy, By-Law or Design Standards

Upon completion of the prioritization and identification of watercourse restoration approaches, the following regulatory implications should be considered which typically apply to watercourse restoration works. This list is not exhaustive and each project should be evaluated on a case-by-case basis to consider all legislation, including the Water Resources Act and others. A key component in gaining appropriate approvals and in considering all policy, by-law, design standards and stakeholder requirements is that of the Duty to Consult with First Nations and Indigenous Peoples. It is understood that the Duty to Consult is identified by the reviewing Agency as a result of the review process required under the Approvals, Policy, By-Law or Design Standards identified hereafter, in particular; the Public Lands Act (MNRF) and the Fisheries Act (DFO). The Duty to Consult is not always a requirement and is one that is typically identified during the detailed design and review process. However, it should be the responsibility of the proponent to engage with all stakeholders early and often. Should the Duty to Consult be required by the Agency, having already completed the preliminary processes would aid in the Regulatory Review process and could further advise in the Duty to Consult process. It is recommended that First Nations and Indigenous Peoples be consulted at the onset a project to incorporate all considerations into the project outcome, when and where appropriate.

Public Lands Act

Public land managed by the Ministry of Natural Resources and Forestry, including the beds of most lakes and rivers and shore lands covered or seasonally inundated by the water of a lake, river, stream or pond, are subject to work permits and exemptions. The Public Lands Act does not manage federal lands and water bodies (e.g., the Trent-Severn waterway) or private land, unless the work potentially affects Crown land, such as shore lands. These works include but are not limited to erosion control works, watercourse crossings and the placement of fill on shore lands (i.e., erosion control features). Work permits may be required to complete watercourse restoration works under this Act.

Fish and Wildlife Conservation Act

The safe and lawful handling of any fish and wildlife is regulated under the *Fish and Wildlife Conservation Act* and is administered by the Ministry or Natural Resources and Forestry (MNRF). Should it be determined that any proposed works have the likelihood of impacting fish or wildlife protected under this Act, Scientific Collector's Permits for both fish and wildlife would be required in order to relocate any and all fish and wildlife out of the work area prior to construction activities.

Fisheries Act

The federal *Fisheries Act* requires that projects avoid causing the death of fish and the harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near waterbodies that support fish at any time during any given year or are connected to waterbodies that support fish at any time during any given year. Therefore, the *Fisheries Act* applies to works many, if not all, potential watercourse restoration projects within the subwatershed study area(s).

Upon completion of any detailed design for potential channel works, the works should be cross-referenced with the DFO "Projects Near Water" online service to determine if a request for regulatory review under the federal *Fisheries Act* is required (Department of Fisheries and Oceans, 2021). If it is deemed that the study site potentially contains fish or is connected to downstream reaches that are confirmed to have fish at any time during any given year, the works would be subject to regulatory review by Fisheries and Oceans Canada. It is also recommended that the proponent exercise the measures listed by Fisheries and Oceans Canada to avoid contravention with the Federal *Fisheries Act* and exercise due diligence by further mitigating accidental death of fish and the harmful alteration, disruption or destruction of fish habitat.

Conservation Authorities Act

A permit under Ontario regulation 167/06 (Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses) will be required through ORCA for works in regulated areas.

Endangered Species Act and Species at Risk Act

The *Endangered Species Act* (ESA), currently under the jurisdiction of the MECP, provides legal protection to SAR and their habitats in Ontario. Specifically, the ESA prohibits the "killing, harming, harassing, possessing, buying, selling, trading, leasing or transporting species listed as threatened, endangered or extirpated". The Act also provides habitat protection by prohibiting "damaging or destroying habitat of endangered and threatened species". Projects which will affect Endangered or Threatened species or their habitat are required to undergo consultation with the MECP in order to determine the project-specific requirements under the ESA.

Similarly, the *Species at Risk Act* (SARA) protects federally-listed species and is administered on a federal level by Environment and Climate Change Canada, or in the case of aquatic SAR, by the DFO. SARA is applied when projects occur on federal lands, or when they affect listed species that are also protected under other federal legislation (namely the *Fisheries Act* and the *Migratory Birds Convention Act*). Qualifying projects which affect federally listed species or their habitat would be required to undergo consultation with the MOECC or the DFO in order to determine the project-specific requirements under the SARA.

Cost

The required costs for watercourse restoration projects are entirely dependent on the size and extent of the restoration works, varying from low cost and low invasiveness techniques such as hand-applied soft- or bio-engineering restoration and riparian plantings, to high cost and high invasiveness techniques such as reach-based natural channel design and channel realignment. In general, watercourse restoration can cost from $3k to $4k for one metre of natural channel design work, including materials and excavation, with a minimum $100k dedicated to mobilization, erosion and sediment control and staging, and environmental protection. At the time where additional studies are completed and priority areas are identified with potential restoration techniques, preliminary costing can be provided which can further inform decision makers.

Funding

The proper management of the City's watercourses, or linear natural assets requires a financial strategy which maintains a desired level of service, limiting risks and protecting the environment. Upon completion of the asset database, these features will become part of the "Stormwater Service Area" in the City's current Asset Management Plan. Capital funding of Stormwater Assets currently comes from two primary reserves; the Wastewater Reserve Fund (Stormwater Protection Funding) and the Flood Reduction Master Plan Reserve. With the addition of these critical assets under the stormwater service area, it is anticipated that the Stormwater Protection Funding portion of the Wastewater Reserve will need to increase proportionally to ensure the ongoing management of these natural features. A detailed financial strategy will be provided for Councils consideration at a later date.

While the majority of funding for the watercourse restoration comes from the general stormwater utility fee revenue, or the Stormwater Protection fee. Additional funding for this program is allocated from:

- The Wastewater Reserve Fund
- The Flood Reduction Master Plan Reserve (FRMP)

Additional incentives can be leveraged in watercourse restoration projects, such as:

- Funding under the Provincial Land Stewardship and Habitat Restoration Program
- Stormwater management credits under an established Fisheries and Oceans Canada Habitat Banking Program

The Otonabee Region Conservation Authority (ORCA) can also provide information, technical advice and guidance for additional funding opportunities, and possibly financial assistance.

Timeframe

Watercourse restoration project timeframes are largely determined by the size and extent of the proposed works. Supporting documentation and studies may be required to accompany permitting and authorizations and in general, guide the decision-making process. These studies and processes, partnered with the detailed design phase, must be accounted for in the lead up to undertaking watercourse restoration projects. Timing considerations for in-water works and environmental management, such as breeding bird and wildlife timing windows must also be accounted for in the project schedule.

Recommendations

It is recommended that the approximately 5.45 km of urban reaches of the 16 catchments within the City of Peterborough undergo additional studies to document potential risks to infrastructure and identify and prioritize restoration opportunities based on these risks as supported by ecological and fisheries considerations. These studies can identify city-wide primary restoration opportunities to be implemented with a definitive schedule, and can also identify secondary opportunities for the City to

monitor and integrate associated solutions where project synergies allow. It is recommended that the City investigate the potential to acquire privately owned land that may be implicated by restoration works, such that any watercourses or features can actively be maintained without implications to private property.

6.5 Shoreline Restoration Measures

The removal of natural shore vegetation for the placement of structures reduces biodiversity along the lakeshore, and the intensified wave energy that results from hard shore edges poses long-term erosion risks related to scour that can be costly to mitigate. Particular to the Peterborough study area, significant portions of the Otonabee River within the urban boundary have been hardened to protect properties from erosion caused by boat traffic. Shorelines can be bio-engineered (or 'softshore'-engineered, or 'landscaped') to 'absorb' wave energy and protect properties from boat and wind-induced waves and scour. Bioengineering and restoration of shorelines can involve the following treatment options: Lowland Riparian Woods (LRW); Vegetated Buffer Zones (VBZ); Sloped Rocky Revetments (SRR); Boulder Clusters and Rock Piles.

Key Next Steps

Shorelines within the study area, in particular those that abut City-owned property, should be assessed for potential restoration opportunities. In general, shorelines should be evaluated under the same guiding principles as discussed for watercourse restoration projects. Shoreline assessments should consider widely differing target species from those identified in smaller watercourses and riverine habitat, and should account for these species in restoration measures. The evaluation of the preliminary alternatives, the selection of the preferred solution, and the development of the preliminary conceptual designs (including cost estimates) for each of the primary site opportunities can then be established.

Approvals, Policy, By-Law or Design Standards

Regulatory implications will largely remain consistent with those identified above. However, as shorelines, particularly those along the Otonabee and the Trent-Severn Waterway, are typically managed under the *Canadian Navigable Water Act,* additional regulations and design standards should be considered to account for boat traffic and navigation.

Cost

As shoreline restoration measures tend to be designed to withstand boat traffic, wind-generated waves, and the associated wake and wake-action erosion, projects may incur a higher cost in materials and environmental management. In general, for projects that use larger rock and materials such as boulders and armourstone, a typical restoration project may cost $6k to $10k per meter, including materials and excavation, with a minimum $100k dedicated to mobilization, erosion and sediment control and staging, and environmental protection. At the time where additional studies are completed and priority areas are identified with potential restoration techniques, preliminary costing can be provided which can further inform decision makers.

Recommendations

It is recommended that the shorelines within the urban centre, primarily those along the Otonabee and the Trent-Severn Waterway within the City of Peterborough, undergo additional studies to document potential risks to infrastructure and identify and prioritize restoration opportunities based on these risks as supported by ecological and fisheries considerations. These studies can identify city-wide primary restoration opportunities to be implemented with a definitive schedule, and can also identify secondary opportunities for the City to monitor and integrate associated solutions where project synergies allow. Privately-owned properties that abut open-water or riverine habitats may be managed under different practises. Similar to above, it is recommended that the City investigate the potential to acquire privately owned land that may be implicated by restoration works, such that any watercourses or features can actively be maintained without implications to private property.

6.6 Terrestrial Restoration

Restoring degraded habitats and converting anthropogenic lands into natural thriving ecological communities can improve habitat beyond the borders of the restored area. Within the City of Peterborough, most subwatersheds do not meet the woodland or wetland cover targets. Generally, lands that should be considered for restoration include 'bays and inlets' along the edge of NHS features that are less than 60 m wide, interior gaps in features less than 0.5 ha; and gaps between features - < 60 m. Within City limits, these guides are not as useful and restoration should target areas where existing proximity linkages and regional connections are already highlighted in the OP, along watercourses, and directly adjacent to existing NHS features.

Key Next Steps

Urban catchments should be assessed for potential restoration opportunities. This can be completed through a subwatershed study or similar project. Locations should be selected based on their potential to improve the NHS as a whole. Restoration locations that widen local or landscape scale corridors, create larger interior habitat within patches (e.g. holes within NH patches or along the edges), and/or along watercourses should be prioritized. Target habitat type should be considered and influenced by the existing physiological conditions as well as the species present and likely to use it. Additionally, wetland restoration projects should be considered where there is greatest potential for infiltration such as sites with sandy soils and areas within significant groundwater recharge areas (SGRAs). They can capture and attenuate overland flows which are expected to increase with climate change. Restoration projects should also consider the potential stressors present including but not limited to invasive species, erosion, anthropogenic disturbance, and climate change.

Future Studies

Secondary Plans should be completed for all greenfields with the goal of characterizing the resources present and provide management strategies and future actions. As a part of a Secondary Plan, potential restoration areas should be highlighted. All restoration projects will require monitoring for a

minimum of five years and a planting success rate of 80% with contingencies to refine design, provide supplemental plantings, etc.

Cost

The required costs for restoration projects are dependent on the size, extent, and target community type of the restoration works. Wetland restorations are likely to cost approximately $95,000/ha and woodlands approximately $50,000/ha. At the time where additional studies are completed and priority areas are identified with potential restoration techniques, preliminary costing can be provided which can further inform decision makers.

Funding

Funding can come from a couple of avenues, as discussed in **Section 6.4**. Currently the City and ORCA do not have a cash-in-leu compensation strategy to offset impacts to NHS features. It may be beneficial to develop a formal ecological offsetting policy, similar to Lake Simcoe Region Conservation Authority's (LSRCA) Ecological Offsetting Policy (2021), which is descriptive on what and how much natural features can be removed as well as how to calculate compensation either monetarily or through restoration. Development projects then may opt to compensate though cash-in-leu which can be applied to restoration project. Grant money may also be available through Ontario Community Environment Fund, Land Stewardship and Habitat Restoration Program or similar Funds. The Otonabee Region Conservation Authority (ORCA) can also provide information, technical advice and guidance for additional funding opportunities, and possibly financial assistance.

Timeframe

Restoration project timeframes are largely determined by the size and extent of the proposed works. Supporting documentation and studies may be required to accompany any required permitting and authorizations and in general, guide the decision-making process. These studies and processes, partnered with the detailed design phase, must be accounted for in the lead up to undertaking restoration projects. Timing considerations for breeding bird and wildlife timing windows must also be accounted for in the project schedule.

6.7 Urban Forest Strategic Plan Updates

The groundwork needed to develop a robust Urban Forest Strategic Plan has already been completed but the next steps are required to determine where efforts should be placed to better allocate planting resources, identify areas of pest concern, identify areas of low species diversity, and highlight ideal locations for larger planting projects could occur.

Key Next Steps

In the 2016 Urban Forest Strategic Plan Update report, several next steps were presented:

- Complete the Street Tree inventory and the identification of infill planting opportunities in the outstanding Forest Management Zones.
- Implement Lidar aerial photography, and spectral imaging to determine tree species. Future plot sampling will include characterizing specific construction and development project areas that impact the urban forest and site-specific species inventory (e.g., Parks and Natural Areas).
- Continue where sites are suitable to plant native species for City tree planting projects. Conduct plot sample inventories in select City woodlots to record native species representation.
- Publish a tree inventory website for public use.
- Continue public outreach and incentives for planting within the community.

The City may also consider publishing another update report to account for the work completed since 2016. It would also be beneficial to publish updated canopy cover statistics along with targeted Forest Management Zone strategies to meet the overarching canopy cover goal stated in the Official Plan of 35% by 2051.

Future Studies

Starting in 2011, an on-going tree inventory of most of the city's right-of-way and some parklands was initiated as a part of the Urban Forest Strategic Plan. It is most important that tree inventory data remains up to date and accurate. This data should be used to guide resource allocation based on which Forest Management Zones (defined in the Urban Forest Management Plan) have the least canopy cover, the least species diversity, and greatest Ash content. The data can be used to guide species selection, planting location, management requirements, and other decisions. Accurate analysis of existing canopy cover should be completed and used to set both practical and attainable canopy cover goals by Forest Management Zones or subwatersheds that will guide to city to their goal of 35% by 2051.

Approvals, Policy, By-law or Design Standards Considerations

The City has two tree conservation by-laws: Tree Removal By-law 21-074; and Woodland Conservation By-law 17-121 for the protection and compensation of trees. As a part of the Urban Forest Management Plan Update (2016), the City released a preferred species list which includes species that are non-native such as varieties of Norway Maple (Acer platanoides), European Hornbeam (Carpinus betulus), Turkish Hazel (Corylus colurna), Hardy Rubber Tree (Eucommia ulmoides), Pyramidal English Oak (Quercus robur), Maidenhair Tree (Ginkgo biloba), Ivory Silk Tree Lilac (Syinga reticulata), and many more. Suggested species should be updated to remove any non-native species and promote native species only.

Facilitators and Contributors

Urban forest management is a municipal responsibility but many stakeholders such as residents, ORCA, and the County play a part in its success. The City and ORCA have come together with community volunteers to complete many tree planting events and tree inventory initiatives in the past and it is encouraged that more events are planned.

Funding

As a part of the City of Peterborough's 2023 Approval, $1,000,000 has been allotted for the urban forest management strategic plan implementation and for tree planting and urban forest management.

6.8 Invasive Species Management Plan

This will require mapping current known hotspots of invasive species including but not limited to European Common Reed and Common Buckthorn. Once locations are quantified, targeted management plans can be developed. An invasive species management plan should include at minimum the following: goals, targets and timelines; methods to prioritize resource allocation, funding opportunities and public engagement plan; costing and staffing requirements, species removal/management methodology, and a monitoring plan.

Key Next Steps and Future Studies

Development of a stakeholders committee lead by the Municipality where local community groups are invited to participate along with ORCA, and indigenous communities. To best allocate resources, priority areas must be determined. This will require surveys of natural areas within the City limits to determine which problematic species are present and the severity of the infestation. This can be completed in tandem with subwatershed studies.

Approvals, Policy, By-law or Design Standards Considerations

Developments adjacent to NHS should have to consider existing the potential for the spread of invasive species. Additionally, clean equipment protocols should be implemented to stop the spread of species between sites.

Facilitators and Contributors

MNRF administers the Invasive Species Act (2015) and associated regulations, and funds organizations, programs, research, and initiatives to understand, prevent, detect, and manage invasive species. Conservation Authorities are to develop and deliver watershed-based resources management programs. Municipalities are responsible for local management and detection and management of local priority species and sites. Municipalities and conservation authorities should work in tandem along with local interest groups and other non-profit organization such as the Invasive Species Centre, Ontario Federation of Anglers and Hunters, Ducks Unlimited Canada, Ontario Invasive Plant Council, and Natural Conservancy of Canada to develop and implement an action plan.

Funding

Grant opportunities may be available through Land Stewardship and Habitat Restoration Fund, Species at Risk Stewardship Fund, Habitat Stewardship Program for Species at Risk, National Conservation Plan – National Wetland Conservation Fund, Walmart-Evergreen Grants, TD Friends of the Environment Grant, and/or EcoAction Community Funding Program.

6.9 Land Acquisition

Several of the strategies discussed above would be dependent on or facilitated by the acquisition of additional property adjacent to existing natural features or areas. The re-naturalization of riparian areas, establishment of expanded VPZs, and other projects which would expand the existing natural cover within the subwatershed are often constrained by existing development on adjacent properties, so opportunities to acquire additional parcels or easements that could be restored and naturalized would contribute to the improvement of terrestrial ecological conditions.

Timeframe

Land acquisition should be integrated into the development, re-development, and site alteration process. The City should request all lands that are designated for environmental protection and their VPZs be transferred to the City as a part of a development or re-development application. Additionally, the city can target woodlots and wetlands on private property and request landowners to sell the land to the City.

Future Studies

As a part of subwatershed studies, ideal restoration locations should be highlighted. To accommodate restoration projects, parcels may need to be acquired or split to achieve the best site design.

Approvals, Policy, By-law or Design Standards Considerations

Section 7 of the City's OP acknowledges that the City may acquire and hold lands within the City for the purposes of implementing the Official Plan in accordance with the provisions of the Planning Act (Section 7.11). This includes hazard lands, open space lands, lands within the Intake Protection Zones and lands designated Natural Areas necessary for conservation, protection, enhancement, and stewardship of natural features and the mitigation and management of natural hazards (Section 7.11 (b)). As a part of the development process, it should be strongly encouraged that lands meeting the above classification should be transferred to the City.

Facilitators and Contributors

Lands within VPZs and NHS features could be donated to either the City or ORCA depending on who would be best to manage it.

Development Requirements

Under the City's Draft OP, the City requires the conveyance of all hazard lands, open space lands, and lands designated Natural Areas through the development approval process (Section 7.11 (c)).

Community Outreach and Awareness

Promotion of natural heritage values and protection could be communicated to local residents and landowners through a targeted outreach program that emphasizes responsible stewardship and best practices. For example, residential landowners with properties abutting onto NHS features could be provided with a mailout emphasizing the ecological significance of the area and discussing items such as avoiding non-native invasive vegetation in gardens near natural areas, including a no-mow strip at the rear lot line adjacent to a natural feature, and the impacts of dumping yard waste and other materials into natural spaces. Throughout the subwatershed, local residents could be encouraged to landscape and garden with native materials through demonstration sites such as community butterfly gardens.

Funding

Grant opportunities may be available through Land Stewardship and Habitat Restoration Fund, Species at Risk Stewardship Fund, Habitat Stewardship Program for Species at Risk, National Conservation Plan – National Wetland Conservation Fund, Walmart-Evergreen Grants, TD Friends of the Environment Grant, and EcoAction Community Funding Program.

6.10 Stormwater Management

Low Impact Development (LID) stormwater management practices used together with conventional stormwater management as part of an overall holistic treatment train approach have been shown to better meet stormwater management targets and objectives, provide better performance, are more cost effective, has lower maintenance burden, and are more protective during extreme storms than conventional stormwater practices alone. The underlying concept is that each LID stormwater management and traditional practice within the treatment train provides successive storage, attenuation and water quality benefits. The approach to stormwater management reflected in this implementation plan uses this holistic approach in order to meet the goals and objectives of the Watershed Plan.

The three main components of the stormwater management solutions proposed as part of the Watershed Plan are:

- Low Impact Development Source Controls on Private Property
- Low Impact Development Conveyance Controls within the Municipal Road Right-of-Way
- End of Pipe Stormwater Controls

6.11 Low Impact Development Source Controls on Private Property

Source control measures are small-scale stormwater treatment systems that are located at the beginning of a drainage system. These practices capture and treat stormwater on-site or close to where the rainfall lands. These measures, as detailed in the Watershed Plan are generally installed on private property within residential, commercial, industrial and institutional land uses.

Source control measures fall outside of the Municipal Class EA process, since they are to be constructed on private property, often by the individual land owner as a retrofit or during development/ redevelopment (i.e. the City is not the proponent).

Source controls on private property should be prioritized in existing stormwater catchments lacking water quality and/or water quantity control. Infiltration-based LIDs (rain gardens, permeable pavement, infiltration galleries, etc.) provide additional hydrologic benefits beyond those that do not support groundwater recharge (biofilters, lined systems, etc.) and should be prioritized in Significant Groundwater Recharge Areas (SGRAs, see Watershed Plan), Ecologically Significant Groundwater Recharge Areas (ESGRAs, see Watershed Plan) and subwatersheds that support cool and coldwater fisheries, these being:

- Bears Creek (coolwater)
- Byersville Creek (coolwater-coldwater)
- Harper Creek (coldwater)
- Riverview Creek (coolwater)

Within the WPS area, two additional subwatershed areas outside of the City of Peterborough have thermal regimes that are sensitive to thermal pollution. These are:

- Cavan Creek headwaters (coolwater-coldwater)
- Jackson Creek headwaters (coldwater)

A cursory review of current drainage practices within the city as well as discussions with City staff indicate that the following source control measures are already being applied:

- **Downspout Disconnection** – for the most part, roof runoff from residential properties is not connected directly to the municipal storm drainage system. In most cases, roof runoff is instead directed overland, thus providing an opportunity for infiltration and reduced runoff volumes. Roof runoff can be directed to impervious surfaces draining away from structures provide opportunities for infiltration and depression storage. To maximize infiltration, a downspout can be connected to an infiltration trench with perforated subdrain.

- **Rain Barrels** – Rain barrels are an excellent way to capture water that can be used in your garden and yard. If emptied after each rainfall, they also contribute to hydrologic and water quality benefits. The Peterborough Utilities Group offers their customers a $25 subsidy when purchasing a rain barrel from GreenUP. Rain barrels are not currently in wide use across the City.

- **Rain Gardens** – A rain garden is a bowl-shaped garden that collects rain and melted snow. The rain garden absorbs stormwater (rain water) and melted snow that runs off impervious surfaces such as rooftops. The garden is designed to have a shallow depression that has deep, loose soil so that it absorbs and naturally filters stormwater, rather than that water entering the storm sewer network. The City of Peterborough, in partnership with Peterborough GreenUP, has implemented a Rain Garden Subsidy program for qualifying residents in Peterborough to offset the cost of installing green infrastructure on private property. The subsidy provides qualifying residents up to $1,000 reimbursement towards a rain garden based on the volume of rain water storage that the garden provides. Rain gardens are not currently in wide use across the City.

While the Rain Garden Subsidy program has had some success, in order achieve subwatershed-level improvements with respect to Watershed Plan goals and objectives relating to water quality and hydrology, significantly more infiltration-based LIDs are needed across existing urban stormwater catchments lacking stormwater controls.

While the above LID practices are primarily solutions for residential properties, there is opportunity in many subwatersheds to improve water quality and reduce urban runoff from commercial, institutional and industrial properties. These properties often have large impervious surfaces such as parking lots and roofs that provide opportunities for runoff interception and capture via infiltration-based LIDs. These alternatives include those noted above for residential properties but also include infiltration chambers, green roofs and permeable pavement. In existing urban areas, implementation of non-residential source controls may be dependent on policy related to infill development (i.e. stormwater and water balance targets for site plan application) and incentive programs such as stormwater credits.

