



**C.C. Tatham & Associates Ltd.**  
Consulting Engineers

**SOPHIA CREEK WATERSHED &  
MULCASTER DRAINAGE AREA  
ENVIRONMENTAL ASSESSMENT  
UPDATE  
City of Barrie**

**Municipal Class Environmental Assessment  
Final Report**

prepared by:

C.C. Tatham & Associates Ltd.  
115 Sandford Fleming Drive, Suite 200  
Collingwood, ON L9Y 5A6  
Tel: (705) 444-2565 Fax: (705) 444-2327  
info@cctatham.com

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# 1 Introduction

In September 2015, the City of Barrie (City) retained C.C. Tatham & Associates Ltd. (CCTA) to undertake the Sophia Creek Watershed and Mulcaster Drainage Area Environmental Assessment (EA) Update. The update is being undertaken in accordance with the Schedule 'B' Municipal Class Environmental Assessment process outlined in the Municipal Engineers Association (MEA) Municipal Class Environmental Assessment Document (October 2000, as amended in 2007, 2011 and 2015). This Municipal Class Environmental Assessment details the drainage deficiencies identified in the study area, improvement options considered to address these deficiencies, and the evaluation of these alternatives towards developing a preferred alternative solution to be implemented moving forward.

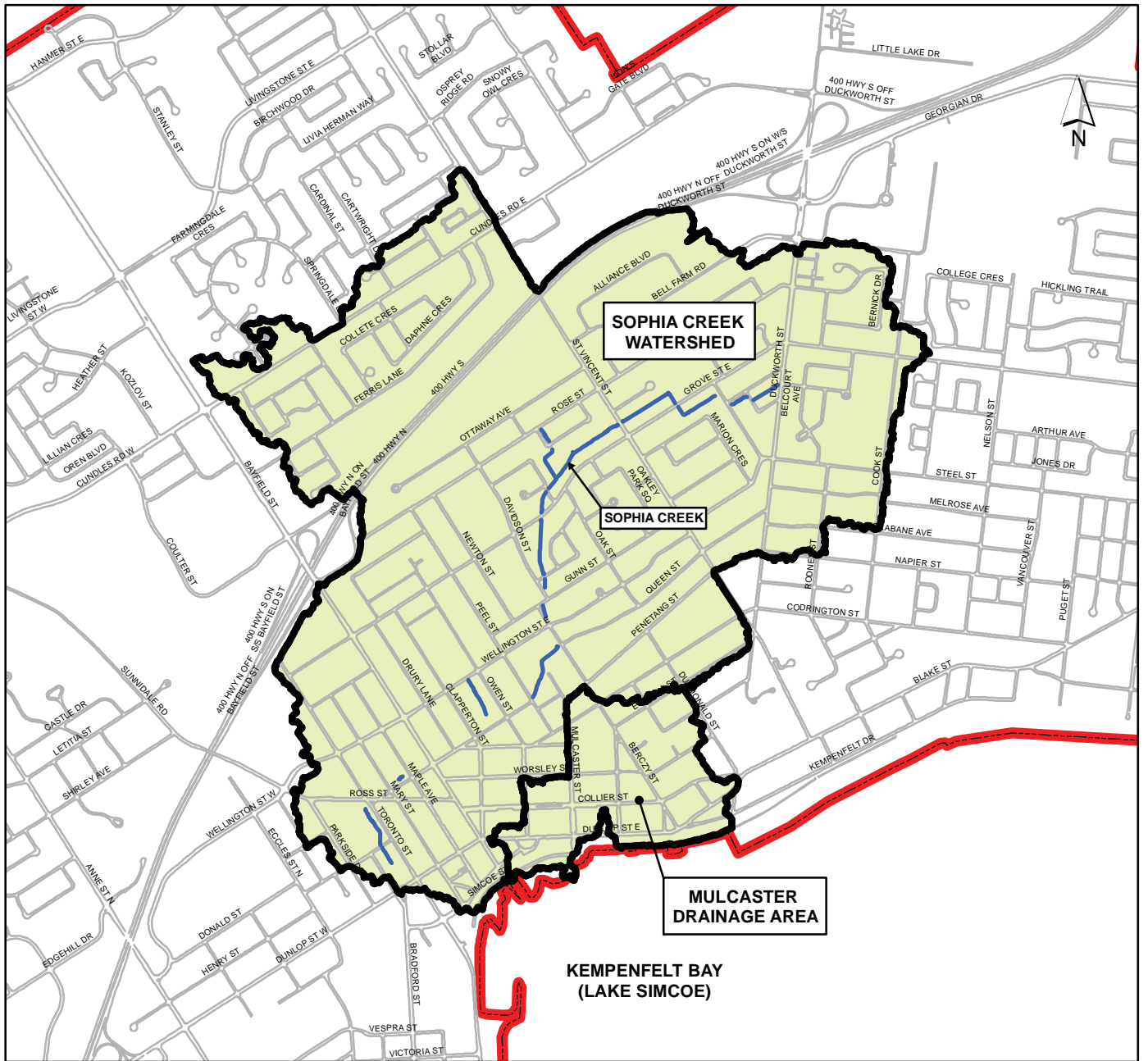
## 1.1 Study Area

The Sophia Creek watershed and Mulcaster drainage area are located in the north end of the City of Barrie, north of Kempenfelt Bay as illustrated on Figure 1 – Study Area provided overleaf. The Sophia Creek watershed and Mulcaster drainage area have drainage areas of approximately 470 ha and 44 ha, respectively. Both the Sophia Creek watershed and Mulcaster drainage area are considered fully developed with future growth expected through intensification. The Sophia Creek headwaters originate in the north end of the watershed at Cundles Road and Duckworth Street. The watercourse drains southwest to Kempenfelt Bay via a combination of open channels and culverts upstream of Peel Street and a trunk storm sewer downstream of Peel Street. The Mulcaster drainage area drains south via a combination of storm sewer and overland flow directly to Kempenfelt Bay.

## 1.2 Background

In February 2002, Skelton, Brumwell & Associates Inc. published the Sophia Creek Watershed Master Drainage Plan detailing the existing drainage conditions across the watershed and evaluating improvement alternatives to address flooding, water quality and safety issues. This report was an update to the Master Drainage Plan Study for Sophia Creek Watershed published by Andrew Brodie Associates Inc. in 1993. The product of the 2002 study was a number of preferred alternative solutions selected to address the identified deficiencies in the drainage system with the goal to minimize the impact on the economic, social and physical environments. A summary of the preferred alternative solutions previously recommended are as follows:

- Increase the capacity of the road crossing culverts along Sophia Creek. It was recommended that local road and collector/arterial road culvert crossings be designed with a 1:5 year and 1:25 year design flood frequency, respectively;
- Construct a stormwater management facility (SWMF) within MacMorrison Park to attenuate flows and improve water quality;



**Legend**

- WATERCOURSE
- ROADS
- STUDY AREA
- MUNICIPAL BORDER

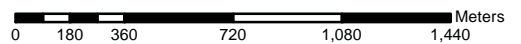


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**SOPHIA CREEK WATERSHED  
 & MULCASTER DRAINAGE AREA  
 EA UPDATE**

FIGURE 1 - STUDY AREA FIGURE



SCALE = 1:25,000

DATE: OCTOBER 2016

- Construct a stormwater management facility (SWMF) upstream of Ottaway Avenue (28 Currie Street and 364 St. Vincent Street) to attenuate flows and improve water quality.
- Increase the capacity of the watercourse between Grove Street and Parkdale Crescent to reduce flooding of private properties;
- Allow fill to be placed along the watercourse between Grove Street and Parkdale Crescent and construct a berm along the watercourse at the rear of 37 Peel Street to prevent frequent flooding during minor storm events;
- Where feasible, implement vegetative buffers along the watercourse to improve water quality; and
- Promote safety through public education programs, installation of safety grates on storm sewers, culverts and SWMF outlets, and provide signage at SWMF's to warn of potential dangers.

The recommended phasing of the preferred alternative solution was 1) construction of the SWMF upstream of Ottaway Avenue; 2) construction of the SWMF within MacMorrison Park; and 3) construction of the culvert crossing and channel upgrades starting at Peel Street proceeding upstream. Specifically, the following culvert and channel improvements were recommended.

**Table 1: MDP Recommended Structural Improvements**

Location	Type	Size
Howard Crescent	Culvert	900 mm × 1800 mm Conc. Box Culvert
Howard Crescent to Lay Street	Channel	1 m bottom width and 3:1 (H:V) side slopes
Lay Street	Culvert	900 mm × 1800 mm Conc. Box Culvert
Grove Street (at Lay Street)	Culvert	Twin 1200 mm × 1800 mm Conc. Box Culverts
St. Vincent Street	Culvert	Twin 1200 mm × 1800 mm Conc. Box Culverts
Ottaway Avenue & Rose Street	Culvert	Twin 900 mm × 1800 mm Conc. Box Culverts
Bothwell Crescent	Culvert	Twin 1500 mm × 3000 mm Conc. Box Culverts
Grove Street	Culvert	Twin 1500 mm × 3000 mm Conc. Box Culverts
Grove Street to Parkdale Crescent	Channel	1.5 m bottom width and 3:1 (H:V) side slopes to a 10 m bottom width and 4:1 (H:V) side slopes
Parkdale Crescent	Culvert	Twin 1500 mm × 3000 mm Conc. Box Culverts
Davidson Street and Gunn Street	Culvert	1500 mm × 2400 Conc. Box Culvert (existing culvert to remain)
Wellington Street and Berczy Street	Culvert	1500 mm × 2400 mm Conc. Box Culvert 1500 mm × 1800 mm Conc. Box Culvert (existing culvert to remain)

Since the publication of the MDP in 2002, the SWMF upstream of Ottaway Avenue has been constructed and the St. Vincent Street culvert crossing has been upgraded. However, the remaining improvements have not been implemented.

It must be noted, that the recommendations and work from the 2002 study were based on historic rainfall data. In 2009 the City of Barrie issued their current Storm Drainage and Stormwater Management Policies and Design Guidelines. The current design standards specify rainfall intensity-duration-frequency curves adjusted to account for climate change (15% increase in historic rainfall intensity from 1979 to 2003).

Also, the previous MDP's briefly considered but did not make a recommendation to improve the trunk storm sewer downstream of Peel Street. The social and economic impacts of constructing a large trunk storm sewer through the downtown core were cited as the primary concerns for this alternative.

Subsequently, CCTA undertook a technical assessment of the Sophia Creek MDP Update in 2007. The assessment included a review/update of the existing hydrologic and hydraulic models of Sophia Creek and the Sophia Creek watershed and development of floodplain mapping. This included a review and update to the SWMHYMO hydrologic model of the Sophia Creek watershed and preparation of a HEC RAS hydraulic model of Sophia Creek including the major overland flow routes downstream of Peel Street, and the PCSWMM hydraulic model of the trunk storm sewer downstream of Peel Street. The technical assessment was completed to establish the existing conditions of the watershed allowing for an update to the MDP to be completed.

In 2008, CCTA prepared the Sophia Creek West Branch – Drainage and Infrastructure Improvements Municipal Class Environmental Assessment. This report focused on the Sophia Creek West Branch west of Bayfield Street. The report recommended constructing a diversion structure at the intersection of Toronto Street/Ross Street, routing a trunk storm sewer south on Toronto Street, and relocating the trunk storm sewer into the municipal road allowance on Sophia Street West, Toronto Street, Dunlop Street West and Mary Street to Kempenfelt Bay. The implementation of the preferred alternative solution began as part of the reconstruction of Toronto Street and Dunlop Street in 2009. However, the trunk storm sewer along Sophia Street West remains on private property underneath several residential and commercial buildings.

In 2015, CCTA was retained by the City of Barrie to develop minor and major drainage system models of the City's storm infrastructure across the entire City of Barrie, including the Sophia Creek watershed and Mulcaster drainage area. CCTA prepared, calibrated, and verified a PCSWMM hydrologic/hydraulic model of Barrie's minor drainage systems citywide. Similarly, CCTA prepared a Visual OTTHYMO hydrologic model and HEC RAS hydraulic models of Barrie's major drainage systems citywide. The models were used to identify the deficiencies in the minor/major drainage systems and allow for the evaluation of proposed infrastructure improvements under a variety of actual and predicted storm events and future watershed conditions. The drainage deficiencies identified for the Sophia and Mulcaster systems are described in subsequent sections of this report.

### 1.3 Project Team

The project team responsible for the preparation of this report and the supporting documentation is comprised of the following:

- City of Barrie (City);
- C.C. Tatham & Associates Ltd. (CCTA) – Engineering;
- Lake Simcoe Region Conservation Authority (LSRCA);
- Azimuth Environmental Consulting, Inc. (AEC) – Natural Heritage;
- Archeoworks Inc. (AW) – Archeological;
- Peto MacCallum Ltd. (Peto) - Geotechnical; and
- Rudy Mak Surveying Ltd. (RMS) – Legal Survey.

### 1.4 Municipal Class Environmental Assessment Process

This Municipal Class Environmental Assessment has been developed in accordance with the Schedule 'B' Municipal Class Environmental Assessment process (provided overleaf) for Master Plans outlined in the Municipal Engineers Association (MEA) Municipal Class Environmental Assessment Document (October 2000, as amended in 2007, 2011 and 2015). It considers all aspects of the environment: physical, natural, social, cultural and economic, and involves consultation with the public, affected parties and review agencies throughout the process.

Master Plans are long-range plans that integrate infrastructure requirements for existing and future land uses with environmental assessment planning processes.

This update to the Sophia Creek Watershed and Mulcaster Drainage Area Environmental Assessment is proceeding through Phases 1 and 2 of the Class EA process as follows:

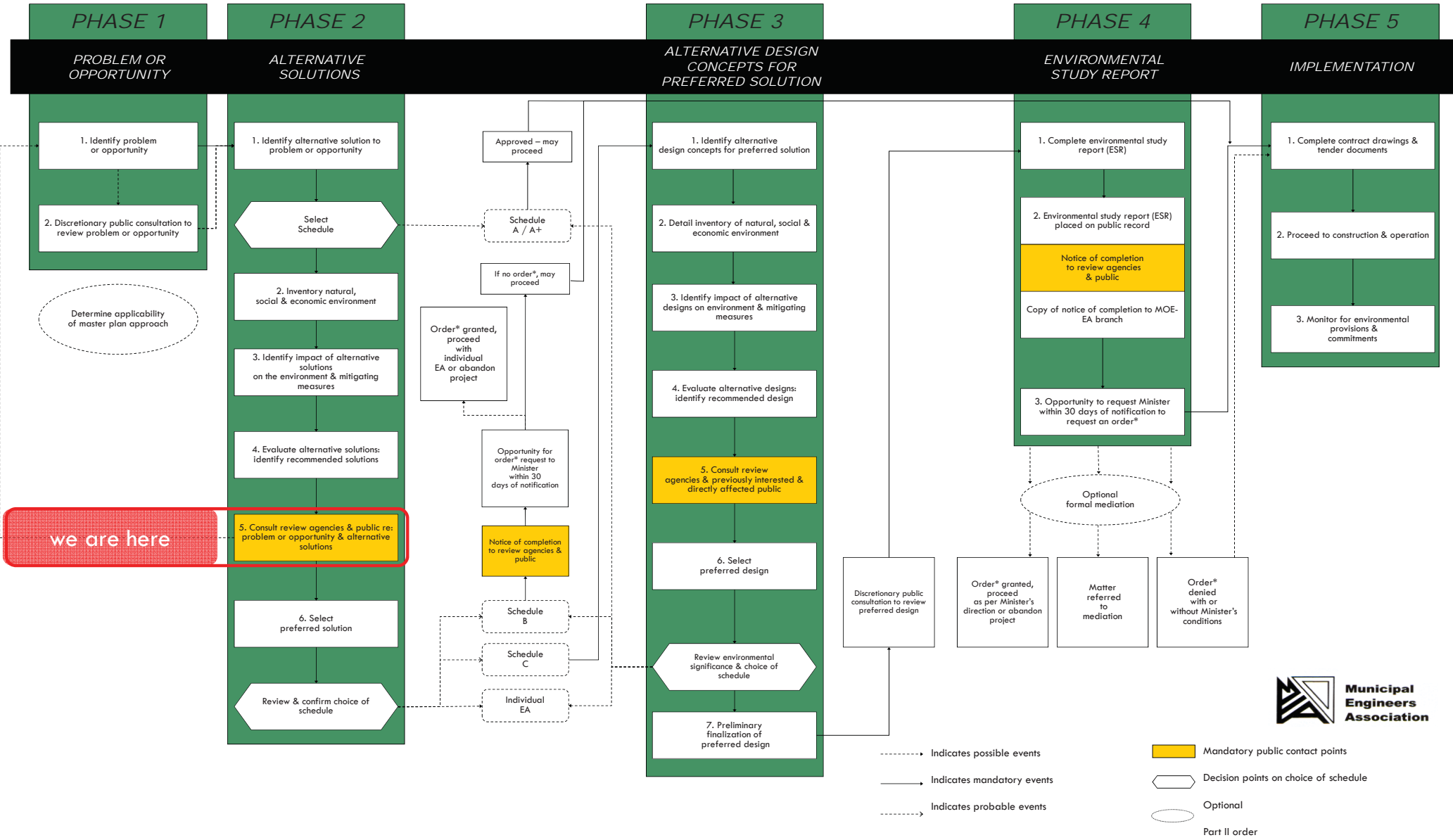
Phase 1: Identify the Problem.

Phase 2: Identify and assess, at a strategic level, alternative solutions to the identified problem, then recommend the preferred master plan that can be implemented as separate subsequent projects.

This update has been prepared upon the conclusion of Phases 1 and 2 of the Class EA process and made available for public comment prior to being approved and adopted by the City.

# Municipal Class EA Process

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Projects undertaken to implement the specific elements of the recommended Master Plan will be the subject of more detailed investigations to fulfil the documentation requirements of the Class EA process.

## 1.5 Existing Policies

There are several policies, regulations and guidelines which are to be adhered to as part of the proposed improvement alternatives within the Sophia Creek watershed and Mulcaster drainage area. The most recent versions of these documents include the following:

### 1.5.1 Storm Drainage and Stormwater Management Policies and Design Guidelines (2009)

The City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines provide direction for the effective management of stormwater in the City. The Policies and Guidelines provide uniform minimum standards and policies for the planning process and stormwater infrastructure design. The document includes the City's policies and guidelines regarding environmental protection (water quality, water quantity, water balance, etc.), natural hazards (flood and erosion hazards), stormwater management facility design, and urban design concepts including traditional concepts and low impact development (LID) techniques. Generally, these guidelines include the mandates of the other policies, regulations and guidelines discussed in this section. As such, these guidelines act as the basis for the development of the improvement alternatives in the study area.

As per the City's guidelines, the minor drainage system (storm sewer) shall be designed to convey the 1:5 year (minimum) design storm peak flow. Watercourses and channels shall be capable of conveying the Regulatory storm peak flow without flooding adjacent private property. Flooding of existing buildings and/or property shall be eliminated where feasible. Road culvert crossings and road elevations shall be designed to satisfy the following design criteria:

**Table 2: Flow Design Guidelines for Road Crossings**

Road Classification	Design Flood Frequency
Arterial	1:100 Year Regional (Hurricane Hazel) – if directed by the City
Collector	1:50 Year
Urban Local	1:50 Year
Rural Local	1:25 Year
Temporary Detour	1:10 Year
Driveway	1:10 Year

Generally, all new development is restricted to areas outside the Regulatory floodplain unless, in the opinion of the City and the Lake Simcoe Region Conservation Authority, the control and extent of flooding

will not be affected by the development. If permission is granted by the City and LSRCA to develop or redevelop in the floodplain, the minimum opening elevations of all buildings must be 500 mm greater than the Regulatory flood elevation.

### **1.5.2 By-Law 90-92: To Prohibit Obstruction of Drains & Watercourses (1990)**

By-Law 90-92 specifies the City's responsibility in continuing to undertake SWM related projects, operate and maintain existing conveyance systems and progressively acquire land or easements for drains, watercourses and storage areas crossing or upon private lands, where it is considered to be in the City's interest to do so.

### **1.5.3 LSRCA Watershed Development Policies and LSRCA Technical Guidelines for Stormwater Management Submissions (2016)**

The principal mandate of the Lake Simcoe Region Conservation Authority is to protect public health and safety, prevent property damage and prevent social disruption caused by natural hazards while conserving, protecting and managing natural resources within the Lake Simcoe watershed. Complementing the Planning Act, the LSRCA administers the Development, Interference with Wetlands and Alterations to Shorelines and Watercourse Regulation (Ontario Regulation 179/06) under Section 28 of the Conservation Authorities Act. Development within the LSRCA Regulation Limits is subject to LSRCA review and approvals allowing the LSRCA to ensure development proposals have regard for the existing natural hazards.

The LSRCA Watershed Development Policies outline the stormwater management and watershed development policies aimed to protect the environmental integrity of the Lake Simcoe watershed. The Policies provide direction on land use and development considering natural hazards, natural heritage features, and the natural environment to protect public health and safety, prevent property damage and social disruption.

Similar to the MOE Stormwater Management Planning and Design Manual and City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines, the LSRCA Technical Guidelines for Stormwater Management provide planning and design direction for the effective management of stormwater in the Lake Simcoe Watershed.

As per the LSRCA Technical Guidelines, road reconstruction projects are subject to stormwater volume control requirements, specifically linear development volume control. Linear development is to retain and treat the larger of the following:

1. The runoff from the 12.5 mm event from the total reconstructed impervious surface; or
2. The runoff from a 25 mm event from the net increase in impervious surface.

As part of road reconstruction projects, attempts are to be made to fully comply with the linear development volume control criteria. If compliance is not achievable due to soil/groundwater conditions

or site constraints, flexible treatment alternatives shall be applied. Given the restrictions to implementing LID techniques in the study area, specifically existing groundwater and soil conditions, a majority of the study area is subject to the LSRCA's flexible treatment alternative for sites with restrictions criteria. The flexible treatment alternatives are described as follows:

- Alternative 1 – Retain the runoff from the 12.5 mm event from the total reconstructed impervious surface;
- Alternative 2 – Achieve runoff volume reduction to the maximum extent possible (minimum 5 mm from all impervious surfaces); or
- Alternative 3 – Off-site control of the runoff from a 25 mm event from the net increase in impervious surface.

#### **1.5.4 Lake Simcoe Protection Plan (2009)**

The Lake Simcoe Protection Plan's priority is to protect and restore the long-term ecological health of the Lake Simcoe watershed. Short term focus includes restoring the health of aquatic life, improving water quality, maintaining water quantity, protecting and rehabilitating shorelines and natural heritage features, and addressing impacts of invasive species, climate change, and recreational activities. The strategies outlined in the LSPP will evolve over time based on scientific research and experience to ensure the objectives are satisfied. The objectives of the Plan as set out in the Lake Simcoe Protection Plan (2009) are to:

- Protect, improve or restore the elements that contribute to the ecological health of the Lake Simcoe watershed, including water quality, hydrology, key natural heritage features and their functions, and key hydrologic features and their functions;
- Restore a self-sustaining coldwater fish community in Lake Simcoe;
- Reduce phosphorus loadings and other nutrients of concern to Lake Simcoe and its tributaries;
- Reduce the discharge of pollutants to Lake Simcoe and its tributaries;
- Respond to adverse effects related to invasive species and, where possible, to prevent invasive species from entering the Lake Simcoe watershed;
- Improve the Lake Simcoe watershed's capacity to adapt to climate change;
- Provide ongoing scientific research and monitoring related to the ecological health of the Lake Simcoe watershed;
- Improve conditions for environmentally sustainable recreation activities related to Lake Simcoe and to promote those activities;
- Promote environmentally sustainable land and water uses, activities and development practices;

- Build on the protections for the Lake Simcoe watershed that are provided by provincial plans that apply in all or part of the Lake Simcoe watershed, including the Oak Ridges Moraine Conservation Plan and the Greenbelt Plan, and provincial legislation, including the Clean Water Act, 2006, the Conservation Authorities Act, the Ontario Water Resources Act, and the Planning Act; and
- Pursue any other objectives set out in the Lake Simcoe Protection Plan.

The Sophia Creek watershed and Mulcaster drainage area are located in the Lake Simcoe watershed and fall under the general authority of the Lake Simcoe Protection Plan (LSPP). Policy 4.5 – SA of the LSPP establishes requirements for SWM Master Plans prepared in accordance with the Municipal Class Environmental Assessment process. Accordingly, the LSPP has been used as a guidance document for this study.

The City is committed to meet all of the requirements of Policy 4.5 of the LSPP including determining the effectiveness of the existing drainage infrastructure at reducing the negative impacts of stormwater on the environment and identifying additional stormwater management retrofit opportunities or improvements to existing storm infrastructure that could improve stormwater treatment. Any retrofit opportunities would be implemented on a site specific basis with the improvements carried through to downstream areas.

### **1.5.5 Stormwater Management Planning and Design Manual (2003)**

The Stormwater Management Planning and Design Manual evolved from the MOE Stormwater Quality Best Management Practices manual (June 1991) in response to evolving stormwater management practices to provide an integrated approach to effective stormwater management planning and design focused on water quality, water quantity and erosion control. The Planning and Design Manual is a tool, not a rulebook, providing practical guidance for the effective design of lot level, conveyance, and end-of-pipe stormwater practices. The objectives of the Planning and Design Manual are to apply an integrated treatment train approach to manage stormwater to maintain the hydrologic cycle, protect water quality and prevent increased erosion and flooding.

In accordance with the City's guidelines and Ontario Regulation 219/09, all new development and SWMF's shall provide as a minimum Enhanced Level water quality control as specified in the Stormwater Management Planning and Design Manual unless it can be demonstrated to the satisfaction of the Director (MOECC) that it is impractical to achieve this level of protection.

### **1.5.6 The City of Barrie Official Plan (2014)**

The Official Plan (OP) outlines the goals, objectives and policies for land use and development within the City of Barrie. The OP provides the City direction for controlling growth, implementing by-laws and making public and private development decisions as a means of ensuring a healthy community. The OP provides guidance for land use changes, municipal initiatives and the provision of public works. As such, the OP provides policies for the effective management of stormwater.

The stormwater management goals of the OP as set out in 2011 are:

- To protect and enhance the water quality and environmental, aesthetic and recreational potential of the City's watercourses, Little Lake, Kempenfelt Bay and Lake Simcoe.
- To encourage effective stormwater management in order to control flooding, erosion, sedimentation and maintain and enhance water quality in the receiving watercourses and water bodies.
- To promote the incorporation of natural waterways, valleys, and ponds into continuous green corridors for wildlife habitat, open space, and parkland.
- To ensure stormwater management policies minimize stormwater peak flows, contaminant loads including phosphorus, and maintain or increase the extent of vegetative and pervious surfaces.

The alternatives for this project, especially as they relate to the environment and future growth and development, will consider these goals, objectives and policies.

### **1.5.7 Provincial Policy Statement (2005)**

The 2005 Provincial Policy Statement was developed as a regulatory policy for land use planning and development. The 2005 Provincial Policy Statement supports the protection of public health and safety, the natural environment and the resources of provincial interest while providing for appropriate development. The policy identifies the natural and built features to be protected and the areas where development and site alteration are restricted. Key requirements of this policy are as follows:

- Development and site alteration are restricted on lands adjacent to natural heritage features unless it is demonstrated that the natural features and their ecological functions are not negatively impacted.
- Development and site alteration are restricted on lands adjacent to sensitive surface water and groundwater features unless mitigative measures or alternate development approaches protect these natural features.
- Significant built heritage features are to be conserved.

### **1.5.8 Low Impact Development Stormwater Management Planning and Design Guide (2010)**

The Credit Valley Conservation Authority (CVC) and Toronto and Region Conservation Authority (TRCA) developed the Low Impact Development Stormwater Management Planning and Design Guide which speaks to the importance of at source SWM controls versus typical end-of-pipe facilities. The advantages of the low impact development approach include:

- Reduction in overall runoff volume;
- Reduction in phosphorus discharge; and
- Reduced long term operation and maintenance.

As such, implementing low impact development measures in the Sophia Creek watershed and Mulcaster drainage area where feasible will help reduce flooding and improve the overall water quality of the watershed. On this basis, all future development should evaluate the use of low impact development principles as part of the stormwater management design.

### **1.5.9 Natural Heritage Strategy**

As a requirement of the Official Plan, the Natural Heritage Strategy has been developed to identify the natural resources within the City and to provide a system of linkages between these resources and the waterfront within the existing urban area. The goal of the strategy is to preserve and improve the natural heritage features, such as watercourses, wetlands and woodlots, remaining in the City over the long term. The Strategy establishes the natural heritage policies needed to ensure the preservation of these features throughout the existing urban area.

### **1.5.10 Natural Hazard Policies**

The Natural Hazard Policies under the Provincial Policy Statement provide direction on land use and development in areas where there is a risk to public health and safety or a risk of property damage from flooding and/or erosion hazards. The Natural Hazard Policies aim to reduce the long-term risk to public health and safety or property damage through land management and by directing development outside hazardous lands. The natural hazard features in the study area have been estimated by the LSRCA and refined through detailed studies. In the study area, the natural hazard policies are administered by the LSRCA under Section 28 of the Conservation Authorities Act through Ontario Regulation 179/06.

### **1.5.11 Growth Plan**

Under the Places to Grow Act, 2005 the Growth Plan for the Greater Golden Horseshoe is a framework for building stronger, prosperous communities by implementing Ontario's vision for managed growth in the region. The Plan provides direction for planning, housing, natural heritage, environmental protection, infrastructure and transportation decisions considering the region as a whole while recognizing the unique characteristics, strengths and economy of each individual community.

### **1.5.12 Phosphorus Reduction Strategy**

The Lake Simcoe Phosphorus Reduction Strategy was produced to satisfy Policy 4.24-SA of the LSPP. The Phosphorus Reduction Strategy presents a series of actions designed to achieve long term continual reductions in phosphorus loads discharged into Lake Simcoe. The Strategy identifies specific goals and potential opportunities to achieve the long-term objective of reducing the phosphorus load in Lake Simcoe to 44 tonnes per year. The Strategy is a living document and will be reassessed every five years to ensure the proper actions are recommended to achieve the desired phosphorus reductions.

## 2 Problem/Opportunity Statement

The 2002 Master Drainage Plan as well as the updated minor and major drainage system models were reviewed in detail to clearly identify the outstanding drainage issues/deficiencies in the study area which need to be addressed. The Problem and Opportunity Statements for this Class EA Update are provided in the following sections and remain generally consistent with the background Master Drainage Plans.

### 2.1 Problem Statement

Currently, portions of the Sophia Creek watershed experience flooding during both minor and major storm events. Frequent flooding of private and municipal property during minor and major storm events has been documented upstream of Peel Street throughout much of the watercourse due to insufficient culvert and channel capacities. Downstream of Peel Street, runoff from minor and major storm events can also surcharge the trunk storm sewer and flood private and municipal property along Sophia Street from Peel to Bayfield Street and along Owen, Clapperton and Bayfield Street from Sophia Street to Kempenfelt Bay. The flooding has caused historic damage to both private and municipal property and causes concern for public safety.

In addition to flooding, the existing storm infrastructure is reaching its service life expectancy and deteriorating. A majority of the aging storm sewers are undersized considering historic rainfall data and current climate models predict future increases in rainfall intensities and volumes. In some locations, municipal storm infrastructure is located on private property outside the municipal right-of-way making it difficult to access and maintain. Development, intensification, urbanization and growth in the watershed have also adversely impacted the stormwater quality and ecological health of Sophia Creek and Lake Simcoe. The culmination of the above noted factors results in a storm system that does not meet the City's engineering and development standards.

Similar to the Sophia Creek watershed, there are areas absent of minor drainage systems and stretches of deficient overland flow routes in the Mulcaster drainage area. As described, flooding occurs through the downtown core within the Mulcaster drainage area during minor and major storm events due to deficient storm infrastructure within the Sophia Creek watershed; specifically the undersized Sophia Street trunk storm sewer.

### 2.2 Watershed & Site Specific Problems

Several existing problem areas have been identified through our review of the available background information and consultation with City staff. These problem areas include the following:

1. Frequent flooding of private properties in the Howard Crescent, Lay Street and Highview Road areas resulting from undersized road crossing culverts and insufficient channel capacities;

2. Flooding of private properties on Ottaway Avenue, Rose Street and Currie Street and channel erosion caused by undersized storm sewer and insufficient channel capacities;
3. The Bothwell Crescent, Grove Street East and Parkdale Crescent road culvert crossings are reaching their service life expectancy, deteriorating and in need of replacement. The culverts are undersized resulting in frequent flooding during minor and major storms events and erosion of the watercourse up and downstream;
4. The private properties backing onto Sophia Creek between Grove Street East and Parkdale Crescent historically flood as a result of insufficient channel capacities, grading concerns and high groundwater levels;
5. Extensive flooding of private property and property damage at the intersection of Gunn and Berczy Streets caused by undersized culverts and insufficient channel capacities;
6. Flooding of private and municipal property along Sophia Street from Peel to Bayfield Street along Owen, Clapperton and Bayfield Street from Sophia Street to Kempenfelt Bay caused by undersized trunk storm sewer, storm sewer surcharging and lack of adequate overland flow routes;
7. Existing trunk storm sewer located on private property underneath residential and commercial buildings along Sophia Street West between Maple and Toronto Streets;
8. Areas/streets absent of minor drainage systems through the study area including, but not limited to, Marion Crescent/Pratt Road, Agnes Street/Peel Street, Albert Street/Eugenia Street, Northpark Road/Parkdale Crescent, and Gunn Street;
9. Undersized existing local storm sewers that do not satisfy the municipal conveyance criteria throughout the study area considering historic and predicted climate models; and
10. Deficient existing overland flow routes throughout the study area leading to flooding of both private and municipal property and potential safety hazards.

