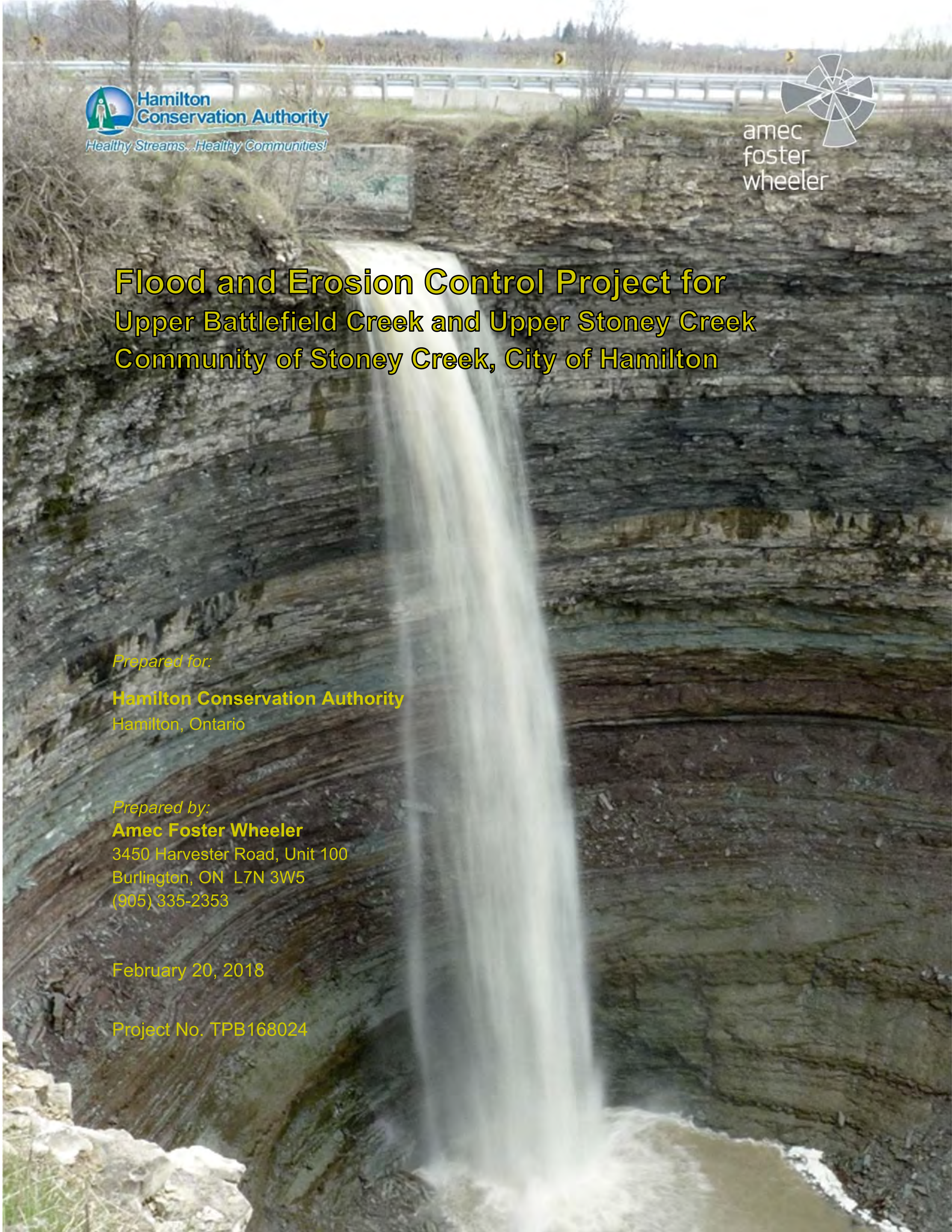

Hamilton Conservation Authority
Healthy Streams...Healthy Communities!

amec foster wheeler

Flood and Erosion Control Project for
Upper Battlefield Creek and Upper Stoney Creek
Community of Stoney Creek, City of Hamilton

Prepared for:

Hamilton Conservation Authority
Hamilton, Ontario

Prepared by:
Amec Foster Wheeler
3450 Harvester Road, Unit 100
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February 20, 2018

Project No. TPB168024

Cover photo credit:
http://www.waterfalls.hamilton.ca/default.asp?waterfall=55

Flood and Erosion Control Project for

Upper Battlefield Creek and Upper Stoney Creek

Community of Stoney Creek, City of Hamilton

Submitted to:

Hamilton Conservation Authority
Hamilton, Ontario

Submitted by:

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Road, Unit 100
Burlington, ON L7N 3W5
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February 20, 2018

TPB168024

February 20, 2018
Our File: TPB168024-10

Hamilton Conservation Authority
838 Mineral Springs Road
P.O. Box 81067
Hamilton (Ancaster), ON L9G 4X1

Attention: Scott Peck, Deputy Chief Administrative Officer/
Director – Watershed Planning & Engineering

Dear Sir:

Re: Flood and Erosion Control Project
Upper Battlefield Creek and Upper Stoney Creek,
Conservation Ontario Class Environmental Assessment,
Community of Stoney Creek, City of Hamilton

Amec Foster Wheeler has worked closely with Hamilton Conservation Authority in preparing the Flood and Erosion Control Project for the Upper Battlefield and Upper Stoney Creek. The technical assessment conducted as part of this Conservation Ontario Class Environmental Assessment supports the creation of strategic storage areas to mitigate flood and erosion risk in the lower reaches of the Stoney and Battlefield Creeks.

The recommendations of this Class Environmental Assessment align well with the objectives Hamilton Conservation Authority's Program Overview ("East Escarpment Conservation Area", February 2015) which expressed the following Goal:

"To create a new conservation area in the east end of the City of Hamilton, specifically the Upper Stoney Creek and Upper Battlefield Creek watersheds above the Niagara Escarpment to provide natural hazard attenuation, natural heritage enhancements and recreation opportunities".

Continued...
Hamilton Conservation Authority
February 20, 2018

Amec Foster Wheeler wishes to thank the Hamilton Conservation Authority for the opportunity to work on this study and looks forward to supporting the implementation of the storage areas and the associated creation of wetlands, wetlands enhancements and a new conservation area.

Yours very truly,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited

Per: **Ron Scheckenberger, M.Eng., P.Eng.**
Principal Consultant

REGISTERED PROFESSIONAL ENGINEER
R. B. SCHECKENBERGER
Feb 20, 2018
PROVINCE OF ONTARIO

Per: **Steve Chipps, P.Eng.**
Associate

LICENSED PROFESSIONAL ENGINEER
S. CHIPPS
02/20/2018
PROVINCE OF ONTARIO

SC/cc

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The preparation of this environmental study was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

1.0 INTRODUCTION

1.1 Purpose/ Overview

The 2011 'Draft' Conservation Ontario Class Environmental Assessment (Class EA) for the Lower Stoney Creek and Lower Battlefield Creek (reference AMEC, 2011) identified a number of private properties bordering the respective creek reaches in the Community of Stoney Creek, below the escarpment as being at risk due to flooding, and to a lessor degree erosion. That Class EA conducted a high-level assessment of the potential for a headwater storage system to potentially mitigate flood and erosion risk; essentially it was concluded that substantial storage would be required to address the Regulatory Flood (Hurricane Hazel), however additional study would be warranted, particularly to determine the efficacy of smaller storage systems (facilities) to address more frequent flood (and erosion) risk.

Hamilton Conservation Authority (HCA) has prepared a Program Overview ("East Escarpment Conservation Area", February 2015) which expressed the following Goal:

"To create a new conservation area in the east end of the City of Hamilton, specifically the Upper Stoney Creek and Upper Battlefield Creek watersheds above the Niagara Escarpment to provide natural hazard attenuation, natural heritage enhancements and recreation opportunities."

With related Objectives:

- *"To utilize the floodplain areas of Upper Battlefield and Upper Stoney Creeks to retain water to provide flood attenuation both above and below the Niagara Escarpment within these watershed areas.*
- *To enhance and enlarge existing wetland areas and to create new wetland areas to provide enhanced wetland hydrologic function to reduce the impacts of high water events and provide water to area watercourses during low flow periods.*
- *To restore the natural features and functions of the watercourses in the area."*

Given the foregoing, it has been the intent of this study to conduct a technical assessment of the effectiveness of various potential storage locations, sizes and combinations to address flood and erosion risk in the lower reaches of the Stoney and Battlefield Creeks. Other environmental factors (natural, social, and economic) have also been considered in this Class EA, as per the Conservation Ontario, Class Environmental Assessment for Remedial Flood and Erosion Control Projects", January 2002 (amended 2013) process. Addressing the flood and erosion risk locations and metrics (flow, velocity, depth and duration of erosive flows) from the 2011 Draft Class EA, has been the basis for this assessment. This Class EA documents findings related to the assessment of various storage facility alternatives, ultimately leading to a preferred solution.

1.2 Description of Study Area

The Battlefield Creek and Stoney Creek Watershed (ref. Figure 1) drain approximately 3089 ha at the outlet to Lake Ontario. Battlefield Creek confluences with Stoney Creek upstream of Barton Street and has a drainage area of 767 ha +/-. The watershed is divided by the Niagara

Escarpment with the 2360 ha area above the Niagara Escarpment primarily being in agricultural use and 729 ha below the Escarpment, being of mixed urban land uses, consisting mostly of residential and employment lands, and to a lesser extent commercial, institutional and open space. Development below the Niagara Escarpment has typically been implemented without stormwater management controls, historically resulting in increased flow rates within both watercourses. Each watercourse has been straightened or modified over time, with development encroaching into the riparian zone of the watercourses and within the Regulatory (Regional Storm) floodplain. Neither watercourse has been enclosed, as has been common for other watercourses within southern Ontario urban areas.

1.3 Background

Flooding and erosion conditions along the lower Stoney Creek and Battlefield Creek have impacted private property and municipal infrastructure, based on the limited historical application of stormwater management and erosion mitigation works implemented since 1989 and previously, as well as floodplain encroachment of private property.

The *2011 'Draft' Conservation Ontario Class Environmental Assessment (Class EA) for the Lower Stoney Creek and Lower Battlefield Creek,* recommended further determined assessment of flood and erosion controls above the Niagara Escarpment. The Class EA assessed two (2) conceptual facilities located upstream of Ridge Road and Third Line, based on maximizing the amount of storage using the existing topography. Two assessments were conducted; the first assessment determined the potential reduction in Regional Storm (Hurricane Hazel) peak flows below the Escarpment, using the available storage upstream of the two (2) road crossings; this resulted in a minimal reduction (1 % ±) in the Regional Storm peak flows. The second assessment notionally determined the magnitude of storage required to reduce Regional Storm peak flows to the 100 year peak flows. Premised on the significant volumes identified for the second assessment, and the limited practicality of implementing flood controls of that magnitude, it was recommended (as part of the Class EA), that the long-term future viability of storage facilities above the Escarpment be considered for more frequent events in a more detailed study.

Within the Study Area, HCA both regulates lands within floodplains, and owns various land parcels, including property above the Escarpment (ref. Figure 21). Notably, HCA has purchased lands above the Escarpment, with land ownership intended to meet the goal of a new conservation area to realize the objectives noted in Section 1.1, to provide flood attenuation and to restore and enhance natural areas, including wetlands.

Based on the objectives of HCA's paper "East Escarpment Conservation Area" aligning with the recommendations for assessment of storage facilities above the Escarpment in the 2011 'Draft', Conservation Ontario, Class Environmental Assessment (Class EA) for the Lower Stoney Creek and Lower Battlefield Creek, HCA initiated this Class EA, to assesses various storage facility locations above the Escarpment within the Stoney Creek and Battlefield subwatersheds.

1.4 Problem Statement

The 2011 Draft Class EA identified significant portions of the Lower Stoney Creek and Battlefield Creeks as being susceptible to flood and erosion risk. In addition, HCA has set a goal of creating a new conservation area in the Upper Stoney Creek and Upper Battlefield Creek watershed. As such, through this Class EA and associated detailed study and consultation, opportunities to provide flood and erosion impact management, through attenuation of runoff in existing and enhanced wetland areas above the Escarpment have been assessed and evaluated. These areas and locations for runoff storage will ultimately also have the potential to become multi-use public spaces as part of a new conservation area.

1.5 Class Environmental Assessment

The "Class Environmental Assessment for Remedial Flood and Erosion Control Projects", Conservation Ontario, January 2002 (amended 2013), along with the "Five-Year Review Report (2012-2016)", Conservation Ontario, January 30, 2017 clearly outline the process and approach related to addressing remedial flooding and erosion problems in riverine settings. The Conservation Ontario Class EA document defines the respective undertakings, which are governed by this process as follows:

> *Remedial Flood and Erosion Control Projects refer to those projects undertaken by Conservation Authorities, which are required to protect human life and property, in previously developed areas, from an impending flood or erosion problem. Such projects do not include works which facilitate or anticipate development.*

The Class Environmental Assessment for Remedial Flood and Erosion Control Projects establishes a planning and approval process for a variety of projects that may be carried out by Conservation Authorities in Ontario (ref. Figure 1.1). The Conservation Ontario Class EA process categorizes proposed municipal projects according to their anticipated environmental impact, and calls for increasingly stringent review requirements as the magnitude of the anticipated environmental impact increases.

The Conservation Ontario Class EA requires notification of, and consultation with, relevant stakeholders. Over the course of this project, HCA and the Project Team have ensured that stakeholders were notified early in the planning process, and throughout the study. Notwithstanding, in the event that stakeholders raise issues that could not be resolved through discussion, these concerns would be referred to the Ministry of Environment and Climate Change for resolution.

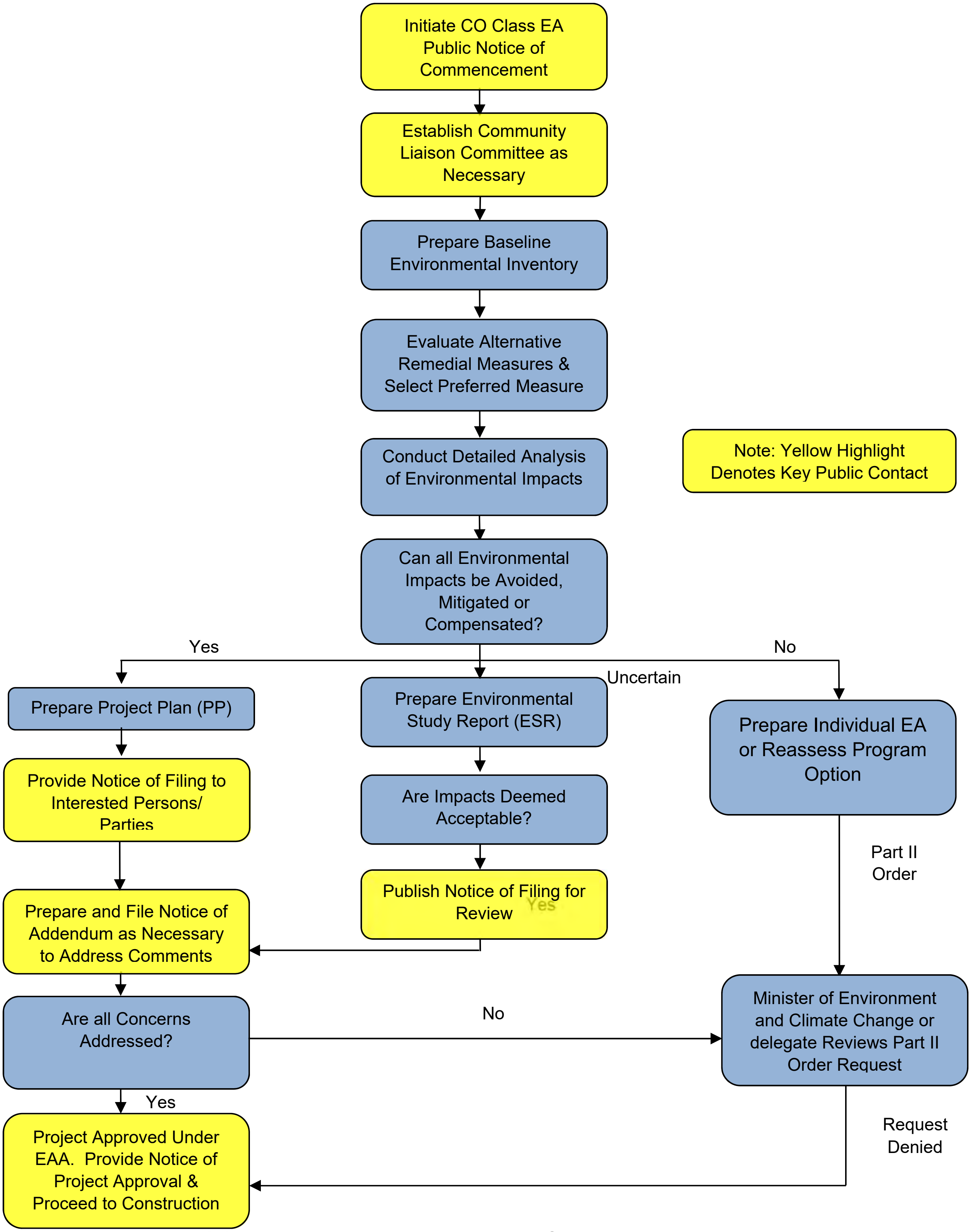

Figure 1.1 Planning and Design Process Class Environmental Assessments
[Note: Figure reproduced from Conservation Ontario, 2017]

1.6 Project Milestones

Project milestones are summarized as follows:

January 11, 2017	Start-up meeting
February 21, 2017	Notice of Intent and Public Information Centre Number 1 published in newspapers, on the Hamilton Conservation Authority's website and sent by mail to the public who had indicated property within 200 m of potential storage facilities.
February and March 2017	Assessment of existing conditions and potential alternatives.
March 28, 2017	Hosting of Public Information Centre Number 1 to present existing conditions in the study area and possible alternatives.
April to October, 2017	Assessment of Alternatives and associated Evaluation.
November 22, 2017	Notice of Public Information Centre Number 2 published in newspapers, on the Hamilton Conservation Authority's website and sent by mail to all who expressed interest.
November 28, 2017	Hosting of Public Information Centre Number 2 to present Alternative Assessment.
Winter 2017/2018	Documentation of Preliminary Preferred Solutions.
Spring 2018	Notice of Filing of Environmental Study Report published in newspapers and sent by mail to all who expressed interest.

1.7 Project Organization

The Project Team consisted of staff from the following organizations:

Proponent: Hamilton Conservation Authority

Scott Peck
Jonathan Bastien

Consultants and Sub-Consultants

Amec Foster Wheeler Environment & Infrastructure (Project Management)
Blackport and Associates
C. Portt and Associates
Matrix Solutions Inc.
Dougan and Associates

1.8 Stakeholder and Agency Consultation

Notice of Intent and Public Information Centre No. 1

A joint Notice of Study of Intent and Public Information Centre Number 1 (PIC No. 1) detailing the study area, summarizing the objectives of the study and requesting comments was sent to stakeholders and agencies by mail on February 21, 2017. Approximately 20 notices were mailed out to residents within 200 m of areas being considered for storage facilities. The Notice was also published in the Hamilton Spectator in early Mach, 2017 and on the Hamilton Conservation Authority's website. Copies of the newspaper advertisement, letters to stakeholders and agencies and copies of all comments received and written responses are contained in Appendix 'A'.

Public Information Centre No. 1

Public Information Centre Number 1 (PIC No. 1) was held on Wednesday March 27, 2017 at the Croatian Community Centre at 166 Green Mountain Road East, Stoney Creek. PIC No. 1 was the first opportunity for the general public to meet with HCA and the Project Team, and to review the study scope and discuss issues related to the project, including background information, local flooding and erosion issues and environmental considerations. Display boards were prepared that presented the following information (ref. Appendix 'A'):

- Study Area;
- Project Overview;
- Study Background and Purpose;
- Study Goal;
- Study Objectives;
- Conservation Ontario Class EA Approach;
- Hydrology Assessment (Surface Water System);
- Hydraulic Assessment;
- Natural Environment (Fish Habitat and Aquatic Community Overview);
- Natural Environment (Terrestrial Ecology Overview);
- Hydrogeology (Groundwater),
- Problem and Opportunity Statement;
- Preliminary Alternatives – Flood and Erosion Control Storage Systems;
- Preliminary Alternative Assessment; and
- Next Steps.

The fist PIC was moderately well attended, with 15 ± people signing in and approximately 20 ± people estimated to have been in attendance. People expressed positive comments regarding the creation of a new conservation area and reduced flooding potential below the Escarpment. Copies of all comments received and written responses are contained in Appendix 'A'.

Public Information Centre No. 2

The Public and Agencies were notified of Public Information Centre Number 2 by letter and newspaper advertisement early November, 2017. Public Information Centre Number 2

(PIC No. 2) was held on Wednesday November 28, 2017 at the Croatian Community Centre at 166 Green Mountain Road East, Stoney Creek. PIC No. 2 included a presentation of the PIC boards by the Project Team and provided the general public an opportunity to ask questions of the Project Team following the presentation. The public was able to review the preliminary preferred alternatives and discuss issues related to the project, including storage area locations and environmental considerations. Letters to stakeholders and agencies, copies of all comments received and written responses are contained in Appendix 'A'. Display boards were prepared that presented the following information (ref. Appendix 'A'):

- Study Area;
- Study Background and Purpose;
- Study Goal;
- Study Objectives;
- Conservation Ontario Class EA Approach;
- Problem and Opportunity Statement;
- Flood and Erosion Control Alternatives;
- Approaches for Flood and Erosion Control Storage Systems;
- Potential Locations for Flood and Erosion Control Storage Systems;
- Alternative Assessment Evaluation Criteria;
- Evaluation/ Screening of Potential Storage Sites;
- Preliminary Preferred Flood and Erosion Control Storage Systems;
- Summary of Results for Preliminary Preferred Flood and Erosion Control Systems;
- Implementation of Flood and Erosion Control Storage Systems; and
- Next Steps.

Approximately 20 people attended the PIC with 15 people signing in. The majority of comments and/or questions on the presentation related to the preferred locations of the storage facilities and details related to the potential new HCA conservation area.

Filing of the Environmental Study Report

All parties having expressed an interest in the project will be notified by letter, regarding the completion of the project and filing of the ESR. In addition, a Notice of Completion will be placed in the local newspaper, Hamilton Spectator on and posted on the Hamilton Conservation Authority's website, in accordance with the requirements of the Class EA.

Copies of the Environmental Study Report will be made available at the following locations:

Hamilton Conservation Authority
Woodend
838 Mineral Springs Road
P.O. Box 81067
Ancaster, Ontario, Canada
Hours: Mon-Fri: 8:30 a.m. to 4:30 p.m.

A review period of not less than thirty (30) days will be provided, during which comments will be received from stakeholders and agencies. Should stakeholders raise issues that cannot be resolved through discussion with Hamilton Conservation Authority and Consultant staff, the stakeholder may request the Minister to require the Hamilton Conservation Authority to complete an individual EA in accordance with Part II of the EA Act. This is known as a “Part II Order” (formerly known as a ‘Bump-up’). However, it is anticipated that all concerns will be resolved through discussion between Hamilton Conservation Authority and the concerned party.

2.0 BACKGROUND INVENTORY

This section provides a summary of the background information which has been collected and reviewed for this study. A significant amount of information has been made available for each sub-discipline: hydrogeology, water resources, aquatics and terrestrial ecology related to system characterization of the study area, however the main focus of this section pertains to the water resources aspects of the project.

2.1 Reports, Studies and Mapping

The following background information has been reviewed by Amec Foster Wheeler as a basis for existing hydrology, hydraulics and erosion conditions.

Mapping:

GIS Mapping Layers:

- Study Area Boundary
- Culverts (No-data)
- Generic Regulatory Flood lines
- 0.5 m Contours (Year Unknown)
- Property Fabric

Digital Elevation Model (Year Unknown)
Culvert Location Plan, 1984

Data:

Rainfall Data:

- 5 minute data at Jones Road (12/30/2012 to 03/23/2016)
- 5 minute data at Queenston Road (8/20/2007 to 03/23/2016)

Flow Data:

- 15 minute data on Stoney Creek north of Queenston Road (06/30/2003 to 06/29/2015)

Reports and Documents:

July 2017: When the Big Storm Hits: the Role of Wetlands to Limit Urban and Rural Flood Damage, the Intact Centre on Climate Adaption

A report documenting the benefits of wetland in reducing urban and rural flood damages due to the peak flow attenuation resulting from wetlands. Two (2) pilot sites were selected, one rural and one urban, located in southern Ontario. Flood damages for the two locations were determined with and without existing wetlands, and determined that with the wetlands in place there would be 29 % and 38 % reduction in rural and urban flood damages.

March 2015: Battlefield Creek Hydrologic and Hydraulic Assessment at Centennial Parkway and CPR Culvert Crossings, Amec Foster Wheeler

A hydrologic and hydraulic assessment of the Battlefield Creek crossings of Centennial Parkway and CPR on behalf of the City of Hamilton to establish recommendations to prevent the flooding of the residential subdivision located west of Greenhill Avenue. Flooding of the residential subdivision occurred on December 1, 2006 and results from a low intensity/ high volume rainfall event ranging in depth from 38 mm to 67 mm. The City of Hamilton determined that a blocked culvert under Centennial Parkway resulted in spill from Battlefield Creek along the Canadian Pacific Tracks to the community west of Greenhill Avenue.

The hydrologic/ hydraulic assessment included an update to the 2011 QUALHYMO hydrologic modelling prepared for the November 2011, Stoney Creek and Battlefield Creek Flood and Erosion Control Class EA. Recommendations included raising the overflow spill elevation of Centennial Parkway Box Culvert # 453 (3.05 m by 1.52 m by 109 m), repair of Culvert # 453, debris trap upstream of Culvert # 453 and improved maintenance access to Culvert #453.

February 2015: East Escarpment Conservation Area Watershed Restoration Program, HCA

Provides Program goals and objectives to determine the feasibility of reducing existing flooding and erosion conditions below the Niagara Escarpment by implementing storage sites above the Escarpment.

November 2011: Stoney Creek and Battlefield Creek Flood and Erosion Control Class Environmental Assessment (EA), AMEC

The Class EA provided a baseline assessment of existing flooding and erosion conditions within Battlefield Creek and Stoney Creek below the Niagara Escarpment. Characterization of existing hydrologic conditions included design event and frequency peak flows from an updated QUALHYMO hydrologic model. Hydraulic characterization was facilitated using a HEC-RAS hydraulic model. Previous hydraulic modeling used HEC-2 prepared for the 1989 City of Stoney Creek Flood Damage Reduction Program. The Class EA provided prioritized local and reach level recommendations for addressing and preventing flooding and erosion conditions.

Storage upstream of the Niagara Escarpment was assessed at a high level based on two (2) conceptual storage facility locations, Ridge Road and Third Line, and the available storage upstream of the road crossings. The Ridge Road conceptual storage facility could provide 22,136 m^3, while the Third Road location could provide 68,795 m^3 of storage.

2010: Integration of the Watercourse Erosion Restoration Implementation Plan, Aquafor Beech Ltd.

The Watercourse Erosion Restoration Implementation Plan identified priority erosion sites according to a City-wide ranking system. Seven of the top 30 ranked priority erosion sites at the time of the 2011 Class EA were identified within the Stoney Creek and Battlefield Creek watershed; as such, the 2011 Class EA integrated the Watercourse Erosion Restoration Implementation Plan findings.

April 2006: Stormwater Quality Management Strategy Community of Stoney Creek Master Plan, Philips Engineering Ltd.

Stormwater quality management measures for each watercourse within the community of Stoney Creek were recommended based on future land use conditions, including source controls, management practices and end-of-pipe controls. Retrofit facilities were recommended were feasible and provided adequate water quality benefit. Prioritization of retrofit and proposed stormwater quality facilities was determined based upon cost efficiency (TSS removed/Cost).

The stormwater management measures recommendations were determined with the objective of no net loss of aquatic habitat and to address to the extent possible the impacts of existing development on water quality through appropriate stormwater management practices. As such the study area inventory not only included water quality but aquatic resources and hydrogeology. Water quality for Stoney Creek was determined to be impaired by development runoff, which was also concluded by the benthic communities found within the creek. The fish community was common to that of most small urban watersheds and was found to be dominated by white sucker, fathead minnow and brook stickleback that said, several rainbow trout were observed upstream of the CNR Bridge.

February 1990: City of Stoney Creek Flood Damage Reduction Program Floodway Analysis Final Report, Philips Planning & Engineering Limited

Following the completion of the detailed hydraulic modelling for the Flood Damage Reduction Program for Stoney and Battlefield Creeks, as well as Watercourses 1-7, 9 and 12, this study determined the floodway alignment and regulatory elevations for each watercourse based on either the 100 year floodplain, floodway width of 63 m and encroachment resulting in 0.15 m increase in Regulatory flood elevations.

June 1989: City of Stoney Creek Flood Damage Reduction Study General Report, Philips Planning & Engineering Limited

This report provides a summary of the, hydrology, hydraulics and flood line delineation determined for Stoney and Battlefield Creeks, Watercourses 1-7, 9 and 12, using the 1986 Ministry of Natural Resources Floodplain Management in Ontario Technical Guidelines.

November 1976: Stoney & Battlefield Creeks Flood Line Mapping Study, Dillon

The Flood Line Mapping Study established peak flows for Stoney and Battlefield Creek using the HYMO hydrologic modelling platform for the 2 to 100 year storm events and Regional Storm Hurricane Hazel. Flood elevations for the 50 year and Regional Storm were determined using the HEC-2 hydraulic modelling platform. General recommendations were provided to assist the Hamilton Region Conservation Authority in preventing flooding conditions.

March 1973, Battlefield and Stoney Creek Flood Line Mapping, Foundation of Canada Engineering Corporation Limited (FENCO)

Based on the hydrology conducted within the 1970 Flood and Erosion Control project, FENCO determined flood lines for Stoney Creek using the Regional Storm peak flow of 70.8 m^3/s (2500 cfs) and a reduced Regional Storm flow based on recommended upstream storage of 42.5 m^3/s (1500 cfs). For Battlefield Creek, the 100 year peak flow was 36.8 m^3/s (1300 cfs).

June 1970: Flood and Erosion Control, Town of Stoney Creek, Foundation of Canada Engineering Corporation Limited

The 1970 study determined peak flows for the 100 year storm and Regional Storm Hurricane Hazel based on rainfall records. Peak flows for the 100 year storm event were determined using synthesized hydrographs. It is unclear how flood elevations and conditions were determined for the Battlefield and Stoney Creek. The study provided recommendations and capital costs estimates to reduce flooding and erosion conditions, including storage upstream of the Niagara Escarpment within three (3) storage areas, 120 acres upstream of Third Line, 50 acres upstream of Green Mountain Road and 60 acres upstream of Tapleytown Road within a dyked area. The storage volume of 1,110,132 m^3 (900 acre feet) located upstream of the Escarpment, was determined to prevent flooding in Stoney Creek, resulting in reducing the Regional Storm peak flows within Stoney Creek from 70.8 m^3/s (2500 cfs) to 42.5 m^3/s (1500 cfs). The study recommended that further assessment be conducted of storage opportunities above the Escarpment.

Models:

No hydrologic and hydraulic models have been provided by HCA or the City of Hamilton. Modelling files from former studies conducted by Amec Foster Wheeler and its predecessors have been used, most notably the QUALHYMO (Hydrology) and HEC-RAS model (hydraulics) from the 2011 Draft Class EA.

3.0 BASELINE INVENTORY

The Conservation Ontario Class EA process requires that a baseline inventory of the study area resources be completed. The baseline inventory completed for this study has been conducted in order to document the background information and assess the potential for impacts related to the proposed storage facilities intended to reduce flood risk and erosion conditions below the Escarpment, including hydrogeology, hydrology, hydraulics, aquatic and terrestrial habitat and stream morphology (critical flows).

3.1 Hydrogeology

The Stoney Battlefield Creek study area straddles three physiographic regions; (i) The Haldimand Clay Plain (ii) The Niagara Escarpment and (iii) the Iroquois Plain. The Haldimand Clay Plain is generally flat to rolling. The Vinemount Moraine and Niagara Falls Moraine transect the Haldimand Clay Plain parallel to the Niagara Escarpment accounting for some of the local relief. The southern limit of the Stoney Creek watershed is delineated in part by the Niagara Falls Moraine which serves as a groundwater divide between Twenty Mile Creek, Forty Mile Creek and the study area. The Niagara Escarpment represents a significant physiographic region which extends as a band across Ontario from Niagara Falls to the east to the Bruce Peninsula to the northwest. The Niagara Escarpment is capped with a resistant dolostone of the Lockport Formation which is typified by a steep rock bluff above a talus till covered slope.

The Haldimand Clay Plain, on top of the Niagara Escarpment, consists of glaciolacustrine clay and silt deposits overlying the Vinemount and Niagara Falls Moraines. These moraines consist of Halton Till which were deposited during the Port Huron Stage of the late Wisconsinian Stage. The overlying clay and silt were deposited shortly thereafter during the same stage at the northern margin of an extensive pre-glacial lake, Lake Warren. The Iroquois Plain represents a north sloping plain with several stranded shoreline features located between the Niagara Escarpment and present day Lake Ontario. Bedrock is very close to ground surface through a large portion of the Stoney and Battlefield Creek below the Niagara Escarpment. Above the Niagara Escarpment overburden is generally less than 8 m thick except in the morainic areas.

The bedrock geology includes the Lockport Dolostone (Gasport and Eramosa Members) above the Niagara Escarpment and the Queenston Shale below the Escarpment. The surficial topography generally reflects the bedrock topography through a majority of the watershed. The bedrock topography slopes towards the Escarpment.

Within the Stoney and Battlefield Creek study area much of the surficial overburden consists of clay material which typically is of a low permeability, that is, it does not transmit water readily. When the clay overburden is thin and overlies a more permeable unit, which acts to underdrain the overburden, extensive fracturing in the clay generally occurs. Throughout the upper portion of the watershed the underlying dolostone bedrock can be highly fractured in the upper 10 m. This bedrock fracturing allows for ready transmittal of groundwater both in the vertical and horizontal direction. The fracturing within the clay is known to occur to depths of 8 m (25 feet) and allows for a significant amount infiltration and movement of groundwater vertically. The horizontal hydraulic connection of the clay fractures is much weaker. Below the Escarpment the underlying bedrock is a low permeable shale which may not provide as significant an underdrain and as such will likely not lead to extensive fracturing in the overlying clay tills.

Above the Niagara Escarpment, where the overburden is generally less than 8 metres thick, precipitation infiltrates through the overburden to the upper bedrock. The groundwater moves horizontally through the fractured dolostones of the Guelph, Eramosa and Gasport Units and would normally discharge to the creek and local tributaries, generally where topographic breaks occur and the bedrock outcrops. This does not appear to occur to any great degree above the escarpment.

The Vinemount Shale will tend act as an aquitard or a barrier to the vertical transmittal of significant amounts of groundwater (ref. Appendix F, Figures GW-1 and GW-2). Groundwater is transmitted to depth under relatively strong hydraulic gradients (i.e. differences in water levels in the various units). The amount transmitted is a smaller percentage of that groundwater which moves through the shallow horizontal flow system due to the low vertical permeability of a number of the geological units, in particular the shale units. In areas along the face of the Niagara escarpment groundwater may discharge as diffuse seeps; this water tends to be lost to evapotranspiration.

Karst features can be characteristic to the dolostone formations within the Hamilton/Stoney Creek area. These features can lead to caves, sinkholes and a generally enhanced network off more permeable connected pathways. These features are known to exist to the west (Eramosa Karst) but have not been reported within the Stoney Battlefield Creek area.

The “Assessment Report – Hamilton Region Source Protection Area”, (August 2015) indicates the eastern area above the escarpment, as well as the area below the escarpment, as a Highly Vulnerable Aquifer that is an aquifer which are more susceptible to contamination from surface sources.

The Assessment Report also indicates the northern area above the escarpment as a significant groundwater recharge area that is susceptible to contamination.

3.2 Hydrology

3.2.1 Modelling Background

Amec Foster Wheeler prepared a calibrated QUALHYMO hydrologic model as part of the 2011 Draft Class Environmental Assessment. The QUALHYMO model was used to determine both design event (SCS Type II 12 Hr) and frequency flows using a continuous simulation (Royal Botanical Gardens rainfall gauge data) for existing and future land use conditions. Design event and frequency peak flows were determined for the 2 to 100 year, and Regional Storm (Hurricane Hazel) peak flows.

In 2015, a hydrologic and hydraulic assessment of the Battlefield Creek crossings of Centennial Parkway and CPR was conducted on behalf of the City of Hamilton to establish recommendations to prevent the flooding of the residential subdivision located west of Greenhill Avenue. The hydrologic/ hydraulic assessment included a local update to the 2011 QUALHYMO hydrologic modelling prepared for the 2011 Draft Class EA.

The 2015 hydrologic model incorporated storage upstream of culvert crossings to determine 'real' peak flows as part of a forensic assessment. The modelling increased the degree of Battlefield Creek catchment discretization, as compared to the 2011 Draft Class EA modelling.

3.2.2 Baseline Condition Modelling

In order to establish a baseline hydrologic model for this project, the 2011 Class EA model (without storage upstream of structures) has been updated with the 2015 Battlefield Creek catchments and creek routing. As noted, the storage upstream of culvert crossings within 2015 hydrologic model has been removed. With the updated baseline condition modelling, a revised catchment plan and associated model schematic has been prepared (ref. Figures 1 and 2). The revised catchment plan has incorporated catchment boundaries specifically required to assess storage locations. Peak flows have been determined for this current assessment using the design event SCS Type II 12 Hour storm with the future land use condition. To validate the baseline condition QUALHYMO modelling, a comparison of the baseline condition and the 2011 Draft Class EA design event derived peak flows has been conducted (ref. Table 3.1). The relative difference between peak flows simulated by the two (2) models has been provided within Table 3.2.

Table 3.1 Comparison of Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
2011 Stoney Creek and Battlefield Creek Class EA							
Stoney Creek							
Edge of Escarpment	6.73	13.53	20.36	27.84	34.57	41.50	136.27
King St.	7.21	14.21	21.19	28.91	35.84	42.92	140.88
Highway 8	7.43	14.49	21.53	29.35	36.34	43.47	142.40
Battlefield/Stoney Creek Confluence	11.52	21.62	30.62	41.11	50.81	59.90	188.01
CNR	11.85	21.63	31.05	41.66	51.12	60.56	189.22
QEW	12.93	23.12	32.78	43.85	53.62	63.35	195.50
Lake Ontario	12.95	23.18	32.83	43.91	53.72	63.43	195.59
Battlefield Creek							
Confluence near Centennial Parkway	1.74	3.35	4.86	6.53	8.08	9.62	29.92
Edge of Escarpment	2.18	4.10	5.88	7.81	9.64	11.45	34.97
King St.	4.22	6.67	8.66	10.95	12.74	14.63	39.44
Highway 8	4.97	7.58	9.68	12.14	14.00	15.96	44.40
Updated Model							
Stoney Creek							
Edge of Escarpment	7.32	14.57	22.08	30.60	38.49	46.70	142.85
King St.	7.61	14.96	22.58	31.20	39.20	47.50	145.21
Highway 8	8.15	15.60	23.33	32.10	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.90	194.14
CNR	12.72	22.84	33.04	44.77	55.40	66.30	198.33
QEW	13.79	24.39	34.86	47.02	58.00	69.20	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
Battlefield Creek							
Confluence near Centennial Parkway	1.38	2.66	4.32	6.23	8.15	10.17	25.77
Edge of Escarpment	2.25	4.13	5.82	7.84	9.59	11.91	33.13
King St.	3.53	5.96	8.06	10.56	12.63	14.81	38.49
Highway 8	4.40	7.09	9.38	12.03	14.16	16.39	43.49

Table 3.2 Percent Difference in Simulated Design Event Peak Flows Current Study to 2011 Class EA (Future Land Use) (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Stoney Creek							
Edge of Escarpment	8.77	7.69	8.45	9.91	11.34	12.53	4.83
King St.	5.55	5.28	6.56	7.92	9.38	10.67	3.07
Highway 8	9.69	7.66	8.36	9.37	10.57	11.69	5.04
Battlefield/ Stoney Creek Confluence	4.60	1.85	5.00	6.08	6.53	8.35	3.26
CNR	7.34	5.59	6.41	7.47	8.37	9.48	4.81
QEW	6.65	5.49	6.35	7.23	8.17	9.23	4.95
Lake Ontario	6.49	5.39	6.27	7.22	8.12	9.22	5.05
Battlefield Creek							
Confluence near Centennial Parkway	-20.69	-20.60	-11.11	-4.59	0.87	5.72	-13.87
Edge of Escarpment	3.21	0.73	-1.02	0.38	-0.52	4.02	-5.26
King St.	-16.35	-10.64	-6.93	-3.56	-0.86	1.23	-2.41
Highway 8	-11.47	-6.46	-3.10	-0.91	1.14	2.69	-2.05

The results in Tables 3.1 and 3.2 indicate that peak flows for Battlefield Creek are moderately unchanged for the less frequent storm events (10 year to 100 year) (<12 % percentage difference) from the original Class EA. Discretization of the Battlefield Creek above the Niagara Escarpment to its base had been increased as part of the 2015 Centennial Parkway Battlefield Creek hydrologic/ hydraulic assessment from six (6) catchments to thirteen (13) catchments. As part of this current assessment, an additional three (3) catchments have been added to Battlefield Creek and eleven (11) catchments have been added to Stoney Creek to account for the potential locations of storage areas. As such, the timing and routing of peak flows has been changed from the original Class EA modelling resulting in the difference in peak flows for the more frequent (2-10 year) events.

The hydrologic modelling of Battlefield Creek for the Centennial Parkway assessment is considered to be an improvement over the Class EA based on discretization, updated land use parameterization and drainage feature hydraulic routing. The 2015 Battlefield Creek investigation also included modelling of the existing Nash Neighbourhood development located north of Green Mountain Road East and west of Centennial Parkway using subdivision detail design drawings and associated stormwater management. This was also considered an improvement of the higher level development detail within the Nash Neighbourhood Stormwater Management Update Study, Philips Engineering Ltd., 1998.

The minor decreases in peak flows for the future land use condition (2 year to 10 year) are considered reasonable based on the Battlefield Creek and Stoney Creek hydrologic modelling revisions and associated higher resolution to refine hydrograph timing.

3.3 Hydraulics

Hydraulic modelling for both the lower Stoney Creek and lower Battlefield Creek had been conducted to the base of the Niagara Escarpment as part of the 2011 Draft Class EA (ref. Figure 4). Subsequently, the 2015 Hydrologic and Hydraulic Assessment of the Battlefield Creek Centennial Parkway crossings, expanded upon the 2011 Draft Class EA hydraulic assessment, by modelling Battlefield Creek to just upstream of Ridge Road above the Niagara Escarpment.