Key Next Steps and Future Studies

Since source control measures are generally implemented within private properties, the City has a limited role in leading the implementation of these measures. However, the City could provide a supportive role through the following initiatives:

1) Developing a “Social Marketing Strategy” and raising awareness within community. The City should refer to the **Grey to Green Residential Retrofits:** Engaging Residents to adopt Low Impact Development on their Properties (CVC, 2015) which describes the step-by-step process to developing a residential marketing strategy.
2) Developing a Visually-Based Advertising Campaign. This may include outdoor signage, point-of-purchase displays, direct mail initiatives and supporting marketing resources that are to be determined, but likely a full-colour, photo-based brochure promoting alternative landscapes

would be the primary print resource. This creates desire and a vision of what a property owners landscape could look like with highly aesthetic LID features.

3) Joint ventures with Key Stakeholders that provide landscape products and services. Garden centers, box stores, landscape design and landscape maintenance firms should be engaged through joint promotional initiatives. Garden centers and nurseries can play a key role, as they are a trusted source of advice on plants, trees and shrubs and the layout of the landscape.

4) Develop a Landscape Consultation Service to support neighbourhood-level GreenUp programs. A landscape consultation service targeting residents in the study area and providing them with a how-to approach to implementing the alternative landscape will help residents make the transition. The consultation service will be linked to the retail stakeholders through promotional discounts at participating retailers and added support in design and plant selection provided by retail personnel.

5) Refine, update or change by-laws related to implementing these measures.

6) Undertake study to determine feasibility of municipal stormwater fee/utility to fund stormwater/watershed programs. To encourage implementation of private LIDs, a credit system can be applied to the programs giving property owners significant savings when they reduce runoff to municipal conveyance infrastructure.

7) Continue to support strategic partnerships with local agencies and public outreach programs, including the GreenUp's DePave Paradise neighbourhood projects.

8) Distribution of existing guidance materials for residential property owners including the "Greening Your Grounds: A Homeowners Guide to Stormwater Landscaping Projects" created by the Toronto and Region Conservation Authority (TRCA) and others.

Figure 6-1: Greening Your Grounds Guidance Material

9) Residential Workshops to educate and inform City of Peterborough residents. In co-operation with participating retailers, workshops to motivate, promote and assist residents with design ideas and how-to information should be part of the overall alternative landscape program, but would be implemented in later years of the program. TRCA's Homa and Garden-Healthy Yards program is a good resource for workshop ideas and materials.

Residential implementation of LIDs may also benefit from demonstration sites that reinforce the City's commitment to LIDs. Pilot project(s) provide the most benefits when located on highly visible public land and should be combined with media releases, educational programs/ campaigns as well as high visibility education signage. By undertaking public land pilot projects, the City is taking a 'leading by example' approach which has been shown to improve private land retrofit uptake rates.

Public open spaces, public schools, and libraries are ideal candidate sites for pilot projects. Pilot projects are suggested within these areas to define variables such as landowners' awareness of the

impacts from stormwater, their willingness to implement, the importance of public funding, and the adoption rates for each of the proposed measures. Potential public land retrofit site(s) should have high community appeal and be a community 'hub' which experiences high volumes of visitors, this can include but is not limited to:

- Schools;
- Parks;
- Libraries; and
- Community centers.

Approvals, Policy, By-law or Design Standards Considerations

It is recommended that the City review its current by-laws to ensure barriers do not exist on the implementation of source control measures including limitations on the naturalized landscape approach, temporarily ponded water (up to 48hrs), uniform grading requirements etc.

Revisions to the following by-laws may be considered:

- Standing Water (City of Peterborough Bylaw, 03-107)
- Property Maintenance (City of Peterborough Bylaw, 96-41)

Additionally, a new by-law requiring upkeep of private water quality units including OGS and LIDs would provide a maintenance enforcement mechanism. Consideration to include when developing the by-law are listed below:

- Municipal access to inspection ports or manholes
- Requirements for maintenance activities as prescribed in respective site plan agreements
- Municipal access to maintenance records upon request
- Provisions for municipality to require rehabilitation of treatment practice at the expense of the site owner

Facilitators and Contributors

To aid in the successful implementation of the Recommended Approach for source controls, key facilitators and contributors would include:

- Otonabee Region Conservation Authority (ORCA)
- Peterborough Environmental Advisory Committee (PEAC)
- Naturalists clubs and local environmental organizations
- GreenUp Peterborough

Costs

Provided below are costs estimates for the implementation of the Recommended Approach for Source Controls including the development of a City of Peterborough Social Marketing Strategy and the implementation of Public Lands Pilot Projects.

Social Marketing Strategy

The approximate cost to implement the Social Marketing Strategy is estimated to be between $100,000 and $400,000 this includes costs for marketing campaign, and production of materials. The lower end is more reflective of targeting small population centers, while the upper end estimate is for a large regional study with a lot of community-level outreach. Through the use of strategic partnerships with groups listed previously, and distribution of existing resources, the costs have the potential to be significantly reduced. It is noted that through the City's Stormwater Quality Management Master Plan (2015), $80,000 per year of " Public Awareness Campaign" funding has been approved to raise awareness and promote source control practices and compliment infrastructure solutions. This includes promoting source-control measures on private properties.

Public Lands Pilot Project(s)

It is suggested that 2 to 3 additional public lands pilot projects be undertaken by the City of Peterborough. The costs to implement a pilot project(s) within a selected, high-visibility, public lands site (municipally owned) including media releases, educational programs/ campaigns as well as high visibility education signage is estimated to cost $100,000 - $200,000.

Funding Considerations

Consistent with current practices, the recommended pilot projects and associated marketing strategy for source controls would be funded through the general tax levies as part of the stormwater protection fee. Alternatively, a review of the City's Stormwater Protection Fee may be required to determine funding opportunities.

A variety of environmental grants and granting agencies (both private and public) are also available and may be a potential source of funds for community-based pilot projects, education programs and training expenses. Municipal funding sources may include the Green Municipal Fund through the Federation of Canadian Municipalities (FCM). Other funding sources may include RBC Blue-Water, TD Green Funds etc. Municipalities are not eligible for all funding/grant programs, and as such, private land-owners may be required to lead the application. This does not limit the involvement, financial and or technical support by the City.

Operation and Maintenance Considerations

Operation and maintenance activities and costs associated with the voluntarily implementation of Source Control measures on private property will be the responsibility of the private property owner. Generally, maintenance requirements for most source control technologies have little difference from most turf, landscaped, or natural areas and do not typically require new or specialized equipment. Typical homeowner activities will include:

- General inspection;
- Litter removal;
- Weed control;
- Grass Cutting; and
- General landscape upkeep (i.e. pruning, mulching and seasonal clean-up activities.)

Municipal guidance could be provided to property owners through the development of operation and maintenance guides/ resources that incorporates source control measures. Typical municipal requirements/ steps include:

- Develop/ adopt operation and maintenance program documents;
- Distribute materials through homeowner outreach; and
- Establish tracking system to document source control measure location, type, size etc. for use in future management scenarios

6.12 Low Impact Development Conveyance Controls within the Municipal Right-of-Way

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

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

As presented in the Watershed Plan, traditional conveyance systems comprise curbs, gutters and buried concrete (or other) piping systems that carry stormwater away from a development area to a water body generally along the road network. In appropriate applications, conveyance control measures can be used to improve water quality conditions at lower cost to the municipality while still providing conveyance of the minor system.

Within the City of Peterborough, conveyance control measures can most feasibly be incorporated into existing ROWs as part of planned road reconstruction works as storm sewers and inlets can be replaced and reconfigured during this process.

The primary stormwater strategies for providing hydrologic and water quality benefits in the municipal road ROW are:

1) Perforated Pipe Systems - Perforated pipe systems, also called exfiltration systems, can be thought of as long infiltration trenches that can be designed for both conveyance and infiltration of stormwater runoff. They are underground stormwater systems composed of perforated pipes installed in gently sloping granular stone beds lined with geotextile fabric that allows infiltration of runoff into the granular bed and underlying native soil. Perforated pipe systems can be used in place of almost any

conventional storm sewer pipes where topography, water table depth, and runoff quality conditions are suitable. They are capable of handling runoff from roofs, walkways, parking lots, and roads. For road applications, these systems can be located within boulevard areas or beneath the roadway surface itself. There are three configurations of perforated pipe systems that are feasible within residential road rights-of-way. The first is a perforated pipe system that functions as the minor system conveyance. The second is a perforated pipe that runs parallel and discharges to the conventional storm sewer. Because the conventional storm sewer meets conveyance requirements, the parallel pipe (also known as a "3rd pipe system") can be sized to infiltrate smaller volumes. The third configuration is a catchbasin lead to either a perforated or solid pipe that conveys flows to an infiltration chamber within the municipal ROW. There are perforated pipes available up to 1200mm in diameter that can be used instead of a solid walled storm sewer to promote infiltration.

2) Bioswales and Enhanced Grass Swales - As a stormwater filtration and infiltration practice, bioretention temporarily stores, treats and infiltrates runoff. The primary component of the practice is the bioretention soil media. This component is comprised of specific ratio of sand, fines and organic material. Another important element of bioretention practices is vegetation, which can be either grass or a more elaborate planting arrangement such as an ornamental garden.

Bioretention can be integrated into a diverse range of landscapes including as roadside practices. Depending on the native soil infiltration rate and site constraints, bioretention practices may be designed without an underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for filtration only (commonly called a biofilter) where infiltration is not desired or where contaminated soils are encountered.

Bioswales are similar to bioretention cells. They include a filter media bed, gravel storage layer and optional underdrain components. The main difference is that bioswales are also designed to provide linear conveyance via their swale-like surface geometry and slope. Pre-treatment and rock check dams are often included in the design. In general, bioswales are open channels designed to convey, treat and attenuate stormwater runoff. Vegetation or aggregate material on the surface of the swale slows the runoff water to allow sedimentation, filtration through the root zone and engineered soil bed, evapotranspiration, and infiltration into the underlying native soil. Bioswales may be planted with grasses or have more elaborate landscaping. They are implemented to provide water quality treatment and water balance benefits beyond those of a conventional ditch. Bioswales are sloped to provide conveyance, but due to their permeable soil media and gravel, surface flows are only expected during intense rainfall events.

3) Enhanced grass swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff (also referred to as enhanced vegetated swales). Check dams and vegetation in the swale slows the water to allow sedimentation, filtration through the root zone and soil matrix, evapotranspiration, and infiltration into the underlying native soil. Simple grass channels or ditches have long been used for stormwater conveyance, particularly for roadway drainage. Enhanced grass swales incorporate design features such as modified geometry and check dams that improve the contaminant removal and runoff reduction functions of simple grass channel and roadside ditch

designs. Enhanced grass swales are not capable of providing the same water balance and water quality benefits as bioswales, as they lack the engineered soil media and storage capacity of that best management practice.

Key Next Steps

To ensure LID stormwater management practices can be seamlessly integrated into existing capital planning, road design and operations and maintenance frameworks, the following technical reviews are recommended:

a) A review and update of cross-section drawings in the City's Engineering Design Standards to reflect the following LID practices:
    - Bioretention Bump-Outs (Curb Extensions)
    - Boulevard Bioretention
    - Bioretention Planters
    - Bioswales
    - Perforated Pipe
    - Permeable Pavement
    - Proprietary Stormwater Quality Treatment Devices

b) In order to ensure the City assumes only LID practices that are designed and constructed properly and will function as intended in the short and long-term; a LID assumption protocol should be developed for all ROW LIDs. Of importance are the requirement for extended contractor maintenance periods for vegetated surface features where applicable. Additionally, it is critical that infiltration capacity be maintained during construction via appropriate construction practices and enhanced erosion and sediment controls. Assumption protocols should mandate post-construction in-situ infiltration testing before municipal assumption.

Prioritization of ROW Works and Future Studies

Within the MECP's LID Stormwater Management Guidance Manual, municipalities are encouraged to undertake **Linear Development Feasibility and Prioritization Studies** to comprehensively and holistically assess stormwater and LID implementation opportunities and constraints within their respective rights-of-way networks to improve cost effectiveness, environmental performance and overall benefit to the receiver and the community. It is recommended that the City of Peterborough undertake one of these studies using a Class EA approach that considers social, environmental, financial, and technical considerations. This approach will use the City`s ROW capital works schedule and will refine retrofit options, provide a framework for implementation, define future study needs, allocate available funding sources and define future funding needs. This study would include GIS analysis and infield assessments to determine constraints and opportunities for all potential projects. Once the Linear Development Feasibility and Prioritization Study is complete, the following tasks must be completed for each ROW retrofit project:

Utility locates: Utility locates are undertaken prior to geotechnical investigations and related drilling activities. The company selected to complete the geotechnical investigation is usually responsible for obtaining utility locates. Utility locates can be scheduled by contacting the Ontario One-Call service.

Geotechnical Investigation: To determine soil and groundwater conditions it is recommended that boreholes and/or hand driven piezometers be used to determine groundwater conditions onsite. In both cases soil samples should be collected as part of geotechnical investigations in order to characterize the soil properties including natural moisture content, plasticity characteristics, particle size distribution, and analytical results for contaminates.

In-situ Infiltration Testing: In–situ infiltration testing characterizes the hydraulic properties of the existing native material on-site. On-site infiltration testing using the Guelph Permeameter test to determine the in-situ saturated hydraulic conductivity and the design infiltration rate per the LID Stormwater Planning and Design Guide is recommended. Testing should be performed within the approximate location and invert of proposed LID practices.

Topographic Survey: To produce base mapping for the detailed design phase, it is necessary to complete a topographic survey of the sites using total station survey or GPS equipment. At a minimum, surveys should include the following site features:

- Topography of the proposed site;
- Identification of above ground and below ground services
- Utility locate markings;
- Inverts and sizes for existing sewers, catch basins, manholes, etc.;
- Location and description of on-site structures;
- Available legal monuments;
- Borehole locations;
- Infiltration testing locations;
- Significant vegetation (coordinated with tree inventory assessment);
- Existing parkland features;
- Fence lines and existing landscaping; and
- Local benchmarks.

Hydrologic Assessment: A hydrologic assessment must be completed to accurately delineate the catchment area. This information is used to determine flow rates and storage volumes used for sizing bioretention components.

Gauge Neighbourhood Interest: It is essential to have buy-in from a target residential neighbourhood prior to implementing a LID feature within the ROW. A project launch BBQ was successfully held in a neighbourhood park on a weekend for the Lakeview Project in Mississauga.

Approvals, Policy, By-law or Design Standards Consideration

Municipal By-Laws

The long-term viability of conveyance control practices such as bioswales and bioretention facilities depend on adherence to grading and planting plans. It is recommended that a review of City of Peterborough Property standards by-law, and any by-laws relating to weed control be conducted to ensure wording allows for the use of plant growth within the ROW and unconventional grading which permit the 'temporary ponding' of water.

Design Standards

City of Peterborough's Engineering Design Standards for road works will need to be updated to reflect the incorporation of LID features. It is recommended that the design specifications within the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (2010, v1.0 or most recent) be used to update design standards in 2023. An additional resource is CVC's Low Impact Development Road Retrofits Guide (2015).

Utilities Agreements

Access agreements with utilities (e.g. cable providers) may need to be altered to ensure that the constructed LIDs are restored or consider implementing enhanced road cut permits which include rectification bonds. Implementation of a "Green Streets Fund" would allow for application of a fee-based system on all road cut permits where fees are equal to a nominal percentage of total capital (actual or estimated) construction budget. Collected fees would be primarily allocated to verification of appropriate rectification post construction as well as to future municipal ROW retrofit projects and operation and maintenance activities.

Cost

The financial impact of implementing preferred road right-of-way LID retrofit alternatives as part of road reconstruction projects will vary depending on the retrofit type and scope of the project. **Table 6-1** identifies additional costs, beyond those incurred through standard road reconstruction for different retrofit alternatives. The costs are based on recent tendered project experience within other Ontario jurisdictions.

Table 6-1: Estimated Unit Costs for Retrofit (Conveyance Control) Measures

Treatment Measure	Unit Cost	
	$/m^2	$/m
Perforated Pipe[1]	-	$180-300*

Bioretention (Boulevard or Bump Out)[2]	-	$275-300 **
Bioswales[3] ***	-	$400-425 **
Permeable Pavement[4]	$300-340	-
OGS with enhanced removal capacities	$ 90,000/unit minimum	

[1] ROW Guide (CVC/MOE)

[2] Sunnyside (Ottawa), Regional Roads (Peel), Stewart Street (Ottawa)

[3] Lakeview (Mississauga), 7th Street (Cornwall), BFC (Brampton), Forest Glen (Newmarket)

[4] Huron Natural Area (Kitchener), Bentall Kennedy (Mississauga)

*Includes cost of road reconstruction

**Added cost to Road Reconstruction cost of $1,150 per linear meter (i.e. bioretention cost = $300 + $1,400 = $1,700

Note: All values in 2023 CDN dollars

Integration

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

a) **Public Transportation**: Transportation Plan Updates should be viewed as an opportunity to provide SWM control within areas of the City which currently lack SWM control. It is recommended that the opportunity for source and conveyance control SWM practices be integrated into intensification planning around public transportation hubs where feasible in order to mitigate the hydrologic and water quality impact of urbanization.

b) **Active Transportation**: There are several ways that LID practices can be integrated into active transportation systems. It is recommended that where possible source and conveyance control SWM practices be integrated into new active transportation infrastructure.

c) **Road Planning**: LID practices may be integrated into the planning of a wide variety of roads projects including those undertaken for traffic calming, road safety and “road diet” lane conversions.

d) **Urban Forestry**: At the detailed design stage for each capital roads project, the project is recommended to proceed with ‘twin objectives’ such that the project can incorporate new SWM infrastructure to achieve SWM objectives as well as achieving Urban Forestry objectives. As noted above these ‘twin objectives’ are one-in-the-same from a stormwater perspective, as trees reduce stormwater impacts, flows and volumes.

Operation and Maintenance

The following steps should be followed to develop an operation and maintenance program for LID practices implemented within the municipal ROW.

Step 1: Where LIDs are proposed on Residential Streets, establish an Operations and Maintenance (O&M) approach which determines the level of maintenance assumed by the municipality and/or undertaken by private land owners.

Step 2: Develop a "Level of Service Model" which details the maintenance program activities and efforts based on the selected maintenance approach. Evaluation of the maintenance requirements of individual LID practices is required at this stage.

In general, there are three (3) O&M approaches for LID measures implemented within municipal ROWs.

- **Approach 1**: Private Owner Maintenance – private property owners are responsible for performing ongoing stormwater facility maintenance with municipal guidance and oversight.
- **Approach 2**: Municipal Maintenance – the municipality is responsible for performing ongoing on-site LID maintenance.

Additional to the two approaches identified below, a Hybrid combining Approaches 1 and 2 with clearly defined roles may be implemented based on opportunities and constraints unique to the area.

Table 6-2 summarizes the requirements/ steps associated with each approach and the advantages and disadvantages to each.

Table 6-2: O&M Approaches for LID Measures with Municipal ROWs

Maintenance Approach	Typical Requirements /Steps	Advantages	Disadvantages
Private Owner Maintenance	1. Develop/ adopt program documents 2. Develop homeowner outreach program and materials 3. Develop Inspection Procedures 4. Establish tracking system	Reduced costs to the municipality	Need enforcement mechanism for maintenance (bylaw).
Municipal Maintenance	1. Collect a detailed inventory of all LID controls 2. Establish maintenance policies	Avoidance of enforcement issues, and	High costs, extensive staffing requirements and

Maintenance Approach	Typical Requirements /Steps	Advantages	Disadvantages
	3. Mandatory easement requirement for site plan approval (new development) 4. Train inspectors and approvals staff 5. Develop tracking system 6. Perform and document maintenance activities	increased control over maintenance frequency May utilized contractors to performance maintenance to reduce costs	administrative burden

There are advantages and disadvantages to each operation and maintenance approach. Adequate training and assembly of maintenance program documents is strongly advised to provide the necessary knowledge required to properly maintain LID practices.

Maintenance requirements for most conveyance control technologies have little difference from most turf, landscaped, or natural areas and do not typically require new or specialized equipment. LID techniques are green 'infrastructure' and do therefore provide a necessary function in communities. The relative importance of this function requires that maintenance personnel and inspectors are well versed in the design, intended function and maintenance requirements of each system. Just as contractor education is critical to ensure proper post-construction function, the education and training of the individuals servicing LID facilities is vital to their long-continued operation.

6.13 End of Pipe Stormwater Controls

A significant portion of the City of Peterborough was developed prior to the development of current stormwater management (SWM) criteria. As such, there are areas within the city where uncontrolled and untreated stormwater runoff is directly discharged to the receiving streams and the Otonabee River. The limited water quality monitoring data summarized as part of the Watershed Planning Study Characterization Report (Draft 2020) indicates that these uncontrolled discharges are responsible for some of the contaminant loadings to receiving watercourses. Along with LID retrofits of private and public spaces, additional methods of adding stormwater control to existing urban catchments include:

6) Identifying SWM retrofit opportunities on publicly-owned lands within large SWM catchments currently lacking stormwater quality treatment and implementing stormwater management ponds or subsurface infiltration chamber systems.
7) Identifying SWM retrofit opportunities within the existing storm sewer network in large SWM catchments currently lacking stormwater quality treatment and implementing proprietary stormwater treatment devices (i.e. Oil Grit Separators).

6.13.1 Prioritization and Future Studies

Ponds or subsurface infiltration chamber systems in municipal properties: As part of the Watershed Planning Study, GIS analysis of stormsewer catchments was undertaken to determine the potential public lands sites which show potential for a stormwater retrofit. The project team used an automated GIS analysis tool to identify all potential SWM facility opportunity locations. The initial parameters for site identification were City owned parcels or vacant land that was within 50 m of a storm sewer with a diameter of 450 mm or larger. SWM facility opportunity parcels were excluded if they were within existing catchments with water quality control. The initial screening assessment of the study area identified several potential sites. Subsequent review and QA/QC for 'false-positives' including but not limited to: sites that are within the City's NHS system, sites where connections to existing storm sewers could not be made, or vacant land that was being developed with stormwater controls.

Table 6-3 Identifies the top 4 locations for implementing Ponds or subsurface infiltration chamber systems in municipal properties. Currently, 13.25% of the urbanized areas of the City of Peterborough are provided with stormwater quality control via SWM ponds or OGS units. The last column identifies the additional percentage of urban area treated via the end of pipe retrofit.

Table 6-3: Summary of Top Infiltration Locations

Subwatershed	Location	Catchment Area (ha) excluding Open Space and NHS	Primary Catchment Land Use	Additional Urban Area Treated (%)
Urban Catchment	Collison Park between Southpark Drive and WWTP	11.4	Residential	0.2
Urban Catchment	RA Morrow Memorial Park	102	Residential and Commercial	1.6
Byersville	Kinsmen Park	10.5	Residential	0.2
Jackson	Hamilton Park	7.4	Residential	0.1

Figure 6-2 through Figure 6-5 show these potential retrofit locations and associated Catchments.

To further assess the feasibility of these sites, it is recommended that an End of Pipe Opportunities Assessment is undertaken. The recommended approach to this type of study is outlined below.

Phase 1 of this study would involve an assessment involved screening based on desktop review of mapping data including but not limited to storm sewer mapping, satellite imagery / aerial photography,

NHS mapping and parcel mapping. Specific constraints assessed at this level include but are not limited to:

1) **Available area** (area must be >1ha);
2) **Land Ownership**: Municipal (M), Conservation Area (C), Provincial (P) including transportation corridors, Hydro Corridor (HC), Unknown land ownership (Unk), and Vacant lands (V);
3) Stormwater Infrastructure
    - Pipe Size: > 450mm,
    - Pipe Depth;
    - Drainage Area;
    - Drainage area (sewershed);
    - Total Impervious Area Percentage (TIMP);
4) Topographic Constraints;
5) Significant Vegetation & Wetlands; and
6) Preliminary Water Quality Estimates.