## 2.3 Opportunity Statement

The City is planning to mitigate the drainage deficiencies and replace the aging and deteriorating storm infrastructure throughout the study area as part of future works. Opportunity exists to improve the drainage system level of service to a level that conforms with current drainage policies and design guidelines, improves water quality and water balance conditions, reduces flooding and erosion, improves maintenance opportunities and eliminates public safety hazards. As such, the City has initiated this Schedule "B" Municipal Class Environmental Assessment Update to identify and evaluate drainage improvements based on their impacts to the physical, natural, social, cultural and economic environments. A set of preferred improvement alternatives having the greatest positive impact and a recommended approach for implementing the alternatives will be the end product of the study.

## **3 Project Environment**

This section provides a description of the existing physical, natural, social, cultural and economic environments within the study area. The detailed description of the project environment has been developed from a review of the available background information as well as recent field investigations.

### **3.1 Physical Environment**

#### **3.1.1 Private Property**

Within the study area there is a mix of residential, commercial, institutional, industrial, and open space land uses. As discussed, the existing drainage systems are located on both municipal and private property in the study area. Also, extensive flooding of private land can occur along Sophia Creek and through the downtown core during minor and major storm events.

The improvement alternatives proposed aim to prevent/reduce flooding on private property. However, the evaluation of the improvement options must also consider the purchase of these properties or acquiring interest therein (easements) to eliminate flooding of private property as per the City's current By-Laws. The private properties identified within the existing floodplain are summarized in the following table:

**Table 3: Private Property Subject to Flooding**

Address (Upstream of Peel Street)					
29 Peel Street	37 Peel Street	166 Berczy Street	168 Berczy Street	47 Gunn Street	56 Gunn Street
15 Davidson Street	2 Northpark Road	17 Davidson Street	4 Northpark Road	19 Davidson Street	6 Northpark Road
8 Northpark Road	10 Northpark Road	12 Northpark Road	31 Davidson Street	133 Grove Street East	2 Bothwell Crescent
1 – 12 Burbank Place	230 Grove Street East	38 Lay Street	36 Lay Street	13 Highview Road	207 Grove Street East
210 Grove Street East	63 – 70 Ottaway Avenue	1 Currie Street	122 Currie Street	124 Currie Street	128 Currie Street
103 Wellington Street	150 Berczy Street	152 Berczy Street	154 Berczy Street		

**Table 3: Private Property Subject to Flooding (continued)**

Address (Downstream of Peel)					
24 Peel Street	26 Peel Street	28 Peel Street	30 Peel Street	34 Peel Street	70 Sophia Street East
68 Sophia Street East	66 Sophia Street East	93 Owen Street	95 Owen Street	97-98 Owen Street	100 – 101 Owen Street
103 Owen Street	18 McDonald Street	20 McDonald Street	22 McDonald Street	24 McDonald Street	26 McDonald Street
28 McDonald Street	30 McDonald Street	32 McDonald Street	34 McDonald Street	38 McDonald Street	40 McDonald Street
47 Sophia Street East	49 Sophia Street East	51 Sophia Street East	76 Owen Street	80 Owen Street	84 Owen Street
88 Owen Street	90 Owen Street	92 Owen Street	11 McDonald Street	60 Clapperton Street	58 Clapperton Street
54 Clapperton Street	30 Worsley Street	59 Owen Street	55 Owen Street	70 Worsley Street	32 Clapperton Street
14 Collier Street	10 Collier Street	44 Collier Street	22 Clapperton Street	53 Bayfield Street	33 Bayfield Street
31 Bayfield Street	11 Collier Street	15 Collier Street	17 Collier Street	21 Collier Street	23 Collier Street
31 Collier Street	33 Collier Street	39 Collier Street	43 Collier Street	45 Collier Street	30 Owen Street
15 Clapperton Street	13 Clapperton Street	11 Clapperton Street	9 Clapperton Street	3 Clapperton Street	2 Dunlop Street East
10 Dunlop Street East	12 Dunlop Street East	16 Dunlop Street East	20 Dunlop Street East	26 Dunlop Street East	34 Dunlop Street East
40 Dunlop Street East	42 Dunlop Street East	44 Dunlop Street East	46 Dunlop Street East	50 Dunlop Street East	54 Dunlop Street East
58 Dunlop Street East	60 Dunlop Street East	64 Dunlop Street East	1 Dunlop Street East	5 Dunlop Street East	11 Dunlop Street East
15 Dunlop Street East	25 Dunlop Street East	29 Dunlop Street East	31 Dunlop Street East	33 Dunlop Street East	39 Dunlop Street East
41 Dunlop Street East	43 Dunlop Street East	47 Dunlop Street East	55 Dunlop Street East	57 Dunlop Street East	26 Owen Street
22 Owen Street	18 Owen Street	23 Owen Street	9 Owen Street	2 Fred Grant Square	15 Bayfield Street

### **3.1.2 Storm Sewer**

Within the study area, the drainage systems consist of storm sewers, culverts, ditches, and open channels. The Sophia Creek headwaters originate in the north end of the study area at Cundles Road and Duckworth Street. The watercourse drains southwest to Kempenfelt Bay via a combination of open channels and culverts upstream of Peel Street and a trunk storm sewer downstream of Peel Street. Local storm sewers convey flow during minor storm events directly to Sophia Creek or the trunk storm sewer. The Mulcaster drainage area drains south via a combination of storm sewer and overland flow directly to Kempenfelt Bay. The existing drainage features are illustrated on Figure 2 – Existing Drainage Features provided overleaf.

As per the City's guidelines, the minor drainage system (storm sewer) shall be designed to convey the 1:5 year (minimum) design storm peak flow. Watercourses and channels shall be capable of conveying the Regulatory storm peak flow without flooding adjacent private property. Flooding of existing buildings and/or property shall be eliminated where feasible. Road culvert crossings and road elevations shall be designed to satisfy the design flood frequency criteria for the corresponding road classification. In the Study Area, the roads are classified as arterial, major/minor collectors, and urban local roads. The design flood frequency criteria for each road classification is provided in Table 2 in section 1.5.1.

The existing storm infrastructure along Sophia Creek is reaching its service life expectancy and deteriorating. A majority of the aging storm sewers are undersized considering historic rainfall data and current climate models predict future increases in rainfall intensities and volumes. In some locations, municipal storm infrastructure is located on private property outside the municipal right-of-way making it difficult to access and maintain. Frequent nuisance flooding during minor storm events, potential public safety hazards, and access/maintenance issues are common throughout the study area. For these reasons, the replacement of storm infrastructure throughout the Sophia Creek watershed and Mulcaster drainage area is required.

The extent/locations of the existing minor and major drainage systems deficiencies are described further in Section 4 – Existing System Analysis and illustrated on Figures 3 through 5.

### **3.1.3 Existing Infrastructure (Sanitary, Water and Utilities)**

Utilities including sanitary sewers, water main, gas, hydro and other buried utilities have been identified in the study area from the available record drawings. Conflicts with existing utilities have been reviewed for each improvement alternative proposed and potential conflicts and resolutions have been identified. Minor utility relocations and lowering of existing water main may be required to accommodate the improvement alternatives being evaluated.



Of note, a trunk sanitary sewer runs parallel to Sophia Creek from Grove Street East to Parkdale Crescent at the rear of the lots fronting onto Northpark Road. Also a trunk watermain runs underneath Lakeshore Drive from Bayfield Street to Mulcaster Street, and limited space is available in the Bayfield Street road allowance for additional services/utilities.

### 3.1.4 Transportation System

In the Study Area, the roads are classified as arterial, major/minor collectors, and urban local roads. The road classifications are summarized in the following table.

**Table 4: Road Classification**

Street	Road Classification	Design Flood Frequency
Duckworth Street	Arterial	1:100
St. Vincent Street		
Wellington Street		
Dunlop Street		
Bayfield Street		
Cundles Road		
Bell Farm Road	Major Collector	1:50
Sunnidale Road		
Simcoe Street		
Mulcaster Street		
Collier Street		
Rose Street		
Grove Street	Minor Collector	1:50
Sophia Street		
Toronto Street		
Penetang Street		
Steel Street	All other roads are classified as Urban Local Roads	

Source: The City of Barrie Official Plan – Schedule D Roads Plan

The proposed improvement alternatives include construction within the roadway to replace culverts and improve channel sections. These improvements will result in isolated disturbances to the existing transportation systems; temporary disturbance during construction. However, construction of a trunk storm sewer through the downtown core will create a temporary disturbance on the existing transportation system during construction, particularly if works occur on arterial and/or collector roads. As such, the impact each improvement alternative has on the transportation systems is an important consideration for this study.

### **3.1.5 Floodplain**

The floodplain throughout the Sophia Creek watershed was originally developed through the previous Master Drainage Plan. Upstream of Peel Street, flooding of private property next to the watercourse has been documented from Howard Street to Peel Street due to undersized culverts and channel reaches. Downstream of Peel Street, runoff from major storm events can also surcharge the trunk storm sewer and flood private and municipal property along Sophia Street from Peel to Bayfield Street and along Owen, Clapperton and Bayfield Street from Sophia Street to Kempenfelt Bay. The flooding has caused historic damage to both private and municipal property and causes concern for public safety.

The delineation of the existing floodplain through the study area is further described in Section 4 – Existing System Analysis and illustrated on Figures 4 and 5.

### **3.1.6 Parkland**

The existing parks are an important consideration within the study area. The parks provide a green space amenity within the City for pedestrian connectivity and community use. The parks are features enjoyed by not only surrounding residents but residents throughout the City. The maintenance of the parks is an important consideration as it relates to the City of Barrie Master Park and Leisure planning policies.

Parkland has been identified for its potential inclusion of low impact development measures and/or stormwater management facilities. Low impact development measures can be constructed in existing parklands to reduce minor drainage system peak flows, enhance water quality treatment, improve the water balance and reduce erosion all while maintaining the existing function/use of the parkland. SWMF's may provide the added benefit of reducing major drainage system peak flows, however at a cost of disturbing the surface features, function and use of the parkland or a portion of it.

## **3.2 Natural Environment**

Azimuth Environmental completed an existing natural heritage features evaluation in the summer of 2016 in support of this Class EA update. The evaluation involved a Species at Risk (SAR) survey, assessment of potential fish and wildlife/SAR habitat, assessment of potential habitat features suitable for frogs and toads, incidental wildlife observations, Ecological Land Classification (ELC) vegetative

community survey and one summer vascular plant survey. The results of the evaluation are summarized in the following sections and detailed in the Natural Heritage Features Evaluation enclosed in Appendix A.

### **3.2.1 Vegetation**

No plant species designated Endangered, Threatened or Special Concern federally or provincially were observed in the areas identified for potential improvement (project footprint). None of vegetation community types are considered rare provincially, and no plant species present are considered rare provincially. A Black Walnut considered rare in the Lake Simcoe watershed was observed, however, Black Walnut are common landscape trees in the City of Barrie. Of the 77 plant species identified within the project footprint, approximately 50 are considered non-native and/or invasive species. Overall, the improvement alternatives will provide opportunities to enhance native plantings.

### **3.2.2 Fisheries**

No fish species or permanent fish habitat was observed in the study area due to the lack of baseflow during the field investigations, perched culverts and dry channel reaches. As such in-water works timing windows should not be required (subject to MNR/DFO confirmation) and standard mitigation measures for working around water should be sufficient for the improvement alternatives.

### **3.2.3 Terrestrial Wildlife**

A total of 15 urban bird species were identified as part of the evaluation. None of the bird species are 'at risk' or species of concern in Ontario. Other possible species at risk wildlife was not observed and the project footprint does not offer significant SAR habitat. No frog or toad species were observed on-site and the project footprint does not appear to be suitable as frog or toad habitat. Overall, the improvement alternatives will provide opportunities to enhance wildlife habitat.

### **3.2.4 Water Quality**

The Sophia Creek watershed and Mulcaster drainage area are predominately developed and accordingly the current development within the study area is not considered as potential new sources of water quality degradation. However, many of the existing developments do not have water quality controls thus, where feasible, opportunities to improve water quality should be considered including the following:

1. Low Impact Development measures;
2. SWMF retrofits;
3. Watercourse daylighting; and

4. Vegetative buffers along the watercourse.

New development in the study area is subject to the policies and regulations outlined in section 1.5 of this report. As such, all new development shall provide as a minimum Enhanced Level water quality control as specified in the Stormwater Management Planning and Design Manual unless it can be demonstrated to the satisfaction of the Director (MOECC) that it is impractical to achieve this level of protection.

### 3.3 Social Environment

#### 3.3.1 Property Value

Existing flooding and the presence of municipal infrastructure on private property can negatively impact property values. As such, any improvement alternative that will prevent/reduce flooding on private property and relocate municipal infrastructure into municipally owned lands would be a positive improvement.

The property values of the private properties identified within the floodplain are summarized in the following table:

Table 5: Property Value Summary

Location	Number of Properties	Average Value	Total Value
Upstream of Peel Street	52	\$254,000	\$19,395,750
Downstream of Peel Street	105	\$637,000	\$66,917,000
<b>Total</b>	<b>157</b>	<b>\$550,000</b>	<b>\$86,312,750</b>

Note: Property Value – Assessed Value (MPAC)

#### 3.3.2 Public Safety

The existing drainage systems throughout the study area operate at levels below current City design standards resulting in flooding on municipal and private property. The flooding presents a potential for public safety concerns. The conveyance of both minor and major storm flows and compliance with the Provincial Policy Statement in this regard is an important consideration in the review of improvement alternatives.

In addition to flooding, the lack of safety grates on storm sewer and culvert inlets/outlets, lack of signage around SWMF's describing the potential hazards, and the lack of pedestrian barricades at fall hazards pose a threat to public safety. As such, the installation of safety grates, signage and pedestrian barricades is required.

### 3.4 Cultural/Archeological Environment

Archeoworks Inc. completed a Stage 1 Archeological Assessment in the summer of 2016 in support of this Class EA update. The assessment concluded that the study area has undergone significant changes since 1954 through urban development, roadway construction, infrastructure installation and grading/landscaping. These activities contribute to the removal of archeological resources. As such, disturbed areas confirmed through on-site property inspection may be classified as “no archeological potential” and may be exempt from Stage 2 test pit surveys.

Any construction activity in lands that are deemed undisturbed during an on-site property inspection require a Stage 2 test pit survey. Similarly, the historic Town of Barrie retains elevated archeological potential for the presence of deeply buried archeological resources. As such, a Stage 2 test pit survey is required within the historic Town of Barrie. Lands classified as uncertain archeological potential or archeological potential requiring a Stage 2 test pit survey within the footprint of the improvement alternatives are summarized as follows and detailed in the Stage 1 Archeological Assessment enclosed in Appendix B for reference.

#### **Uncertain Archeological Potential**

1. Historic Town of Barrie

#### **Archeological Potential**

2. Ferris Park
3. College Heights Park
4. Steel Street Park
5. H.G Robertson Park
6. MacMorrison Park
7. 364 St. Vincent Street

It is noted that no construction activities shall take place within the study area prior to the MTCS (Archaeology Program Unit) confirming in writing that all archaeological licensing and technical review requirements have been satisfied.

## **3.5 Economic Environment**

### **3.5.1 Drainage System Maintenance Costs**

Throughout the study area, the City incurs costs to maintain their existing drainage systems on both municipal and private property. Clearing obstructions, repairing erosion and removing accumulated sediment are routine maintenance activities the City coordinates to complete. Unfortunately, as existing storm infrastructure reaches its service life expectancy and deteriorates, the maintenance costs increase. Limited access to drainage infrastructure on both private and municipal lands also increases maintenance costs. For these reasons, the maintenance costs in the Sophia Creek watershed are generally higher than other watersheds in the City of Barrie.

The improvement alternatives being considered aim to attenuate peak flows, improve water quality, increase conveyance capacities and prevent/reduce the flooding on private property. As such, the maintenance costs along Sophia Creek are expected to be reduced. However, periodic maintenance will be required to maintain the function of stormwater management facilities (SWMF) and Low Impact Development (LID) measures. Improvement alternatives proposing SWMF's or LID measures will require routine maintenance.

### **3.5.2 Property Acquisition Costs**

By-Law 90-92 provides direction to the City to acquire lands or interests therein (easements) adjacent to the watercourse where it is in the City's interest to do so. As per the By-Law, if the City does not acquire the lands or interest therein (easements), the owner of the lands upon which a watercourse is located shall maintain the watercourse on their lands. Future development lands may be dedicated to the City through the Subdivision Agreement or Site Plan Conditions. Existing properties, or portions of the properties, may be acquired through negotiations with the land owner or under the worst case scenario through expropriation.

Currently, extensive flooding of private property occurs throughout the study area during major storm events. As part of the previous MDP and recent updates to the major drainage system models, the private properties subject to flooding during major storm events were identified (Table 3 - Private Property Subject to Flooding). The improvement alternatives proposed aim to prevent/reduce the flooding on private property. However, to implement several of the improvement alternatives, acquisition of private property by the City is required. The cost to acquire these lands is included in preliminary cost estimates prepared for each alternative and presented in Appendix C for reference. The property and easement acquisition costs for each improvement alternative are summarized in Section 7 – Improvement Alternatives Analysis.

### **3.5.3 Construction Costs**

Each improvement alternative has a capital cost to construct. Preliminary cost estimates have been prepared for each improvement alternative considered to aid in the evaluation of the economic impacts to implement each alternative. The preliminary cost estimates are included in Appendix C for reference. The construction costs for each improvement alternative are summarized in Section 7 – Improvement Alternatives Analysis.

## 4 Existing System Analysis

In 2015, CCTA was retained by the City of Barrie to develop minor and major drainage system models of the City's existing storm infrastructure across Barrie, including the Sophia Creek watershed and Mulcaster drainage area. CCTA prepared, calibrated, and verified a PCSWMM hydrologic/hydraulic model of Barrie's minor drainage systems citywide. Similarly, CCTA prepared a Visual OTTHYMO hydrologic model and HEC RAS hydraulic models of Barrie's major drainage systems citywide. The results of these models represent existing conditions across the study area and were used in this study. The model results are summarized in the following sections and provided in Appendix D for reference.

### 4.1 Hydrologic Analysis

The hydrologic model results from the major drainage system Visual OTTHYMO model are the primary reference for this section of the study. The existing condition major drainage system hydrologic model results are summarized in the following table and provided in detail in Appendix D for reference. It is noted that the 6 Hour SCS design storms produce the greatest peak flows and the 1:100 Year 6 Hour SCS design storm is the Regulatory storm event.

**Table 6: Existing Conditions Hydrologic Model Results Summary**

Point of Interest / Culvert Crossing	Peak Flow (m <sup>3</sup> /s) – SCS 6 Hour Design Storms				
	1:5 Year	1:10 Year	1:25 Year	1:50 Year	1:100 Year
Howard Crescent	3.7	5.0	6.8	8.3	9.8
Grove Street (A)	5.7	7.6	10.4	12.8	15.0
St. Vincent Street	6.9	9.3	12.5	15.4	18.0
Ottaway Avenue/Rose Street	4.7	7.7	11.3	14.1	17.0
Laurie Crescent	5.4	8.5	12.4	15.4	18.7
Bothwell Crescent	15.0	21.2	30.4	37.3	44.4
Grove Street (C)	16.3	22.7	32.5	39.9	47.4
Parkdale Street	16.2	22.6	32.3	39.8	47.3
Davidson Street/Gunn Street	16.9	23.5	33.6	41.3	49.1
Wellington Street/Berczy Street	18.3	25.2	36.0	44.3	52.4
Peel Street (Trunk Storm Sewer)	19.2	26.4	37.5	46.3	54.9

Point of Interest / Culvert Crossing	Peak Flow (m <sup>3</sup> /s) – Chicago 4 Hour Design Storms				
	1:5 Year	1:10 Year	1:25 Year	1:50 Year	1:100 Year
Howard Crescent	2.8	3.6	4.8	5.7	6.9
Grove Street (A)	4.2	5.5	7.4	8.8	10.7
St. Vincent Street	5.1	6.7	8.9	10.7	12.8
Ottaway Avenue/Rose Street	3.2	4.6	7.3	9.2	11.2
Laurie Crescent	3.7	5.3	8.2	10.2	12.5
Bothwell Crescent	10.8	14.5	20.5	25.2	30.2
Grove Street (C)	11.8	15.7	22.0	27.0	32.4
Parkdale Street	11.8	15.7	22.0	26.9	32.4
Davidson Street/Gunn Street	12.3	16.4	22.8	28.0	33.6
Wellington Street/Berczy Street	13.4	17.9	24.6	30.1	36.2
Peel Street (Trunk Storm Sewer)	14.1	18.8	25.7	31.5	37.8

Point of Interest / Culvert Crossing	Peak Flow (m <sup>3</sup> /s)			
	1:100 Year SCS	Timmins	Hurricane Hazel	Regulatory Storm
Howard Crescent	9.8	4.8	6.5	9.8
Grove Street (A)	15.0	7.0	9.4	15.0
St. Vincent Street	18.0	8.7	11.7	18.0
Ottaway Avenue/Rose Street	17.0	8.3	11.4	17.0
Laurie Crescent	18.7	10.3	13.8	18.7
Bothwell Crescent	44.4	23.0	30.6	44.4
Grove Street (C)	47.4	24.6	32.8	47.4
Parkdale Street	47.3	25.0	33.3	47.3
Davidson Street/Gunn Street	49.1	26.1	34.8	49.1
Wellington Street/Berczy Street	52.4	28.5	37.9	52.4
Peel Street (Trunk Storm Sewer)	54.9	30.3	40.6	54.9

Note: Regulatory Storm – 100 Year 6 Hour SCS Design Storm

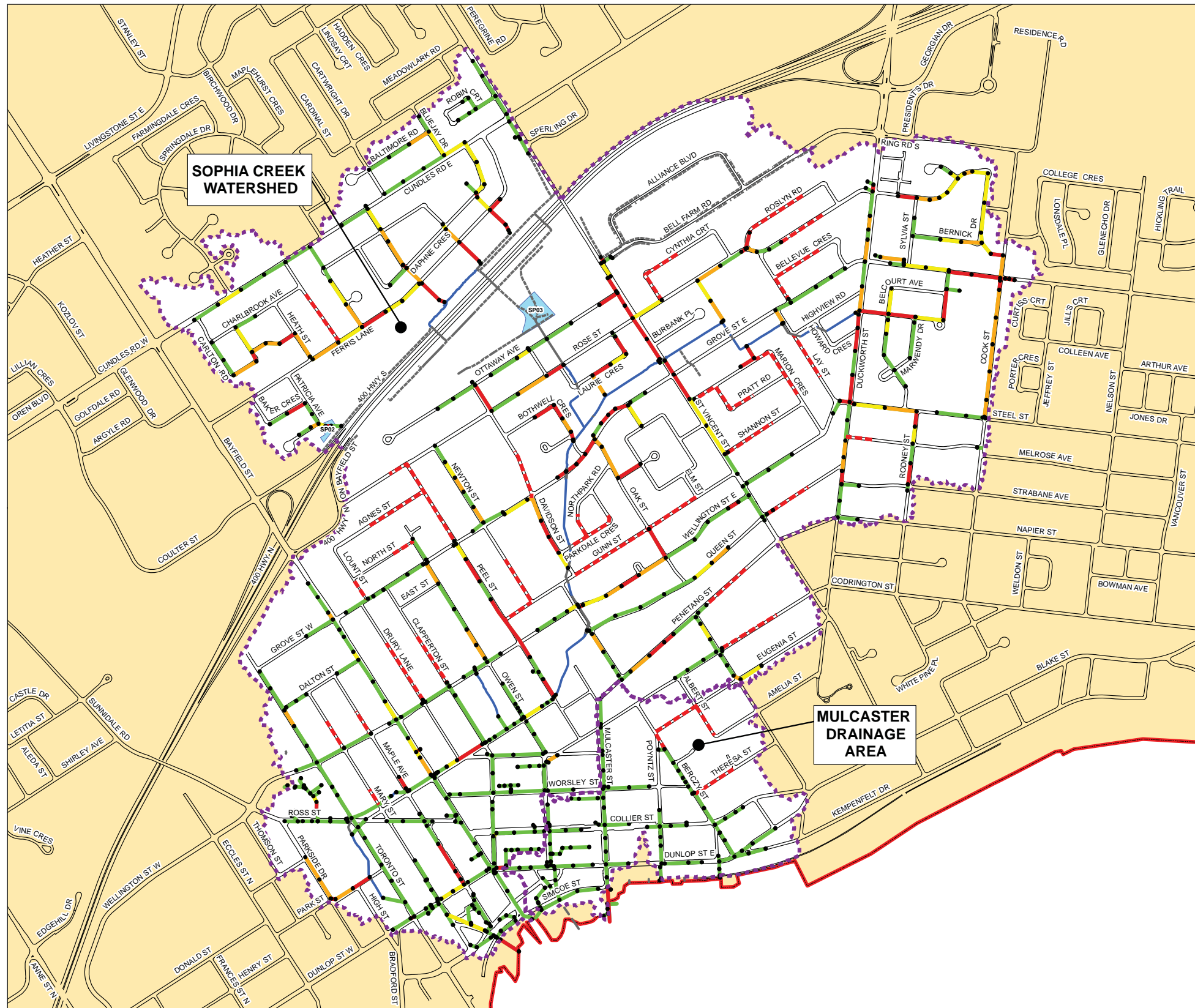
## 4.2 Hydraulic Analysis

The existing conditions PCSWMM minor drainage system model was used to establish the existing deficiencies in the minor drainage system across the study area. For the purpose of this study, the deficiencies were identified for the 1:5 year 6 hour SCS design storm. The minor drainage system deficiencies are illustrated on Figure 3 – Minor Drainage System Deficiencies provided overleaf. For this study, the storm sewer has been characterized as follows based on conveyance capacity:

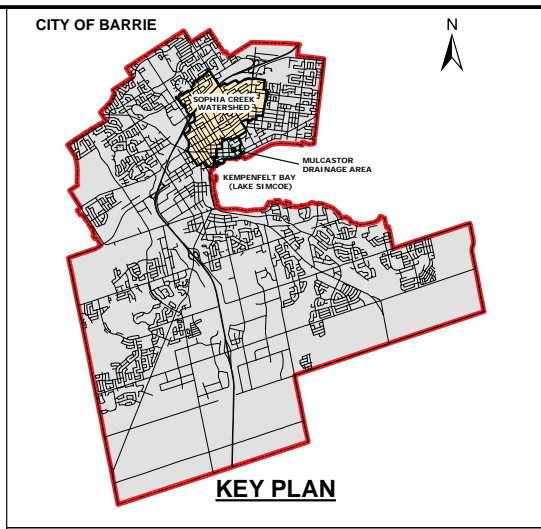
1. **Peak Flow/Storm Sewer Full Flow Capacity ( $Q_{max}/Q_{fullflow}$ ) < 85%** - storm sewer capacity exceeds design storm peak flow (storm sewer has adequate capacity) by greater than 15% and satisfies the current municipal conveyance criteria.
2. **85% < Peak Flow/Storm Sewer Full Flow Capacity ( $Q_{max}/Q_{fullflow}$ ) < 100%** - storm sewer capacity exceeds design storm peak flow (storm sewer has adequate capacity) by less than 15%. As such, the peak flow is approaching full flow capacity.
3. **101% < Peak Flow/Storm Sewer Full Flow Capacity ( $Q_{max}/Q_{fullflow}$ ) < 115%** - design storm peak flow exceeds storm sewer capacity (deficient conveyance capacity) by up to 15% - moderate exceedance.
4. **Peak Flow/Storm Sewer Full Flow Capacity ( $Q_{max}/Q_{fullflow}$ ) > 115%** - design storm peak flow exceeds storm sewer capacity (deficient conveyance capacity) by greater than 15% - severe exceedance.

The areas/streets absent of a minor drainage system are also illustrated on Figure 3 – Minor Drainage System Deficiencies. The streets absent of storm sewer identified on Figure 3 where highlighted due to the length of road missing a minor drainage system. The City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines specify a maximum catch basin spacing of 90 m. As such, any road longer than 90 m absent of existing storm sewer was identified.

The existing condition HEC RAS hydraulic model of Sophia Creek from Duckworth Street and Ottaway Avenue to Peel Street has been used to establish the existing capacities of the major road culvert crossings, and consequently the level of service provided, upstream of Peel Street. Similarly, the PCSWMM hydraulic model of the trunk storm sewer downstream of Peel Street to Kempenfelt Bay has been used to establish the existing capacity and level of service of the trunk storm on Sophia Street. The existing capacities of the road crossing culverts and trunk storm sewer are summarized in Table 7 – Existing Culvert/Trunk Storm Sewer Capacity Summary. The major drainage system deficiencies and the Regulatory floodplain are illustrated on Figures 4 and 5 provided overleaf.



NOTE: DEFICIENCIES IDENTIFIED FOR 5-YEAR 6 HOUR SCS DESIGN STORM

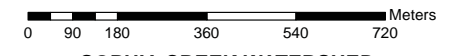


- Legend**
- STORM DEVICES
  - CULVERT
  - DITCH
  - WATERCOURSE
  - - - - - ABSENT/REQUIRED STORM SEWER
  - STORM SEWER (QMAX/QFULL FLOW 85%-100%)
  - STORM SEWER (QMAX/QFULL FLOW 101%-115%)
  - STORM SEWER (QMAX/QFULL FLOW >115%)
  - STORM SEWER (QMAX/QFULL FLOW < 85%)
  - ROADS
  - SWMF
  - ⋯ STUDY AREA
  - ▭ MUNICIPAL BORDER

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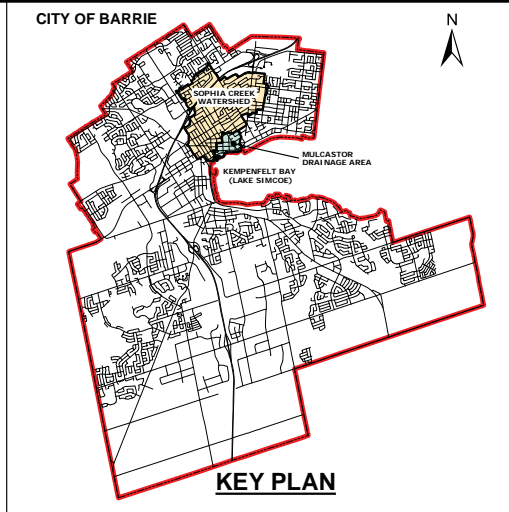
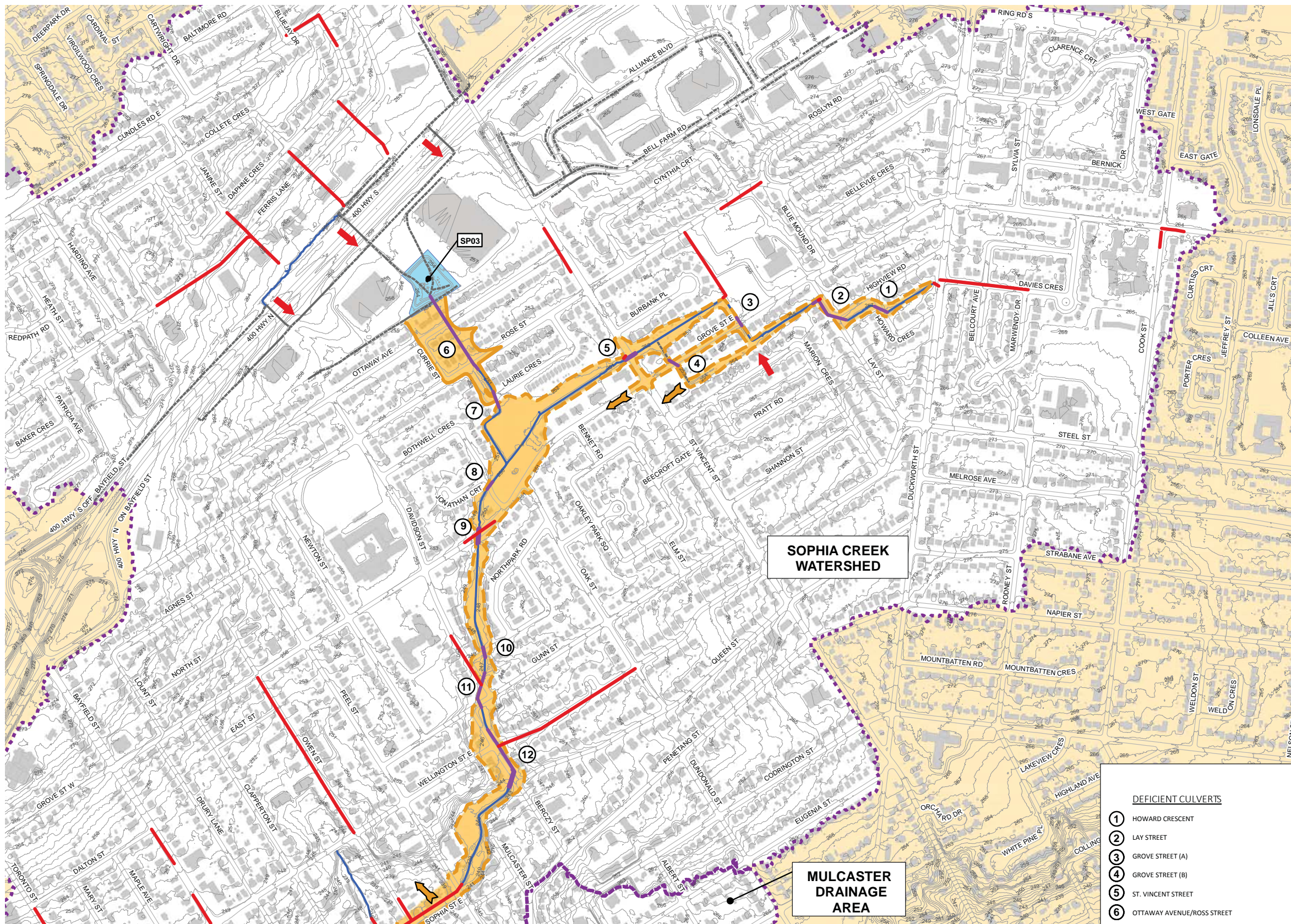
SCALE = 1:7,000



**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
FIGURE 3 – MINOR DRAINAGE SYSTEM DEFICIENCIES

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- Legend**
- MAJOR OVERLAND FLOW
  - ROUTE DEFICIENCIES
  - DEFICIENT CULVERTS
  - REGULATORY FLOODLINE
  - CULVERT
  - DITCH
  - WATERCOURSE
  - ROADS
  - SWMF
  - REGULATORY FLOODPLAIN
  - BUILDINGS
  - STUDY AREA
  - MUNICIPAL BORDER
  - SPILL LOCATION/DIRECTION

**SOPHIA CREEK WATERSHED**

**MULCASTER DRAINAGE AREA**

- DEFICIENT CULVERTS**
- 1 HOWARD CRESCENT
  - 2 LAY STREET
  - 3 GROVE STREET (A)
  - 4 GROVE STREET (B)
  - 5 ST. VINCENT STREET
  - 6 OTTAWAY AVENUE/ROSS STREET
  - 7 LAURIE CRESCENT
  - 8 BOTHWELL CRESCENT
  - 9 GROVE STREET (C)
  - 10 PARKDALE CRESCENT
  - 11 DAVIDSON STREET/GUNN STREET
  - 12 WELLINGTON STREET/BERCZY STREET

NOTE: CULVERT DEFICIENCIES BASED ON MDP RECOMMENDED 1:25 YEAR DESIGN FLOOD FREQUENCY CRITERIA.