As part of the current project, the detailed hydraulic model for Battlefield Creek, has been extended for the balance of upper Battlefield Creek. Furthermore, a hydraulic model for upper Stoney Creek has also been developed using the City of Hamilton's contour mapping in the limits shown (ref. Figure 20).

Field reconnaissance and topographic survey has been conducted to provide detail of the road crossings above the Niagara Escarpment and the associated immediate upstream and downstream creek reaches (ref. Figure 3.1). Appendix B provides a photographic inventory and field notes of the culverts observed; Amec Foster Wheeler's survey scope for the subject area culverts included:

i. Review Mapping and Set controls and Benchmarks
ii. Conduct survey of culverts (dimensioning, upstream and downstream inverts and sections at culvert faces)
iii. Conduct survey of watercourses upstream and downstream of culverts

The new HEC-RAS hydraulic modelling has been used to determine flood elevations for the 2 to 100 year and Regional Storm events (ref. Figure 20 for the 100 year and Regional Storm floodlines). Spill conditions have also been indicated on Figure 20, where the watercourse system has inadequate capacity to fully contain the 100 year storm and / or Regional Storm.

Table 3.3 provides the details of the hydraulic crossings (culverts and bridges) including appropriate hydraulic capacity based on the results of the HEC-RAS hydraulic modelling. The hydraulic capacity of culverts has been compared to the requirements cited in the 2008 Ministry of Transportation (MTO) Highway Drainage Design Standards, which for Rural Collector or Arterial Roads require hydraulic structures less than 6 m span to convey the 25 year storm peak flow with an appropriate freeboard and clearance and all structures greater than 6 m span to similarly convey the 50 year storm peak flow.

As shown by Table 3.3, several structures do not convey the 25/50 year storm peak flows as required by the 2008 MTO Highway Drainage Design Standards, with flood elevations in many locations overtopping the roadways.

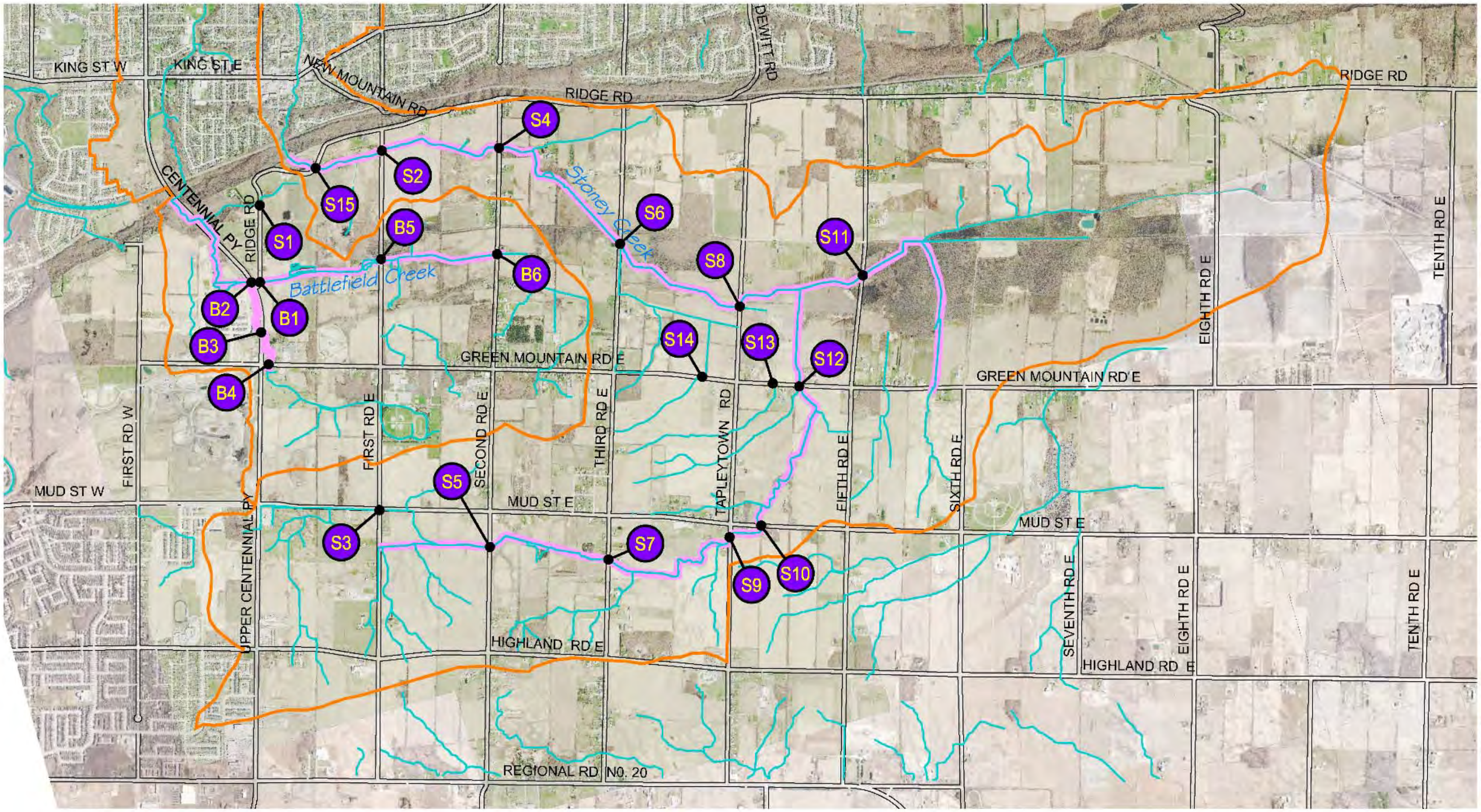

Figure 3.1 Culvert Field Reconnaissance Plan

Table 3.3 Culvert Summary

Culvert Location			Culvert Type			Culvert Dimensions			General Channel Dimensions			Required Capacity	Actual Capacity	Additional Notes
ID#	Creek	Road Crossing	Material	Shape	Type	Rise	Span	EOP	BF Width	BF Depth	WL	$(m^3/s)/yr$	$(m^3/s)/yr$	
B1	Battlefield	Ridge Rd (Just North of Ridge Rd and Upper Centennial)	Conc.	Box	O	1.26	1.86	2.86	3.45	0.76	0.24	4.29/25	2.70/10	UPS/DS channel dimensions are very different.
B2	Battlefield	Upper Centennial (Just North of Ridge Rd and Upper Centennial)	Conc.	Box – Hexagon opening UPS	O/C	1.28* C Rise	1.50* C Span	2.90	0.48	0.445	0.31	4.29/25	4.29/25	UPS culvert is closed, DS culvert is box – transition in middle – different on both ends.
B3	Battlefield	Upper Centennial (Between Ridge Rd and Green Mountain Rd)	Conc.	Box	O/C	0.94* C Rise	1.05* C Span	6.94	8.3* DS channel dimensions	0.93	0.04	1.29/25	1.88/100	UPS culvert is closed box, DS culvert is open box – transition in middle – different on both ends.
B4	Battlefield	Green Mountain (Just East of Upper Centennial)	Conc.	Box	C	1.20	1.90	2.80	5.325	0.45	0.08	1.29/25	6.09/Reg	DS culvert is closed box, assumed UPS culvert is closed box – looks new.
B5	Battlefield	First Rd (Between Ridge Rd and Green Mountain Rd)	Conc.	Box	O	1.00	2.13	1.30	3.58	0.80	0.28	4.29/25	0.74/2	UPS/DS channel dimensions are very different, DS leads to pond.
B6	Battlefield	Second Rd (Between Ridge Rd and Green Mountain Rd)	CSP	Circle	C	0.74 D = 0.90* From 1984 dwg	1.04	1.19	4.19	0.455	0.175	2.06/25	0.51/2	Circular culvert slightly bent over time.
S1	Stoney	Ridge Rd (North of B1, before Ridge Rd turns East)	CSP	Arch or sed filled Circle	O	0.35	0.87	0.82	3.10	0.555	0.00	NA/25	NA	Dry undefined channel, CSP culvert is damaged on DS side.
S2	Stoney	First Rd (North of B5, between Ridge Rd and Green Mountain Rd)	Dual Conc.	Box	O	1.31	3.00	1.71	11.20	1.775	0.19	28.26/25	13.57/5	Dual conc. culverts have same dimensions, LB culvert filled with more sediment – shorter rise.
S3	Stoney	First Rd (Just South of Mud St and First Rd intersection)	Conc.	Box	N/A	0.87	2.45	1.19	3.0	0.645	0.125	3.00/25	2.16/10	Sediment overflow in culvert from adjacent roads, not on 1984 dwg.
S4	Stoney	Second Rd (North of B6, btw Ridge and Green Mountain)	Conc.	Box	O	1.55	6.10	2.0	10.30	0.84	0.14	35.44/50	6.70/2	Both UPS/DS extents have CSP culverts on both banks – from ditch.
S5	Stoney	Second Rd (Between Mud St and Highland Rd)	Conc.	Box	O	0.80	4.88	1.60	4.0	0.60	0.15	6.76/25	4.81/10	DS channel not as defined as UPS.
S6	Stoney	Third Rd (Between Ridge and Green Mountain)	Conc.	Box	O	1.42	8.0	1.90	9.30	1.07	0.31	33.74/50	12.94/5	Wide stagnant channel.
S7	Stoney	Third Rd (Between Mud St and Highland Rd)	Conc.	Box	O	1.13	5.80	1.68	8.25	0.795	0.08	6.76/25	10.21/100	Wide, shallow, grassy braiding channel.
S8	Stoney	Tapleytown Rd (Between Powerline Rd and Green Mountain)	Conc. & Metal	Box - bridge	O	1.21	7.20	2.01	7.40	1.22	0.175	31.14/50	11.98/5	Pooling at UPS culvert, braiding at DS culvert
S9	Stoney	Tapleytown Rd (Just South of Mud, between Mud St and Highland Rd)	Conc. & Metal	Box - bridge	N/A	1.10	8.10	1.90	1.90	0.605	0.135	11.73/50	14.10/100	UPS extent bed in culvert is bedrock/conc, DS extent had sediment.
S10	Stoney	Mud St (Between Fifth Rd and Tapleytown Rd)	Conc. & Rock	Box - bridge	O	1.185	14.0	1.99	10.50	1.025	0.115	11.73/50	6.72/10	River rock bank lining outside and in culvert
S11	Stoney	Fifth Rd (Between Powerline Rd and Green Mountain Rd)	Conc.	Box	N/A	0.905	2.21	1.41	4.70	1.02	0.17	9.34/25	<2.21/<2	Sediment in culvert.

Table 3.3 Culvert Summary

Culvert Location			Culvert Type			Culvert Dimensions			General Channel Dimensions			Required Capacity	Actual Capacity	Additional Notes
ID#	Creek	Road Crossing	Material	Shape	Type	Rise	Span	EOP	BF Width	BF Depth	WL	(m^3/s)/yr	(m^3/s)/yr	
S12	Stoney	Green Mountain (Between Fifth Rd and Tapleytown Rd)	Conc.	Box	N/A	1.165	6.15	1.77	3.85	0.505	0.065	16.67/50	16.67/50	Sediment and saturated woody debris in culvert.
S13	Stoney	Green Mountain (West of S12, between Fifth Rd and Tapleytown Rd)	CSP	Circle	C	D = 0.61 = 2 ft		1.16	2.20* DS channel dimensions	0.96	0.44	NA/25	NA	UPS no defined channel – spillway depression from a private culvert. DS culvert is damaged.
S14	Stoney	Green Mountain (Between Third Rd and Tapleytown Rd)	Dual CSP	Circle	C	D = 0.61 = 2 ft For both		0.81	3.07	0.70	0.00	NA/25	NA	Dry ditch channel UPS and dry channel DS.
S15	Stoney	Ridge Rd. (Immediately upstream of Devil's Punchbowl)	Conc.	Box	O	2.30	6.0	3.32	7.40	0.71	0.00	29.53/25	44.78/100	Bedrock bed, at UPS ext rise=2.20 m, in mid culvert bed downcut additional 0.55 m.

NOTES: ID# – Chosen by field inspector, B = Battlefield Creek, S = Stoney Creek
Culvert Type – O = Open, C = Closed, N/A = Could not tell from inspection – sediment coverage
Culvert Dimensions – Rise and Span are of culvert opening, EOP is estimated from creek invert to road elevation
Channel Dimensions – Bankful Width and Depth at low flow conditions, WL = water level taken during inspection
*Dimensions of Channel and Culvert are generalized by UPS (Upstream) and DS (Downstream) conditions to make one measurement – Averaged
*All dimensions are in metres (m)
NA – Flows not available

3.4 Flood and Erosion Risk

The flood and erosion risks within the lower Stoney Creek and Battlefield Creek were established as part of the 2011 Draft Class EA. The hydrology for both creek systems was updated from the OTTHYMO-83 hydrologic modelling used in the 1989 City of Stoney Creek Flood Damage Reduction Study, to a calibrated QUALHYMO model as part of the Class EA. In addition the Class EA study updated the hydraulic HEC-2 modelling from the 1989 study format to HEC-RAS. The hydraulic modelling was used to determine the level of flood risk on a reach by reach basis.

The 2011 Draft Class EA summarized flooding and erosion issues on a reach basis. Flooding mechanisms vary on a reach by reach basis, ranging from restricted culvert and bridge flow capacity to existing development encroachment. Figure 4 graphically depicts the 100 year and Regional Storm floodlines providing a better understanding of flooding risks for each reach. Flood issues and key risks identified within the 2011 Draft Class EA for each reach are detailed in Table 3.5 (ref. Figure 3 for reach references).

Erosion risks were also determined on a reach basis, primarily through field reconnaissance. To supplement the field reconnaissance, the fluvial system was further assessed using a Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT). The RGA documents observed indicators of channel instability (ref. MOE, 1999). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41) (reference Table 3.4).

Data from Table 3.4 suggest that the majority of the reaches along both Stoney Creek and Battlefield Creek are in a state of *transition,* exhibiting lower stream health. The key geomorphic process occurring along these reaches appears to be channel widening with aggradation occurring to a lesser degree. The low stream health rating is due primarily to a combination of relatively poor channel stability, clear evidence of basal scour, and low quality (and quantity of) in-stream aquatic habitat.

Table 3.4 Summary of 2011 Class EA RGA and RSAT Assessments

Reach[1]	RGA score	Condition	RSAT score	Condition
BC-1	0.32	Transitional	22	Moderate
BC-2	0.27	Transitional	18.5	Low
BC-3	0.25	Transitional	19	Low
BC-4	0.22	Transitional	17	Low
BC-5	0.25	Transitional	16	Low
SC-1	0.24	Transitional	17	Low
SC-2	0.33	Transitional	16	Low
SC-3	0.09	In Regime	20	Moderate
SC-4	0.30	Transitional	21	Moderate
SC-5	0.34	Transitional	16.5	Low
SC-6	0.22	Transitional	17.5	Low
SC-7	0.17	In Regime	19	Low

Note: [1] Reference Figure 3 for location of reaches

Key erosion issues are related to several factors including confinement of the channel by previous development, lack of historical application of stormwater management, locations of valley wall contact and existing structures that are failing. As noted, this has led to the dominant mode of adjustment along the majority of reaches being widening and aggradation. Existing erosion risks as identified within the 2011 Draft Class EA are detailed for each reach in Table 3.5.

The Watercourse Erosion Restoration Implementation Plan (Aquafor Beech, 2010) identified priority erosion sites according to a City-wide ranking system. Seven of the top 30 ranked priority erosion sites at the time of the 2011 Draft Class EA were identified within the Stoney Creek and Battlefield Creek watershed; as such, this Class EA project has integrated the Watercourse Erosion Restoration Implementation Plan findings (ref. Table 3.6).

Table 3.5 Summary of Flood and Erosion Risks along Battlefield Creek and Stoney Creek

Reach	Flooding Mechanism	Flooding Risks	Existing Erosion	Existing Modification	Erosion Risks
BC-1	Hydraulic Capacity of Barton Street crossing and floodplain encroachment. CNR crossing capacity – limited impact	▶ Rear yard of 1 house on Blueberry Dr. (Regional Storm) (< .5 m +/-) ▶ 1 residential lot, 3 front yards on Huckleberry Dr (Regional Storm) (0 – 3 m +/-) ▶ 2 rear yards and 5 front yards on Lake Ave. N. (Regional Storm) (0 – 2.5 m +-/)	Minor erosion -tree-lined banks prevent channel widening due to dense roots.	Historically realigned, particularly at confluence with Stoney Creek.	None identified. A sewer pipeline is present in the floodplain along the east bank, however, tree-lining limits lateral channel migration.
BC-2 (Henry & Beatrice Warden Park)	Hydraulic Capacity of Barton Street crossing and floodplain encroachment.	▶ 2 residential lots on Lake Ave. N. (< 100 year storm) (4 m +/-) ▶ Apartment complex walkway on Lake Ave. (Regional Storm) (< .5 m +/-) ▶ 1 front yard on Lake Ave. N. (Regional Storm) (< .5 m +/-)	Minor to moderate erosion. Channel is confined causing erosion to above top of bank. Localized valley wall contact Contains Priority Erosion Site*	Trees being used as ad-hoc bank protection. Historic realignment due to road crossing at downstream end.	Undermining of several stormwater outfalls. Bank erosion adjacent to Queenston Road. Queenston Road sanitary sewer.
BC-3 (Green acres Park)	Queenston Road crossing capacity, and floodplain encroachment. Queenston Road has a hydraulic impact on 50 year to Regional Storm flood elevations for 200 m +/- upstream.	▶ Hydro transformer station on Queenston Road (Regional Storm) (< 2 m +/-) ▶ 3 rear yards on Galbraith Dr. (Regional Storm) (< 2.5 m +/-) ▶ 1 rear yard on Avalon Ave. (rear yard) (< 1 m +/-) ▶ 1 rear yard on Valley Dr. (< .5 m +/-) ▶ Most flooding occurs upstream of the hydraulic influence of Queenston Rd.	Localized valley wall contact on east bank (2 locations).	Historically straightened. Failed bank protection adjacent to Randall Avenue. Ad-hoc bank protection on west bank by upstream baseball pitch. Trail and sewer run along west bank through most of the reach. Mowing to top of bank in places	Randall Avenue road crossing. Private backyards mid-reach. Undermined stormwater outfalls mid reach and upstream of Queenston Road.
BC-4 (Hopkins Park)	Floodplain encroachment. King St. overflow (Regional Storm)	▶ School property on Randall Ave., not building (Regional Storm) (< 1 m +/-) ▶ 13 residential lots with at least half with homes flooded on Faircourt Dr. (< .5 m +/-) ▶ 9 homes/apartments north of King St., 5 of which flood less than 100 year Storm and rest 100 year to Regional (< 3 m +/-)	Localized erosion and valley contact on east bank where the channel still has sinuous planform. Contains 2 Priority Erosion Sites*	Historically straightened. Gabion bank protection on east bank mid-reach. Mowing to top of bank in places	Private backyards and driveway Undermined stormwater outfall
BC-5 (Battlefield Park)	King St. culvert flow capacity, but mostly floodplain encroachment.	▶ 3 properties immediately south of King St. (Regional Storm) (< 1 m)	Bank erosion due to incised nature of channel although banks are dominated by dense trees.	Mowing to top of bank in places downstream.	Property (Battlefield House Museum) in downstream section of the reach.
SC-1	QEW corridor crossings resulting in significant Regional Storm backwater conditions. CNR crossing upstream results in spill during Regional Storm.	▶ Minor Regional Storm flooding of rear industrial lots (< 1m +/-)	Scouring of channel banks caused by backing up from lake during high flows. Localized valley wall contact on east bank but dense trees	Upstream of South Service Road. High amount of urban debris.	None identified.

Table 3.5 Summary of Flood and Erosion Risks along Battlefield Creek and Stoney Creek

Reach	Flooding Mechanism	Flooding Risks	Existing Erosion	Existing Modification	Erosion Risks
SC-2	CNR crossing capacity resulting in Regional Storm backwater conditions.	▶ 16 industrial lots on either side of creek, at risk during the Regional Storm, with significant depth (0.5 to 1.0 m +/-)	Limited erosion. Currently slow flow and fine sediment deposition prevails. Issues relate to several large debris dams (natural and urban).	Historically straightened downstream of Barton Street East. Creation of debris dams due to beaver activity High amount of urban debris.	None identified.
SC-3	CNR crossing capacity resulting in Regional Storm backwater conditions.	▶ North end of townhouse complex at Bow Valley Dr. and Barton St. (Regional Storm) (< 0.5 m +/-)	Scouring of channel banks caused by backing up during high flows.	Historically straightened. Road culvert (7-8m wide) at downstream end. Not considered to be a restriction to flows (backing up is from CN Railway culvert downstream)	None identified.
SC-4	Queenston Rd. crossing hydraulic capacity – Regional Storm flood levels impacted for 200 m upstream of road. Development encroachment within floodplain and creek is completely within private property.	▶ Regional Storm flooding of residential yards along east side of creek (< 0.5 m) ▶ Flooding of rear lots < 1.5 m for storm events less than a 100 year along west side of creek. ▶ Flooding occurs mostly beyond backwater affect of Queenston Rd.	Channel entrenchment and confinement causing erosion to top of bank. Valley wall contact on west bank. Contains Priority Erosion Site MS2*	Pedestrian bridge mid-reach. Sewer runs on west bank then east bank crossing the creek mid-reach.	Private backyard Sanitary sewer crossing and maintenance hole downstream of pedestrian bridge
SC-5			Bank erosion undermining existing protection. Valley wall contact mid-reach at Donn Avenue causing slope instability Contains 3 Priority Erosion Site (ES9, ES13 & 14)*.	Failing existing bank protection in upstream section of reach. Development up to top of bank in upstream section and mid-reach.	Private property at upstream and mid-reach sections.
SC-6	Development has encroached within the floodplain. Residential rear yards form part of the creek block.	▶ Flooding occurs at most storm frequencies. Regional Storm flood depths in the range of 0.3 +/- ▶ Creek has a capacity of a 2 to 5 yr. storm flow capacity	Highly constrained channel due to historical urban development. Bank erosion undermining existing channel protection Contains 4 Priority Erosion Sites (ES15,16,18,19)*	Historical straightening Development to top of bank throughout the reach completely disconnecting the floodplain. Ad-hoc landowner bank protection.	Private backyards. Parking lot in upstream section.
SC-7	King St. culvert has a localized Regional Storm backwater effect of 1 m +/- for 100 m +/-	▶ Rear yard flooding for most storm events, < 1.5 m, but lateral extent of flooding is limited due to slope of watercourse valley and rear yard grading.	Highly constrained channel due to urban development. Localized bank erosion Contains 4 Priority Erosion Sites (ES20-23)*	Development to top of bank throughout the reach completely disconnecting the floodplain. Ad-hoc landowner bank protection.	Parking lot in upstream section. Private backyards.

Table 3.6 Priority Erosion Sites Identified in the City of Hamilton's Watercourse Erosion Restoration Implementation Plan

Rank (of 30)	Erosion Site	Watercourse	Reach	Reach Nomenclature for this study	Risk	Conceptual Design	Benefit
5	MS 2	Stoney Creek	ST 3	SC-4	▶ Sanitary access chamber	▶ Realign channel to increase distance from access chamber ▶ Repair and encase infrastructure as necessary ▶ Build riffle over sanitary lateral	▶ Reduction in risk to access chamber and sanitary sewer ▶ Aquatic habitat
7	ES 3	Battlefield Creek	BTF 2	BC-2	▶ Queenston Road Sanitary sewer ▶ Exposed storm sewer outfalls	▶ Realign channel to a more sinuous form and reinstate floodplain access -Encase sanitary sewer at crossing and protect with riffle ▶ Repair storm sewer outfalls and incorporate energy dissipation prior to confluence with channel	▶ Reduction in risk to Queenston Road and sanitary access chamber
9	ES 13-16	Stoney Creek	ST 6	SC-5 / SC-6	▶ Private property (yards and structures)	▶ Replace infrastructure in disrepair with toe protection, fascines, and vegetative cover	▶ Reduction in risk to private property
11	ES 9	Stoney Creek	ST 5	SC-5	▶ Private property	▶ Realign channel to a more sinuous form away from private property and reinstate floodplain access ▶ Assess cover over sanitary sewer and provide protection as required	▶ Reduction in risk to private property ▶ Reconnection to floodplain
15	ES 18-21	Stoney Creek	ST 7	SC-6 / SC-7	▶ Parking lot ▶ Driveway ▶ Private property ▶ Buildings/structure	▶ Replace infrastructure in disrepair with toe protection, fascines, and vegetative cover	▶ Reduction in risk to private property, buildings, and parking lot
19	ES 6-7	Battlefield Creek	BTF 4	BC-4$_1$	▶ Storm sewer outfall ▶ Private driveway	▶ Minor adjustment of channel planform away from private property ▶ Repair storm sewer outfall and provide energy dissipation	▶ Reduction in risk to private property ▶ Aquatic habitat
9	ES 22-23	Stoney Creek	ST 8	SC-7	▶ Private property ▶ Parking lot	▶ Remove existing bank protection that is in disrepair ▶ Refill/regrade bank and vegetate to stabilize ▶ Apply bioengineering and vegetation treatments to top of bank as property ownership allows	▶ Protection of private property ▶ Aquatic habitat

3.4.1 Refined Flood Risk Assessment

In order to potentially mitigate all, or part, of the flood and erosion risks cited earlier, (ref. Section 3.4) detention storage has been advanced in a number of previous studies as a potential management approach. Notionally, storage systems sited in the upper Stoney Creek and Battlefield Creek, would reduce peak flows, to address flooding and erosion conditions above and below the Escarpment. In establishing the potential for storage opportunities above the Escarpment, a systematic process of determining the potential benefit of flow reduction below the Escarpment has been advanced. The flood risk benefits resulting from flow reductions below the Escarpment have been quantified based on the:

- Number of buildings and properties removed from the floodplain(s)
- Reduction in flood frequency of properties and buildings. (i.e. 10 year storm to 25 year storm)
- Reduction in flood frequency of road and track crossings

The 2011 Draft Class EA, as noted in Table 3.5, determined that certain creek reaches were more flood prone than others (ref. Figure 4). The Draft Class EA also provided direction on the severity of flooding by determining flooding conditions on a reach basis, primarily for the Regional Storm. To further establish flooding conditions on a reach basis the number of properties and buildings for each storm frequency have been determined using the 2011 Draft Class EA hydraulic modelling, associated flood elevations and mapping (ref. Tables 3.7 and 3.8) (Note: Peak Flows reported in Tables 3.7 and 3.8 are based on continuous hydrologic modelling from 2011 Draft Class EA). Properties and buildings have been classified by land use as per the following:

- Residential
- Institutional
- Commercial
- Industrial
- Open Space
- Utility

Through a review of the number of properties and buildings at risk of flooding for all storm frequencies (2 to 100 year and Regional Storm), the flood risk and severity for each reach has been ascertained. In addition, critical peak flow targets associated with a potential significant reduction in flood risk, have been determined. For instance, critical peak flow targets for Stoney Creek Reach SC-6 have considered the 50 year flow of 35.7 m^3/s, which if reduced to the 25 year flow of 25.7 m^3/s, would reduce the number of residential buildings flooded from seven (7) to one (1). As such, a critical flow target of 25.7 m^3/s for the 50 year storm could notionally be set for this reach. Using this approach, the targets in Tables 3.9 and 3.10 for Stoney Creek and Battlefield Creek respectively, have been advanced for consideration on a reach-by-reach basis. These critical flow targets have been used to provide direction in sizing storage areas and associated discharge rates (Note: Peak Flows reported in Tables 3.7 and 3.8 are based on continuous hydrologic modelling from 2011 Draft Class EA).

Table 3.7 Lower Stoney Creek Flood Characterization

	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Reach SC-0	Flow (m^3/s):	13.79	24.43	34.89	47.08	58.08	69.28	205.47	
Property Type	Public/Open Space			1	1	1	1	1	
Roadway	Queen Elizabeth Way (Freeway)							1	
Reach SC-1	Flow (m^3/s):	13.79	24.39	34.86	47.02	58	69.2	205.18	Portions of Stoney Creek located within private property (industrial)
Property Type	Industrial							4	
Roadway	Lake Ave. N. (Collector)							1	
Railway	CNR							1	
Reach SC-2	Flow (m^3/s):	12.72	22.84	33.04	44.77	55.4	66.3	198.33	Spill condition upstream of CNR tracks for storm events greater than 100 year
Property Type	Industrial		1	1	1	1	1	16	Spill condition crosses Lake Avenue North
Building Type	Industrial							14	Properties potentially affected by spill condition not included in count
Roadway	Industrial							14	Portion of Reach located within Hydro Lands
Reach SC-3	Flow (m^3/s):	12.05	22.02	32.15	43.61	54.13	64.9	194.14	
Property Type	Residential							1	
	Industrial							1	
Building Type	Industrial							1	
Roadway	Barton St. E. (Arterial)							1	
Reach SC-4	Flow (m^3/s):	8.15	15.6	23.33	32.1	40.18	48.55	149.58	Portions of Reach located within private property (low density residential - houses)
Property Type	Residential		1	2	2	2	2	2	
Reach SC-5	Flow (m^3/s):	8.15	15.6	23.33	32.1	40.18	48.55	149.58	Majority of Reach located within private property (low density residential - houses)
Property Type	Residential		1	8	10	11	13	19	
	Institutional				1	1	1	1	
Building Type	Residential						1	4	
Roadway	Queenston Rd. (Arterial)							1	
	Donn Ave. (Local)						1	1	
Reach SC-6	Flow (m^3/s):	7.61	14.96	22.58	31.2	39.2	47.5	145.21	Entire Reach located within private property (low density residential - houses, commercial)
Property Type	Residential		6	18	34	52	57	78	
	Commercial		1	1	4	4	4	4	
	Public/Open Space				1	1	1	1	
Building Type	Residential			1	6	19	32	58	
	Commercial		1	1	1	3	4	4	
Roadway	Collegiate Ave. (Local)				1	1	1	1	
	Donn Ave. (Local)						1	1	
	James Ave. (Local)					1	1	1	
	Jones St. (Local)				1	1	1	1	

Table 3.7 Lower Stoney Creek Flood Characterization

	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Reach SC-7	Flow (m^3/s):	7.32	14.57	22.08	30.6	38.49	46.7	142.85	Spill condition upstream of King St. E. for storm events greater than 50 year
Property Type	Residential						4	12	Spill condition reaches Elm Ave. in Regional storm event
	Commercial						2	2	Properties potentially affected by spill condition not included in count
Building Type	Residential							2	Majority of Reach located within private property (low density residential - houses, high density residential - apartments, commercial)
	Commercial							2	
Roadway	King St. E. (Arterial)						1	1	
	Elm Ave. (Local)							1	

Table 3.8 Lower Battlefield Creek Flood Characterization

	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Reach BC-1	Flow (m^3/s):	4.4	7.09	9.38	12.03	14.16	16.39	43.49	
Property Type	Residential							15	
	Public/Open Space		1	1	1	1	1	1	
Building Type	Residential							2	
Roadway	Huckleberry Dr. (Local)							1	
	Jackson Ln. (Local-Private)				1	1	1	1	
Reach BC-2	Flow (m^3/s):	4.4	7.09	9.38	12.03	14.16	16.39	43.49	Portion of Reach located within private property (high density residential - apartments)
Property Type	Residential		1	1	2	2	3	6	
	Public/Open Space		1	1	1	1	1	1	
Building Type	Residential						2	2	
Roadway	Lake Ave. N. (Collector)						1	1	
Reach BC-3	Flow (m^3/s):	4.4	7.09	9.38	12.03	14.16	16.39	43.49	Portion of Reach located within private property (commercial)
Property Type	Residential								
	Commercial						1	1	
	Public/Open Space	1	1	1	1	1	1	1	
	Utility - Hydro							1	
Building Type	Public						3	5	
	Utility - Hydro							1	
Roadway	Queenston Rd. (Arterial)							1	
Reach BC-4	Flow (m^3/s):	3.53	5.96	8.06	10.56	12.63	14.81	38.49	Portions of Reach located within private property (low density residential - houses, commercial) & within Green Acres School yard
Property Type	Residential		2	2	2	2	4	18	
	Commercial		1	2	2	2	4	4	Two lots, zoned commercial, are currently used as residential and are being counted as residential
	Institutional			1	1	1	1	1	
	Public/Open Space						1	1	
Building Type	Residential		1	1	1	1	1	15	
	Commercial						2	4	
Roadway	Randall Ave. (Local)							1	
Reach BC-5	Flow (m^3/s):	3.53	5.96	8.06	10.56	12.63	14.81	38.49	Entire Reach located within Battlefield Heritage site
Property Type	Commercial							1	
	Public/Open Space							1	
Building Type	Commercial							1	
Roadway	King St. W. (Arterial)							1	
	Laneway Crossing							1	

Table 3.9 Lower Stoney Creek Peak Flow Reduction Targets

Reach	Preliminary / Potential Target	Comments/ Flood Risk Reduction Potential
SC-0	Reduce to extent possible	No specific flow target
SC-1	Reduce Regional Storm to extent possible	Regional Storm flood risk – reduce to extent possible
SC-2	Reduce Regional Storm to extent possible	Regional Storm flood risk – reduce to extent possible
SC-3	Reduce Regional Storm to extent possible	Regional Storm flood risk– reduce to extent possible
SC-4	Reduce 25 yr to 10 year (32.1 m^3/s to 23.33 m^3/s)	Would reduce flood risk to 1 residential property
SC-5	Reduce 25 yr to 5 year (32.1 m^3/s to 15.6 m^3/s)	Would reduce flood risk by at least 9 residential properties
SC-6	Reduce 50 yr to 25 year (39.2 m^3/s to 31.2 m^3/s)	Would reduce flood risk by at least 18 residential properties
SC-7	Reduce 100 yr to 50 year (46.7 m^3/s to 38.49 m^3/s)	Would reduce flood risk by at least 4 residential and 2 commercial properties

Table 3.10 Lower Battlefield Creek Peak Flow Reduction Targets

Reach	Preliminary / Potential Target	Comments/ Flood Risk Reduction Potential
BC-1	Reduce Regional Storm to extent possible	Regional Storm flood risk– reduce to extent possible
BC-2	Reduce 100 yr to 50 year (16.39 m^3/s to 14.16 m^3/s)	Would reduce flood risk by 2 residential buildings and at least 1 residential property
BC-3	Reduce 100 yr to 50 year (16.39 m^3/s to 14.16 m^3/s)	Would reduce flood risk by 3 public buildings and 1 commercial property
BC-4	Reduce Regional Storm (38.49 m^3/s) to extent possible. 100 year peak flow is 14.81 m^3/s	Regional Storm flood risk – reduce to extent possible
BC-5	Reduce Regional Storm to extent possible	Only 1 commercial building and property and 1 public/ open space property with Regional Storm flood risk.

3.4.2 Refined Erosion Risk Summary

Erosion risk as part of the 2011 Draft Class EA was determined using three (3) techniques:

- Field reconnaissance
- Rapid Geomorphic Assessment (RGA) and,
- Rapid Stream Assessment Technique (RSAT)

To complement the erosion characterization completed for the 2011 Draft Class EA, critical erosion flows have been determined for both creeks for the reaches that are considered to have the highest erosion potential as part of this study. To facilitate the critical erosion flow assessment, Matrix Solutions (formerly Parish Geomorphic) conducted a critical flow assessment (ref. Appendix E). Accordingly, Battlefield Creek reach BC-1 and Stoney Creek reach SC-4 would be considered to have the highest erosion potential and risk on the respective systems. Appendix E provides critical flow assessment summary tables.

Critical erosive flows have been assessed by conducting measurements on three (3) cross-sections for each reach and then applying appropriate empirical relationships (Rapid Geomorphic Assessment – RGA) for each cross-section, to determine an average critical flow for each reach. The critical erosive flows are within expectations based on the erosion assessment documented in the 2011 Draft Class EA.

Based on the critical flow assessment, for the Stoney Creek, the critical flow has been established as 7.53 m^3/s which compares to a 2 year storm of 7.94 m^3/s. The Battlefield Creek critical flow has been established as 1.93 m^3/s which compares to a 2 year storm peak flow of 4.62 m^3/s.

3.5 Aquatic Habitat

The fish habitat in upper Stoney Creek, like most fish habitat, is significantly influenced by the landscape. The mainstream of Stoney Creek above the Niagara Escarpment runs roughly parallel to the Niagara Escarpment edge due to the height of land that stretches east along the edge of the Escarpment from where Stoney Creek falls off the Escarpment at the Devil's Punch Bowl. This section of Stoney Creek occupies a flat landscape, with its main source in the Vinemount South Swamp at its east end, through which it flows almost exclusively through ditched and straightened channels to the Devil's Punch Bowl. This section of Stoney Creek is separated from another similarly flat area, to the south and roughly along Mud Street, by the Eramosa Escarpment. The watercourse in this area has its main source in a swamp in the southwest corner of Mud Street and Centennial Parkway. From here it is mostly ditched and flows east, before turning north and over the Eramosa Escarpment to the west end of the Vinemount South Swamp.

The portion of Battlefield Creek on top of the Niagara Escarpment occupies a much smaller watershed than Stoney Creek, situated on the relatively flat land between the Niagara Escarpment edge to the north and the Stoney Creek watershed to the east and south. The Eramosa Escarpment crosses the south portion of the Battlefield Creek watershed, and there are some sink holes just south of the Eramosa Escarpment. Like Stoney Creek, its channels are mainly ditched through agricultural areas or along roads.

The low-gradient, mainly ditched and channelized watercourses of upper Stoney and Battlefield Creeks on top of the Niagara Escarpment, has resulted in generally broad and shallow watercourses, with few riffle habitats, though there are some deeply excavated sections of watercourse and excavated on-line ponds. Substrates are generally fine clay and/or silt, though flat bedrock has been noted in many locations in the sections nearer to the Niagara Escarpment. Most watercourses are heavily vegetated with emergent aquatic plants that can tolerate the lack of water later in the summer. The annual lack of flow leaves almost all of watercourses dry except for standing water in the vicinity of road culverts, in sections that were ditched deep, or in dugout ponds. The Vinemount South Swamp has standing water during dry periods. There appears to be little evidence of groundwater inputs.

Given the habitat conditions as described in the foregoing, as well as the complete barrier to upstream fish migration created by the Niagara Escarpment, the fish community is composed entirely of non-migratory fishes that are tolerant of high water temperatures and low dissolved oxygen, that are typically found in isolated small shallow pools or ponds during summer, and can tolerate the low oxygen in these same ice-covered pools and ponds during winter. The nine species of fish that have been found upstream of the Niagara Escarpment are: Fathead Minnow, Creek Chub, Northern Redbelly Dace, Central Mudminnow, Brown Bullhead, Brook Stickleback, Pumpkinseed, Green Sunfish, and Banded Killifish; none are considered species at risk.

The pattern of species distribution is related to species' habitat requirements/tolerances. Brown Bullhead are typically found in deeper, still-water habitats, and the two instances of this species occur in excavated on-line ponds. Creek Chub prefer coarser substrate and may need coarser substrate for spawning, and was only found at one location in a section of Stoney Creek that has a few short riffle sections. The Banded Killifish is known from the area around the Vinemount Quarry (Forty Mile Creek watershed), possibly due to the specialized habitats in that area of shallow wetlands perched on areas with some bedrock exposure. Since the demarcation between the headwaters of Stoney Creek, east of the Vinemount South Swamp, and Forty Mile Creek, is weak, it is not surprizing that Banded Killifish were found in this headwater area of Stoney Creek. Brook Stickleback, Fathead Minnow, and Central Mudminnow are very tolerant of conditions within the small isolated pools that occur when the flow in these watercourses are reduced to zero during the summer, and hence they are the most widespread of the fishes in this watershed.

Fieldwork was conducted in 2017 to validate background information characterization. Aquatic habitat associated with the five potential storage facilities (ref. Section 5) was examined on June 20, 2017, by C. Portt and Associates staff (G. Coker), as part of this study. Field observations were limited to public right-of-ways and Hamilton Conservation Authority controlled lands, with other required areas assessed through examination of aerial imagery. A dip net was used to look for fish in observed habitats where there was water. All fish captured were identified and released unharmed at the point of capture. All digital photographs, observations, measurements, and fishing locations were georeferenced using a hand-held GPS unit (Garmin GPSmap 76CSx).

The observations made on June 20, 2017, occurred during unusually wet conditions. The long-term average precipitation for May, as recorded at the John C. Munroe Hamilton International Airport (https://weather.gc.ca/) is 79.4 mm (1981-2010). In 2017, the May precipitation was

151.4 mm, considerably higher than the long-term average. Taking into consideration additional rain events in June, including 10.6 mm of rain over the two days prior to the June 20, 2017 field examination, it is assumed that flow conditions within the watercourses examined, and thus the extent of observed potential fish habitat, was greater than usual for that time of year.

3.6 Terrestrial Ecology

The following background information has been reviewed as part of this study to summarize terrestrial ecology conditions for the upper Stoney Creek and Battlefield Creek:

- Hamilton Natural Areas Inventory Project 3rd Edition – Site Summaries Document (Schwetz 2014a)
- Hamilton Natural Areas Inventory Project 3rd Edition - Species Checklist Document (Schwetz 2014b)
- Tapleytown Woods ESA (STCK-138) Site Summary (in Schwetz 2014a)
- Devil’s Punchbowl Escarpment ESA (STCK-76) Site Summary (in Schwetz 2014a)
- Vinemount South Swamp ESA (STCK-77) Site Summary (in Schwetz 2014a)
- NHIC (Natural Heritage Information Centre) Make-a-Map Natural Heritage Mapping

3.6.1 Hamilton Natural Areas Inventory Project

The Stoney Creek and Battlefield Creek watershed above the Niagara Escarpment is primarily agricultural landscape with fragmented small woodlots connected by hedgerows. Three 'Natural Areas' have been identified by the 20~4 NAI as per the following:

STCK-77Vinemount South Swamp (69 ha)

This is the largest remaining natural woodlot south of the Niagara Escarpment in the City of Hamilton (ELC is available) and is classified as a Provincially Significant Wetland (PSW) located along the southern edge of the Vinemount Moraine, the Vinemount South Swamp forms the headwaters of Stoney Creek and Forty Mile Creek, and is a significant groundwater recharge zone.

STCK-38Tapleytown Woods (3 ha)

This is classified as a deciduous forest (ELC is available) with riparian habitat extending to the Vinemount South Swamp.

STCK-7. (Un-named)

A deciduous forest and thicket (ELC is available for part of natural area).

3.6.2 Natural Heritage Information Centre (NHIC) Database Query

The NHIC database was queried in October 2017 to identify any records of wildlife SAR and/or provincially significant wildlife species (S-ranks of S1 to S3) in the vicinity of the ten sites. A total of 30 - 1 km by 1 km squares that contained the ten sites, and their adjacent lands (within 120 m) and surrounding areas, were checked. The results of the query are displayed below in Table 3.11.