Phase 2 of this study would involve field reconnaissance to confirm and or identify site characteristics which were not evident within the GIS mapping and aerial photography examined during the Phase 1 – desktop assessment. General site characteristics that may be noted and or delineated in the field may include:

- General site characteristics
- Topography
- Existing stormwater infrastructure and drainage issues
- Confirmation and/or observation of utilities
- Confirmation of current use, programming and condition
- Vegetation boundaries
- Identification of invasive species (where possible)
- Confirmation of wetland areas
- Observation of delineated floodplain limits
- Watercourse and outfall water quality conditions
- Confirmation of vacant lands (surface cover and evidence of activity)
- Related infrastructure issues
- Surrounding land-uses and encroachments onto non-private property

Phase 3 of this type of study is a performance assessment intended to develop conceptual SWM facility alternatives for each of the feasible or possible SWM opportunity locations carried forward from Phases 1 and 2 using a set of primary and secondary evaluation criteria. The conceptual alternatives identify details such as SWM facility type, size, configuration and function for each potential location.

While public parks are ideal spaces to implement end-of-pipe stormwater retrofits for large catchment areas, their primary use remains public recreation and any changes to park infrastructure must be

approved and planned in collaboration with municipal parks planners and management staff. While subsurface facilities have little long-term impact on recreational use and operations, consideration must be given to construction-phase closures. In order to identify constraints, opportunities and synergies with other City of Peterborough projects (e.g. Park Rehabilitations), it is recommended that **Phase 4** consisting of consultation with City staff responsible for municipal park planning and management be undertaken before conceptual designs are formalized and priorities are set.

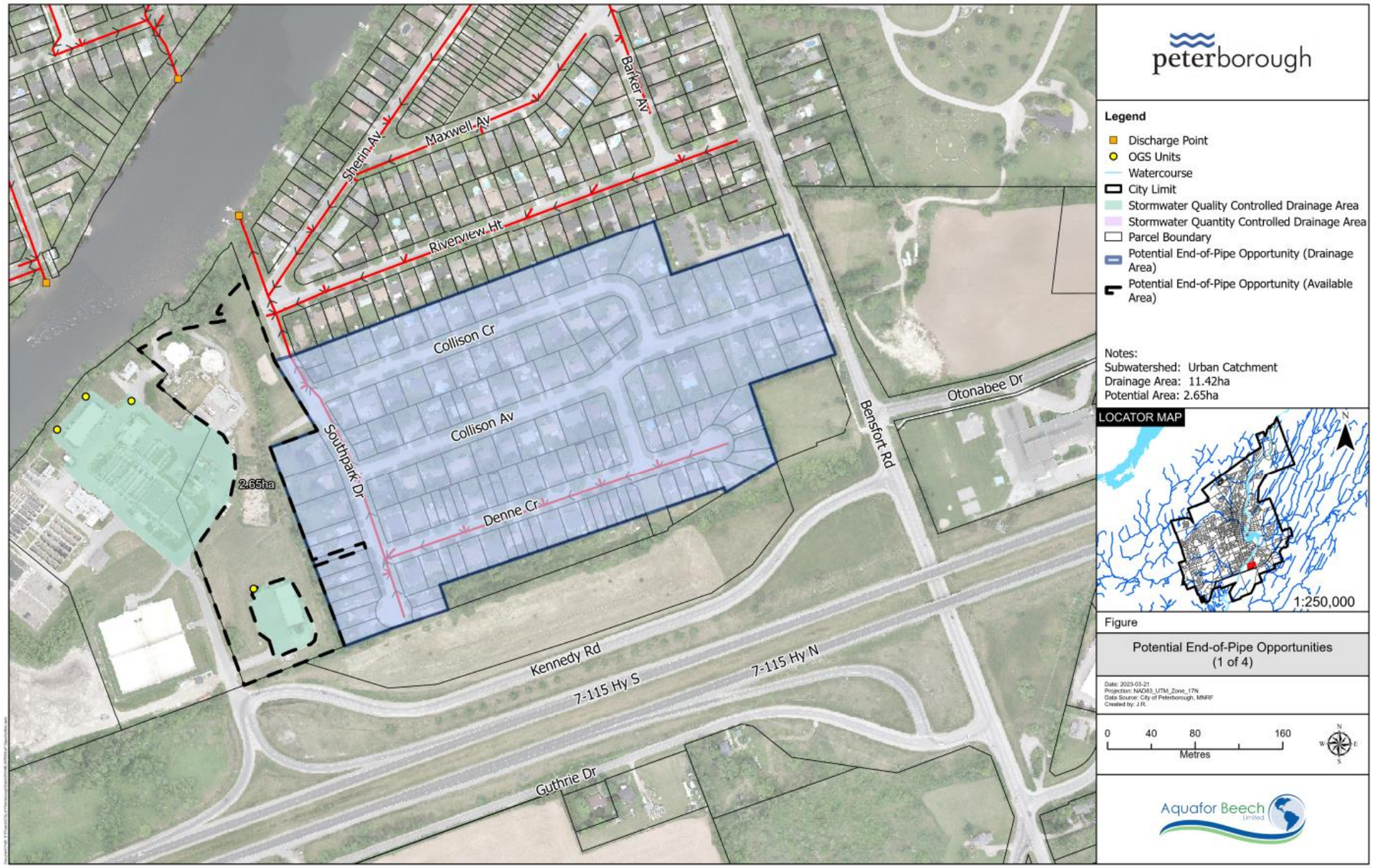

Figure 6-2: Retrofit location 1 and associated catchment

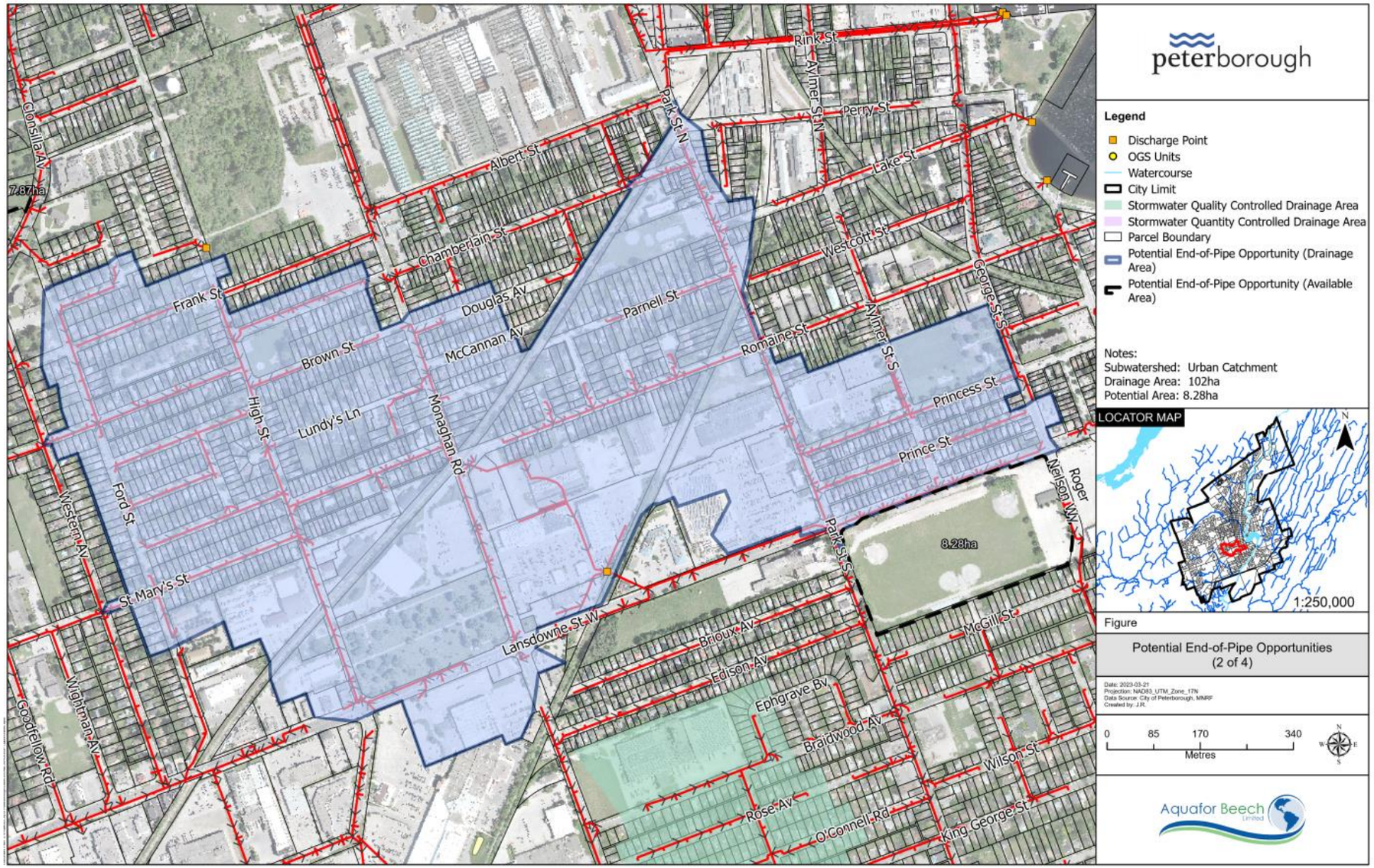

Figure 6-3: Retrofit location 2 and associated catchment

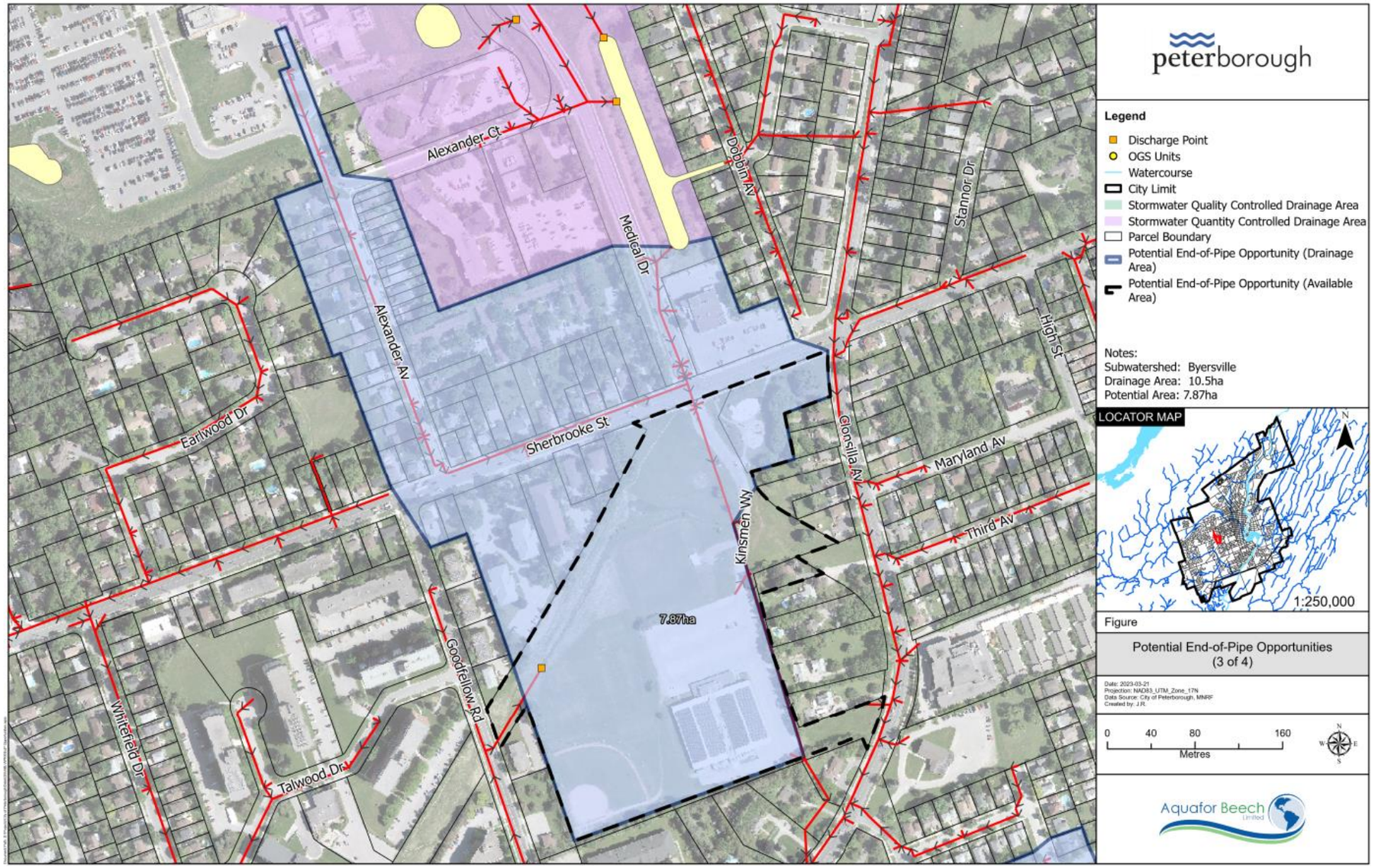

Figure 6-4: Retrofit location 3 and associated catchment

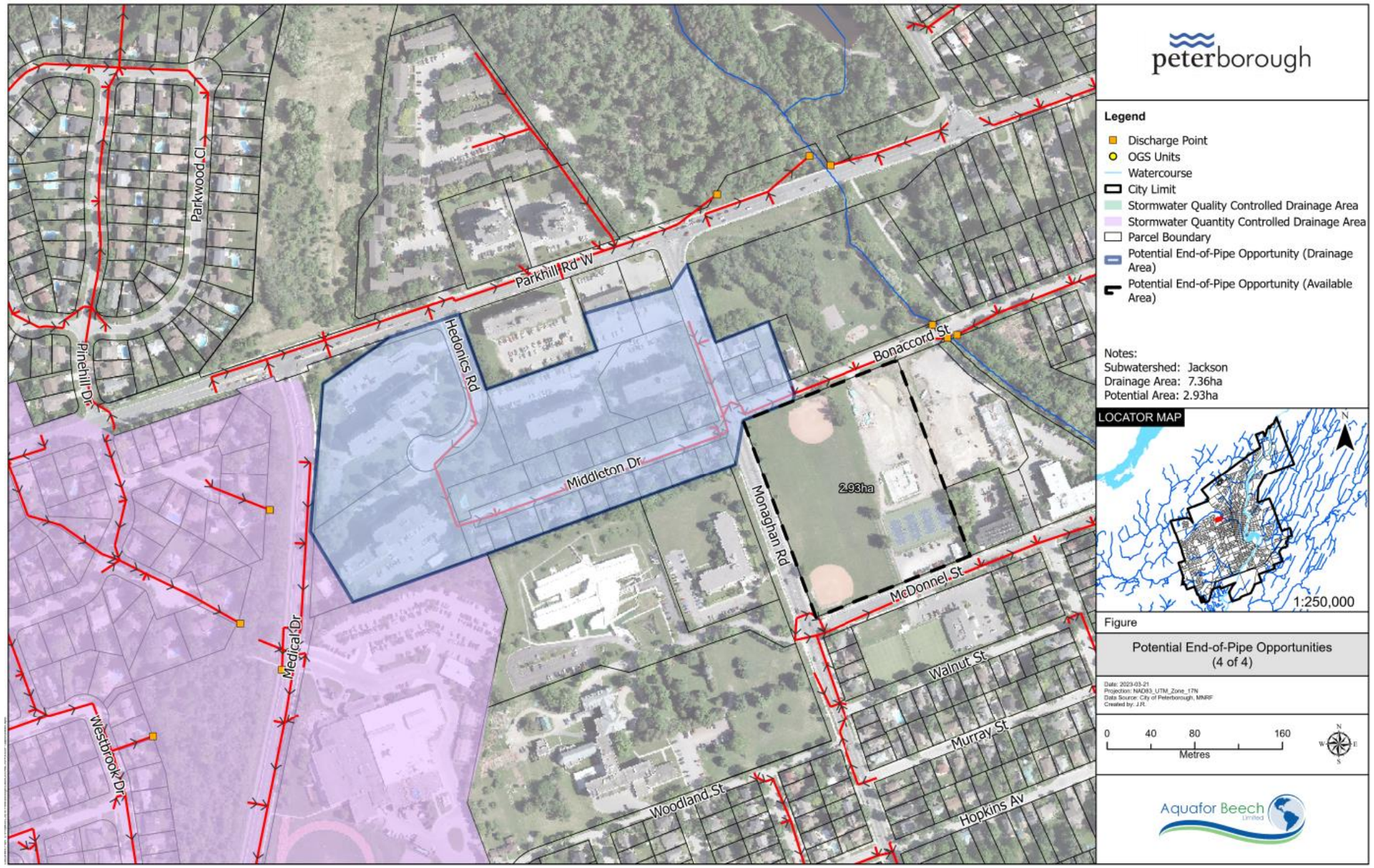

Figure 6-5: Retrofit location 4 and associated catchment

OGS Units within the existing Storm Sewer Network: As part of the Watershed Planning Study, GIS analysis of stormsewer catchments was undertaken to identify the largest uncontrolled catchments with direct drainage to the Otonabee River. In the urban area of the city, these sites typically lack large public spaces at the outfall for pond or subsurface retrofits. These areas are ideal for the implementation of OGS units.

Table 6-4 Identifies the ten largest uncontrolled catchments with direct drainage to the Otonabee River. Currently, 13.25% of the urbanized areas of the City of Peterborough are provided with stormwater quality control via SWM ponds or OGS units. The last column identifies the additional percentage of urban area treated via the end of pipe retrofit.

Table 6-4: Largest uncontrolled catchments with drainage to the Otonabee River

Subwatershed	Outfall No.	Total Catchment Area (ha)	Catchment Area (ha) excluding Open Space and NHS	Primary Catchment Land Use	Additional Urban Area Treated (%)
Jackson	139976 and 139977	198	198	Residential, Commercial and Industrial	3.1
Urban Catchments	262497	56	56	Residential and Commercial	0.9
Urban Catchments	139814	67	47	Residential	0.7
Urban Catchments	139818 Note: Also identified Opportunity for Park Retrofit	52	42	Residential	0.7
Urban Catchments	160321	85	39	Residential and Institutional	0.6
Urban Catchments	16569	38	38	Residential and Commercial	0.6
Urban Catchments	139832	50	36	Residential	0.6

Subwatershed	Outfall No.	Total Catchment Area (ha)	Catchment Area (ha) excluding Open Space and NHS	Primary Catchment Land Use	Additional Urban Area Treated (%)
Urban Catchments	139913	31	30	Residential,	0.5
Urban Catchments	139983	31	29	Residential and Industrial	0.5
Urban Catchments	168035	31	25	Residential	0.4

Figure 6-6 through Figure 6-15 show these potential OGS retrofit locations and associated catchments.

Because the removal efficiencies of OGS units are dependent on the particle sizes and tend to be higher for sediment with coarse particle size distribution, the City of Peterborough may consider undertaking a sediment analysis to characterize the average particle size distribution of sediment in the City. For such a study it is recommended that sediment samples be collected from catch basins located in different areas within the City to ensure representative samples are analysed. Ideally the study would also estimate loading rates from different land uses by measuring sediment depth accumulated in catch basin sumps.

To ensure results are applicable to all areas of the City, samples could be taken in:

- industrial/commercial areas;
- new subdivisions (immediately after assumption);
- mature subdivision (minimum of 10 years post assumption); and
- old subdivisions (minimum of 30 years post assumption).

Once an average representative particle size distribution is identified for the City, the removal efficiency of ETV certified OGS units can be approximated using the removal efficiencies and assumed surface loading rates in the ETV protocol.

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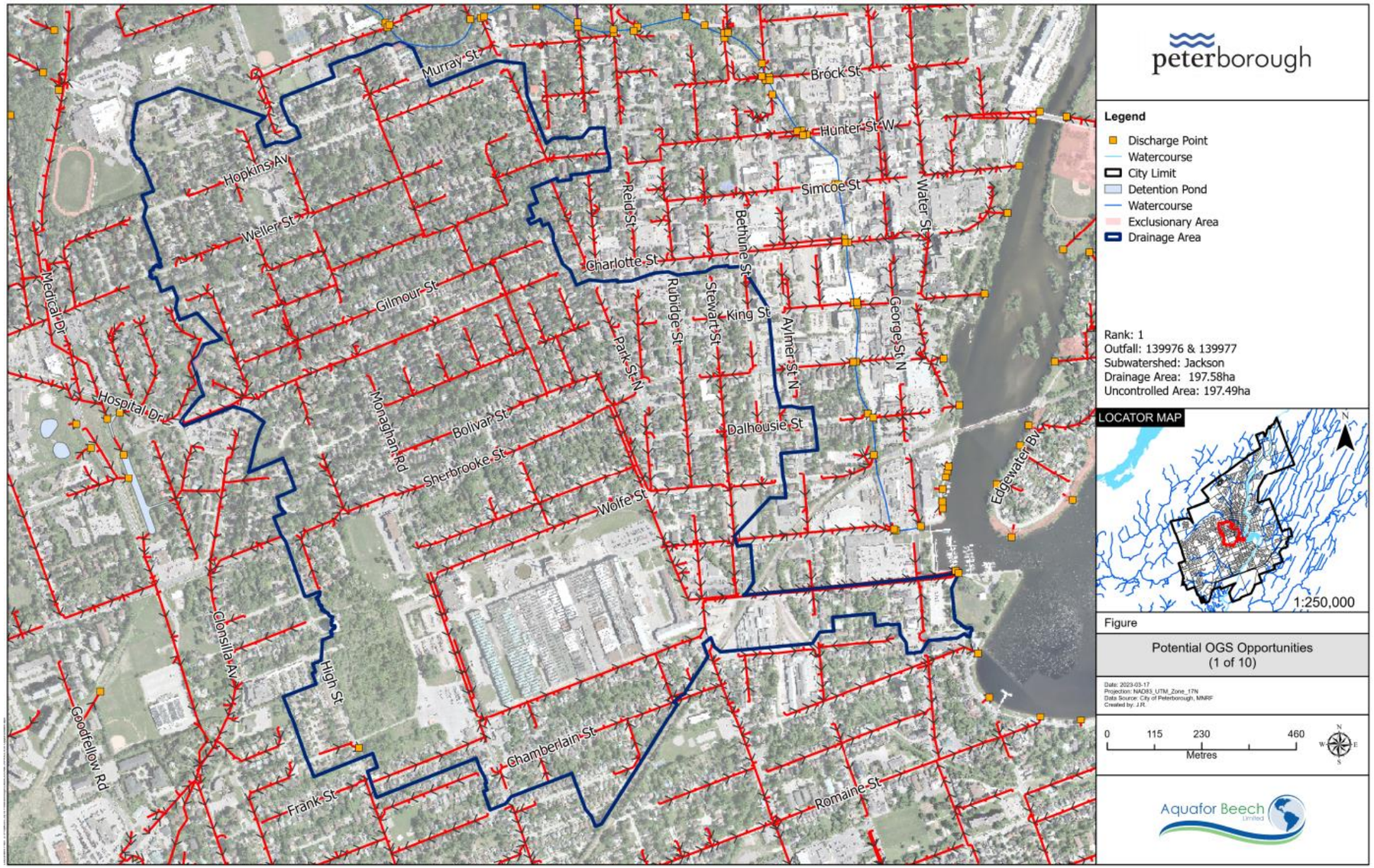