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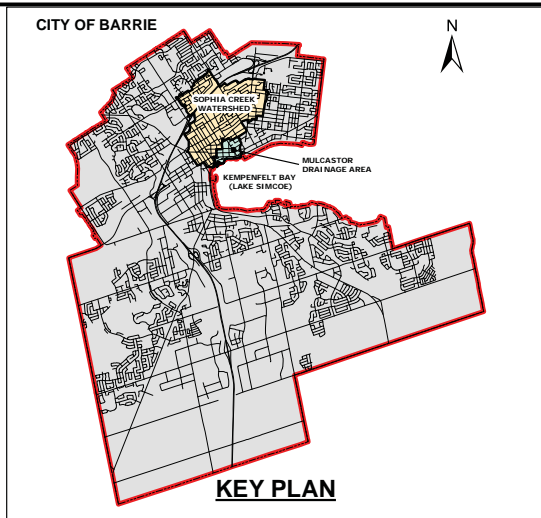
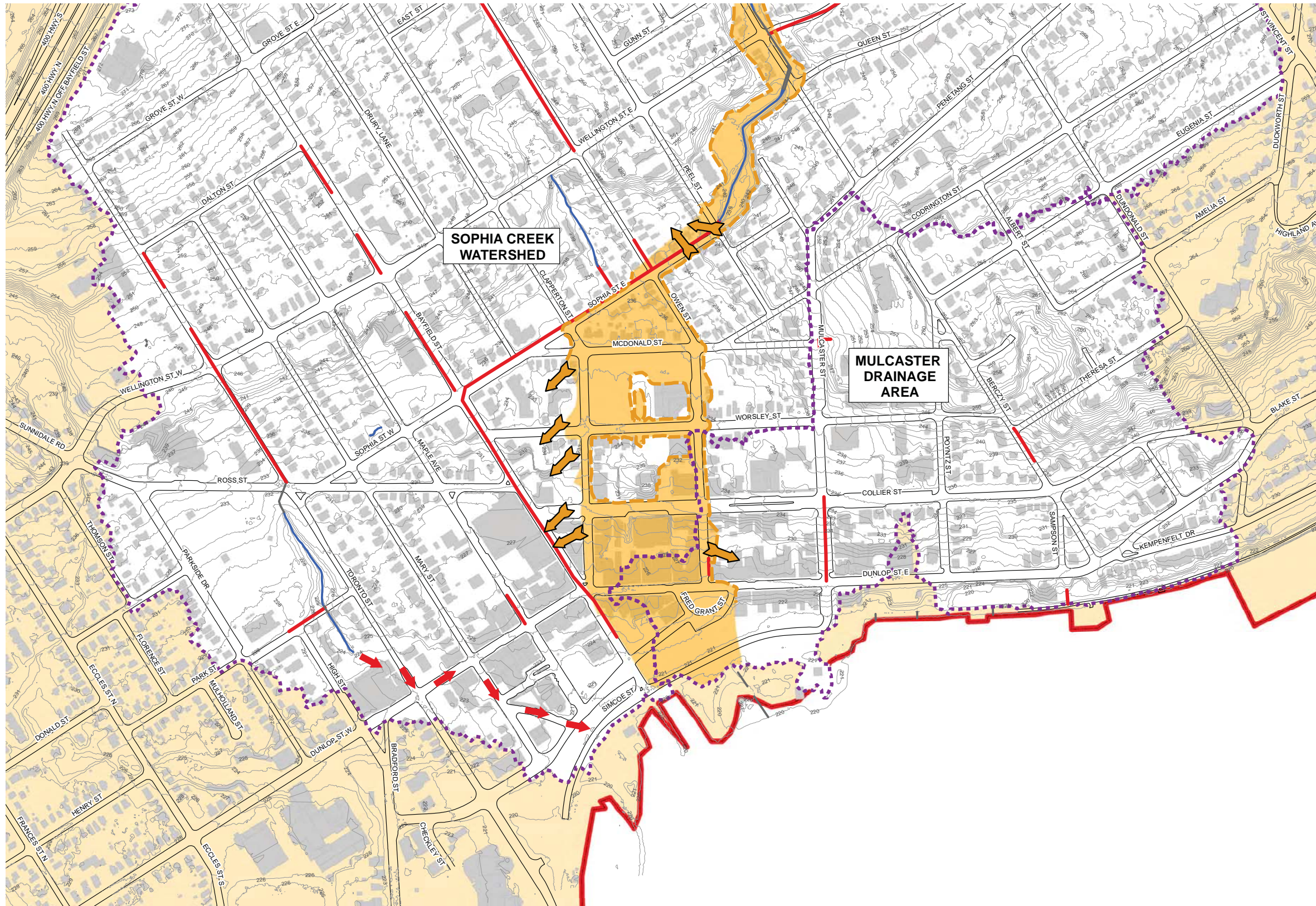
**The City of BARRIE**

SCALE = 1:4,000

0 50 100 200 300 400 Meters

**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
 FIGURE 4 - MAJOR DRAINAGE SYSTEM DEFICIENCIES (SHEET A - NORTH OF PEEL STREET)

DATE: OCTOBER 2016



- Legend**
- MAJOR OVERLAND FLOW ROUTE DEFICIENCIES
  - CULVERT
  - DITCH
  - WATERCOURSE
  - REGULATORY FLOODLINE
  - ROADS
  - REGULATORY FLOODPLAIN
  - BUILDINGS
  - STUDY AREA
  - MUNICIPAL BOARDER
  - SPILL LOCATION/DIRECTION

NOTE: TRUNK STORM SEWER DEFICIENCIES BASE ON MDP RECOMMENDED 1:25 YEAR DESIGN FREQUENCY CRITERIA.

**DISCLAIMER**

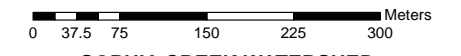
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SCALE = 1:3,000



**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 5 - DRAINAGE SYSTEM DEFICIENCIES (SHEET B - SOUTH OF PEEL STREET)

DATE: OCTOBER 2016

**Table 7: Existing Culvert/Trunk Storm Sewer Capacity Summary**

Location	Size	Capacity (m <sup>3</sup> /s)	Level of Service	Design Criteria
Howard Crescent	800 mm × 1250 mm CSPE	1.4	< 1:5 Year	1:50 Year
Lay Street	850 mm × 1350 mm CSPE	2.6	< 1:5 Year	1:50 Year
Grove Street (A)	1200 mm × 1800 mm CSPA	3.3	< 1:5 Year	1:50 Year
St. Vincent Street	1200 mm × 1800 mm Conc. Box	4.3	< 1:5 Year	1:100 Year
Ottaway Avenue/Rose Street	1200 mm × 2400 mm Conc. Box	9.0	1:10 Year	1:50 Year
Laurie Crescent	1500 mm × 3000 mm Conc. Box	9.0	1:10 Year	1:50 Year
Bothwell Crescent	1500 mm Dia. Conc.	4.1	< 1:5 Year	1:50 Year
Grove Street (C)	Twin 900 mm × 1900 mm CSPA 900 mm × 1600 mm CSPA	6.2	< 1:5 Year	1:50 Year
Parkdale Crescent	Twin 1200 mm Dia. Conc.	8.3	< 1:5 Year	1:50 Year
Davidson Street/Gunn Street	1560 mm × 1850 mm Conc. Box	8.9	< 1:5 Year	1:50 Year
Wellington Street/Berczy Street	1540 mm × 1840 Conc. Box	9.5	< 1:5 Year	1:100 Year
Sophia Street Trunk Sewer	1220 mm × 1980 mm Conc. Box	12.0	< 1:5 Year	1:100 Year

The existing conditions PCSWMM minor drainage system model was also used to establish the existing deficiencies in the overland flow routes throughout the study area. For the purpose of this study, deficiencies were defined by the LSCRA safe access/egress criteria as follows:

1. Depth of flow exceeds 0.30 m;
2. Velocity of flow exceeds 1.7 m/s; or
3. Depth velocity product exceeds 0.4 m<sup>2</sup>/s.

The results for the PCSWMM dual drainage system corresponding to the 1:100 year 6 Hour SCS design storm were evaluated against the safe access/egress criteria. The overland flow routes that do not satisfy the aforementioned criteria are deficient. The deficient overland flow routes are illustrated on Figures 4 and 5.

For this study, the major overland deficiencies have been evaluated using the dual drainage system in PCSWMM and standardized road cross-sections between storm structures. The cross-sections do not necessarily mimic existing conditions, however, they do provide an estimate of the overland flow depths and velocities along the roadway during major storm events. As such, it is recommended that solutions to address the major overland deficiencies be evaluated as part of future road reconstruction projects and improvements be made where feasible.

## 5 Screening of Improvement Options

For this study, a number of improvement options are being considered to address the problem statement and correct the noted deficiencies. The following improvement options were pre-screened:

### **Flow Reduction/Water Quality Improvement Options**

1. SWMF Retrofit/Expansion/Creation
2. Low Impact Development (LID's)
3. Flow Diversions

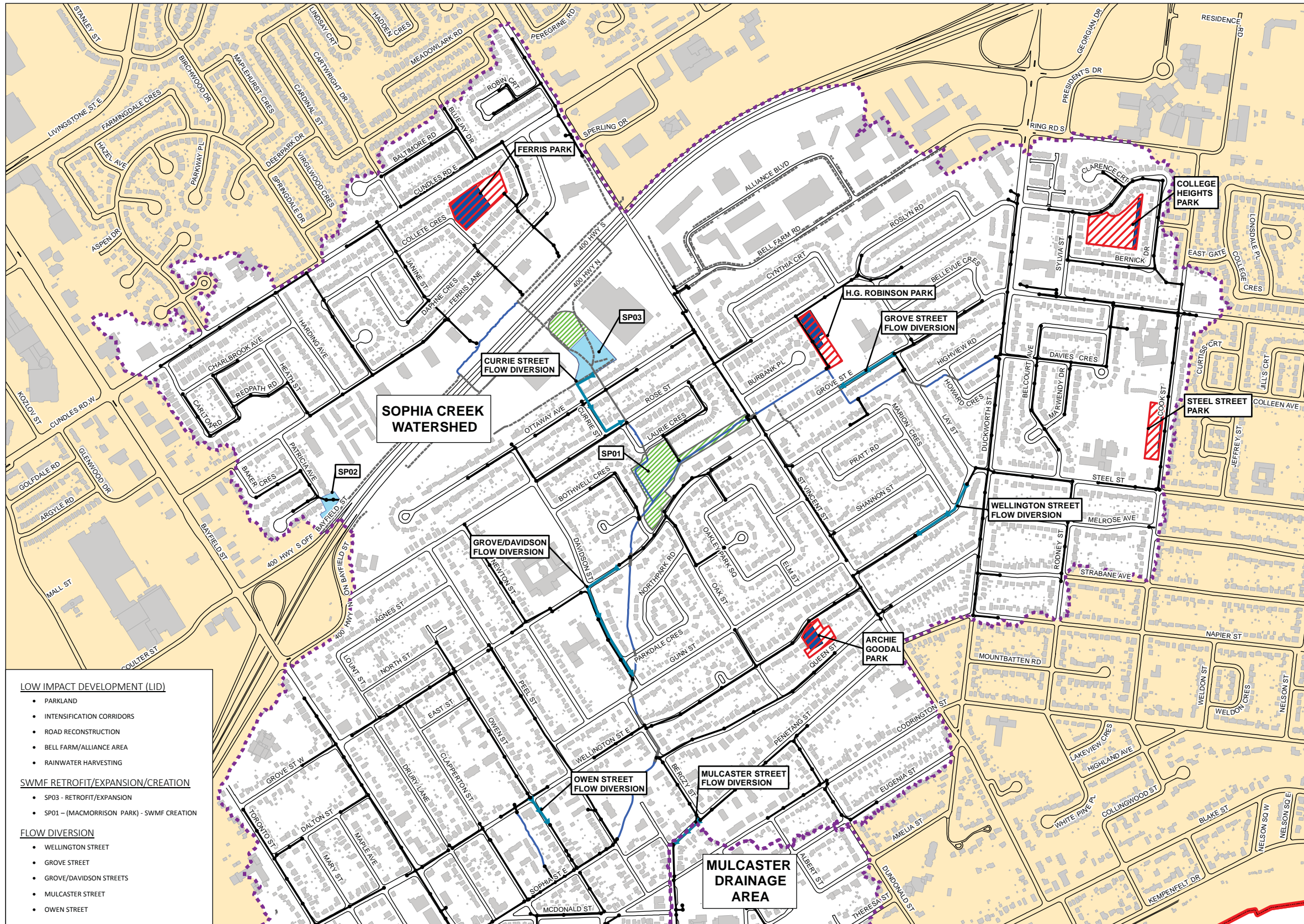
### **Conveyance Capacity Improvement Options**

4. Culvert Improvements
5. Channel Improvements
6. Trunk Storm Sewer
7. Minor Drainage System Improvements

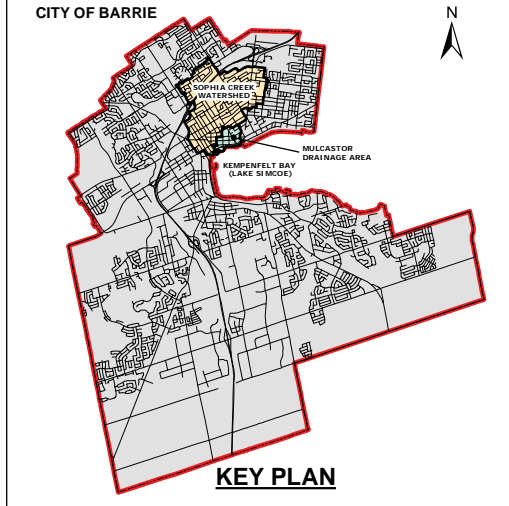
The improvement options were reviewed and pre-screened based on their physical, natural, social, cultural and economic impacts to narrow the options into improvement alternatives that would be further evaluated. Eliminating those options that produced negative impacts on the environment or the least positive impact compared to other options providing the same function. The improvement options were divided into water quality/flow reduction improvement options and conveyance capacity improvement options as described in the following sections and illustrated on the Figures 6 through 8 provided overleaf.

### 5.1 Flow Reduction/Water Quality Improvement Options

Opportunities exist in the study area to implement SWM measures to attenuate flows, improve water quality and divert flows around areas susceptible to flooding. These opportunities include retrofitting, expanding and creating SWM detention facilities, implementing Low Impact Development (LID) measures, and storm sewer flow diversions. The water quality/flow reduction improvement options screened as part of this study are described in the following sections.



- LOW IMPACT DEVELOPMENT (LID)**
- PARKLAND
  - INTENSIFICATION CORRIDORS
  - ROAD RECONSTRUCTION
  - BELL FARM/ALLIANCE AREA
  - RAINWATER HARVESTING
- SWMF RETROFIT/EXPANSION/CREATION**
- SP03 - RETROFIT/EXPANSION
  - SP01 - (MACMORRISON PARK) - SWMF CREATION
- FLOW DIVERSION**
- WELLINGTON STREET
  - GROVE STREET
  - GROVE/DAVIDSON STREETS
  - MULCASTER STREET
  - OWEN STREET



- Legend**
- STORM DEVICES
  - ➔ FLOW DIVERSION
  - CULVERT
  - - - - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - ▨ PARK LAND
  - CENTRALIZED LID LOCATION
  - ▨ SWMF RETROFIT/EXPANSION/CREATION
  - EXISTING SWMF
  - BUILDINGS
  - ⋯ STUDY AREA
  - ▭ MUNICIPAL BORDER

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SEE FIGURES 8A THROUGH 8E FOR PARKLAND LOW IMPACT DEVELOPMENT (LID) AREAS

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SCALE = 1:5,000

0 62.5 125 250 375 500 Meters

**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 6A - WATER QUALITY/FLOW REDUCTION IMPROVEMENT OPTIONS



**Legend**

- EXISTING STORM DEVICES
- PROPOSED STORM SEWER
- EXISTING STORM SEWER
- - - PROPERTY LINE
- ▨ POTENTIAL LOW IMPACT DEVELOPMENT AREA
- STUDY AREA
- ▭ MUNICIPAL BOARDER

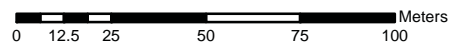


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 & MULCASTER DRAINAGE AREA  
 EA UPDATE**

FIGURE 6B - FERRIS PARK  
 POTENTIAL LOW IMPACT DEVELOPMENT AREA






SCALE = 1:2,000

DATE: OCTOBER 2016



**Legend**

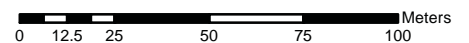
- EXISTING STORM DEVICES
- EXISTING STORM SEWER
- - - PROPERTY LINE
-  POTENTIAL LOW IMPACT DEVELOPMENT AREA
-  STUDY AREA
-  MUNICIPAL BOARDER

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 EA UPDATE**

FIGURE 6C – H.G. ROBINSON PARK  
 POTENTIAL LOW IMPACT DEVELOPMENT AREA



SCALE = 1:2,000

DATE: OCTOBER 2016



**Legend**

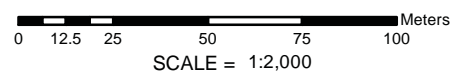
- EXISTING STORM DEVICES
- PROPOSED STORM SEWER
- EXISTING STORM SEWER
- - - PROPERTY LINE
- ▨ POTENTIAL LOW IMPACT DEVELOPMENT AREA
- ▨ STUDY AREA
- ▭ MUNICIPAL BOARDER

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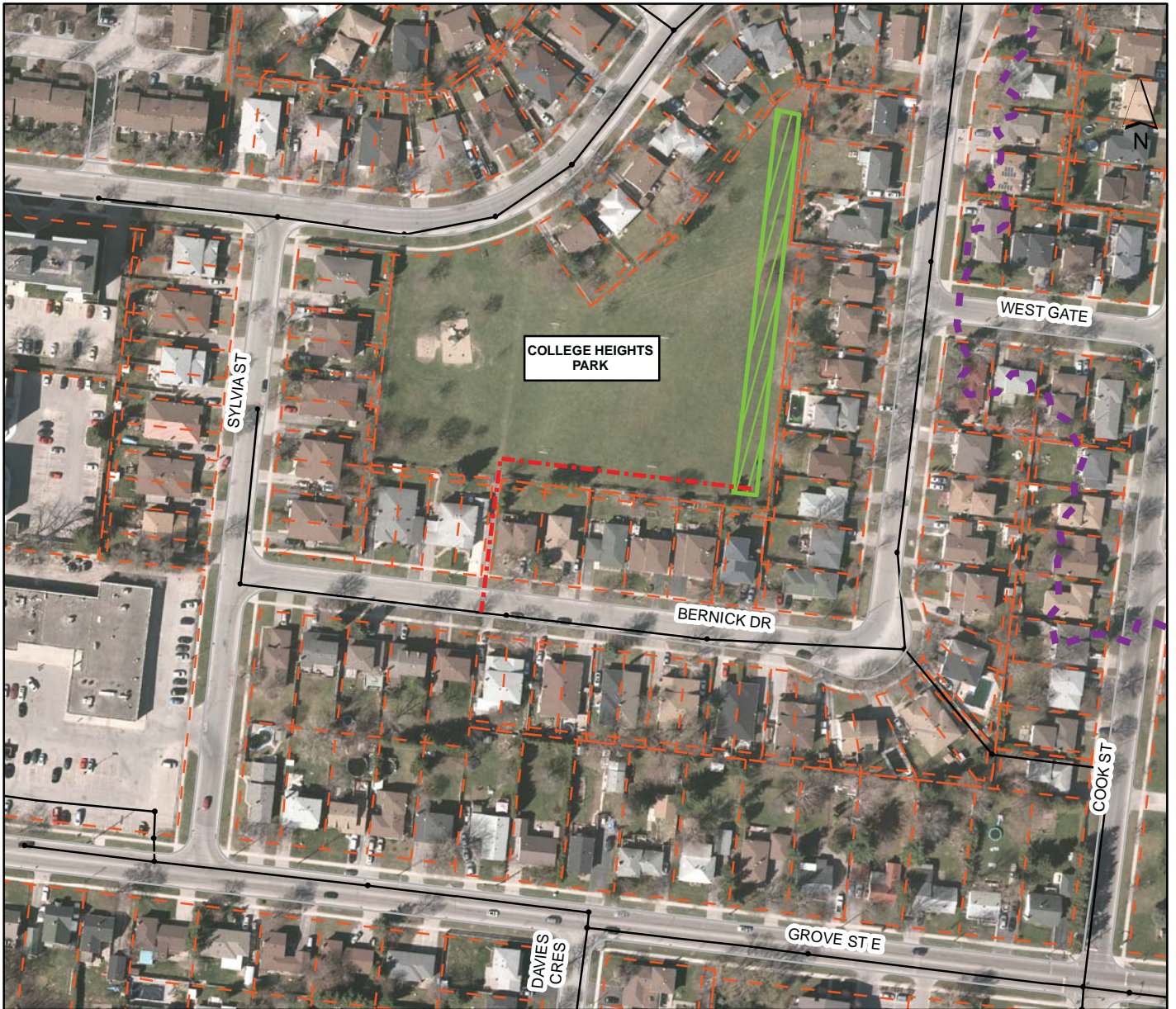


**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA  
 EA UPDATE**




FIGURE 6D – ARCHIE GOODALL PARK  
 POTENTIAL LOW IMPACT DEVELOPMENT AREA



DATE: OCTOBER 2016



### Legend

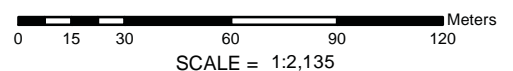
- EXISTING STORM DEVICES
- PROPOSED STORM SEWER
- EXISTING STORM SEWER
- - - PROPERTY LINE
-  POTENTIAL LOW IMPACT DEVELOPMENT AREA
-  STUDY AREA
-  MUNICIPAL BORDER


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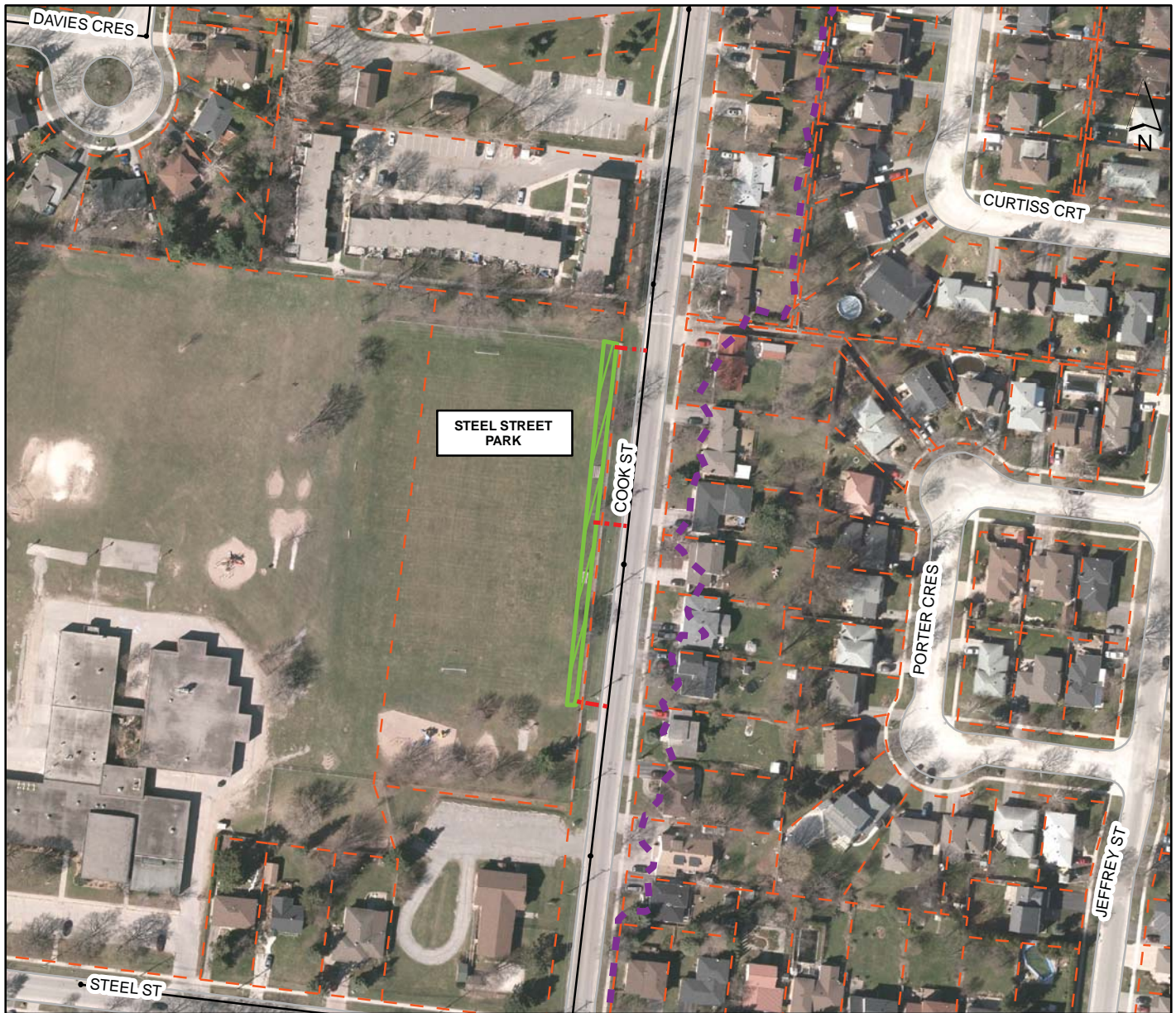
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### SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE

FIGURE 6E – COLLEGE HEIGHTS PARK POTENTIAL LOW IMPACT DEVELOPMENT AREA



DATE: OCTOBER 2016



### Legend

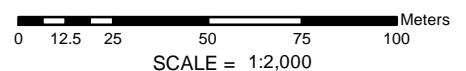
- EXISTING STORM DEVICES
- PROPOSED STORM SEWER
- EXISTING STORM SEWER
- - - PROPERTY LINE
- ▨ POTENTIAL LOW IMPACT DEVELOPMENT AREA
- ▭ STUDY AREA
- ▭ MUNICIPAL BOARDER


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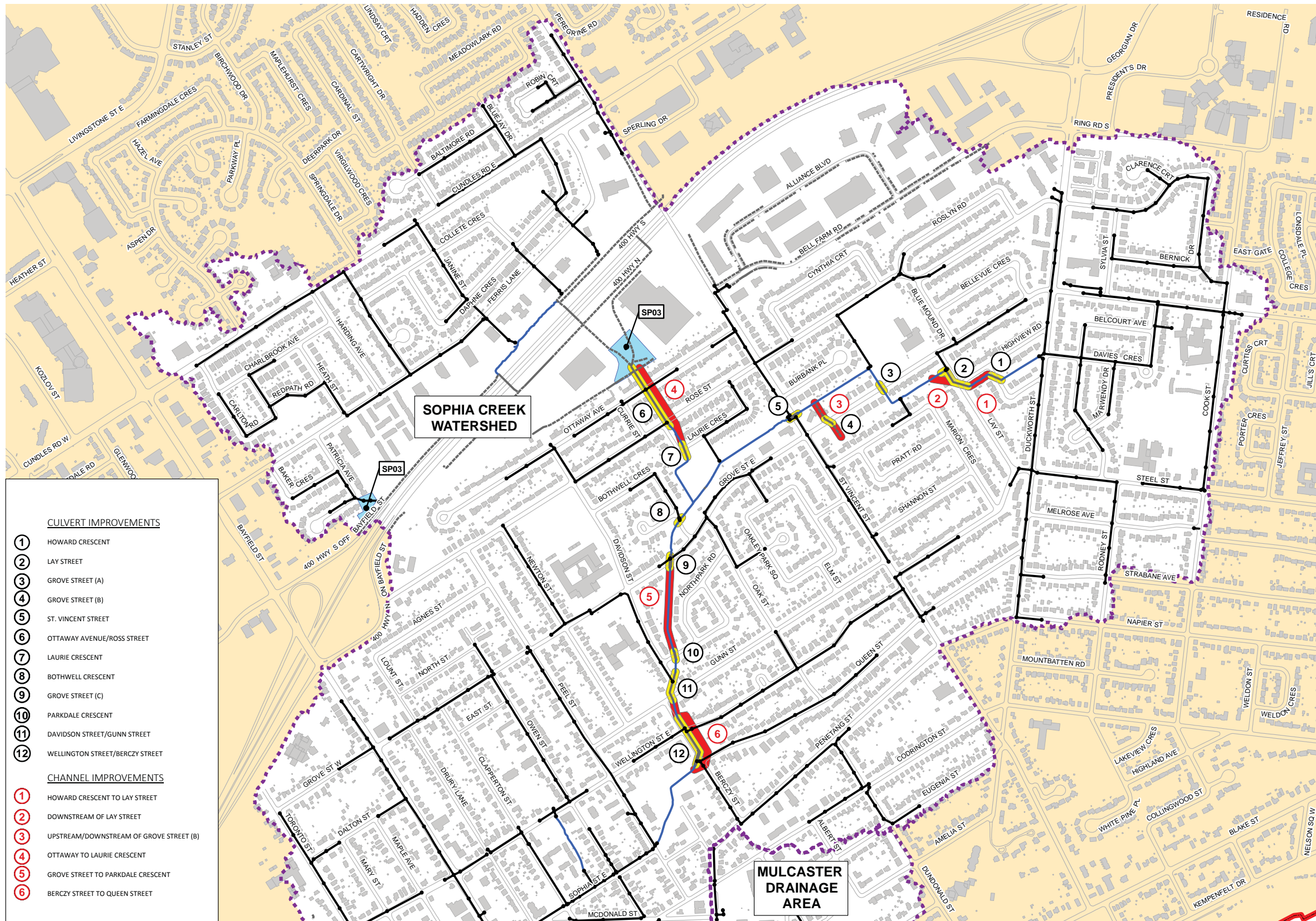


### SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE

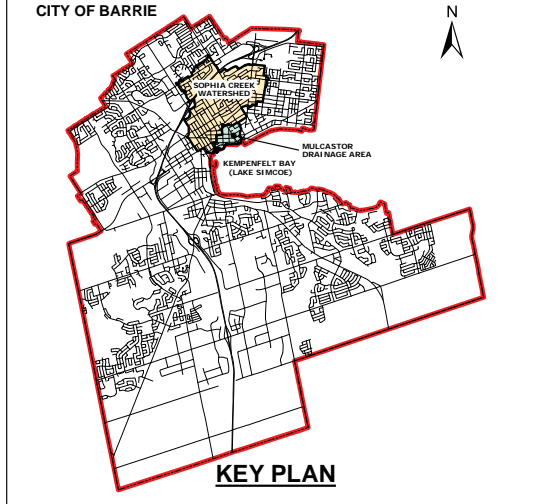
FIGURE 6F – STEEL STREET PARK POTENTIAL LOW IMPACT DEVELOPMENT AREA



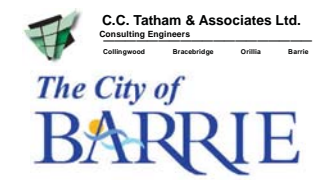
DATE: OCTOBER 2016



- CULVERT IMPROVEMENTS**
- ① HOWARD CRESCENT
  - ② LAY STREET
  - ③ GROVE STREET (A)
  - ④ GROVE STREET (B)
  - ⑤ ST. VINCENT STREET
  - ⑥ OTTAWAY AVENUE/ROSS STREET
  - ⑦ LAURIE CRESCENT
  - ⑧ BOTHWELL CRESCENT
  - ⑨ GROVE STREET (C)
  - ⑩ PARKDALE CRESCENT
  - ⑪ DAVIDSON STREET/GUNN STREET
  - ⑫ WELLINGTON STREET/BERCZY STREET
- CHANNEL IMPROVEMENTS**
- ① HOWARD CRESCENT TO LAY STREET
  - ② DOWNSTREAM OF LAY STREET
  - ③ UPSTREAM/DOWNSTREAM OF GROVE STREET (B)
  - ④ OTTAWAY TO LAURIE CRESCENT
  - ⑤ GROVE STREET TO PARKDALE CRESCENT
  - ⑥ BERCZY STREET TO QUEEN STREET



- Legend**
- STORM DEVICES
  - CULVERT
  - - - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - CULVERT IMPROVEMENTS ①
  - CHANNEL IMPROVEMENTS ①
  - SWMF
  - BUILDINGS
  - STUDY AREA
  - MUNICIPAL BORDER

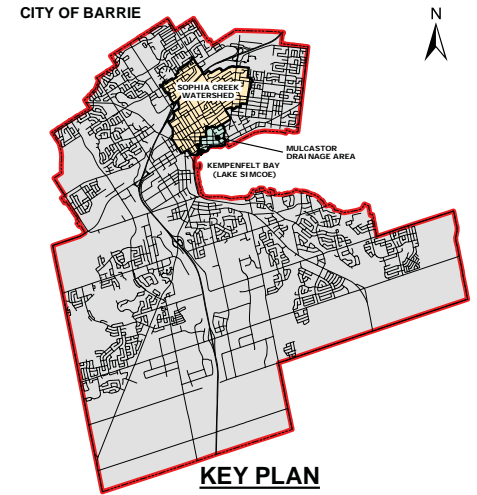
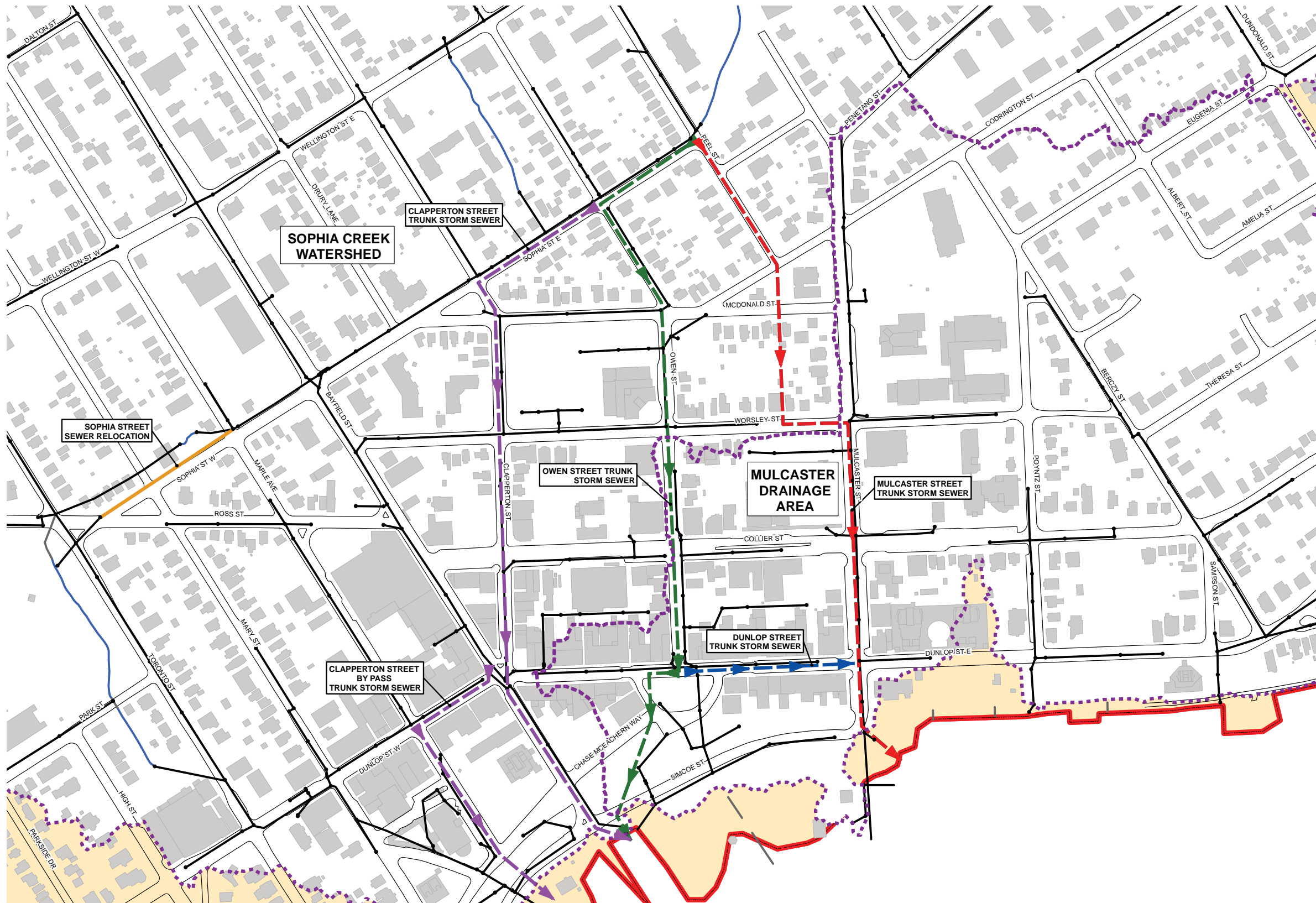


SCALE = 1:5,000  
 0 62.5 125 250 375 500 Meters

**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
 FIGURE 7 - CONVEYANCE IMPROVEMENT ALTERNATIVES (SHEET A - NORTH OF PEEL STREET)

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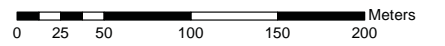


- Legend**
- STORM DEVICES
  - ▶ CLAPPERTON STREET TRUNK STORM SEWER
  - ▶ OWEN STREET TRUNK STORM SEWER
  - ▶ MULCASTER STREET TRUNK STORM SEWER
  - ▶ DUNLOP STREET TRUNK STORM SEWER
  - SEWER RELOCATION
  - CULVERT
  - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - BUILDINGS
  - ⋯ STUDY AREA
  - ▭ MUNICIPAL BORDER

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SCALE = 1:2,000



**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 8 - CONVEYANCE IMPROVEMENT ALTERNATIVES (SHEET B - SOUTH OF PEEL STREET)

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### **5.1.1 SWMF Retrofit/Expansion/Creation**

There is limited municipal land available within the study area to construct stormwater management facilities that will have an appreciable reduction in peak flow. However, an opportunity exists to retrofit and expand the existing Ottaway Avenue and Currie Street SWMF (SWMF SP03) by purchasing additional privately owned lands immediately north of the existing pond (364 St. Vincent Street). SWMF SP03 may be expanded to double the active storage volume provided (20,000 m<sup>3</sup>) and reduce the 1:100 year design storm peak flows downstream to Bothwell Crescent and downstream of Grove Street East by approximately 27% and 13%, respectively. Retrofitting and expanding this existing SWMF will also have an added benefit of improving water quality.

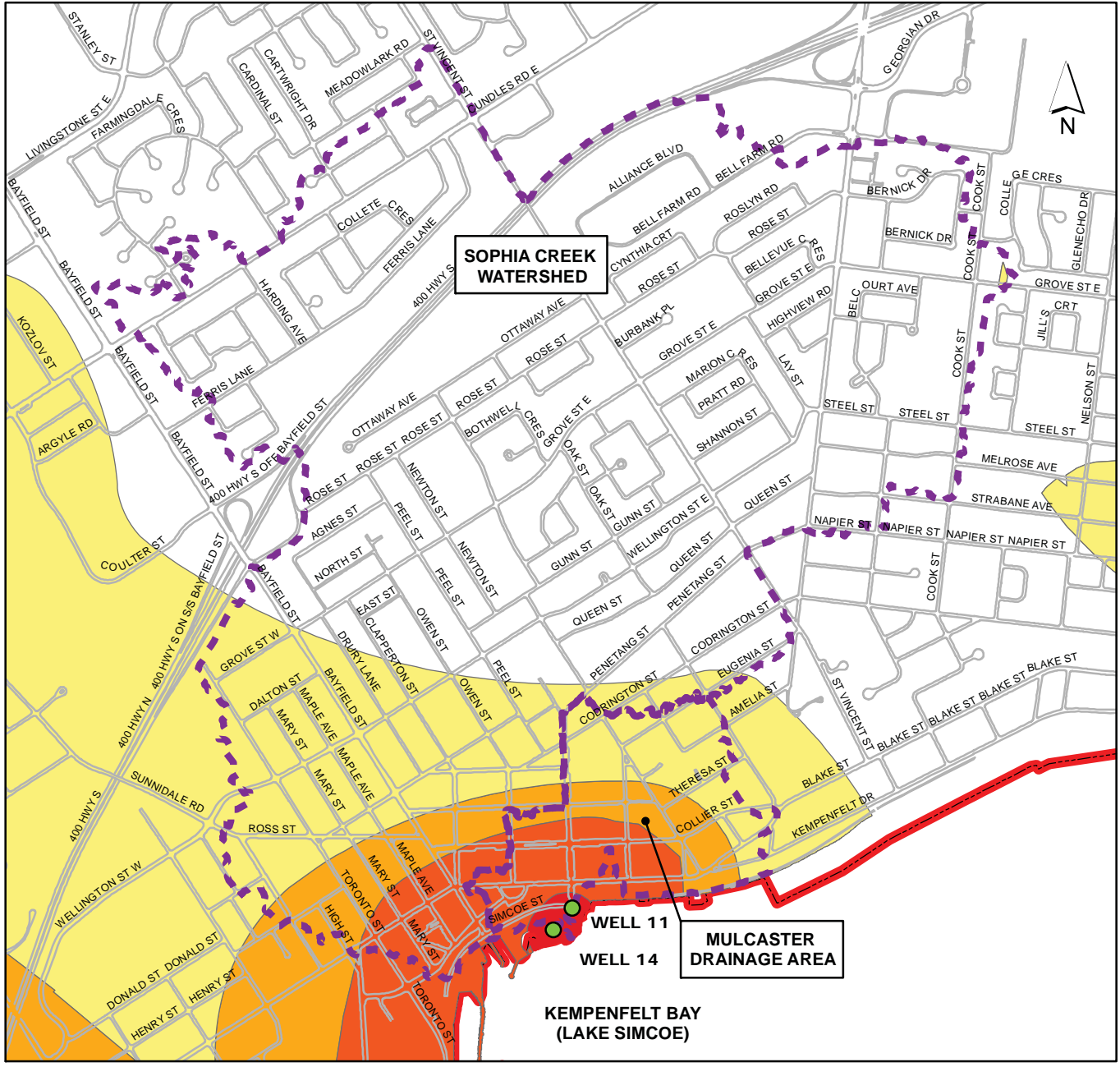
An opportunity also exists to convert MacMorrison Park into a SWM detention facility. This location was identified and recommended for the construction of a SWM detention facility as part of the original MDP and the facility was designated SP01. However, the SWM detention facility has not been constructed. We estimate a SWM detention facility having an active storage volume of approximately 30,000 m<sup>3</sup> may be constructed in the park footprint. The resulting reduction in the 1:100 year design storm peak flow downstream is approximately 17%. Construction of the SWMF will also have the added benefit of improving water quality and wildlife habitat.

The SWMF retrofit/expansion/creation options provide the greatest positive impact on the environment considering the water quality/flow reduction improvement options evaluated. As such, the SWM detention facilities were carried forward as an improvement alternative.

### **5.1.2 Low Impact Development (LID) Measures**

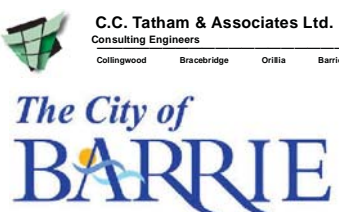
From a review of the available background reports, specifically the Evaluation of Low Impact Development Stormwater Technologies for the Uncontrolled Urban Areas in the Lake Simcoe Region (Ryerson University, March 2010), the implementation of Low Impact Development (LID) measures in the study area would be limited to rainwater harvesting, bioretention and porous pavement. The implementation of wide scale and extensive LID measures is limited by the existing groundwater and soil conditions in the study area. The southern half of the study area has been identified as a known wellhead protection area and over 50% of the northern half of the study area consists of silty clay loam soils having infiltration rates less than 15 mm/hour (see figures provided overleaf).

For this study, the implementation of LID measures involving infiltration was not recommended in the known wellhead protection areas. However, implementing infiltration LID measures throughout the remainder of the Study Area was considered. Within the wellhead protection areas, perforated pipe systems wrapped in an impervious liner to limit infiltration was considered. The perforated pipe systems will intercept runoff and provide peak flow attenuation. There is no water quality or water balance improvements from the perforated pipe systems however. Opportunities exist to construct LID measures as follows:

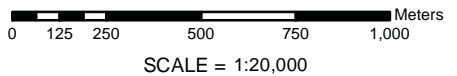


**Legend**

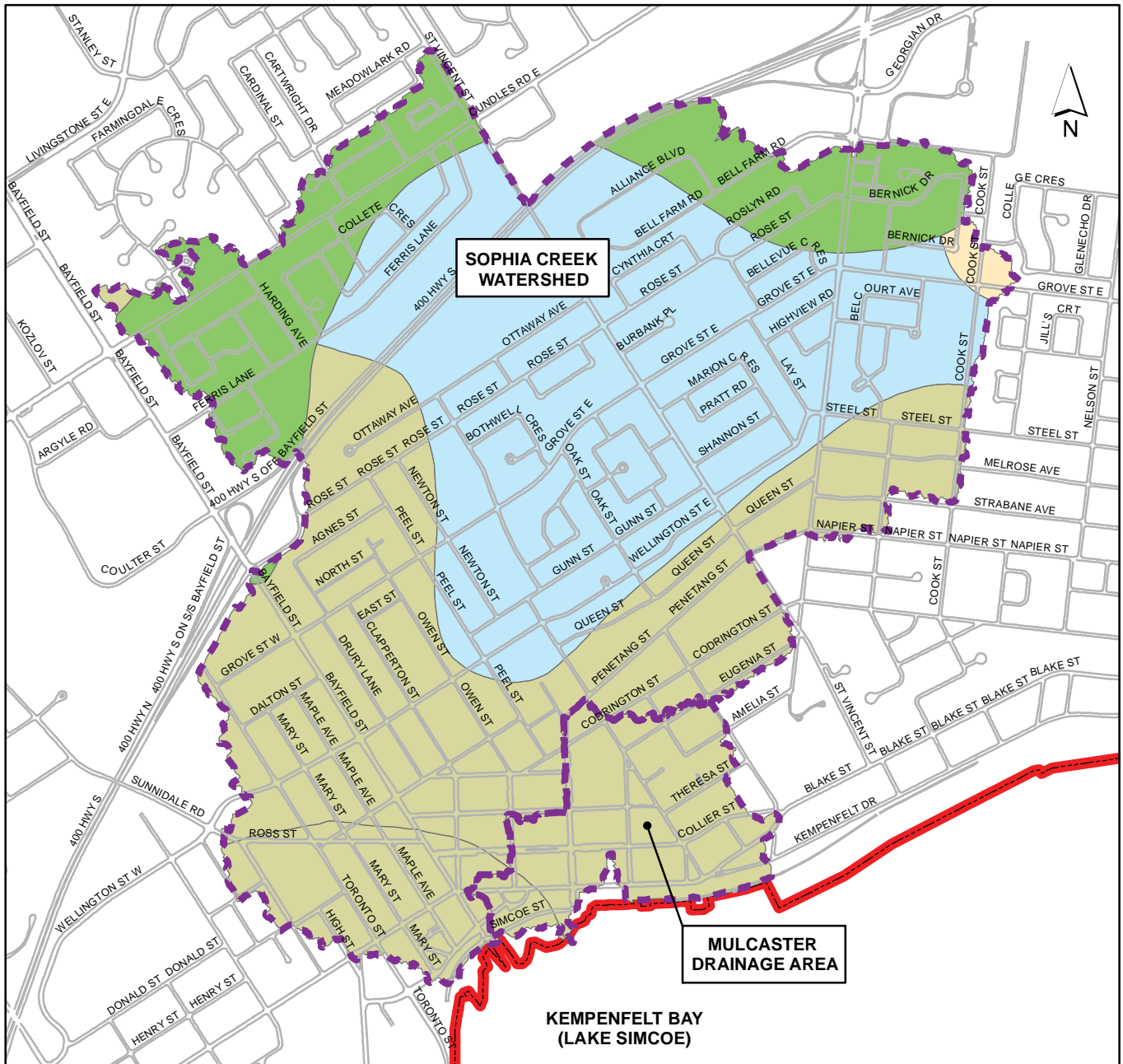
- ROADS
- ▬ STUDY AREA
- ▬ MUNICIPAL BOARDER
- WELLHEAD PROTECTION AREA (WHPA)**
  - WHPA-A (100m RADIUS)
  - WHPA-B (2yr TIME OF TRAVEL)
  - WHPA-C (10yr TIME OF TRAVEL)
  - WHPA-D (25yr TIME OF TRAVEL)



**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
 FIGURE 9 - KNOWN WELLHEAD PROTECTION AREAS



DATE: OCTOBER 2016



**Legend**

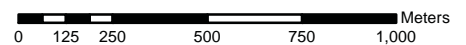
- ROADS
- STUDY AREA
- BI - BONDHEAD LOAM (B)
- Shsc - SCHOMBERG SILTY CLAY LOAM (C)
- Tis - TIOGA LOAMY SAND (A)
- Vasl - VASEY SANDY LOAM (AB)
- MUNICIPAL BORDER

C.C. Tatham & Associates Ltd.  
 Consulting Engineers  
 Collingwood Bracebridge Orillia Barrie



**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 10 - HYDROLOGIC SOILS GROUP PLAN



SCALE = 1:20,000

DATE: OCTOBER 2016

1. Underground within existing parkland (Ferris Park, H.G. Robinson Park, Archie Goodal Park, College Heights Park, and Steel Street Park);
2. As part of the contemplated intensification corridors along Duckworth Street/Codrington Street and Bayfield Street;
3. As part of road reconstruction;
4. Within the Bell Farm Road and Alliance Boulevard roadside ditches; and
5. Rainwater harvesting throughout the entire study area.

Given the restrictions to implementing LID techniques in the study area, calculations were performed to establish realistic objectives for the LID measures listed above. Based on the available land and soil conditions, LID measures installed as part of road reconstruction projects or in the intensification corridors can typically intercept the first 5 mm to 10 mm of runoff from a storm event. This satisfies Alternative 2 of the LSRCA's flexible treatment alternative for sites with restrictions criteria, specifically a minimum 5 mm runoff volume reduction. LID measures implemented in the parks identified may intercept the first 10 mm to 20 mm of runoff during a storm event from their contributing drainage areas. Supporting calculations are enclosed in Appendix E for reference.

The hydrologic analysis was updated to consider the inclusion of the LID measures given the assumptions described above and evaluate the effectiveness of the LID measures to attenuate peak flows in the study area. The results of the analysis indicate that LID measures could reduce the major storm peak flows by 2% to 6% throughout the study area. As such, while beneficial from a water quality and water balance perspective the benefit from a quantity control and major drainage system storm infrastructure perspective is limited.

Although the LID measures do not significantly reduce major system flows, they do attenuate peak flows from the more frequent storm events, reducing frequent nuisance flooding. The LID measures also effectively treat stormwater and improve the water balance at a relatively low cost without changing the existing land use/surface features.

The LID measures considered result in a positive impact on the environment, however do not provide the quantity control that the SWM detention facilities option does. It is recommended that LID measures be implemented as capital improvement projects proceed (i.e. road reconstruction projects, intensification corridor redevelopment, and in the available parkland) where feasible under each improvement alternative considered. Lot level controls (soakaway pits, infiltration trenches, and downspout disconnection) and rainwater harvesting should also be encouraged throughout the study area.

### 5.1.3 Flow Diversions

There are opportunities in the watershed to divert flow away from private property through municipally owned lands, reducing flooding through these areas of concern. Five potential flow diversions have been identified north (upstream) of Peel Street that will reduce the flow through the open channel and/or flood susceptible reaches of Sophia Creek to varying degrees. A sixth flow diversion has been identified downstream of Peel Street that will reduce the flow of municipal stormwater through private property. The flow diversions are summarized as follows:

1. Wellington Street flow diversion – diverting the minor drainage system at the intersection of Duckworth Street and Steel Street west along Wellington Street to Berczy Street. This flow diversion will reduce peak flows in the open channel portion of Sophia Creek from Duckworth Street to Wellington Street.
2. Grove Street flow diversion – diverting the minor drainage system on Grove Street (east of Lay Street) west on Grove Street to the existing Grove Street East culvert crossing. This flow diversion will reduce peak flows in Sophia Creek from Lay Street to Grove Street East.
3. Grove/Davidson Street flow diversion – diverting drainage at Grove Street west on Grove Street then south on Davidson Street to the existing Davidson Street and Gunn Street culvert crossing. This flow diversion will reduce peak flows in Sophia Creek from Grove Street to Davidson Street.
4. Mulcaster Street flow diversion – divert the minor drainage system at the intersection of Penetang Street and Berczy Street west to Mulcaster Street then south to Kempenfelt Bay. This flow diversion will reduce peak flows in Sophia Creek from Berczy Street to Kempenfelt Bay.
5. Currie Street flow diversion – divert the flows exceeding the existing trunk storm sewer downstream of SWMF SP03 south on Currie Street to Rose Street then east on Rose Street to Sophia Creek. This flow diversion will reduce flooding between SWMF SP03 and Rose Street.
6. Owen Street flow diversion – divert the minor drainage system at the intersection of Owen Street and Wellington Street south on Owen Street to Sophia Street. This flow diversion will reduce the overland flow and flooding through the private properties bound by Wellington Street, Owen Street, Sophia Street, and Clapperton Street.

To evaluate the effectiveness of the flow diversions at reducing the peak flows through the study area, the existing condition models were updated to include the flow diversions and the peak flows at various points of interest were compared. With the exception of the reach of Sophia Creek from Grove Street to Davidson Street, the flow diversion alternatives only reduced peak flows along Sophia Creek by 0% to 5% for the various designs storms. The Grove/Davidson Street flow diversion is capable of conveying approximately 10 m<sup>3</sup>/s, potentially reducing the peak flows through Sophia Creek from Grove Street to Davidson Street by 20% - 80% depending on the storm event.

Only the Grove/Davison Street, Currie Street and Owen Street flow diversions provide an appreciable impact on peak flows in the existing drainage system. As such, the Wellington Street, Grove Street and Mulcaster Street flow diversions have been excluded from the improvement alternatives and have not been considered further as part of this study.

The Grove/Davidson Street flow diversion has a significant capital construction cost associated with its implementation and based on our pre-screening evaluation, there are conveyance capacity improvement options available that will reduce flooding downstream of Grove Street with greater positive impacts on the environment. As such, the Grove/Davidson Street flow diversion has also been excluded from the detailed evaluation of improvement alternatives and will not be considered further as part of this study.

Similarly, the Currie Street flow diversion has significant limitations in its implementation such as service conflicts that will result in significant capital construction costs. There are conveyance capacity improvement options available that will reduce flooding downstream of SWMF SP03 with greater positive impacts on the environment. As such, the Currie Street flow diversion has also been excluded from the detailed evaluation of improvement alternatives and will not be considered further as part of this study.

Of all the flow diversion options, the Owen Street flow diversion generates the greatest positive impact on the environment and satisfies the City's objectives of reducing private property flooding and relocation of municipal drainage from private lands. As such, it is recommended that the Owen Street diversion be considered for analysis and evaluation.

## **5.2 Conveyance Capacity Improvements Options**

As described in the previous MDP, there are opportunities in the study to implement conveyance capacity improvements to reduce flooding on both private and municipal property. These opportunities include culvert improvements, channel improvements, constructing trunk storm sewers and minor drainage system improvements. The conveyance capacity improvement options presented as part of this study are described in the following sections

### **5.2.1 Culvert Improvements**

As part of the previous MDP, culvert improvements were recommended as outlined in Section 1.2 of this report. It was recommended that local road and collector/arterial road culvert crossings be designed with a 1:5 year and 1:25 year design flood frequency, respectively. The City has updated design standards (Storm Drainage and Stormwater Management Policies and Design Guidelines, 2009) stipulating stricter design flood frequency criteria and rainfall data adjusted to account for climate change. As part of the study, the following road crossing culverts were evaluated:

1. Howard Street
2. Lay Street

3. Grove Street (A) – west of Lay Street
4. Grove Street (B) – east of St. Vincent Street
5. St. Vincent Street
6. Ottaway Avenue/Rose Street
7. Laurie Crescent
8. Bothwell Crescent
9. Grove Street (C) – west of Bothwell Crescent
10. Parkdale Crescent
11. Davidson Street/Gunn Street
12. Wellington Street/Berczy Street

The culvert improvements listed above are considered to each be of benefit and are being carried forward in combination with the channel improvements discussed below.

### **5.2.2 Channel Improvements**

Similar to the culvert improvements, the previous MDP recommended channel improvements upstream of Peel Street as outlined in Section 1.2 of this report. It was recommended that the channel between Howard Crescent and Lay Street and between Grove Street and Davidson Street be improved to reduce flooding on private property. With the changes in the City's design standards and the need to improve maintenance access along the watercourse and improve water quality throughout the study area, the previously recommended channel improvements have been considered along with several new channel improvement options that are being evaluated as part of this study as follows:

1. Howard Crescent to Lay Street – channel improvements to reduce flooding and improve the hydraulic function of the Howard Crescent culvert crossing.
2. Downstream of Lay Street – channel improvements to improve hydraulic function of the Lay Street culvert crossing.
3. Upstream/Downstream of Grove Street (B) culvert crossing – channel improvements to intercept flood waters from the rear yards south of Grove Street and redirect these waters back into Sophia Creek.
4. Ottaway Avenue to Rose Street – daylighting the watercourse from SWMF SP03 to the existing channel downstream of Rose Street to reduce flooding and improve water quality.

5. Grove Street to Parkdale Crescent – channel improvements to reduce flooding of private property and improve the hydraulic function of the Grove Street (C) culvert crossing.
6. Berczy Street to Queen Street – daylighting the watercourse from Wellington Street to the existing watercourse downstream of the Berczy Street to reduce flooding of private property and improve the hydraulic function of the upstream culvert crossings.

The channel improvements are being carried forward in combination with the culvert improvements discussed previously.

### **5.2.3 Trunk Storm Sewer**

As identified in the background reports and models, runoff from minor and major storm events can surcharge the trunk storm sewer downstream of Peel Street and flood private and municipal property along Sophia Street from Peel to Bayfield Street and along Owen, Clapperton and Bayfield Street from Sophia Street to Kempenfelt Bay. The flooding has caused historic damage to both private and municipal property and causes concern for public safety.

The previous MDP's briefly considered but did not make a recommendation to improve the trunk storm sewer downstream of Peel Street. The social and economic impacts of constructing a large trunk storm sewer through the downtown core were cited as the primary concerns for this alternative. However, as part of this study, constructing an additional trunk storm sewer from Peel Street to Kempenfelt Bay is being re-evaluated given the extensive flooding that can occur.

Opportunities exist to construct additional trunk storm sewers within the municipal road allowance downstream of Peel Street to Kempenfelt Bay to supplement the existing trunk storm sewer. These opportunities are summarized as follows:

1. Owen Street trunk storm sewer – construction a second trunk storm sewer west on Sophia Street to Owen Street, then south on Owen Street to Kempenfelt Bay through Memorial Square.
2. Mulcaster Street trunk storm sewer – construct a second truck storm sewer on Peel Street to Codrington Street, then north across private property to Worsley Street, east on Worsley Street to Mulcaster Street and south on Mulcaster to Kempenfelt Bay.
3. Clapperton Street trunk storm sewer – construct a second trunk storm sewer west on Sophia Street to Clapperton Street, then south on Clapperton Street to Bayfield Street and south on Bayfield Street to Kempenfelt Bay.
4. Dunlop Street trunk storm sewer – construct a second trunk storm sewer west on Sophia Street to Owen Street, then south on Owen Street to Dunlop Street, east on Dunlop Street to Mulcaster Street, and south on Mulcaster Street to Kempenfelt Bay.

These alternatives are being carried forward as improvement alternatives being considered.

## 5.2.4 Minor Drainage System Improvements

The existing storm infrastructure in the study area is reaching its service life expectancy and deteriorating. A majority of the aging storm sewers are undersized considering historic rainfall data and current climate models predict future increases in rainfall intensities and volumes. In some locations, municipal storm infrastructure is located on private property outside the municipal right-of-way making it difficult to access and maintain. For these reasons, replacement of storm infrastructure throughout the Sophia Creek watershed and Mulcaster drainage area is strongly suggested. As such, as a general requirement for all capital projects, it is recommended that consideration of upsizing the local storm sewers to satisfy current design standards be considered as part of future road reconstruction projects. Included with this study is the minor system PCSWMM storm model that includes the current sizing and capacities of the local system. This modeling should be consulted when evaluating replacement alternatives. The minor drainage system deficiencies are illustrated on Figure 3 – Minor Drainage System Deficiencies provided in Section 4 of this report.

Similarly, relocating storm sewer to the municipal road allowance should also be considered. The relocation of the trunk storm sewer under residential and commercial properties on Sophia Street West was previously recommended as part of the Sophia Creek West Branch – Drainage and Infrastructure Improvements Municipal Class Environmental Assessment. This trunk storm sewer should be relocated as part of the reconstruction of Sophia Creek West in the future.

Through our review of the drainage systems, we have identified several areas and streets in the study area that are absent of minor drainage systems. Of note are the Marion Crescent/Pratt Road and Agnes Street areas. After reviewing these areas, it was determined that appropriate outlets are available on St. Vincent Street and Peel Street to allow minor drainage systems to service these two areas. As such, it is recommended that consideration be given to service these areas with storm sewer as part of future road reconstruction projects. Consideration should be given to also service the streets absent of a minor drainage system throughout the study area. The areas/streets absent of minor drainage systems are illustrated on Figure 3 – Minor Drainage System Deficiencies provided in Section 4 of this report.

**Table 8: Construction Costs – Minor Drainage System Improvements**

Improvement Alternative	Construction Cost
General Recommendations	
a) Minor Drainage System Improvements	\$1,198,630
b) Owen Street Flow Diversion	\$69,902
c) New Storm Sewer (where absent/required)	\$4,780,994
<b>Total</b>	<b>\$6,049,526</b>

## 6 Description of Improvement Alternatives

Integral to the planning process is the consideration and evaluation of alternatives to address the problem statement and where possible correct the noted deficiencies. The improvement alternatives developed as part of this study are described in the following sections and illustrated on Figures 6 and 7 provided in Section 5 of this report.