Table 3.11 Results of the NHIC Database Query for the Stoney Creek Feasibility Study Lands

Scientific Name	Common Name	NHIC Srank	Federal status	Provincial status	Last observation date
Reptiles:					
Crotalus horridus	Timber Rattlesnake	SX	Extirpated	Extirpated	1950
Amphibians:					
Ambystoma jeffersonianum	Jefferson Salamander	S2	Endangered	Endangered	1991
Birds:					
Dolichonyx oryzivorus	Bobolink	S4	Threatened	Threatened	2003-06-27
Sturnella magna	Eastern Meadowlark	S4	Threatened	Threatened	2001-07-01; 2003-06-27
Plants:					
Chimaphila maculata	Spotted Wintergreen	S2	Threatened	Endangered	1886-07-01
Cornus florida	Eastern Flowering Dogwood	S2	Endangered	Endangered	1889-05-17
Bacidia trachona	Lichen	S1S2	---	---	1978-06-26
Juglans cinerea	Butternut	S2	Endangered	Endangered	1991-08-12
Carex oligocarpa	Eastern Few-fruited Sedge	S3	---	---	1975

Wildlife

From a wildlife perspective, four species were found: one snake (Timber Rattlesnake), one amphibian (Jefferson Salamander), and two birds (Bobolink and Eastern Meadowlark).

Note that Timber Rattlesnake is considered extirpated from the entire province, with no records since the 1950s. Jefferson Salamander is extant in the area but is largely confined to forested areas along the Niagara Escarpment, which is to the north of the study area. Both Bobolink and Eastern Meadowlark are known from the entire study area, where they are common and widespread within suitable open country sites.

Plants

Five plant species were recorded for the study area and adjacent lands, including one tree (Butternut), one shrub (Eastern Flowering Dogwood), one herbaceous species (Spotted Wintergreen) one lichen (Bacidia trachona), and one graminoid species (Eastern Few-fruited Sedge).

Butternut typically grows in moist, well-drained soils often along streams and is usually found in deciduous forests or hedgerows. Eastern-flowering dogwood prefers drier deciduous and mixed forests, but can also be found in slightly moist environments and can grow in edge habitat and hedgerows. Spotted Wintergreen generally grows in sandy habitats in dry-mesic oak-pine woods. Eastern few-fruited Sedge typically grows in mesic or dry-mesic deciduous forests, usually on rocky slopes above streams where soils are calcium-rich loams. The lichen species typically grows on calcareous rock in shaded underhangs of rock or at the base of tree trunks or on tree roots.

Species at Risk (SAR) Screening

An Information Request was submitted to the Guelph District Ministry of Natural Resources and Forestry (MNRF) in June 2016. A response was received in November 2016 from Anne Marie Laurence, Management Biologist. The following Species at Risk (SAR) have records from the local area in the MNRF database:

- Birds: Barn Swallow (Threatened), Bobolink (Threatened), Chimney Swift (Threatened), Eastern Meadowlark (Threatened), Peregrine Falcon (Special Concern), and Wood Thrush (Special Concern).
- Reptiles/amphibians: Jefferson Salamander (Endangered) and Snapping Turtle (Special Concern).
- Plants: Butternut (Endangered).

A screening of all known wildlife Species at Risk (SAR) that have been known to occur in the City of Hamilton through May 9, 2017, was undertaken; the list was obtained from the Guelph District MNRF office. The known habitats for these wildlife species were screened against the habitats contained within the subject lands, based on 2017 field investigations and desktop assessments, with the likelihood of their presence being indicated. The full screening is presented as Appendix F.

Initial Opportunities & Constraints

The following constraints and opportunities have been determined.

Constraints:

- The three 'Natural Areas' identified by the 2014 NAI.
- Existing riparian habitat and hedgerows/woodlots.
- Potential presence of recently-listed Species at Risk (which would not be documented by historical record-keeping) • e.g. open habitat species utilizing agricultural fields.

Opportunities:

- Potential for the creation of much better habitat than currently exists on the landscape if considering compensation.
- Few constraints with the prevalence of agricultural fields.

3.7 Property Ownership

As noted in the Introduction, as well as inherent in the Goals and Objectives for this project, HCA has a complementary interest in establishing a new conservation area, which would have many attributes and benefits for the area, including the potential for system-wide flood and erosion risk mitigation. On this basis, the HCA has been actively acquiring lands in the study area for this express purpose. These holdings (ref. Figure 21), while not a direct determinant in siting storage systems, do provide a direct opportunity as part of an implementation strategy in the future. HCA has indicated that this approach to land acquisition for the purpose of this plan, is based on the premise of “willing seller – willing buyer”.

4.0 LONG-LIST OF ALTERNATIVES

In order to address the identified riverine-based flooding potential and erosion conditions within the lower Stoney Creek and Battlefield Creeks, a long-list of potential storage facility alternatives has been established. The long-list of storage locations has been screened based on various functional aspects including engineering principles, such as the effectiveness of improving flood protection and reducing erosion potential; property requirements and other environmental considerations. This has resulted in a short-list of potential storage system alternatives for more detailed consideration.

4.1 Storage System Assessment

Potential storage locations within both the upper Battlefield Creek and Stoney Creek have been identified for opportunities to attenuate and reduce peak flows below the Niagara Escarpment for creek reaches with significant flooding and erosion potential. The following general considerations/ evaluation factors have been used to identify the potential storage locations:

i. *Storage locations should, to the extent possible, not be in series. In series storage is considered to be less effective versus storage that is achieved on side tributaries and with a single storage cell on the main watercourse branch.*

ii. *Storage locations should be within relatively flat sloped areas with a low gradient longitudinal slope.*

iii. *Storage locations should be in areas that are not significantly developed or planned to be developed.*

iv. *Storage cells should, to the extent possible, not impact external properties upstream of the adjacent road crossings.*

v. *Grading required to facilitate storage within naturalized areas should be minimized*

The following long-list of storage sites has been identified for Battlefield Creek (BC) and Stoney Creek (SC) (ref. Figure 6 for locations):

Long-list of Storage Sites

BC-1: Upstream or east of First Road East, north of Green Mountain Road East and downstream or west of Second Road East.

SC-1: Upstream or east of Tapleytown Road, north of Green Mountain Road East and downstream of Fifth Road East.

SC-2: Upstream or east of Third Road East, north of Green Mountain Road East and downstream of Tapleytown Road, on the south Stoney Creek tributary.

SC-3: Upstream or east of Fifth Road East, north of Green Mountain Road East on the Stoney Creek south tributary.

SC-4: Upstream or west of Second Road East, south of Mud Street East and east of First Road East.

SC-5: Upstream (east and south) of Ridge Road, immediately upstream of the Devil's Punchbowl on the main branch of Stoney Creek.

SC-6: Upstream (east of First Road East and south of Ridge Road), on the main branch of Stoney Creek.

SC-7: Upstream (east of Third Road East and south of Dofasco Trail System), on the main branch of Stoney Creek.

SC-8: Upstream (south of Green Mountain Road East and west of Fifth Road East) on the south branch of Stoney Creek.

Site BC-1:

BC-1 is upstream of an existing 1.75 m span by 0.9 m rise concrete box culvert, with an upstream invert of 186.30 m +/- and road at 187.50 m +/-, resulting in only 0.30 m +/- cover. Based on the limited depth of storage due to the shallow culvert crossing, it is proposed to raise the road by 1.8 m to approximately 189.30 m (ref. Figure 8) or create an equivalent standalone berm upstream of the crossing. No private driveways would be impacted by the raising First Road East in the vicinity of the creek crossing. The maximum elevation and depth of storage would be 189.00 m and 2.70 m based on providing 0.30 m to freeboard to the First Road East. The preliminary stage/ storage/ discharge relationship has been provided in Table 4.1, with the final column representing the preliminary optimized discharge flows for the storage available. Table 4.2 provides the Battlefield Creek peak flows with and without storage. The relative difference between peak flows simulated within and without storage has been provided within Table 4.3. Based on the results in Tables 4.2 and 4.3, there would be a reduction in peak flows at the confluence near Centennial Parkway of over 40% for the 2 year to 100 year storms, which is reduced to 4 % +/- at Highway 8. The reduction in the percentage difference is considered a result of the timing in peak flows. An assessment through hydrograph tracking has been conducted and has confirmed that timing of flows contributes to the reduction in percentage difference (ref. Appendix C). Timing of hydrographs is also considered to be the reason for the slight increase in Regional Storm peak flows.

Table 4.1 Storage Site BC-1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.0/186.30	0	0.00
1.31/187.61	12000	0.10
1.70/188.00	35500	1.00
2.20/188.50	109500	1.50

Table 4.2 Comparison of Battlefield Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site BC-1							
Confluence near Centennial Parkway	1.38	2.66	4.32	6.23	8.15	10.17	25.77
Edge of Escarpment	3.2	5.28	7	8.95	10.47	12.12	34.74
King St.	3.53	5.96	8.06	10.56	12.63	14.81	38.49
Highway 8	4.40	7.09	9.38	12.03	14.16	16.39	43.49
With Storage Site BC-1							
Confluence near Centennial Parkway	0.80	1.56	2.26	3.13	3.92	4.71	26.21
Edge of Escarpment	2.14	3.91	5.44	7.33	8.88	10.50	32.62
King St.	3.45	5.78	7.72	10.06	11.98	13.99	37.94
Highway 8	4.33	6.91	9.02	11.57	13.42	15.36	42.57

Table 4.3 Percent Difference in Simulated Battlefield Creek Peak Flows With and Without Storage Site BC-1 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Confluence near Centennial Parkway	-42.03	-41.35	-47.69	-49.76	-51.90	-53.69	1.71
Edge of Escarpment	-33.13	-25.95	-22.29	-18.10	-15.19	-13.37	-6.10
King St.	-2.27	-3.02	-4.22	-4.73	-5.15	-5.54	-1.43
Highway 8	-1.59	-2.54	-3.84	-3.82	-5.23	-6.28	-2.12

Storage Site SC-1:

The *SC-1* storage site is upstream of the Tapleytown Road bridge (7.2 m span by 1.25 m rise), with 0.8 m +/- freeboard to the road, resulting in a flood depth, including the low flow channel of only 2 m +/- (ref. Figure 9). In order to increase the storage depth and potential storage, the road could be raised 1 m from an elevation of 192.0 m to 193 m +/- or create an equivalent standalone berm upstream of the crossing. The maximum storage elevation would be 192.70 m (+/-), with a storage depth of 2.7 m, which would result in minor flooding beyond Fifth Road East and the Dofasco Trail. No private driveways on Tapleytown Road would be impacted by the 1 m (+/-) increase in road elevation in vicinity of the Stoney Creek crossing. The preliminary stage/ storage/ discharge relationship has been provided in Table 4.4, with the final column representing the preliminary optimized discharge flows for the storage available. Table 4.5 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated within and without storage has been provided (ref. Table 4.6). Based on the results reported in

Tables 4.5 and 4.6, there would be a reduction in peak flows of 40% to 60% from the Escarpment to Highway 8. A 0.6% increase in peak flows occurs at the Escarpment for the Regional Storm, again due to timing of peak flows.

Table 4.4 Storage Site SC-1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/190.00	0	0.00
2.04/192.04	40000	0.27
2.50/192.50	193700	2.97
2.57/192.57	240000	3.30
2.70/192.70	320500	22.00

Table 4.5 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-1							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Site SC-1							
Edge of Escarpment	1.62	3.55	5.56	12.77	18.93	24.52	141.98
King St.	1.92	4.00	6.13	13.05	19.35	25.03	144.27
Highway 8	2.50	4.91	7.31	13.42	19.97	25.74	148.48

Table 4.6 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-1 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-1							
Edge of Escarpment	-77.87	-75.63	-74.82	-58.27	-50.82	-47.49	-0.61
King St.	-74.77	-73.26	-72.85	-58.17	-50.64	-47.31	-0.65
Highway 8	-69.33	-68.53	-68.67	-58.19	-50.30	-46.98	-0.74

The combined benefit of reduced peak flows resulting from the storage within both BC-1 and SC-1 in the Stoney Creek from the confluence to Lake Ontario has been reported in Tables 4.7 and 4.8. Peak flows for the 2 year to 100 year storms would be reduced 30% to 40% +/-, with the Regional Storm realizing slight decreases of 1.8% to 3.2% +/-.

Table 4.7 Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1 and SC-1							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites BC-1 and SC-1							
Battlefield/Stoney Creek Confluence	6.72	11.58	15.92	20.99	26.99	34.27	191.42
CNR	7.71	12.98	17.68	22.98	27.94	35.11	195.02
QEW	9.10	14.84	19.92	25.72	31.08	36.87	201.61
Lake Ontario	9.13	14.88	19.97	25.81	31.18	36.93	201.87

Table 4.8 Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1 and SC-1 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-44.23	-47.41	-50.48	-51.87	-50.14	-47.20	-1.40
CNR	-39.39	-43.17	-46.49	-48.67	-49.57	-47.04	-1.67
QEW	-34.01	-39.16	-42.86	-45.30	-46.41	-46.72	-1.74
Lake Ontario	-33.79	-39.09	-42.76	-45.18	-46.32	-46.69	-1.75

Storage Site SC-2:

The *SC-2* storage site is upstream of the Third Road East 8.0 m span by 1.42 m rise bridge on the Stoney Creek main branch, with 1.9 m +/- freeboard to the road (ref. Figure 10). The tributary to the main branch has an invert of 190.50 m +/- with the road in the immediate vicinity having an elevation of 191.0 m, resulting in a flood depth, including the low flow channel of only 0.2 m +/-. In order to increase the storage depth and potential storage, the road could be raised 1.9 m from an elevation of 191.0 m to 192.9 m +/- or create an equivalent standalone berm upstream of the crossing. The maximum storage elevation would be 192.60 m (+/-), with a storage depth of 2.1 m, which would just avoid the private residential buildings to the south. No private driveways on Tapleytown Road would be impacted by the 1.9 m (+/-) increase in road elevation in vicinity of the tributary along the east of Third Road East. To separate the storage area from the main creek branch located to the north, a berm would have to be constructed to an elevation of 192.90 m with a maximum berm height of 1.90 m.

The preliminary stage/ storage/ discharge relationship has been provided in Table 4.9, with the final column representing the preliminary optimized discharge flows for the storage available. Table 4.10 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated with and without storage has been provided within Table 4.11.

Based on the results reported in Tables 4.10 and 4.11, there would be a reduction in peak flows at the Edge of the Escarpment of approximately 5% to 6% (2 year to 100 year). The Regional Storm exhibits a slight 0.2% increase in peak flows.

Table 4.9 Storage Site SC-2 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/190.50	0	0.00
0.87/191.37	2500	0.015
1.50/192.00	24200	0.30
2.00/192.50	55300	0.75

Table 4.10 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-2							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Site SC-2							
Edge of Escarpment	6.70	13.34	20.14	27.80	34.75	42.09	141.39
King St.	6.98	13.72	20.62	28.40	35.46	42.90	143.65
Highway 8	7.48	14.35	21.38	29.32	36.54	44.10	147.72

Table 4.11 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-2 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-2							
Edge of Escarpment	-8.47	-8.44	-8.79	-9.15	-9.72	-9.87	-1.02
King St.	-8.28	-8.29	-8.68	-8.97	-9.54	-9.68	-1.07
Highway 8	-8.22	-8.01	-8.36	-8.66	-9.06	-9.17	-1.24

The combined benefit of reduced peak flows resulting from the storage within sites BC-1 and SC-2 in the Stoney Creek from the confluence to Lake Ontario has been reported in Tables 4.12 and 4.13. Peak flows for the 2 year to 100 year storms have been reduced 1% to 4% +/-, with the Regional Storm realizing slight increases of 2.6% +/-.

Table 4.12 Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1 and SC-2							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites BC-1 and SC-1							
Battlefield/Stoney Creek Confluence	11.06	19.85	28.74	38.66	47.74	57.25	190.82
CNR	11.72	20.72	29.64	39.87	49.07	58.70	194.20
QEW	12.79	22.30	31.47	42.13	51.65	61.62	200.70
Lake Ontario	12.79	22.35	31.52	42.20	51.73	61.69	200.84

Table 4.13 Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1 and SC-2 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-8.22	-9.85	-10.61	-11.35	-11.80	-11.79	-1.71
CNR	-7.86	-9.28	-10.29	-10.94	-11.43	-11.46	-2.08
QEW	-7.25	-8.57	-9.72	-10.40	-10.95	-10.95	-2.18
Lake Ontario	-7.25	-8.51	-9.66	-10.37	-10.93	-10.96	-2.25

Storage Site SC-3:

The *SC-3* storage site is upstream of the Fifth Road East 2.2 m span by 1.4 m rise box culvert, with 1.4 m +/- freeboard to the road (ref. Figure 11). The storage location is upstream of the road and is a tributary to the main branch. The low flow channel at the potential outlet from the storage area is at an elevation of 192.50 m +/-, with the adjacent roads (Fifth Road East and Sixth Road East) at grades of 192.50 m +, as such to increase the storage depth and potential storage, the roads could be raised 0.5 m from an elevation of 192.5 m to 193 m +/- or create an equivalent standalone berm upstream of the crossing. The maximum storage elevation would be 192.70 m (+/-), with a storage depth of only 0.2 m, which would result in flooding on private properties located on Green Mountain Road East. As such a berm would be required to be constructed along the property boundaries to contain the storage (ref. Figure 11). A berm with an elevation of 193 m would also be required within the wooded area to contain the storage area. In addition, excavation to an elevation of 192.50 m beyond the wooded area would be required to obtain sufficient storage.

The preliminary stage/ storage/ discharge relationship has been provided in Table 4.14, with the final column representing the discharge flows for the storage available. Table 4.15 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated with and without storage has been provided within Table 4.16. Based on the results in Tables 4.15 and 4.16 there would be a reduction in peak flows at the edge of the Escarpment of approximately 11-13% (2 year to 100 year), with a 0.15% increase in peak flows at the Escarpment for the Regional Storm, due to timing of peak flows.

Table 4.14 Storage Site SC-3 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/192.50	0	0.00
0.02/192.52	6600	0.02
0.17/192.67	57500	0.70

Table 4.15 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-3							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Site SC-3							
Edge of Escarpment	6.21	12.40	18.70	25.90	32.57	39.22	141.32
King St.	6.49	12.78	19.19	26.51	33.29	40.04	143.62
Highway 8	7.00	13.44	20.00	27.47	34.42	41.33	147.73

Table 4.16 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-3 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-3							
Edge of Escarpment	-15.16	-14.89	-15.31	-15.36	-15.38	-16.02	-1.07
King St.	-14.72	-14.57	-15.01	-15.03	-15.08	-15.71	-1.09
Highway 8	-14.11	-13.85	-14.27	-14.42	-14.34	-14.87	-1.24

The combined benefit of reduced peak flows resulting from the storage within both sites BC-1 and SC-3 in the Stoney Creek from the confluence to Lake Ontario has been provided in Tables 4.17 and 4.18. Peak flows for the 2 year to 100 year storms have been reduced 4%-8%, with the Regional Storm realizing slight increases of 2.6% to 2.7% +/-.

Table 4.17. Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1 and SC-3							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites BC-1 and SC-3							
Battlefield/Stoney Creek Confluence	10.65	19.13	27.33	36.96	45.83	54.73	190.78
CNR	11.34	20.09	28.33	38.23	47.24	56.29	194.22
QEW	12.42	21.70	30.23	40.54	49.87	59.28	200.77
Lake Ontario	12.43	21.75	30.28	40.62	49.94	59.36	200.91

Table 4.18. Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1 and SC-3 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-11.62	-13.12	-14.99	-15.25	-15.33	-15.67	-1.73
CNR	-10.85	-12.04	-14.26	-14.61	-14.73	-15.10	-2.07
QEW	-9.93	-11.03	-13.28	-13.78	-14.02	-14.34	-2.15
Lake Ontario	-9.86	-10.97	-13.21	-13.72	-14.02	-14.32	-2.22

Storage Site SC-4:

The *SC-4* storage site is upstream of the Second Road East 4.8 m span by 1.8 m rise box culvert, with 0.8 m +/- freeboard to the road, resulting in a flood depth, including the low flow channel of only 1.9 m +/- (ref. Figure 12). In order to increase the storage depth and potential storage, the road could be raised 0.3 m from an elevation of 204.0 m to 204.3 m +/- or create an equivalent standalone berm upstream of the crossing. The intersection of Mud Street East and First Road East would also have to be raised by 0.30 m +/-.

The preliminary stage/ storage/ discharge relationship has been provided in Table 4.19, with the final column representing the preliminary optimized discharge flows for the storage available. Table 4.20 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated within and without storage has been provided within Table 4.21. Based on the results reported in Tables 4.20 and 4.21, there would be a reduction in peak flows at the edge of Escarpment of approximately 12% to 18% (2 year to 100 year). A 0.4% increase in peak flows occurs at the Escarpment for the Regional Storm, again due to timing of peak flows.

Table 4.19 Storage Site SC-4 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/201.90	0	0.00
1.61/203.51	7400	0.08
2.10/204.00	41200	6.80

Table 4.20 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-4							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Site SC-4							
Edge of Escarpment	5.80	11.93	18.40	25.53	32.26	39.07	140.55
King St.	6.09	12.32	18.88	26.14	32.97	39.89	142.81
Highway 8	6.65	12.98	19.67	27.13	34.12	41.18	146.89

Table 4.21 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-4 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-4							
Edge of Escarpment	-20.77	-18.12	-16.67	-16.57	-16.19	-16.34	-1.61
King St.	-19.97	-17.65	-16.39	-16.22	-15.89	-16.02	-1.65
Highway 8	-18.40	-16.79	-15.69	-15.48	-15.08	-15.18	-1.80

The combined benefit of reduced peak flows resulting from the storage within sites BC-1 and SC-4 in the Stoney Creek from the confluence to Lake Ontario has been provided in Tables 4.22 and 4.23. Peak flows for the 2 year to 100 year storms have been reduced 5% to 8% +/-, with the Regional Storm realizing a slight increase of 2.2% +/-.

Table 4.22 Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1 and SC-4							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites BC-1 and SC-4							
Battlefield/Stoney Creek Confluence	10.39	18.81	26.99	36.54	45.36	54.35	190.02
CNR	11.14	19.86	28.02	37.83	46.79	55.90	193.42
QEW	12.25	21.49	29.92	40.17	49.44	58.88	199.91
Lake Ontario	12.26	21.54	29.97	40.24	49.51	58.96	200.06

Table 4.23 Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1 and SC-4 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-13.78	-14.58	-16.05	-16.21	-16.20	-16.26	-2.12
CNR	-12.42	-13.05	-15.19	-15.50	-15.54	-15.69	-2.48
QEW	-11.17	-11.89	-14.17	-14.57	-14.76	-14.91	-2.57
Lake Ontario	-11.09	-11.83	-14.10	-14.53	-14.76	-14.90	-2.63

Scenario Assessment

For storage sites (SC-5 to SC-8), two (2) scenarios have been considered. The existing topographic conditions have been used a baseline. The existing storage upstream of the adjacent roadway crossings associated with the foregoing is very limited and would offer little to no reduction in peak flows for all storm events and virtually no reduction in the erosion durations of critical flows below the Escarpment. Hence, in order to enhance storage potential, the following approaches have been considered:

Scenario 1: Modified road grades or create an equivalent standalone berm upstream of the crossing and 'limited grading' within the storage site. Property requirements are limited by either berming or proposed storage elevations.

Scenario 2: Modified road grades or create an equivalent standalone berm upstream of the crossing and 'aggressive grading' within the storage site; property requirements are typically increased compared to Scenario 1. Storage is contained either through berming or proposed storage elevations.

For storage sites BC-1, SC-1 to SC-4, due to the existing property grades, property fabric configuration, natural areas and adjacent road grades, only Scenario 1 has been considered. The following provides additional details of the specifics associated with each site:

SC-5 Scenario 1:

The property immediately west of First Road East and north of the Dofasco Trail System that is owned by HCA (ref. Figure 13) would be used for storage under this scenario. There is no existing crossing at the downstream limit of the proposed storage site, as such localized berming and an outlet control structure (size and configuration to be determined) would be required. The maximum ponding elevation would be 187.0 m (+/-) at a maximum depth of 3.0 m (+/-), resulting in the ponding extending easterly beyond First Road East, but within the existing Regional Storm floodplain. Grading of the lands would notionally be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 57,000 m^3. The storage site would be approximately 13.19 ha in area.

SC-5 Scenario 2:

The available storage from Scenario 1 would be extended to Ridge Road at the Devils Punchbowl at a maximum storage elevation of 187.0 m (ref. Figure 14). Land purchase would be required by HCA of approximately 7.42 ha, along with berming and the raising of Ridge Road from an existing elevation of 185.50 m to an elevation of 187.30 m or create an equivalent standalone berm upstream of the crossing and raising of First Road East from an elevation of 186.50 m to 187.30 m or create an equivalent standalone berm upstream of the crossing. The storage site would be approximately 23.11 ha in area. The maximum ponding elevation would be 187.0 m (+/-) at a maximum depth of 4.0 m (+/-), resulting in the ponding extending easterly beyond First Road East, but within the existing Regional Storm floodplain. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 204,000 m^3. Modifications to the existing 6.0 m by 2.3 m open bottom concrete culvert crossing of Ridge Road may be required.

SC-6 Scenario 1:

Storage area SC-6 would require an outlet structure to be constructed, as no structure currently exists at the downstream limit (ref. Figure 15). Localized berming to an elevation of 189.0 m along the east and north sides of the storage area and an outlet control structure (size and configuration to be determined) would be required. The maximum ponding elevation would be 188.7 m (+/-) at a depth of 2.7 m (+/-), resulting in the ponding extending easterly beyond Second Road East, but within the existing Regional Storm floodplain. Grading of the lands would be at a 0.50% slope to facilitate positive drainage. The maximum storage would be approximately 40,500 m^3. The storage site would be approximately 10.68 ha in area, and would require land purchase by HCA. Based on the existing topography and creek alignment, a second more aggressive scenario is not considered possible for this storage site.

SC-7 Scenario 1:

The SC-7 storage area would be located between Tapleytown Road and Fifth Road East and north of Green Mountain Road East (ref. Figure 16). The maximum storage elevation would be

190.7 m (+/-) at a depth of 1.7 m (+/-). Tapleytown Road would require raising from an elevation of 190.50 m to 191.0 m or create an equivalent standalone berm upstream of the crossing. The storage site would be approximately 16.72 ha in area, all of which would have to be purchased by HCA. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 35,500 m^3. Modifications to the existing 8.0 m by 1.42 m open bottom concrete culvert crossing of Tapleytown Road may be required.

SC-7 Scenario 2:

The SC-7 storage area from Scenario 1 would be extended further west towards Fifth Road East (ref. Figure 17). The maximum storage elevation would be 191.2 m (+/-) at a depth of 2.2 m (+/-). Tapleytown Road would require raising from an elevation of 190.5 m to 191.5 m or create an equivalent standalone berm upstream of the crossing. A 0.5 m +/- berm would be required in the vicinity of Tapleytown Road. The storage site would be approximately 45.09 ha in area, all of which would have to be purchased by HCA. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 146,000 m^3. Modifications to the existing 8.0 m by 1.42 m open bottom concrete culvert crossing of Tapleytown Road may be required.

SC-8 Scenario 1:

The SC-8 storage area would be located between Tapleytown Road and Fifth Road East and south of Green Mountain Road East (ref. Figure 18). The maximum storage elevation would be 193.7 m (+/-) at a depth of 1.7 m (+/-). Green Mountain Road East would require raising from an elevation of 193.5 m to 194.0 m or create an equivalent standalone berm upstream of the crossing. The storage site would be approximately 12.16 ha in area, all of which would have to be purchased by HCA. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 31,400 m^3. Modifications to the existing 6.0 m by 1.1 m open bottom concrete culvert crossing of Green Mountain Road East may be required.

SC-8 Scenario 2:

The SC-8 storage area from Scenario 1 would extended further south towards Mud Street East (ref. Figure 19). The maximum storage elevation would be 193.7 m (+/-) at a depth of 1.7 m (+/-). Green Mountain Road East would require raising from an elevation of 193.5 m to 194.0 m or create an equivalent standalone berm upstream of the crossing. The storage site would be approximately 15.33 ha in area, all of which would have to be purchased by HCA. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 48,400 m^3. Modifications to the existing 6.0 m by 1.1 m open bottom concrete culvert crossing of Green Mountain Road East may be required.

A summary of the size and implementation considerations for each storage site is provided in Table 4.24. Ground photos of the existing conditions at each storage facility location are provided in Appendix D.

Table 4.24 Storage Facility Summary

Storage Site I.D.	Area Coverage (ha)	Available Storage (m^3)	Implementation Considerations
BC-1	25.65	221,400	▶ Outlet control to be implemented into existing culvert crossing at First Rd. E. ▶ First Rd. E. to be raised 1.8 m or create an equivalent standalone berm upstream of the crossing ▶ Portions of ponding limits within HCA controlled property
SC-1	69.88	320,500	▶ Outlet control to be implemented into existing bridge crossing at Tapleytown Rd. ▶ Tapleytown Rd. to be raised 1.0 m or create an equivalent standalone berm upstream of the crossing ▶ Fifth Rd. E. to be raised varying amounts (typically 0.5 m) to a minimum elevation of 193.00 m. Road Raising impacts residential driveways ▶ Majority of ponding is within agricultural lands ▶ Multiple residential dwellings affected by ponding
SC-2	8.93	63,600	▶ Outlet control to be implemented ▶ Third Rd. E. to be raised 1.9 m or create an equivalent standalone berm upstream of the crossing. Road raising impacts residential driveway ▶ Berming required along majority of north boundary to contain ponding and separate the storage area from the Stoney Creek main branch ▶ Majority of ponding is within agricultural lands ▶ Multiple residential dwellings affected by ponding ▶ Potential storage volume is not significant
SC-3	30.31	65,800	▶ Outlet control to be implemented ▶ Fifth Rd. E. to be raised 0.50 m or create an equivalent standalone berm upstream of the crossing. Road raising impacts residential driveways ▶ Sixth Rd. E. to be raised varying amounts (typically 0.5 m) to a minimum elevation of 193.00 m ▶ Berm to be constructed at outlet and around existing residential property lines to contain ponding ▶ Ponding areas outside of significant woodlot to be lowered (typically 0.5 m) to provide storage ▶ Drainage channel to be constructed through significant woodlot area to connect storage areas ▶ A berm to be constructed along the Stoney Creek main branch to separate the storage area from the main branch and would require grading to the Dofasco Trail ▶ Portions of ponding limits & construction works are within HCA controlled property

Table 4.24 Storage Facility Summary

Storage Site I.D.	Area Coverage (ha)	Available Storage (m^3)	Implementation Considerations
SC-4	11.54	41,200	▶ Outlet control to be implemented into existing culvert crossing at Second Rd. E. ▶ Second Rd. E. to be raised 0.3 m or create an equivalent standalone berm upstream of the crossing ▶ Intersection of Mud St. E. & First Rd. E. to be raised 0.3 m ▶ Ponding is within agricultural lands ▶ Potential storage volume is not significant
SC-5 (Scenario 1)	13.19	57,000	▶ Outlet control to be implemented ▶ First Rd. E. to be raised 0.8 m or create an equivalent standalone berm upstream of the crossing ▶ A berm to be constructed along portions of the west and north property boundaries to create the storage area and maximize storage volume ▶ Re-grading of lands is required to maximize storage volume ▶ Ponding is within agricultural lands ▶ Potential storage volume is not significant ▶ Ponding limits & construction works are within HCA controlled property
SC-5 (Scenario 2)	23.11	204,000	▶ Outlet control to be implemented into existing culvert crossing at Ridge Rd. ▶ First Rd. E. to be raised 0.8 m, Ridge Rd. to be raised 1.8 m or create an equivalent standalone berm upstream of the crossing ▶ Road raising on Ridge Rd. to transition down to existing grades, west of Ridge Rd. culvert ▶ Berms to be constructed along portions of the west and north property boundaries to create the storage area and maximize storage volume ▶ Re-grading of lands is required to maximize storage volume ▶ Ponding is within agricultural lands ▶ Requires existing parcel to be severed to minimize property purchase requirements ▶ Ponding limits & construction works are within HCA controlled property and HCA properties of interest
SC-6	10.68	40,500	▶ Outlet control to be implemented ▶ A berm to be constructed along portions of the west and north property boundaries to create the storage area and maximize storage volume ▶ Re-grading of lands is required to maximize storage volume ▶ Ponding is within agricultural lands ▶ Potential storage volume is not significant ▶ Ponding limits & construction works are within HCA controlled property and HCA properties of interest

Table 4.24 Storage Facility Summary

Storage Site I.D.	Area Coverage (ha)	Available Storage (m^3)	Implementation Considerations
SC-7 (Scenario 1)	16.72	35,500	▶ Outlet control to be implemented into existing culvert crossing at Tapleytown Rd. ▶ Tapleytown Rd. to be raised 0.5 m or create an equivalent standalone berm upstream of the crossing. Road raising impacts residential driveway ▶ A berm to be constructed along a portion of the north property boundary to create the storage area and maximize storage volume ▶ Re-grading of lands is required to maximize storage volume ▶ Majority of ponding is within agricultural lands ▶ Single residential dwelling affected by ponding ▶ Ponding limits & construction works are within HCA properties of interest ▶ Potential storage volume is not significant
SC-7 (Scenario 2)	45.09	140,000	▶ Outlet control to be implemented into existing culvert crossing at Tapleytown Rd. ▶ Tapleytown Rd. to be raised 1.0 m or create an equivalent standalone berm upstream of the crossing. Road raising impacts residential driveway ▶ A berm to be constructed along a portion of the north property boundary to create the storage area and maximize storage volume ▶ Re-grading of lands is required to maximize storage volume ▶ Majority of ponding is within agricultural lands ▶ Ponding limits & construction works are within HCA properties of interest ▶ Single residential dwelling affected by ponding
SC-8 (Scenario 1)	12.16	31,400	▶ Outlet control to be implemented into existing culvert crossing at Green Mountain Rd. E. ▶ Green Mountain Rd. E. to be raised 0.5 m or create an equivalent standalone berm upstream of the crossing ▶ Re-grading of lands is required to maximize storage volume ▶ Ponding is within agricultural lands
SC-8 (Scenario 2)	15.33	48,400	▶ Outlet control to be implemented into existing culvert crossing at Green Mountain Rd. E. ▶ Green Mountain Rd. E. to be raised 0.5 m or create an equivalent standalone berm upstream of the crossing ▶ Re-grading of lands is required to maximize storage volume ▶ Ponding is within agricultural lands ▶ Requires existing parcel to be severed to minimize property purchase requirements

SC-5 Scenarios 1 and 2:

Preliminary stage-storage-discharge relationships for storage site SC-5 for Scenario 1 and Scenario 2 are provided in Tables 4.25 and 4.26 respectively. Storage for Scenario 2 is significantly more than Scenario 1, based on the larger storage surface area and greater storage depth (+/-).

Table 4.25 Storage Site SC-5 Scenario 1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 184.00	0	0
2.75/ 186.75	45000	0.38
2.90/ 186.90	50000	40
3.00/ 187.00	56916	47
3.05/ 187.05	60000	144

Table 4.26 Storage Site SC-5 Scenario 2 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 183.00	0	0
2.75/ 185.90	45000	0.38
3.00/ 186.00	52963	5.5
3.50/ 186.50	116528	25.5
4.00/ 187.00	204351	30.5
4.05/ 187.05	210000	145

Scenario 2 peak flow reduction results in Tables 4.27 and 4.28 are significantly improved over the results for Scenario 1, with 30.93% versus 4.69% reduction in 100 year peak flows respectively. The reduction in peak flow magnitude for Scenario 2 reflects the greater storage [i.e. four (4) times +/- that of Scenario 1 (204,000 m^3 versus 57,000 m^3)].

Table 4.27 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-5 Scenarios 1 and 2							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Site SC-5 Scenario 1 Only							
Edge of Escarpment	6.27	14.70	22.29	30.86	38.82	45.99	143.55
King St.	6.37	15.09	22.80	31.48	39.56	46.82	145.81
Highway 8	6.42	15.60	23.56	32.39	40.56	48.03	150.27
Battlefield/Stoney Creek Confluence	8.57	20.32	30.73	41.81	52.08	61.47	186.67
CNR	8.92	20.98	31.45	42.89	53.35	62.99	191.02
QEW	9.68	22.35	33.16	45.08	55.93	65.95	198.00
Lake Ontario	9.67	22.38	33.19	45.13	55.99	66.03	198.29
With Storage Site SC-5 Scenario 2 Only							
Edge of Escarpment	5.12	12.02	18.40	25.46	27.68	30.42	143.48
King St.	5.31	12.34	18.82	26.01	28.28	31.06	145.81
Highway 8	5.59	12.85	19.44	26.81	29.21	32.05	150.26
Battlefield/Stoney Creek Confluence	7.88	17.32	25.60	35.09	39.24	43.41	186.67
CNR	8.22	18.00	26.34	36.12	40.52	44.89	191.01
QEW	8.94	19.22	27.90	38.12	42.98	47.75	197.98
Lake Ontario	8.95	19.24	27.94	38.21	43.07	47.85	198.25

Table 4.28 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-5 Scenarios 1 and 2 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
With Storage Site SC-5 Scenario 1 Only							
Edge of Escarpment	-14.34	0.89	0.95	0.85	0.86	-1.52	0.49
King St.	-16.29	0.87	0.97	0.90	0.92	-1.43	0.41
Highway 8	-21.23	0.00	0.99	0.90	0.95	-1.07	0.46
Battlefield/Stoney Creek Confluence	-28.88	-7.72	-4.42	-4.13	-3.79	-5.29	-3.85
CNR	-29.87	-8.14	-4.81	-4.20	-3.70	-4.99	-3.69
QEW	-29.80	-8.36	-4.88	-4.13	-3.57	-4.70	-3.50
Lake Ontario	-29.88	-8.39	-4.87	-4.14	-3.60	-4.69	-3.49
With Storage Site SC-5 Scenario 2 Only							
Edge of Escarpment	-30.05	-17.50	-16.67	-16.80	-28.09	-34.86	0.44
King St.	-30.22	-17.51	-16.65	-16.63	-27.86	-34.61	0.41
Highway 8	-31.41	-17.63	-16.67	-16.48	-27.30	-33.99	0.45
Battlefield/Stoney Creek Confluence	-34.61	-21.34	-20.37	-19.54	-27.51	-33.11	-3.85
CNR	-35.38	-21.19	-20.28	-19.32	-26.86	-32.29	-3.69
QEW	-35.17	-21.20	-19.97	-18.93	-25.90	-31.00	-3.51
Lake Ontario	-35.10	-21.24	-19.92	-18.84	-25.84	-30.93	-3.51

SC-6 Scenario 1:

The preliminary stage-storage-discharge relationship for storage site SC-6 Scenario 1 is provided in Table 4.29. The 40,500 m^3 storage is the maximum storage that could be reasonably obtained from the lands located north of the creek. Storage is not considered feasible south of the creek based on the steep topography.

Table 4.29 Storage Site SC-6 Scenario 1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 186.00	0	0
2.35/ 188.35	23600	1.15
2.50/ 188.50	26507	25
2.70/ 188.70	40396	45.5
2.75/ 188.75	45000	140

Standalone Storage Site SC-6 Scenario 1 peak flow reduction results in Table 4.30 and 4.31 exhibit limited reduction in 100 year peak flows in comparison to the results from Site SC-5 Scenario 1. In addition, due to less storage in SC-6 (40,500 m^3) versus SC-5 (57,000 m^3 +/-), SC-5 is also located downstream of SC-6 and therefore has a larger contributing area, resulting in more effective storage.

Table 4.30 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-6 Scenario 1							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Site SC-6 Scenario 1							
Edge of Escarpment	7.04	14.63	22.19	30.34	38.06	46.07	143.46
King St.	7.25	15.02	22.70	30.96	38.75	46.89	145.76
Highway 8	7.47	15.66	23.47	31.89	39.76	47.96	150.17
Battlefield/Stoney Creek Confluence	10.18	20.97	30.99	41.37	51.08	61.17	186.62
CNR	10.60	21.73	31.84	42.58	52.38	62.58	190.91
QEW	11.48	23.21	33.64	44.85	55.00	65.49	197.82
Lake Ontario	11.48	23.25	33.67	44.91	55.08	65.56	198.08

Table 4.31 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-6 Scenario 1 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Edge of Escarpment	-3.83	0.41	0.50	-0.85	-1.12	-1.35	0.43
King St.	-4.73	0.40	0.53	-0.77	-1.15	-1.28	0.38
Highway 8	-8.34	0.38	0.60	-0.65	-1.05	-1.22	0.39
Battlefield/Stoney Creek Confluence	-15.52	-4.77	-3.61	-5.14	-5.63	-5.75	-3.87
CNR	-16.67	-4.86	-3.63	-4.89	-5.45	-5.61	-3.74
QEW	-16.75	-4.84	-3.50	-4.62	-5.17	-5.36	-3.59
Lake Ontario	-16.75	-4.83	-3.50	-4.61	-5.17	-5.37	-3.60

SC-7 Scenarios 1 and 2:

Preliminary stage-storage-discharge relationships for storage site SC-7 for Scenario 1 and Scenario 2 are provided in Table 4.32 and 4.33 respectively. Storage for Scenario 2 is significantly more than Scenario 1, based on over twice the storage area and 3.2 m versus 2.7 m storage depth.

Table 4.32 Storage Site SC-7 Scenario 1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 189.00	0	0
1.50/ 190.50	23000	1.06
1.70/ 190.70	35546	43.5
1.75/ 190.75	40000	135

Table 4.33 Storage Site SC-7 Scenario 2 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 189.00	0	0
1.60/ 190.60	40100	0.34
2.00/ 191.00	94103	24.5
2.20/ 191.20	145946	33
2.25/ 191.25	150000	130

Scenario 2 peak flow reduction results in Table 4.34 and 4.35 are significantly improved over the results for Scenario 1, with 23.48% versus 3.16% reduction in 100 year peak flows respectively. The reduction in peak flows for Scenario 2 reflects the higher of storage [four (4) times +/- that of Scenario 1 (146,000 m^3 versus 35,500 m^3)].