Figure 6-6: OGS retrofit location 1 and associated catchment

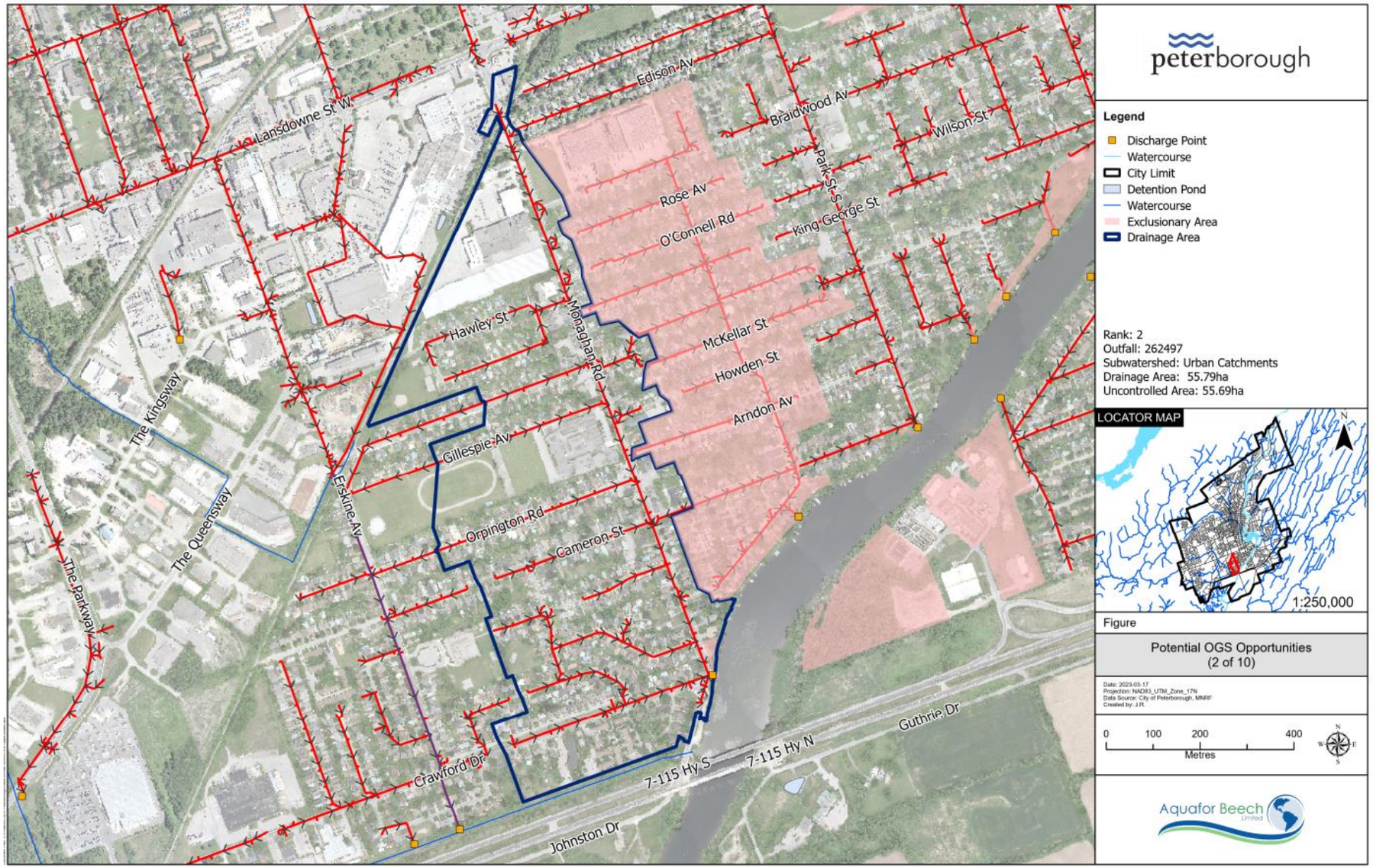

Figure 6-7: OGS retrofit location 2 and associated catchment

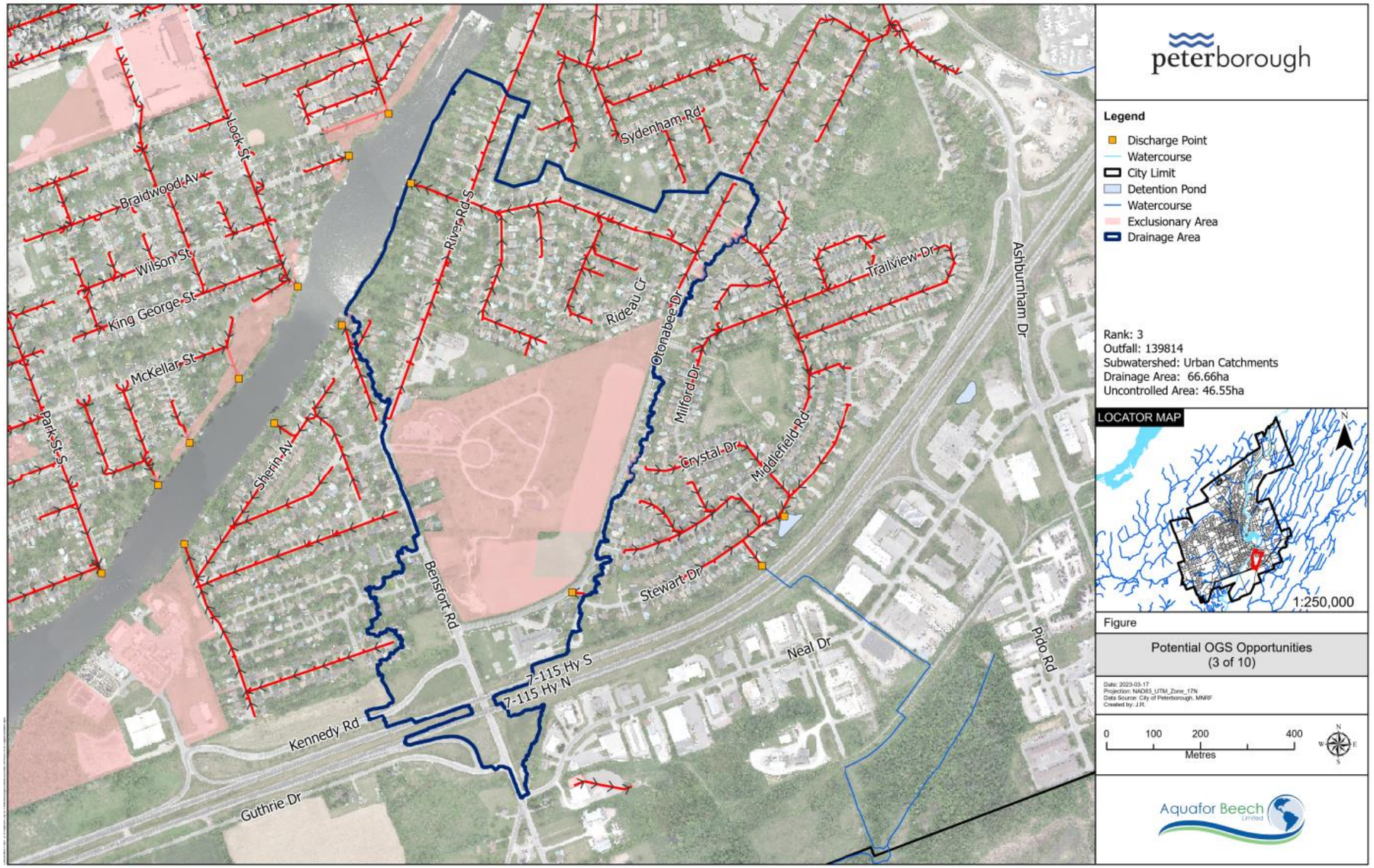

Figure 6-8: OGS retrofit location 3 and associated catchment

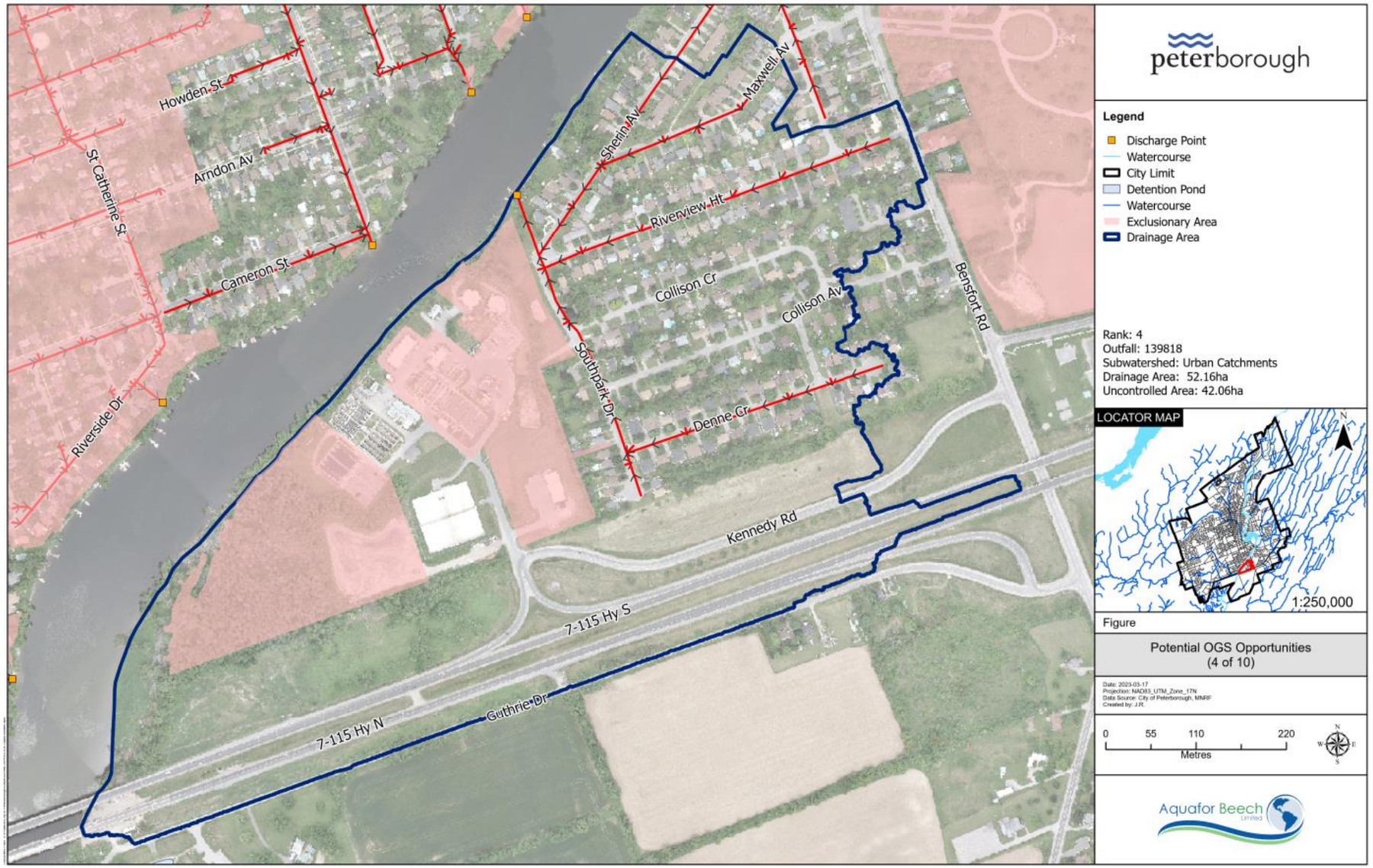

Figure 6-9: OGS retrofit location 4 and associated catchment

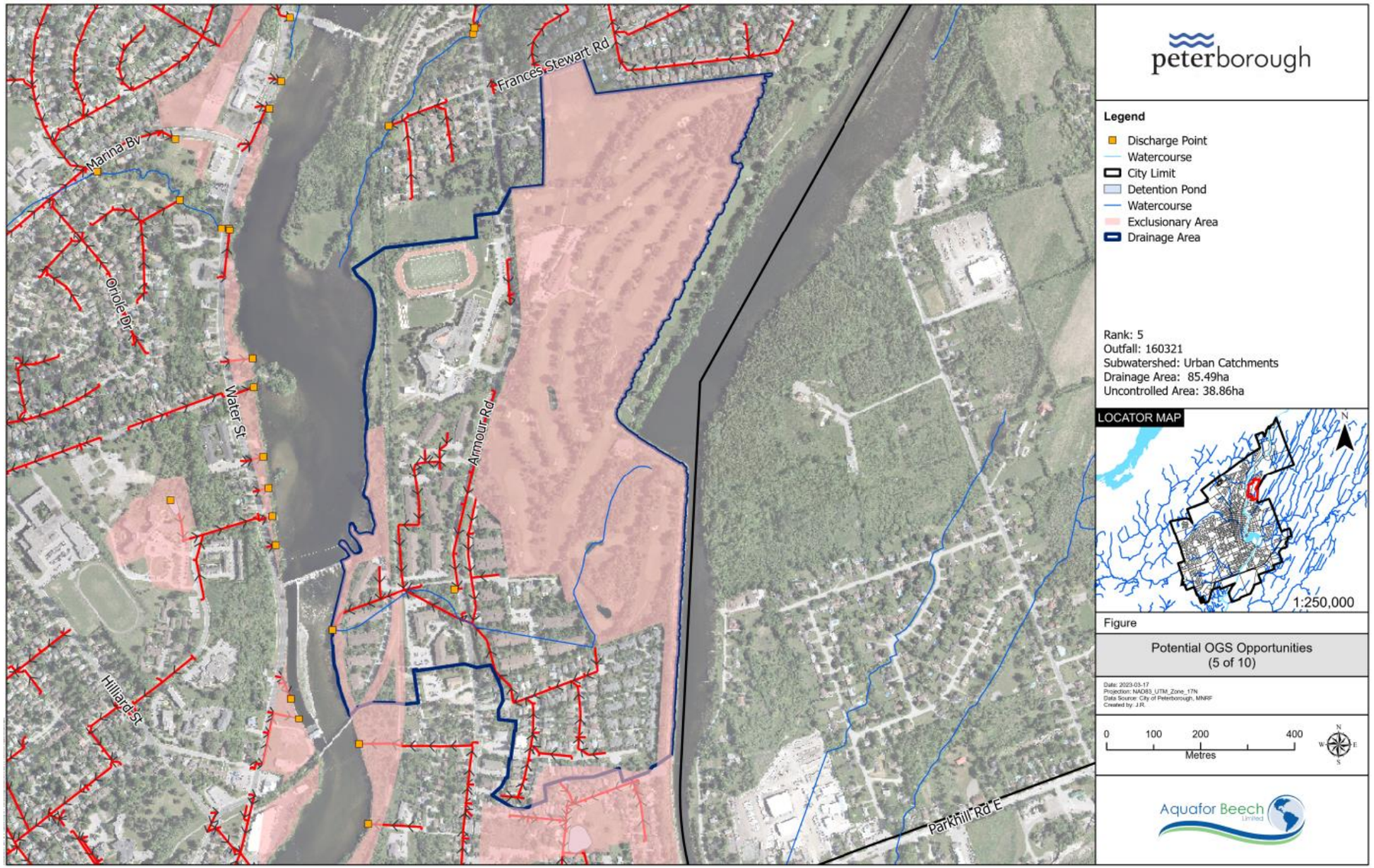

Figure 6-10: OGS retrofit location 5 and associated catchment

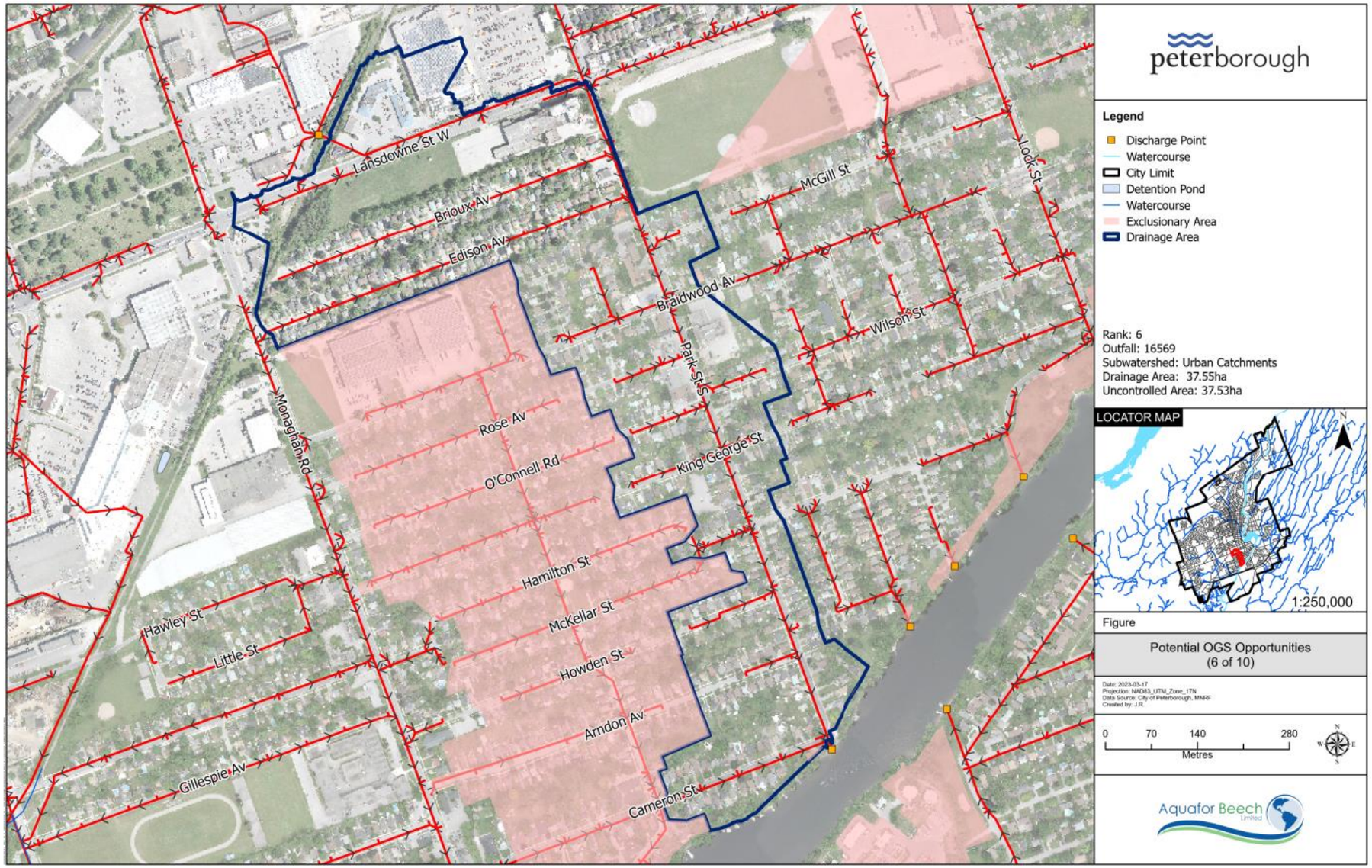

Figure 6-11: OGS retrofit location 6 and associated catchment

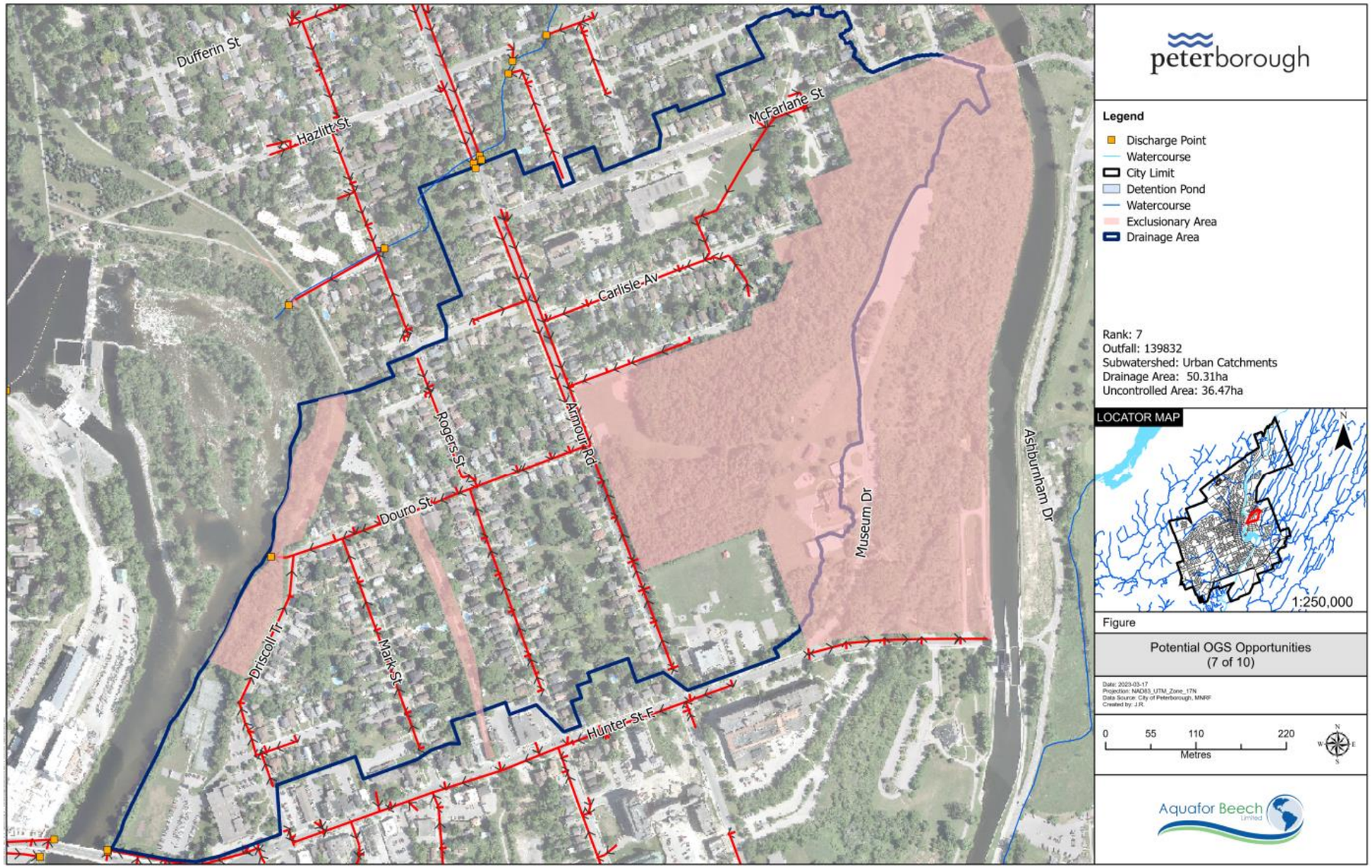

Figure 6-12: OGS retrofit location 7 and associated catchment

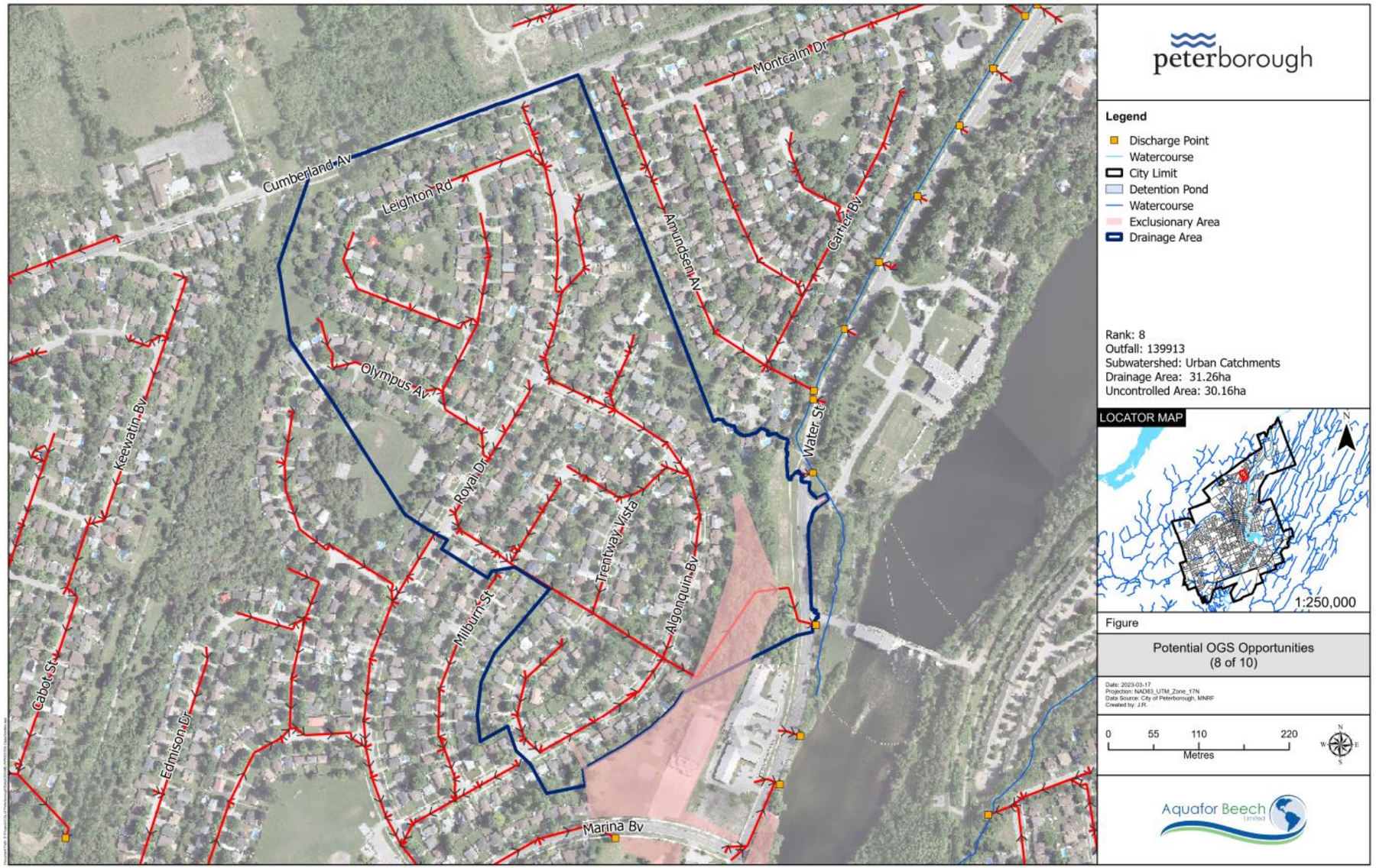

Figure 6-13: OGS retrofit location 8 and associated catchment

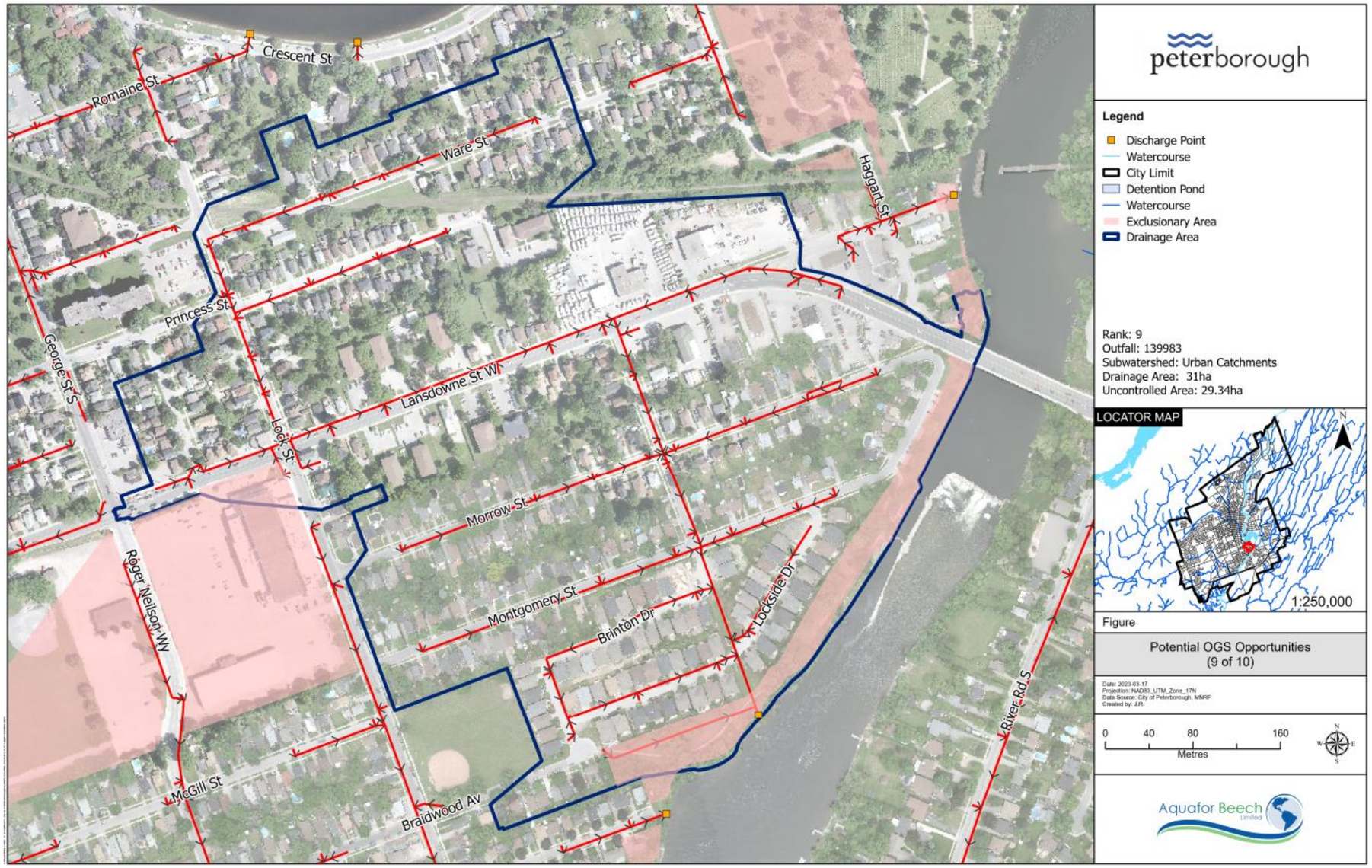

Figure 6-14: OGS retrofit location 9 and associated catchment

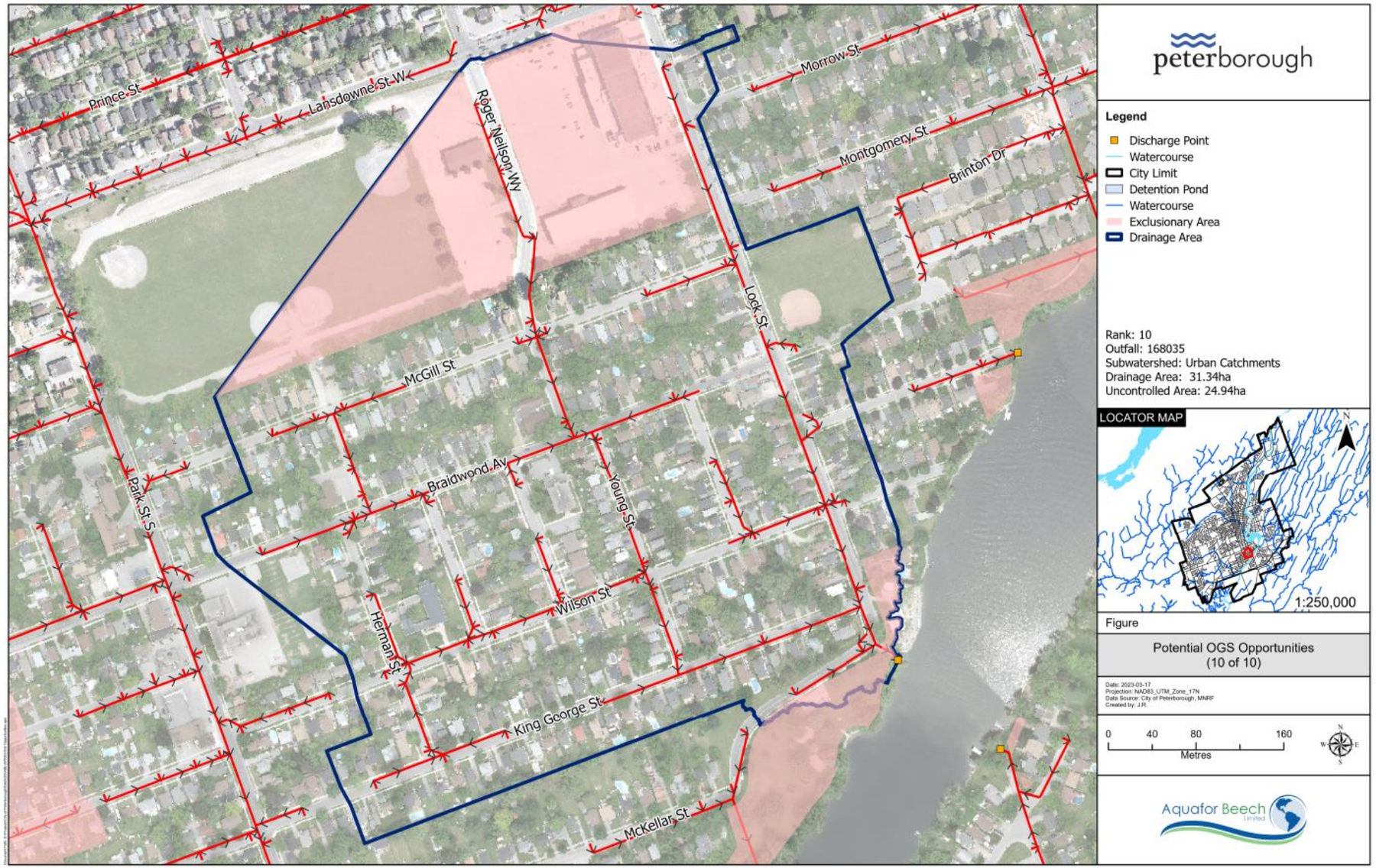

Figure 6-15: OGS retrofit location 10 and associated catchment

Approvals, Policy, By-law or Design Standards Consideration

End of Pipe SWM Facilities in existing Parks

The recommended works for new SWM facilities must be completed following a Municipal Class EA process. A city-wide study covering all potential locations is recommended using Schedule B. This study must consider all environmental, social, economic and culture impacts of SWM works. After the city-wide study is complete, the City can proceed directly to detailed design and implementation. Public Consultation must be undertaken as part of this Class EA process.

The project would follow the City's CLI Compliance Approval process per Section 53 of the Ontario Water Resources act / Application for Approval of Municipal and Private Sewage works will be required prior to the construction of all new SWM facilities.

MNRF permits will only be required where projects may impact Species at Risk. Under the Endangered Species Act, the Ministry of Natural Resources can grant different types of permits or other authorizations for activities that would otherwise not be allowed, with conditions that are aimed at protecting and recovering species at risk.

DFO administers development requirements relating to aquatic habitat under the Fisheries Act. This applies to work being conducted in or near waterbodies that support fish that are part of or that support a commercial, recreational or Aboriginal fishery. To protect fish and fish habitat, efforts should be made to avoid, mitigate and/or offset harm. A self-assessment will need to be undertaken for new park projects involving works in wetlands and watercourses.

A permit under Ontario regulation 167/06 - Development, Interference with Wetlands and alterations to Shoreline Watercourse will be required through the ORCA for new facilities within regulations limits that impacts a wetland or requires the establishment of an outlet.

OGS Units in Existing Storm Sewer Networks

MECP approval through the City's CLI process is required for all new OGS units. The Ministry has also developed the Checklist for Technical Requirements for a Complete ECA Submission, which will be used by Ministry staff to review and assess each application against the legislative and ministry requirements. For OGS units the following must be submitted for review:

- Engineering Drawings, stamped & signed by P.Eng.
- Manufacturer specifications and modeling

- Sediment capacity
- Oil capacity
- Total holding capacity
- Flow rate
- Catchment area
- Impervious area (%)
- Annual TSS removed (%)
- Annual runoff treated (%)

Cost

The material and installation costs associated with OGS units are considerable and depending on the unit type and size. Purchase costs for the units themselves can range from approximately $80,000 for those capable of treating areas smaller than 1 ha to $500,000 for those capable of treating 10 ha. The largest units, capable of treating upwards of 50 ha cost approximately $1 million and multiple units may be required to treat larger catchment areas. Capital costs associated with construction will vary significantly depending on the location and site-specific constraints such as bedrock removal or dewatering requirements.

The removal of sediment and liquid waste (accumulated hydrocarbons) is a considerable cost associated with ongoing operation of OGS units. Contracting out the maintenance of municipal OGS units may be feasible to avoid staffing and equipment costs. Based on available tendered costs from Ontario municipalities, the cost of sediment removal is approximately $725/tonne while the cost of liquid waste removal is approximately $80/$m^3$.

Implementing SWM Treatment in Parks

As a high-level estimate of the construction cost associated with surface and subsurface storage facilities, the following must be considered:

1) The unit costs for subsurface facilities ranged from $350/$m^3$ to $450/$m^3$ per unit of water quality storage volume provided. This is based on costing for each subsurface storage unit has been based on unit costs of previously constructed facilities in the GTHA, through discussions with several municipalities and product distributors.
2) A minimum construction cost of $350,000 per facility for smaller facilities should be considered to account for costs associated with mobilization, demobilization, bonding, erosion and sediment control and dewatering etc.

Parks Rehabilitation

In addition to the above, the cost to rehabilitate the respective park and or park features has been estimated based on similarly scoped retrofits. Three (3) levels of park rehabilitation have been assigned:

1) Low Park Rehabilitation ($50,000 to $100,000) – represent minor repairs, relocation of existing park features, tree planting and minor improvements to trails.
2) Moderate Park Rehabilitation ($250,000 to $500,000) - represent moderate repairs, relocation of existing park features, tree planting and moderate improvements to trails and general construction of new park features.
3) High Park Rehabilitation ($500,000 to $1,000,000) - represent reconstruction of high value park features and general construction of new park features (sports fields etc.).

Integration