### 6.1 Existing Conditions

#### 6.1.1 Alternative 1 – “Do Nothing”

The “Do Nothing” alternative allows for the consideration of not implementing any changes to the existing drainage infrastructure within the study area. This alternative is being considered to provide a benchmark to gauge the physical, natural, social, cultural, and economic implications of the other alternatives. If this alternative were selected, consideration should be given by the City to acquiring the private properties or interests therein (easements) that are impacted by flooding to comply with the City of Barrie Drainage Policies.

### 6.2 Flow Reduction/Water Quality Improvements

#### 6.2.1 Alternative 2A – Retrofit/New Stormwater Management Facilities (SWMF)

An opportunity exists to retrofit and expand the existing Ottaway Avenue/Currie Street SWMF (SWMF SP03) and to convert MacMorrison Park into a SWM detention facility. By purchasing additional private property to the immediate north (364 St. Vincent Street) of existing SWMF SP03, the active storage volume provided by the detention pond may be significantly increased. The increase in active storage volume combined with retrofitting the existing outlet controls will reduce peak flows downstream. Converting MacMorrison Park into a SWM detention facility was identified and recommended as part of the original MDP and the facility was designated SP01. By converting the park, approximately 30,000 m<sup>3</sup> of active storage may be created within the parks footprint. Adding the active storage volume in combination with improvements to the Bothwell Street culvert crossing will attenuate peak flows downstream along Sophia Creek to Kempenfelt Bay.

#### 6.2.2 Alternative 2B – Low Impact Development (LID's)

An opportunity exists to implement Low Impact Development LID's throughout the watershed outside the source water protection area to attenuate peak flows, promote infiltration, and improve the water balance and watershed water quality. Opportunities exist to construct LID's as part of road reconstruction projects, as part of intensification and within existing parkland. Bioretention, perforated

pipe systems, permeable pavement and rainwater harvesting have been identified as LID's suitable for the study area.

### **6.3 Conveyance Capacity Improvements (Sophia Creek Watershed – Upstream of Peel Street)**

#### **6.3.1 Alternative 3A – Culvert/Channel/Major Drainage System Improvements (1:25 Year Conveyance Capacity)**

Main culvert and channel improvements can be implemented along Sophia Creek north of Peel Street as recommended as part of the original MDP. The culvert improvements would satisfy the 1:25 year design storm peak flow as a minimum as recommended as part of the original MDP. The channel improvements would reduce flooding of existing buildings and/or property where feasible. This option will only improve the storm infrastructure north of Peel Street and the implementation of specific culvert and channel improvements will require the purchase of private properties or acquiring interest therein (easements) to accommodate the improvements, reduce flooding of existing buildings, and provide for maintenance access.

#### **6.3.2 Alternative 3B – Culvert/Channel/Major Drainage System Improvements (Design Flood Frequency Criteria)**

Under this alternative, the same culvert and channel improvements can be implemented along Sophia Creek as described under Alternative 3A. However, the culvert improvements would satisfy the City's design flood frequency criteria as a minimum. As the roads in the study area are generally classified as local urban/collector and arterial roads, the design flood frequency criteria are the 1:50 and 1:100 year design storm peak flows, respectively. Similarly, the channel improvements would reduce flooding of existing buildings and/or property where feasible. This option will only improve the storm infrastructure north of Peel Street and the implementation of specific culvert and channel improvements will require the purchase of private properties or acquiring interest therein (easements) to accommodate the improvements, reduce flooding of existing buildings, and provide for maintenance access.

### **6.4 Conveyance Capacity Improvements (Sophia Creek Watershed – Downstream of Peel Street)**

#### **6.4.1 Alternative 4A – Owen Street Trunk Storm Sewer and Major Drainage System Improvements**

The opportunity exists to supplement the capacity of the existing trunk storm sewer downstream of Peel Street by constructing a second trunk storm sewer on Owen Street within the existing road allowance. Given the potential for extensive flooding downstream of Peel Street through the downtown core under existing conditions, the existing and proposed trunk storm sewers combined should satisfy the 1:100

year design flood frequency criteria. This will satisfy the City's mandate to eliminate flooding of existing buildings and private property, improve public safety and the use of the existing transportation systems.

A second trunk storm sewer can be constructed from Peel Street on Sophia Street to Owen Street in the municipal road allowance parallel to the existing trunk storm sewer. At Owen Street, the new trunk storm sewer can run south on Owen Street to Dunlop Street and Memorial Square. Downstream of Memorial Square, the trunk storm sewer can follow one of two alignments; 1) the trunk storm sewer can run southwest across the northwest corner of Memorial Square crossing Fred Grant Square, Simcoe Street and Lakeshore Drive before reaching Kempenfelt Bay; or 2) the trunk storm sewer can run east on Dunlop Street to Fred Grant Way then south to Lakeshore Drive and Kempenfelt Bay. From an engineering perspective, alignment 1 is preferred. However, it is understood that significant works are proposed within Memorial Square and an alignment avoiding crossing the square may be the most desirable option.

#### **6.4.2 Alternative 4B – Mulcaster Street Trunk Storm Sewer and Major Drainage System Improvements**

The opportunity exists to supplement the capacity of the existing trunk storm sewer downstream of Peel Street by constructing a second trunk storm sewer on Mulcaster Street. Given the potential for extensive flooding downstream of Peel Street through the downtown core under existing conditions, the existing and proposed trunk storm sewers combined should satisfy the 1:100 year design flood frequency criteria. This will satisfy the City's mandate to eliminate flooding of existing buildings and private property, improve public safety and the use of the existing transportation systems.

A second trunk storm sewer can be constructed from Sophia Creek south on Peel Street to Codrington Street. At Codrington Street, the trunk storm sewer can run south across private property to Worsley Street. On Worsley Street the trunk storm sewer can run east to Mulcaster Street then south on Mulcaster to Kempenfelt Bay. This trunk storm sewer alignment requires the purchase of private properties and/or acquiring interest therein (easements) to accommodate the trunk storm sewer. In order to create positive fall from Sophia Creek to Mulcaster Street, the trunk storm sewer will have to be installed at depths exceeding 7 m. Due to the depth, the trunk storm sewer will likely have to be installed through jack and bore horizontal tunnelling.

#### **6.4.3 Alternative 4C – Clapperton Street Trunk Storm Sewer and Major Drainage System Improvements**

The opportunity exists to supplement the capacity of the existing trunk storm sewer downstream of Peel Street by constructing a second trunk storm sewer on Clapperton Street. Given the potential for extensive flooding downstream of Peel Street through the downtown core under existing conditions, the existing and proposed trunk storm sewers combined should satisfy the 1:100 year design flood frequency

criteria. This would satisfy the City's mandate to eliminate flooding of existing buildings and private property, improve public safety and the use of existing transportation systems.

A second trunk storm sewer can be constructed from Peel Street west on Sophia Street to Clapperton Street. At Clapperton Street, the trunk sewer can run south to Bayfield Street. At Bayfield Street, the trunk storm sewer can follow one of two alignments; 1) south on Bayfield Street to Kempenfelt Bay (replace existing trunk storm sewer); or 2) west on Dunlop Street to Maple Avenue, then south on Maple Avenue to Kempenfelt Bay (existing Bayfield Street trunk storm sewer to remain). From an engineering perspective, alignment 1 is preferred. However, it is understood that there are significant construction costs, transportation disruptions and service/utility relocations associated with this alignment. As such, an alignment avoiding the reconstruction of Bayfield Street may be the most desirable option.

#### **6.4.4 Alternative 4D – Dunlop Street Trunk Storm Sewer and Major Drainage System Improvements**

The opportunity exists to supplement the capacity of the existing trunk storm sewer downstream of Peel Street by constructing a second trunk storm sewer on Dunlop Street. Given the potential for extensive flooding downstream of Peel Street through the downtown core under existing conditions, the existing and proposed trunk storm sewers combined should satisfy the 1:100 year design flood frequency criteria. This would satisfy the City's mandate to eliminate flooding of existing buildings and private property, improve public safety and the use of existing transportation systems.

A second trunk storm sewer can be constructed from Peel Street on Sophia Street to Owen Street in the municipal road allowance parallel to the existing trunk storm sewer. At Owen Street, the new trunk storm sewer can run south on Owen Street to Dunlop Street, then east on Dunlop Street to Mulcaster Street and south on Mulcaster Street to Kempenfelt Bay. This alignment avoids Memorial Square and the jack and bore horizontal tunnelling required under Alternatives 4A and 4B, respectively.

## 7 Improvement Alternatives Assessment

To assess the effectiveness of the improvement alternatives to reduce flooding, the existing conditions minor and major drainage system models of the study area have been revised to include the proposed improvement alternatives. The results of the analysis, specifically the reductions in peak flow, required culvert sizes, and flooding impacts under each improvement alternative are discussed in the subsequent sections. As outlined in the previous alternative screening section, the implementation of the minor drainage system improvements have been carried through and are to be brought forward regardless of the other alternatives suggested.

### 7.1 Existing Conditions

#### 7.1.1 Alternative 1 – “Do Nothing”

Alternative 1 represents the “do nothing” alternative and generally does not meet with the City of Barrie design standards unless significant property acquisition is completed to remove potential flood-prone properties from the floodplain. The assessed property values of the 157 private properties identified within the floodplain total \$86,312,750. Because the extent of flooding, particularly downstream of Peel Street, is extensive and currently encompasses a significant amount of residential and commercial properties, the implementation of this alternative has been eliminated as it is not practical due to economic and social implications.

The economic impacts stretch beyond the purchase price of the properties. 105 properties have been identified in the floodplain downstream of Peel Street. 69 are commercial properties having a total assessed property value of \$58,839,000 covering approximately three City blocks in the downtown core within the historic Town of Barrie.

### 7.2 Flow Reduction/Water Quality Improvements

#### 7.2.1 Alternative 2A – Retrofit/New Stormwater Management Facilities (SWMF)

The Visual OTTHYMO hydrologic model of the major drainage catchments in the study area was revised to include the expansion/retrofit of the Ottaway Avenue/Currie Street SWMF (SWMF SP03) and the creation of a SWMF in MacMorrison Park (SWMF SP01). The hydrologic model results and the stage-storage-discharge curves developed for two proposed SWM detention facilities are enclosed in Appendix F along with conceptual SWMF designs for reference. The flow reductions resulting from the implementation of Improvement Alternative 2 are summarized in the following table.

**Table 9: Flow Reduction Hydrologic Model Results Summary**

Point of Interest / Culvert Crossing	Peak Flow (m <sup>3</sup> /s) – SCS 6 Hour Design Storms				
	1:5 Year	1:10 Year	1:25 Year	1:50 Year	1:100 Year
Howard Crescent	3.7	5.0	6.8	8.3	9.8
Grove Street (A)	5.7	7.6	10.4	12.8	15.0
St. Vincent Street	6.9	9.3	12.5	15.4	18.0
Ottaway Avenue/Rose Street	2.6 (4.7)	4.5 (7.7)	8.1 (11.3)	11.2 (14.1)	14.5 (17.0)
Laurie Crescent	3.1 (5.4)	5.3 (8.5)	9.0 (12.4)	12.0 (15.4)	15.4 (18.7)
Bothwell Crescent	11.8 (15.0)	15.3 (21.2)	21.9 (30.4)	27.3 (37.3)	29.4 (44.4)
Grove Street (C)	12.9 (16.3)	16.6 (22.7)	23.4 (32.5)	29.1 (39.9)	31.3 (47.4)
Parkdale Street	12.9 (16.2)	16.7 (22.6)	23.5 (32.3)	29.2 (39.8)	31.6 (47.3)
Davidson Street/Gunn Street	13.5 (16.9)	17.5 (23.5)	24.3 (33.6)	30.2 (41.3)	33.0 (49.1)
Wellington Street/Berczy Street	14.8 (18.3)	19.1 (25.2)	26.1 (36.0)	32.3 (44.3)	36.1 (52.4)
Peel Street (Trunk Storm Sewer)	15.7 (19.2)	20.3 (26.4)	24.5 (37.5)	33.8 (46.3)	38.5 (54.9)

Point of Interest / Culvert Crossing	Peak Flow (m <sup>3</sup> /s) – Chicago 4 Hour Design Storms				
	1:5 Year	1:10 Year	1:25 Year	1:50 Year	1:100 Year
Howard Crescent	2.8	3.6	4.8	5.7	6.9
Grove Street (A)	4.2	5.5	7.4	8.8	10.7
St. Vincent Street	5.1	6.7	8.9	10.7	12.8
Ottaway Avenue/Rose Street	1.8 (3.2)	2.5 (4.6)	4.4 (7.3)	6.1 (9.2)	8.1 (11.2)
Laurie Crescent	2.3 (3.7)	3.0 (5.3)	5.1 (8.2)	7.0 (10.2)	9.1 (12.5)
Bothwell Crescent	9.0 (10.8)	11.5 (14.5)	14.9 (20.5)	17.9 (25.2)	22.0 (30.2)
Grove Street (C)	9.9 (11.8)	12.6 (15.7)	16.2 (22.0)	19.3 (27.0)	23.6 (32.4)
Parkdale Street	9.9 (11.8)	12.7 (15.7)	16.4 (22.0)	19.5 (26.9)	23.8 (32.4)
Davidson Street/Gunn Street	10.4 (12.3)	13.3 (16.4)	17.1 (22.8)	20.4 (28.0)	24.7 (33.6)
Wellington Street/Berczy Street	11.3 (13.4)	14.6 (17.9)	18.7 (24.6)	22.2 (30.1)	26.7 (36.2)
Peel Street (Trunk Storm Sewer)	12.0 (14.1)	15.5 (18.8)	19.9 (25.7)	23.6 (31.5)	28.2 (37.8)

Note: (3.2) – Flows in brackets correspond to existing peak flows (uncontrolled)

The analysis demonstrates that the expansion/retrofit of SWMF SP03 alone produces a reduction in peak flow of 15% to 45% downstream to SWMF SP01 and 5% to 20% downstream of SWMF SP01 to Kempenfelt Bay during the 1:100 year and 1:5 year design storms, respectively. The creation of SWMF SP01 alone produces a reduction in peak flow of 13% to 27% downstream to Kempenfelt Bay during the 1:5 year and 1:100 year design storms, respectively. When implemented in combination as proposed in Alternative 2A, the SWM detention facilities reduce peak flows by 16% to 34% downstream to Kempenfelt Bay during the 1:5 year and 1:100 year design storms respectively. This results in a 1:100 year design storm peak flow of 38.5 m<sup>3</sup>/s at Peel Street which is a reduction of 16.4 m<sup>3</sup>/s.

The existing condition HEC RAS hydraulic model of Sophia Creek upstream of Peel Street was revised to include the reduced peak flows under this improvement alternative. This was completed to evaluate the impact the reduced peak flows have on the level of service provided by the existing road culvert crossings. A summary of the results is presented in the following table:

**Table 10: Culvert Summary – Alternative 2A**

Location	Size	Capacity (m <sup>3</sup> /s)	Level of Service	Design Criteria
Howard Crescent	800 mm × 1250 mm CSPE	1.4	< 1:5 Year	1:50 Year
Lay Street	850 mm × 1350 mm CSPE	2.6	< 1:5 Year	1:50 Year
Grove Street (A)	1200 mm × 1800 mm CSPA	3.3	< 1:5 Year	1:50 Year
St. Vincent Street	1200 mm × 1800 mm Conc. Box	4.2	< 1:5 Year	1:100 Year
Ottaway Avenue/Rose Street	1200 mm × 2400 mm Conc. Box	9.0	1:25 Year	1:50 Year
Laurie Crescent	1500 mm × 3000 mm Conc. Box	9.0	1:25 Year	1:50 Year
Bothwell Crescent	7.93 m Conc. Span	> 29.4	1:100 Year	1:50 Year
Grove Street (C)	Twin 900 mm × 1900 mm CSPA 900 mm × 1600 mm CSPA	6.2	< 1:5 Year	1:50 Year
Parkdale Crescent	Twin 1200 mm Dia. Conc.	8.3	< 1:5 Year	1:50 Year
Davidson Street/Gunn Street	1560 mm × 1850 mm Conc. Box	8.9	< 1:5 Year	1:50 Year
Wellington Street/Berczy Street	1540 mm × 1840 Conc. Box	9.5	< 1:5 Year	1:100 Year
Sophia Street Trunk Sewer	1220 mm × 1980 mm Conc. Box	13.0	< 1:5 Year	1:100 Year

The analysis demonstrates that the level of service provided by the road culvert crossings considering flow reduction from Alternative 2 alone does not generally satisfy the City's current design flood frequency criteria or the previous recommendations of the MDP. The flow reduction alone does not eliminate flooding of existing buildings and/or properties along Sophia Creek. As such, additional improvements are required.

It is noted that upgrades to the Bothwell Crescent culvert crossing and the downstream channel to Grove Street are required to construct SWMF SP01. As such, the culvert and channel improvements are required in order to provide the active storage volume and peak flow attenuation specified in this alternative.

A preliminary construction cost estimate has been prepared for Improvement Alternative 2A. The preliminary construction cost estimate is included in Appendix C and summarized in the following table:

**Table 11: Preliminary Construction Cost Estimate – Alternative 2A**

SWMF	Preliminary Construction Cost Estimate
SP01	\$3,042,190
SP03	\$524,050
<b>Total</b>	<b>\$3,566,240</b>

Note: Excludes property acquisition costs.

The properties considered for acquisition to construct/retrofit the SWMF's under this improvement alternative are summarized in the following table:

**Table 12: Property Acquisition Summary – Alternative 2A**

Address	Property Acquisition Cost
2 Bothwell Crescent	\$217,000
364 St. Vincent Street	\$650,000
<b>Total Property Acquisition Costs</b>	<b>\$867,000</b>

Note: Excludes property acquisition costs of properties within floodplain (\$86,312,750); Property Value – Assessed Value (MPAC)

### **7.2.2 Alternative 2B – Low Impact Development (LID's)**

As previously discussed, calculations were performed to establish realistic objectives for LID's implemented in the study area. Based on the available land and soil conditions, LID's installed as part of road reconstruction projects or in the intensification corridors can typically intercept the first 5 mm to

10 mm of runoff from a storm event. This satisfies Alternative 2 of the LSRCA's flexible treatment alternative for sites with restrictions criteria, specifically a minimum 5 mm runoff volume reduction. LID's implemented in the parks identified may intercept the first 10 mm to 20 mm of runoff during a storm event from their contributing drainage areas. Supporting calculations are enclosed in Appendix E for reference.

The hydrologic analysis was updated to consider the inclusion of the LID's given the assumptions described above and evaluate the effectiveness of the LID's to attenuate peak flows in the study area. The results of the analysis indicate that LID's could reduce the major storm peak flows by 2% to 6% throughout the study area. As such, while beneficial from a water quality and water balance perspective the benefit from a quantity control perspective and the major drainage system storm infrastructure in the watershed is limited.

Although the LID's do not significantly reduce major system flows, they do attenuate peak flows from the more frequent storm events, reducing frequent nuisance flooding. The LID's also effectively treat stormwater and improve the water balance at a relatively low cost without changing the existing land use/surface features.

Preliminary construction cost estimates have been developed for the implementation of LID's in the study area under the following conditions:

1. Implementation of infiltration measures within the study area is restricted to areas outside the known wellhead protection area;
2. 10% of the road allowance can be utilized for LID's; and
3. LID design satisfies Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010).

The preliminary construction costs estimates are summarized in the following table:

**Table 13: Low Impact Development (LID's) Implementation Costs**

LID	Unit Price	Area	Construction Cost
Porous Pavement	\$47,400/ha	42.5	\$2,014,500
Bioretention	\$62,800/ha	10.0	\$628,000
Pervious Pipe System	\$62,800/ha	10.0	\$628,000

Source: Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010); Unit price is per impervious hectare treated and exclude engineering design fees, contract administration/construction inspection fees, utility relocation costs, and contingencies

It is noted, the acquisition of private property is not required for this alternative.

## 7.3 Conveyance Capacity Improvements (Sophia Creek Watershed – Upstream of Peel Street)

### 7.3.1 Alternative 3A – Culvert/Channel/Major Drainage System Improvements (1:25 Year Conveyance Capacity)

The existing condition HEC RAS hydraulic model of Sophia Creek upstream of Peel Street was revised to determine the culvert sizes and channel improvements required to satisfy the previously recommended 1:25 year design storm peak flow conveyance criteria. A summary of the required culvert sizes is presented in the following table and the detailed model results are included in Appendix G for reference.

Table 14: Culvert Summary – Alternative 3A

Location	Size	Capacity (m <sup>3</sup> /s)	Level of Service
Howard Crescent	1200 mm × 2400 mm Conc. Box	6.8	1:25 Year
Lay Street	1200 mm × 2400 mm Conc. Box	8.4	1:50 Year
Grove Street (A)	1200 mm × 3600 mm Conc. Box	8.8	1:25 Year
Grove Street (B)	900 mm × 2400 Conc. Box	4.4	1:25 Year
St. Vincent Street	Twin 1200 mm × 3000 mm Conc. Box	12.5	1:25 Year
Ottaway Avenue	1500 mm × 3000 mm Conc. Box	13.2	1:25 Year
Rose Street	1500 mm × 3600 mm Conc. Box	11.8	1:25 Year
Laurie Crescent	1500 mm × 3600 mm Conc. Box	15.4	1:50 Year
Bothwell Crescent	8.53 m Conc. Span	37.3	1:50 Year
Grove Street (C)	8.53 m Conc. Span	33.5	1:25 Year
Parkdale Crescent	8.53 m Conc. Span	36.4	1:25 Year
Davidson Street/Gunn Street	8.53 m Conc. Span	41.3	1:50 Year
Berczy Street	8.53 m Conc. Span	39.7	1:25 Year
Wellington Street	8.53 m Conc. Span	44.3	1:50 Year
Sophia Street Trunk Sewer	1220 mm × 1980 mm Conc. Box	13.0	< 1:5 Year

The analysis demonstrates that the level of service provided by the road culvert crossings under this alternative do not generally satisfy the City's current design flood frequency criteria. They do satisfy the recommendations of the previous MDP.

The proposed channel improvements under this improvement alternative are summarized as follows:

1. Howard Crescent to Lay Street – regrading and improvement of the channel cross-section to accommodate the proposed Howard Crescent culvert crossing, improve hydraulic function, and reduce flooding along the watercourse. Lowering the grade of the channel at Howard Crescent by 0.5 m accommodates the upsized culvert crossing under this scenario and a channel cross-section with a 2.4 m bottom width and 3:1 (H:V) side slopes contains the 100 year design storm peak flow.
2. Downstream of Lay Street – regrade the channel for the first 50 m downstream of Lay Street to accommodate the Lay Street culvert crossing, improve hydraulic function, and reduce flooding along the watercourse.
3. Upstream/Downstream of Grove Street (B) – construct a channel having a cross-section with a bottom width of 2.4 m and 3:1 (H:V) side slopes to intercept surface runoff and convey it downstream back into Sophia Creek. Easements are required over 207 Grove Street East and 265 St. Vincent Street and the acquisition of 210 Grove Street East is required to implement these channel improvements.
4. Ottaway Avenue to Laurie Crescent – minor grading improvements to the existing channel downstream of Laurie Crescent to Bothwell Crescent will improve drainage in this area. The opportunity also exists to extend the existing channel between Rose Street and Laurie Crescent upstream of Ottaway Avenue to SWMF SP03 to reduce flooding, improve maintenance access and water quality. Extending the channel upstream with a cross-section consistent with the existing channel between Rose Street and Laurie Crescent will reduce flooding in the area. Property acquisition is required to implement these channel improvements (69 and 70 Ottaway Avenue and 128 Rose Street).
5. Grove Street to Parkdale Crescent – regrade and improve the channel cross-section through this area to reduce flooding of private property adjacent to the watercourse. Regrading the channel and improving the cross-section to have a 3 m bottom width and 3:1 (H:V) side slopes matching to existing grade at property line will reduce the extent and frequency of flooding on private property. Improvements to be completed within existing easement.
6. Berzcy Street to Queen Street – eliminate the existing culvert along Berzcy Street and replace it with an open channel having a cross-section consistent with the downstream channel between Berzcy Street and Peel Street. The channel can run on the west side of Berzcy Street, crossing both Wellington Street and Berzcy Street with culverts. The channel can run upstream to Gunn Street. Property acquisition is required to implement these channel improvements (47 Gunn Street, 150, 152, 154, 166, and 168 Berzcy Street, and 103 Wellington Street East).

A summary of the HEC RAS results for the channel improvements is provided in the following table:

**Table 15: Channel Improvements Summary**

Channel Improvement	1:100 Year Peak Flow (m <sup>3</sup> /s)	Capacity (m <sup>3</sup> /s)	
		Existing	Proposed
Howard Crescent to Lay Street	9.8	6.6	9.8
Downstream of Lay Street	9.8	9.8	9.8
Upstream/Downstream of Grove Street (B)	7.4	1.9	8.8
Ottaway Avenue to Laurie Crescent	17.0	13.1	15.1
Grove Street to Parkdale Crescent	47.4	22.1	31.1
Berczy Street to Queen Street	52.4	-	45.5

A preliminary construction cost estimate has been prepared for Improvement Alternative 3A. The preliminary construction cost estimate is included in Appendix C and summarized in the following table:

**Table 16: Preliminary Construction Cost Estimate – Alternative 3A**

Culvert Crossing	Preliminary Construction Cost Estimate
Howard Crescent	\$370,255
Lay Street	\$563,450
Grove Street (A)	\$384,032
Grove Street (B)	\$328,123
St. Vincent Street	\$698,394
Ottaway Avenue	\$454,037
Rose Street	\$514,595
Laurie Crescent	\$750,599
Bothwell Crescent	\$1,249,884
Grove Street (C)	\$2,017,920
Parkdale Crescent	\$1,452,004
Davidson Street/Gunn Street	\$4,151,141
Berczy Street	\$1,743,305
Wellington Street	\$1,524,070
Channel Improvement	Preliminary Construction Cost Estimate
Howard Crescent to Lay Street	\$98,493
Downstream of Lay Street	\$109,008
Upstream/Downstream of Grove Street (B)	\$129,552
Ottaway Avenue to Laurie Crescent	\$287,206
Grove Street to Parkdale Crescent	\$81,083
Berczy Street to Queen Street	\$512,146
<b>Total</b>	<b>\$17,419,597</b>

For this option, property acquisition and/or interests therein (easements) are required. The easements/properties considered for acquisition under this improvement alternative are summarized in the following table:

**Table 17: Easement/Property Acquisition Summary – Alternative 3A**

Address		
207 Grove Street East	69 Ottaway Avenue	166 Berczy Street
210 Grove Street East	128 Rose Street	103 Wellington Street
70 Ottaway Avenue	2 Bothwell Crescent	154 Berczy Street
168 Berczy Street	56 Gunn Street	152 Berczy Street
150 Berczy Street	47 Gunn Street	265 St. Vincent Street
<b>Total Property Acquisition Costs</b>		<b>\$3,382,000</b>

Note: Property Value – Assessed Value (MPAC)

It is noted, a drainage swale at the rear of 207 – 229 Grove Street East and 8 – 26 Marion Crescent conveys flow from Sophia Creek west through the rear yards of the aforementioned properties to St. Vincent Street. The drainage swale conveys municipal drainage through private property and the City should consider acquiring an easement over these lands. The City should considered obtaining an easement to ensure that the swale is maintained and development does not encroach into the existing swale/drainage feature or existing floodplain.

As Improvement Alternatives 2A and 3A alone do not satisfy the City’s current design flood frequency criteria independently, we have reviewed the impacts on peak flows and culvert sizing considering the implementation of both alternatives in combination. To do so, we updated the Improvement Alternative 3A HEC RAS hydraulic model to include the reduced peak flows produced by Improvement Alternative 2A.

The analysis demonstrates that the level of service provided by the road culvert crossings under this scenario generally satisfy the City’s current design flood frequency criteria downstream of the proposed SWM detention facilities. In fact, the road culvert crossings generally exceed the City’s criteria. However, the level of service provided does not change from Howard Crescent to St. Vincent Street as the proposed SWMF SP03 retrofit and SWMF SP01 creation do not reduce flows through this reach of Sophia Creek.

The same channel improvements are required as Alternative 3A. However, the level of service provided increases when considering the flow reduction. Similarly, the preliminary construction cost estimates and property acquisition requirements for Improvement Alternative 2A and 3A still apply.

### 7.3.2 Alternative 3B – Culvert/Channel/Major Drainage System Improvements (Design Flood Frequency Criteria)

The existing condition HEC RAS hydraulic model of Sophia Creek upstream of Peel Street was revised to determine the culvert sizes and channel improvements required to satisfy the City's design flood frequency criteria. A summary of the required culvert sizes is presented in the following table and the detailed model results are included in Appendix H for reference.

Table 18: Culvert Summary – Alternative 3B

Location	Size	Capacity (m <sup>3</sup> /s)	Level of Service
Howard Crescent	1200 mm × 3600 mm Conc. Box	9.3	1:50 Year
Lay Street	1200 mm × 3600 mm Conc. Box	9.8	1:100 Year
Grove Street (A)	1200 mm × 3600 mm Conc. Box	8.8	1:50 Year
Grove Street (B)	1200 mm × 3600 mm Conc. Box	6.1	1:50 Year
St. Vincent Street	Twin 1200 mm × 3600 mm Conc. Box	> 18.0	1:100 Year
Ottaway Avenue	1500 mm × 3600 mm Conc. Box	16.0	1:50 Year
Rose Street	Twin 1500 mm × 2400 mm Conc. Box	15.0	1:50 Year
Laurie Crescent	Twin 1500 mm × 2400 mm Conc. Box	> 18.7	1:100 Year
Bothwell Crescent	8.53 m Conc. Span	37.3	1:50 Year
Grove Street (C)	Twin 5.79 m Conc. Span	39.7	1:50 Year
Parkdale Crescent	Twin 5.79 m Conc. Span	45.3	1:50 Year
Davidson Street/Gunn Street	Twin 5.79 m Conc. Span	48.9	1:50 Year
Berczy Street	Twin 5.79 m Conc. Span	47.4	1:50 Year
Wellington Street	Twin 5.79 m Conc. Span	52.4	1:100 Year
Sophia Street Trunk Sewer	1220 mm × 1980 mm Conc. Box	13.0	< 1:5 Year

The analysis demonstrates that the level of service provided by the road culvert crossings under this alternative satisfies the City's current design flood frequency criteria. It is noted that the same channel improvements are required under Alternative 3B as Alternative 3A. Refer to Section 7.3.1 for a description of the channel improvements required.

A preliminary construction cost estimate has been prepared for Improvement Alternative 3B. The preliminary construction cost estimate is included in Appendix C and summarized in the following table:

**Table 19: Preliminary Construction Cost Estimate – Alternative 3B**

Culvert Crossing	Preliminary Construction Cost Estimate
Howard Crescent	\$484,192
Lay Street	\$734,356
Grove Street (A)	\$384,032
Grove Street (B)	\$433,258
St. Vincent Street	\$873,456
Ottaway Avenue	\$479,465
Rose Street	\$609,461
Laurie Crescent	\$877,087
Bothwell Crescent	\$1,249,884
Grove Street (C)	\$3,227,380
Parkdale Crescent	\$2,315,904
Davidson Street/Gunn Street	\$6,742,841
Berczy Street	\$2,779,985
Wellington Street	\$2,387,970
Channel Improvement	Preliminary Construction Cost Estimate
Howard Crescent to Lay Street	\$98,493
Downstream of Lay Street	\$109,308
Upstream/Downstream of Grove Street (B)	\$129,552
Ottaway Avenue to Laurie Crescent	\$287,206
Grove Street to Parkdale Crescent	\$81,083
Berczy Street to Queen Street	\$512,146
<b>Total</b>	<b>\$24,797,058</b>

The properties considered for acquisition under Improvement Alternative 3B remain the same as under Improvement Alternative 3A and are summarized in the following table:

**Table 20: Easement/Property Acquisition Summary – Alternative 3B**

Address		
207 Grove Street East	69 Ottaway Avenue	166 Berczy Street
210 Grove Street East	128 Rose Street	103 Wellington Street
70 Ottaway Avenue	2 Bothwell Crescent	154 Berczy Street
168 Berczy Street	56 Gunn Street	152 Berczy Street
150 Berczy Street	47 Gunn Street	265 St. Vincent Street
<b>Total Property Acquisition Costs</b>		<b>\$3,382,000</b>

Note: Property Value – Assessed Value (MPAC)

Alternative 3B satisfies the City's current design flood frequency criteria, however, there is an opportunity to reduce the size of the required culvert crossings and potentially save costs considering the implementation of Alternative 3B in combination with Alternative 2A. As such, we have reviewed the impacts the flow reduction from the SWMF retrofit/creation alternative has on the culvert sizes under Alternative 3B. To do so, we updated the Improvement Alternative 3B HEC RAS hydraulic model to include the reduced peak flows produced by Improvement Alternative 2A.

The analysis demonstrates that the culvert sizes may be reduced significantly downstream of MacMorrison Park when Alternative 2A is implemented in combination with Alternative 3B. However, the culvert sizes do not change from Howard Crescent to St. Vincent Street as the proposed SWMF SP03 retrofit and SWMF SP01 creation do not reduce flows through this reach of Sophia Creek.