Table 4.34 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-7 Scenarios 1 and 2							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Site SC-7 Scenario 1 Only							
Edge of Escarpment	6.73	14.63	22.44	31.30	39.29	47.58	144.56
King St.	6.95	15.00	22.94	31.89	40.06	48.39	146.88
Highway 8	7.22	15.56	23.62	32.69	40.98	49.44	151.35
Battlefield/Stoney Creek Confluence	9.91	20.72	30.96	42.10	52.41	62.85	187.68
CNR	10.32	21.45	31.75	43.20	53.70	64.25	192.07
QEW	11.19	22.90	33.49	45.41	56.29	67.16	199.05
Lake Ontario	11.20	22.94	33.52	45.45	56.35	67.24	199.38
With Storage Site SC-7 Scenario 2 Only							
Edge of Escarpment	4.69	11.83	18.57	26.10	30.41	35.18	114.58
King St.	4.86	12.16	19.00	26.66	31.07	35.92	146.90
Highway 8	5.12	12.65	19.61	27.44	32.08	37.03	151.37
Battlefield/Stoney Creek Confluence	7.39	17.09	25.81	35.85	42.24	48.85	187.70
CNR	7.85	17.76	26.54	36.85	43.45	50.20	192.09
QEW	9.29	18.96	28.10	38.87	45.85	52.91	199.07
Lake Ontario	9.32	18.99	28.14	38.94	45.93	53.01	199.41

Table 4.35 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-7 Scenarios 1 and 2 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
With Storage Site SC-7 Scenario 1 Only							
Edge of Escarpment	-8.06	0.41	1.63	2.29	2.08	1.88	1.20
King St.	-8.67	0.27	1.59	2.21	2.19	1.87	1.15
Highway 8	-11.41	-0.26	1.24	1.84	1.99	1.83	1.18
Battlefield/Stoney Creek Confluence	-17.76	-5.90	-3.70	-3.46	-3.18	-3.16	-3.33
CNR	-18.87	-6.09	-3.90	-3.51	-3.07	-3.09	-3.16
QEW	-18.85	-6.11	-3.93	-3.42	-2.95	-2.95	-2.99
Lake Ontario	-18.78	-6.10	-3.93	-3.46	-2.98	-2.94	-2.96
With Storage Site SC-7 Scenario 2 Only							
Edge of Escarpment	-35.93	-18.81	-15.90	-14.71	-20.99	-24.67	-19.79
King St.	-36.14	-18.72	-15.85	-14.55	-20.74	-24.38	1.16
Highway 8	-37.18	-18.91	-15.95	-14.52	-20.16	-23.73	1.20
Battlefield/Stoney Creek Confluence	-38.67	-22.39	-19.72	-17.79	-21.97	-24.73	-3.32
CNR	-38.29	-22.24	-19.67	-17.69	-21.57	-24.28	-3.15
QEW	-32.63	-22.26	-19.39	-17.33	-20.95	-23.54	-2.98
Lake Ontario	-32.41	-22.27	-19.35	-17.29	-20.92	-23.48	-2.95

SC-8 Scenarios 1 and 2:

Preliminary stage-storage-discharge relationships for storage site SC-8 for Scenario 1 and Scenario 2 are provided in Table 4.36 and 4.37 respectively. The storage ratio between Scenarios 2 and 1 is approximately 1.5. Scenario 2 with a storage of 48,400 m^3 would only provide 17,000 m^3 more storage than Scenario 1 with a storage of 31,400 m^3.

Table 4.36 Storage Site SC-8 Scenario 1 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 192.00	0	0
1.40/ 193.40	13300	0.22
1.50/ 193.50	17409	12.5
1.70/ 193.70	31416	17
1.75/ 193.75	35000	56

Table 4.37 Storage Site SC-8 Scenario 2 Preliminary Stage Storage Discharge Relationship

Stage/ Elevation (m)	Storage (m^3)	Discharge (m^3/s)
0.00/ 192.00	0	0
1.40/ 193.40	13300	0.22
1.50/ 193.50	27140	12
1.70/ 193.70	48419	15.5
1.75/ 193.75	53000	56

Scenario 2 peak flow reduction results in Table 4.38 and 4.39 are only moderately improved over results for Scenario 1, with 12.67% versus 9.28% reduction in 100 year peak flows respectively. The limited reduction in peak flows for Scenario 2 is a direct result of minor increase in storage compared to that of Scenario 1.

Table 4.38 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Site SC-8 Scenarios 1 and 2							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Site SC-8 Scenario 1 Only							
Edge of Escarpment	6.09	13.58	21.31	29.85	36.37	43.08	143.18
King St.	6.30	13.93	21.76	30.44	37.09	43.90	145.53
Highway 8	6.58	14.47	22.42	31.28	38.12	45.12	149.89
Battlefield/Stoney Creek Confluence	9.65	19.53	29.56	40.46	49.32	58.37	186.49
CNR	10.48	20.31	30.37	41.57	50.62	59.82	190.48
QEW	11.65	21.78	32.11	43.76	53.19	62.76	197.28
Lake Ontario	11.66	21.83	32.15	43.82	53.27	62.85	197.55
With Storage Site SC-8 Scenario 2 Only							
Edge of Escarpment	5.63	12.82	20.17	28.24	34.53	40.69	143.13
King St.	5.84	13.17	20.62	28.84	35.23	41.53	145.48
Highway 8	6.14	13.71	21.29	26.98	36.26	42.75	149.84
Battlefield/Stoney Creek Confluence	9.65	18.68	28.27	38.77	47.36	55.97	186.45
CNR	10.48	19.47	29.08	39.88	48.68	57.47	190.42
QEW	11.65	20.95	30.83	42.09	51.24	60.41	197.22
Lake Ontario	11.65	21.00	30.87	42.16	51.31	60.50	197.49

Table 4.39 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-7 Scenarios 1 and 2 (%)							
Location/Model	**Return Period (Years)**						
	2	**5**	**10**	**25**	**50**	**100**	**Regional**
With Storage Site SC-8 Scenario 1 Only							
Edge of Escarpment	-16.80	-6.79	-3.49	-2.45	-5.51	-7.75	0.23
King St.	-17.21	-6.89	-3.63	-2.44	-5.38	-7.58	0.22
Highway 8	-19.26	-7.24	-3.90	-2.55	-5.13	-7.06	0.21
Battlefield/Stoney Creek Confluence	-19.92	-11.31	-8.06	-7.22	-8.89	-10.06	-3.94
CNR	-17.61	-11.08	-8.08	-7.15	-8.63	-9.77	-3.96
QEW	-15.52	-10.70	-7.89	-6.93	-8.29	-9.31	-3.85
Lake Ontario	-15.45	-10.64	-7.85	-6.92	-8.28	-9.28	-3.85
With Storage Site SC-8 Scenario 2 Only							
Edge of Escarpment	-23.09	-12.01	-8.65	-7.71	-10.29	-12.87	0.20
King St.	-23.26	-11.97	-8.68	-7.56	-10.13	-12.57	0.19
Highway 8	-24.66	-12.12	-8.74	-15.95	-9.76	-11.95	0.17
Battlefield/Stoney Creek Confluence	-19.92	-15.17	-12.07	-11.10	-12.51	-13.76	-3.96
CNR	-17.61	-14.75	-11.99	-10.92	-12.13	-13.32	-3.99
QEW	-15.52	-14.10	-11.56	-10.48	-11.66	-12.70	-3.88
Lake Ontario	-15.52	-14.04	-11.52	-10.45	-11.66	-12.67	-3.88

Property Impact Assessment

The assessment of the effectiveness of the potential storage areas has been further evaluated by approximating the number of properties and buildings that would be at risk of flooding for the 2 year to 100 year and Regional Storm, as compared to existing conditions. Table 4.40 provides the flood risk for Battlefield Creek and Stoney Creek below the Escarpment for each storage area scenario.

Table 4.40 Lower Battlefield Creek and Stoney Creek – Total Properties and Buildings at Risk

Scenario	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Existing Battlefield Creek[3]	Property	1	7	9	10	10	16	52	
	Buildings		1	1	1	1	9	31	
Storage Area BC-1[1]	Property	1	7	8	9	10	14	52	Negligible impact on flooding numbers within Battlefield Creek.
	Buildings		1	1	1	1	8	31	
Existing Stoney Creek[3]	Property		10	31	54	73	86	142	
	Buildings		1	2	7	22	37	85	
Existing Combined Battlefield Creek and Stoney Creek	Property	1	17	40	64	83	102	194	Sum of Existing Battlefield Creek & Existing Stoney Creek.
	Buildings		2	3	8	23	46	116	
Storage Area SC-1[2]	Property				8	21	38	142	Reduces 100 year flooding numbers to less than 25 year flooding numbers within Stoney Creek.
	Buildings				1	1	2	85	
Storage Area SC-2[2]	Property		7	21	38	68	86	142	Reduction in 25 year flooding numbers. All other storm events have negligible or no reduction in flooding numbers.
	Buildings		1	1	2	10	37	85	
Storage Area SC-3[2]	Property		7	21	38	68	78	142	Reduction in 25 year & 100 year flooding numbers. All other storms have negligible or no reduction in flooding numbers.
	Buildings		1	1	2	10	24	85	
Storage Area SC-4[2]	Property		7	21	38	68	78	142	Reduction in 25 year & 100 year flooding numbers. All other storms have negligible or no reduction in flooding numbers.
	Buildings		1	1	2	10	24	85	
Storage Area SC-5[2] (Scenario 1)	Property		10	31	54	73	86	142	No reduction in flooding numbers.
	Buildings		1	2	7	22	37	85	
Storage Area SC-5[2] (Scenario 2)	Property		6	20	38	51	54	142	Reduces 100 year flooding numbers to less than 25 year flooding numbers within Stoney Creek.
	Buildings		1	1	2	5	6	85	
Storage Area SC-6[2]	Property		10	31	54	72	86	142	Negligible or no reduction in flooding numbers.
	Buildings		1	2	6	21	37	85	
Storage Area SC-7[2] (Scenario 1)	Property		9	31	54	73	86	142	Negligible or no reduction in flooding numbers.
	Buildings		1	2	7	23	37	85	

Table 4.40 Lower Battlefield Creek and Stoney Creek – Total Properties and Buildings at Risk

Scenario	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Storage Area SC-7[2] (Scenario 2)	Property		2	8	14	15	15	142	Significant reduction in flooding numbers for 2 – 100 year storm events. Reduces 100 year flooding numbers to less than 10 year flooding numbers within Stoney Creek.
	Buildings							85	
Storage Area SC-8[2] (Scenario 1)	Property		7	28	53	70	84	142	Small reduction in flooding numbers for 2 – 100 year storm events.
	Buildings		1	1	6	16	35	85	
Storage Area SC-8[2] (Scenario 2)	Property		7	24	45	68	78	142	Small reduction in flooding numbers for 2 – 100 year storm events.
	Buildings		1	1	4	10	29	85	

NOTES:
[1] Property / building numbers listed along Battlefield Creek only
[2] Property / building numbers listed along Stoney Creek only
[3] Flood risk identified based on 2011 Class EA peak flows (continuous) and associated rating curves to determine property and buildings at risk

4.2 Erosion Risk Assessment

The storage locations assessed in Section 4.1 in addition to providing flood control to reduce flooding risk, have the potential ability to reduce erosive flow durations within lower Stoney Creek and Battlefield Creek, thereby mitigate a portion of erosion issues.

In order to better quantify the current erosion risk, the Team conducted field work to determine critical erosion causing flow rates (ref. Section 3.4 and Appendix E). Based on the critical flow assessment, the Stoney Creek critical flow has been established as 7.53 m^3/s for the reach immediately downstream of Highway 8 and upstream of the confluence of Stoney Creek and Battlefield Creek. Flows at Highway 8 are considered to be the most representative of flows through the reach, with an upstream drainage area of 2010 ha (ref. Figure 6).

For the Battlefield Creek, the critical flow is 1.93 m^3/s as compared to the 2 year storm frequency flow of 4.62 m^3/s for the reach downstream of Lake Avenue North and upstream of the confluence of Stoney Creek and Battlefield Creek. Flows have been determined at Lake Avenue North with an upstream drainage area of 759.3 ha (ref. Figure 6).

An initial screening of the storage facilities has been completed, using the ration of peak flows to storage volumes for the first portion of the stage / storage discharge relationship, to determine the potential erosion reduction effectiveness. Based on this assessment, the following storage facilities are anticipated to provide the most effective erosion reduction benefits:

- SC-1,
- SC-2,
- SC-3,
- SC-4,
- SC5 (Scenario 1),
- SC5 (Scenario 2), and
- SC7 (Scenario 2)

4.3 Hydrogeological Assessment

To develop an understanding of any potential hydrogeological constraints, the depth to bedrock has been mapped for above the Escarpment (ref. Figure 4.1). The depth to bedrock varies significantly across the Escarpment ranging from less than 1 m to over 13 m. The depth to bedrock for each storage facility alternative apart from potentially SC-1 and SC-6, based on measurements in Figure 4.1 should not impact the feasibility of constructing a facility. At SC-1 and SC-6 the depth of bedrock could be less than 1 m in certain locations, therefore requiring rock excavation to develop a wetland feature which reduces its potential to practically attain required storage volume.

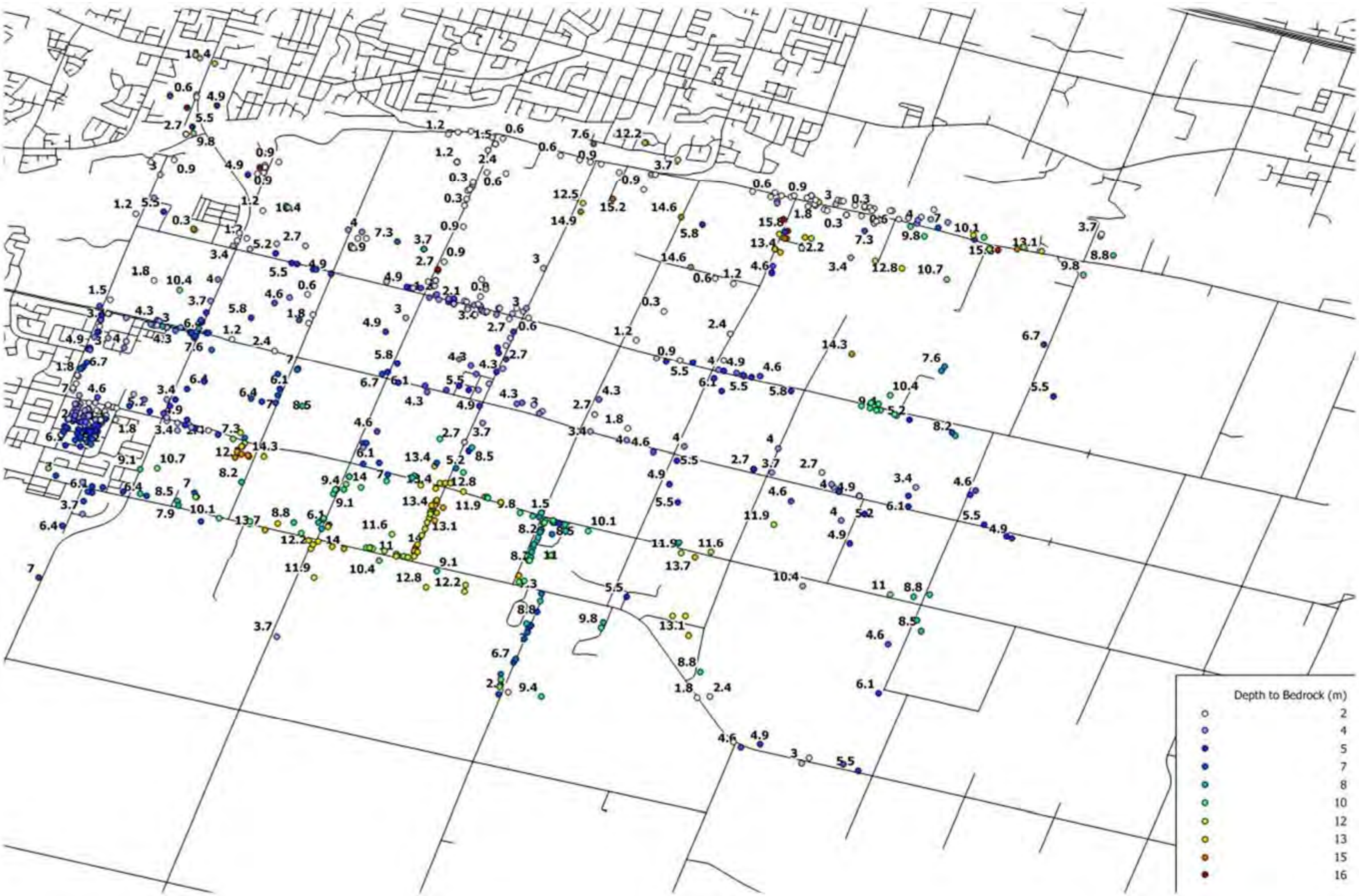

Figure 4.1 Depth to Bedrock

4.4 Terrestrial Assessment

4.4.1 Methods

4.4.1.1 Vegetation

A botanical inventory was completed by Dougan & Associates' staff on June 8, 2017. Vegetation Communities were identified based on the protocols outlined in the Ecological Land Classification (ELC) System for Southern Ontario, first approximation (Lee et. al., 1998). Species were recorded for the five sites from the roadside and via the Dofasco 2000 Trail (adjacent to sites SC-3 and BC-1). ELC Ecosite codes were assigned to the various study sites based solely on the species observed from the roadside or trail as no soil samples were taken. Polygons were identified from aerial imagery, and in some instances, were corroborated from property lines (trail and/or roadside). A full list of vascular plants is provided as Appendix F including scientific name, common name, and relevant status information including local, regional and provincial rarity status.

An additional five sites were later assessed via desktop using Google Earth ™ on November 10, 2017. These sites include SC-5A, SC-5B, SC-6, SC-7, and SC-8 (ref. Appendix F for site locations). ELC Community Series were applied to these additional sites based on satellite imagery and Google Earth Street View ™.

4.4.1.2 Wildlife

Two breeding bird surveys were conducted on June 11 and June 25, 2017, following the protocols outlined in the Ontario Breeding Bird Atlas (OBBA 2001). This protocol stipulates that the surveys be conducted between sunrise and 10:00 a.m., between May 24 and July 12, 2017, during appropriate weather conditions (i.e., light winds, no heavy rains). Note that these surveys were conducted at sites BC-1, SC-1, SC-2, SC-3, and SC-4 only. See Table 4.41 for details.

Table 4.41 Summary of 2017 Wildlife Survey Visits to the Study Area

Date (2017)	Observer	Time	Weather Conditions	Purpose
June 11	Ian Richards	06:30 – 09:40	Clear, southwest winds (Beaufort 2 to 4), 20 – 26°C	Breeding Bird Survey #1
June 25	Ian Richards	06:30 – 09:30	Clear, southwest winds (Beaufort 2 to 3), 14 – 18°C	Breeding Bird Survey #2

4.4.2 Findings

4.4.2.1 Roadside Vegetation Assessment

Ecological Land Classification (ELC)

Stoney Creek Storage Sites 1, 2, and 4 (SC-1, SC-2, and SC-4) possess similar vascular plant species and ecological structure. Introduced willow species *(Salix spp.)* and dying green ash (*Fraxinus pennsilvanica*) formed the canopy and the sub-canopy was predominately comprised of Common Buckthorn (*Rhamnus cathartica*). The herbaceous layer was primarily Canary Reed Grass (*Phalaris arundinacea*) and other introduced graminoid species indicative of a highly disturbed and degraded ecological community. These three sites are surrounded by agricultural fields that possess very little biological diversity. These polygons were observed from the roadside and ranged from Green Ash Mineral Deciduous Swamp Type (SWD2-2) to Grey Dogwood Mineral Thicket Swamp Type (SWT2-9) or Agricultural (AGR) depending on the extent of tree and shrub cover adjacent to the creek.

Stoney Creek Storage Site 3 (SC-3) has three distinct ELC community polygons. The first is a Mineral Cultural Woodland dominated by Black Cherry (*Prunus serotina*) and Trembling Aspen (*Populus tremuloides*) in the canopy layer with and an abundance of Climbing Poison Ivy (*Toxicodendron radicans*) from the canopy to the ground layer. The second polygon is situated along the watercourse and is classified as a Gray Dogwood Mineral Thicket Swamp Type (SWT2-9) whereby there was a dominant understory layer (very little canopy) represented by Gray Dogwood (*Cornus racemosa*) followed by American Elm (*Ulmus americana*), Riverbank Grape (*Vitis riparia*), and Nannyberry (*Viburnum lentago*). The third polygon, observed from the Dofasco 2000 Trail, boasts an abundance of native species, which is indicative of a more intact ecological community. It was determined that, based on the vegetation and presence of surface water, it is most likely a deciduous swamp (Bur Oak Mineral Deciduous Swamp Type: SWD1-2), however this was not verified with soil sampling, nor was it assessed using the Ontario Wetland Evaluation System (OWES). The dominant canopy species is Bur Oak (*Quercus marcrocarpa*) followed by Silver Maple (*Acer saccharinum*). The sub-canopy consists of native species Bur Oak, Silver Maple, and Bebb's Willow (*Salix bebbii*). The understory was found to be predominately Gray Dogwood and Meadowsweet (*Spiraea alba*); both native to the region. For a full vascular plant list, please refer to Appendix F.

Battlefield Creek (BC-1) is highly diverse with a combination of native and introduced species. The canopy was found to be mostly Bur Oak and dying Green Ash. Many of the species are indicative of a wetland system, however without soil samples, it is unclear whether this site is a Bur Oak Deciduous Forest (FOD9-2) or a Bur Oak Mineral Deciduous Swamp. For the purpose of this study, this site is categorized as the latter, SWD1-2. Within the forested section is a shallow marsh (MAS), see Appendix F for location on map.

Table 4.42 ELC Community Ecosite and Vegetation Type of Roadside Assessed Sites

ELC Code	ELC Description	Area					
		SC-1	SC-2	SC-3	SC-4	BC-1	Total
CUW1	Mineral Cultural Woodland			x			1
MAM2-2	Reed-canary Grass Mineral Meadow Marsh		x		x		2
MAS	Shallow Marsh					x	1
SWT2-9	Gray Dogwood Mineral Thicket Swamp			x			1
SWD1-2	Bur Oak Mineral Deciduous Swamp			x		x	2
SWD2-2	Green Ash Mineral Deciduous Swamp	x					1

Though all sites are located along the Creek corridors, some sites were assessed as wetland while others were deemed to be more upland (or potentially tiled). A list of wetlands both recognized as provincially significant and not evaluated are included in Table 4.43.

Table 4.43 Sites with Wetlands and Woodlands

Feature Type	ELC Types Included	SC-1	SC-2	SC-3	SC-4	BC-1
Wetlands (PSW)	SWD1-2 SWT2-9			X		
Wetlands (not evaluated)	SWD2-2 MAM2-2	X			X	
Woodlands	CUW1	X		X		X

Botanical Inventory

A total of 120 vascular plants were observed during the site visit on June 8, 2017. Of these, 108 were identified to species level, with 64 (59.3%) native to Ontario, and 44 (40.7%) that are non-native. All of the species observed are common and widespread in both Canada and Ontario, with S-ranks of S5 or S4, indicating Secure or Apparently Secure provincial populations. While none of the species observed are considered significant within Hamilton Region, several species are uncommon in the neighbouring Niagara Region. These nine (9) species include Virginia Virgin's-bower (*Clematis virginiana)*, Red-osier Dogwood (*Cornus stolonifera)*, Barren Strawberry (*Geum fragarioides)*, Water Loosestrife (*Lysimachia thyrsiflora)*, Star-flowered False Solomon's Seal (*Maianthemum stellatum)*, Virginia Creeper (*Parthenocissus quinquefolia)*, Bur Oak (*Quercus macrocarpa)*, Arrow-leaved Aster (*Symphyotrichum urophyllum)*, and Orange-fruited Horse-gentian (*Triosteum aurantiacum).* One (1) species, Alderleaf Buckthorn (*Rhamnus alnifolia)*, is considered rare in Niagara Region.

4.4.2.2 Desktop Vegetation Assessment

Stoney Creek Storage Site 5 (SC-5) is subdivided into A and B. Sub-site A is situated along the watercourse near Ridge Road where there appears to be a dense deciduous canopy cover surrounded by agricultural fields, a coniferous plantation, and a residential property. Sub-site B is further east along Stoney Creek with the same canopy cover surrounded by a combination of agricultural fields, coniferous plantation, and shrub thicket.

The deciduous tree cover appears wider at SC-6 and connects to a parcel of land that may be undergoing natural revegetation (a combination of shrub thicket and early successional tree species). This location is too far from any roads for Google Street View, thereby restricting the desktop review to satellite imagery.

SC-7 is in among a tree covered section of the creek, further north along 3 Road East from SC-2. A combination of Silver Maple, Sugar Maple, Ash, and Buckthorn line the street. This section of Stoney Creek is connected to a 28 hectare swath of deciduous forest before it exits toward SC-1.

Further east SC-8 is found adjacent to Green Mountain Road East. This section of the Creek has little to no tree cover. There is evidence of cattails, a shrub thicket, and a few scattered deciduous trees within a larger agricultural field and residential properties.

Table 4.44 ELC Community Series of Desktop Assessed Sites

ELC Code	ELC Description	Area					
		SC-5A	SC-5B	SC-6	SC-7	SC-8	Total
AGR	Agriculture	x	x	x		x	4
CUP3	Coniferous Cultural Plantation	x	x				2
FOD	Deciduous Forest				x		1
SWT	Swamp Thicket	x	x	x		x	4
SWD	Deciduous Swamp				x		1

4.4.2.3 Species-at-Risk

No Species at Risk (SAR) were observed during the field investigations; however, these site visits were limited to roadside screenings as there was no property access to the interior of each site. Further field investigations are recommended given the possibility of Species at Risk presence. Table 4.45 is a list of vascular plant SAR that are known to occur in the City of Hamilton, as per correspondence with Guelph District MNRF, that may be present at one or more of the study sites based on habitat suitability.

Table 4.45 Potential Species-at-Risk within Study Areas (MNRF, Guelph District)

Species at Risk	Provincial Status	Area									
		SC-1	SC2	SC-3	SC-4	BC-1	SC-5A	SC-5B	SC-6	SC-7	SC-8
American Chestnut (*Castanea dentata)*	END									x	
American Columbo (*Frasera caroliniensis)*	END	x		x		x	x		x	x	x
American Ginseng (*Panax quinquefolius)*	END			x			x			x	
Broad Beech Fern (*Phegopteris hexagonoptera)*	SC	x			x	x				x	
Butternut (*Juglans cinerea)*	END	x	x	x		x					
Eastern Flowering Dogwood (*Cornus florida)*	END									x	
Green Dragon (*Arisaema dracontium)*	SC			x							
Red Mulberry (*Morus rubra)*	END			x		x	x			x	
White Wood Aster (*Eurybia divaricata)*	THR									x	

4.4.2.4 Wildlife

Breeding Bird Surveys

BC-1:

A total of 18 species of birds were detected during the breeding bird surveys. All species observed are considered native to the province and none of them are considered Species at Risk (SAR) federally (COSEWIC 2016) or provincially (OMNRF 2017).

At a provincial level, all of the 18 breeding species have been assigned an Srank of either S4 or S5 by the Natural Heritage Information Centre (NHIC 2017b), which indicates that their provincial populations are Apparently Secure or Secure, respectively (NHIC 2017a).

At a local level, all 18 of the potentially breeding species are considered common to abundant and widespread in the City of Hamilton (Smith 2014).

None of the breeding birds observed are considered area sensitive by the Ontario Ministry of Natural Resources and Forestry (OMNR 2000). This indicates that none of them require large areas of suitable habitat for their long-term survival and thus are not as sensitive to development.

For application of the Migratory Birds Convention Act (MBCA 1994), 14 of the 18 species recorded as at least possibly breeding are protected by the Act. As such, it means that it is illegal to harm or kill these species, or to harm or destroy their nests and nesting habitat. The four species that are afforded no protection from the Act are Blue Jay, Red-winged Blackbird, Common Grackle, and Brown-headed Cowbird. Note that Blue Jay is afforded protection from the provincial Fish and Wildlife Conservation Act (2002).

SC-1:

A total of 22 species of birds were detected during the breeding bird surveys. Four species – Great Blue Heron, Green Heron, Turkey Vulture, and Common Grackle – were observed flying over the site only, and were not considered breeding. Of the 18 species of breeding birds, one of them is considered introduced (non-native): European Starling. Of the remaining 17 species, none of them are considered a Species at Risk (SAR), whether federally (COSEWIC 2016) or provincially (OMNRF 2017).

At a provincial level, all of the 17 native breeding species have been assigned an Srank of either S4 or S5 by the Natural Heritage Information Centre (NHIC 2017b), which indicates that their provincial populations are “apparently secure” or “secure”, respectively (NHIC 2017a).

At a local level, all 18 of the potentially breeding species are considered common to abundant and widespread in the City of Hamilton (Smith 2014).

The Ontario Ministry of Natural Resources and Forestry (OMNR 2000) considers Savannah Sparrow to be area sensitive. This indicates that it requires large areas of suitable habitat for its long-term survival and thus can be sensitive to development.

For application of the Migratory Birds Convention Act (MBCA 1994), 14 of the 18 species recorded as at least possibly breeding are protected by the Act. As such, it means that it is illegal to harm or kill these species, or to harm or destroy their nests and nesting habitat. The four species that are afforded no protection from the Act are Red-tailed Hawk, American Crow, European Starling, and Brown-headed Cowbird. Note that Red-tailed Hawk is afforded protection by the provincial Fish and Wildlife Conservation Act (2002).

SC-2:

A total of 21 species of birds were detected during the breeding bird surveys. Two species – Wild Turkey and American Crow – were observed flying over the site only, and were not considered breeding. Of the 19 species of breeding birds, three of them are considered introduced (non-native): Ring-necked Pheasant, European Starling and House Sparrow. Of the remaining 16 species, none of them are considered a Species at Risk (SAR), whether federally (COSEWIC 2016) or provincially (OMNRF 2017).

At a provincial level, all of the 16 native breeding species have been assigned an Srank of either S4 or S5 by the Natural Heritage Information Centre (NHIC 2017b), which indicates that their provincial populations are Apparently Secure or Secure, respectively (NHIC 2017a).

At a local level, 17 of the 19 species of potentially breeding species are considered common to abundant and widespread in the City of Hamilton (Smith 2014). The two exceptions are Ring-necked Pheasant (rare – introduced) and Northern Mockingbird, which is considered "uncommon".

None of the species observed are considered area sensitive by the Ontario Ministry of Natural Resources and Forestry (OMNR 2000). This indicates that none of them require large areas of suitable habitat for their long-term survival and thus are not sensitive to development.

For application of the Migratory Birds Convention Act (MBCA 1994), 12 of the 19 species recorded as at least possibly breeding are protected by the Act. As such, it means that it is illegal to harm or kill these species, or to harm or destroy their nests and nesting habitat. The seven species that are afforded no protection from the Act are Ring-necked Pheasant, Red-tailed Hawk, Blue Jay, European Starling, House Sparrow, Common Grackle, and Brown-headed Cowbird. Note that Red-tailed Hawk and Blue Jay are afforded protection by the provincial Fish and Wildlife Conservation Act (2002).

SC-3:

A total of 32 species of birds were detected during the breeding bird surveys. Two species – Common Grackle and Brown-headed Cowbird – were observed flying over the site only or were at an extreme distance (beyond 250 metres), and were not considered breeding at or adjacent to the site. All 30 species of potentially breeding birds are considered native.

Of the 30 species of breeding birds, two of them are considered Species at Risk (SAR): Eastern Wood-Pewee (Special Concern) and Wood Thrush (Threatened (federally) and Special Concern (provincially) (COSEWIC 2016; OMNRF 2017).

At a provincial level, all of the 30 native breeding species have been assigned an Srank of either S4 or S5 by the Natural Heritage Information Centre (NHIC 2017b), which indicates that their provincial populations are Apparently Secure or Secure, respectively (NHIC 2017a).

At a local level, 25 of the 30 species of potential breeders are considered common to abundant and widespread in the City of Hamilton (Smith 2014). The five exceptions are Yellow-billed Cuckoo (rare), Black-billed Cuckoo (uncommon), Ruby-throated Hummingbird (uncommon), Red-bellied Woodpecker (uncommon), and Hairy Woodpecker (uncommon).

The Ontario Ministry of Natural Resources and Forestry (OMNR 2000) considers Hairy Woodpecker and White-breasted Nuthatch to be area sensitive, which indicates that they require large areas of suitable habitat for their long-term survival and thus are sensitive to development.

For application of the Migratory Birds Convention Act (MBCA 1994), 27 of the 30 species recorded as at least possibly breeding are protected by the Act. As such, it means that it is illegal to harm or kill these species, or to harm or destroy their nests and nesting habitat. The three species that are afforded no protection from the Act are Blue Jay, American Crow, and Red-winged Blackbird. Note that Blue Jay is afforded protection by the provincial Fish and Wildlife Conservation Act (2002).

SC-4:

A total of 20 species of birds were detected during the breeding bird surveys. Seven species – Mallard, Rock Pigeon, Ring-billed Gull, Northern Flicker, American Crow, Barn Swallow, and Common Grackle – were observed flying over the site only or were at an extreme distance (beyond 250 metres), and were not considered breeding at or adjacent to the site. Of the 13 species of breeding birds, all of them are considered native and none of them are Species at Risk (SAR), whether federally (COSEWIC 2016) or provincially (OMNRF 2017).

At a provincial level, all of the 13 native breeding species have been assigned an Srank of either S4 or S5 by the Natural Heritage Information Centre (NHIC 2017b), which indicates that their provincial populations are Apparently Secure or Secure, respectively (NHIC 2017a).

At a local level, 11 of the 13 species of potential breeders are considered common to abundant and widespread in the City of Hamilton (Smith 2014). The two exceptions are American Kestrel and Northern Mockingbird, which are both considered uncommon.

The Ontario Ministry of Natural Resources and Forestry (OMNR 2000) considers Savannah Sparrow to be area sensitive, which indicates that it requires large areas of suitable habitat for its long-term survival and thus is sensitive to development.

For application of the Migratory Birds Convention Act (MBCA 1994), 10 of the 13 species recorded as at least possibly breeding are protected by the Act. As such, it means that it is illegal to harm or kill these species, or to harm or destroy their nests and nesting habitat. The three species that are afforded no protection from the Act are American Kestrel, Red-winged Blackbird, and Brown-headed Cowbird. Note that American Kestrel is afforded protection by the provincial Fish and Wildlife Conservation Act (2002).

For full details on the breeding bird surveys for this site, please see Appendix F.

Other sites:

Breeding bird surveys were not conducted at SC-5 A, SC-5 B, SC-6, SC-7, and SC-8. These were assessed by desktop only.

4.4.2.5 Significant Wildlife Habitat (SWH) Assessment

During all field investigations, habitats on site were screened against the Significant Wildlife Habitat (SWH) categories contained within the *Significant Wildlife Habitat Technical Guide* (OMNR 2000) and the *Significant Wildlife Habitat Criteria Schedules for Ecoregion 7E* (OMNRF 2015).

Of the 38 categories of SWH, the following are considered “Confirmed”, “Candidate” or “Unknown” for the ten sites and their adjacent lands (within 120 metres):

BC-1: Seven Candidate and one Unknown

- Seasonal Concentration Areas of Animals: Bat Maternity Colony – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Seasonal Concentration Areas of Animals: Landbird Migratory Stopover Areas – Candidate
- Rare Vegetation Communities: Other Rare Vegetation Communities – Candidate
- Specialized Habitat for Wildlife: Amphibian Breeding Habitat (Woodlands) – Candidate
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Candidate. No Special Concern or Rare species (e.g. with provincial Sranks of S1 to S3) were found during field investigations. However, Snapping Turtle (SC) may be present in the watercourse and two ponds to the west. Potential habitat for Eastern Wood-Pewee (SC) and Wood Thrush (SC) exists in the adjacent woods although none were detected during 2017 breeding bird surveys. Monarch (SC) may occur in open areas within 120 metres of the site where its hostplant (Common Milkweed) exists; given the location of the site, it is unlikely that this species would be present in significant numbers, whether as breeder or during migration.
- Animal Movement Corridors: Amphibian Movement Corridors – Candidate. Small numbers of amphibians may move primarily in an east-west direction (i.e., along the watercourse). Given the overall lack of large wetlands and the surrounding agricultural habitats, these movements would not be significant in nature. Note that thresholds for this category have not yet been established by the MNRF or City of Hamilton.

SC-1: Two Unknowns

- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown. No Special Concern or Rare species (e.g. with provincial Sranks of S1 to S3) were found during field investigations. However, Snapping Turtle (SC) may be present in the watercourse and Monarch (SC) may occur in open areas within 120 metres of the site

where its hostplant (Common Milkweed) exists. Given the location of the site, it is unlikely that Monarch would be present in significant numbers, whether as breeder or during migration.

Note that this site is 240 metres from a large woodlands to the north-northwest (Tapleytown Woods ESA: STCK-138). Therefore, a shift of the location in that direction may bring it to within 120 metres and thereby 'trigger' additional categories associated with the woodlot.

SC-2: One Candidate and two Unknowns

- Seasonal Concentration Areas of Animals: Raptor Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown. No Special Concern or Rare species (e.g. with provincial Sranks of S1 to S3) were found during field investigations. Monarch (SC) may occur in open areas within 120 metres of the site where its hostplant (Common Milkweed) exists; given the location of the site, it is unlikely that this species would be present in significant numbers, whether as breeder or during migration.

Note that this site is 190 metres from a large woodlands to the northeast (Tapleytown Woods ESA: STCK-138). Therefore, a shift of the location in that direction may bring it to within 120 metres and thereby 'trigger' additional categories associated with the woodlot.

SC-3: Two Confirmed, thirteen Candidate, two Unknowns

This location is within the Vinemount South Swamp ESA (STCK-77). This ESA encompasses the largest remaining woodlot (169 hectares) in the City of Hamilton, south of the Niagara Escarpment. It is located along the southern edge of the Vinemount Moraine and, as such, functions as a groundwater recharge zone. It also forms the headwaters of both Stoney and Forty Mile creeks. It has been identified as a Regional Earth Science ANSI (Vinemount Moraine) and a PSW (Vinemount Swamp). Given this location, it is not surprising that this site has triggered the most SWH categories of all the site, especially those relating to larger forests and wetlands.

- Seasonal Concentration Areas of Animals: Waterfowl Stopover and Staging Areas (Aquatic) – Candidate
- Seasonal Concentration Areas of Animals: Bat Maternity Colony – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Candidate
- Seasonal Concentration Areas of Animals: Colonially-Nesting Bird Breeding Habitat (Tree/Shrubs) – Candidate
- Seasonal Concentration Areas of Animals: Landbird Migratory Stopover Areas – Candidate
- Seasonal Concentration Areas of Animals: Deer Winter Congregation Areas – Candidate
- Rare Vegetation Communities: Old Growth Forest – Confirmed
- Rare Vegetation Communities: Other Rare Vegetation Communities – Candidate
- Specialized Habitat for Wildlife: Waterfowl Nesting Area – Candidate

- Specialized Habitat for Wildlife: Woodland Raptor Nesting Habitat – Candidate
- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Specialized Habitat for Wildlife: Seeps and Springs – Candidate
- Specialized Habitat for Wildlife: Amphibian Breeding Habitat (Woodland) – Candidate
- Specialized Habitat for Wildlife: Woodland Area-Sensitive Bird Breeding Habitat – Candidate
- Habitat for Species of Conservation Concern: Terrestrial Crayfish – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Confirmed. Eastern Wood-Pewee (SC) and Wood Thrush (SC) are breeding on site.
- Animal Movement Corridors: Amphibian Movement Corridors – Candidate

Note that the proposed location is assumed to be in the centre of the woodlot. If it is shifted to the north, it will be within 120 metres of open country habitat and any SAR associated with them (e.g. Barn Swallow, Bobolink) will need to be considered.

SC-4: One Unknown

- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown. No Special Concern or Rare species (e.g. with provincial Sranks of S1 to S3) were found during field investigations. However, Snapping Turtle (SC) may be present in the watercourse and Monarch (SC) may occur in open areas within 120 metres of the site where its hostplant (Common Milkweed) exists. Given the location of the site, it is unlikely that Monarch would be present in significant numbers, whether as breeder or during migration.

This site is surrounded to some distance by open country (agricultural) habitat. Therefore, it could be moved fairly substantially without being within 120 metres of any additional SWH categories.

SC-5 A: One Confirmed, eight Candidate, nine Unknown

This location is within 120 metres of the Devil's Punchbowl Escarpment ESA (STCK-76), which contains a Regional Earth Science ANSI (Vinemount Moraine), a Provincial Earth Science ANSI (Devil's Punch Bowl), and two Provincial Life Science ANSIs (Fruitland Escarpment and Niagara Section Escarpment). The ESAs have records of Special Concern and S1 to S3 flora and/or fauna.

- Seasonal Concentration Areas of Animals: Raptor Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Bat Maternity Colony – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Unknown
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Seasonal Concentration Areas of Animals: Colonially-Nesting Bird Breeding Habitat (Bank and Cliff) – Unknown
- Seasonal Concentration Areas of Animals: Migratory Butterfly Stopover Areas - Unknown
- Seasonal Concentration Areas of Animals: Landbird Migratory Stopover Areas – Candidate
- Seasonal Concentration Areas of Animals: Deer Winter Congregation Areas – Candidate
- Rare Vegetation Communities: Cliff and Talus Slopes – Confirmed
- Rare Vegetation Communities: Old Growth Forest – Candidate

- Rare Vegetation Communities: Other Rare Vegetation Communities – Unknown
- Specialized Habitat for Wildlife: Woodland Raptor Nesting Habitat – Candidate
- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Specialized Habitat for Wildlife: Amphibian Breeding Habitat (Wetlands) – Unknown
- Specialized Habitat for Wildlife: Woodland Area-Sensitive Bird Breeding Habitat – Candidate
- Habitat for Species of Conservation Concern: Open Country Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Shrub/Early Successional Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Candidate

SC-5 B: One Candidate, ten Unknown

- Seasonal Concentration Areas of Animals: Raptor Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Unknown
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Seasonal Concentration Areas of Animals: Colonially-Nesting Bird Breeding Habitat (Bank and Cliff) – Unknown
- Seasonal Concentration Areas of Animals: Migratory Butterfly Stopover Areas - Unknown
- Rare Vegetation Communities: Other Rare Vegetation Communities – Unknown
- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Specialized Habitat for Wildlife: Amphibian Breeding Habitat (Wetlands) – Unknown
- Habitat for Species of Conservation Concern: Open Country Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Shrub/Early Successional Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown

The proposed location of this site is 160 metres from the escarpment woodlands associated with Devil's Punchbowl Escarpment ESA (STCK-76). Therefore, if the location is moved more than 40 metres to the north then the SWH categories associated with this area (see SC-5 A) will need to be considered.

SC-6: One Candidate, nine Unknown

- Seasonal Concentration Areas of Animals: Waterfowl Stopover and Staging Areas (Aquatic) – Unknown
- Seasonal Concentration Areas of Animals: Raptor Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Unknown
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Seasonal Concentration Areas of Animals: Migratory Butterfly Stopover Areas - Unknown
- Rare Vegetation Communities: Other Rare Vegetation Communities – Unknown

- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Habitat for Species of Conservation Concern: Open Country Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Shrub/Early Successional Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown

SC-7: Seven Candidate, seven Unknown

This location is within 120 metres of the Tapleytown Woods ESA (STCK-138), a 31 hectare woodlot which contains portions of the Vinemount Moraine Regional Earth Science ANSI.