Integration with existing public usage in critical to the implementation of SWM retrofits in public spaces such as parks. While subsurface facilities have little long-term impact on recreational use and operations, consideration must be given to construction-phase closures. Surface facilities require additional integration strategies including safety, proximity to other park features, maintenance access / staging, impact on wildlife including nuisance species, undesired public interactions, and walkability.

Operation and Maintenance

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

6.13.2 Pollution Prevention Measures

1. **Catch Basin Programs** – The removal and off-site disposal of sediment from end-of-pipe (EOP) facilities are the most substantial costs associated with maintaining such facilities. As such, the optimization of a catch basin clean-out program may represent a significant

reduction in sediment within EOP facilities, reduce total maintenance costs and extend their required performance for a longer period. In order to understand the effect of a catch basin clean-out program on final sediment removal and disposal cost, when compared to EOP facilities clean-outs in the City of Peterborough, a long-term analysis of loading rates and sediment quality may be undertaken**.**

2. **Sediment Removal from Oil and Grit Separators** – OGS units use hydrodynamic separation to remove sediment and hydrocarbons from urban runoff. These units require regular inspection and maintenance in order to function as designed. The City is responsible for the operation and maintenance of these OGS units per the conditions of the respective MECP CLI Environmental Compliance Approval (ECA). Long-term analysis of loading rates and sediment quality may provide optimized scheduling and prevent bypasses to natural stream receivers.

6.14 Flood Risk Mitigation

As part of this project a Future Flood Assessment was undertaken to identify and prioritize areas within the City where floodplain mapping needs to be updated, taking into account existing floodplain mapping, recent developments, and future climate change projections. This component of the study included an analysis of changes to IDF parameters based on downscaled climate models and an assessment of the impact of climate change on the Regional regulatory event. In the City of Peterborough all floodlines were developed for the Regional storm event (1961 Timmins storm). Since the Regional storm is not a statistical event, analogous return periods can be used to assess potential impacts on such infrequent events. It should also be noted that changes in annual snow pack may also play a role in flood frequency as climate trends result in flashier winter hydrologic systems.

Prioritization and Future Studies

Recommendations related to Floodplain Mapping Prioritization and Future Studies are identified in the recommendations of the Future Flood Studies Report :

- Prioritize Floodplain Mapping updates in Byserville Creek (note: underway), Bears Creek and Riverview Creek due to the age of Floodplain Mapping and gaps in coverage within these subwatersheds.
- As the City complete projects from the Flood Reduction Study, that these changes are updated in hydraulic models to account for changes in hydrology or hydraulics resulting from the project.
- That the City incorporate water quality improvement, habitat enhancement, and other watershed health improvement components to flood mitigation projects were feasible.
- That the impacts of backwater effects of the Otonabee River flooding be investigated as part of future urban flood studies.

Costing for Floodplain Mapping Updates

Updates to floodplain mapping will range in cost significantly depending on:

- Whether significant lengths of channel cross-sections need to be updated via LiDAR and verified via ground truthing;
- Whether infield surveys are needed at crossings or as built drawings can be used;
- Whether all catchments need to be re-parametrized; and
- Whether 2D modelling is required to determine risk in urban areas.

A simple update of hydraulics to account for changes to channel profiles and/or crossings or an update to catchments where urbanization has occurred may cost less than $20,000. Updating to flow rates to account for climate risk may also be done at smaller cost using existing hydraulic models. Full updates to both hydraulic and hydrologic models and preparation of Floodplain Mapping will cost $50,000 to $100,000 depending on

6.15 Project Prioritization Recommendations

As part of the Characterization Report, each subwatershed was ranked based on overall subwatershed health. Overall subwatershed health was determined by analyzing available data related to stormwater management systems, water quality, the local aquatic ecosystem, and the local terrestrial ecosystem. The results of this ranking are identified in **Figure 6-16.** Overall subwatershed health scores are made up of stormwater management, water quality, aquatic ecosystem, and terrestrial ecosystem scores. Degraded or unsatisfactory conditions are given a higher score, with a maximum of five (5) points given in each category. When subwatershed health improvement projects are being prioritized, those in subwatersheds with higher subwatershed health scores should be prioritized higher than similar projects in lower priority subwatersheds. Priority 1 subwatersheds include: Curtis Creek (Downstream), Bears Creek (Urban), Stewart Hall (Urban), Byersville Creek, Fisher Creek (Urban), and Whitlaw Creek.

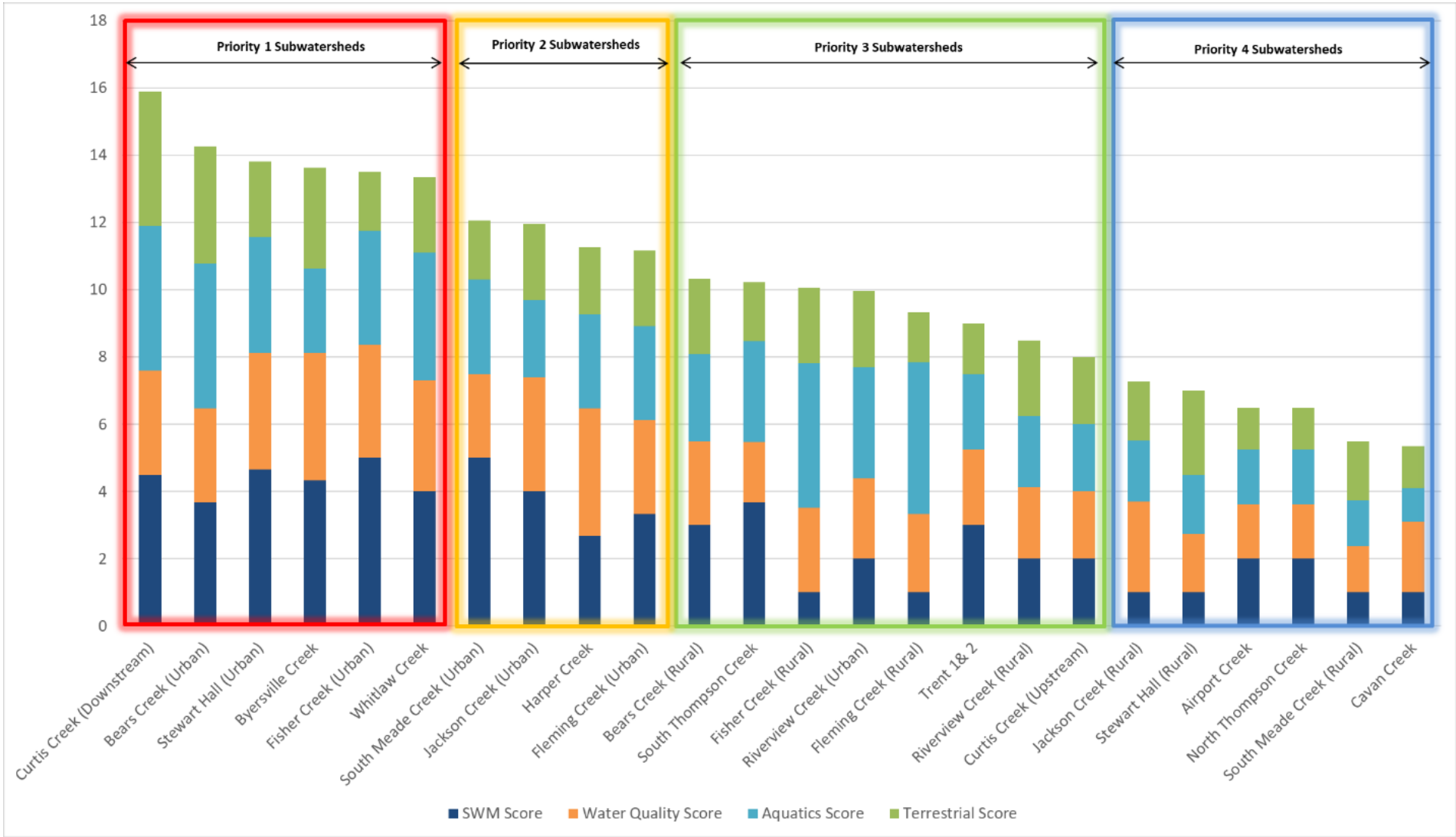

Figure 6-16: Priority Subwatersheds

The City of Peterborough has already completed a ranking process of 101 of the projects identified through the Flood Reduction Study process. **Appendix A** provides the ranking of each project, but the top 20 projects have also been identified in **Table 6-5**. Of the 20 projects, 10 are in process or complete, while the remaining projects are in the budgeting phase.

As these and other infrastructure projects are completed, it is important to continue updating the models to account for changes in hydrology or hydraulics resulting from the project. As a project reaches completion, it is recommended that as-built drawings are shared with modelers at the City of Peterborough and at Otonabee Conservation, and that the modelers prioritize regularly updating the models with the new information.