The same channel improvements are required under Alternative 3B. However, the level of service provided increases when considering the flow reduction.

Preliminary construction cost estimates have been prepared for the implementation of Improvement Alternative 2A and 3B in combination. Similarly, the property acquisition costs have been determined for both alternatives. The preliminary construction cost estimates and property acquisition costs are \$10,815,896 (excluding \$4,434,190 to retrofit/construct SWMF's) and \$3,165,000, respectively. That results in a reduction in construction cost of \$13,981,162.

It is noted that the property acquisition cost for the implementation of Alternative 3B in combination with Alternative 2A is \$3,165,000, \$217,000 less than the property acquisition costs required for Alternative 3B implemented independently. Under Alternative 2A, the purchase of 2 Bothwell Street is required and included in the cost to retrofit/construct the SWMF's (\$4,434,190). As such, the purchase of 2 Bothwell

Crescent (\$217,000) has been subtracted from the property acquisition cost of Alternative 3B when implemented in combination with Alternative 2A.

## **7.4 Conveyance Capacity Improvements (Sophia Creek Watershed – Downstream of Peel Street)**

### **7.4.1 Alternative 4A – Owen Street Trunk Storm Sewer and Major Drainage System Improvements**

The existing condition PCSWMM hydraulic model of the Sophia Creek trunk storm sewer downstream of Peel Street was revised to determine the required Owen Street trunk storm sewer size to convey the major system flows downstream to Kempenfelt Bay.

The analysis demonstrated that an 1800 mm × 3600 mm concrete box installed at 1.9% on Sophia Street can convey approximately 36.7 m<sup>3</sup>/s. In combination with the existing Sophia Street/Bayfield Street trunk storm sewer, the total capacity of the system is approximately 49.7 m<sup>3</sup>/s. As such, the trunk storm sewer would have capacity to convey the peak flow generated by the 1:50 year design storm (5.2 m<sup>3</sup>/s less than the 1:100 year design storm peak flow) and reduce/eliminate overland flow and flooding through the downtown core significantly. Under this alternative, the section of trunk storm sewer on Sophia Street has the limiting capacity. The section of trunk storm sewer on Owen Street to Kempenfelt Bay may be reduced in size to an 1800 mm × 3000 concrete box without any reduction in the level of service provided.

Replacing the existing Sophia Street trunk storm sewer between Peel Street and Clapperton Street with 1500 mm x 2400 mm, 1500 mm x 2700 mm and 1800 mm x 2700 mm concrete box culvert (increasing in size moving west) will increase the capacity of the drainage system to 54.7 m<sup>3</sup>/s. The conveyance capacity of the system will equal the peak flow generated by the 1:100 year design storm.

Similar to Improvement Alternatives 3A and 3B, Improvement Alternative 4A was analysed considering the implementation of Improvement Alternative 2A and the resultant flow reduction. The analysis demonstrated that the trunk storm sewer on Sophia Street and Owen Street may be reduced in size to a 1500 mm × 3000 mm concrete box while still conveying the peak flow generated by the 1:50 year design storm. Replacing the existing Sophia Street trunk storm sewer will again increase the conveyance capacity of the system to the peak flow generated by the 1:100 year design storm.

The detailed model results are included in Appendix I for reference.

Preliminary construction cost estimates have been prepared for Alternative 4A and the implementation of Improvement Alternative 2A and 4A in combination. The preliminary construction cost estimates are included in Appendix C and summarized in the following table:

**Table 21: Preliminary Construction Cost Estimate – Alternative 4A**

Alternative	Preliminary Construction Cost Estimate
Alternative 4A	\$18,010,278
Alternative 4A (with 2A implemented)	\$17,166,916
Difference	\$843,362

It is noted, the trunk storm sewer may be constructed in the existing road allowance and property acquisition is not required.

**7.4.2 Alternative 4B – Mulcaster Street Trunk Storm Sewer and Major Drainage System Improvements**

The existing condition PCSWMM hydraulic model of the Sophia Creek trunk storm downstream of Peel Street was also revised to determine the required Mulcaster Street trunk storm sewer size to convey the major system flows downstream to Kempenfelt Bay.

The analysis demonstrated that a 3000 mm diameter concrete pipe is required from Sophia Creek to Mulcaster Street at Collier Street. The capacity of the trunk sewer is approximately 36.5 m<sup>3</sup>/s. In combination with the existing Sophia Street/Bayfield Street trunk storm sewer, the total capacity of the system is approximately 49.5 m<sup>3</sup>/s. As such, the trunk storm sewer would have capacity for the peak flow generated by the 1:50 year design storm (5.4 m<sup>3</sup>/s less than the 1:100 year design storm peak flow) and reduce overland flow and flooding through the downtown core significantly.

As previously discussed, the section of trunk storm sewer from Sophia Creek to Mulcaster Street at Collier Street will likely have to be installed through jack and bore horizontal tunnelling. Downstream of Collier Street, a 1200 mm × 3000 mm concrete box culvert is required to Dunlop Street and a 2400 mm × 3600 mm concrete box culvert is required downstream of Dunlop Street to Kempenfelt Bay.

Replacing the existing Sophia Street trunk storm sewer between Peel Street and Clapperton Street with 1500 mm x 2400 mm, 1500 mm x 2700 mm and 1800 mm x 2700 mm concrete box culvert (increasing in size moving west) will increase the capacity of the drainage system to 54.5 m<sup>3</sup>/s. The conveyance capacity of the system will equal the peak flow generated by the 1:100 year design storm.

The detailed model results are included in Appendix J for reference.

For this option, property acquisition and/or interests therein (easements) are required. The easements/properties considered for acquisition under this improvement alternative are summarized in the following table:

**Table 22: Easement/Property Acquisition Summary – Alternative 4B**

Address			
Property Acquisition	71 McDonald Street	92 Worsley Street	
Easement Acquisition	13 Codrington Street	88 Mulcaster Street	76 Mulcaster Street
<b>Easement/Property Acquisition Cost</b>			<b>\$764,600</b>

Note: Property Value – Assessed Value (MPAC)

Similar to Improvement Alternative 4A, Improvement Alternative 4B was analysed considering the implementation of Improvement Alternative 2A and the resultant flow reduction. The analysis demonstrated that the trunk storm sewer from Sophia Creek to Mulcaster Street at Collier Street may be reduced in size to a 2400 mm diameter concrete pipe. Downstream of Collier Street, a 1200 mm × 2100 mm concrete box culvert is required to Dunlop Street and an 1800 mm × 3600 mm concrete box culvert is required downstream of Dunlop Street to Kempenfelt Bay.

Preliminary construction cost estimates have been prepared for Alternative 4B and the implementation of Improvement Alternative 2A and 4B in combination. The preliminary construction cost estimates are included in Appendix C and summarized in the following table:

**Table 23: Preliminary Construction Cost Estimate – Alternative 4B**

Alternative	Preliminary Construction Cost Estimate
Alternative 4B	\$29,952,473
Alternative 4B (with 2A implemented)	\$21,492,773
Difference	\$8,459,700

### **7.4.3 Alternative 4C – Clapperton Street Trunk Storm Sewer and Major Drainage System Improvements**

The existing condition PCSWMM hydraulic model of the Sophia Creek trunk storm sewer downstream of Peel Street was also revised to determine the required Clapperton Street trunk storm sewer size to convey the major system flows downstream to Kempenfelt Bay.

The analysis demonstrated that an 1800 mm x 3600 mm concrete box culvert installed on Sophia Street and Clapperton Street can convey approximately 41.5 m<sup>3</sup>/s. As such, the trunk storm sewer would have a capacity to convey the peak flow generated by the 1:50 year design storm (0.5 m<sup>3</sup>/s less than the 100

year design storm peak flow) and reduce/eliminate overland flow and flooding through the downtown core significantly.

The existing trunk storm sewer on Bayfield Street downstream of Dunlop Street has a capacity of approximately 27 m<sup>3</sup>/s. A second trunk storm sewer can be run west on Dunlop Street to Maple Avenue (2000 mm diameter concrete storm sewer) and south on Maple Avenue to Simcoe Street (1800 mm x 3600 mm concrete box culvert). Twin 1250 mm x 2700 mm concrete box culvert can be run from Simcoe Street to Kempenfelt Bay. The Maple Avenue trunk storm sewer can convey approximately 14 m<sup>3</sup>/s. In combination, the Maple Avenue and existing Bayfield Street trunk storm sewers have capacity to convey approximately 41 m<sup>3</sup>/s (1:25 year design storm capacity). To increase the capacity of the system and reduce flooding, the existing Bayfield Street trunk storm sewer can be replaced with an 1800 mm x 3600 mm concrete box culvert with a capacity of approximately 35.5 m<sup>3</sup>/s increasing the combined capacity to 49.5 m<sup>3</sup>/s (5.4 m<sup>3</sup>/s less than the 1:100 year design storm peak flow).

Similar to Alternatives 4A and 4B, Improvement Alternative 4C was analysed considering implementation of Alternative 2A and the resultant flow reduction. The analysis demonstrated that the trunk storm sewer on Sophia Street and Clapperton Street may be reduced in size to a 1500 mm x 3000 mm concrete box culvert. The existing trunk storm sewer on Bayfield Street may be replaced with an 1800 mm x 3600 mm concrete box culvert. Under this option, the trunk storm sewer will have a conveyance capacity of 35.5 m<sup>3</sup>/s, 3.0 m<sup>3</sup>/s less than the 1:100 year design storm peak flow.

Alternatively, the Maple Avenue trunk storm sewer may be constructed supplementing the existing Bayfield Street trunk storm sewer. Under this option, the trunk storm sewer will have a conveyance capacity of 41 m<sup>3</sup>/s which is greater than the predicted 1:100 year design storm peak flow.

The detailed model results are included in Appendix K for reference.

Preliminary Construction cost estimates have been prepared for Alternative 4C and the implementation of Alternative 2A and 4C in combination. The preliminary construction cost estimates are included in Appendix C and summarized in the following table:

**Table 24: Preliminary Construction Cost Estimate – Alternative 4C**

Alternative	Preliminary Construction Cost Estimate
Alternative 4C	\$21,757,159
Alternative 4C (with 2A implemented)	\$14,258,099
Difference	\$7,499,060

It is noted that the trunk storm sewer may be constructed in the existing road allowance and property acquisition is not required.

#### **7.4.4 Alternative 4D – Dunlop Street Trunk Storm Sewer and Major Drainage System Improvements**

The existing condition PCSWMM hydraulic model of the Sophia Creek trunk storm sewer downstream of Peel Street was also revised to determine the required Dunlop Street trunk storm sewer size to convey the major system flows downstream to Kempenfelt Bay.

For this alternative, the required trunk storm sewer sizes between Peel Street and Dunlop Street remain the same as Alternative 4A. Twin 1800 mm x 2400 mm concrete box culverts installed on Dunlop Street and Mulcaster Street can convey approximately 31.0 m<sup>3</sup>/s. In combination with the existing Sophia Street trunk storm sewer, the total capacity of the system is approximately 44.0 m<sup>3</sup>/s. As such, the trunk storm sewer would have a capacity to convey the peak flow generated by the 1:50 year design storm (10.9 m<sup>3</sup>/s less than the 1:100 year design storm peak flow). As per Alternative 4A, replacing the existing Sophia Street trunk storm sewer between Peel Street and Clapperton Street will increase the capacity of the drainage system to 49 m<sup>3</sup>/s, (5.9 m<sup>3</sup>/s less than the 1:100 year design storm peak flow).

Similar to Improvement Alternatives 4A through 4C, Alternative 4D was analysed considering the implementation of Improvement Alternative 2A and the resultant flow reduction. The analysis demonstrated that the trunk storm sewer on Dunlop Street and Mulcaster Street may be reduced in size to a 1800 mm x 3000 mm concrete box culvert and provide sufficient capacity to convey the 1:100 year design storm peak flow.

The detailed model results are included in Appendix M for reference.

Preliminary Construction cost estimates have been prepared for Alternative 4D and the implementation of Improvement Alternative 2A and 4D in combination. The preliminary construction cost estimates are included in Appendix C and summarized in the following table:

**Table 25: Preliminary Construction Cost Estimate – Alternative 4D**

Alternative	Preliminary Construction Cost Estimate
Alternative 4D	\$21,283,399
Alternative 4D (with 2A implemented)	\$18,418,348
Difference	\$2,865,051

It is noted, the trunk storm sewer may be constructed in the existing road allowance and property acquisition is not required.

## **7.5 Summary of Improvement Alternatives Assessment**

In summary, this assessment demonstrates that the proposed improvement alternatives benefit the study area to varying degrees. Each alternative reduces flooding through portions of the study area and provide additional benefits to the environment. However, a single alternative does not address all of the drainage issues across the study area.

The flow reduction/water quality improvements alternatives (2A/2B) will reduce the extent and frequency of flooding downstream. Under these alternatives, flooding will persist during major storm events and the level of service provided by the downstream storm infrastructure will not satisfy City design standards.

The conveyance capacity improvements upstream of Peel Street reduce the extent and frequency of flooding along Sophia Creek through this reach. Improvement Alternatives 3A and 3B will not only reduce flooding, they satisfy the previous recommendations of the MDP and the City's design flood frequency criteria, respectively. However, these alternatives do not impact or reduce flooding through the downtown core. As such, flooding will continue to occur during minor and major storm events downstream of Peel Street.

Similarly, the conveyance capacity improvements downstream of Peel Street reduce the extent and frequency of flooding through the downtown core. However, these alternatives do not improve flooding along Sophia Creek upstream of Peel Street.

Based on this assessment, a combination of improvement alternatives is likely required to address the drainage issues across the study area. Conveyance capacity improvements up and downstream of Peel Street are required to address the flooding concerns. These alternatives may be paired with the flood reduction/water quality improvements to provide additional environmental benefits at reduced costs. The combination of improvement alternatives that produce the greatest benefit to the environment while addressing the identified problem statement will be selected as the preferred alternative solution moving forward.

A summary of the easement/property acquisition and estimated construction costs for the various improvement alternatives is provided in the following tables:

**Table 26: Cost Estimate Summary – Alternatives 1 through 4D**

Improvement Alternative	Construction Cost	Property/Easement Acquisition Cost	Total Cost
1	0	\$86,312,750	\$86,312,750
2A	\$3,566,238	\$867,000	\$4,433,238
2B	\$628,000	\$0	\$628,000
3A	\$17,419,597	\$3,382,000	\$20,801,597
3B	\$24,797,058	\$3,382,000	\$28,179,058
4A	\$18,010,278	\$0	\$18,010,278
4B	\$29,952,473	\$764,400	\$30,716,873
4C	\$21,757,159	\$0	\$21,757,159
4D	\$21,283,399	\$0	\$21,283,399

Note: Property Value – Assessed Value (MPAC)

**Table 27: Cost Estimate Summary – Alternatives Implemented in Combination with 2A**

Improvement Alternative	Construction Cost	Property/Easement Acquisition Cost	Total Cost – Alternative 2A	Total Cost
3A	\$17,419,597	\$3,382,000	\$4,433,238	\$25,234,835
3B	\$10,815,896	\$3,165,000	\$4,433,238	\$18,414,134
4A	\$17,166,916	\$0	\$4,433,238	\$21,600,154
4B	\$21,492,773	\$764,400	\$4,433,238	\$26,690,411
4C	\$14,258,099	\$0	\$4,433,238	\$18,691,337
4D	\$18,418,348	\$0	\$4,433,238	\$22,851,586

Note: The construction costs and property acquisition costs for Alternative 3A do not decrease with the implementation of alternative 3A, however, the level of service provided improves; Property Value – Assessed Value (MPAC)

## 8 Alternatives Evaluation

The improvement alternatives developed in Section 6 have been evaluated with respect to their impact on the physical, natural, social, cultural and economic environments presented in Section 3.

The evaluation of the improvement alternatives as previously described is descriptive or qualitative in nature allowing for a comparative evaluation of the pros and cons associated with each alternative. The evaluation is focussed on the ability of the alternatives to adequately address the problem statement, and in doing so, provide a solution that is consistent with the requirements of the governing policies. The evaluation of each improvement alternative is provided in the following tables.

Table 27: Assessment of Improvement Alternatives – Flow Reduction / Water Quality Improvement Alternatives

Evaluation Criteria	How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 2A: Retrofit/New Stormwater Management Facilities (SWMF)		Design Alternative 2B: Low Impact Development (LID)		
Physical Environment	Impact on Existing Private Property	Increase/Decrease in the extent and frequency of private property flooding		Continued flooding of private property during minor and major storm events along Sophia Creek and through the downtown core		Reduction of peak flows downstream of SWMF's during minor and major storm events resulting in a decrease in private property flooding, however, flooding will still occur		Reduction of minor storm peak flows resulting in the reduction of frequent nuisance flooding. Insignificant reduction in major system peak flows and flooding
	Impact on Existing Storm Sewer System	Increase/Decrease of flow to local and trunk storm sewer throughout the study area		Aging/deteriorating storm infrastructure deficient throughout study area. Areas absent of any minor drainage system		Reduction in peak flow to the Sophia Street/Bayfield Street trunk storm sewer through downtown core, however, no impact on local storm sewers		Reduction of flows to local and trunk storm sewer during minor storm events, however no significant reduction of flows during major storm events
	Impact on Existing Sanitary Sewer System	Severity/Number of conflicts with existing sanitary sewer/services Increase/Decrease in stormwater inflow to sanitary sewer		No conflicts with the existing sanitary sewer system/services Continued inflow of stormwater to sanitary sewer system during minor and major storm events		No conflicts with the existing sanitary sewer system or services Reduction of stormwater inflow to sanitary sewer during minor and major storm events		No conflicts between LID's in road allowance and sanitary sewer system of services Reduction of stormwater inflow to sanitary sewer during minor storm events
	Impact on Existing Water Main	Severity/Number of conflicts with existing water main/services		No conflicts with the existing water mains/services		No impact on existing water mains or services		Potential conflicts between LID's in road allowance and water services
	Impact on Existing Utilities	Severity/Number of conflicts with existing underground utilities		No impact on existing utilities		No impact on existing utilities		Potential conflicts between LID's in road allowance and utilities
	Impact on Existing Transportation System	Increase/Decrease in the extent and frequency of flooding within the road allowance Severity of the disturbance to the transit system during construction		Continued flooding of existing transportation system during minor and major storms No disturbance to existing transits system as no construction is involved in this alternative		Decrease in flooding of existing transportation system along Sophia Creek and through downtown core; temporary disturbance to local roadway during construction		Minor decrease in frequent nuisance flooding in localized areas, however no reduction during major storms; temporary disturbance to roadways to implement LID's during road reconstruction
	Impact on Existing Flood Lines	Increase/Decrease in flood level along Sophia Creek and through the downtown core		No impact on flood levels in study area		Decrease in flood levels and extent of floodplain along Sophia Creek and through downtown core due to decrease flows		No significant decrease in flows during major storm events resulting in no significant decrease in flood levels in the study area
	Impact on Parklands	Loss/Gain of parkland and/or green space		No impact on parkland or green space		Loss of baseball diamond in MacMorrison Park for SWMF construction, SWMF will remain passive parkland for public use		Minor loss/disturbance to parkland, however surface use will generally be maintained
Natural Environment	Impact on Existing Vegetation	Loss/Gain of vegetation (trees, shrubs, etc.) designated endangered, threatened or special concern Enhancement/Diminishment of native species		No impact on existing vegetation		Minor loss of vegetation (grasses) through SWMF retrofit/construction Opportunity to enhance native plantings		Minor loss of vegetation in parkland and boulevards during construction of LID measures Opportunity to enhance native plantings
	Impact on Fisheries within Creek	Alteration, disruption and/or destruction of fish habitat and aquatic features in Sophia Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek
	Impact on Terrestrial Wildlife	Loss/Gain of wildlife habitat throughout the study area		No impact to wildlife habitat in the study area		Opportunity to enhanced wildlife habitat in SWMF SP03 and SP01		No impacts to wildlife in the study area
	Impact on Existing Water Quality	Improvement/Diminishment of storm water runoff quality		Continued diminishment of the stormwater quality throughout the watershed		Improvement in water quality for SWMF SP03 and SWMF SP01 drainage areas; no improvement in water quality downstream of SWMF's		Improvement of water quality throughout the watershed north of Peel Street during minor storm events

Evaluation Criteria		How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 2A: Retrofit/New Stormwater Management Facilities (SWMF)		Design Alternative 2B: Low Impact Development (LID)	
Social Environment	Impact on Property Value	Increase/Decrease in property values due to the extent and frequency of flooding Presence of municipal infrastructure on private property		Decrease in property value due to continued flooding during minor/major storm events Municipal Infrastructure to remain on private property		Increase in property values downstream of SWMF's SP03 and SP01 along Sophia Creek and through downtown core due to reduced flooding; Alternative does not remove municipal infrastructure from private property		Increase in property values north or Peel Street due to reduce frequent nuisance flooding during minor storm events, Alternative does not remove municipal infrastructure from private property
	Impact on Public Safety	Increase/Decrease in potential public safety hazards due to flooding and erosion		Potential public safety concerns remain due to continued flooding and erosion during minor/major storms		Decrease in potential public safety hazards due to reduction flows, flooding and erosion during minor/major storm events		Decrease in potential public safety hazards due to reduction of frequent nuisance flooding during minor storm events
Cultural Heritage	Archeological and Heritage Impacts	Potential contribution to the removal of archeological resources		No archaeological or heritage impacts		Potential contribution to the removal of archaeological resources in MacMorrison Park and 364 St. Vincent Street through SWMF retrofit/construction		Potential contribution to the removal of archaeological resources in parkland
Economic Environment	Impact on Drainage System Maintenance Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance to municipal drainage systems Improvement/diminishment of access to drainage infrastructure		Increase in drainage system maintenance costs due to aging/deteriorating storm infrastructure and continued flooding/erosion No improvement to access to the existing drainage infrastructure		Reduction in peak flows and flooding along with an improvement in water quality will decrease maintenance requirements No impact on access to existing drainage infrastructure		Reduction if frequent nuisance flooding and improvement in water quality will reduce maintenance requirements No impact on access to existing drainage infrastructure
	Impact on Property Acquisition Costs	Property and easement acquisition costs		\$86,312,750		\$867,000		\$0
	Impact on Construction Costs	Preliminary estimated construction costs		\$0		\$3,566,238		\$628,000
	Impact on Private Property Maintenance Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance on private property		Increase in private property maintenance costs due to aging/deteriorating storm infrastructure and continued flooding		Reduction in peak flows and flooding along with an improvement in water quality will decrease maintenance requirements		Reduction if frequent nuisance flooding and improvement in water quality will reduce maintenance requirements

Legend

Negative				Neutral Impact	Positive			
Greatest			Least		Least			Greatest

Table 28: Assessment of Improvement Alternatives – Conveyance Improvements (Upstream of Peel Street)

Evaluation Criteria		How Criteria is Being Assessed		Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 3A: Culvert/Watercourse/Major Storm Sewer Improvements to Convey the 1:25 Year		Design Alternative 3B: Culvert/Watercourse/Major Storm Sewer Improvements to Convey the 1:50 and 1:100	
Physical Environment	Impact on Existing Private Property	Increase/Decrease in the extent and frequency of private property flooding		Continued flooding of private property during minor and major storm events along Sophia Creek and through the downtown core		Reduction in the extent and frequency of flooding on private property during storms up to and including the 25 year storm event upstream of Peel Street		Reduction in the extent and frequency of flooding on private property during storms up to and including the 50 year storm event upstream of Peel Street	
	Impact on Existing Storm Sewer System	Increase/Decrease of flow to local and trunk storm sewer throughout the study area		Aging/deteriorating storm infrastructure deficient throughout study area. Areas absent of any minor drainage system		No impact on flow to local and trunk storm sewer		No impact on flow to local and trunk storm sewer	
	Impact on Existing Sanitary Sewer System	Severity/Number of conflicts with existing sanitary sewer/services		No conflicts with the existing sanitary sewer system/services Continued inflow of stormwater to sanitary sewer system during minor and major storm events		No conflicts with the existing sanitary sewer system Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events (up to the 25 year storm)		No conflicts with the existing sanitary sewer system Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events (up to the 50 year storm)	
	Impact on Existing Water Main	Severity/Number of conflicts with existing water main/services		No conflicts with the existing water mains/services		Conflict with the existing water main requiring the water main to be lowered at multiple road crossings		Conflict with the existing water main requiring the water main to be lowered at multiple road crossings	
	Impact on Existing Utilities	Severity/Number of conflicts with existing underground utilities		No impact on existing utilities		Conflict with the existing utilities requiring the utilities to be relocated at multiple road crossings		Conflict with the existing utilities requiring the utilities to be relocated at multiple road crossings	
	Impact on Existing Transportation System	Increase/Decrease in the extent and frequency of flooding within the road allowance Severity of the disturbance to the transit system during construction		Continued flooding of existing transportation system during minor and major storms No disturbance to existing transits system as no construction is involved in this alternative		Decrease in the extent and frequency of flooding within the road allowance during storms up to the 25 year storm; temporary disturbance to the transit system at each road crossing during construction		Decrease in the extent and frequency of flooding within the road allowance during storms up to the 50 year storm; temporary disturbance to the transit system at each road crossing during construction	
	Impact on Existing Flood Lines	Increase/Decrease in flood level along Sophia Creek and through the downtown core		No impact on flood levels in study area		Decrease in flood levels along Sophia Creek (upstream of Peel Street) during minor and major storm events up to the 25 year storm		Decrease in flood levels along Sophia Creek (upstream of Peel Street) during minor and major storm events up to the 50 year storm	
	Impact on Parklands	Loss/Gain of parkland and/or green space		No impact on parkland or green space		No loss/gain of parkland and/or green space or use thereof		No loss/gain of parkland and/or green space or use thereof	
Natural Environment	Impact on Existing Vegetation	Loss/Gain of vegetation (trees, shrubs, etc.) designated endangered, threatened or special concern Enhancement/Diminishment of native species		No impact on existing vegetation		Minor loss of vegetation along Sophia Creek; opportunity to enhance native species along improved channel sections		Minor loss of vegetation along Sophia Creek; opportunity to enhance native species along improved channel sections	
	Impact on Fisheries within Creek	Alteration, disruption and/or destruction of fish habitat and aquatic features in Sophia Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek	
	Impact on Terrestrial Wildlife	Loss/Gain of wildlife habitat throughout the study area		No impact to wildlife habitat in the study area		Opportunity to enhanced wildlife habitat along improved channel sections		Opportunity to enhanced wildlife habitat along improved channel sections	
	Impact on Existing Water Quality	Improvement/Diminishment of storm water runoff quality		Continued diminishment of the stormwater quality throughout the watershed		Daylighting watercourse will provide minor improvement to storm water quality		Daylighting watercourse will provide minor improvement to storm water quality	

Evaluation Criteria		How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)	Design Alternative 3A: Culvert/Watercourse/Major Storm Sewer Improvements to Convey the 1:25 Year	Design Alternative 3B: Culvert/Watercourse/Major Storm Sewer Improvements to Convey the 1:50 and 1:100
Social Environment	Impact on Property Value	Increase/Decrease in property values due to the extent and frequency of flooding Presence of municipal infrastructure on private property	Decrease in property value due to continued flooding during minor/major storm events Municipal Infrastructure to remain on private property	Increase in property values along Sophia Creek (upstream of Peel Street) due to reduced flooding during minor and major storms up to the 25 year storm	Increase in property values along Sophia Creek (upstream of Peel Street) due to reduced flooding during minor and major storms up to the 50 year storm
	Impact on Public Safety	Increase/Decrease in potential public safety hazards due to flooding and erosion	Potential public safety concerns remain due to continued flooding and erosion during minor/major storms	Decrease in potential public safety hazards upstream of Peel Street due to reduced flooding and erosion during minor and major storms up to the 25 year storm	Decrease in potential public safety hazards upstream of Peel Street due to reduced flooding and erosion during minor and major storms up to the 50 year storm
Cultural Heritage	Archeological and Heritage Impacts	Potential contribution to the removal of archeological resources	No archaeological or heritage impacts	No archaeological or heritage impacts	No archaeological or heritage impacts
Economic Environment	Impact on Drainage System Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance to municipal drainage systems Improvement/Diminishment of access to drainage infrastructure	Increase in drainage system maintenance costs due to aging/deteriorating storm infrastructure and continued flooding/erosion No improvement to access to the existing drainage infrastructure	Reduction in flooding along will decrease maintenance requirements Improved access to existing drainage infrastructure	Reduction in flooding along will decrease maintenance requirements Improved access to existing drainage infrastructure
	Impact on Property Acquisition Costs	Property and easement acquisition costs	\$86,312,750	\$3,382,000	\$3,382,000
	Impact on Construction Costs	Preliminary estimated construction costs	\$0	\$17,419,597	\$24,797,058
	Impact on Private Property Maintenance Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance on private property	Increase in private property maintenance costs due to aging/deteriorating storm infrastructure and continued flooding	Reduction in flooding will decrease private property maintenance requirements	Reduction in flooding will decrease private property maintenance requirements

Legend

Negative				Neutral Impact	Positive			
Greatest			Least		Least			Greatest

Table 29: Assessment of Improvement Alternatives – Conveyance Improvements (Downstream of Peel Street)

Evaluation Criteria	How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 4A: Owen Street Trunk Storm Sewer and Other Major Drainage Improvements		Design Alternative 4B: Mulcaster Street Trunk Storm Sewer and Other Major Drainage Improvements	
Physical Environment	Impact on Existing Private Property		Continued flooding of private property during minor and major storm events along Sophia Creek and through the downtown core		Reduction of the extent and frequency of flooding of private property downstream of Peel street through the downtown core		Reduction of the extent and frequency of flooding of private property downstream of Peel street through the downtown core
	Impact on Existing Storm Sewer System		Aging/deteriorating storm infrastructure deficient throughout study area. Areas absent of any minor drainage system		No impact on flow to local and trunk storm sewer		No impact on flow to local and trunk storm sewer
	Impact on Existing Sanitary Sewer System		No conflicts with the existing sanitary sewer system/services Continued inflow of stormwater to sanitary sewer system during minor and major storm events		Sanitary sewer on Sophia Street will have to be relocated Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events		No conflicts with the existing sanitary sewer system Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events
	Impact on Existing Water Main		No conflicts with the existing water mains/services		Conflict with the existing water main requiring the water main to be lowered at multiple locations		Conflict with the existing water main requiring the water main to be lowered at multiple locations
	Impact on Existing Utilities		No impact on existing utilities		Conflict with the existing utilities requiring the utilities to be relocated at multiple locations		Conflict with the existing utilities requiring the utilities to be relocated at multiple locations
	Impact on Existing Transportation System		Continued flooding of existing transportation system during minor and major storms No disturbance to existing transits system as no construction is involved in this alternative		Decrease ion the extent and frequency of flooding in road allowance through downtown core during minor and major storm events; significant temporary disturbance to transit system during construction (local, collector and arterial roads)		Decrease ion the extent and frequency of flooding in road allowance through downtown core during minor and major storm events; significant temporary disturbance to transit system during construction (local, collector and arterial roads)
	Impact on Existing Flood Lines		No impact on flood levels in study area		Decrease in flood levels during minor and major storm events through downtown core		Decrease in flood levels during minor and major storm events through downtown core
	Impact on Parklands		No impact on parkland or green space		No loss/gain of parkland or green space		No loss/gain of parkland or green space No disturbance to parkland or use thereof
Natural Environment	Impact on Existing Vegetation		No impact on existing vegetation		No impact on existing vegetation in the study area; no opportunity to enhance native plantings		No impact on existing vegetation in the study area; no opportunity to enhance native plantings
	Impact on Fisheries within Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek
	Impact on Terrestrial Wildlife		No impact to wildlife habitat in the study area		No impact to wildlife habitat downstream of Peel Street		No impact to wildlife habitat downstream of Peel Street
	Impact on Existing Water Quality		Continued diminishment of the stormwater quality throughout the watershed		No impact on stormwater quality		No impact on stormwater quality