- Seasonal Concentration Areas of Animals: Raptor Wintering Area – Candidate
- Seasonal Concentration Areas of Animals: Bat Maternity Colony – Candidate
- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Candidate
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Seasonal Concentration Areas of Animals: Migratory Butterfly Stopover Areas – Unknown
- Seasonal Concentration Areas of Animals: Landbird Migratory Stopever Areas – Candidate
- Rare Vegetation Communities: Old Growth Forest – Candidate
- Rare Vegetation Communities: Other Rare Vegetation Communities – Unknown
- Specialized Habitat for Wildlife: Woodland Raptor Nesting Habitat – Candidate
- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Specialized Habitat for Wildlife: Amphibian Breeding Habitat (Woodland) – Unknown
- Specialized Habitat for Wildlife: Woodland Area-Sensitive Bird Breeding Habitat – Candidate
- Habitat for Species of Conservation Concern: Open Country Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown

SC-8: Six Unknowns

- Seasonal Concentration Areas of Animals: Turtle Wintering Areas – Unknown
- Seasonal Concentration Areas of Animals: Reptile Hibernaculum – Unknown
- Rare Vegetation Communities: Other Rare Vegetation Communities – Unknown
- Specialized Habitat for Wildlife: Turtle Nesting Areas – Unknown
- Habitat for Species of Conservation Concern: Open Country Bird Breeding Habitat – Unknown
- Habitat for Species of Conservation Concern: Special Concern and Rare Wildlife Species – Unknown

The full SWH screening table is found in Appendix F.

SWH Ranking

The following ranking of the ten sites in Table 4.46 with regard to constraint level for SWH is based on the number of confirmed and candidate SWH categories, along with the Unknowns. Five of the sites were screened by desktop only, so their general proximity to woodlands, wetlands, and watercourses were also taken into consideration.

Table 4.46 Ranking of the Ten (10) Sites With Regard to SWH Constraints

SWH Constraint Level	Sites
High	SC-3, SC-5 A, SC-7
Medium	BC-1, SC-5 B, SC-6
Low	SC-1, SC-2, SC-4, SC-8

4.4.2.6 Species-at-Risk Screening

A list of SAR for the City of Hamilton and surrounding areas, updated to May 9, 2017, was provided by Guelph District MNRF. The habitats on site were screened against known habitat requirements of these species to determine if any potential species could be present. The results of this screening is found in Appendix F and is summarized in Table 4.47.

Table 4.47 SAR Known or With Potential to Occur Within 120 metres of the Ten (10) Sites

Site	Number of confirmed SAR	Number of Potential SAR
BC-1	0	19 (10 E, 2 T, 7 SC)
SC-1	0	12 (5 E, 2 T, 5 SC)
SC-2	0	7 (3 E, 2 T, 2 SC)
SC-3	2 SC	22 (12 E, 3 T, 7 SC)
SC-4	1 T	7 (2 E, 2 T, 3 SC)
SC-5 A	0	17 (8 E, 3 T, 6 SC)
SC-5 B	0	8 (2 E, 2 T, 4 SC)
SC-6	0	7 (2 E, 1 T, 4 SC)
SC-7	0	19 (10 E, 2 T, 7 SC)
SC-8	0	5 (1 E, 1 T, 3 SC)

SC – Special Concern; T – Threatened; E – Endangered

SAR Ranking

Based on the results of the number of species known, or with the potential to occur, for each site, the ten sites were assigned either High, Medium, or Low constraint from a SAR perspective. Note that these results are tentative as field work was limited for a number of the sites by restricted property access, and five of the sites were assessed by desktop only. More field work, especially using species-specific MNRF-endorsed protocols, may change the categorization of the ten sites.

Table 4.48 Ranking of the ten sites from a SAR constraint perspective

SAR Constraint Level	Sites
High	BC-1, SC-3, SC-5 A, SC-7
Medium	SC-1, SC-2, SC-4, SC-5 B
Low	SC-6, SC-8

4.4.2.7 Incidental Species

No surveys were conducted for other wildlife groups, such as mammals and insects. Any sightings of these groups were done on an incidental basis during all other surveys.

No snakes were seen during the field investigations. Two species of mammals were detected at several sites: Gray Squirrel (*Sciurus carolinensis*) and Coyote (*Canis latrans*). Individual Green Frogs (*Lithobates clamitans*) were also seen and heard along the watercourses at a number of sites. All three species are common and widespread in the City of Hamilton (Schwetz 2014) and have Sranks of S5 in Ontario, indicating that their populations are Secure (NHIC 2016). It is likely that dedicated surveys for these groups, along with insects, would detect additional common and widespread species.

4.5 Aquatic Habitat Assessment

Stoney and Battlefield Creeks, above the Niagara Escarpment, have generally similar aquatic habitats. The flat landscape results in uniform gradients and substrate, and also necessitates the ditching and straightening of watercourses for agricultural purposes. The study area is isolated from downstream populations of migratory fishes by the Niagara Escarpment. The watercourses support a non-migratory fish community that prefers slow-flowing and/or still water and is tolerant of high summer water temperatures and low dissolved oxygen concentrations. These fishes are found wherever there is sufficient water throughout the year to support them, with the larger species restricted to the deeper areas. It is not expected that any of the storage facilities under consideration, which would only function during short periods of significant precipitation or spring melt conditions, would significantly impact the habitat of the fish community. The primary concern is that where fish habitat occurs upstream, the flow-control structures should be constructed in a manner that will not impede the movement of small fishes when they are not actively providing flood control, which is the majority of the time.

4.6 Long-list Alternatives Screening

4.6.1 Evaluation Methodology

In order to evaluate alternative sites for storage facilities, an evaluation system, has been advanced to assess the suitability of each alternative against appropriate "evaluation factors". The evaluation factors consist of considerations related to a two-tier hierarchy of potential impacts/issues organized by Evaluation Category, which have been supplemented by more detailed and specific Evaluation Criteria.

Evaluation Category

A broad description of the type of impacts and issues under consideration includes:

i. **Functional** – Impacts that the alternative may have on how a system is intended to work as related to flood and erosion mitigation.
ii. **Environmental** – Potential impacts or benefits that alternatives may have on terrestrial and aquatic habitat.
iii. **Social** – Impacts/issues relating property and to the interaction of the community and greater public with the implementation of the proposed alternative.
iv. **Economic** – Immediate costs of land and construction and future costs of the alternative including operations and maintenance.

Evaluation Criteria:

Specific evaluation criteria relevant to each Evaluation Category has been summarized in Table 4.49.

Table 4.49 Flood and Erosion Mitigation Alternatives Evaluation Approach

Evaluation Category	Evaluation Criteria	Criteria Description
Functional	Effectiveness of Flooding Mitigation	Each alternative, to varying degrees, provides opportunities to reduce downstream flooding conditions
	Effectiveness of Erosion Mitigation	Each alternative, to varying degrees, provides opportunities to reduce downstream flooding conditions
	Constructability	Reflects the construction degree of difficulty
Environmental	Terrestrial Ecology Impacts/ Opportunities	Depending on the alternative impacts or benefits to the existing terrestrial system may occur.
	Fisheries Impacts/ Opportunities	Depending on the alternative, fish habitat may be enhanced or negatively impacted.
Social	Public Use Impacts/ Opportunities	Relates to the potential impacts or benefits for public use of the land resulting from a storage facility being implemented.
	Safety Impacts/ Opportunities	Depending on the configuration of the works, the storage facility lands may have different levels of safety.
	Adjacent Property Impacts/ Opportunities	Relates to potential direct and indirect changes to adjacent properties.
	Land Use Impacts/ Opportunities	Depending on the alternative there are varying degrees of land use impacts or opportunities to enhance the existing land use.
	Recreation Impacts/ Opportunities	Each alternative to varying degrees will impact or improve existing recreational use of the land.
Economic	Land Costs	High costs are negative. Low costs are positive.
	Capital Costs	High costs are negative. Low costs are positive.
	Operations and Maintenance Costs	High costs are negative. Low costs are positive.

Each of the storage alternatives have been assessed in Table 4.50 to determine if each alternative location could be carried forward independently. Each storage alternative could be considered as part of group of facilities.

Storage alternatives SC-1 to SC-4 and SC-6 based on the evaluation would not be considered as independent storage facility alternatives. Storage alternative SC-1 would be costly and difficult to implement due to the significant amount of land required to purchase. Storage alternatives SC-2 to SC-4 and SC-6 do not provide adequate flood risk reduction as standalone alternatives.

Table 4.50 Storage Facility Alternatives Evaluation

Evaluation Category	Evaluation Criteria	Battlefield Creek Site	Stoney Creek Sites							
		BC-1	SC-1	SC-2	SC-3	SC-4	SC-5	SC-6	SC-7	SC-8
Functional	Effectiveness of Flooding Mitigation	✓	✓	X	X	X	✓	X	✓	X
	Effectiveness of Erosion Mitigation	✓	✓	✓	X	X	✓	X	✓	✓
	Constructability	✓	X	X	X	✓	X	X	X	✓
Natural	Terrestrial Ecology Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fisheries Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
Social	Public Use Impacts/Opportunities	✓	✓	X	✓	X	✓	X	✓	✓
	Safety Impacts/ Opportunities	✓	X	✓	✓	✓	✓	✓	✓	✓
	Adjacent Property Impacts/Opportunities	X	X	✓	X	✓	✓	X	✓	✓
	Land Use Impacts/Opportunities	✓	X	X	X	X	X	✓	✓	X
	Recreation Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
Economic	Land Costs	✓	X	X	X	X	✓	✓	X	X
	Capital Costs	X	X	✓	✓	✓	X	✓	X	✓
	Maintenance Costs	X	X	✓	X	✓	X	✓	X	X
Carry Forward as Independent Storage Location (Yes/No)		✓	X	X	X	X	✓	X	✓	✓

5.0 SHORT-LISTED ALTERNATIVE ASSESSMENT

The long-list of alternatives has been evaluated to determine the effectiveness of flood risk and erosion mitigation and the associated benefits and / or impacts. Based on the evaluation results a set of short-listed alternatives consisting of combinations of storage facilities has been developed.

5.1 Combined Storage Sites Optimization Alternatives

The following short-listed alternatives have been developed:

- Alternative 1 (SC-1, SC-4 and BC-1)
- Alternative 2 (SC-1 to SC-4 and BC1)
- Alternative 3 (SC-5, SC-7, SC-8 and BC-1)

A description and reason for the various alternatives have been provided in the following sections.

5.2 Scenario 1 (SC-1, SC-4, BC-1)

Each of the Stoney Creek storage area assessments, for the purpose the short-listed alternative assessment, has included Battlefield Creek storage area BC-1. Battlefield Creek storage area BC-1 has been included as it is the only viable storage area on Battlefield Creek. Based on the individual peak flow reduction results, storage facilities SC-1 and SC-4 provide the most flood reduction. For an Optimized Scenario considering multiple storage areas for Stoney Creek, SC-1 and SC-4 along with BC-1 on Battlefield Creek has been assessed to determine the combined benefit of multiple storage areas.

Table 5.1 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated with, and without, storage has been provided within Table 5.2 Based on the results reported in Tables 5.1 and 5.2, there would be a reduction in 2 year to 100 year peak flows at the Escarpment of 47% to 67%, compared to 45% to 77% for just SC-1 standalone storage area. A 1.6% to 2.8% (0.6% SC-1 standalone) increase in peak flows occurs at the Escarpment for the Regional Storm, due to timing of peak flows. The reduction in peak flows resulting from combining storage areas SC-1 and SC-4 is thus considered quite limited.

Table 5.1 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1, SC-1 and SC-4							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Sites BC-1, SC-1 and SC-4							
Edge of Escarpment	1.61	3.49	5.38	11.94	18.18	23.45	141.45
King St.	1.90	3.95	5.97	12.18	18.57	23.93	143.77
Highway 8	2.47	4.87	7.18	12.45	19.14	24.58	147.92

Table 5.2 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Site SC-4 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1, SC-1 and SC-4							
Edge of Escarpment	-78.01	-76.05	-75.63	-60.98	-52.77	-49.79	-0.98
King St.	-75.03	-73.60	-73.56	-60.96	-52.63	-49.62	-0.99
Highway 8	-69.69	-68.78	-69.22	-61.21	-52.36	-49.37	-1.11

The combined benefit of reduced peak flows resulting from the storage within storage areas BC-1, SC-1 and SC-4 in the Stoney Creek from the confluence to Lake Ontario has been provided in Tables 5.3 and 5.4. Peak flows for the 2 year to 100 year storms would be reduced 34% to 52% +/- (29% to 41% with standalone SC-1), with the Regional Storm realizing a slight decrease of 2.80% (3.2% with standalone SC-1). Hence there is limited benefit by adding SC-4 to SC-1.

Table 5.3 Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites BC-1 and SC-4							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites BC-1, SC-1 and SC-4							
Battlefield/Stoney Creek Confluence	6.71	11.56	15.83	20.85	25.74	32.55	190.96
CNR	7.71	12.96	17.60	22.85	27.77	33.35	194.43
QEW	9.09	14.82	19.86	25.61	30.91	35.92	201.02
Lake Ontario	9.12	14.87	19.91	25.70	31.02	36.04	201.19

Table 5.4 Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1, SC-1 and SC-4 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-44.32	-47.50	-50.76	-52.19	-52.45	-49.85	-1.64
CNR	-39.39	-43.26	-46.73	-48.96	-49.87	-49.70	-1.97
QEW	-34.08	-39.24	-43.03	-45.53	-46.71	-48.09	-2.03
Lake Ontario	-33.87	-39.13	-42.93	-45.41	-46.59	-47.98	-2.08

5.3 Scenario 2 (BC-1, SC-1, SC-2, SC-3 and SC-4)

A further storage scenario has been assessed which has included storage facilities BC-1, SC-1 to SC-4) to determine the potential benefit in peak flow reduction by adding SC-2 and SC-3 to Alternative 1.

Table 5.5 provides the Stoney Creek peak flows with and without storage. The relative difference between peak flows simulated with and without storage has been provided within Table 5.5. Based on the results reported in Tables 5.5 and 5.6, there would be a reduction in peak flows at the edge of the Escarpment of approximately 56% to 83% +/- (29% to 41% with SC-1 and BC-1) for the 2 year to 100 year. A 0.6% decrease in peak flows occurs at the Escarpment for the Regional Storm, due to timing of peak flows, which is the same result as with combined storage areas SC-1 and BC-1.

Table 5.5 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
With Storage Sites							
Edge of Escarpment	1.23	2.95	4.34	9.75	15.68	20.54	141.95
King St.	1.39	3.12	4.61	9.95	16.00	20.97	144.24
Highway 8	2.44	3.70	5.31	10.15	16.41	21.59	148.33

Table 5.6 Percent Difference in Simulated Stoney Creek Peak Flows With and Without Storage Sites

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage							
Edge of Escarpment	-83.20	-79.75	-80.34	-68.14	-59.26	-56.02	-0.63
King St.	-81.73	-79.14	-79.58	-68.11	-59.18	-55.85	-0.67
Highway 8	-70.06	-76.28	-77.24	-68.38	-59.16	-55.53	-0.84

The combined benefit of reduced peak flows resulting from the subject sites in the Stoney Creek from the confluence to Lake Ontario has been provided in Tables 5.7 and 5.8. Peak flows for the 2 year to 100 year storms have been reduced 35% to 57% +/- (29% to 41% with BC-1 and SC-1), with the Regional Storm realizing a slight decrease of 1.4 % to 1.98 %+/- (3.2% with BC-1 and SC-1).

Table 5.7 Comparison of Stoney Creek (Downstream of Confluence) Simulated Design Event Flows (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Storage Sites							
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.90	194.14
CNR	12.72	22.84	33.04	44.77	55.40	66.30	198.33
QEW	13.79	24.39	34.86	47.02	58.00	69.20	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Storage Sites							
Battlefield/Stoney Creek Confluence	6.40	10.57	14.17	18.44	22.62	29.02	191.37
CNR	7.46	12.05	16.02	20.61	24.69	29.70	194.77
QEW	8.90	14.02	18.40	23.46	27.94	32.41	201.29
Lake Ontario	8.95	14.08	18.47	23.56	28.06	32.54	201.41

Table 5.8 Percent Difference in Simulated Stoney Creek (Downstream of Confluence) Peak Flows With and Without Storage Sites BC-1, SC-1 and SC-4 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Battlefield/Stoney Creek Confluence	-46.89	-52.00	-55.93	-57.72	-58.21	-55.29	-1.43
CNR	-41.35	-47.24	-51.51	-53.96	-55.43	-55.20	-1.79
QEW	-35.46	-42.52	-47.22	-50.11	-51.83	-53.16	-1.90
Lake Ontario	-35.10	-42.37	-47.06	-49.96	-51.69	-53.03	-1.98

5.4 Scenario 3 (BC-1, SC-5, SC-7, and SC-8)

An optimized storage scenario with a total storage of 398,400 m^3 (sum of SC-5 Scenario 2, SC-7 Scenario 2, and SC-8 Scenario 1 storage) has been considered based on the individual peak flow reduction results. The following storage sites and associated scenarios have been optimized in this regard (ref. Figure 22):

- SC-5 Scenario 2 (Available storage of 204,000m^3, 51% of 398,300m^3)
- SC-7 Scenario 2 (Available storage of 146,000m^3,37%, 398,400m^3)
- SC-8 Scenario 1 (Available storage of 48,400m^3,12% of 398,400m^3)

The combined benefit of reduced peak flows resulting from the storage within storage areas SC-5, SC-7 and SC-8 in the Stoney Creek from the confluence to Lake Ontario has been provided in Tables 5.9 and 5.10. Peak flows for the 2 year to 100 year storms would be reduced 29.18 % to 70.43% with the Regional Storm realizing a slight decrease of 1.88 % to 2.92 %. Alternative 3 uses storage facilities in series which is considered to be less effective than singular storage sites, or sites in parallel such as Alternatives 1 and 2.

Table 5.9 Comparison of Stoney Creek Simulated Design Event Flows (Future Land Use) (m^3/s)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
Without Optimized Storage Scenario							
Edge of Escarpment	7.32	14.57	22.08	30.6	38.49	46.7	142.85
King St.	7.61	14.96	22.58	31.2	39.2	47.5	145.21
Highway 8	8.15	15.6	23.33	32.1	40.18	48.55	149.58
Battlefield/Stoney Creek Confluence	12.05	22.02	32.15	43.61	54.13	64.9	194.14
CNR	12.72	22.84	33.04	44.77	55.4	66.3	198.33
QEW	13.79	24.39	34.86	47.02	58	69.2	205.18
Lake Ontario	13.79	24.43	34.89	47.08	58.08	69.28	205.47
With Optimized Storage Scenario							
Edge of Escarpment	2.24	9.40	15.05	21.67	23.41	25.46	145.54
King St.	2.29	9.62	15.36	22.10	23.84	25.88	147.87
Highway 8	2.41	9.96	15.80	22.72	24.50	26.53	152.38
Battlefield/Stoney Creek Confluence	5.75	13.53	20.90	29.85	32.86	35.42	188.48
CNR	6.93	13.94	21.38	30.50	33.89	36.64	193.23
QEW	8.53	14.74	22.49	32.00	35.90	39.09	200.34
Lake Ontario	8.61	14.74	22.52	32.02	35.97	39.18	200.67

Table 5.10 Percent Difference in Simulated Stoney Creek Peak Flows With and Without the Optimized Storage Scenarios 1 and SC-1 (%)

Location/Model	Return Period (Years)						
	2	5	10	25	50	100	Regional
With Optimized Scenario							
Edge of Escarpment	-69.40	-35.48	-31.84	-29.18	-39.18	-45.48	1.88
King St.	-69.91	-35.70	-31.98	-29.17	-39.18	-45.52	1.83
Highway 8	-70.43	-36.15	-32.28	-29.22	-39.02	-45.36	1.87
Battlefield/Stoney Creek Confluence	-52.28	-38.56	-34.99	-31.55	-39.29	-45.42	-2.92
CNR	-45.52	-38.97	-35.29	-31.87	-38.83	-44.74	-2.57
QEW	-38.14	-39.57	-35.48	-31.94	-38.10	-43.51	-2.36
Lake Ontario	-37.56	-39.66	-35.45	-31.99	-38.07	-43.45	-2.34

5.5 Flood Risk Mitigation

The assessment of the storage areas has been further advanced by approximating the number of properties and buildings that would be removed from risk of flooding for the 2 year to 100 year and Regional Storm, as compared to existing conditions. Table 5.11 provides the flood risk mitigation for Battlefield Creek and Stoney Creek below the Escarpment for the Optimized Storage Area Scenario.

Table 5.11 Lower Battlefield Creek and Stoney Creek – Total Properties and Buildings at Risk for Storage Areas Scenarios

Scenario	Storm Event:	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional	Comments
Existing Battlefield Creek[3]	Property	1	7	9	10	10	16	52	
	Buildings		1	1	1	1	9	31	
Storage Area BC-1[1] (Alternatives 1-3)	Property	1	7	8	9	10	14	52	Negligible impact on flooding numbers within Battlefield Creek.
	Buildings		1	1	1	1	8	31	
Existing Stoney Creek[3]	Property		10	31	54	73	86	142	
	Buildings		1	2	7	22	37	85	
Combined Storage Facilities Alternative 1 (Stoney Creek Only)	Property				7	21	38	142	Reduces 100 year flooding numbers to near 10 year flooding numbers within Stoney Creek.
	Buildings				1	1	2	85	
Combined Storage Areas Alternative 2 (Stoney Creek Only)	Property				1	14	21	142	Reduces 100 year flooding numbers to less than 10 year flooding numbers within Stoney Creek.
	Buildings					1	1	85	
Combined Storage Alternative 3 (Stoney Creek Only)	Property		2	11	29	31	38	142	Reduces 100 year flooding numbers to less than 25 year flooding numbers within Stoney Creek.
	Buildings			1	1	1	2	85	
Existing Combined Battlefield Creek and Stoney Creek	Property	1	17	40	64	83	102	194	Sum of Existing Battlefield Creek & Existing Stoney Creek
	Buildings		2	3	8	23	46	116	
Combined Storage Alternative 1 (Combined Stoney and Battlefield Creek)	Property	1	7	8	16	31	52	194	Reduces 100 year flooding numbers to approximately the 10 to 25 year flood numbers
	Buildings	0	1	1	2	2	10	116	
Combined Storage Alternative 2 (Combined Stoney and Battlefield Creek)	Property	1	7	8	10	24	35	194	Reduces 100 year flooding numbers to approximately the 10 to 25 year flood numbers
	Buildings	0	1	1	1	2	9	116	
Combined Storage Alternative 3 (Combined Stoney and Battlefield Creek)	Property		9	19	38	41	52	194	Reduces 100 year property flooding numbers to less than 25 year flooding numbers. Reduces 100 year building flooding numbers to less than 50 year flooding numbers.
	Buildings		1	2	2	2	10	116	

NOTES:
[1] Property/Building numbers listed for Storage Area BC-1 include Properties/Buildings along Battlefield Creek only.
[2] Property/Building numbers listed for Storage Areas SC-1 through 4 include Properties/Buildings along Stoney Creek only. Note: Stoney Creek extends to Lake Ontario (past confluence of Stoney Creek & Battlefield Creek).
[3] Flood risk identified based on 2011 Class EA Peak Flows (Continuous) and associated rating curves to determine property and buildings at risk

5.6 Erosion Control Assessment with Storage Areas Scenarios

The storage areas scenarios assessed for providing flood control for reduced flooding risk have also been assessed to determine the potential ability to reduce erosive flow durations within lower Stoney Creek and Battlefield Creek.

In order to better quantify the current erosion risk, Matrix Solutions has conducted field work to determine critical erosion causing flow rates (ref. Section 3.4 and Appendix E). Based on the critical flow assessment, the Stoney Creek critical flow has been established as 7.53 m^3/s for the reach immediately downstream of Highway 8 and upstream of the confluence of Stoney Creek and Battlefield Creek. Flows at Highway 8 are considered to be the most representative of flows through the reach, with an upstream drainage area of 2010 ha (ref. Figure 6).

For the Battlefield Creek, the critical flow is 1.93 m^3/s as compared to the 2 year storm frequency flow of 4.62 m^3/s for the reach downstream of Lake Avenue North and upstream of the confluence of Stoney Creek and Battlefield Creek. Flows have been determined at Lake Avenue North with an upstream drainage area of 759 ha (ref. Figure 6).

In order to determine flow durations for “existing” conditions and “with storage” scenarios, the QUALHYMO hydrologic model has been executed continuously using the 2011 Draft Class EA rainfall file from the RBG for the full 34 year period (Note: as part of the Class EA the meteorologic time series can be extended to 2015). Based on the continuous simulations, flow durations for various scenarios including existing conditions, BC-1 and SC-1 storage in place and storage locations BC-1, SC-1 and SC-4 in place have been assessed. Critical flow durations for both the Stoney Creek and Battlefield Creek have been provided in Table 5.12.

Table 5.12 Critical Flow Durations With and Without Storage (hrs/% reduction)

Scenarios	Battlefield Creek	Stoney Creek
Existing	191/NA	99/NA
Alternative 1	130/32%	25/75%
Alternative 2	130/32%	17/83%
Alternative 3	130/32%	72/27%

Based on the results of this assessment, the reduction in durations above critical flows with the storage systems in place range between 27 % and 83 % depending on location and scenario. This improvement is significant demonstrating the potential to address erosion risk in the receiving systems (lower Stoney Creek and lower Battlefield Creek).

5.7 Property Requirements

HCA owns properties within both the Battlefield Creek and Stoney Creek subwatersheds above the Escarpment (ref. Figure 21). HCA has purchased properties for various reasons, with the primary objective of protecting and enhancing the existing natural heritage system. HCA has also noted properties that are considered to be properties of interest, which are not owned, but HCA would be interested in owning. Summaries of the property requirements for the storage facilities are provided in Table 5.13, with the property requirement assessment being conducted using full property parcels, not partial properties requiring land severances.

Table 5.13 HCA Storage Facility Property Ownership Summary (ha)

Storage Facility	Property Requirement	HCA Properties	HCA Properties of Interest	Property Requirement	Number of Properties
BC-1	109.5	22.2	0	87.3	2
SC-1	89.4	0	0	89.4	12
SC-2	70.1	0	38.6	70.1	2
SC-3	78.5	5.7	10.2	72.8	4
SC-4	41.1	0	0	41.1	2
SC-5 Scenario 1	50.9	19.1	0	31.8	1
SC-5 Scenario 2	70.6	19.1	0	51.5	2
SC-6	43.8	1.9	11.3	41.9	2
SC-7 Scenario 1	86.8	0	63.2	86.8	4
SC-7 Scenario 2	86.8	0	63.2	86.8	4
SC-8 Scenario 1	44.7	0	0	44.7	2
SC-8 Scenario 2	44.7	0	0	44.7	2
Alternative 1	240.0	22.2	0	217.8	16
Alternative 2	388.6	27.9	48.8	360.7	22
Alternative 3	311.6	41.3	63.2	270.3	10

Based on the property requirements summarized in Table 5.13, Storage Facility SC-1, followed by BC-1, SC-7 the SC-3 would require the most property to be acquired by HCA. Storage Facilities SC-4, SC-5, SC-6 and SC-8 would require the least amount of land to be acquired by HCA. Noteworthy, is that out of the 86.8 ha required for storage facility SC-7, 63.2 ha (73 %) of the lands are of current interest to HCA. Flood facility SC-1 would require the acquisition of 12 different land parcels.

6.0 PREFERRED ALTERNATIVE

Alternative 3 (BC-1, SC-5 Scenario 2, SC-7 Scenario 2, and SC-8 Scenario 1) has been selected as the preferred combined storage area alternative. Storage facility BC-1 is common to each of the three (3) alternatives. Total land requirements would be 217.8 ha and 360.7 ha for Alternative 1 and Alternative 2 respectively versus 270.3 ha for Alternative 3. One significant difference between Alternatives 1, 2 and 3, is that Alternative 3 does not include SC-1, which would require 12 land parcels, increasing the complexity for HCA to obtain the lands required to implement the storage facility.

While Alternative 3 would not mitigate flooding risk and erosion potential downstream to the same extent as Alternatives 1 and 2, it would, based on the results presented in Section 5, still reduce the 100 year storm peak flows by approximately 45 % downstream of the Escarpment and reduce the duration of erosive flows by nearly 30 %. Alternative 3 would allow HCA to implement storage facilities based on the current HCA property ownership and to add to constructed storage facilities once identified properties are purchased.

6.1 Design Considerations

Design considerations for each of the Alternative 3 storage facilities are discussed in the following section, including grading, road alterations and structures.

BC-1:

The existing 1.75 m span by 0.9 m rise concrete box culvert, has only a 0.30 m +/- cover. Based on the limited depth of storage, it is proposed to raise the road by 1.8 m to 189.30 m (ref. Figure 8) or create an equivalent standalone berm upstream of the crossing. Approximately 346 m of road would have to be raised. The maximum elevation and depth of storage would be 189.00 m and 2.70 m based on providing 0.30 m to freeboard to the First Road East. No excavation would be required to achieve storage requirements. Portions of the ponding would be within HCA's property.

SC-5 Scenario 2:

The property immediately west of First Road East and north of the Dofasco Trail System that is owned by HCA (ref. Figure 14) would be used for storage under this scenario. Berming and the raising of Ridge Road would be required from an existing elevation of 185.50 m to an elevation of 187.30 m (or create an equivalent standalone berm upstream of the crossing) and raising of First Road East from an elevation of 186.50 m to 187.30 m (or create an equivalent standalone berm upstream of the crossing). Road works of approximately 780 m length would be required. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 204,000 m^3. Excavation of 240,936 m^3 would be required. The 6.0 m by 2.3 m open bottom concrete culvert crossing of Ridge Road may have to be modified.

SC-7 Scenario 2:

The SC-7 storage area would be located between Tapleytown Road and Fifth Road East and north of Green Mountain Road East (ref. Figure 16). The maximum storage elevation would be

191.2 m at a depth of 2.2 m. Tapleytown Road would require raising from an elevation of 190.50 m to 191.5 m or create an equivalent standalone berm upstream of the crossing. A 0.5 m +/- berm would be required in the vicinity of Tapleytown Road. Grading of the lands would be at 0.25% slope to facilitate positive drainage. The maximum storage would be approximately 140,000 m^3. Modifications to the existing 1.0 m by 1.42 m open bottom concrete culvert crossing of Tapleytown Road may be required.

SC-8 Scenario 1:

The SC-8 storage area would be located between Tapleytown Road and Fifth Road East and south of Green Mountain Road East (ref. Figure 19). The maximum storage elevation would be 193.7 m at a depth of 1.7 m. Green Mountain Road East would require raising from an elevation of 193.5 m to 194.0 m or create an equivalent standalone berm upstream of the crossing. Road works of approximately 127 m would be required. The storage site would be approximately 15.33 ha in area, all of which would have to be purchased by HCA. Grading of the lands would be at 0.25% slope to facilitate positive drainage. Excavation of 95,477 m^3 would be required. The maximum storage would be approximately 31,400 m^3. Modifications to the existing 6.0 m by 1.1 m open bottom concrete culvert crossing of Green Mountain Road East may be required.

6.2 Capital Costs

Construction cost estimates are presented in Table 6.1. Costing has been split into four (4) main categories; soil excavation and export, berm construction, road construction, and restoration. Soil excavation and export includes works associated with the proposed grading, as it is shown on the storage facility figures. The unit rate includes costs to cut and place/compact or export the soils from the storage facilities. Berm construction includes works associated with creating a water tight berm required for the storage facilities as shown on the figures. Road reconstruction includes works associated with removal of the existing two (2) lane road and reconstruction at the raised elevations. Restoration includes the works associated with incorporating the vegetation aspects, including the creation of wetland areas within the storage facilities. The cost estimate does not include any traffic control, erosion and sediment control, etc. associated with construction works.

Table 6.1 Estimated Construction Cost of Preferred Alternative #3

Facility		SC5-2	SC7-2	SC8-1	BC-1
Soil Excavation & Export	Excavation & Export Volume (m^3)	240936	519494	95447	0
	Unit Rate ($/$m^3$)	$ 15.00	$ 15.00	$ 15.00	$ 15.00
	Cost ($)	$ 3,614,040	$ 7,792,411	$ 1,431,706	$ -
Berm Construction	Fill Volume (m^3)	9524	9586	3166	0
	Unit Rate ($/$m^3$)	$ 7.50	$ 7.50	$ 7.50	$ 7.50
	Cost ($)	$ 71,434	$ 71,892	$ 23,742	$ -
Road Reconstruction [1]	Length (m)	780	502	127	346
	Unit Rate ($/m)	$ 210.00	$ 210.00	$ 210.00	$ 210.00
	Cost ($)	$ 163,696	$ 105,479	$ 26,571	$ 72,675
Plantings	Planting Area (m^2)	213912	353204	121638	256485
	Unit Rate ($/$m^2$)	$ 5.00	$ 5.00	$ 5.00	$ 5.00
	Cost ($)	$ 1,069,562	$ 1,766,020	$ 608,191	$ 1,282,425
Total		**$ 4,918,732**	**$ 9,735,803**	**$ 2,090,210**	**$ 1,355,099**

NOTES: [1] A standalone earthen berm could be built as an alternative to roadway raising and reconstruction. The decision as to the preferred approach will relate to the age of the road and potential for complementary road works with the City of Hamilton. Overall costs are anticipated to be equivalent.

7.0 IMPLEMENTATION STRATEGY

This section outlines the specifics associated with the implementation of the preferred storage areas including:

- Prioritization / Sequencing / Staging Plan
- Land Ownership
- Financing
- Detailed Design Process
- Monitoring Requirements

7.1 Prioritization / Sequencing / Staging Plan

The prioritization/ sequencing of the four (4) preferred storage facilities, BC-1, SC-5 (Scenario 2), SC-7 (Scenario 2) and SC-8 (Scenario 1) must remain flexible as it is dependent upon HCA's land holdings. The prioritization of storage facilities based on flood mitigation alone would result in the priority sequence of SC-5 (Scenario 2), SC-7 (Scenario 2), SC-8 (Scenario 1) and then BC-1.

In addition to prioritization of the storage facilities, staging of individual storage facilities based on HCA's land holdings could also be considered, should HCA be unable to acquire all the lands necessary to implement an entire storage facility. Temporary interim grading and outlet control configurations may also be required as part of staging a storage facility.

7.2 Land Ownership

In addition to implementing storage areas, HCA has a complementary interest in establishing a new Conservation Area, which would have many ancillary benefits for the area. On this basis, the HCA has been actively acquiring lands in the study area in an effort to establish a new Conservation Area, restore terrestrial habitat and to facilitate potential storage areas. HCA's current land holdings provide an opportunity to implement the preferred storage facilities, although additional land would be required before implementing any one (1) of the four (4) storage facilities. In implementing any of the storage facilities, HCA would increase land holdings using a "willing seller – willing buyer" approach. As such discussions between HCA and current land owners within the limits of the preferred storage facility areas would occur following study completion.

7.3 Financing

To implement any of the four (4) storage facilities, HCA requires financing to purchase lands, cover capital construction costs and to operate and maintain the storage facilities. Financing is available from Federal, Provincial, Municipal and private sources. A summary of the some of the potential funding sources to be considered by HCA are listed below:

Federal

- National Wetland Conservation Fund
- The Great Lakes Protection Initiative
- Environmental Damages Fund
- Habitat Stewardship Program for Species at Risk
- EcoAction Community Funding Program

Provincial

- Great Lakes Guardian Community Fund
- Species at Risk Stewardship Fund
- Land Stewardship and Habitat Restoration Program
- Ontario Community Environment Fund:

Hamilton Conservation Authority

- HCA's annual funding

Municipal

- Capital project cost sharing – road and hydraulic structure works

Private

- Grants from the public and/or private organizations

7.4 Detailed Design and Approvals Process

Prior to the detailed design of a storage area, additional detailed assessments would need to be conducted as per the following:

- Topographic survey of the storage facility and adjacent lands;
- Geotechnical assessment to determine bedrock and groundwater elevations. The geotechnical assessment would also need to include soil quality as material will be relocated off-site;
- Hydrogeological assessment to determine groundwater fluctuations and potential recharge areas;
- Terrestrial ecology (Vegetation) assessment, including ELC mapping, vegetation inventory, tree inventory, SAR survey, and significant wildlife habitat (SWH) screening, including bats;
- Terrestrial ecology (Wildlife) assessment, including breeding bird survey, nocturnal amphibian survey, turtle surveys, SWH screening and SAR survey;
- Fisheries and aquatic habitat mapping;
- Stream morphology of the creek reaches within the storage facility;
- Refined hydrologic and hydraulic assessment;
- Cultural heritage assessment; and,
- Archaeological Stage 1 assessment.

The detailed design through Hamilton Conservation Authority will have to consider the following:

- Detailed grading including the wetland depths;
- Road alterations such as raising road grades and associated drainage impacts;
- Culvert structure alterations or replacement (which may include weir structures to reduce peak flows);
- Storage volumes and elevations;
- Flooding durations including the wetland wet period;
- Baseflow attenuation through the control of storm runoff response;

- Wetland terrestrial habitat requirements;
- Aquatic habitat enhancements; and,
- Bedrock and ground water elevations.

The detailed design will require approval from various governmental agencies. The City of Hamilton would need to provide a site alteration permit for any area not located in HCA's regulated areas. Other agencies such as NEC, MNRF, MOECC and DFO will be required to provide approvals for each storage facility. Notably at the time of pre-design and final design, consultation should take place with MNRF on the potential for the water retaining structures to qualify as dams and thereby require permitting through the Lakes and Rivers Improvement Act.

7.5 Monitoring Program

The recommended storage facilities will allow for the creation of wetlands, providing improved aquatic habitat and riparian and upland terrestrial habitats with anticipated benefits for the creek and associated environmental systems, both within the storage facility and adjacent lands. To assess the performance of the storage facilities requires an appropriate level of monitoring, prior to, and after, construction by the HCA. Each storage facility would require a monitoring plan to be administered by the HCA. The monitoring plan should evaluate the performance of the storage facilities and allow for adjustments and/or optimization through Adaptive Management.

The duration of the monitoring would typically be a minimum length of 2 to 3 years depending on input received from approval agencies such as DFO and MNRF and MOECC for the storage facilities. Monitoring of the performance of the storage facilities could include:

Stream Morphology

To be conducted downstream of the storage facilities and at downstream erosion sites:

- Stream Cross-sections (Controls)
- Erosion pins (Tractive Force, Critical Shear Stress)
- Bank Properties (Height, Angle, Material, Vegetation, Root Depth, Undercuts and In-situ Shear Strength)
- Longitudinal Profile Survey (Energy Gradient, Top and Bottom Riffles, Max Pool Depth)
- Photographic record

Natural Heritage System

- Community Structure/Health – Ecological Integrity, Habitat Boundary Integrity, Problem Species, Overall Species and Habitat Diversity, Buffer Effectiveness, Human Activity Impacts
- Local Hydrology (water levels, soil moisture, etc.)

Hydrometeorologic

- Rainfall - Continuous
- Streamflow- Storm Response
- Baseflow – Flow Rate (Spot measurements)

Water Quality/Biophysical

- Benthic Invertebrates – Community Structure
- Water Temperature – Continuous
- Sediment- Total Suspended Solids
- Fisheries- (Electrofishing)

The monitoring plan(s) specifics would be determined as part of the approved conditions related to the subsequent detail designs for each storage facility.

8.0 SUMMARY AND RECOMMENDATIONS

8.1 Summary

i. As part of this Class EA a detailed technical assessment of various storage systems (flood and erosion) has been conducted to determine the potential to achieve HCA's goal, as outlined in Section 1.0, specific to creating a new Conservation Area(s) within the Upper Stoney Creek and Upper Battlefield Creek watersheds and concurrently addressing flood and erosion risk downstream in the lower reaches.

ii. A new HEC-RAS model has been created to prepare preliminary floodplain mapping for the Upper Stoney Creek and Upper Battlefield Creek watercourses. The hydraulic model used available contour mapping as well as information obtained from hydraulic structure surveys completed by Amec Foster Wheeler. The hydraulic model has been prepared using an analytical approach to develop floodplain mapping, as well as assess the hydraulic capacity of existing road crossings. The mapping provides a basis for better understanding those areas currently at risk of flooding during extreme events in the context of the study area objectives and possible storage areas.

iii. The QUALHYMO hydrologic model prepared for the *Stoney Creek and Battlefield Creek Flood and Erosion Control Class Environmental Assessment (AMEC, 2011)* has, as part of this study been updated to incorporate the subcatchments developed for the *Battlefield Creek Hydrologic and Hydraulic Assessment at Centennial Parkway and CPR Culvert Crossings (Amec Foster Wheeler, 2015),* as well as further discretization within the Upper Stoney Creek and Upper Battlefield Creek watershed.

iv. To supplement the erosion characterization completed for the 2011 Class EA, reach specific critical erosion flows for Stoney Creek and Battlefield Creek have been determined at locations that were considered to have the highest erosion potential. A duration analysis related to the erosion causing flows has been conducted for the storage facility alternatives.

v. The updated / refined hydraulic, hydrologic, and erosion assessment information has been used to determine a preferred combined storage facility alternative. The potential benefits to the receiving systems (in terms of flood and erosion risk reduction) resulting from the implementation of the preferred storage alternative have been determined.

vi. Storage facility alternatives have been assessed using environmental (terrestrial, aquatic and hydrogeological) evaluation criteria.

vii. Assessment of the storage alternatives has been conducted with consideration to existing HCA owned properties and properties of interest.

8.2 Recommendations

i. Based on the storage area assessment, the preferred alternative would be a combination of storage facilities BC-1, SC-5 (Scenario 2), SC-7 (Scenario 2) and SC-8 (Scenario 1).

ii. The HCA is to consider implementation of the storage areas with consideration to existing land ownership.

iii. As part of the preliminary and detailed design process, the additional environmental investigations and other assessments listed in Section 7.4 be conducted at the pre-design stage.

iv. HCA consider formally presenting the findings of this Class EA to the City of Hamilton and Niagara Escarpment Commission.

v. HCA discuss with the City of Hamilton the potential road works that will be required for each storage facility(s) or alternatively consider standalone berms upstream of the road crossings, and consult with MNRF.

vi. That a monitoring program be implemented for existing conditions based on the guidance provided in Section 7.5 prior to the detailed design process and after construction.