Table 6-5: Top 20 Project Priorities

Subwatershed	Project Ranking	Terrestrial Health	Stormwater Management	Water Quality	Aquatic Health	Subwatershed Rank	Impact on Watershed Health Metrics	Task Name	Description	Status
Jackson (Urban)	1	Fair	Marginal	Marginal	Fair	8	Improve Aquatic Health (if concrete removed wherever possible)	B-19	Upgrade Brookdale channel with armour stone	In Process
Byersville	2	Fair	Poor	Marginal	Fair	4	Improve Aquatic Health	Culvert Replacement at CPR East of Parkway	The twin 2.0m CSP culverts under the CPR rail line east of The Parkway, will have an interceptor berm constructed that would limit inlet flows to high flood conditions and redirect runoff to main channel west of the Parkway which will be compensated for by excavation.	In Process
Byersville	3	Fair	Poor	Marginal	Fair	4	Improve Water Quality and Stormwater Management	Kawartha Heights Pond Improvements	Replace or modify the existing outlet control structure at the pond dam to make better use of available storage in the pond, and thereby reduce peak outflows from the pond. Large OGS units to be placed at the two park inlets as part of project.	In Process
Urban	4	NA	NA	NA	NA	1	Improve Water Quality (if OGS units, catch basin shields, or other best	Simcoe Street	Add 11 CBs	In Process

Subwatershed	Project Ranking	Terrestrial Health	Stormwater Management	Water Quality	Aquatic Health	Subwatershed Rank	Impact on Watershed Health Metrics	Task Name	Description	Status
							practices used)			
Byersville	5	Fair	Poor	Marginal	Fair	4	-	Weller Street Parkway Improvements	Ensure an adequate and properly designed overland flow route to take excess flow from the Weller Street low point southward along The Parkway corridor	Complete
Whitlaw	6	Fair	Marginal	Marginal	Marginal	6	-	Walker Avenue Between Bramble Road and Meadowview Road	Intercept flows and transmit them safely to a proposed outlet to Whitlaw Creek & construct overland flow route to Whitlaw Creek	Complete
Jackson (Urban)	7	Fair	Marginal	Marginal	Fair	8	-	Diversion Sewer	New sewer to divert high flows in Jackson Creek directly to the Otonabee River	In Process
Bears (Urban)	8	Marginal	Marginal	Fair	Poor	2	-	Major System Capture and By-pass	To substantially increase the flow-carrying capacity along Marina Boulevard from Hilliard Street to the Royal Drive intersection.	Complete
Jackson (Urban)	9	Fair	Marginal	Marginal	Fair	8	Improve Water Quality (if OGS units, catch basin shields, or other best practices used)	SEJ-4	Upgrade Charlotte Street sewer from Downie Street to Jackson Creek to 100 year capacity	In Process
Byersville	10	Fair	Poor	Marginal	Fair	4	Improve Stormwater	Clonsilla Avenue/Parkway Detention Basin	Existing City-owned land parcel along the west side of Byersville Creek between Clonsilla Avenue and Lansdowne Street	

Subwatershed	Project Ranking	Terrestrial Health	Stormwater Management	Water Quality	Aquatic Health	Subwatershed Rank	Impact on Watershed Health Metrics	Task Name	Description	Status
							Management		West is large enough to provide for an estimated 40,000 m^3 of storage.	
Jackson (Urban)	11	Fair	Marginal	Marginal	Fair	8	Improve Water Quality (if OGS units, catch basin shields, or other best practices used)	NEJ-1	Construct a relief storm sewer parallel to existing - from: Hilliard, along Phillip, McLennan, Gilbert, Elizabeth & Nicholls - from Nicholls & Dumble upsize exiting pipe to 100yr capacity	
Jackson (Urban)	12	Fair	Marginal	Marginal	Fair	8	Improve Water Quality (if OGS units, catch basin shields, or other best practices used)	NEJ-3	100-year storm sewers along Water & Simcoe	
Jackson (Urban)	13	Fair	Marginal	Marginal	Fair	8	Improve Water Quality (if OGS units, catch basin shields, or other best practices used)	SEJ-3	Upgrade Simcoe Street sewer from Stewart Street to Jackson Creek to 100 year capacity	

Subwatershed	Project Ranking	Terrestrial Health	Stormwater Management	Water Quality	Aquatic Health	Subwatershed Rank	Impact on Watershed Health Metrics	Task Name	Description	Status
Urban	14	NA	NA	NA	NA	2	-	River Road South -OLF Easement	Regrade easement west of Southlawn	
Jackson (Urban)	15	Fair	Marginal	Marginal	Fair	8	-	B-9	Regrade private property (381 Highland)	
Urban	16	NA	NA	NA	NA	3	-	Fisher Drive	Construct 190m-long berm behind building	
Jackson (Urban)	17	Fair	Marginal	Marginal	Fair	8	-	SWJ-4	Regrade 868 Valleyview Drive	
Jackson (Urban)	18	Fair	Marginal	Marginal	Fair	8	-	B-14	Regrade private property (582 Gilchrist)	
Jackson (Urban)	19	Fair	Marginal	Marginal	Fair	8	-	B-16	Regrade private property (638 Stormont)	
Curtis (Downstream)	20	Marginal	Poor	Marginal	Poor	1	Improve Aquatic Health (use best practices for culvert design)	Rogers St/Tivey Outlet Improvements	2 - 3.0 m x 1.5 m box culverts and associated channel improvements	Complete

6.16 Modelling Prioritization Recommendations

The top three subwatersheds recommended for modeling upgrades include Byersville Creek, Bears Creek and Riverview Creek. Within all three subwatersheds, infrastructure upgrades and new developments have occurred since floodplain mapping was last completed. All three also contain Designated Greenfield Areas where new developments are slated to occur.

1) **Byersville Creek –** Modeling in Upper Byersville Creek was last completed in 1991, although the lower reaches of the creek were modelled in 2014. However, the 2014 models included structural prevention measures not supported by the MNRF. Byersville Creek also ranked second highest for risk to structures if the floodplain were to increase. Since Harper Creek is a tributary to Byersville Creek, it should be included in the model update.
2) **Bears Creek –** Modeling was last completed in 1991, although some portions of the floodplain were modeled in 2020. Bears Creek also ranked third highest for risk to structures if the floodplain were to increase.
3) **Riverview Creek –** Modeling of Riverview Creek was completed in 2009 and 2011, although Otonabee Conservation has named concerns regarding topographic information, and noted that the model does not extend all the way to the watershed extents. Riverview Creek also ranked fourth highest for risk to structures if the floodplain were to increase.

Although the Otonabee River is outside of the scope of this project, it should be noted that its floodplain mapping has not been updated since 1991 and the greatest number of structures at risk if the floodplain becomes larger are within the Urban Subwatersheds. It is therefore recommended that the Otonabee River floodplain mapping be updated such that accurate information is available for Emergency.

6.16.1 Future Studies Recommendations

The present study did not investigate the effect of backwater from the Otonabee River on flooding within the study's primary subwatersheds. The completion of flood reduction projects will have negligible impact on this type of flooding. It is recommended to distinguish between Otonabee backwater and flooding from the creek in question to determine whether upstream upgrades have a potential to reduce this flooding.

6.17 Updates to City of Peterborough Engineering Design Standards

Engineering standards including design targets, assumptions and analysis techniques related to stormwater management are described in City of Peterborough Engineering Design Standards

(2022). This study has identified a number of recommended updates to the Engineering Design Standards. These recommendations are summarized in Table 7-6.

Table 6-6: Recommended Engineering Design Standard Updates

Recommended Update	Description
Add Climate Change Rainfall IDFs	Climate Change Derived IDF Parameters to be added to **Section B.1.7 of the 2022 Engineering Design Standards** to allow for Climate Change "Stress Test" on Conveyance infrastructure.
Add ROW Cross-Sections with LIDs	LID Practices to be added to Standard R.O.W. Cross-Sections on **Pages 106 through 113 of the 2022 Engineering Design Standards**.
Add LID-specific Erosion and Sediment Control	Update **Section D.2.4.H of the 2022 Engineering Design Standards** to require proper staging and protection of infiltration practices during construction.
Differentiate 90th Percentile Water Quality Capture Targets from Water Balance Targets	Update **Section D.2.4.D of the 2022 Engineering Design Standards** to clearly differentiate the water balance targets from the 90th percentile water quality target.

7 Recommended Approach for Rural Subwatersheds

7.1 Ecological Restoration and Enhancement

Rural Subwatershed areas tend to be on the edge of the City. Ecological protection and restoration opportunities differ in a rural setting as compared to an urban environment. Rural lands are less likely to be experiences significant land use changes in the coming years. Additionally, the existing natural heritage features tend to be larger, more connected, and more resilient. In rural landscapes, connectivity and patch size are the most important aspects of a healthy NHS.

Restoration efforts outside of the city limit will require coordination with ORCA, the County of Peterborough, adjacent municipalities, and First Nations. Location of potential restoration projects should consider two factors:

1) Where will they be most effective for improving connectivity and ecological integrity; and
2) Where will they be most effective for mitigating future climate change impacts.

Restoration of wetlands along watercourses addresses both factors. Wetlands adjacent to watercourses will improve the landscape's capacity to capture increased high flow events and store more water before it flows downstream into urban areas.

Watercourses often connect natural features within the rural area and frequently do not have sufficient riparian buffer to act as a wildlife movement corridor. Environment Canada suggests a minimum corridor width of 50 m to accommodate most wildlife movement. (Environment Canada, 2013). Kawartha Naturally Connected identified large-scale terrestrial corridors and riparian linkages (2013) which revealed that the Cavan Creek, Curtis Creek, Fleming Creek, and South Meade Creek Subwatersheds have watercourses with significant gaps where the watercourse has little to no riparian habitat. The Fleming Creek, North Thompson Creek, and South Meade Creek Subwatersheds are shown to have long gaps along the terrestrial corridors. Restoration efforts should be considered along these corridors.

7.2 Regional Guidance and Policies Recommendations

One of the biggest threats to wildlife in a rural setting are roadways as they can result in habitat loss, direct mortality, inaccessibility to resources, and population fragmentation and isolation. Habitat loss occurs through the direct removal of natural features for the road footprint when a road is first built or expanded. Indirect impacts that extend further into the natural feature such as noise and light pollution, increased contaminants, and greater spread of non-native invasive

species can further reduce usable habitat available (i.e., reduced quality of remaining habitat limits its function).

Direct mortality occurs when there is a collision between wildlife and vehicles; larger, busier roads adjacent to natural heritage areas tend to experience higher levels of wildlife mortality due to collisions. This effect can create a partial or complete barrier to wildlife movement at the road, limiting or blocking access by wildlife to required resources and/or fragmenting populations which increases the risk of local extirpation[6].

The Region should consider developing a guidance document on how to balance the sensitivities of the natural environment with the needs or rural roadways. This document should provide guidance on new roads and existing roads. New roads should consider the large-scale linkages across the landscape when deciding on where they will lie and what road designs are to be implemented. Existing roads can be improved through alterations to road management and rules as well as retrofits. Some species such as frogs, snakes, and turtles have a peak migration window where targeted road closures can dramatically improve the survival rates. Traffic calming measures and reduced speed limits can also decrease the likelihood of direct collisions. Exclusion fencing, ecopassages, curb design, road surface selection, and improved line of sight through targeted lighting and vegetation management can also reduce the risk of direct collisions.

In addition to roads, agriculture can be a source of indirect impacts to natural features through contamination from pesticides and fertilizers as well as soil erosion causing increased sedimentation. Pesticides can have a negative effect on non-target species and causes pollinator decline as well as can bioaccumulate impacting larger wildlife. Fertilizers can run off and enter watercourses causing eutrophication. Better farming practices to reduce erosion and run off can be encouraged through stewardship programs (See **Section 7.4** for more information).

7.3 Subwatershed Studies and Monitoring Plans

This strategy will result in an inventory of the NHS and water resources including natural heritage features, functions, and cultural values. The goal of rural subwatershed studies is to categorize existing resources and provide guidance on how to mitigate existing and potential impacts to the NHS caused by current anthropogenic land use and any proposed changes in land use. They are often completed prior to secondary plans but can also be completed where land use changes are not imminent. The emphasis should be on highlighting areas where

[6] Extirpation is the local extinction of a species but it continues to exist elsewhere.

restoration could be most beneficial and establishing baseline conditions that can lead into a long-term monitoring plan.

Subwatershed studies should build upon the work completed by Kawartha Naturally Connected. Studies should target large forest and wetland patches, potential SAR species and their habitat, locations of potential significant wildlife habitat, ANSIs, and connectivity corridors. Studies should result in a long list of recommendations that can be considered to improve the connectivity and resiliency of the natural landscape. As roads are one of the greatest barriers to connectivity, this should include consideration to where road mortality is most likely and propose potential solutions.

Subwatershed studies should consider all local, provincial, and federal policies listed in **Appendix A** and will result large scale guidance on environmental sensitives that should be considered when developing new road networks and land use changes. Targeted management recommendations and design considerations would also be developed.

The City and Region should consider developing a holistic monitoring plan at a larger scale to evaluate the status of their natural features as climate change and development increase pressures on the natural environment. Holistic monitoring plans usually include the terrestrial and aquatic ecology, groundwater, rainfall, surface flow, water quality, fluvial geomorphology, and storm water. Programs of this nature can also be completed with coordination with ORCA's monitoring efforts.

Facilitators and Contributors

Subwatershed studies require coordination with many stakeholders including but not limited to ORCA, the County, adjacent lower-tier municipalities, indigenous communities, local interest groups such as Kawartha Naturally Connected, and landowners.

Cost

Smaller scale subwatershed studies tend to cost around $300,000 but can extend up to $400,000 or more depending on study area size, level of detail, and complexity of the overall projects.

7.4 Watercourse Restoration Measures

Outside of the Municipal Boundary where urbanization is abundant and outside of the 5.45 km of urban-impacted watercourses across the study area, approximately 696.31 km of the remaining watercourses are bound by rural land uses such as agriculture and open-space. These reaches are subject to widely different impacts from those identified in urban and urbanizing

watercourses. Rural watercourse degradation has historically been exacerbated by intensification of farming practices, leading to straightened watercourses for drainage, diffuse or non-point source contamination and pollution, and limited riparian area for maximized cattle grazing and planting area leading to warming, bank erosion and increased suspended sediment. In rural settings, restoration techniques tend to involve naturalization of the riparian area and watercourse and land management. In-channel techniques, such as those implemented in urban rivers, can have less impact and fewer benefits in rural streams. Within rural reaches of the Watershed Planning Study, areas that support headwater drainage features (HDFs) may not demonstrate defining characteristics of a watercourse, but should be restored and managed similarly to provide benefits to downstream aquatic habitat. Restoration efforts can largely be focused on more passive techniques, such as riparian and watercourse naturalization.

Key Next Steps

Rural catchments should be assessed for potential restoration and naturalization opportunities. In general, watercourses should be evaluated based on existing and historical catchment characteristics and supported by aquatic ecology studies to prioritize watercourses and watercourse habitat for potential restoration. In areas that have been historically altered to support farming and livestock, riparian areas should be restored and naturalized under the same policies and guiding principles as identified for watercourses managed as urban and urbanizing watercourses (i.e., 30 m from the high water mark in the case of fish habitat should be naturalized and not actively tilled or used for grazing). A key next step in this process would be aerial imagery interpretation and landowner engagement and education.

Future Studies

A Fisheries Management Plan should be considered for the rural catchments to identify target species for each catchment which can be used to refine watercourse restoration approaches. Headwater Drainage Feature (HDF) Assessments should also be considered to guide management recommendations for key hydrologic resources that contribute to downstream fish habitat and watercourses. These assessments should be completed using the CVC/TRCA HDF assessment protocol in conjunction with Ontario Stream Assessment Protocol (OSAP). Examples of HDFs include small streams, springs, wetlands, swales, and ditches (natural or human-modified). These features are also important sources, conveyors, or sinks of sediment, nutrients, and flow. Some HDFs may function as important habitat for terrestrial and wetland species as breeding areas or corridors for travel and should therefore be protected alongside the City's rural watercourses.

Approvals, Policy, By-Law or Design Standards

Upon completion of the prioritization and identification of watercourse restoration approaches, similar regulatory implications should be considered as noted for urban and urbanizing watercourses. In addition, the Evaluation, Classification, and Management of Headwater Drainage Features Guidelines set forth by the CVC and TRCA (CVC & TRCA, 2014) should be

considered. This approach was developed with guidance from multiple stakeholder groups and is recognized by municipalities as a tool to provide direction specifically with regard to HDF management. HDFs have not traditionally been a part of most protection or management efforts. However, understanding of the importance of such features has been growing and HDFs are now protected features under certain local and provincial regulations. The 2020 Growth Plan for the Greater Golden Horseshoe, prepared under the Places to Grow Act (2005), considers HDFs to be a component of the "significant surface water contribution areas" and recommends their protection as Key Hydrologic Features. The City of Peterborough Official Plan (2023) further notes that:

The City will protect, improve or restore the quality and quantity of water by: Identifying water resource systems consisting of groundwater features, **hydrologic functions**, natural heritage features and areas, and **surface water features** which are necessary for the ecological and hydrological integrity of the watershed.

While protection and management of each individual of each feature may vary, applying the Evaluation, Classification, and Management of Headwater Drainage Features Guidelines set forth by the CVC and TRCA (CVC & TRCA, 2014) will guide decision makers in the appropriate application of and relevant Approvals, Policy, By-Law or Design Standards to ensure the integrity of the watershed is protected and/or enhanced.

Cost

The cost for riparian and watercourse naturalization projects is largely dependent on the size and extent of the restoration works. In the case of rural watercourses which are largely bound by active and ongoing agricultural land, compensation or land acquisition may also need to be considered to receive support from landowners and managers. Often, where agricultural land is left fallow, naturalization of riparian zones can occur without intervention. Fencing or other deterrents may also be considered to keep cattle and other livestock from entering the riparian zone during this time, along with the watercourse which in turn will mitigate contributing to erosion, sedimentation and nutrient loading. In areas where intervention is required, naturalization and riparian plantings can vary for a cover crop approach to a blended planting plan, with costing estimates provided below in **Table 7-1**. At the time where additional studies are completed and priority areas are identified with potential restoration techniques, preliminary costing can be provided which can further inform decision makers.

Table 7-1: Estimated Naturalization and Planting Costs

Description	Unit	Low	Median (2022)	High
Supply and Place Trees (60 mm Diameter)	ea	$ 500.00	$ 700.00	$ 900.00
Supply and Place Shrubs (2L Potted)	ea	$ 30.00	$ 60.00	$ 80.00
Supply and Placement of Topsoil for Restoration (300mm depth)	m^2	$ 12.00	$ 21.00	$ 28.00
Supply and Placement of Seed Mixes (Terraseeding 50mm depth)	m^2	$ 8.00	$ 9.00	$11.00
Supply and Placement of Erosion Control Blanket	m^2	$ 8.00	$ 30.00	$ 40.00

Funding

The majority of funding for watercourse restoration comes from the general stormwater utility fee revenue, or the Stormwater Protection fee. Additional funding for this program is allocated from:

- The Wastewater Reserve Fund
  The Flood Reduction Master Plan Reserve (FRMP)

Additional incentives can be leveraged in watercourse restoration projects, such as:

- Funding under the Provincial Land Stewardship and Habitat Restoration Program
- Stormwater management credits under an established Fisheries and Oceans Canada Habitat Banking Program

The Otonabee Region Conservation Authority (ORCA) can also provide information, technical advice and guidance for additional funding opportunities, and possibly financial assistance.

Timeframe

Similar to timing considerations for urban and urbanizing watercourse restoration projects, timing for rural projects is largely determined by the size and extent of the proposed works. Supporting documentation and studies may be required to accompany permitting and authorizations and in general, guide the decision-making process. Timing considerations for in-water works and environmental management, such as breeding bird and wildlife timing windows, must also be accounted for in the project schedule.

Recommendations

It is recommended that the rural catchments outside of the City of Peterborough undergo additional studies to document historical and ongoing land use changes associated with

agriculture, identify potential areas that may benefit from naturalization and buffer enhancement, and support these findings with recommendations as supported by ecological and fisheries considerations. These studies may be limited to aerial imagery interpretation and analysis or may include localized approaches such as landowner engagement ad education programs, HDF assessments and management recommendations. These studies can also identify secondary opportunities for the City to monitor and integrate associated solutions where project synergies allow.

7.5 Rural Best Management Practices

Rural best management practices will rely on stakeholders (landowners, ORCA, stewardship groups, etc.) outside of the City of Peterborough for planning and implementation. These include:

- **Agricultural Best Management Practices**: Agricultural producers are key stakeholders in the protection of environmental resources. Best management practices on these properties can have significant benefits to downstream stakeholders. Operational changes such as no-till planting and cover cropping can have significant impact on long term soil conservation. Non-structural BMPs on agricultural properties can include establishing/rehabilitating riparian buffers and terrestrial corridors. Structural BMPs on agricultural properties include improvements to manure storage and handling facilities can also greatly benefit water quality for those stakeholders downstream.

- **Rural Estate Measures**: Rural residential and recreational properties can impact water quality and watershed function both during the development and post-development phases. During development, ensuring natural heritage system function is preserved through sustainable development planning is critical. Over the long-term, the continued function of septic systems is important to maintain both groundwater and surface water quality. Septic inspection and replacement programs are thus important especially in areas sensitive to nutrient loading.

Future Studies and Next Steps

It is suggested that the County reach out to local groups such as 4-H Peterborough County, Dairy Farmers of Ontario, Easter Central Soil & Crop Association, Farms at Work, Junior Farmers, Peterborough County Federation of Agriculture OFA, Peterborough County Holstein Club and/or The Peterborough County Cattleman to develop a best management practice that is implementable to reduce the risks of agricultural impacts to adjacent natural features.

Additionally, the County might consider a stewardship program where farmers can be compensated for making changes to their practices that reduce the risk of nutrient and

sediment loading into the waterways. Additionally, farms could be compensated for planting native tree species and removing non-native invasive plants such as Common Reed.

8 Watershed Monitoring Plan

In order to ensure the goals and objectives of the Watershed Plan are accomplished over time, a refocused watershed-wide monitoring program has also been recommended as part of this Implementation Plan. The monitoring plan has been developed in keeping with the Adaptive Environmental Management (AEM) process whereby "A systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form - "active" environmental management - employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed."

Numerous definitions of the AEM exist in the literature, but the process can be described as a risk management strategy utilizing a "learning-by-doing" and "revising-as-appropriate" approach. The primary benefit of an AEM compared to the standard approach is the opportunity to modify the approach by introducing an adjustment step where monitoring program can be adjusted to better meet the needs of the subwatershed.

8.1 Background

Within the study area, several monitoring programs exist that are expected to support the AEM framework. These programs include:

City of Peterborough Groundwater Monitoring: The City of Peterborough collects groundwater monitoring levels across the City. Water levels have been collected monthly since 2005. This information will continue to be critical in understanding the urban geologic and hydrogeologic conditions as well as trends associated with changes in recharge rates resulting from land use changes, the implementation of infiltration-based stormwater strategies and climate change. For modelling purposes, the transient water levels collected by the City are of particular importance across the study as they provide key information on seasonal and inter-annual variation in depth to water table and related groundwater feedback (rejected recharge).

ORCA Watershed Health Monitoring: Otonabee Conservation staff use an integrated, science-based approach to understanding the ecological processes and state of natural resources in the watershed. Field staff can be regularly seen in action monitoring water quality and quantity through partnership programs. These programs include collecting data for the Provincial Water Quality Monitoring Network, the Ontario Benthos Biomonitoring Network, and the Provincial Groundwater Monitoring Network.

City of Peterborough Consolidated Linear Infrastructure (CLI) monitoring for Stormwater Management: In 2022 the MECP updated the Environmental Compliance Approval process to

include a Consolidated Linear Infrastructure (CLI) application review and approval process. As part of the application process, municipal applications must satisfy stormwater management criteria outlined in Appendix A of the submission form (MECP, 2022, August 25). These criteria vary slightly between development scenarios and retrofit scenarios but cover key subwatershed issues related to development, including maintaining water balance, improving water quality, controlling watercourse erosion, mitigating flooding, and reducing/controlling erosion and sediment deposition during development activities. Information collected and targets set during the (sub)watershed study process should feed into this approvals process, which is then tracked through long-term monitoring. It is important to note that the MECP has yet to provide guidance on the monitoring requirements associated with the CLI-ECA agreement.

The CLI requirements for a monitoring plan are typically intended to ensure that current receiver health is assessed and effectiveness of the overall stormwater management infrastructure is verified without resulting in significant burden on the municipalities. If stormwater discharge will impact a receiver containing one or more of the following, then monitoring is required:

- Coldwater fisheries,
- species at risk,
- environmentally sensitive areas;
- recreational activities such as swimming and fishing; or,
- where the water quality in a receiver exceeds a provincial water quality objective;

The City's CLI Monitoring Plan will be implemented to paint a picture of the overall health of the watershed.

The monitoring plan implemented in conjunction with regular inspection activities can also have added benefits to the municipalities. These include:

- Demonstrating that the stormwater management system is performing optimally and flag when maintenance and/or improvement in the stormwater is required.
- Reducing risk and liability by demonstrating accountability through reporting of monitoring activities and results.
- Building resiliency to the impending impacts of climate change by informing on both maintenance activities and sizing of stormwater infrastructure.
- Informing on long-term maintenance programs of stormwater infrastructure and the impact of maintenance on water quality/quantity.
- Informing asset management plans and help reduce overall costs by extending the lives of existing assets and support decisions about rehabilitation, repair and replacement through efficient and focused operations and maintenance activities (Lessons Learned:

CVC Stormwater Management and Low Impact Development (LID) Monitoring and Performance Assessment Guide, 2015)

- Track the effectiveness of policies of the Source Protection Plans (SPP) under the Clean Water Act in reducing threats to drinking water sources.

There are four (4) levels of monitoring proposed in the City's CLI Monitoring Program, all are confined to the geographical limits of the municipality:

Level 1 monitoring requires municipalities to monitor the inlet and outlet of major tributaries within the Municipality's boundaries. For example, Jackson Creek and the Otonabee River at the City limits. This level of monitoring relates directly to the level proposed in the Watershed Monitoring Plan.

Level 2 monitoring isolates individual tributaries via monitoring upstream and downstream of major tributary systems. Examples include creek systems at their confluence with the Otonabee River.

Level 3 monitoring can be used to isolate major areas of concern (for example, tracking water quality changes in the receiver as a result of large-scale development within the area). This is done by monitoring the end of pipe large SWM outlets in addition to downstream receiver conditions which will help identify and isolate problem areas within the municipality.

If Level 3 monitoring indicates an area of concern that requires further investigation, the Municipality may consider **Level 4** monitoring which isolates the problem within the stormwater management system by monitoring the inlet and outlet of the treatment train. This approach helps determine if the system is performing as designed or if the design is inadequate.