Evaluation Criteria		How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 4A: Owen Street Trunk Storm Sewer and Other Major Drainage Improvements		Design Alternative 4B: Mulcaster Street Trunk Storm Sewer and Other Major Drainage Improvements	
Social Environment	Impact on Property Value	Increase/Decrease in property values due to the extent and frequency of flooding Presence of municipal infrastructure on private property		Decrease in property value due to continued flooding during minor/major storm events Municipal Infrastructure to remain on private property		Increase in property values downstream of Peel Street due to reduced flooding during minor and major storms		Increase in property values downstream of Peel Street due to reduced flooding during minor and major storms
	Impact on Public Safety	Increase/Decrease in potential public safety hazards due to flooding and erosion		Potential public safety concerns remain due to continued flooding and erosion during minor/major storms		Decrease in potential public safety hazards downstream of Peel Street due to reduced flooding during minor and major storms		Decrease in potential public safety hazards downstream of Peel Street due to reduced flooding during minor and major storms
Cultural Heritage	Archeological and Heritage Impacts	Potential contribution to the removal of archeological resources		No archaeological or heritage impacts		Potential contribution to the removal of deep archaeological resources through historic Town of Barrie		Potential contribution to the removal of deep archaeological resources through historic Town of Barrie
Economic Environment	Impact on Drainage System Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance to municipal drainage systems Improvement/Diminishment of access to drainage infrastructure		Increase in drainage system maintenance costs due to aging/deteriorating storm infrastructure and continued flooding/erosion No improvement to access to the existing drainage infrastructure		Reduction in flooding will reduce drainage system maintenance requirements through downtown core		Reduction in flooding will reduce drainage system maintenance requirements through downtown core
	Impact on Property Acquisition Costs	Property and easement acquisition costs		\$86,312,750		\$0		\$764,400
	Impact on Construction Costs	Preliminary estimated construction costs		\$0		\$18,010,278		\$29,952,473
	Impact on Private Property Maintenance Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance on private property		Increase in private property maintenance costs due to aging/deteriorating storm infrastructure and continued flooding		Reduction in flooding will reduce private property maintenance requirements through downtown core		Reduction in flooding will reduce private property maintenance requirements through downtown core

Legend

Negative				Neutral Impact	Positive			
Greatest			Least		Least			Greatest

Table 30: Assessment of Improvement Alternatives – Conveyance Improvements (Downstream of Peel Street)

Evaluation Criteria	How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)		Design Alternative 4C: Clapperton Street Trunk Storm Sewer and Other Major Drainage Improvements		Design Alternative 4D: Dunlop Street Trunk Storm Sewer and Other Major Drainage Improvements		
Physical Environment	Impact on Existing Private Property	Increase/Decrease in the extent and frequency of private property flooding		Continued flooding of private property during minor and major storm events along Sophia Creek and through the downtown core		Reduction of the extent and frequency of flooding of private property downstream of Peel street through the downtown core		Reduction of the extent and frequency of flooding of private property downstream of Peel street through the downtown core
	Impact on Existing Storm Sewer System	Increase/Decrease of flow to local and trunk storm sewer throughout the study area		Aging/deteriorating storm infrastructure deficient throughout study area. Areas absent of any minor drainage system		No impact on flow to local and trunk storm sewer		No impact on flow to local and trunk storm sewer
	Impact on Existing Sanitary Sewer System	Severity/Number of conflicts with existing sanitary sewer/services		No conflicts with the existing sanitary sewer system/services Continued inflow of stormwater to sanitary sewer system during minor and major storm events		Sanitary sewer on Sophia Street will have to be relocated Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events		Sanitary sewer on Sophia Street will have to be relocated Reduction in stormwater inflow into the sanitary sewer system during minor and major storm events
	Impact on Existing Water Main	Severity/Number of conflicts with existing water main/services		No conflicts with the existing water mains/services		Conflict with the existing water main requiring the water main to be lowered at multiple locations		Conflict with the existing water main requiring the water main to be lowered at multiple locations
	Impact on Existing Utilities	Severity/Number of conflicts with existing underground utilities		No impact on existing utilities		Conflict with the existing utilities requiring the utilities to be relocated at multiple locations		Conflict with the existing utilities requiring the utilities to be relocated at multiple locations
	Impact on Existing Transportation System	Increase/Decrease in the extent and frequency of flooding within the road allowance Severity of the disturbance to the transit system during construction		Continued flooding of existing transportation system during minor and major storms No disturbance to existing transits system as no construction is involved in this alternative		Decrease in the extent and frequency of flooding in road allowance through downtown core during minor and major storm events; significant temporary disturbance to transit system during construction (local, collector and arterial roads)		Decrease in the extent and frequency of flooding in road allowance through downtown core during minor and major storm events; significant temporary disturbance to transit system during construction (local, collector and arterial roads)
	Impact on Existing Flood Lines	Increase/Decrease in flood level along Sophia Creek and through the downtown core		No impact on flood levels in study area		Decrease in flood levels during minor and major storm events through downtown core		Decrease in flood levels during minor and major storm events through downtown core
	Impact on Parklands	Loss/Gain of parkland and/or green space		No impact on parkland or green space		No loss/gain of parkland or green space No disturbance to parkland or use thereof		No loss/gain of parkland or green space No disturbance to parkland or use thereof
Natural Environment	Impact on Existing Vegetation	Loss/Gain of vegetation (trees, shrubs, etc.) designated endangered, threatened or special concern Enhancement/Diminishment of native species		No impact on existing vegetation		No impact on existing vegetation in the study area; no opportunity to enhance native plantings		No impact on existing vegetation in the study area; no opportunity to enhance native plantings
	Impact on Fisheries within Creek	Alteration, disruption and/or destruction of fish habitat and aquatic features in Sophia Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek		No fisheries or fish habitat identified within Sophia Creek, as such no impact on fisheries within the Creek
	Impact on Terrestrial Wildlife	Loss/Gain of wildlife habitat throughout the study area		No impact to wildlife habitat in the study area		No impact to wildlife habitat downstream of Peel Street		No impact to wildlife habitat downstream of Peel Street
	Impact on Existing Water Quality	Improvement/Diminishment of storm water runoff quality		Continued diminishment of the stormwater quality throughout the watershed		No impact on stormwater quality		No impact on stormwater quality

Evaluation Criteria		How Criteria is Being Assessed	Design Alternative 1: "Do Nothing" (Existing Conditions)	Design Alternative 4C: Clapperton Street Trunk Storm Sewer and Other Major Drainage Improvements	Design Alternative 4D: Dunlop Street Trunk Storm Sewer and Other Major Drainage Improvements
Social Environment	Impact on Property Value	Increase/Decrease in property values due to the extent and frequency of flooding Presence of municipal infrastructure on private property	Decrease in property value due to continued flooding during minor/major storm events Municipal Infrastructure to remain on private property	Increase in property values downstream of Peel Street due to reduced flooding during minor and major storms	Increase in property values downstream of Peel Street due to reduced flooding during minor and major storms
	Impact on Public Safety	Increase/Decrease in potential public safety hazards due to flooding and erosion	Potential public safety concerns remain due to continued flooding and erosion during minor/major storms	Decrease in potential public safety hazards downstream of Peel Street due to reduced flooding during minor and major storms	Decrease in potential public safety hazards downstream of Peel Street due to reduced flooding during minor and major storms
Cultural Heritage	Archeological and Heritage Impacts	Potential contribution to the removal of archeological resources	No archaeological or heritage impacts	Potential contribution to the removal of deep archaeological resources through historic Town of Barrie	Potential contribution to the removal of deep archaeological resources through historic Town of Barrie
Economic Environment	Impact on Drainage System Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance to municipal drainage systems Improvement/Diminishment of access to drainage infrastructure	Increase in drainage system maintenance costs due to aging/deteriorating storm infrastructure and continued flooding/erosion No improvement to access to the existing drainage infrastructure	Reduction in flooding will reduce drainage system maintenance requirements through downtown core	Reduction in flooding will reduce drainage system maintenance requirements through downtown core
	Impact on Property Acquisition Costs	Property and easement acquisition costs	\$86,312,750	\$0	\$0
	Impact on Construction Costs	Preliminary estimated construction costs	\$0	\$21,757,159	\$21,283,399
	Impact on Private Property Maintenance Costs	Increase/Decrease in maintenance required to clear obstructions, repair erosion, remove accumulated sediment, and perform routine maintenance on private property	Increase in private property maintenance costs due to aging/deteriorating storm infrastructure and continued flooding	Reduction in flooding will reduce private property maintenance requirements through downtown core	Reduction in flooding will reduce private property maintenance requirements through downtown core

Legend

Negative				Neutral Impact	Positive			
Greatest			Least		Least			Greatest

## 9 Public Consultation

For the Sophia Creek and Mulcaster Drainage Area Municipal Class EA Update, Public consultation was completed in accordance with the Schedule 'B' Municipal Class Environmental Assessment process outlined in the Municipal Engineers Association (MEA) Municipal Class Environmental Assessment Document (October 2000, as amended in 2007, 2011 and 2015). The public consultation undertaken for this study is outlined in the following sections.

### 9.1 Notice of Study Commencement and Public Information Centre

A Public Information Centre (PIC) was held Wednesday, October 26, 2016 at City Hall to present the alternative design solutions to the identified drainage issues in the study area. At the PIC, local residents, business owners and interested stakeholders were presented the various alternative design solutions and encouraged to provide input / feedback regarding the study. Comment sheets were provided and attendees were encouraged to identify their preferences regarding the alternative design solutions. The PIC presentation materials are enclosed in Appendix M for reference.

Prior to the PIC, a Draft Environmental Assessment document was prepared for agency circulation and was made available for public review at the Barrie Public Library (Downtown and Painswick Branch), City of Barrie Clerk's Office and City of Barrie Engineering. The document was also made accessible via the City's webpage. Also, a notification letter was distributed October 10, 2016 to local residents and stakeholders presenting the alternative drainage solutions and notifying them of the PIC. The notification included a copy of the PIC comment sheet to provide everyone with an opportunity to provide input / comments regarding the study. The notification letter is enclosed in Appendix M for reference.

### 9.2 Results of Public Consultation

The Public Information Centre (PIC) was attended by thirteen (13) interested stakeholders, eleven (11) of which provided written comment. Of the eleven, four (4) identified a preferred alternative solution(s). In addition to the interested stakeholders who attended the PIC, written comments were received from the following parties/agencies:

- Bereton Field Naturalists Club;
- Infrastructure Ontario;
- Ministry of Tourism, Culture and Sport;
- Ministry of Infrastructure;
- Lake Simcoe Region Conservation Authority;

- Hiawatha First Nations; and
- Chippewa's of Rama First Nations.

The Lake Simcoe Region Conservation Authority identified a preferred alternative solution as part of their written comments.

A copy of the PIC attendance sheet as well as the comments received are available in Appendix N for reference. Also, a summary of the comments received is provided in Appendix N for reference.

### 9.3 Public Preference

The majority of public and agency response preferred a combination of alternative drainage solutions to address the identified drainage issues. Implementing the flow reduction / water quality improvement options (Alternatives 2A and 2B) in combination with the culvert/channel/major drainage system improvements upstream of Peel Street that satisfy the City's design flood frequency criteria (Alternative 3B) and one of either the Owen Street or Clapperton Street trunk storm sewer alternatives (alternatives 4A and 4C) are the public preference.

A summary of the public and agency preferred alternative drainage solution(s) is included in the following table:

**Table 31: Public/Agency Preferred Alternative Solution Summary**

Respondent	Preferred Alternative Solution(s)
Respondent 1	Combination of Alternatives 2A, 2B, 3B and 4C or 4D
Respondent 2	Combination of Alternative 2A, 3B and 4A
Respondent 3	Alternative 2A
Respondent 4	Combination of Alternative 2A, 3B, 4A
Lake Simcoe Region Conservation Authority	Combination of Alternative 2A, 2B, 3B and 4A

## 10 Selection of the Preferred Alternative Solution

Following a comprehensive review of the alternatives, receipt of all comments from the interested stakeholders and agencies, and completion of the improvement alternatives evaluation the preferred alternative solution has been selected. The preferred alternative solution is outlined in the following sections.

### 10.1 General Recommendations

As a general requirement for all capital projects, it is recommended that consideration of upsizing the local storm sewers to satisfy current design standards be considered as part of future road reconstruction projects. The minor drainage system deficiencies are illustrated on Figure 3 – Minor Drainage System Deficiencies provided in Section 4 of this report.

Similarly, relocating storm sewer to the municipal road allowance should also be considered. The relocation of the trunk storm sewer under residential and commercial properties on Sophia Street West was previously recommended as part of the Sophia Creek West Branch – Drainage and Infrastructure Improvements Municipal Class Environmental Assessment. This trunk storm sewer should be relocated as part of the reconstruction of Sophia Creek West in the future.

It is also recommended that consideration be given to service the Marion Crescent/Pratt Road and Agnes Street areas with storm sewer as part of future road reconstruction projects. Consideration should be given to also service the streets absent of a minor drainage system throughout the study area. The areas/streets absent of minor drainage systems are illustrated on Figure 3 – Minor Drainage System Deficiencies provided in Section 4 of this report.

It is recommended that the Owen Street flow diversion be implemented in the future when Owen Street is reconstructed. Specifically, divert the minor drainage system at the intersection of Owen Street and Wellington Street south on Owen Street to Sophia Street. This flow diversion will reduce the overland flow and flooding through the private properties bound by Wellington Street, Owen Street, Sophia Street, and Clapperton Street.

For this study, the major overland deficiencies have been evaluated using the dual drainage system in PCSWMM and standardized road cross-sections between storm structures. The cross-sections do not necessarily mimic existing conditions, however, they do provide an estimate of the overland flow depths and velocities along the roadway during major storm events. As such, it is recommended that solutions to address the major overland deficiencies be evaluated as part of future road reconstruction projects and improvements be made where feasible.

A number of the deficiencies will be addressed through the implementation of the preferred alternative solution. For those that remain outstanding, consideration should be given to oversizing the storm sewer

and/or adjusting the road profile/cross-section as part of road reconstruction projects. A list of the major overland deficiencies is provided in Appendix O for reference. The list includes the overland flow depths and velocities and identifies the exceedance in the safe access/egress criteria used to identify major overland flow route deficiencies.

## **10.2 Flow Reduction / Water Quality Improvements**

### **10.2.1 Alternative 2A – Retrofit/New Stormwater Management Facilities (SWMF)**

Retrofit and expand the existing Ottaway Avenue/Currie Street SWMF (SWMF SP03) and to convert MacMorrison Park into a SWM detention facility. Purchase additional private property to the immediate north (364 St. Vincent Street) of existing SWMF SP03, increase the active storage volume provided by the detention pond and retrofit the existing outlet controls to reduce peak flows downstream. Convert MacMorrison Park into a SWM detention facility (previously designated SWMF SP01). Approximately 30,000 m<sup>3</sup> of active storage may be created within the parks footprint. Adding the active storage volume in combination with improvements to the Bothwell Street culvert crossing will attenuate peak flows downstream along Sophia Creek to Kempenfelt Bay.

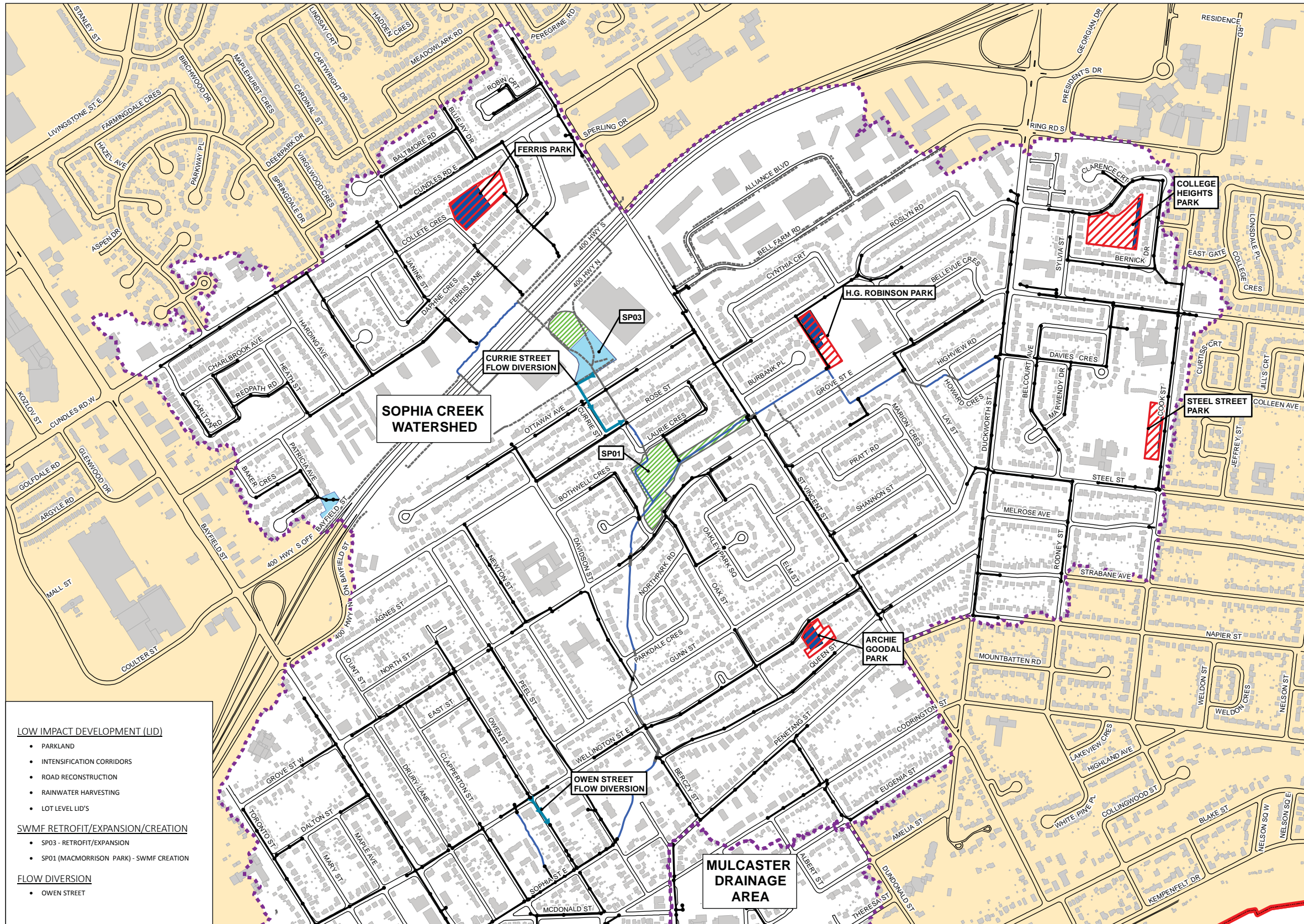
### **10.2.2 Alternative 2B – Low Impact Development (LID's)**

Implement Low Impact Development LID's throughout the watershed to attenuate peak flows, promote infiltration, and improve the water balance and watershed water quality. Construct LID's as part of road reconstruction projects, as part of intensification and within existing parkland. Bioretention, perforated pipe systems, permeable pavement and rainwater harvesting have been identified as LID's suitable for the study area.

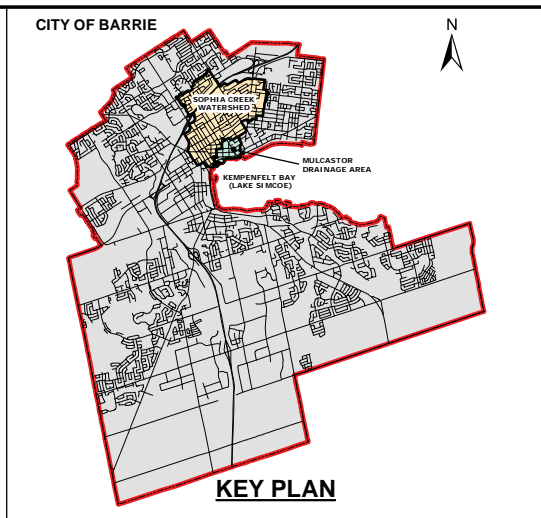
It is recommended that LID measures be implemented as capital improvement projects proceed (i.e. road reconstruction projects, intensification corridor redevelopment, and in the available parkland) where feasible under each improvement alternative considered. Lot level controls (soakaway pits, infiltration trenches, and downspout disconnection) and rainwater harvesting should also be encouraged throughout the study area.

Given the restrictions to implementing LID techniques in the study area, LID measures installed as part of road reconstruction projects or in the intensification corridors should be designed to intercept the first 5 mm to 10 mm of runoff from a storm event. This satisfies Alternative 2 of the LSRCA's flexible treatment alternative for sites with restrictions criteria, specifically a minimum 5 mm runoff volume reduction. LID measures implemented in the parks identified should be designed to intercept the first 10 mm to 20 mm of runoff during a storm event from their contributing drainage areas.

The preferred flow reduction / water quality improvements are illustrated on Figure 11 – Preferred Alternative Solution (Water Quality / Flow Reduction) provided overleaf.



- LOW IMPACT DEVELOPMENT (LID)**
- PARKLAND
  - INTENSIFICATION CORRIDORS
  - ROAD RECONSTRUCTION
  - RAINWATER HARVESTING
  - LOT LEVEL LID'S
- SWMF RETROFIT/EXPANSION/CREATION**
- SP03 - RETROFIT/EXPANSION
  - SP01 (MACMORRISON PARK) - SWMF CREATION
- FLOW DIVERSION**
- OWEN STREET



- Legend**
- STORM DEVICES
  - ➔ FLOW DIVERSION
  - CULVERT
  - - - - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - ▨ PARK LAND
  - ▨ CENTRALIZED LID LOCATION
  - ▨ BUILDINGS
  - ▨ SWMF RETROFIT/EXPANSION/CREATION
  - ▨ EXISTING SWMF
  - ▨ STUDY AREA
  - ▨ MUNICIPAL BORDER

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SCALE = 1:5,000

0 62.5 125 250 375 500 Meters

**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 11 - PREFERRED ALTERNATIVE SOLUTION (WATER QUALITY/FLOW REDUCTION)

DATE: SEPTEMBER 2017

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### 10.3 Conveyance Capacity Improvements (Sophia Creek Watershed – Upstream of Peel Street)

#### 10.3.1 Alternative 3B – Culvert/Channel/Major Drainage System Improvements (Design Flood Frequency Criteria)

Implement culvert and channel improvements along Sophia Creek north of Peel Street sized to satisfy the City’s design flood frequency criteria as a minimum. As the roads in the study area are generally classified as local urban/collector and arterial roads, the design flood frequency criteria are the 1:50 and 1:100 year design storm peak flows, respectively. Similarly, the channel improvements would reduce flooding of existing buildings and/or property where feasible.

Implementing Alternative 3B in combination with Alternative 2A reduces the size of the required culvert crossings upstream of Peel Street. The recommend culvert sizes are summarized in the following table:

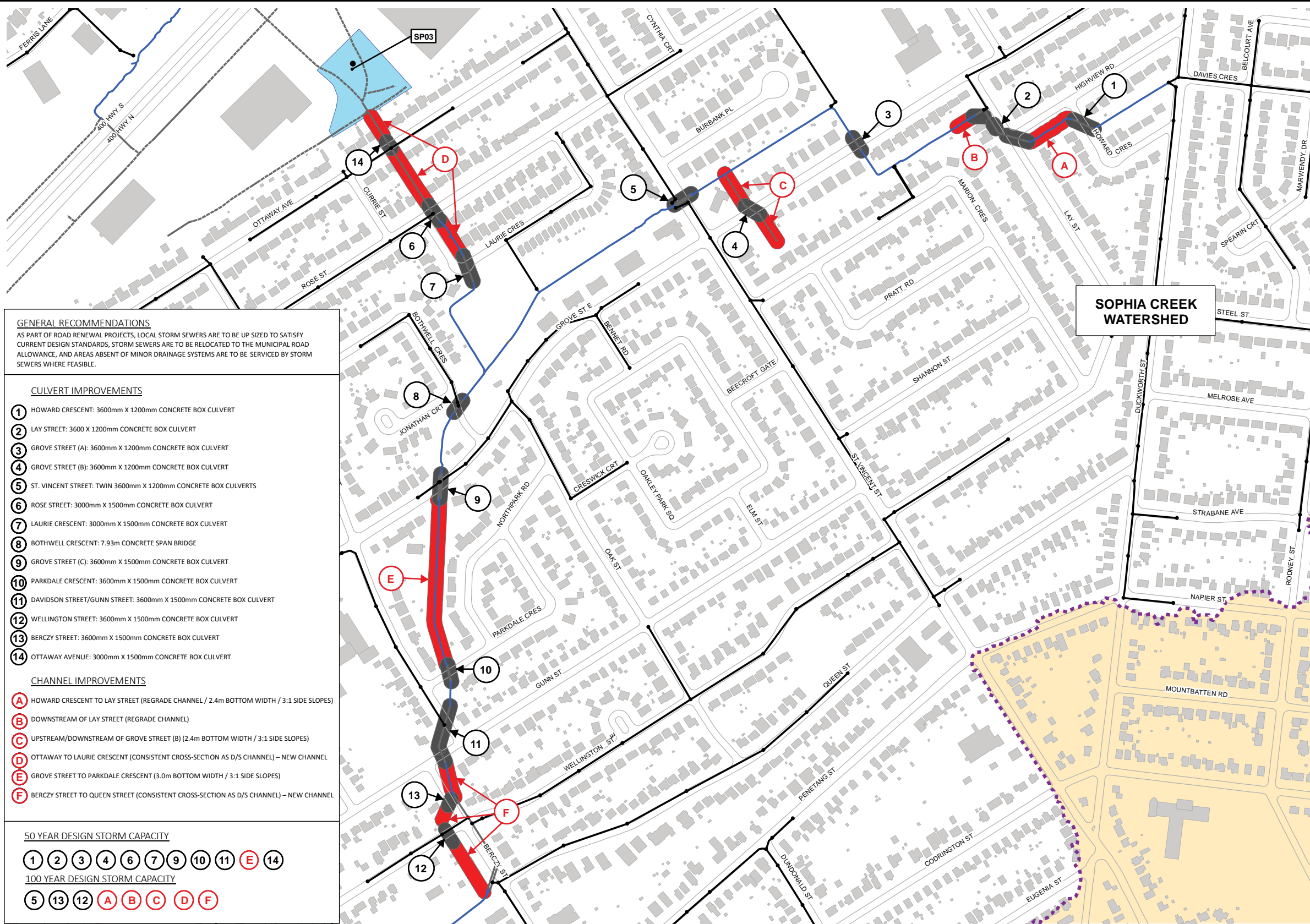
**Table 32: Culvert Summary – Preferred Alternative Solution (Alternative 3B)**

Location	Size	Level of Service
Howard Crescent	1200 mm × 3600 mm Conc. Box	1:50 Year
Lay Street	1200 mm × 3600 mm Conc. Box	1:50 Year
Grove Street (A)	1200 mm × 3600 mm Conc. Box	1:50 Year
Grove Street (B)	1200 mm × 3600 mm Conc. Box	1:50 Year
St. Vincent Street	Twin 1200 mm × 3600 mm Conc. Box	1:100 Year
Ottaway Avenue	1500 mm × 3000 mm Conc. Box	1:50 Year
Rose Street	1500 mm × 3000 mm Conc. Box	1:50 Year
Laurie Crescent	1500 mm × 3000 mm Conc. Box	1:50 Year
Bothwell Crescent	7.93 m Conc. Span	1:50 Year
Grove Street (C)	Twin 1500 mm x 3600 mm Conc. Box	1:50 Year
Parkdale Crescent	Twin 1500 mm x 3600 mm Conc. Box	1:50 Year
Davidson Street/Gunn Street	Twin 1500 mm x 3600 mm Conc. Box	1:50 Year
Berczy Street	Twin 1500 mm x 3600 mm Conc. Box	1:100 Year
Wellington Street	Twin 1500 mm x 3600 mm Conc. Box	1:100 Year

The proposed channel improvements under this improvement alternative are summarized as follows:

1. Howard Crescent to Lay Street – regrading and improvement of the channel cross-section to accommodate the proposed Howard Crescent culvert crossing, improve hydraulic function, and reduce flooding along the watercourse. Lowering the grade of the channel at Howard Crescent by 0.5 m accommodates the upsized culvert crossing under this scenario and a channel cross-section with a 2.4 m bottom width and 3:1 (H:V) side slopes contains the 100 year design storm peak flow.
2. Downstream of Lay Street – regrade the channel for the first 50 m downstream of Lay Street to accommodate the Lay Street culvert crossing, improve hydraulic function, and reduce flooding along the watercourse.
3. Upstream/Downstream of Grove Street (B) – construct a channel having a cross-section with a bottom width of 2.4 m and 3:1 (H:V) side slopes to intercept surface runoff and convey it downstream back into Sophia Creek. Easements are required over 207 Grove Street East and 265 St. Vincent Street and the acquisition of 210 Grove Street East is required to implement these channel improvements.
4. Ottaway Avenue to Laurie Crescent – minor grading improvements to the existing channel downstream of Laurie Crescent to Bothwell Crescent will improve drainage in this area. The opportunity also exists to extend the existing channel between Rose Street and Laurie Crescent upstream of Ottaway Avenue to SWMF SP03 to reduce flooding, improve maintenance access and water quality. Extending the channel upstream with a cross-section consistent with the existing channel between Rose Street and Laurie Crescent will reduce flooding in the area. Property acquisition is required to implement these channel improvements (69 and 70 Ottaway Avenue and 128 Rose Street).
5. Grove Street to Parkdale Crescent – regrade and improve the channel cross-section through this area to reduce flooding of private property adjacent to the watercourse. Regrading the channel and improving the cross-section to have a 3 m bottom width and 3:1 (H:V) side slopes matching to existing grade at property line will reduce the extent and frequency of flooding on private property. Improvements to be completed within existing easement.
6. Berczy Street to Queen Street – eliminate the existing culvert along Berczy Street and replace it with an open channel having a cross-section consistent with the downstream channel between Berczy Street and Peel Street. The channel can run on the west side of Berczy Street, crossing both Wellington Street and Berczy Street with culverts. The channel can run upstream to Gunn Street. Property acquisition is required to implement these channel improvements (47 Gunn Street, 150, 152, 154, 166, and 168 Berczy Street, and 103 Wellington Street East).

The preferred conveyance capacity improvements upstream of Peel Street are illustrated on Figure 12 – Preferred Alternative Solution (Conveyance Improvements – Upstream of Peel Street) provided overleaf. The detailed model results for the preferred alternative solution are included in Appendix O for reference.



**GENERAL RECOMMENDATIONS**  
 AS PART OF ROAD RENEWAL PROJECTS, LOCAL STORM SEWERS ARE TO BE UP SIZED TO SATISFY CURRENT DESIGN STANDARDS, STORM SEWERS ARE TO BE RELOCATED TO THE MUNICIPAL ROAD ALLOWANCE, AND AREAS ABSENT OF MINOR DRAINAGE SYSTEMS ARE TO BE SERVICED BY STORM SEWERS WHERE FEASIBLE.

**CULVERT IMPROVEMENTS**

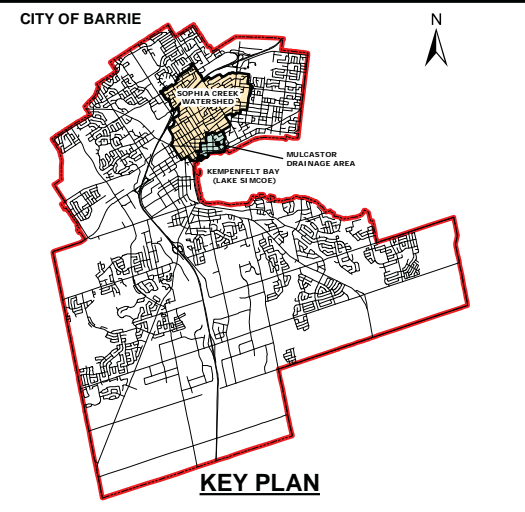
- ① HOWARD CRESCENT: 3600mm X 1200mm CONCRETE BOX CULVERT
- ② LAY STREET: 3600 X 1200mm CONCRETE BOX CULVERT
- ③ GROVE STREET (A): 3600mm X 1200mm CONCRETE BOX CULVERT
- ④ GROVE STREET (B): 3600mm X 1200mm CONCRETE BOX CULVERT
- ⑤ ST. VINCENT STREET: TWIN 3600mm X 1200mm CONCRETE BOX CULVERTS
- ⑥ ROSE STREET: 3000mm X 1500mm CONCRETE BOX CULVERT
- ⑦ LAURIE CRESCENT: 3000mm X 1500mm CONCRETE BOX CULVERT
- ⑧ BOTHWELL CRESCENT: 7.93m CONCRETE SPAN BRIDGE
- ⑨ GROVE STREET (C): 3600mm X 1500mm CONCRETE BOX CULVERT
- ⑩ PARKDALE CRESCENT: 3600mm X 1500mm CONCRETE BOX CULVERT
- ⑪ DAVIDSON STREET/GUNN STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
- ⑫ WELLINGTON STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
- ⑬ BERCY STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
- ⑭ OTTAWAY AVENUE: 3000mm X 1500mm CONCRETE BOX CULVERT

**CHANNEL IMPROVEMENTS**

- Ⓐ HOWARD CRESCENT TO LAY STREET (REGRADE CHANNEL / 2.4m BOTTOM WIDTH / 3:1 SIDE SLOPES)
- Ⓑ DOWNSTREAM OF LAY STREET (REGRADE CHANNEL)
- Ⓒ UPSTREAM/DOWNSTREAM OF GROVE STREET (B) (2.4m BOTTOM WIDTH / 3:1 SIDE SLOPES)
- Ⓓ OTTAWAY TO LAURIE CRESCENT (CONSISTENT CROSS-SECTION AS D/S CHANNEL) – NEW CHANNEL
- Ⓔ GROVE STREET TO PARKDALE CRESCENT (3.0m BOTTOM WIDTH / 3:1 SIDE SLOPES)
- Ⓕ BERCY STREET TO QUEEN STREET (CONSISTENT CROSS-SECTION AS D/S CHANNEL) – NEW CHANNEL

**50 YEAR DESIGN STORM CAPACITY**  
 ① ② ③ ④ ⑥ ⑦ ⑨ ⑩ ⑪ Ⓔ ⑭

**100 YEAR DESIGN STORM CAPACITY**  
 ⑤ ⑬ ⑫ Ⓐ Ⓑ Ⓒ Ⓓ Ⓕ

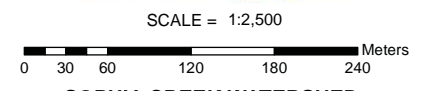


**Legend**

- STORM DEVICES
- CULVERT
- - - - DITCH
- WATERCOURSE
- STORM SEWER
- ROADS
- CULVERT IMPROVEMENTS ①
- CHANNEL IMPROVEMENTS Ⓐ
- SWMF
- BUILDINGS
- STUDY AREA
- MUNICIPAL BORDER

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**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
 FIGURE 12 - PREFERRED ALTERNATIVE SOLUTION (CONVEYANCE IMPROVEMENTS - UPSTREAM OF PEEL STREET)

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## **10.4 Conveyance Capacity Improvements (Sophia Creek Watershed – Downstream of Peel Street)**

### **10.4.1 Combination of Alternative 4A and 4C – Owen Street Trunk Storm Sewer, Clapperton Street Trunk Storm Sewer and Major Drainage System Improvements**

Supplement the capacity of the existing trunk storm sewer downstream of Peel Street by constructing additional trunk storm sewers on Owen Street and Clapperton Street within the existing road allowance. The total conveyance capacity of the drainage system downstream of Peel Street should equal the peak flow generated by the 1:100 year design storm.