9.0 References

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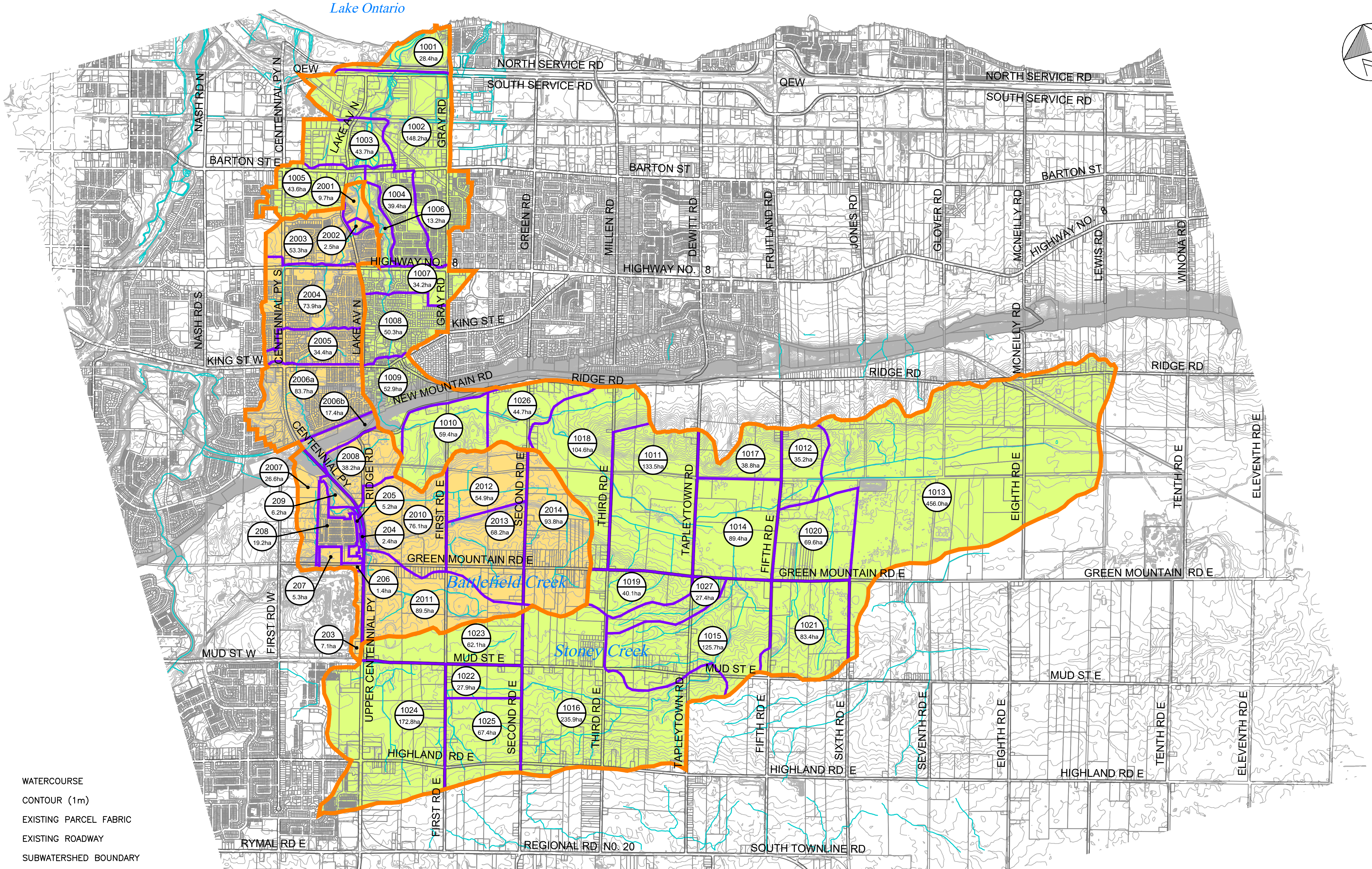


LEGEND

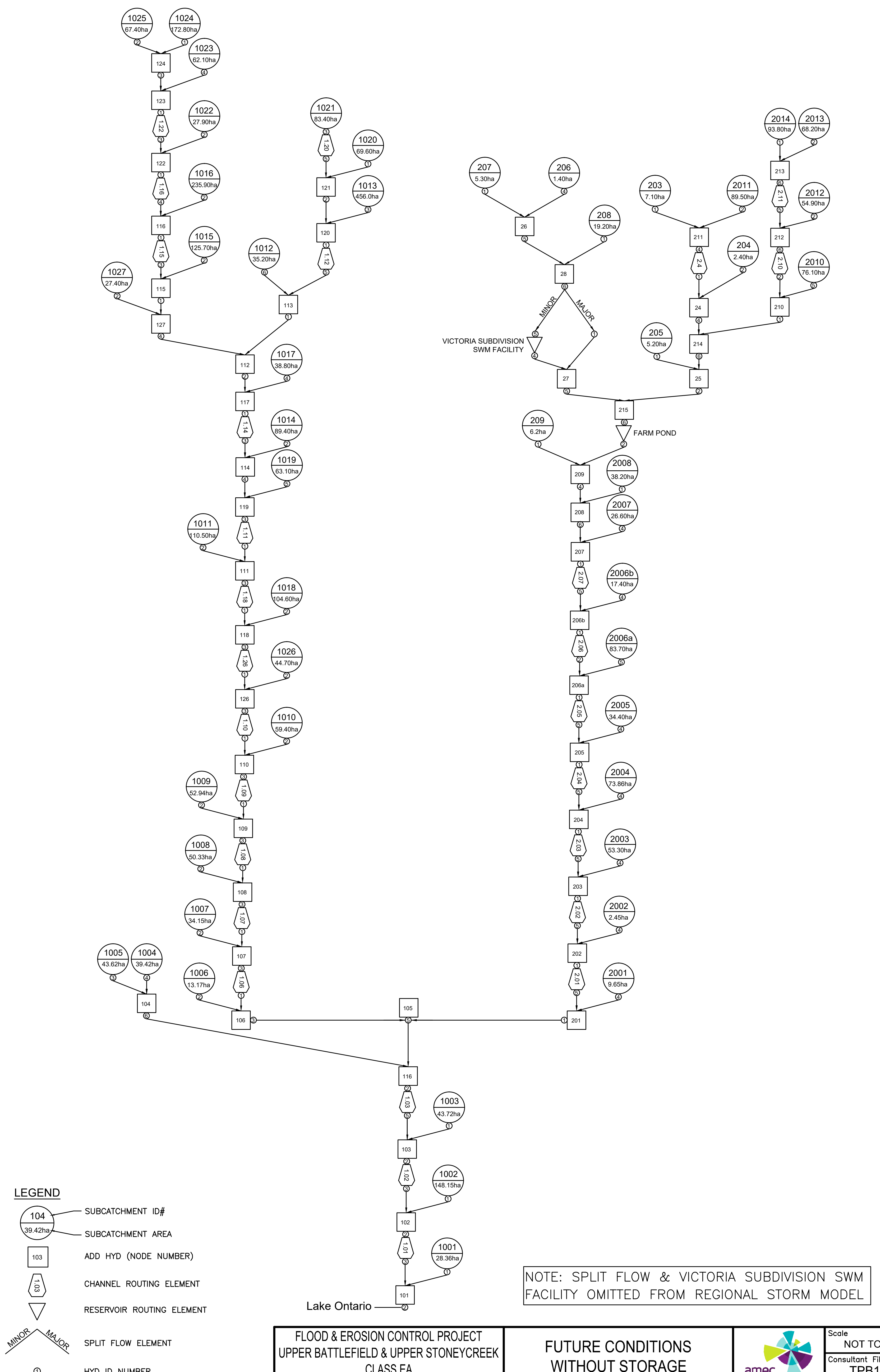
- WATERCOURSE
- CONTOUR (1m)
- EXISTING PARCEL FABRIC
- EXISTING ROADWAY
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- BATTLEFIELD CREEK SUBWATERSHED
- STONEY CREEK SUBWATERSHED

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	BATTLEFIELD & STONEY CREEK FUTURE CATCHMENT PLAN	amec foster wheeler	Scale 1:20000 (0 200 400 800) Consultant File No. TPB168024 Figure No. 1

Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrftFin)\Fig1 Catchment.dwg

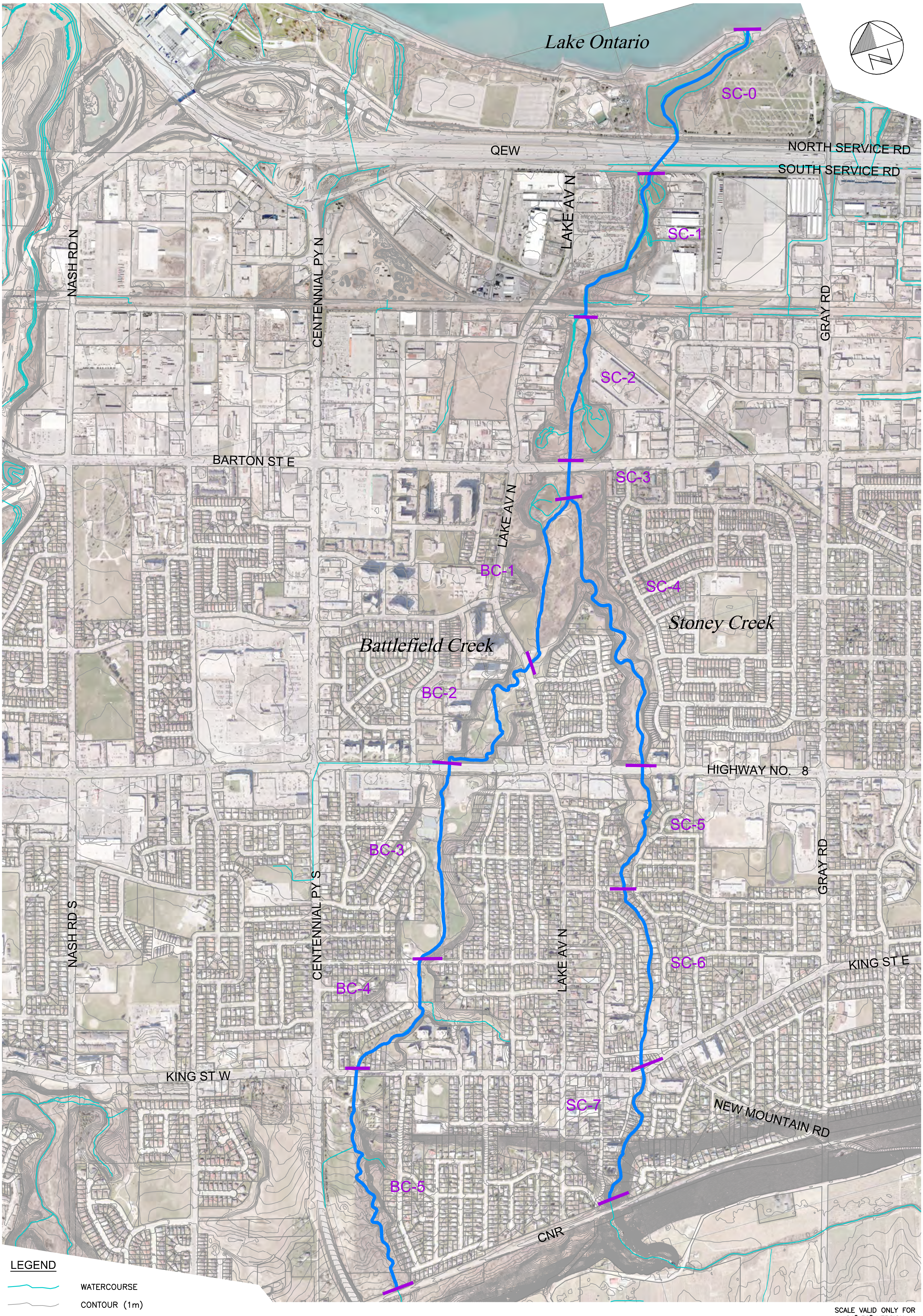
Plotted: 2018-02-14 Plotted By: richard.bartolo
Last Saved: 2018-02-12 Last Saved By: richard.bartolo



NOTE: SPLIT FLOW & VICTORIA SUBDIVISION SWM FACILITY OMITTED FROM REGIONAL STORM MODEL

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEYCREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	FUTURE CONDITIONS WITHOUT STORAGE MODEL SCHEMATIC	amec foster wheeler	Scale: NOT TO SCALE Consultant File No. TPB168024 Figure No. 2

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig2 Schematic(WOStor).dwg
Plotted By: richard.bartolo
Plotted: 2018-02-14
Last Saved By: richard.bartolo
Last Saved: 2018-02-14



LEGEND

WATERCOURSE
CONTOUR (1m)
EXISTING PARCEL FABRIC
LOWER BATTLEFIELD AND STONEY CREEK
REACH BREAKS
BC-5 REACH REFERENCE NUMBER

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

LOWER BATTLEFIELD &
LOWER STONEY CREEK
EXISTING REACH DELINEATION

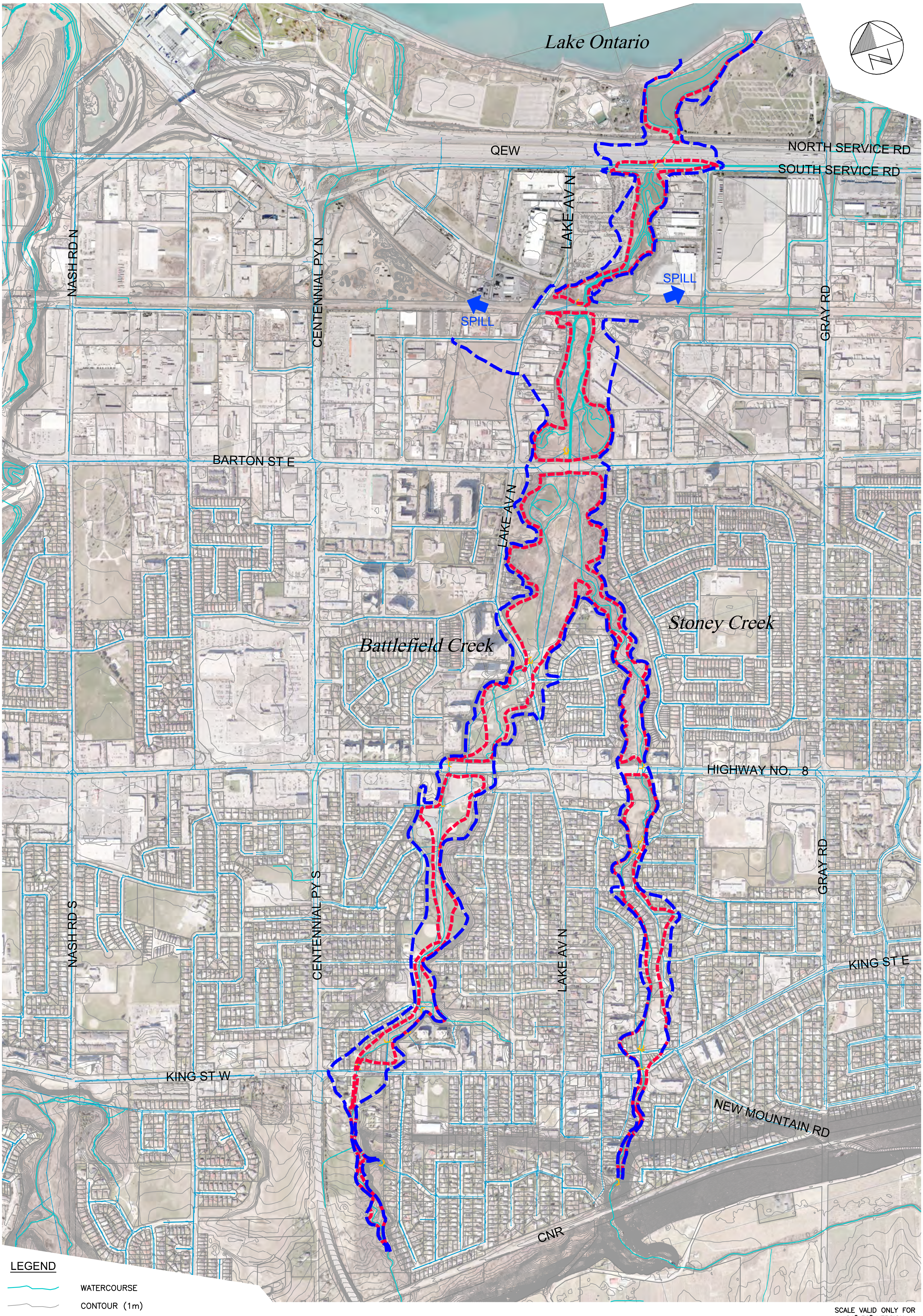
amec foster wheeler

Scale 1:6000
0 75 150 300

Consultant File No.
TPB168024

Figure No.
3

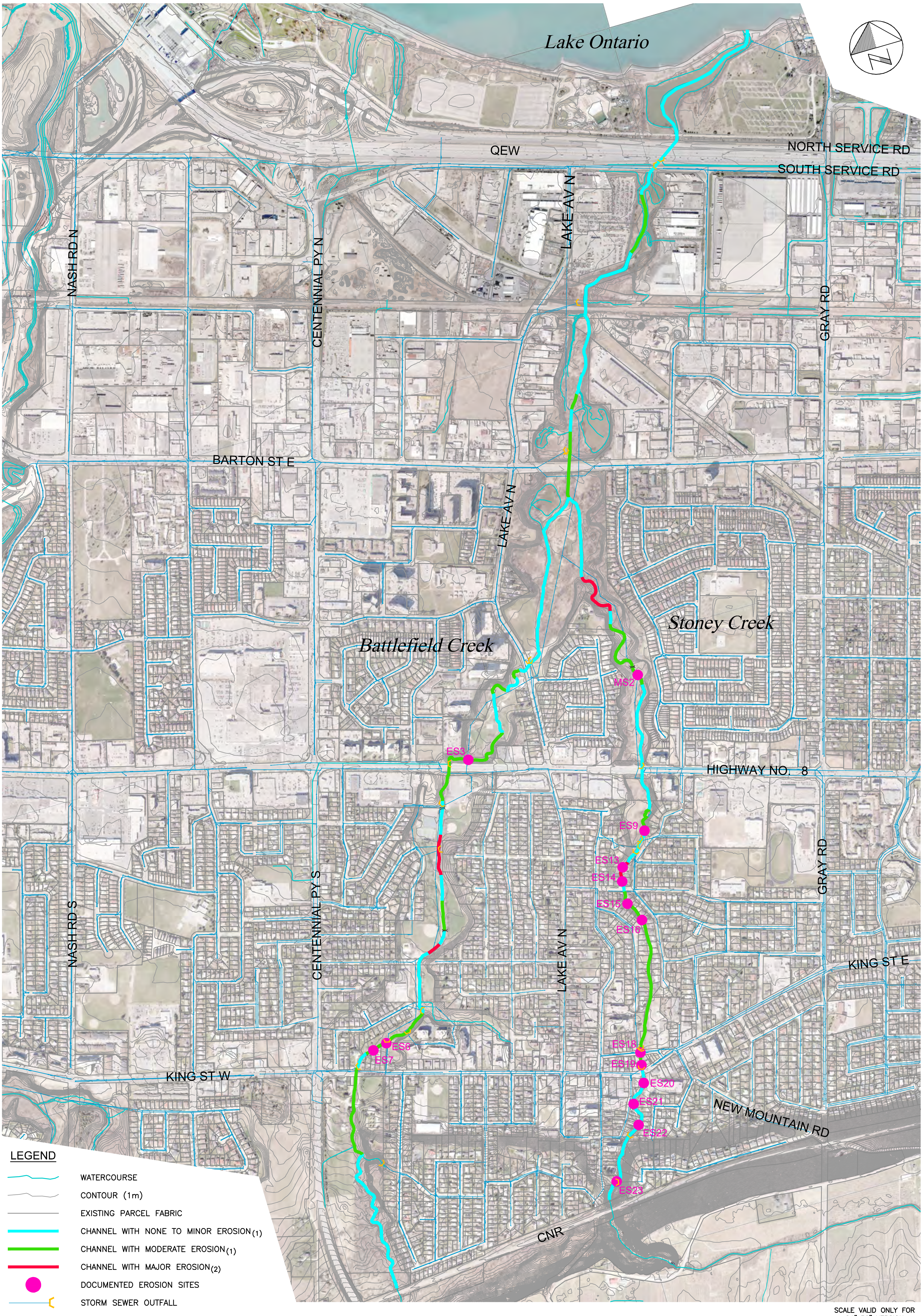
Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES–ENG\01_CAD\02_DWGS\05_WR\18–02(RepDrFin)\Fig3 Reaches.dwg Plotted By: richard.bartolo Plotted: 2018–02–14 Last Saved By: richard.bartolo Last Saved: 2018–02–12



SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	LOWER BATTLEFIELD & LOWER STONEY CREEK EXISTING FLOODPLAIN	amec foster wheeler	Scale 1:6000 (0 75 150 300) Consultant File No. TPB168024 Figure No. 4

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig4 LowerFloodplain.dwg
Plotted By: richard.bortolo
Plotted: 2018-02-14
Last Saved By: richard.bortolo
Last Saved: 2018-02-12



Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig5 ErosionControl.dwg

Plotted By: richard.bartolo Plotted: 2018-02-14

Last Saved By: richard.bartolo Last Saved: 2018-02-14

SCALE VALID ONLY FOR 24"x36" VERSION

NOTE:
(1) STONEY CREEK AND BATTLEFIELD CREEK FLOOD AND EROSION CONTROL CLASS ENVIRONMENTAL ASSESSMENT (2011)
(2) CITY OF HAMILTON WATERCOURSE EROSION ASSESSMENT STUDY (2010)

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

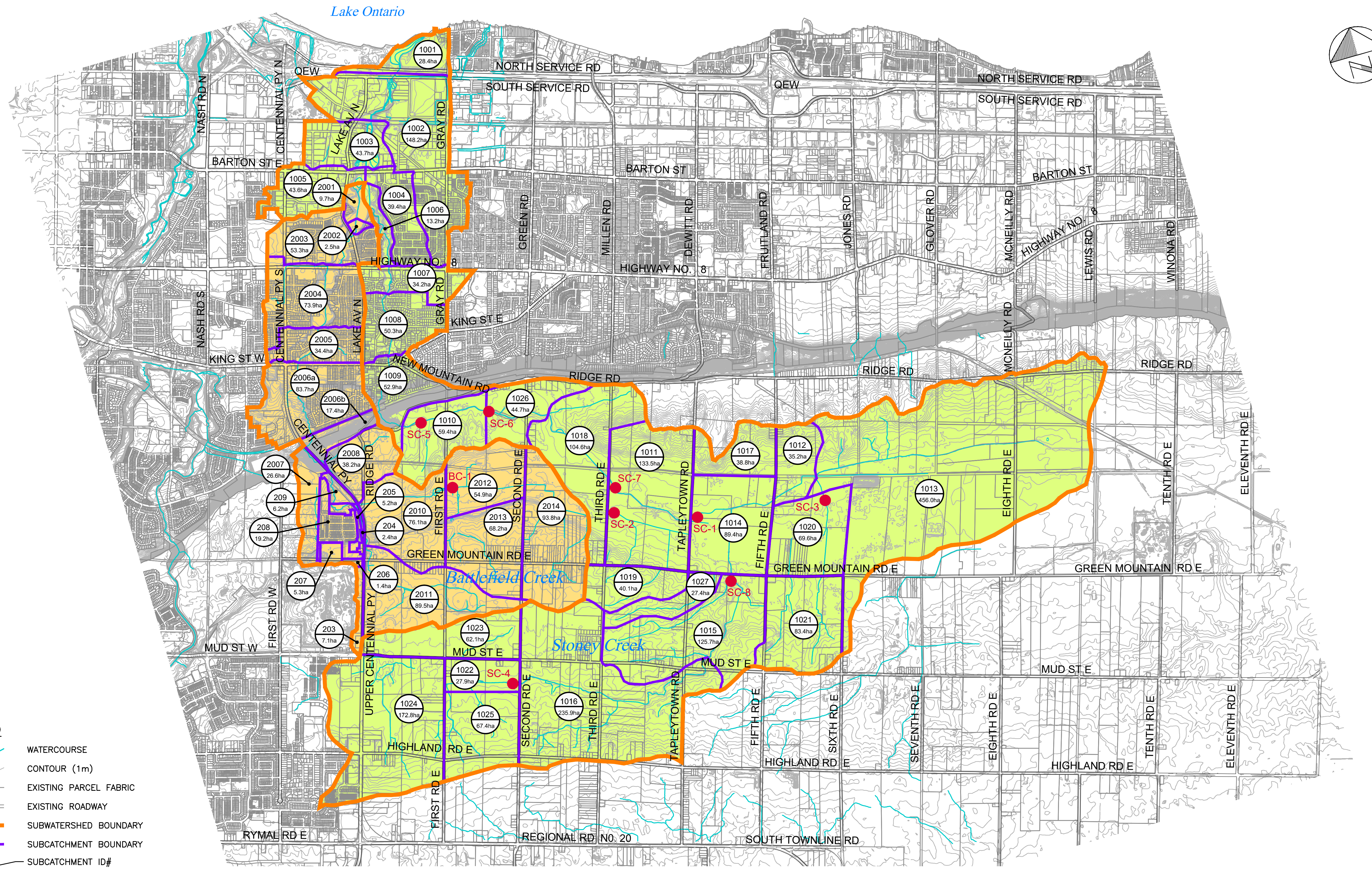
LOWER BATTLEFIELD &
LOWER STONEY CREEK
EXISTING EROSION POTENTIAL

amec foster wheeler

Scale 1:6000
0 75 150 300

Consultant File No.
TPB168024

Figure No.
5

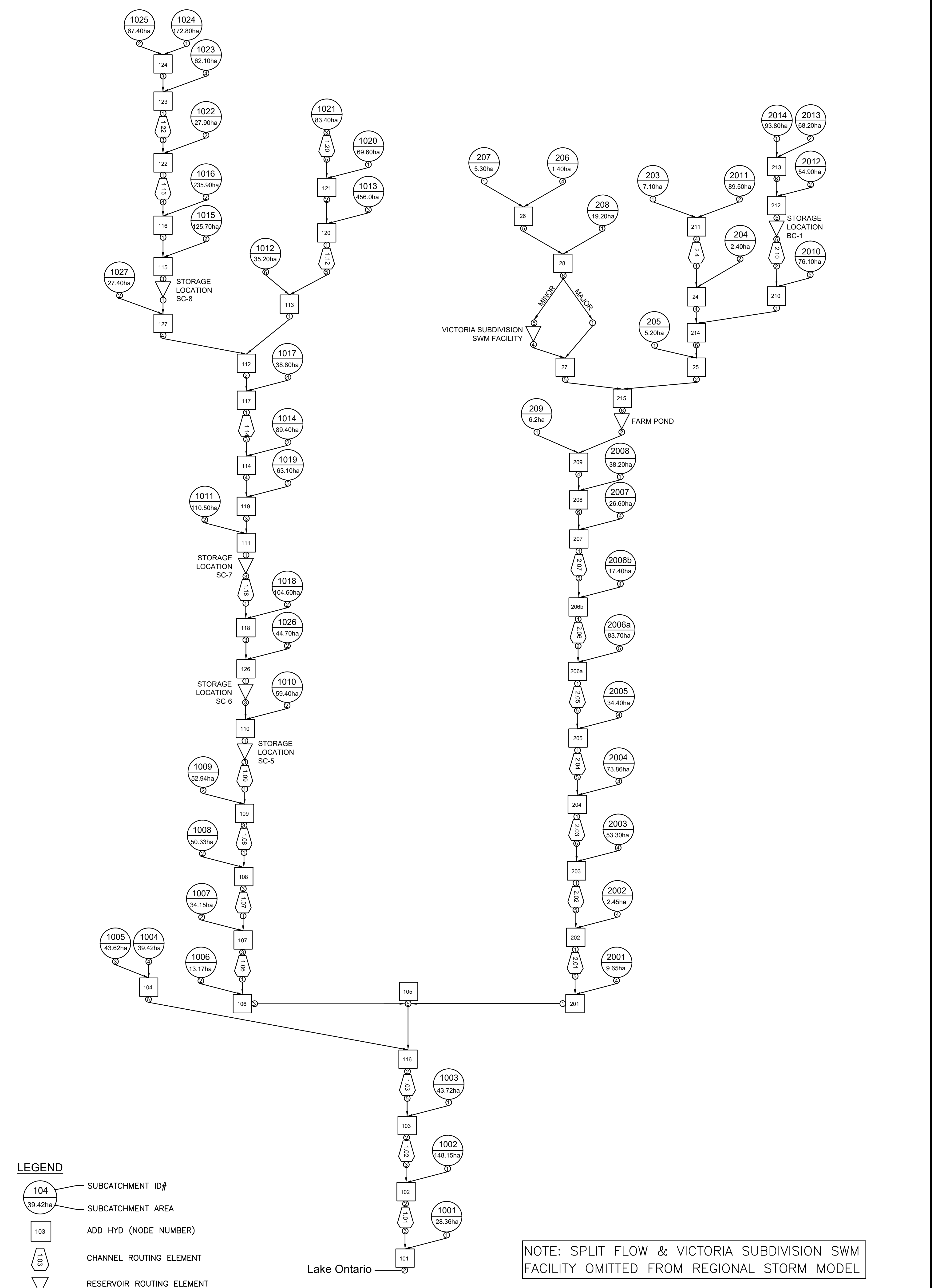


LEGEND

- WATERCOURSE
- CONTOUR (1m)
- EXISTING PARCEL FABRIC
- EXISTING ROADWAY
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- BATTLEFIELD CREEK SUBWATERSHED
- STONEY CREEK SUBWATERSHED
- BC-1 ● STORAGE LOCATION FOR FUTURE CONSIDERATION AND REFERENCE ID

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	BATTLEFIELD & STONEY CREEK FUTURE CATCHMENT AND STORAGE LOCATION PLAN	amec foster wheeler	Scale 1:20000 (0 200 400 800) Consultant File No. TPB168024 Figure No. 6

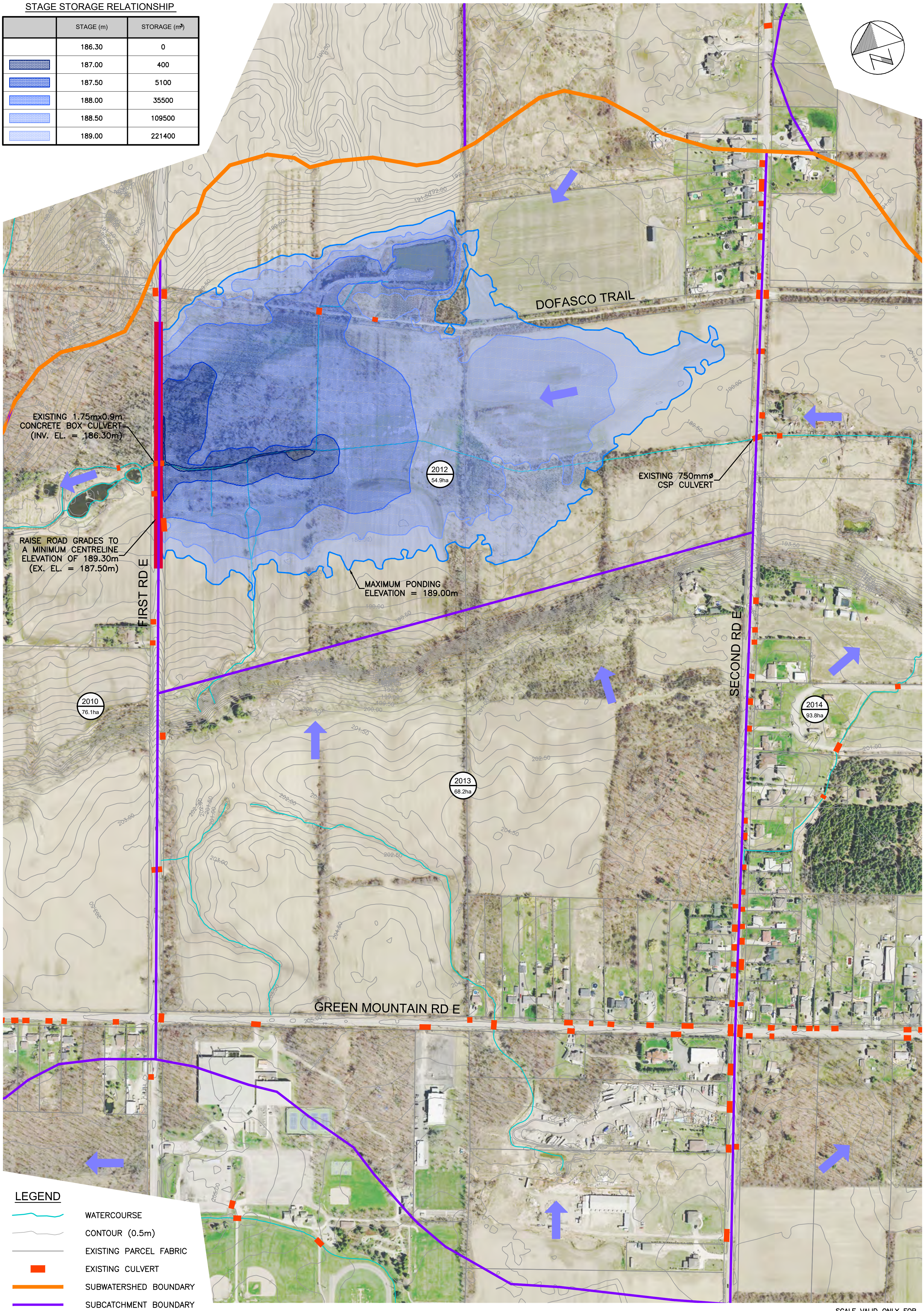


NOTE: SPLIT FLOW & VICTORIA SUBDIVISION SWM FACILITY OMITTED FROM REGIONAL STORM MODEL

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	FUTURE CONDITIONS WITH STORAGE MODEL SCHEMATIC	amec foster wheeler	Scale: NOT TO SCALE Consultant File No.: TPB168024 Figure No.: 7

STAGE STORAGE RELATIONSHIP

	STAGE (m)	STORAGE (m³)
	186.30	0
	187.00	400
	187.50	5100
	188.00	35500
	188.50	109500
	189.00	221400



LEGEND

WATERCOURSE

CONTOUR (0.5m)

EXISTING PARCEL FABRIC

EXISTING CULVERT

SUBWATERSHED BOUNDARY

SUBCATCHMENT BOUNDARY

100 SUBCATCHMENT ID#

25.0ha SUBCATCHMENT AREA

OVERLAND FLOW DIRECTION

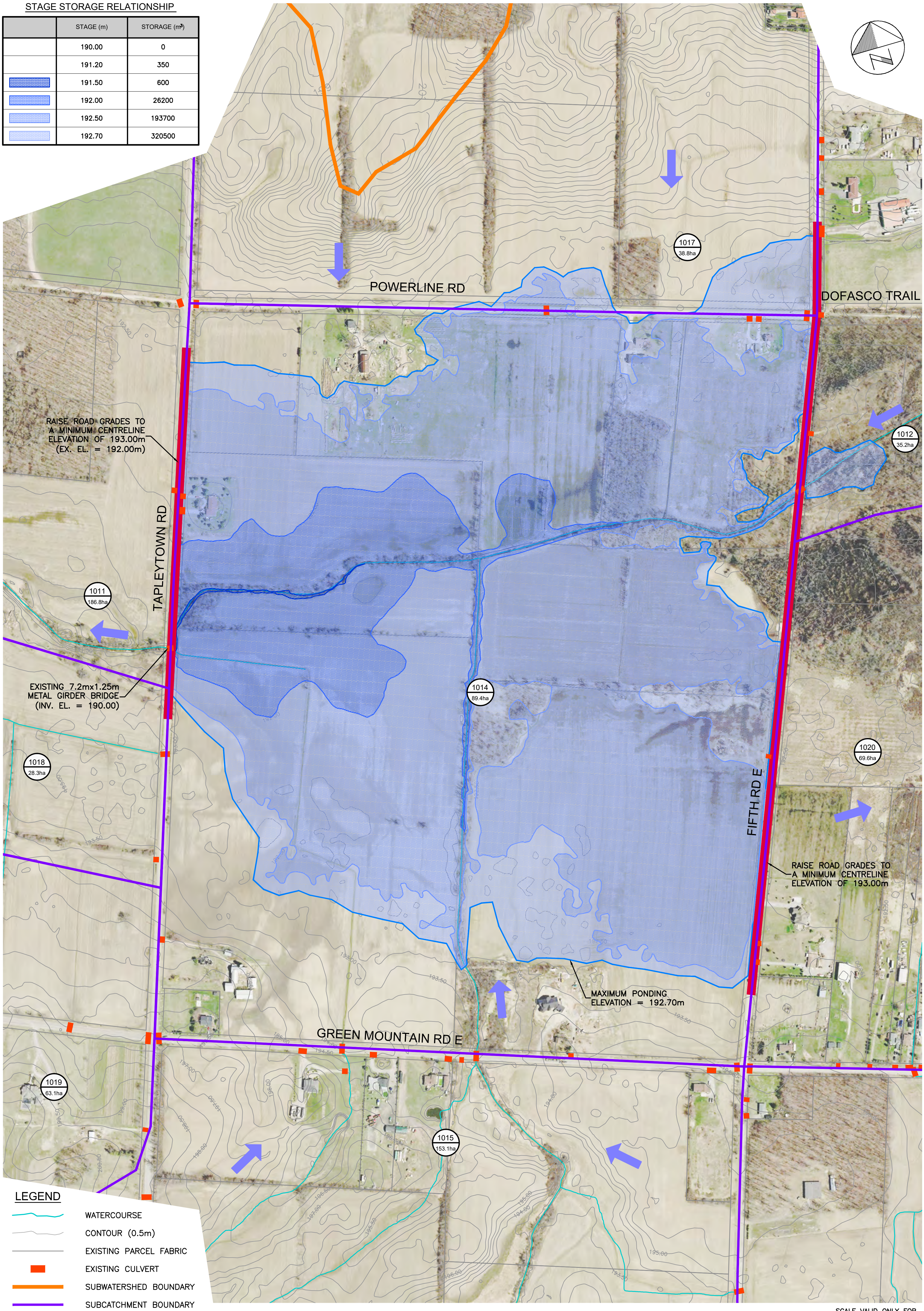
LIMIT OF STORAGE

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY BC-1	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 8

STAGE STORAGE RELATIONSHIP

	STAGE (m)	STORAGE (m³)
	190.00	0
	191.20	350
	191.50	600
	192.00	26200
	192.50	193700
	192.70	320500



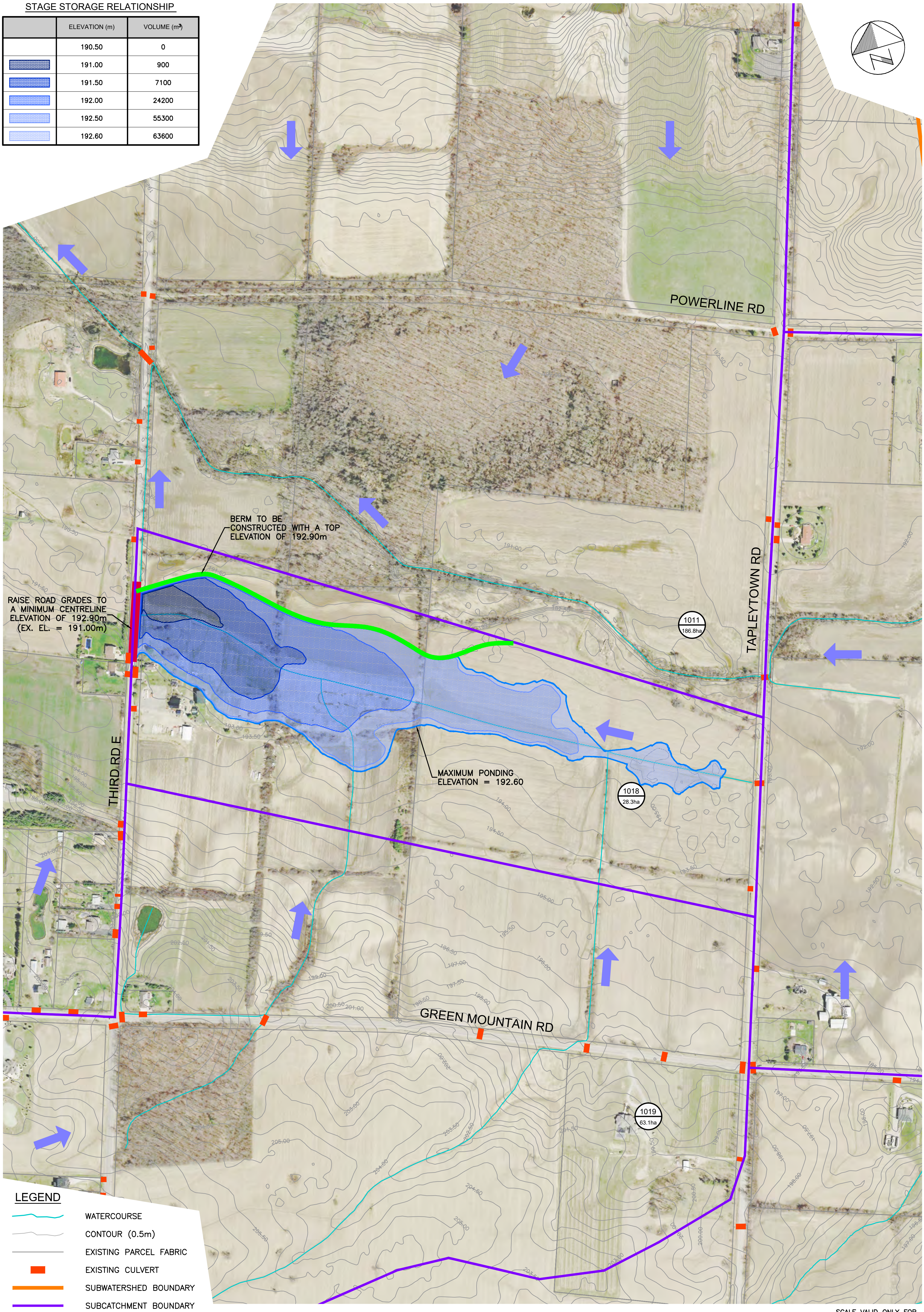
SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-1	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 9

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig9 StageStoragePlans(SC1).dwg
Plotted By: richard.bartolo
Plotted: 2018-02-14
Last Saved By: richard.bartolo
Last Saved: 2018-02-12

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m^3)
	190.50	0
	191.00	900
	191.50	7100
	192.00	24200
	192.50	55300
	192.60	63600