The Watershed Monitoring Plan outlined below is intended to fill in geographical gaps left by existing programs and provide monitoring enhancements for tracking watershed health via expanded methodology.

8.2 Terrestrial Natural Heritage System Monitoring Plan

The City of Peterborough states in the OP that it will work in partnership with the CA to develop and implement a comprehensive program to "monitor the effects of development on the form and function, including wildlife, of the Jackson Creek East Provincially Significant Wetland, the Jackson Creek Valley, Jackson Creek and its tributaries, and unevaluated wetlands within the

Planning Area" as a part of the Lily Lake Secondary Plan (Section 9.1). All findings are to be summarized annually with adaptive recommendations. As other designated greenfield areas are proposed for development, secondary plans should require the same commitment from the City, CA, and development proponents to monitor natural features and functions within the vicinity of the secondary plan areas. Additionally, a similar development agreement could be required as a part of redevelopment application that will result in urban densification. Monitoring programs should consider all aspect of the NHS features and functions that are present. Efforts should be made to quantify the species and sensitivity present within NHS patches, ecological communities and their functions, local connectivity pathways, presence and abundance of invasive species, and potential existing impacts. Annual monitoring should be tailored to the existing NHS resources to monitor changes over time and provide adaptive mitigation measures that can reduce/mitigate the severity of potential impacts caused by densification and climate change over time. These studies can work in tandem with other recommendations made in **Section 6.1.1** such as the Invasive Species Management Plan and subwatershed studies.

8.3 Aquatic Ecology Monitoring Plan

The City of Peterborough has developed a Stormwater Monitoring Guidance document for the Consolidated Linear Infrastructure (CLI) Environmental Compliance Approval (ECA). As part of the recommendations to meet the requirements outlined in the CLI ECA, as administered by the Ministry of Environment, Conservation and Parks (MECP), a city-wide monitoring program was recommended to ensure that the implementation of the stormwater infrastructure projects have been and continue to proceed towards and to ensure a "net gain" to the municipal SWM system. The city-wide monitoring program has not yet been implemented.

In order to ensure the goals and objectives of the Watershed Study and Implementation Plan are accomplished over time, it is recommended that a refocused monitoring program be established as part of this Implementation Plan.

8.3.1 Aquatic Monitoring Plan Overview

The monitoring program in its current state is targeted towards stormwater monitoring. However, as noted above, the Monitoring Program will largely be developed around guidance from the MECP as it is related to the CLI-ECA agreement. As this guidance is currently pending, it is assumed that monitoring will be phased to permit City staff to build capacity with the municipality, vet the proposed monitoring program with partner agencies (specifically the ORCA), and permit the alignment of future budgets with the revised program needs. To satisfy the requirements of the CLI-ECA (pending), as administered by the MECP, a monitoring program should be implemented to establish baseline monitoring results (existing conditions) in order to evaluate the effectiveness of SWM infrastructure throughout the City. This monitoring program should: identify baseline conditions of watercourses and assets across the City; establish monitoring criteria to maintain or enhance baseline conditions and to detect changes

as a result of the infrastructure or development; and, provide guidance for future SWM infrastructure in the City and be designed to align with the MECP monitoring requirements. Monitoring efforts are focused on urban systems within the City which currently have SWM infrastructure within the catchment(s) and are therefore regulated under the CLI-ECA.

The program was developed to include the following and is defined by Level 1 and Level 2 Jurisdictional Scale:

- **Water Quality** – grab sample water quality sampling to be representative of baseflow conditions (1 sample/station/season), rainfall event conditions (2 samples/station/season representing spring, summer and fall), and snowmelt event conditions (1-2 sample(s)/station/during winter and/or early spring). The following considerations were made for the program:
- Sampling constituents to account for Provincial Water Quality Objectives (PWQO) for various representative pollutants.
- On-site water temperature and pH sampling to be collected at the time of grab sampling.
- Collected water quality samples shall be submitted to a private accredited laboratory for analysis.
- **Precipitation Monitoring** – Continuous weather monitoring at a gauge station within 0-15 km of a municipalities geographic center. These locations should be selected in consideration of the City's existing rain gauge stations.
- Monitoring Locations: Level 1 and Level 2 monitoring locations are depicted in **Figure 8-1**
- **Level 1**: All major tributaries within or crossing a municipality jurisdictional border.
- **Level 2:** Continuation of Level 1 locations with the addition of all major confluences along the watercourse(s).

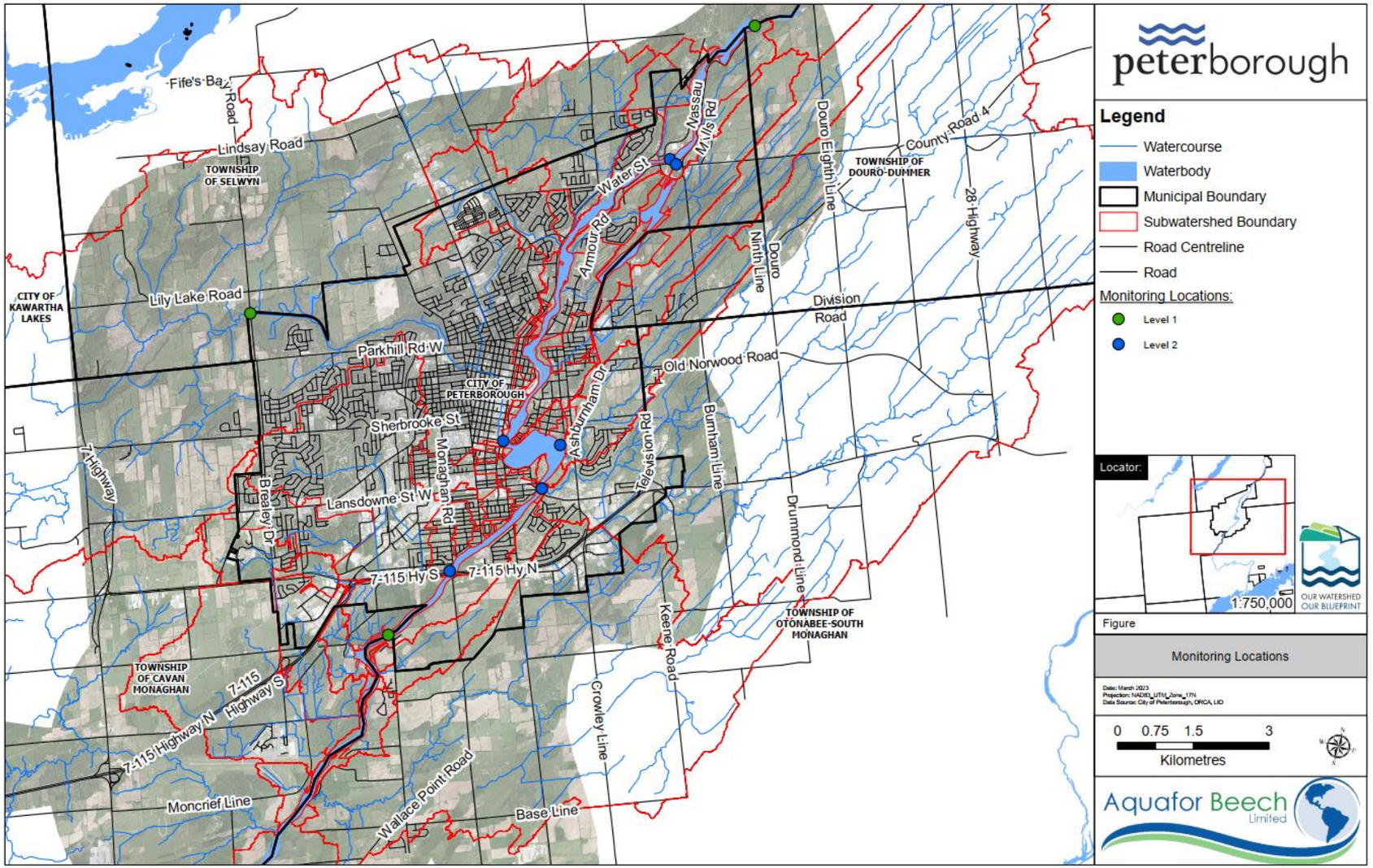

Figure 8-1: Level 1 and Level 2 Monitoring Locations

8.3.2 Aquatic Monitoring Program Recommendations

Monitoring locations and protocols should be refined to align with the implementation approach of prioritizing works based on the watersheds in the most need and where there are opportunities to improve conditions but also recognizes the need to protect existing watershed health. Monitoring should also focus on the collection of data within subwatersheds that are determined to have insufficient data and establish long-term monitoring sites for the collection of water quality data within priority subwatersheds. It is recommended that the Updated Monitoring Plan incorporates ecological monitoring and indicators which can advise on the overall health of the watershed. Additional Recommendations include:

- **Water Quality** – Grab samples provide only an instantaneous measure of concentration during an event period and do not provide an indication of pollutant loading. Grab samples are also difficult to use to develop accurate comparisons between watercourses and monitoring years. It is therefore recommended that grab sampling be replaced with flow proportionate automated sampling to develop Event Mean Concentrations (EMC) for the sampling locations.

The use of flow proportionate samples taken for at least one benchmark site is typically required to thoroughly assess the variability of water quality through the course of the runoff events and over the course of several seasons and/or years. In this regard it is recommended that the City consider the need to install automated flow and water quality sampling equipment.

The objective, as explained below, would be to collect 'flow proportionate samples' for at least eight events in order to more rigorously characterize the variability of water quality over the period of sampling. This information, which would be taken at the same locations as the previous sites, would assist in defining the statistical reliability of the results. A basic overview of the protocol is provided below.

There are a number of fundamentals for undertaking flow and water quality monitoring that we have learned through previous projects. These fundamentals are outlined below.

Variability of Pollutant Concentration during an Event: Pollutant concentrations vary considerably during an event. It is therefore important to gather flow proportionate samples in order to obtain an accurate representative of the average concentration during the event (Event Mean Concentration) as well as the pollutant loading.

Variability of Event Mean Concentration (EMC) from Event to Event: The EMC will vary significantly from event to event. This is a result of a number of factors including rainfall

patterns, inter event period and time of year. Therefore, it is necessary to collect flow and water quality information from at least 8 events from storm sewer outfalls if mass loadings are to be reasonably defined.

Relationship between Nutrients and Total Suspended Solids: Previous studies show a strong relationship between nutrient concentrations and Total Suspended Solids. Collection of nutrient data and TSS data is therefore valuable.

Influence of Land Uses: Previous studies have shown that the concentrations from different land uses (i.e., industrial, commercial and residential) do not vary as much as is generally thought. Typically, EMCs from different land uses are within 10-20 percent.

Based on the above information, it is recommended that the City consider the following:

1) Establishment of flow proportionate sampling, at minimum, at Level 2 sites shown above. Mass loadings are the true measure of the effectiveness of implemented stormwater management measures and have been utilized to gauge the performance Best Management Practices (BMPs) implemented within municipalities across the province of Ontario and assists the development of international databases such as the International Stormwater Best Management Practice Database to better understand factor influencing BMP performance. This would also eliminate the need for staff requirements to visit each monitoring site during the runoff event to obtain grab sampling and would ensure that the peak flow was sampled to better represent potential nutrient and pollutant loading. Monitoring activities at the flow proportionate sites would include the following:
    a) Installation of a Teledyne ISCO (ISCO) automated sampling devices at each site. The ISCO 730 Bubbler Flow Module already held by the Town would be utilized to trigger sampling as flow rates change. Flow meters would record continuous flow data in order to develop the EMC. Recording water levels every 15 minutes is suitable for developing EMCs.
    b) A minimum of 8 sampling events per year should be undertaken, with 2 events per season (i.e., Spring, Summer, Fall, and Winter) to ensure statistical significance.
    c) A minimum of 3 dry weather sampling events should be conducted at each sampling location with one event in each of spring, summer, and fall season. Dry weather sampling will remain consistent with the past monitoring protocol.

2) It is recommended that a minimum of one (1) year of flow proportionate monitoring be conducted at each of the selected monitoring stations in order to develop the EMC. Once

completed and a defensible EMC has been established, subsequent years of water quality monitoring can be staggered to coincide with development or changes in the watershed.

Integrate results of water quality monitoring into monitoring and adaptive management plans. Should water quality results continue to exceed established thresholds, mitigation measures should be identified and integrated into restoration and monitoring plans to better represent the target species.

3) Previous studies using automated sampling equipment and monitoring protocols typically have a much higher up-front cost but can save proponents thereafter due to lower labour costs since staff are not required to be on site to conduct the monitoring. Following the initial year, only equipment maintenance and installation, collection and lab fees would be accounted for. Initial costing estimates, exclusive of HST, to establish a single site for automated sampling are as follows:

ISCO 6712 Full-Size Portable Sampler, including all accessories:	$10,000
ISCO 730 Bubbler Flow Module (required for flow automated sampling):	$5,500
Deep-cycle Marine Batteries (x3) and accessories:	$1,000
Anti-Vandalism and Theft Equipment Housing and accessories:	$800
Optional Solar Station and Controller and accessories:	$500
Subtotal:	$17,800

Additional to the capital costs above, staff time is needed for monitoring station set-up, site maintenance, sample collection, and site disassembly.

- **Water Quantity** – Continuous water level monitoring for the stations annually corresponding to the flow proportionate water quality sampling stations. Water quantity monitoring would also be useful for the purpose of flood monitoring and flood risk model calibration. This will include the installation of an in-stream pressure transducer and a barometric compensation unit to collect and correct data for continuous water level. A staff gauge should also be installed at an area adjacent to the equipment to ensure data accuracy. Initial costing estimates, exclusive of HST, to establish a single site for continuous water level monitoring are as follows:

HOBO U-20 Pressure Transducer (x2):	$1,200
Ceramic Staff Gauge:	$100
Anti-Vandalism and Theft Equipment Housing and accessories:	$300

Subtotal: $1,600

Additional to the capital costs above, staff time is needed for monitoring station set-up, data collection, and site disassembly.

Flow Monitoring - Discrete flow measurements should be collected at the station using a SonTek Flow Tracker or equivalent by the velocity-area method, measuring the incremental water velocity, water depth, and channel width during the time of sampling. Flow measurements will be used to develop stage-discharge rating curves and would be used to evaluate continuous flow conditions as well as to program the aforementioned flow-proportionate water quality sampling equipment. Based on our extensive experience with developing EMC and rating curves, the establishment of a rating curve requires at least eight (8) paired discharge-stage measurements.

Additional to the flow monitoring at the EMC stations, it is recommended that flow monitoring occur in major tributaries to characterize summer low flow conditions in urban creek systems. Where feasible, EMC stations may overlap with low flow monitoring stations resulting in less velocity-depth profiles needed to establish rating curves.

- **Temperature Monitoring** - Continuous temperature monitoring would be collected at the established Water Quantity stations, corresponding to the flow proportionate water quality sampling stations, and would be collected using the same monitoring equipment. Continuous water temperature monitoring can help evaluate thermal regimes for the watercourse and can help guide management recommendations and further support ecological considerations for the subwatershed(s).

- **Invertebrate Community Sampling** – Benthic macroinvertebrate monitoring should be conducted on an annual basis at each water quality monitoring station and water quantity station following Ontario Stream Assessment Protocol (OSAP) and the Ontario Benthos Biomonitoring Network (OBBN). The benthic community composition can change very quickly if habitat quality changes (benthics have limited mobility and a short life span), therefore monitoring is best conducted frequently. The results would be compared to previous years, to track changes over time. Results provide a measure of how the benthic community has changed over time and are an excellent indication of in-stream conditions. Costing can vary, depending on staffing requirements and species identification requirements. Initial costing estimates, exclusive of HST, to establish a single site for benthic community monitoring are as follows, and do not include collection or habitat assessment staff fees:

Lab Analysis to Family Level (x3 sites per Standard Protocol): $1,500

Sample Preservatives and Containers:	$200
Sub-total:	$1,700

- **Fish Community and Habitat Sampling -** For each sampling station, it is recommended that annual data be collected for a minimum of two (2) years to establish baseline conditions at each station beginning with Level 2 locations at a minimum. Fish community sampling is not recommended for stations with a significant sampling history from previous years that includes more than 1 year of fisheries data. After baseline conditions have been established for all station, monitoring can be conducted per the following:
    - Stations with no identified sensitive species – sampling may be conducted at a reduced frequency (bi-annual or longer). Station locations are recommended to rotate annually following the recommendations developed in initial monitoring years.
    - Stations where sensitive species have been identified, monitoring may be conducted at an increased frequency (annual basis). If sensitive species are found at a station where no sensitive species have been previously identified, monitoring should be conducted at an increased frequency for subsequent years.

This recommendation has the potential to reduce the overall sampling effort (reduced number of analyzed samples) but more importantly focuses sampling effort and budget on a priority basis relating to those stations with sensitive species. Field investigations should be completed using the Ontario Stream Assessment Protocol (OSAP; Stanfield, 2017) and should include observations of aquatic habitat conducted using Section 4: Module 1 of OSAP for Rapid Assessment Methodology for Channel Structure. The information collected should include parameters such as channel measurements, bank undercuts and instream cover, point source impacts, flow regime characteristics, substrate, critical habitats, and riparian cover and shading, and other contributing factors such as groundwater indicators, erosion areas and point source contamination sources.

- **Monitoring Locations:** Additional monitoring location recommendations are depicted in **Figure 8-2**, with justification as follows:

    - **Priority 1:** All major tributaries which cross the municipal boundary should be monitored at the municipal boundary to represent upstream catchment conditions (i.e., rural) prior to being impacted by any potential urban land use, as well as at the confluence with any major receiving watercourse to represent

changes in water quality are flow is conveyed through the municipal urban center.

- **Priority 2:** Continuation of Priority 1 locations with the addition of all major tributaries outside of the municipal boundary, at the downstream extent to represent upstream rural catchment conditions, as well as any watercourses previously unassessed.
- Station locations are recommended to rotate annually to include all Level 2 stations at a minimum, followed by Priority 1 stations and Priority 2 stations. Within these groups, sites can be rotated to account for areas of concern or development applications. The level of effort would be evaluated each year following the AEM process.

A reference Monitoring Program Procedures and Protocols is included as **Appendix A.** Additional monitoring stations, outside of the CLI-ECA requirements, dedicated to flood monitoring or individual impacts should be identified on an as-needed basis, including but not limited to, the Bethune Diversion Sewer. In circumstances where additional monitoring sites are identified, sites should be established upstream and downstream of the study area to understand and quantify potential impacts. For monitoring efforts such as Invertebrate Community and Fish Community and Habitat Sampling, considerations could be made to reduce or streamline monitoring efforts following the establishment of a baseline. Guidance provided by ORCA suggests that surveys/data collection for are to be conducted at a minimum of 3 years to establish natural variability/trends with periodic sampling post baseline. At minimum, a review of monitoring design should be conducted every 5 years. ORCA also supports the possibility of this data being integrated into Conservation Authority programs and public reporting.

8.4 Adaptive Management Approach for Watershed Monitoring Program

Adaptive management plans developed as part of monitoring studies are used to gauge whether the preferred strategy is effective in meeting short, medium, and long-term targets associated with hydrology, hydrogeology, terrestrial ecology, fluvial geomorphology, water quality and aquatic biology. In this regard, monitoring results may also support and inform whether goals, objectives and targets are being met, or if municipal and (sub)watershed plans need to be updated.

Existing conditions and/or data trends are documented in annual reports, trend and status reports, and watershed report cards. Where specific management practices or elements of the preferred strategy are not having the desired effect on key performance indicators, follow-up analysis is often required to inform appropriate adaptive management strategies that support municipal plans and provincial reporting.

It is recommended that on a 5 year basis the City of Peterborough review and refine the overall stormwater monitoring program. Monitoring program refinements should be in keeping with the goals and objectives of the Watershed Plan.

Where possible, monitoring conducted as a part of other efforts or institutions should be considered, including but not limited to First Nations traditional knowledge. Additionally, it is understood that the following initiatives are continuous across the watershed and results could be made available upon request:

1. Trent U Environmental Science Program (Misc local research) - Stephen Hill (Director)
2. Trent U Community Research (Project based program)
3. Master of Bioenvironmental Monitoring & Assessment (paid placement program) - Jennifer Bull (Graduate Placement Coordinator)
4. Community Groups and Environmental Stewards (Friends of Jackson Park, Peterborough Field Naturalists, Odoonabii Watershed Stewards

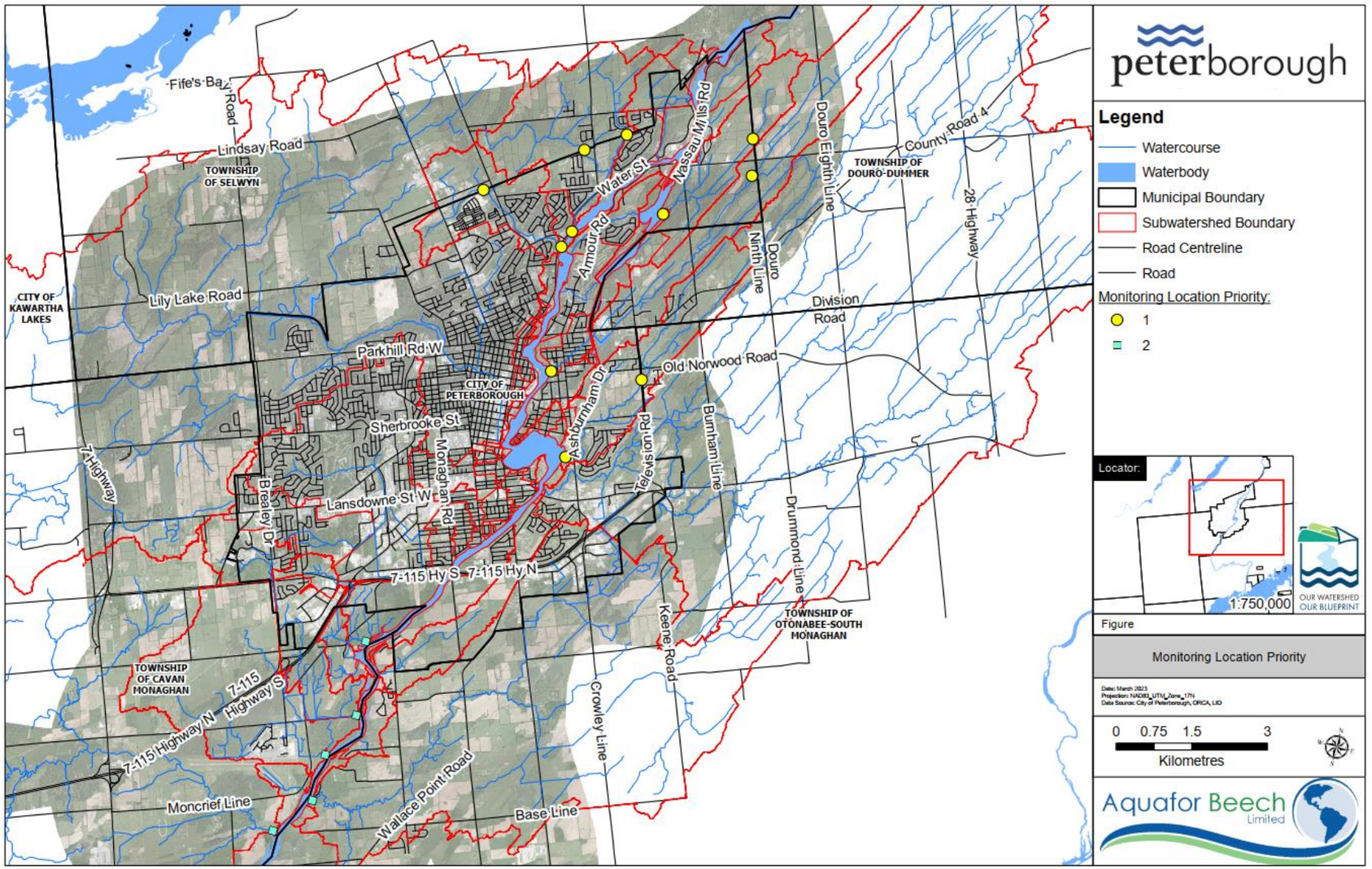

Figure 8-2: Recommended Priority 1 and 2 Monitoring Locations

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Appendix A - Existing Policy Breakdown

Natural Heritage Policies

Policy	Description
Fisheries Act (1985)	The purpose of this Act is to provide a framework for the proper management and control of fisheries and the conservation and protection of fish and fish habitat, including preventing pollution (Section 2.1 of the Act).
Migratory Birds Convention Act (1994)	The purpose of this Act is to protect migratory birds and their nests Section 4) through protecting migratory birds, their eggs, and their nests from destruction by wood harvesting, hunting, trafficking and commercialization.
Species at Risk Act (2002)	This federal Act is intended "to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened" (Section 6 of the Act).
Endangered Species Act (2007)	Similar to the Species at Risk Act, this provincial Act aims to identify and protect species at risk and their habitat as well as promote stewardship activities in the protection and recovery of species at risk.
Fish and Wildlife Conservation Act (1997)	This Act regulates hunting, trapping, and fishing while striving to preserve at risk species. This Act works in conjunction with the Endangered Species Act.
Ontario Regulation (O.Reg.) 167/06 and *Conservation Authorities Act*	ORCA regulates wetlands and natural hazards within the Otonabee watershed which includes the subwatersheds that make up the study area. ORCA published their Watershed Planning & Regulation Policy Manual (2012, updated 2015) which defines their roles and applicable regulations.
More Homes Built Faster Act (2022)	This Act received royal assent in November 2022 and was developed with the goal of addressing the housing supply shortage through streamlining the development process. Key changes to NHS policy include updates to the roles of MNRF, Conservation Authorities, and municipalities as well as updates to Ontario Wetland Evaluation System (OWES).
Places to Grow Act (2005) and A Place to Grow: Growth Plan for the Greater Golden Horseshoe (2019)	A small portion of the Cavan Creek subwatershed is located within the Greater Golden Horseshoe. This Plan states that "municipalities are required to undertake watershed planning to inform the protection of water resource systems and decisions related to planning for growth." It also establishes an NHS for the Growth Plan that municipalities must incorporate in their Official Plans.