A second trunk storm sewer can be constructed on Sophia Street from Peel Street to Owen Street within the municipal road allowance parallel to the existing trunk storm sewer. At Owen Street, the new trunk storm sewer will split. One branch can run south on Owen Street to Dunlop Street and Memorial Square. At Dunlop Street, the trunk storm sewer can run east on Dunlop Street to Fred Grant Way then south to Lakeshore Drive through Memorial Square. The trunk storm sewer can then run west on Lakeshore Drive following the alignment of the existing storm sewer servicing Memorial Square to Kempenfelt Bay. The second branch can run west from Owen Street on Sophia Street to Clapperton Street then south on Clapperton Street to Bayfield Street.

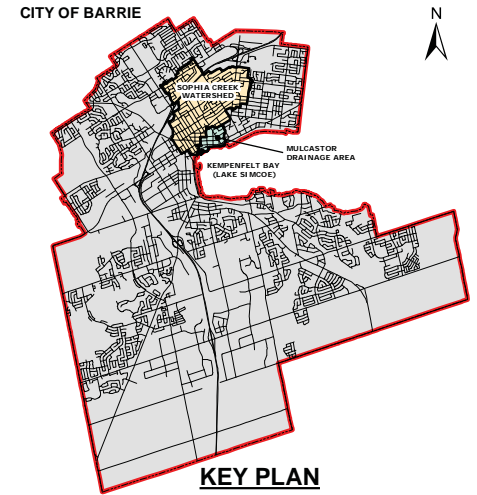
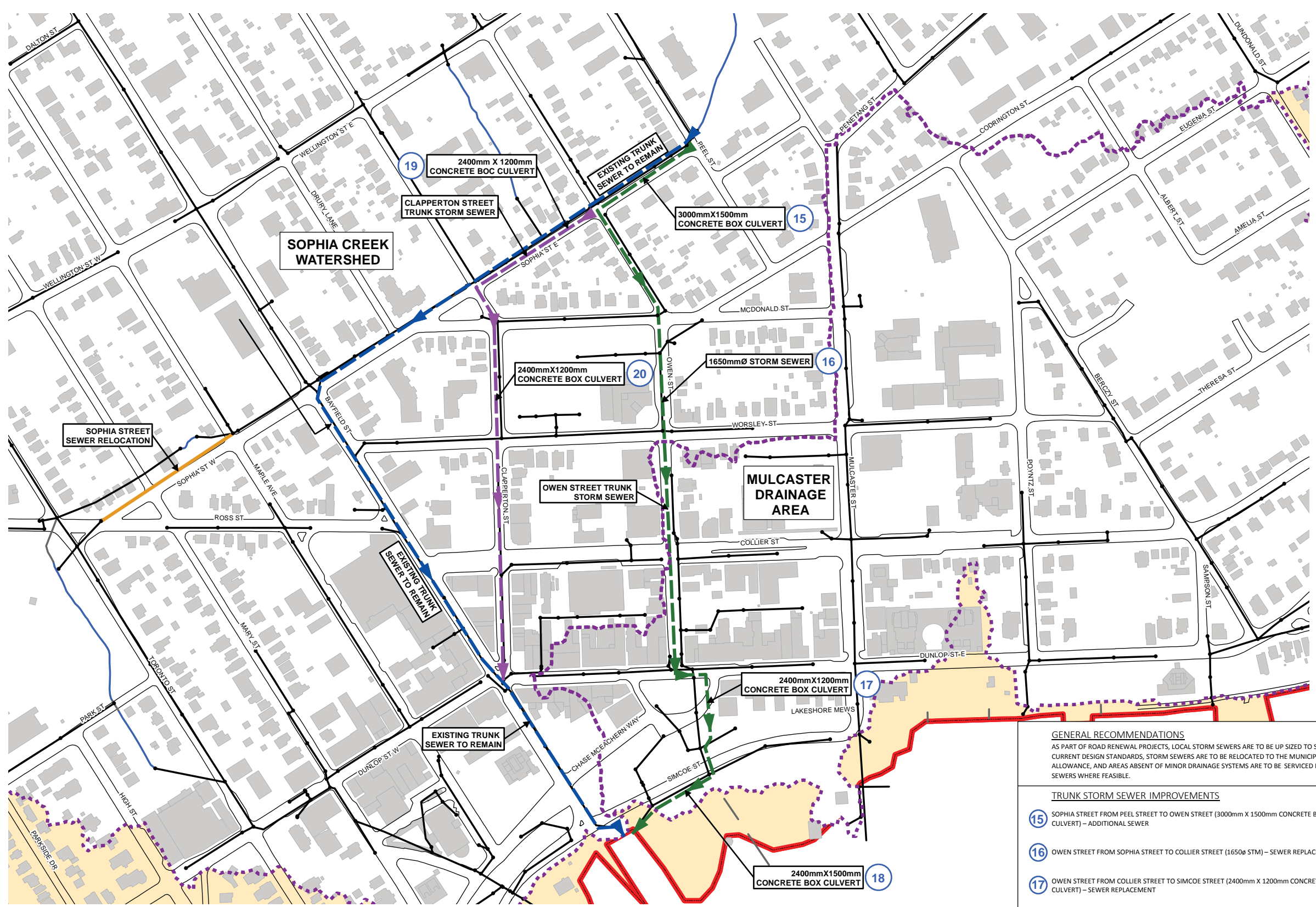
The existing trunk storm sewer on Bayfield Street downstream of Dunlop Street has a capacity of approximately 27 m<sup>3</sup>/s. The capacity of the existing Sophia Street trunk storm sewer that contributes to the Bayfield trunk storm sewer is limited to 12 m<sup>3</sup>/s between Owen Street and Clapperton Street. To utilize the full capacity of the existing Bayfield Street trunk storm sewer, the Clapperton Street trunk storm sewer should be sized to convey approximately 15 m<sup>3</sup>/s. To avoid replacing the existing Bayfield Street trunk storm sewer while still providing a combined conveyance capacity within the drainage system equal to the 1:100 year design storm peak flow, the Owen Street trunk storm sewer should be designed to convey approximately 12 m<sup>3</sup>/s.

To provide the required conveyance capacity to satisfy the 1:100 year design storm peak flow criteria, a 1500 mm x 3000 mm concrete box culvert is required on Sophia Street between Peel Street and Owen Street. A 1650 mm diameter storm sewer is required on Owen Street from Sophia Street to approximately Collier Street. Downstream, a 1200 mm x 2400 mm concrete box culvert is required on Owen Street, Dunlop Street, and through Memorial Square. A 1500 mm x 2400 mm concrete box culvert is required on Lakeshore Drive. A 1200 mm x 2400 mm concrete box culvert is required on Sophia Street from Owen Street to Clapperton Street and on Clapperton Street from Sophia Street to the existing trunk storm sewer on Bayfield Street.

Implementing Alternatives 4A (Owen Street trunk storm sewer) and 4C (Clapperton Street trunk storm sewer) in combination provides several advantages compared to implementing the alternatives individually. A few of the advantages are as follows:

- Utilizes the existing Sophia Street trunk storm sewer avoiding the replacement of the existing trunk storm sewer on Sophia Street between Peel Street and Clapperton Street;
- Utilizes the existing Bayfield Street trunk storm sewer downstream of Dunlop Street avoiding the replacement of this trunk storm sewer and significant transportation and service interruptions;
- Reduces the size of the individual trunk storm sewers on both Clapperton Street and Owen Street; and
- The level of service provided downstream of Peel Street is maintained even during the construction of the additional trunk storm sewers and the existing Sophia Street and Bayfield Street trunk storm sewer is maintained.

The preferred conveyance capacity improvements downstream of Peel Street are illustrated on Figure 13 – Preferred Alternative Solution (Conveyance Improvements – Downstream of Peel Street) provided overleaf. The detailed model results for the preferred alternative solution are included in Appendix O for reference. Figure 14 – Preferred Alternative Solutions provided overleaf illustrates the various water quality, flow reduction and conveyance capacity improvements recommended across the watershed.



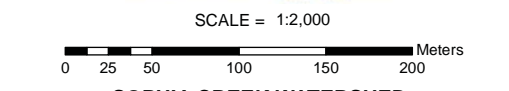
- Legend**
- STORM DEVICES
  - ▶▶▶ CLAPPERTON STREET TRUNK STORM SEWER
  - ▶▶▶ EXISTING SOPHIA STREET/BAYFIELD STREET TRUNK STORM SEWER
  - ▶▶▶ OWEN STREET TRUNK STORM SEWER
  - SEWER RELOCATION
  - CULVERT
  - - - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - BUILDINGS
  - ▭ STUDY AREA
  - ▭ MUNICIPAL BORDER

**GENERAL RECOMMENDATIONS**  
 AS PART OF ROAD RENEWAL PROJECTS, LOCAL STORM SEWERS ARE TO BE UP SIZED TO SATISFY CURRENT DESIGN STANDARDS, STORM SEWERS ARE TO BE RELOCATED TO THE MUNICIPAL ROAD ALLOWANCE, AND AREAS ABSENT OF MINOR DRAINAGE SYSTEMS ARE TO BE SERVICED BY STORM SEWERS WHERE FEASIBLE.

- TRUNK STORM SEWER IMPROVEMENTS**
- 15 SOPHIA STREET FROM PEEL STREET TO OWEN STREET (3000mm X 1500mm CONCRETE BOX CULVERT) – ADDITIONAL SEWER
  - 16 OWEN STREET FROM SOPHIA STREET TO COLLIER STREET (1650ø STM) – SEWER REPLACEMENT
  - 17 OWEN STREET FROM COLLIER STREET TO SIMCOE STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT
  - 18 LAKESHORE DRIVE FROM MEMORIAL SQUARE TO KEMPENFELT BAY (2400mm X 1500mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT
  - 19 SOPHIA STREET FROM OWEN STREET TO CLAPPERTON STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – ADDITIONAL SEWER
  - 20 CLAPPERTON STREET FROM SOPHIA STREET TO BAYFIELD STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT

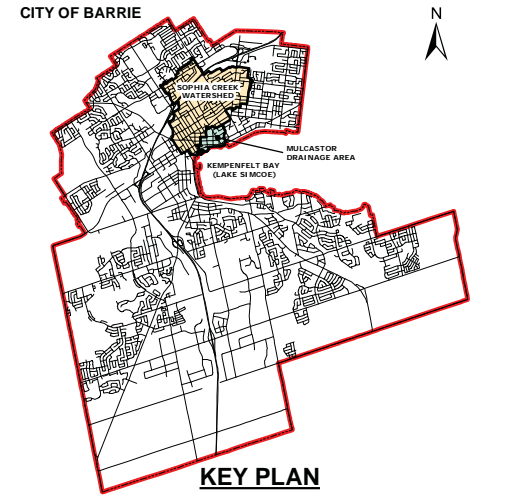
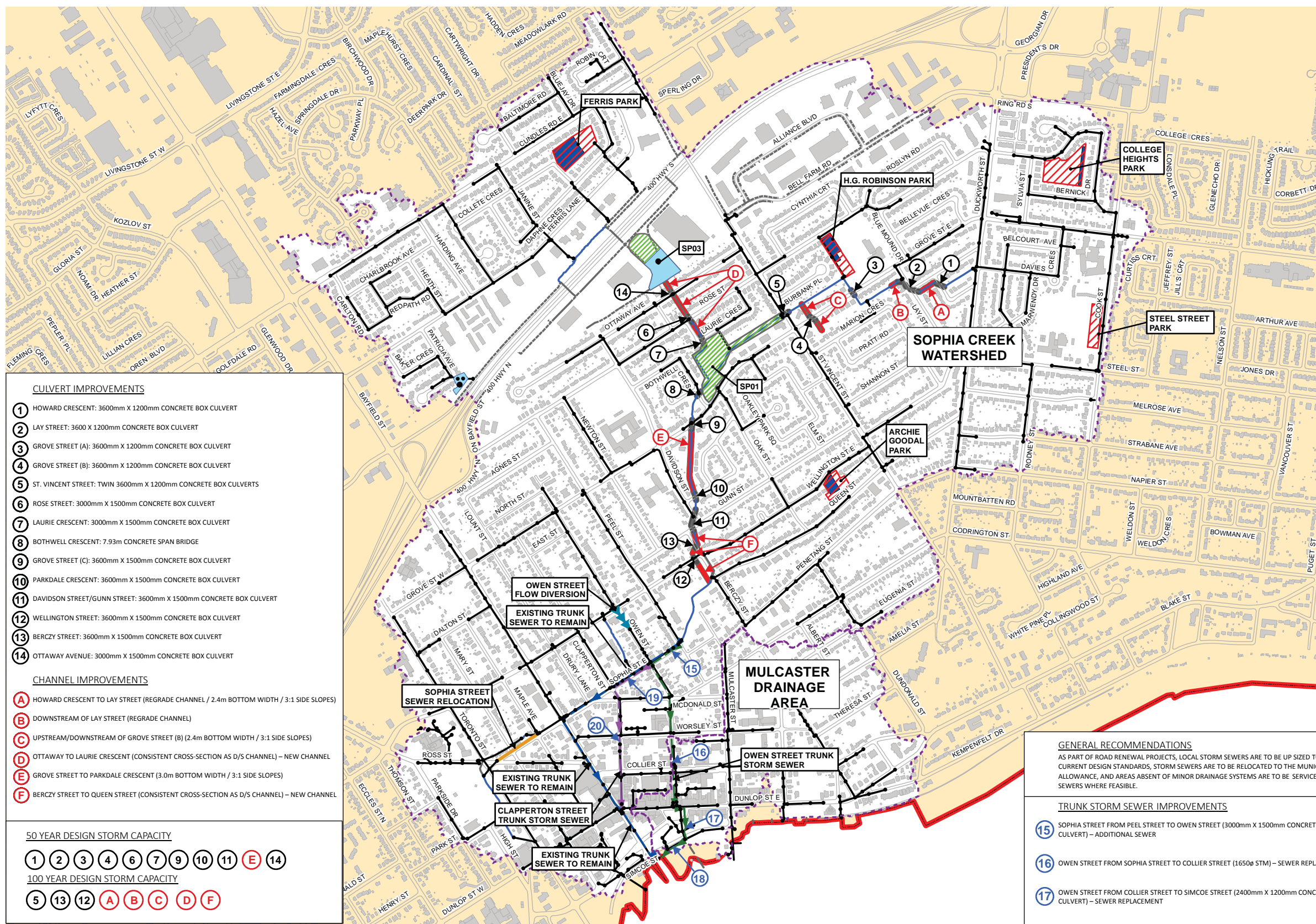
EXISTING SOPHIA STREET/BAYFIELD STREET TRUNK STORM SEWER, PROPOSED OWEN STREET TRUNK STORM SEWER AND PROPOSED CLAPPERTON STREET TRUNK STORM SEWER TO HAVE COMBINED 100 YEAR DESIGN STORM CAPACITY.

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**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**  
 FIGURE 13 - PREFERRED ALTERNATIVE SOLUTION (CONVEYANCE IMPROVEMENTS - DOWNSTREAM OF PEEL STREET)

DATE: SEPTEMBER 2017



- CULVERT IMPROVEMENTS**
- 1 HOWARD CRESCENT: 3600mm X 1200mm CONCRETE BOX CULVERT
  - 2 LAY STREET: 3600 X 1200mm CONCRETE BOX CULVERT
  - 3 GROVE STREET (A): 3600mm X 1200mm CONCRETE BOX CULVERT
  - 4 GROVE STREET (B): 3600mm X 1200mm CONCRETE BOX CULVERT
  - 5 ST. VINCENT STREET: TWIN 3600mm X 1200mm CONCRETE BOX CULVERTS
  - 6 ROSE STREET: 3000mm X 1500mm CONCRETE BOX CULVERT
  - 7 LAURIE CRESCENT: 3000mm X 1500mm CONCRETE BOX CULVERT
  - 8 BOTHWELL CRESCENT: 7.93m CONCRETE SPAN BRIDGE
  - 9 GROVE STREET (C): 3600mm X 1500mm CONCRETE BOX CULVERT
  - 10 PARKDALE CRESCENT: 3600mm X 1500mm CONCRETE BOX CULVERT
  - 11 DAVIDSON STREET/GUNN STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
  - 12 WELLINGTON STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
  - 13 BERCY STREET: 3600mm X 1500mm CONCRETE BOX CULVERT
  - 14 OTTAWAY AVENUE: 3000mm X 1500mm CONCRETE BOX CULVERT
- CHANNEL IMPROVEMENTS**
- A HOWARD CRESCENT TO LAY STREET (REGRADE CHANNEL / 2.4m BOTTOM WIDTH / 3:1 SIDE SLOPES)
  - B DOWNSTREAM OF LAY STREET (REGRADE CHANNEL)
  - C UPSTREAM/DOWNSTREAM OF GROVE STREET (B) (2.4m BOTTOM WIDTH / 3:1 SIDE SLOPES)
  - D OTTAWAY TO LAURIE CRESCENT (CONSISTENT CROSS-SECTION AS D/S CHANNEL) – NEW CHANNEL
  - E GROVE STREET TO PARKDALE CRESCENT (3.0m BOTTOM WIDTH / 3:1 SIDE SLOPES)
  - F BERCY STREET TO QUEEN STREET (CONSISTENT CROSS-SECTION AS D/S CHANNEL) – NEW CHANNEL
- 50 YEAR DESIGN STORM CAPACITY**
- 1 2 3 4 6 7 9 10 11 E 14
- 100 YEAR DESIGN STORM CAPACITY**
- 5 13 12 A B C D F

- GENERAL RECOMMENDATIONS**
- AS PART OF ROAD RENEWAL PROJECTS, LOCAL STORM SEWERS ARE TO BE UP SIZED TO SATISFY CURRENT DESIGN STANDARDS, STORM SEWERS ARE TO BE RELOCATED TO THE MUNICIPAL ROAD ALLOWANCE, AND AREAS ABSENT OF MINOR DRAINAGE SYSTEMS ARE TO BE SERVICED BY STORM SEWERS WHERE FEASIBLE.
- TRUNK STORM SEWER IMPROVEMENTS**
- 15 SOPHIA STREET FROM PEEL STREET TO OWEN STREET (300mm X 1500mm CONCRETE BOX CULVERT) – ADDITIONAL SEWER
  - 16 OWEN STREET FROM SOPHIA STREET TO COLLIER STREET (1650ø STM) – SEWER REPLACEMENT
  - 17 OWEN STREET FROM COLLIER STREET TO SIMCOE STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT
  - 18 LAKESHORE DRIVE FROM MEMORIAL SQUARE TO KEMPENFELT BAY (2400mm X 1500mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT
  - 19 SOPHIA STREET FROM OWEN STREET TO CLAPPERTON STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – ADDITIONAL SEWER
  - 20 CLAPPERTON STREET FROM SOPHIA STREET TO BAYFIELD STREET (2400mm X 1200mm CONCRETE BOX CULVERT) – SEWER REPLACEMENT
- EXISTING SOPHIA STREET/BAYFIELD STREET TRUNK STORM SEWER, PROPOSED OWEN STREET TRUNK STORM SEWER AND PROPOSED CLAPPERTON STREET TRUNK STORM SEWER TO HAVE COMBINED 100 YEAR DESIGN STORM CAPACITY.

**DISCLAIMER**

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- Legend**
- STORM DEVICES
  - CLAPPERTON STREET TRUNK STORM SEWER
  - EXISTING SOPHIA STREET/BAYFIELD STREET TRUNK STORM SEWER
  - OWEN STREET TRUNK STORM SEWER
  - FLOW DIVERSION
  - PARK LAND
  - CENTRALIZED LID LOCATION
  - SWMF RETROFIT/EXPANSION/CREATION
  - EXISTING SWMF
  - SEWER RELOCATION
  - CULVERT
  - DITCH
  - WATERCOURSE
  - STORM SEWER
  - ROADS
  - CULVERT IMPROVEMENTS 1
  - CHANNEL IMPROVEMENTS A
  - SWMF
  - BUILDINGS
  - STUDY AREA
  - MUNICIPAL BORDER

C.C. Tatham & Associates Ltd.  
Consulting Engineers  
Collingwood Bradbridge Orillia Barrie

**The City of BARRIE**

SCALE = 1:6,500

0 80 160 320 480 640 Meters

**SOPHIA CREEK WATERSHED & MULCASTER DRAINAGE AREA EA UPDATE**

FIGURE 14 - PREFERRED ALTERNATIVE SOLUTIONS

DATE: SEPTEMBER 2017

## 10.5 Property Acquisition

To implement the preferred alternative solution, a number of properties or portions thereof have been identified for acquisition by the City. The properties required for acquisition under the preferred alternative solution are summarized in the following table and illustrated on the figure provided overleaf:

**Table 28: Property Acquisition Summary – Preferred Alternative Solution**

Address		
207 Grove Street East	69 Ottaway Avenue	166 Berczy Street
210 Grove Street East	128 Rose Street	103 Wellington Street
70 Ottaway Avenue	2 Bothwell Crescent	154 Berczy Street
168 Berczy Street	56 Gunn Street	152 Berczy Street
150 Berczy Street	47 Gunn Street	364 St. Vincent Street

Note: Only a portion of 364 St. Vincent Street is required for the implementation of Alternative 2A

It is noted that each property identified for acquisition by the City in support of the preferred alternative solution is located within the existing floodplain, with the exception of 364 St. Vincent Street. As per By-Law 90-92, the City may acquire land where it is considered to be in the City's interest to do so. Purchasing the identified properties will allow for the implementation of the preferred alternative solution resulting in reduced private property flooding, reduced maintenance requirements and improved maintenance access throughout the watershed.

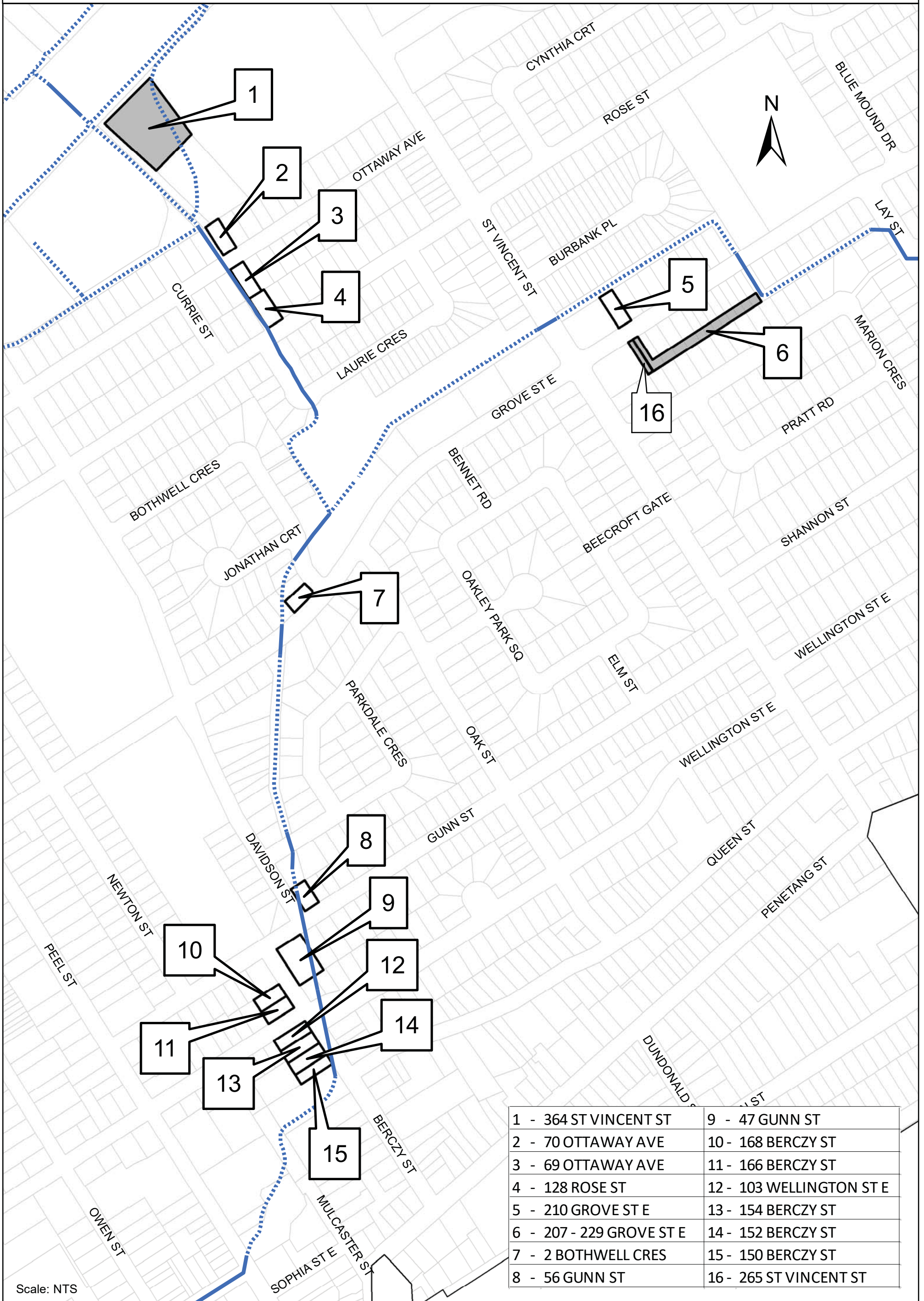
The property acquisition costs associated with the preferred alternative solution are summarized in the following table.

**Table 29: Property Acquisition Costs – Preferred Alternative Solution**

Improvement Alternative	Property Acquisition Cost
Alternative 2A	\$867,000
Alternative 3B	\$3,165,000
<b>Total</b>	<b>\$4,032,000</b>

Note: Property acquisition cost for Alternative 3B excludes cost of purchasing 2 Bothwell Crescent which is included in Alternative 2A; Property Value – Assessed Value (MPAC)

# Sophia and Mulcaster Drainage Area Property Acquisition ( Preferred Solution )



Scale: NTS



- Watershed Boundary
- Property to be Acquired
- Partially Acquired Property
- Watercourse
- Pipe/Culvert

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 For information please contact Service Barrie at 705-726-4242 or ServiceBarrie@barrie.ca

Infrastructure Planning 11/16/2017

Although it is not required for the implementation of the preferred alternative, it is recommended that the City acquire an easement over the rear of 207 – 229 Grove Street East and 8 – 26 Marion Crescent. A drainage swale at the rear of these properties conveys flow from Sophia Creek west through the rear yards to St. Vincent Street. The drainage swale conveys municipal drainage through private property and the City should consider acquiring an easement over these lands to ensure that the swale is maintained and development does not encroach into the existing swale/drainage feature or existing floodplain.

## 10.6 Construction Costs

Preliminary construction cost estimates have been prepared for the general recommendations presented in Section 10. Specifically, construction cost estimates have been prepared for the recommended minor drainage system improvements, Owen Street flow diversion and addition of new storm sewer in areas absent of existing minor drainage infrastructure. Given the general recommendations are to be implemented as part of road reconstruction projects, the estimates reflect the cost to upsize the storm sewer being replaced as part of the renewal works. The estimates reflect the cost above the replacement cost to upsize the sewer. The preliminary construction cost estimates for the preferred alternative solution are included in Appendix O or reference.

A summary of the projected construction costs is included in the following table:

**Table 30: Construction Costs - Preferred Alternative Solution**

Improvement Alternative	Construction Cost
General Recommendations	
d) Minor Drainage System Improvements	\$1,198,630
e) Owen Street Flow Diversion	\$69,902
f) New Storm Sewer (where absent/required)	\$4,780,994
Alternative 2A	\$3,566,240
Alternative 3B	\$10,815,896
Alternative 4A/4C Combined	\$13,206,670
<b>Total – Construction Costs</b>	<b>\$33,638,332</b>
<b>Total Cost (including Land Acquisition)</b>	<b>\$37,670,332</b>

Note: Estimated Construction Cost excludes implementation of LID's.

## 11 Detailed Design and Construction

Following ratification by City Council and successful completion of the Class EA process, the individual projects will proceed to detailed design and construction subject to available capital funding. Prior to construction, approval for the proposed works will be required from the Lake Simcoe Region Conservation Authority (LSRCA) under Ontario Regulation 179/06 and from the Ministry of the Environment and Climate Change (MOECC) under the Ontario Water Resources Act. All subsequent permits and approvals that may be required for the implementation of the Preferred Alternative Solution are as follows:

- Development, Interference with Wetlands & Alteration to Shorelines & Watercourses Permit – LSRCA;
- Certificate of Approval for Municipal and Private Sewage Works – MOECC; and
- Permit to Take Water – MOECC (If required)

During the detailed design of the Preferred Alternative Solution, the owners of the existing utilities in the Sophia Creek watershed should be notified of the proposed works, of any impacts the proposed works will have on the existing utilities, and of any conflicts or relocations required to complete the infrastructure improvements. Coordination with existing utilities will be required throughout detailed design and construction.

Implementation of Alternative 2A is recommended ahead of the conveyance capacity improvements. Implementing the conveyance capacity improvements recommended under the preferred alternative solution should start at the downstream end and progress upstream. However, it is understood that the existing infrastructure upstream of Peel Street, particularly the major culvert crossings, are reaching their service life expectancy and rapidly deteriorating. As such, the implementation of culvert and channel improvements may not progress in the order recommended to protect public safety.

It is envisioned that the implementation of the conveyance capacity improvements downstream of Peel Street will be completed in conjunction with road reconstruction projects as the trunk storm sewer is being constructed in the municipal road allowance. This will save on construction costs while minimizing transportation and service disruptions associated with construction.

## 12 Conclusion

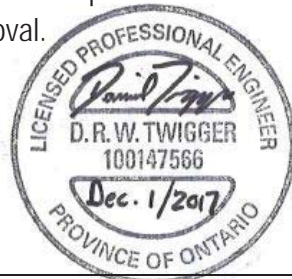
The recommendations contained herein were presented to the General Committee and ratified by City council. Those individuals and parties that requested to be kept informed of the Municipal Class EA process will be notified of the selection of a Preferred Alternative Solution and the steps of the process moving forward after ratification.

If concerns are raised during this process which cannot be resolved in discussion with the City of Barrie, the Minister of the Environment and Climate Change may be requested to make an Order for the project to comply with Part II of the Environmental Assessment Act (referred to as a Part II Order), which addresses individual Environmental Assessments. Requests must be received by the Minister at the address below within thirty (30) days of the publication of the Notice of Completion for the project. A copy of the request must also be sent to the City of Barrie Infrastructure Planning Group.


The Honourable Chris Ballard  
Minister of the Environment and Climate Change  
77 Wellesley Street West  
Ferguson Block, 11<sup>th</sup> Floor  
Toronto, ON M7A 2T5

Lorran Cooney, C.E.T.  
Infrastructure Planning  
The Corporation of the City of Barrie  
70 Collier Street  
Barrie, ON L4M 4T5

Following the successful completion of the Municipal Class EA process (no Part II Orders received) it would be the City's intention to implement the Preferred Alternative Solution, subject to available capital funding and Council approval.



Authored by: Daniel Twigger, B.Sc.Eng., P.Eng.  
Senior Engineer, Project Manager

  
Reviewed by: Dan Hurley, B.A.Sc., P.Eng., LEED AP  
Vice President,  
Manager – Water Resources Engineering

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