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

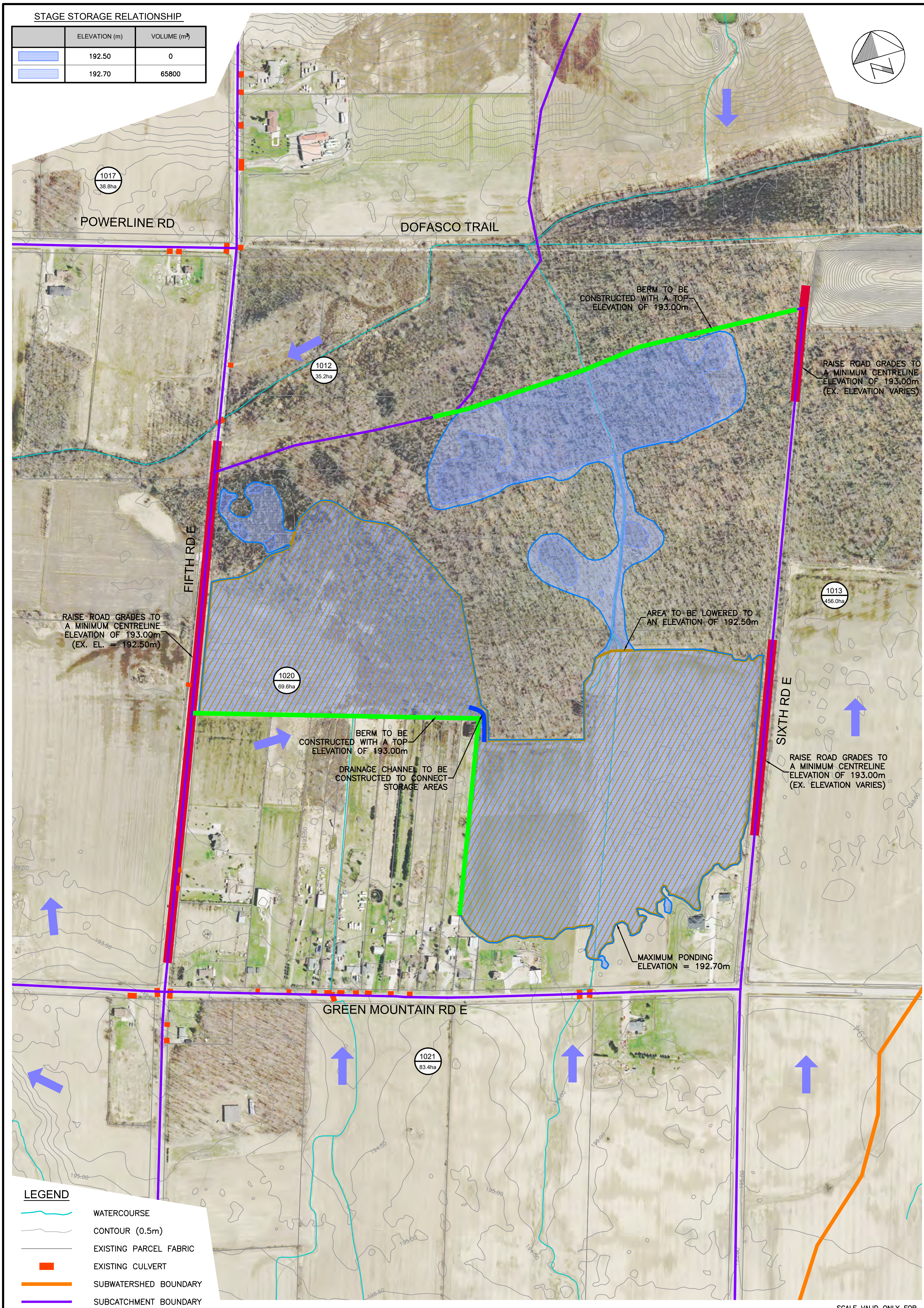
Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig10-12 StageStoragePlans(SC2-4).dwg Plotted By: richard.bartolo Plotted: 2018-02-14 Last Saved By: richard.bartolo Last Saved: 2018-02-12

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-2	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 10

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	192.50	0
	192.70	65800



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 SUBCATCHMENT ID#
- 25.0ha SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

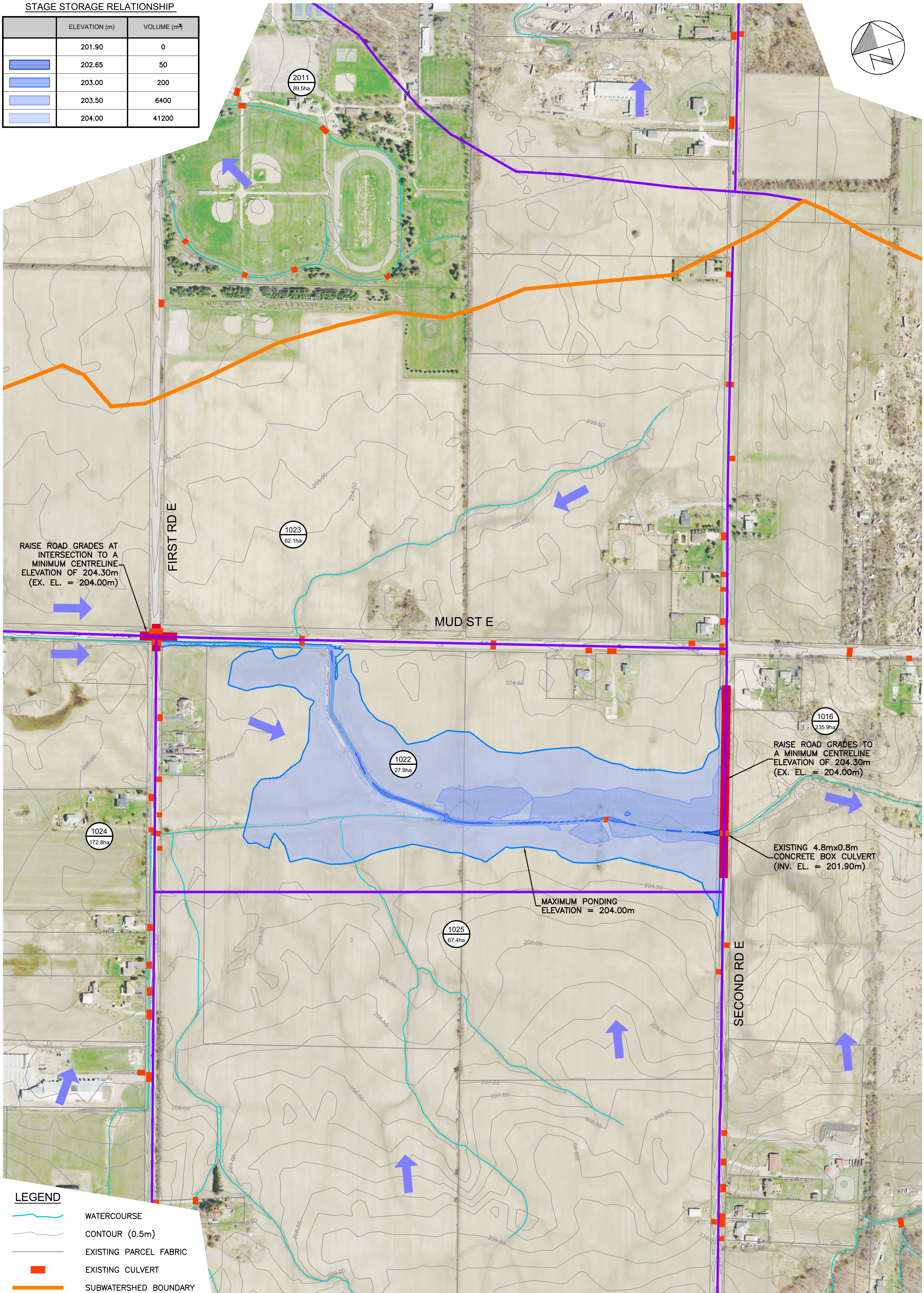
SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-3	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 11

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig10-12 StageStoragePlans(SC2-4).dwg Plotted By: richard.bartolo Plotted: 2018-02-14 Last Saved By: richard.bartolo Last Saved: 2018-02-12

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m^3)
	201.90	0
	202.65	50
	203.00	200
	203.50	6400
	204.00	41200



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

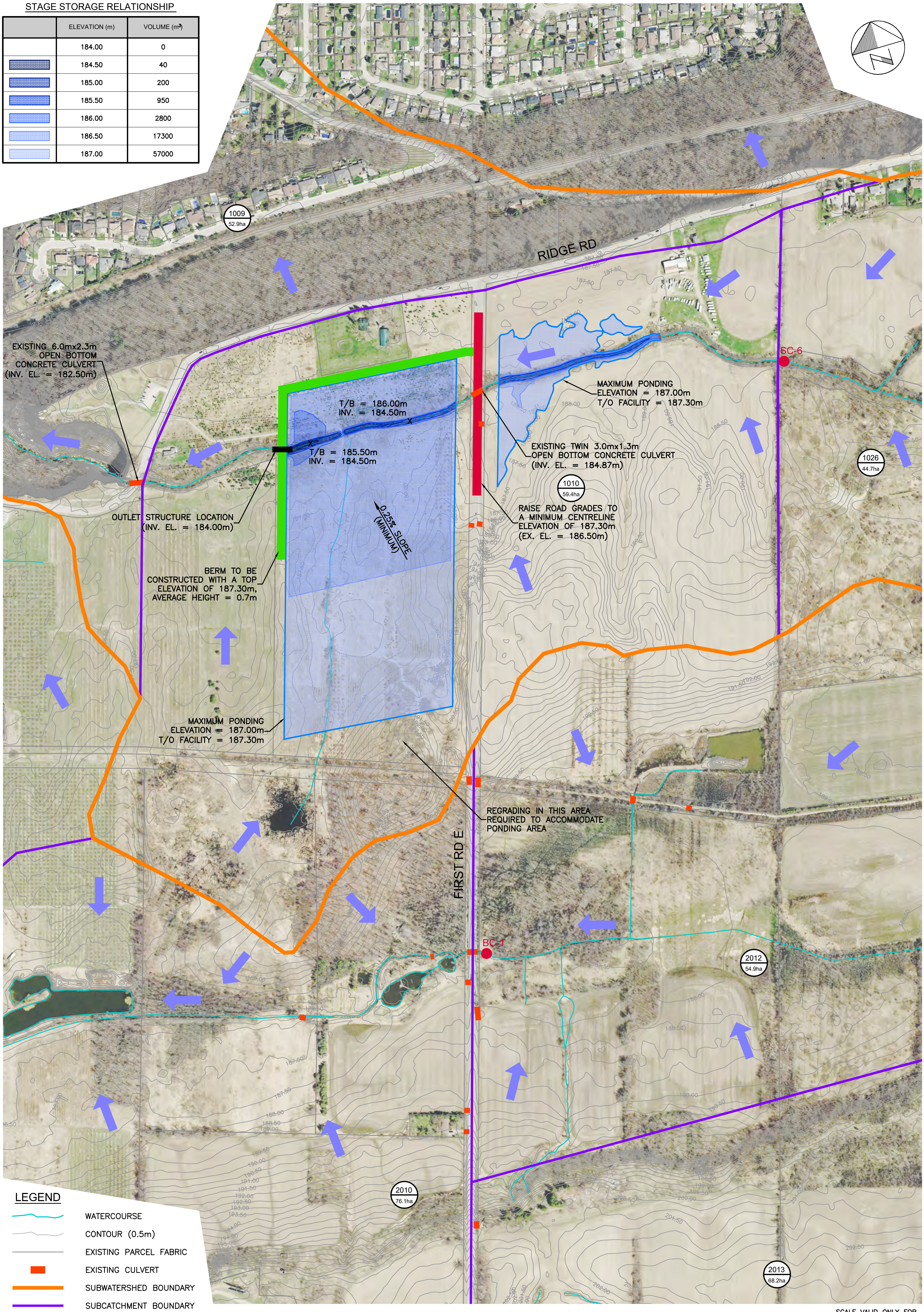
SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-4	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 12

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig10-12 StageStoragePlans(SC2-4).dwg
Plotted By: richard.bartolo Plotted: 2018-02-14 Last Saved By: richard.bartolo Last Saved: 2018-02-12

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	184.00	0
	184.50	40
	185.00	200
	185.50	950
	186.00	2800
	186.50	17300
	187.00	57000



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 SUBCATCHMENT ID#
- 25.0ha SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

STORAGE FACILITY
SC-5
(SCENARIO 1)

amec foster wheeler

Scale 1:2500
0 25 50 100

Consultant File No.
TPB168024

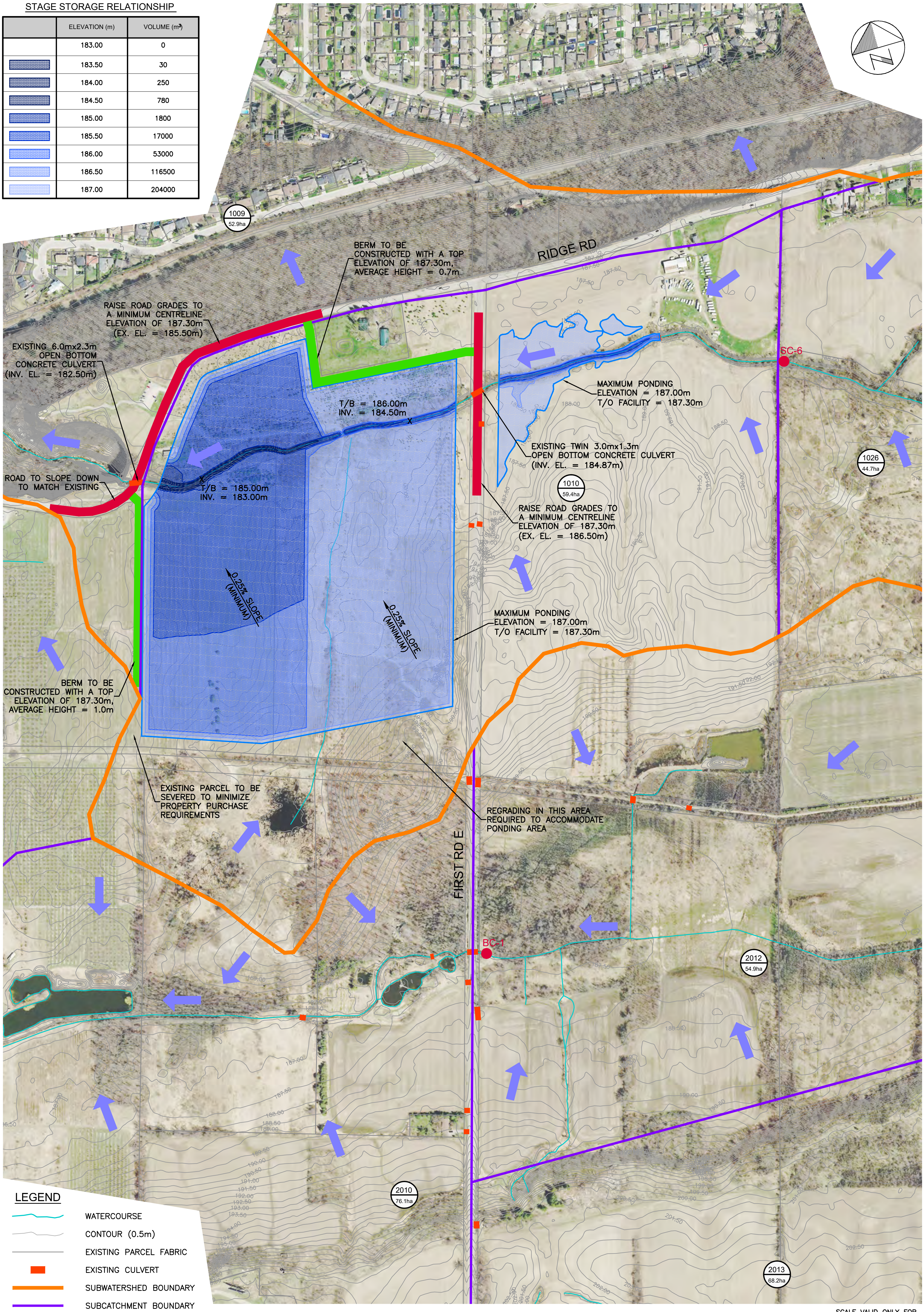
Figure No.
13

Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig13-19 StageStoragePlans(SC5-8).dwg

Last Saved: 2018-02-12 Last Saved By: richard.bartolo Plotted: 2018-02-14 Plotted By: richard.bartolo

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m^3)
	183.00	0
	183.50	30
	184.00	250
	184.50	780
	185.00	1800
	185.50	17000
	186.00	53000
	186.50	116500
	187.00	204000



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

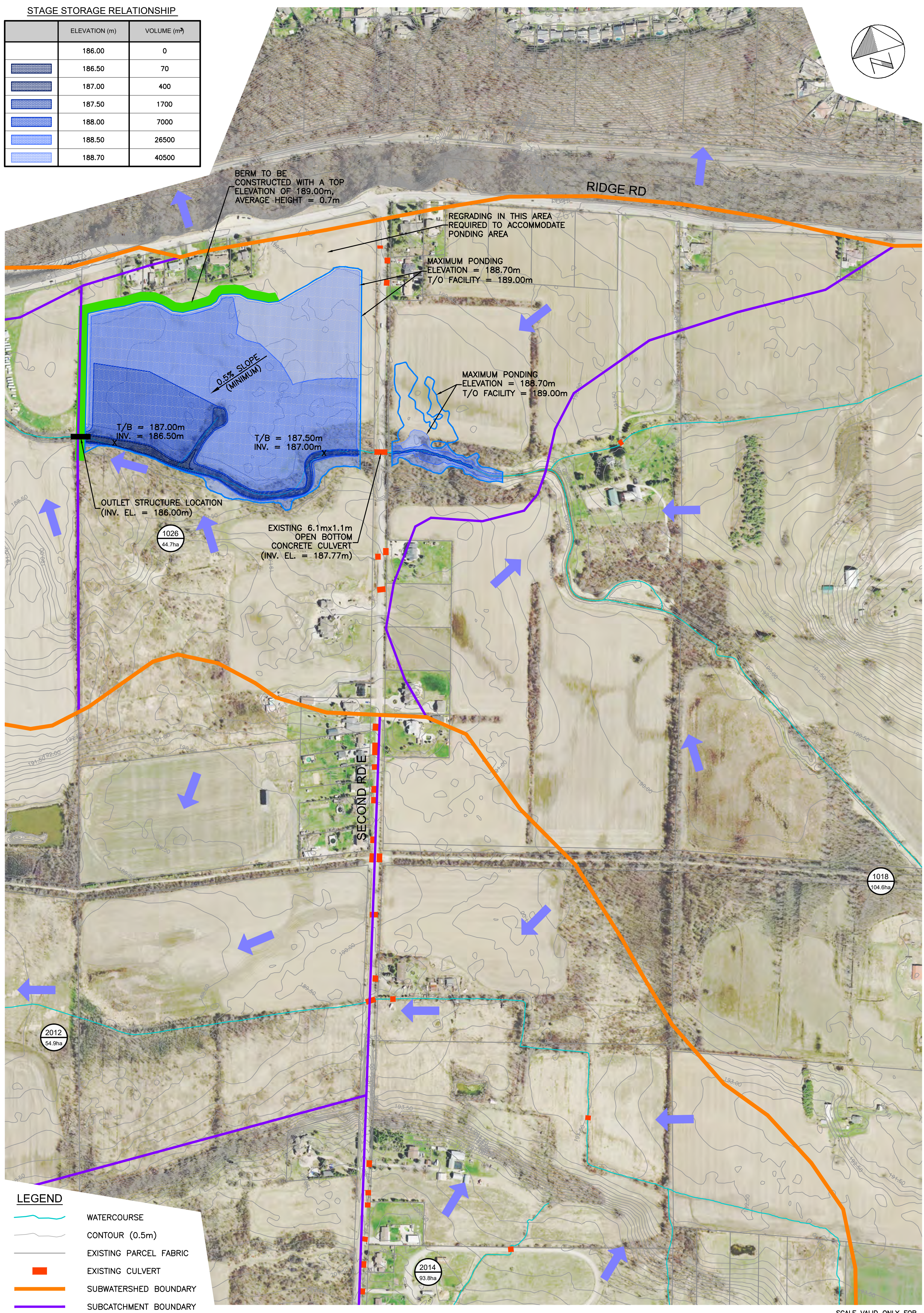
SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-5 (SCENARIO 2)	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 14

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig13-19 StageStoragePlans(SC5-8).dwg Plotted By: richard.bartolo Plotted: 2018-02-14 Last Saved By: richard.bartolo Last Saved: 2018-02-12

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	186.00	0
	186.50	70
	187.00	400
	187.50	1700
	188.00	7000
	188.50	26500
	188.70	40500



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 — SUBCATCHMENT ID#
- 25.0ha — SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

STORAGE FACILITY
SC-6

amec foster wheeler

Scale 1:2500

Consultant File No. TPB168024

Figure No. 15

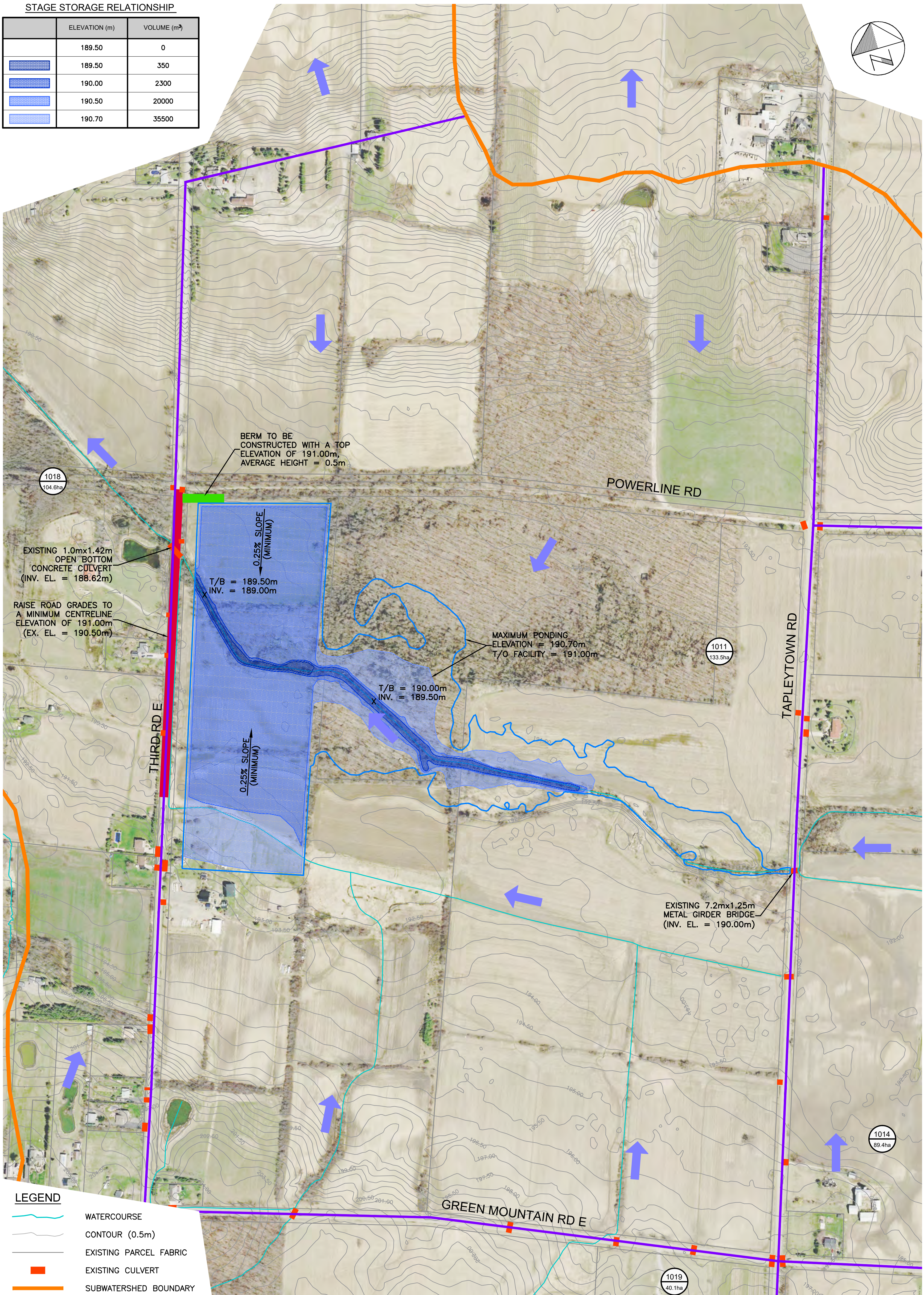
Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig13-19 StageStoragePlans(SC5-8).dwg

Plotted By: richard.bartolo Plotted: 2018-02-14

Last Saved By: richard.bartolo Last Saved: 2018-02-12

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m^3)
	189.50	0
	189.50	350
	190.00	2300
	190.50	20000
	190.70	35500



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 / 25.0ha — SUBCATCHMENT ID# / SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-7 (SCENARIO 1)	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 16

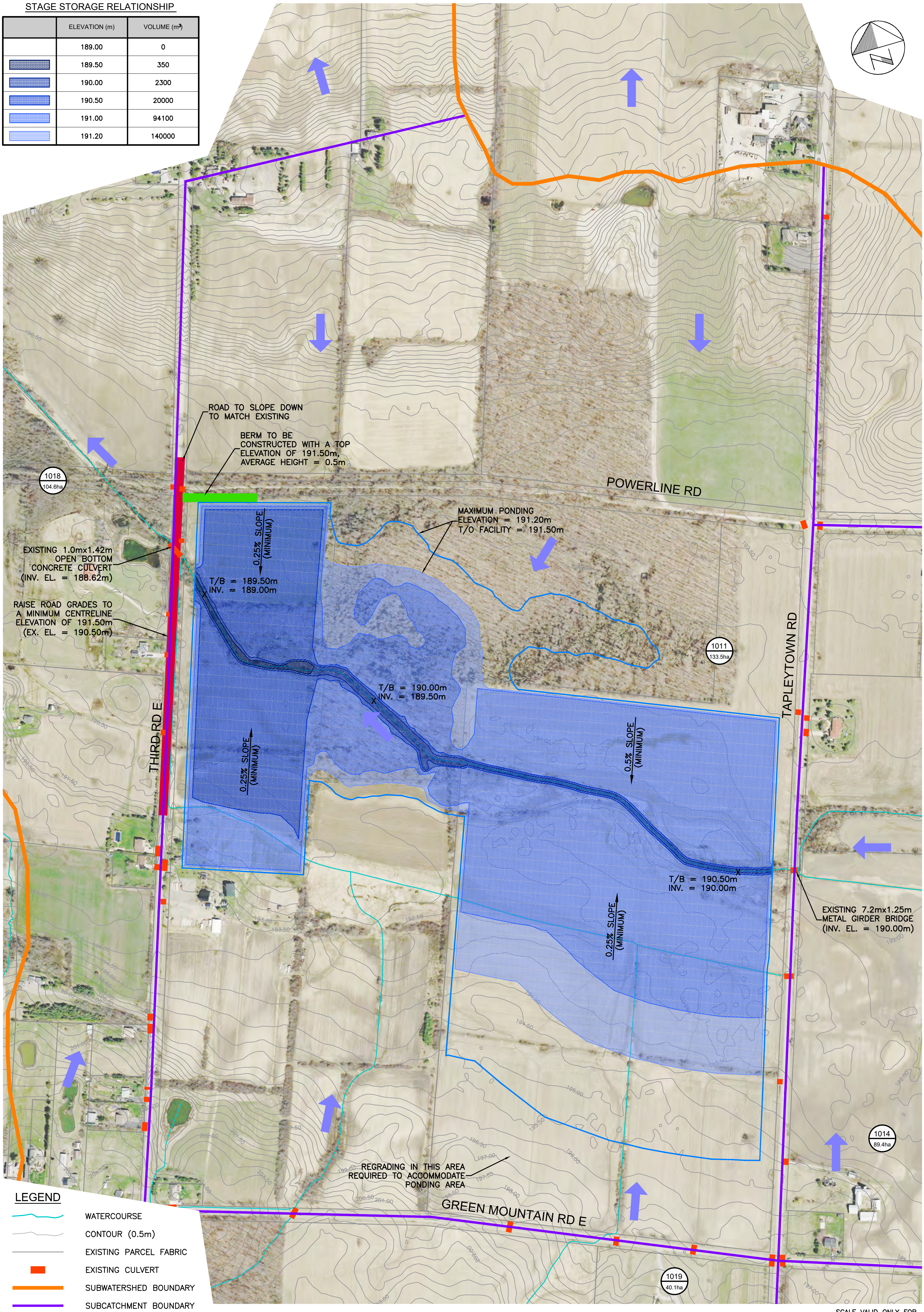
Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrFin)\Fig13-19 StageStoragePlans(SC5-8).dwg

Plotted: 2018-02-20 Plotted By: richard.bartolo

Last Saved: 2018-02-20 Last Saved By: richard.bartolo

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	189.00	0
	189.50	350
	190.00	2300
	190.50	20000
	191.00	94100
	191.20	140000



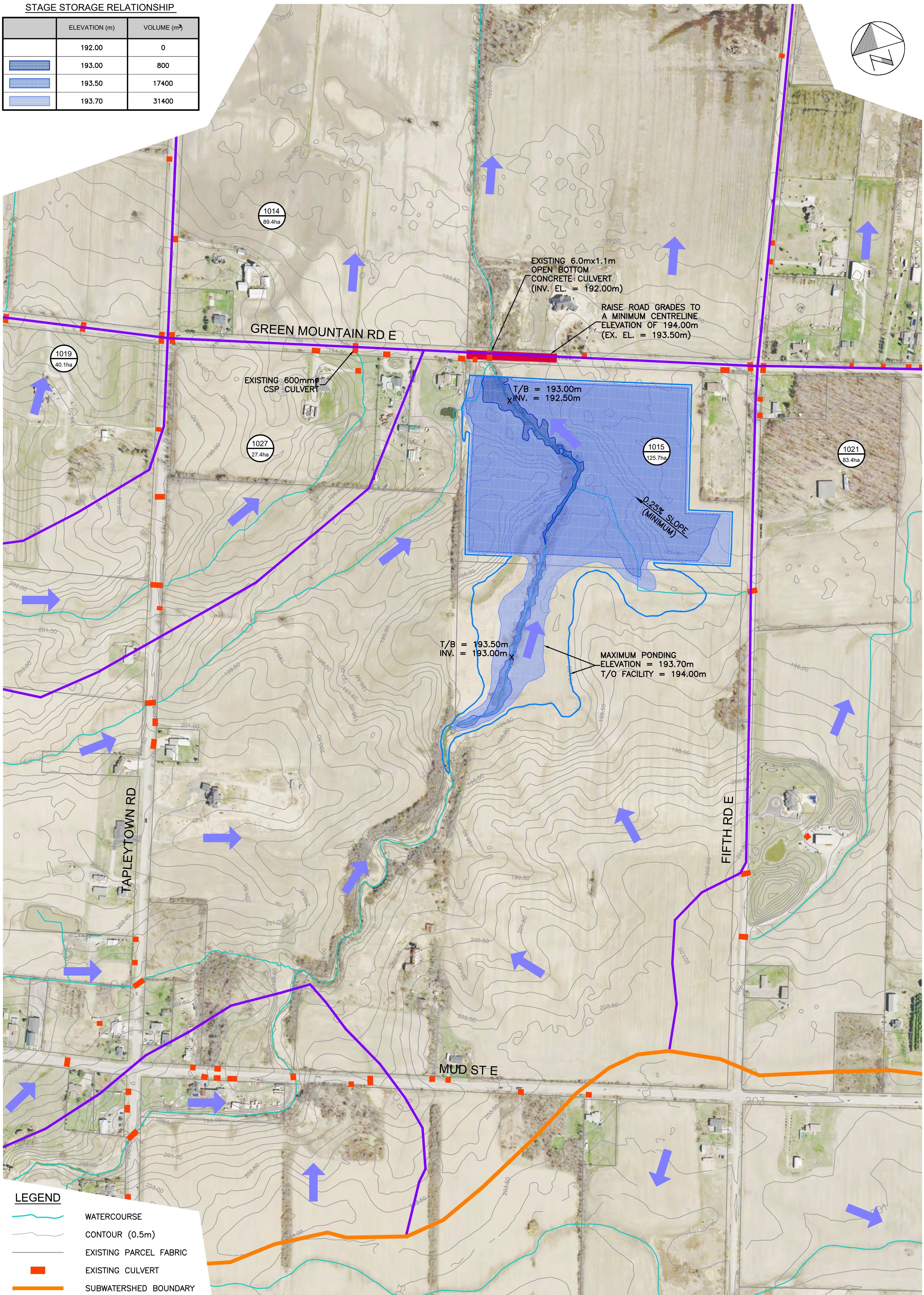
Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig13-19 StageStoragePlans(SC5-8).dwg
Plotted By: richard.bartolo Plotted: 2018-02-20
Last Saved By: richard.bartolo Last Saved: 2018-02-20

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	STORAGE FACILITY SC-7 (SCENARIO 2)	amec foster wheeler	Scale 1:2500 (0 25 50 100) Consultant File No. TPB168024 Figure No. 17

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	192.00	0
	193.00	800
	193.50	17400
	193.70	31400



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 / 25.0ha — SUBCATCHMENT ID# / SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrftFin)\Fig13-19 StageStoragePlans(SC5-8).dwg
Plotted By: richard.bartolo Plotted: 2018-02-14
Last Saved By: richard.bartolo Last Saved: 2018-02-12

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

STORAGE FACILITY
SC-8
(SCENARIO 1)

amec foster wheeler

SCALE VALID ONLY FOR 24"x36" VERSION

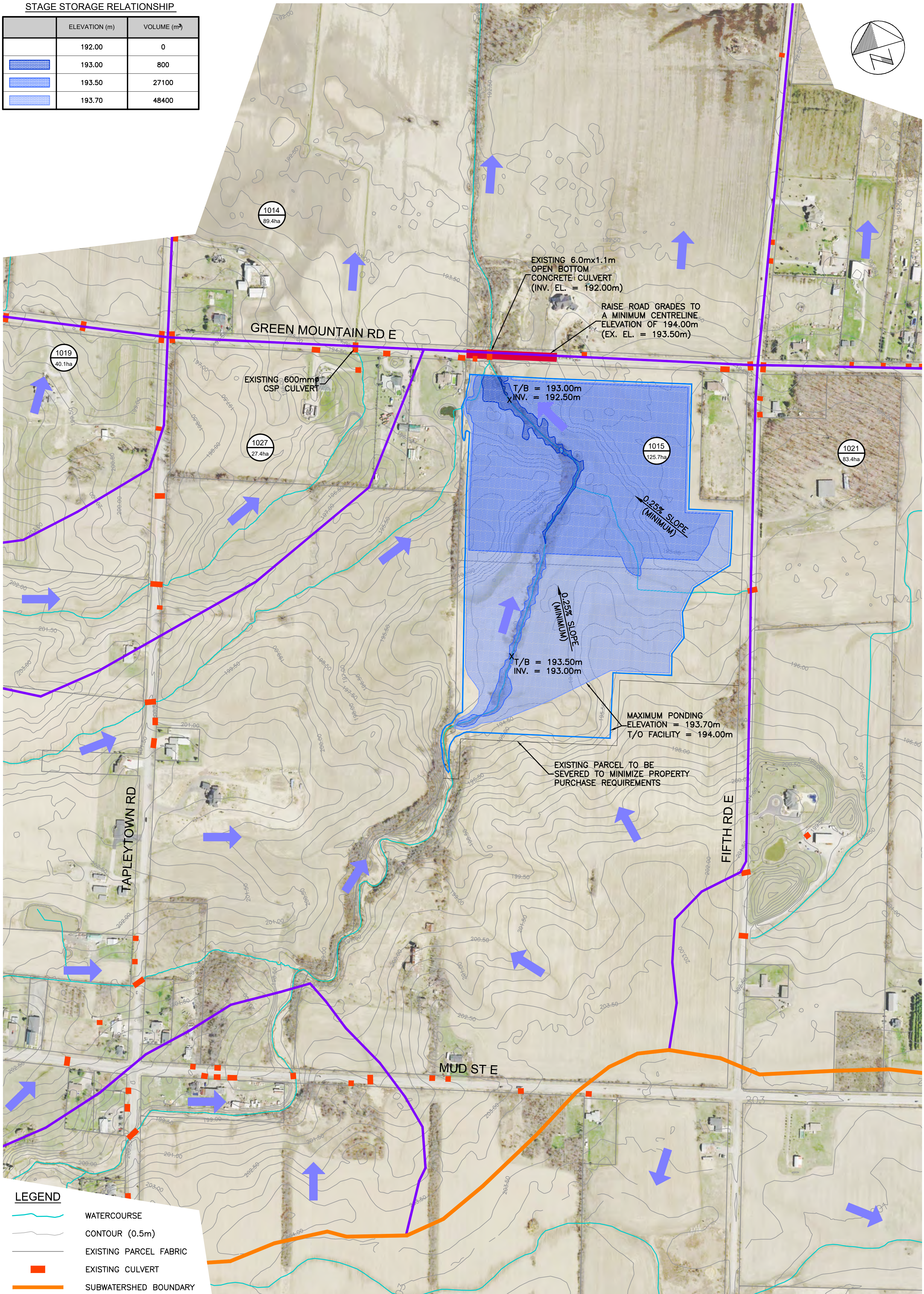
Scale 1:2500 (0 25 50 100)

Consultant File No. TPB168024

Figure No. 18

STAGE STORAGE RELATIONSHIP

	ELEVATION (m)	VOLUME (m³)
	192.00	0
	193.00	800
	193.50	27100
	193.70	48400



LEGEND

- WATERCOURSE
- CONTOUR (0.5m)
- EXISTING PARCEL FABRIC
- EXISTING CULVERT
- SUBWATERSHED BOUNDARY
- SUBCATCHMENT BOUNDARY
- 100 / 25.0ha — SUBCATCHMENT ID# / SUBCATCHMENT AREA
- OVERLAND FLOW DIRECTION
- LIMIT OF STORAGE

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

STORAGE FACILITY
SC-8
(SCENARIO 2)

amec foster wheeler

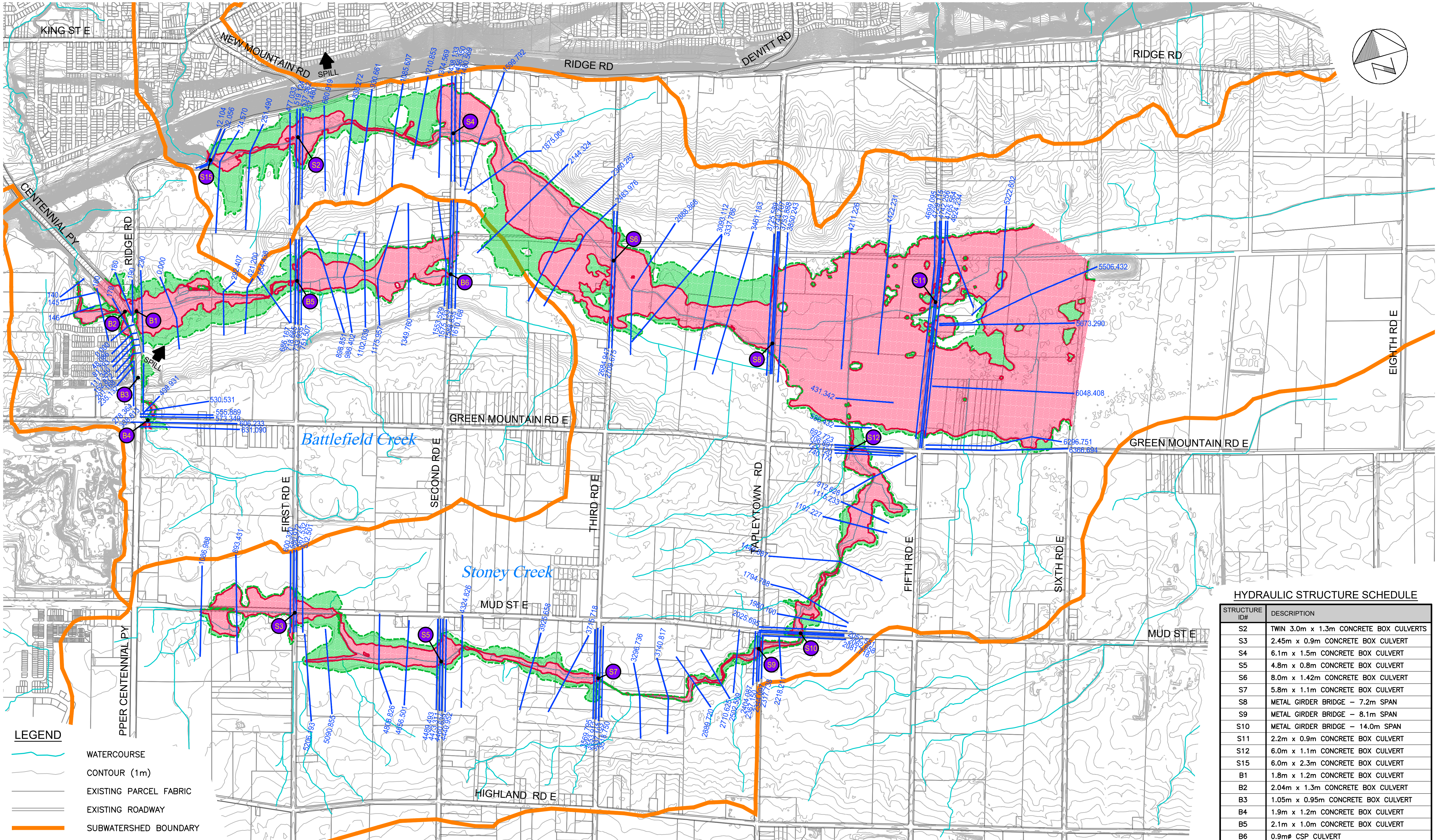
Scale 1:2500 (0 25 50 100)

Consultant File No. TPB168024

Figure No. 19

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig13-19 StageStoragePlans(SC5-8).dwg

Last Saved: 2018-02-12 Last Saved By: richard.bartolo Plotted: 2018-02-14 Plotted By: richard.bartolo



HYDRAULIC STRUCTURE SCHEDULE

STRUCTURE ID#	DESCRIPTION
S2	TWIN 3.0m x 1.3m CONCRETE BOX CULVERTS
S3	2.45m x 0.9m CONCRETE BOX CULVERT
S4	6.1m x 1.5m CONCRETE BOX CULVERT
S5	4.8m x 0.8m CONCRETE BOX CULVERT
S6	8.0m x 1.42m CONCRETE BOX CULVERT
S7	5.8m x 1.1m CONCRETE BOX CULVERT
S8	METAL GIRDER BRIDGE – 7.2m SPAN
S9	METAL GIRDER BRIDGE – 8.1m SPAN
S10	METAL GIRDER BRIDGE – 14.0m SPAN
S11	2.2m x 0.9m CONCRETE BOX CULVERT
S12	6.0m x 1.1m CONCRETE BOX CULVERT
S15	6.0m x 2.3m CONCRETE BOX CULVERT
B1	1.8m x 1.2m CONCRETE BOX CULVERT
B2	2.04m x 1.3m CONCRETE BOX CULVERT
B3	1.05m x 0.95m CONCRETE BOX CULVERT
B4	1.9m x 1.2m CONCRETE BOX CULVERT
B5	2.1m x 1.0m CONCRETE BOX CULVERT
B6	0.9mø CSP CULVERT