Policy	Description
	An update to the PPS and this document is currently underway. Any recommendations can and will be modified to align with new Provincial Policy.
Oak Ridges Moraine Act (2001) and Oak Ridges Moraine Conservation Plan (2017)	A small portion of Cavan Creek subwatershed is located within the Oak Ridges Moraine. The Oak Ridges Moraine Conservation Plan (2017) defines Natural Core Areas as areas with the "greatest concentrations of key natural heritage features which are critical to maintaining the integrity of the Moraine as a whole" and Natural Linkage Areas as areas that are "critical natural and open space linkages between the Natural Core Areas and along rivers and streams" (P.4 of ORMCP).
Trent Source Protection Plan (2014)	A source protection plan covering Kawartha-Haliburton, Crowe Valley, Lower Trent, and Otonabee-Peterborough Source Protection Areas. This plan delineates Intake Protection Zone generally along the Otonabee River upstream of the urban area.
County of Peterborough Official Plan (2022)	The County's new OP was adopted by council June 2022 but is still waiting upon MMAH approval. The NHS includes "significant wetlands, fish habitat, significant woodlands, habitat of endangered species and threatened species, significant wildlife habitat, significant valleylands and significant areas of natural and scientific interest, which are important for their environmental and social values as a legacy of the natural landscapes of an area." Additionally, sand barrens, savannahs, tallgrass prairies, and alvars are to be protected under the policies of the Growth Plan and the PPS. County of Peterborough's OP acts and an update to tall township's OPs except Cavan-monghan.
City of Peterborough Official Plan (2023)	The City of Peterborough recently updated their OP and natural heritage mapping. Features have been divided into Level A, Level B, and Level C. The draft also outlines regional and proximity linkages.
Township of Cavan Monaghan Official Plan (2013)	This Official Plan document divides the NHS into Natural Core Areas, Natural Linkage Areas, ORM - Natural Core Area, and ORM - Natural Linkage Area, and includes "significant wildlife habitat, significant wetlands, significant woodlands, significant valley lands, areas of natural and scientific interest, buffer areas around these features and lands that link those areas" (Section 6 of OP).

Stormwater Management Policies

Stormwater Management Policies in City of Peterborough Official Plan (2021)

The City's OP, which was adopted by Council in November 2021 includes several policies related to stormwater management. Planning-level stormwater policies in this document include provisions for innovative stormwater strategies that have been shown to mitigate the impact of the urban environment on natural watershed features and processes. Of specific note are the following:

5.3.8 Parkland and Stormwater Management

a) In cases where parks or portions of parkland include or are designed to include stormwater management facilities, such facilities would be subject to the approval of the City and the Conservation Authority. Where a stormwater facility precludes the use of a portion of the land for parkland purposes, the stormwater management facility shall not be accepted as a part of parkland dedication.

b) The following principles shall be adhered to in the design of stormwater facilities involving parkland or other open spaces, or as identified by this Plan:
   i. Stormwater will be considered a resource rather than a waste product of development;
   ii. Stormwater facilities will be designed to maintain or improve the ecological integrity of the environment;
   iii. Where open watercourses exist, or are used for stormwater management and/or conveyance purposes, they are to be retained, wherever feasible, in their uncovered, unchannelized, natural state in order to maintain the natural integrity of the watercourse;
   iv. Stormwater facilities will be designed, wherever possible, to provide community amenities. Lands immediately adjacent to watercourses shall be planted to establish riparian buffers for the protection of water quality. Where possible, such facilities will be designed with naturalized edges to a standard that would not require fencing from the standpoint of public safety; and,
   v. Stormwater management facilities must be maintained in accordance with any Federal or Provincial regulations and operating requirements. While stormwater management facilities can naturalize overtime, their primary role will be stormwater management.

c) Where existing parks or portions of parkland are retrofitted to include stormwater management facilities, such facilities shall be situated within the park to minimize adverse impacts on the parkland.

6.1.4 Water Resources

d) The City will promote and play a leadership role in the efficient and sustainable use of water resources, including practices for water conservation and sustaining water quality. Such practices may include encouraging educational initiatives, supporting other agencies with programs related to water conservation, sustaining water quality, respecting Indigenous Knowledge systems, incorporating stormwater management best practices, including green infrastructure and/or low impact development and considering technological and other system improvements to address such issues as inflow and infiltration of sanitary sewers.

e) Development and site alteration will be restricted in or near sensitive surface water features and sensitive groundwater features such that these features and their related hydrologic functions will be protected, improved or restored. Mitigative measures and/or alternative development approaches may be required in order to protect, improve or restore sensitive surface water features, sensitive groundwater features, and their hydrologic functions.

f) The City will require hydrogeological assessments in support of all major development applications, which will include requirements to maintain pre-to-post development water balances and measures to substantially maintain infiltration, recharge, and peak flow rates relative to existing conditions.

g) For a large development proposal on a waterbody, an impact assessment or equivalent shall be required to ensure water quality protection. The study should take into consideration the existing water quality of the water body, surface water run-off, impact and loadings of phosphorous from septic systems if applicable, type of soils, stormwater management and nature of vegetation. For new lot creation, development, including the septic system tile bed if applicable, must be set back a minimum of 30 metres from the normal-high water mark or active channel/bankfull level of the waterbody with non-disturbance of the native soils and very limited removal of shoreline vegetation. For existing lots of record, new development should be set back 30 metres if possible, otherwise as far back as the lot permits.

h) The City will protect, improve or restore the quality and quantity of water by:
    i. Using the watershed as the ecological meaningful scale for integrated and long-term planning;
    ii. Minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;
    iii. Identifying water resource systems consisting of groundwater features, hydrologic functions, natural heritage features and areas, and surface water features which are necessary for the ecological and hydrological integrity of the watershed;
    iv. Implementing restrictions on development and site alteration to:

- Protect all municipal drinking water supplies and designated Vulnerable Areas; and,
- Protect, improve or restore vulnerable surface water and groundwater, sensitive surface water features and sensitive groundwater features, and their hydrologic functions;

v. Maintaining linkages and related functions among surface water and groundwater features, hydrologic functions, and natural heritage features and areas, and surface water features including shoreline areas;

vi. Promoting planning for efficient and sustainable use of water resources, including through practices for water conservation and sustainable water quality, such as water demand management and water recycling; and,

vii. Ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

6.1.5 Water Resources

a) The effects and impact of stormwater management, including quantity and quality control and low impact development features, form an integral and important part of development, redevelopment and public works. As such, stormwater management should be an important part of any development consideration.

b) The objectives for stormwater management are as follows:
   i. Maintaining or enhancing surface water quality;
   ii. Preventing and limiting flood risk for both new development and existing built up areas;
   iii. Maintaining and enhancing the natural hydrologic cycle, including the promotion of water balance, volume control and low impact development;
   iv. Creating a system that is sustainable, well maintained and cost effective; and,
   v. Promoting a system that enhances the environmental, aesthetic and recreational potential of the City.

c) Stormwater management facilities, including stormwater management ponds, shall be permitted on lands in any land use designation, with the exception of the Natural Areas Designation, the vegetation protection zone for a natural heritage feature, or a natural hazard unless authorized by the Conservation Authority. Notwithstanding the above, limited engineering components, such as stormwater management pond outlets, may be considered in the Natural Areas Designation, the vegetation protection zone for a natural heritage feature, or a natural hazard, subject to the results of an Environmental Impact Study and subject to the approval of the City and Conservation Authority.

d) All new development in the City shall utilize stormwater management techniques to control the quality of run-off and control erosion and sedimentation during and after

construction, in accordance with the City's prevailing engineering design standards, in order to minimize adverse effects on the receiving body of water. The City's Watershed Plan, Flood Reduction Master Plan and Engineering Design Standards will guide the quality and quantity control criteria.

e) Stormwater quality control, in accordance with the latest Provincial guidelines, shall be implemented for new development, incorporating an integrated treatment train approach. Every effort will be made to incorporate low impact development techniques, green infrastructure and other innovative methodologies to minimize changes to the water balance on the development site by reducing peak flow and runoff volumes, and provide appropriate quality and quantity control of runoff at the source.

f) The City encourages development proponents to propose innovative stormwater management works, including but not limited to, underground stormwater storage and source control techniques, to control stormwater quality and quantity, erosion, sedimentation and temperature, subject to approval by the City and the Conservation Authority.

g) The City will pursue opportunities to implement quantity and quality controls for stormwater management works and/or source control programs where current controls do not exist or are not adequate.

h) The City will develop a stormwater plan, or equivalent for its serviced settlement area that:
    i. Is informed by watershed planning;
    ii. Protects the quality and quantity of water by assessing existing stormwater facilities and systems;
    iii. Characterizes existing environmental conditions;
    iv. Examines the cumulative environmental impacts of stormwater from existing and planned development, including an assessment of how extreme weather events will exacerbate these impacts and the identification of appropriate strategies for building adaptive capacity;
    v. Incorporates appropriate low impact development and green infrastructure;
    vi. Identifies the need for stormwater retrofits, where appropriate;
    vii. Identifies the full life cycle costs of the stormwater infrastructure, including maintenance costs, and develops options to pay for these costs over the long-term; and,
    viii. Includes an implementation and maintenance plan.

i) The City recognizes that effective stormwater management involves a hierarchy of planning and management techniques. As such, in addition to a Watershed Plan, the City may undertake Sub-watershed Plans, Master Drainage Plans, Functional Servicing Plans and Stormwater Plans to ensure appropriate stormwater control and management.

j) No Official Plan Amendment, Zoning By-Law Amendment or Plan of Subdivision shall be approved if the proposed development would have an adverse impact on the hydrologic cycle.

k) Required stormwater facilities shall not be considered as part of any parkland dedication where the lands are not useable for any other purpose. The City will encourage stormwater management works which allow the land to be usable for other purposes.

l) The City may acquire, where deemed appropriate, access to watercourses or easements along watercourses for the purposes of stream improvement works and maintenance, flood/hazard mitigation and works to protect human health.

m) Stormwater Management Plans are required for all new Secondary Plans, Plans of Subdivision, Official Plan Amendments, vacant land Plan of Condominiums, Zoning By-Law Amendments, developments under Site Plan Control, and may be required for developments, which by their nature, magnitude or location have a potential for negative impact on the drainage area. The proposed Stormwater Management Plan shall be acceptable to the relevant agencies and bodies having jurisdiction and shall be designed in accordance with any City design standards, and if applicable, the Master Drainage Plan for the sub-watershed area. The Stormwater Management Plan will:
    i. Be informed by a sub-watershed plan or equivalent;
    ii. Incorporate an integrated treatment approach to minimize stormwater flows and reliance on stormwater ponds, including the incorporation of appropriate low impact development and green infrastructure;
    iii. Establish planning, design and construction practices to minimize vegetation removal, grading and soil compaction, sediment erosion, and impervious surfaces;
    iv. Align with the City-wide stormwater master plan, where applicable; and,
    v. Address such matters as best management practices, consideration of watershed flow regimes and headwater areas, stormwater flow control, centralized facilities, impact on groundwater resources, maintenance of base flow and storage levels and effects on water quality including temperature, wildlife, fisheries and the implementation of any mitigating measures.

n) The City shall establish a protocol to monitor and maintain its stormwater management infrastructure throughout the City.

Stormwater Policies in City of Peterborough Engineering Design Standards (2022)

The City's Engineering Design Standards, were adopted in December 2022. These standards include several policies related to water quality treatment of stormwater, mitigation of flooding

via stormwater detention, and maintenance of the pre-development water balance. Of specific note are the following sections of the Engineering Design Standards.

Section D 2.5 of the Engineering Design Standards identifies the requirements for stormwater management reports submitted as part of the integral design of the proposed development. Design considerations for stormwater management reports must include runoff quantity, runoff quality, water balance, low impact development, erosion control (watershed), and construction erosion and sediment control components.

Section D.2.5.A identifies **stormwater quantity control** requirements. From the perspective of subwatershed health, the following criteria are relevant:

- Peak regulated post-development flow must not exceed pre-development conditions.
- 100-year frequency - 12 and 24 hour duration Chicago or SCS Type II rainfall events should also be assessed to confirm the volumetric and outlet performance of stormwater quantity facilities. Chicago storms implementing IDF curve parameters should be modified to ensure that total rainfall depths are at least 98.4mm and 108.7mm respectively for the 12- and 24-hour durations.
- Temporary post-development peak attenuation runoff storage to meet predevelopment peak flows is typically provided in the form of a stormwater management pond, often integrated with a stormwater quality wet pond. All reports should include the proposed basin's elevation-discharge-storage relationship.
- All stormwater management facilities shall outlet to an adequate receiving watercourse or storm sewer. To ensure assumed pond performance, the outlet should be above the receiving watercourse's 100-year flood level, with an outlet above the Regional flood level preferred.

Section D.2.5.B identifies **stormwater quality control** requirements. From the perspective of subwatershed health, the following criteria are relevant:

The City of Peterborough now encourages the maintenance of existing hydrological patterns and addressing water quality controls as close as possible to where the precipitation falls to meet water quality control. Low Impact Development (LID) practices noted in the 2010 CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide will be reviewed with greater weight for due consideration as part of the 'treatment train' approach to water quality. LID requirements are noted in **Section D.2.5.D.** The City's Stormwater Management System Environmental Compliance Approval requires 'control' of the 90th percentile rainfall event and if conventional methods are necessary, then suspended solids control is to be implemented.

Typically, 'Enhanced' (80% TSS removal) is the water quality control target to be achieved for end of pipe solutions, however, 'Normal' (70% TSS removal) may be considered acceptable on a case by case basis with sufficient justification.

Traditionally, the most common form of end of pipe permanent water quality control for subdivisions is the Wet Pond, integrated with the stormwater quantity control noted above. Due to inherent high long term maintenance and clean out costs associated with maintaining MECP (or City SWM System) ECA compliance, wet ponds will only be accepted for catchment areas greater than 5 hectares and alternative means of achieving water quality control are encouraged to be investigated such as the use of a dry pond with an oil grit separator(s) inlet.

Where wet ponds are proposed, the subdivision hydrogeology report should include boreholes within the location of the stormwater management report to provide information on existing soil types and groundwater levels at this location to ensure no interaction between the permanent pool and groundwater. To maintain the permanent pool, a clay liner (or adequate equivalent) is typically proposed. In the event that native or alternative material is proposed, documentation from a geotechnical engineer as to the hydraulic conductivity of the material in relation to the retention of a permanent pool must be provided. Collars should be placed around outlet pipes to prevent seepage along the perimeter of the pipes.

Wet ponds proposed within the Byersville Creek watershed may not be accepted by the City arising out of concerns in relation to thermal effects on the cold water stream. Any proposed wet pond within the catchment must include designs to ensure thermal impacts on the watercourse will be minimal.

Section D.2.5.C identifies **water balance design** requirements. From the perspective of subwatershed health, the following criteria are relevant:

The Engineering Design Standards note that until such time as the City's Watershed Plan is completed and adopted, the City of Peterborough requires a water balance analysis for subdivision applications in order to estimate impacts on the hydrologic cycle in terms of infiltration and runoff if the 90th percentile rainfall event is not 'controlled' as defined in Appendix A of the City's Stormwater Management System ECA.

Methodologies such as Thornwaite and Mather based upon location, monthly rainfall and temperature records, vegetation, and soils may be used to complete the water balance in lieu of detailed groundwater modeling.

For consistency in applications, an annual total precipitation depth of 855mm (Based upon 1981 - 2010 Peterborough Airport Climatic Data) an adjusted potential evapotranspiration of 570mm, and total water surplus of 285mm may be used. Infiltration factors can be determined from the sum of Topography, Soils and Cover values tabulated in Table 2 of the 1995 MOEE Hydrogeological Technical Information Requirements for Land Development Application or Table 3.1 of the MOEE Stormwater Management Planning and Design Manual.

Section D.2.5.D identifies **Low Impact Development** design requirements. From the perspective of subwatershed health, the following criteria are relevant:

Low Impact Development (LID) shall be required as part of the stormwater management system for subdivision applications. The 2010 CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide provides approaches to LID design and should be referred to in conjunction with proposed development applications.

While the City's Stormwater Management System ECA design criteria does not include a category titled 'LID', the Water Balance and Water Quality components refer to a 'control' of the 90th percentile rainfall event. Said 'control' refers to a hierarchical design approach as follows where each level is provided to the feasible limit prior to proceeding to the next level:

1) Retention (infiltration, reuse, or evapotranspiration)
2) LID Filtration
3) Conventional Stormwater Management

The 90th percentile rainfall event for the City is defined as having a depth of 27mm.

Along with the above policy, the Engineering Design Standards note that the City is in the process of completing its Watershed Plan which will provide further refinement and guidance of its Stormwater Management ECA design and performance criteria. In the interim prior to its completion, we are providing interim standards which should be implemented as part of engineering submission of subdivision applications. Due to the inherent need for the decentralized nature of LID implementation over large areas, it would likely require the use of privately owned lands within the subdivision. LID within the road right of ways, parkland blocks, open space blocks, and SWM pond blocks will have to be considered as well as components of an overall complete design.

Appendix B – Reference Monitoring Program Procedures and Protocols

Autosampling Stations

At each autosampler station, water quality monitoring shall be conducted using automated flow proportionate sampling in order to produce Event Mean Concentrations (EMCs) for selected constituents and therefore enable calculation of pollutant mass loadings into receiving waters. Monitoring activities at the flow proportionate sites would include the following:

1) Installation of an automated sampling device at the selected sites. A flow meter compatible with the selected automated sampling device would be utilized to trigger sampling as flow rates change. Flow meters would record continuous flow data in order to develop the EMC. Recording water levels every 15 minutes is suitable for developing EMCs.
    - A minimum of eight (8) sampling events per year should be undertaken, with two (2) events per season (i.e. Spring, Summer, Fall, and Winter) to ensure statistical significance.

    - Undertaking a minimum of five (5) single discrete flow measurements and installation of a staff gauge is recommended in order to develop a rating curve (i.e. depth versus flow relationship). Continuously recorded depth values are translated to flow rates per the relationship developed by the corresponding rating curve.

    - Continuous temperature monitoring is recommended at the automated flow proportionate sampling locations in order to establish baseline thermal regimes at the respective sampling location. Data should be recorded every 15 minutes.

    - A minimum of three (3) dry weather sampling events should be conducted at each sampling location with one event in each of spring, summer and fall season. Dry weather sampling consists of grab samples which are analyzed to provide an indication of failing infrastructure or contamination due to spills upstream. Dry weather sampling shall be limited to days without rain events and is not conducted within 48 hours of a significant storm event.

    - sampling methodology and detection limits should be consistent with the previous sampling efforts to ensure consistency amongst past datasets.

Table A-1: Water Quality Parameters Sampling & Sampling Procedure

Parameters	Sampling Procedure/ Dry Weather Sites	Sampling Procedure/Type Flow Proportionate Sites
Chloride	Grab	Automated
E.coli	Grab	Automated
Nitrate	Grab	Automated
Copper	Grab	Automated
Lead	Grab	Automated
Zinc	Grab	Automated
Total and Dissolved Phosphorous	Grab	Automated
Total Suspended Solids (TSS)	Grab	Automated
Hardness (as $CaCO_3$)	Grab	Automated
Additional Water Quality Parameters Sampled		
pH	Field Measurement – collected at time of sample retrieval	
Temperature	Field Measurement – collected at time of sample retrieval	
Dissolved Oxygen	Field Measurement – collected at time of sample retrieval	
Conductivity	Field Measurement – collected at time of sample retrieval	

Water Quantity

Continuous measurements shall be uniform in terms of frequency and representative of the flow regime. Therefore, it is recommended that a 15-min interval be employed.

Biological Monitoring

Fisheries Monitoring

A Single Pass Backpack Electrofishing Survey will be conducted annually in spring (second week in March), summer (third week in July) and fall (last week of September) at the sampling station using OSAP Section 3: Module 1. This approach is used to produce a comprehensive fish species inventory within a site, characterizing the fish community, spawning activity and providing a

qualitative assessment of species abundance. Species identification, number of fish, individual length and weight will be recorded.

Benthic Macroinvertebrate Sampling

Standard sampling protocols should be followed including the Ontario Benthos Biomonitoring Network Protocol (OBBN) (Jones, 2007) and Ontario Stream Assessment Protocol (OSAP). Benthic samples should be analysed using a multimetric approach to summarize the condition. In addition to richness (e.g. total number of taxa) and composition metrics (e.g. % Diptera), macroinvertebrate can also be classified according to:

- functional feeding groups (e.g., % Collector-Filterers, % Scrapers, % Shredders)
- habit/behavior characteristics (e.g., % Clingers)

Functional feeding groups provide an indication of food web relationships. Habitat and behaviour characteristics indicate the functionality of the organism (e.g., the way it moves or searches for food).

The samples will be analysed using a multi-metric approach to summarize the condition of the watercourse using the following indices:

- Taxa Richness
- % EPT (Ephemeroptera, Plecoptera and Trichoptera)
- # EPT Taxa
- % Oligochaeta
- % Diptera
- % Chironomidae
- % Collector-filterer
- % Collector-gatherer
- % Scraper
- % Shredder
- % Clinger
- Shannon's Diversity Index
- Hilsenhoff's Biotic Index

Water Quality Database Submission Requirements

The following is the minimum data requirements for laboratory submissions. The data submitted to the consultant must include, but not be limited to the following fields.

Field Name	Description	Type	Size
Source:	Name of the laboratory	Text	32
ID:	Unique sample number	Long	9
STATION ID:	Name of sampling site	Text	11
PARAMETER DESCRIPTION:	Full description of parameter	Text	50
SAMPLE DATE:	Date of sampling event	Text	12
SAMPLE TIME:	Time of sample event	Text	9
SAMPLE MATRIX:	The medium of the sample (water)	Text	20
RESULT:	Result value	Double	8
UNITS:	Abbreviated form of result unit	Text	28
METHOD DETECTION LIMIT:	The detection limit of the associated method	Double	8
METHOD:	Description of test method	Text	50
SAMPLE TYPE:	Grab, spike, duplicate	Text	20
EQUIPMENT:	Used for continuous sampling	Text	20
EASTING:	UTM Coordinate of sampling site	Double	20
NORTHING:	UTM Coordinate of sampling site	Double	20
MONITORING PROGRAM NAME:	Name of monitoring program	Text	16

Other information that must be provided is the full address and contact information of the laboratory. This data must be delivered as a digital file (.xls, .xlsx, .dbf, .csv).