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT
UPPER BATTLEFIELD & UPPER STONEY CREEK
CLASS EA

HAMILTON CONSERVATION AUTHORITY

UPPER BATTLEFIELD &
UPPER STONEY CREEK
FLOODPLAIN MAPPING

amec foster wheeler

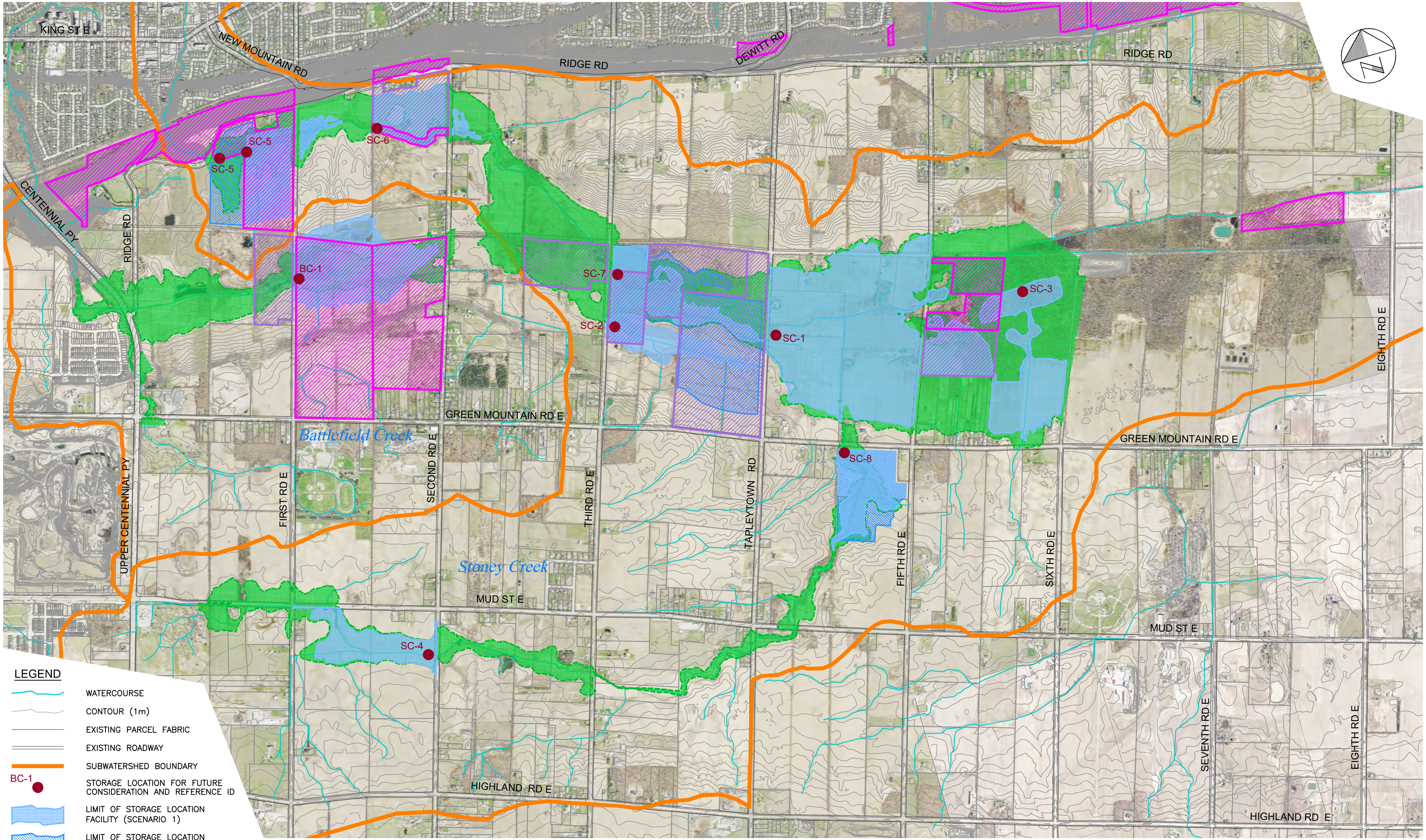
Scale 1:10000

Consultant File No. TPB168024

Figure No. 20

Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrftFin)\Fig20 UpperFloodPlain.dwg

Plotted: 2018-02-14 Plotted By: richard.bartolo
Last Saved: 2018-02-12 Last Saved By: richard.bartolo



LEGEND

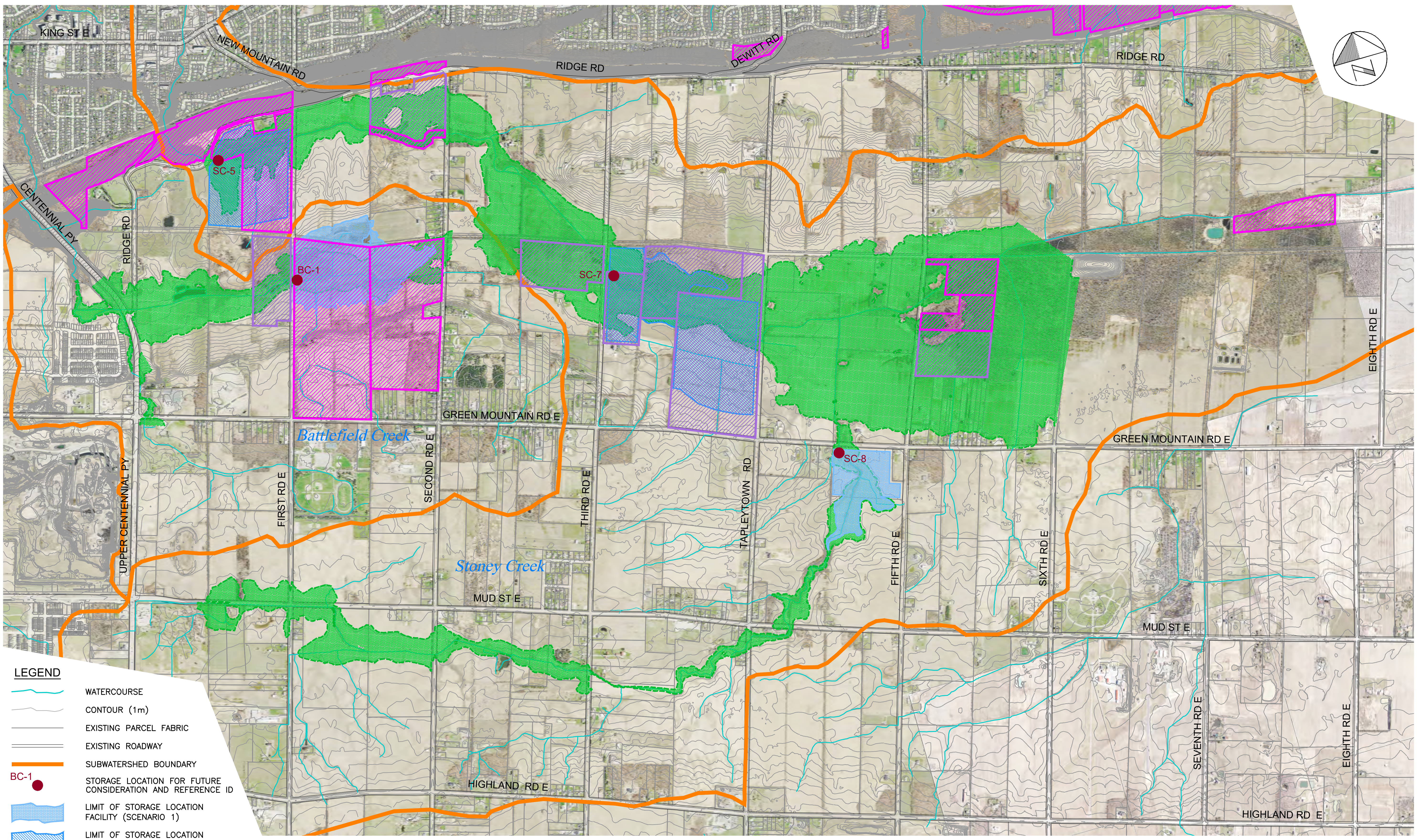
- WATERCOURSE
- CONTOUR (1m)
- EXISTING PARCEL FABRIC
- EXISTING ROADWAY
- SUBWATERSHED BOUNDARY
- BC-1 — STORAGE LOCATION FOR FUTURE CONSIDERATION AND REFERENCE ID
- LIMIT OF STORAGE LOCATION FACILITY (SCENARIO 1)
- LIMIT OF STORAGE LOCATION FACILITY (SCENARIO 2)
- REGIONAL STORM FLOODPLAIN
- HAMILTON REGION CONSERVATION AUTHORITY CONTROLLED PROPERTIES
- HAMILTON REGION CONSERVATION AUTHORITY PROPERTIES OF INTEREST

Path: P:\2016\Projects\TPB168024 - Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrftFin)\Fig21-22 StorageLocations.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo
Plotted: 2018-02-14
Last Saved: 2018-02-14

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	REGIONAL STORM FLOODPLAIN, AUTHORITY PROPERTIES AND STORAGE AREAS	amec foster wheeler	Scale 1:10000 (0 100 200 400) Consultant File No. TPB168024 Figure No. 21



Path: P:\2016\Projects\TPB168024 – Stoney Creek HCA Study\06_DES-ENG\01_CAD\02_DWGS\05_WR\18-02(RepDrfFin)\Fig21-22 StorageLocations.dwg

Plotted: 2018-02-14 Plotted By: richard.bartolo
Last Saved: 2018-02-14 Last Saved By: richard.bartolo

SCALE VALID ONLY FOR 24"x36" VERSION

FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	REGIONAL STORM FLOODPLAIN, AUTHORITY PROPERTIES AND PREFERRED STORAGE AREAS	amec foster wheeler	Scale 1:10000 (0 100 200 400) Consultant File No. TPB168024 Figure No. 22

Appendix A

Public Correspondence

Flood and Erosion Control Study
Stoney Creek and Battlefield Creek
Conservation Ontario Class Environmental Assessment
Notice of Intent and Public Information Centre No.1

THE STUDY

The Hamilton Conservation Authority (HCA) has commenced a study to investigate possible flood and erosion control alternatives for the Stoney Creek and Battlefield Creek watersheds. The focus it to investigate possible options above the escarpment that would help to alleviate the flooding and erosion occurring below the escarpment. The study area is shown on the attached map.

THE PROCESS

The study is being conducted in accordance with Conservation Ontario's procedures as outlined in the Class Environmental Assessment (EA) for Remedial Flood and Erosion Control Projects (2002, amended June 2013). The Class EA process includes public and agency consultation, characterization of the study area, evaluation of preliminary alternatives and determination of the potential environmental, social and economic effects of the proposed preferred alternative including identification of measures to mitigate any potential adverse impacts.

PUBLIC CONSULTATION

Please join us at our first Public Information Centre to learn more about the study, existing conditions in the study area, possible alternatives to be considered, and the next steps in the study process. The Public Information Centre will be a drop-in open house that will provide an opportunity for you to view display boards, discuss the project with the HCA, consultant staff, and provide input into the planning process. Details are as follows:

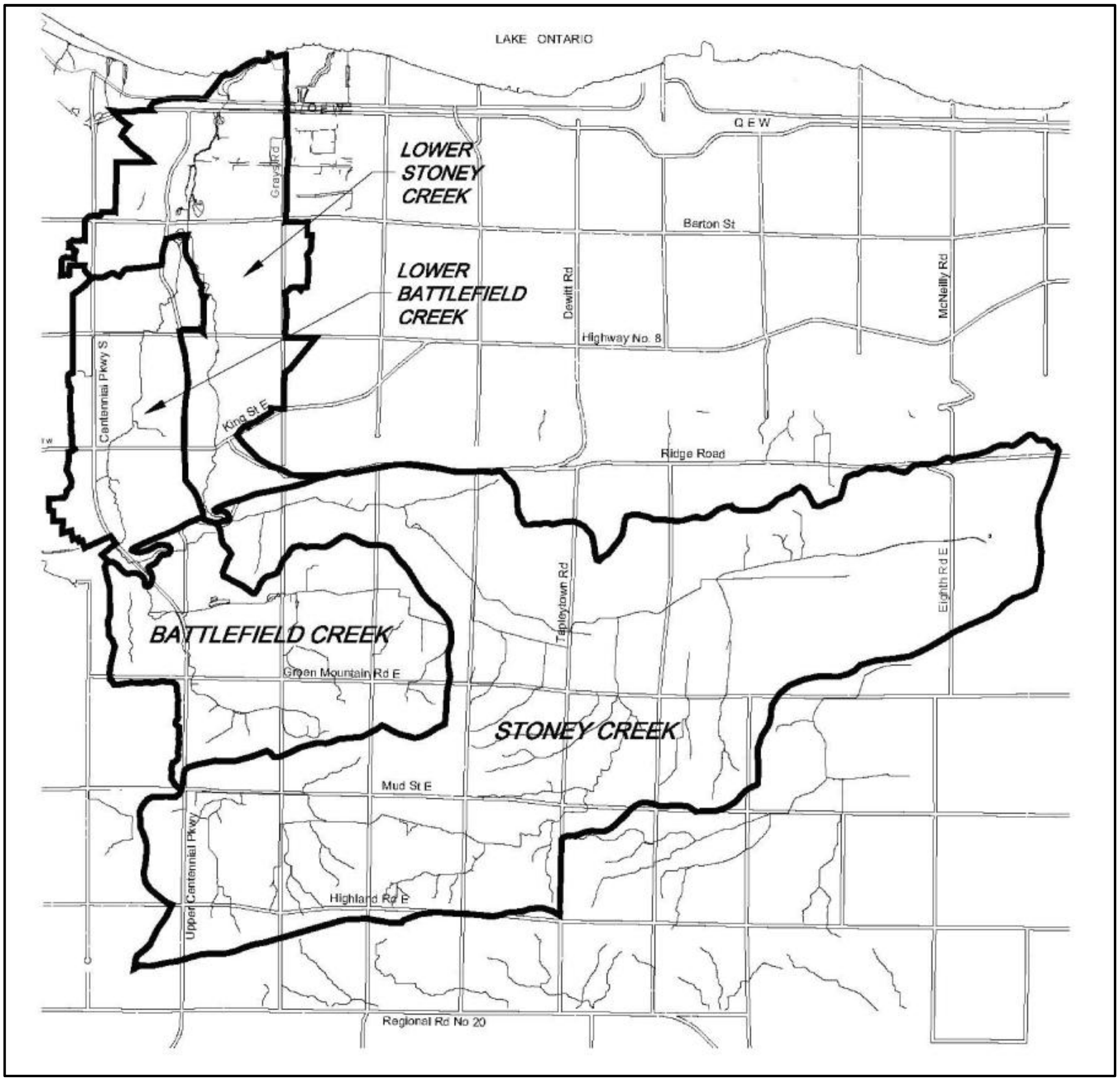
DATE: March 28, 2017
TIME: 6:00 p.m. to 8:00 p.m.
LOCATION: Croatian Community Centre
166 Green Mountain Rd E, Stoney Creek

Comments and information regarding the study will be collected to assist the HCA in meeting the requirements of the Class EA process. If you wish to be involved in this study, provide comments, ask questions, or receive information, please contact one of the project representatives identified below. Additional information on the project, as well as additional consultation opportunities will be made available as the study progresses.

Hamilton Conservation Authority

Mr. Scott Peck, MCIP, RPP
Director – Watershed Planning & Engineering
838 Mineral Springs Road
Ancaster ON L9G 4X1
Tel: 905.525.2181 ext. 130
Email: tspeck@conservationhamilton.ca

Amec Foster Wheeler
Environment & Infrastructure
Mr. Ron Scheckenberger, M.Eng., P.Eng.
Project Manager
3215 North Service Road, P.O. Box 220
Burlington ON L7N 3G2
Tel: 905.335.2353
Email: ron.scheckenberger@amecfw.com


LAKE ONTARIO
Q E W
LOWER STONEY CREEK
LOWER BATTLEFIELD CREEK
Grays Rd
Barton St
Dewitt Rd
McNeilly Rd
Highway No. 8
Centennial Pkwy S
King St E
Ridge Road
Tapleytown Rd
Eighth Rd E
BATTLEFIELD CREEK
Green Mountain Rd E
STONEY CREEK
Mud St E
Upper Centennial Pkwy
Highland Rd E
Regional Rd No 20

East Escarpment Properties Mailing List								
Landowner	Property Address	Mailing Address	Mailing Address 2	Municipality	Postal Code	Phone Number	Phone Number2	Phone Number3

Hamilton Conservation Authority
Healthy Streams...Healthy Communities!

amec foster wheeler

Comment Sheet

Public Information Centre No.1
March 28, 2017

PROJECT: **Hamilton Conservation Authority**
Stoney Creek and Battlefield Creek
Flood and Erosion Control Project

PLEASE PRINT

NAME:

Date: Mar. 28/17

E-mail:

(Number & Street)

(Municipality)

(Postal Code)

Comments:

As members of the Hamilton Naturalist's Club we are very aware of the importance of natural areas. We strongly support the initiatives of the HCA in preserving & enhancing those areas. As a child survivor of Hurricane Hazel in the 1950's I very much understand the importance of flood control.

KEEP UP THE GOOD WORK!!

Please send your comments by April 12, 2017 to:

Hamilton Conservation Authority

Mr. Scott Peck, MCIP, RPP
Director – Watershed Planning & Engineering
838 Mineral Springs Road
Ancaster ON L9G 4X1
Tel: 905.525.2181 ext. 130
Email: tspeck@conservationhamilton.ca

Amec Foster Wheeler
Environment & Infrastructure
Mr. Ron Scheckenberger, M.Eng., P.Eng.
Project Manager
3215 North Service Road, P.O. Box 220
Burlington ON L7N 3G2
Tel: 905.335.2353
Email: ron.scheckenberger@amecfw.com

AGENCY MAILING LIST										Issue Date: 10/27/2015
Last Name	***First Name***	***Title***	***Job Title***	***Organization***	***Street Address***	***City and Province***	***Postal Code***	***Contact Information***	***Link to Documents/ Webpages***	***Special Notes and Instructions***
City of Hamilton Staff										
Cunliffe	Dave	Mr.	Deputy Fire Chief	Hamilton Fire Department	1227 Stone Church Road East	Hamilton, ON	L8W 2C6	905-546-2424 x3340		**To be emailed a pdf copy of the mailout**
DeCaire	Glen	Mr.	Commander in Charge	Hamilton Police Service				gdecaire@hamiltonpolice.on.ca		**To be emailed a pdf copy of the mailout**
DeJager	Shawn	Mr.	Senior Project Manager	Hamilton Fire Department	1227 Stone Church Road East, 3rd Floor	Hamilton, ON	L8W 2C6	905-546-2424 x3378		**To be emailed a pdf copy of the mailout**
Eisenberger	Fred	Mr.	Mayor	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4200		**To be emailed a pdf copy of the mailout**
Grice	Andrew	Mr.	Director, Water & Wastewater Operations	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x1461		**To be emailed a pdf copy of the mailout**
Matthews-Malone	Betty	Ms.	Director of Operations	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x4622		**To be emailed a pdf copy of the mailout**
McKinnon	Dan	Mr.	General Manager	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905.546.2424 x5941		**To be emailed a pdf copy of the mailout**
Bainbridge	Mark	Mr.	Acting Director, Hamilton Water	Public Works	78 James St. N., Suite 400	Hamilton, ON	L8R 2K4			
Murdoch	Craig	Mr.	Director of Environmental Services	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x4490		**To be emailed a pdf copy of the mailout**
Norman	Robert	Mr.	Director, Strategic Planning	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x2298		**To be emailed a pdf copy of the mailout**
Robichaud	Steve	Mr.	Director of Planning	Planning & Economic Development	71 Main Street West, 6th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4281		**To be emailed a pdf copy of the mailout**
Moore	Gary	Mr.	Director of Engineering Services	Public Works	77 James Street North, Suite 320	Hamilton, ON	L8R 2K3			
Murray	Chris	Mr.	City Manager	Hamilton City Hall	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5			
Sergi	Tony	Mr.	Senior Director, Growth Management	Planning & Economic Development	71 Main St W 6th flr	Hamilton, ON	L8P 4Y5	905-546-2424 x2274		**To be emailed a pdf copy of the mailout**
Smith	Darrell	Mr.	Manager, Development Engineering	Planning & Economic Development	71 Main Street West, 5th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x1322		**To be emailed a pdf copy of the mailout**
Thorne	Jason	Mr	General Manager	Planning & Economic Development	71 Main Street West, 7th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4339		**To be emailed a pdf copy of the mailout**
Councillors										
Conley	Doug	Mr.	Councillor, Ward 9	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x 2703		**To be emailed a pdf copy of the mailout**
Johnson	Aidan	Mr.	Councillor, Ward 1	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x2416		**To be emailed a pdf copy of the mailout**
Provinicial Authorities										
Cunningham	Robert	Mr.		Ministry of Agriculture and Food	1 Stone Rd. W., 2nd Floor	Guelph, ON	N1G 4Y2			
Environmental Assessment & Approvals Branch			E/A Project Co-ordination Section	Ministry of the Environment and Climate Change	2 St. Clair Ave. W. 14th Floor	Toronto, ON	M4V 1L5	MEA.NOTICES.EAAB@ontario.ca		**To be emailed a pdf ONLY FOR NOTICE OF PROJECT COMPLETION. (no hardcopy)**
Hagman	Ian	Mr.	District Manager, Guelph District Office	Ministry of Natural Resources and Forestry	1 Stone Rd. W.	Guelph, ON	N1G 4Y2	519-826-4931 Fax 519-826-4929		
Durst	Joad	Mr.	Resource Management Supervisor	Ministry of Natural Resources and Forestry	4890 Victoria Avenue North, P.O.Box 5000	Vineland, ON	L0R 2E0			
Slattery	Barbara	Ms.	Environmental Assessment & Planning Co-ordinator	Ministry of the Environment and Climate Change	119 King St. W., 12th Floor	Hamilton, ON	L8P 4Y7	905-521-7864 Fax 905-521-7806 barbara.slattery@ontario.ca		
Hatcher	Laura		Team Lead - Heritage Land Use Planning	Ministry of Tourism, Culture & Sport	401 Bay Street, 17th Floor	Toronto, ON	M7A 0A7	416-314-3108 Fax 416-314-7175 laura.e.hatcher@ontario.ca		

First Nations										
Durand	Tina	Ms.	Secretary Political Sector	Huron-Wendat Nation Council	255 Place Chef Michel-Laveau	Wendake, QC	G0A 4V0	418-843-3767 1-877-712-3767 Fax: 418-842-1108	http://www.wendake.ca/	
General	Paul	Mr.	Lands & Resources	Six Nations Eco-Centre	1721 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-0330 pgeneral@sixnations.ca		**Email Notices**
Bomberry	Lonny	Mr.	Director of Lands & Resources	Six Nations of the Grand River Territory	P.O. Box 5000, 2498 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-2201 Fax: 519-445-4208		
Hill	Leroy	Hohahes	Secretary to Haudenosaunee Conferacy Chiefs Council	Haudenosaunee Chiefs Council	2634 6th Line RR2	Oshweken, ON	N0A 1M0	(519) 753-0665 Fax (519) 753-3449		
LaForme	Mark	Mr.	Director, Department of Consultation and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Tel: (905) 768-4260 Fax: (905) 768-9751 Cell: (289) 527-6577 Email: Mark.Laforme@Newcreditfirstnation.com, doca@newcreditfirstnation.com		**Email Notices**
Sault	Fawn		Manager, Department of Consultaiton and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Fawn.sault@newcreditfirstnation.com		**2nd point of contact for missisaugas of new credit first nation, contact if cannot reach Mark Laforme**
Utilities										
Ardelli	Terri	Ms.	Land Analyst, Urban	TransCanada Pipelines	450-1st Street S.W.	Calgary, AB	T2P 5H1	403-920-7370		
Blakely	John	Mr.	Senior Right-of-Way Agent	Enbridge Pipelines Inc.	801 Upper Canada Drive	Sarnia, ON	N7W 1A3	(519)339-0507		
Carello	Jack	Mr.	Manager, Utilities East	Canadian Pacific Railway	1290 Central Parkway West,	Mississauga, ON	L5C 4R3	Phone: 905-803-3417		
Greco	Enzo	Mr.	Construction Project Manager	Union Gas	918 South Service Road	Stoney Creek, ON	L8E 5M4	Phone: (289) 649-2061 Cell: (905) 741-8395 Email: egreco@uniongas.com	www.uniongas.com	
Harten	Ron	Mr.	General Manager, Hamilton Community Energy	Hamilton Utilities Corporation	The Textile Building 10 George Street Suite 300	Hamilton, ON	L8P 1C8	Ron.Harten@hamiltonucorp.com		
Oriotis	Jim	Mr.		Hydro One	483 Bay Street, North Tower 15th Floor	Toronto, ON	M5G 2P5	jim.oriotis@hydroone.com		
Lane	Paul	Mr.		Sun Canadian Pipeline	830 Highway 6 North P.O. Box 470	Waterdown, ON	L0R 2H0	905-689-6641 x136 Fax 514-395-5613 plane@sun-canadian-com		
Leppert	Randy	Mr.	Planning Lead Hand Niagara/Hamilton	Cogeco Cable Inc	7170 McLeod Rd	Niagara Falls, ON	L2G 3H5	Phone: 289-296-6228 Cell: 905- 351-3771 randy.leppert@cogeco.com		
Linder	Stefan	Mr.	Manager, Public Works Design & Construction	CN	4 Welding Way off Administration Road	Vaughan, ON	L4K 1B9	905-669-3264 email: Stefan.Linder@cn.ca		
Milano	Bruno	Mr.	Planner/Designer	Source Cable	1090 Upper Wellington St	Hamilton, ON	L9A 3S6	Work # 905-318-4663 Cell # 905-971-2762		
Mitchell	Colleen	Ms.	Land Agent - Eastern Pipeline Operations	Imperial Oil Products & Chemical Division	100 - 5th Concession Rd. E.	Waterdown, ON	L0R 2H1	1-888-242-6660 x242 colleen.m.mitchell@esso.com		
Newman	Ann	Ms.	Crossings Co-ordinator, Eastern Region	Enbridge Pipelines Inc.	801 Upper Canada Drive P.O Box 128	Sarnia, ON	N7W 1A3	(519)339-0503		
Ontario Power Generation	Sir/Madam				700 University Avenue	Toronto, ON	M5G 1X6	416-592-2555		
Jakubowski	Mark	Mr.	Acting Manager of Capital Projects	Horizon Utilities Corporation	55 John St. N., 6th Floor	Hamilton, ON	L8R 3M8			
Sutton	Eleanor	Ms.		Bell Canada	20 Hunter St. W.	Hamilton, ON	L8N 3H2	(905) 577-6093		
Winkley	John	Mr.	Regional Director - Marketing	Southern Ontario Railway	241 Stuart St. W.	Hamilton, ON	L8N 3P9			

Ministry of Tourism, Culture and Sport

Heritage Program Unit
Programs and Services Branch
401 Bay Street, Suite 1700
Toronto ON M7A 0A7
Tel: 416 314 7147
Fax: 416 212 1802

Ministère du Tourisme, de la Culture et du Sport

Unité des programmes patrimoine
Direction des programmes et des services
401, rue Bay, Bureau 1700
Toronto ON M7A 0A7
Tél: 416 314 7147
Téléc: 416 212 1802

Ontario

April 7, 2017 (EMAIL ONLY)

Mr. Scott Peck, MCIP, RPP
Director – Watershed Planning & Engineering
Hamilton Conservation Authority
838 Mineral Springs Road
Ancaster, ON L9G 4X1
E: tspeck@conservationhamilton.ca

RE: MTCS file #: 25WT055
Proponent: Hamilton Conservation Authority
Subject: Notice of Intent and Public Information Centre No. 1 Stoney Creek and Battlefield Creek
Location: City of Hamilton, Ontario

Dear Mr. Peck:

Thank you for providing the Ministry of Tourism, Culture and Sport (MTCS) with the Notice of Intent and Public Information Centre No. 1 for your project. MTCS's interest in this Environmental Assessment (EA) project relates to its mandate of conserving Ontario's cultural heritage, which includes:

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

Under the EA process, the proponent is required to determine a project's potential impact on cultural heritage resources.

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

Archaeological Resources

The MTCS *Criteria for Evaluating Archaeological Potential* and *Criteria for Evaluating Marine Archaeological Potential* are normally used for screening a study area to determine if an archaeological assessment is needed. In this case, we are aware that a Stage 1 background study was carried out for the lower reaches of the subject watersheds as part of a related earlier study in 2011. Similar work will need to be carried out for the upstream parts of the study area. At the proposed locations of project components that would require ground disturbance, all required archaeological survey work should be carried out during the EA process and its results included in the evaluation of alternatives.

Built Heritage and Cultural Heritage Landscapes

The MTCS *Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes* should be completed to help determine whether your EA project may impact cultural heritage resources. The Clerk for the City of Hamilton can provide information on property registered or designated under the *Ontario Heritage Act*. Municipal Heritage Planners can also provide information that will assist you in completing the checklist.

If potential or known heritage resources exist, MTCS recommends that a Heritage Impact Assessment (HIA), prepared by a qualified consultant, should be completed to assess potential project impacts. Our Ministry's *Info Sheet #5: Heritage Impact Assessments and Conservation Plans* outlines the scope of HIAs. Please send the HIA to MTCS and the City of Hamilton for review, and make it available to local organizations or individuals who have expressed interest in review.

Environmental Assessment Reporting
All technical heritage studies and their recommendations are to be addressed and incorporated into EA projects. Please advise MTCS whether any technical heritage studies will be completed for your EA project, and provide them to MTCS before issuing a Notice of Completion. If your screening has identified no known or potential cultural heritage resources, or no impacts to these resources, please include the completed checklists and supporting documentation in the EA report or file.

Thank you for consulting MTCS on this project: please continue to do so through the EA process, and contact me for any questions or clarification.

Sincerely,

Dan Minkin
Heritage Planner
dan.minkin@ontario.ca

It is the sole responsibility of proponents to ensure that any information and documentation submitted as part of their EA report or file is accurate. MTCS makes no representation or warranty as to the completeness, accuracy or quality of the any checklists, reports or supporting documentation submitted as part of the EA process, and in no way shall MTCS be liable for any harm, damages, costs, expenses, losses, claims or actions that may result if any checklists, reports or supporting documents are discovered to be inaccurate, incomplete, misleading or fraudulent.

Please notify MTCS if archaeological resources are impacted by EA project work. All activities impacting archaeological resources must cease immediately, and a licensed archaeologist is required to carry out an archaeological assessment in accordance with the Ontario Heritage Act and the Standards and Guidelines for Consultant Archaeologists.

If human remains are encountered, all activities must cease immediately and the local police as well as the Cemeteries Regulation Unit of the Ministry of Government and Consumer Services must be contacted. In situations where human remains are associated with archaeological resources, MTCS should also be notified to ensure that the site is not subject to unlicensed alterations which would be a contravention of the Ontario Heritage Act.

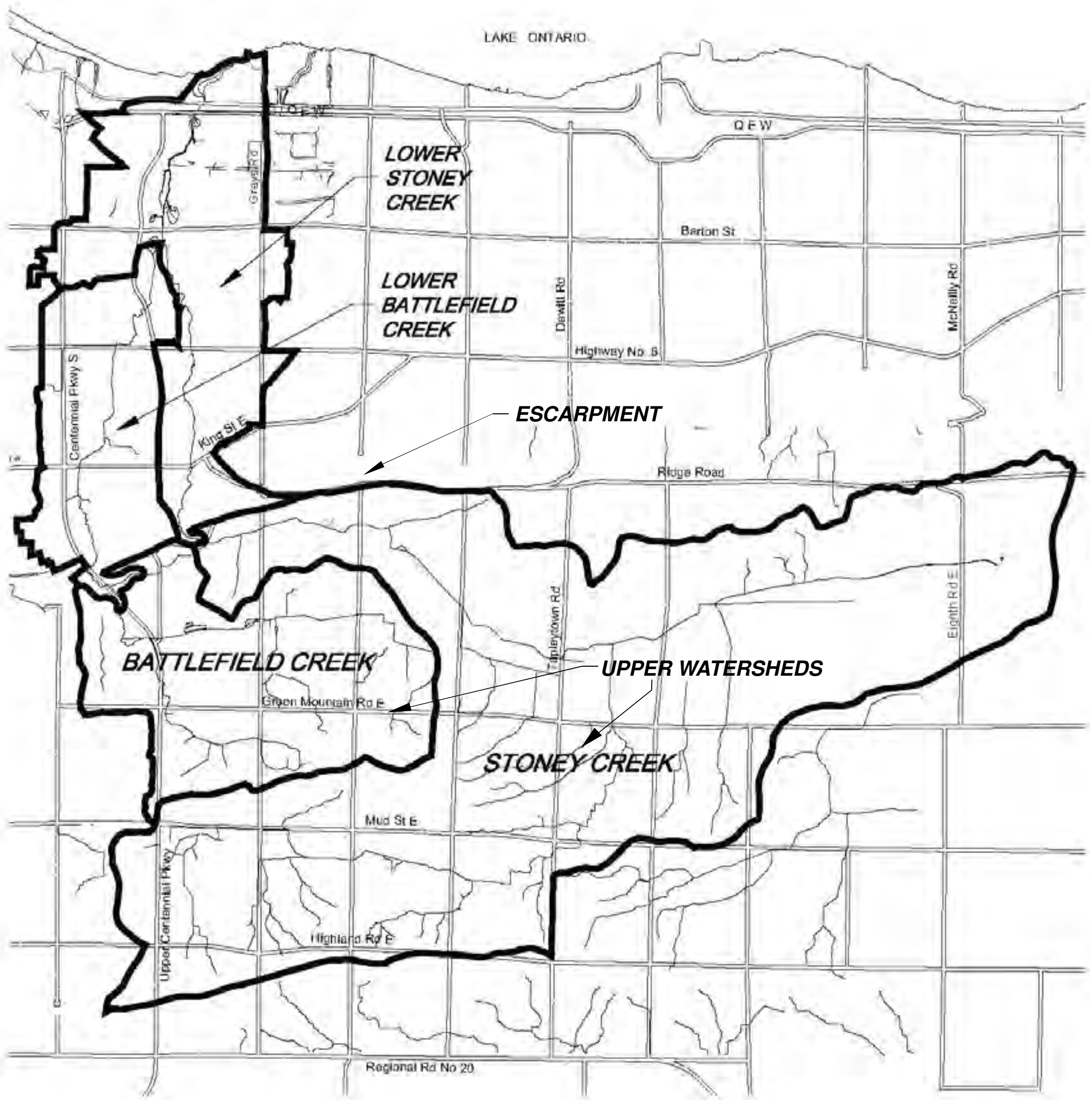
Public Information Centre No. 1

Stoney Creek and Battlefield Creek
Flood and Erosion Control Project
East Escarpment Watershed Restoration Program
Conservation Ontario Class Environmental Assessment

Date: March 28, 2017 / Location: Croatian Community Centre / Time: 6:00 p.m. to 8:00 p.m.

Study Area

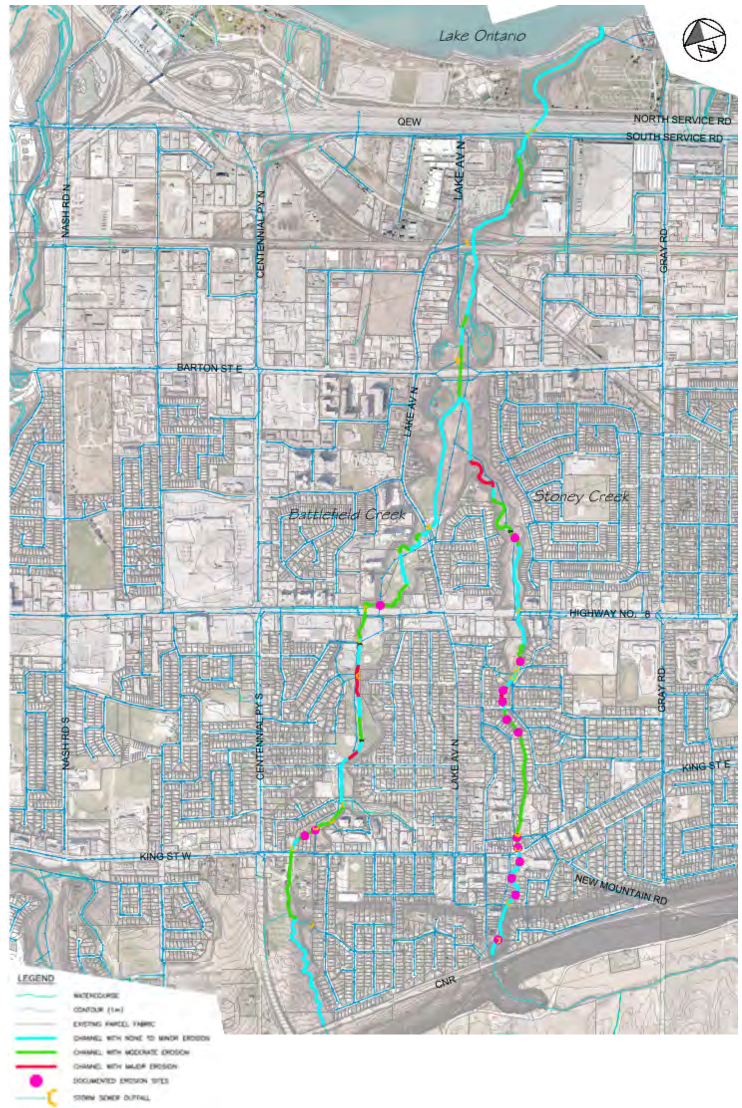
The Study area includes the erosion-prone Lower Stoney Creek and Battlefield Creek watersheds as well as the vast headwater above the escarpment.



Project Overview

Study Background and Purpose

- In 2011, the Hamilton Conservation Authority (HCA) and the City of Hamilton prepared a Class Environmental Assessment (EA) for the Lower Stoney Creek and Lower Battlefield Creek (sections of the watershed below the escarpment) which identified areas that were susceptible to flooding and erosion.
- As part of that study, the feasibility of storage based solutions located above the escarpment to address flood and erosion risk in the lower reaches was assessed.



Project Overview

Study Goal

- In 2015, the HCA released a discussion paper entitled "East Escarpment Conservation Area" which expressed the goal:
  - *" To create a new conservation area in the east end of the City of Hamilton, specifically the Upper Stoney Creek and Upper Battlefield Creek watersheds above the Escarpment to provide natural hazard attenuation, natural heritage enhancements and recreation opportunities."*

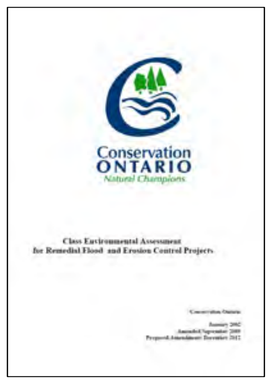
Project Overview

Study Objectives

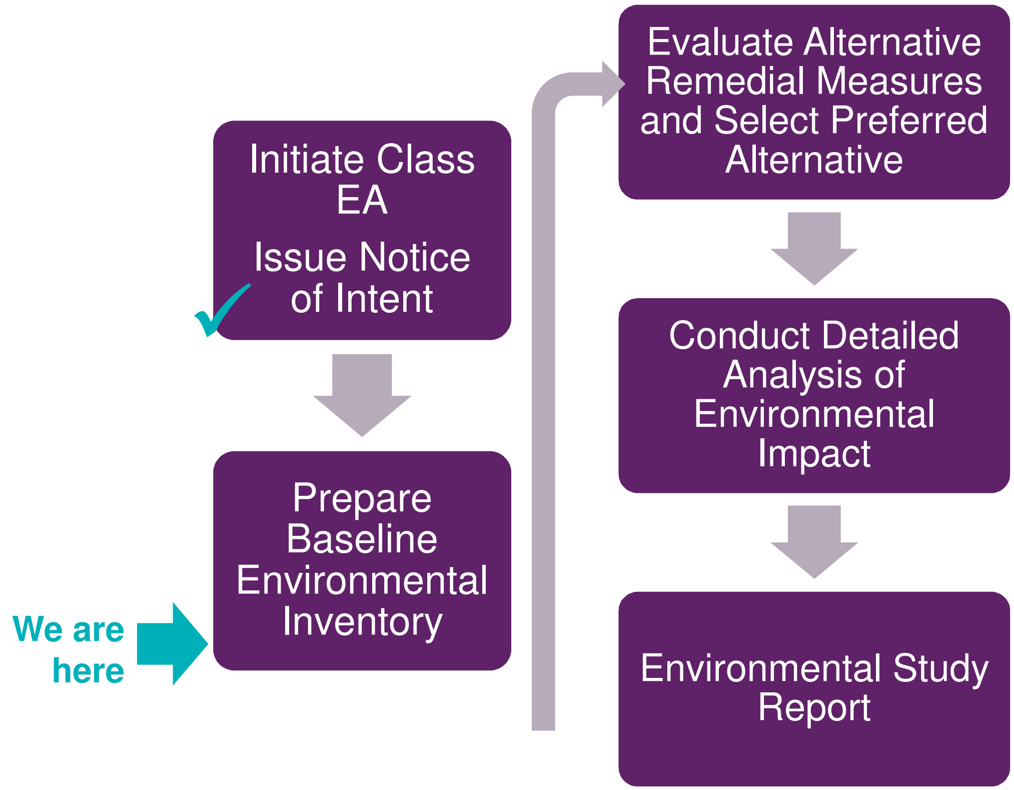
- To utilize the floodplain areas of Upper Battlefield and Upper Stoney Creeks to retain water to provide flood attenuation both above and below the Niagara Escarpment within these watershed areas.
- To enhance and enlarge existing wetland areas and to create new wetland areas to provide enhanced wetland hydrologic function to reduce the impacts of high water events and provide water to area watercourses during low flow periods.
- To restore the natural features and functions of the watercourses in the area.
- To restore, enhance and enlarge the natural heritage features associated with the floodplains, wetlands and watercourses of the area.

Conservation Ontario Class EA Approach

- This study follows the process outlined in: Conservation Ontario's Class Environmental Assessment for Remedial Flood and Erosion Control Projects
- The process provides a project planning and design framework for proponents (Conservation Authorities like Hamilton Conservation Authority) to ensure they meet the requirements of the Provincial Environmental Assessment Act.



- Consultation is required with all stakeholders including the public and agency partners at all stages.



Baseline Inventories

Hamilton Conservation Authority
Healthy Streams...Healthy Communities!

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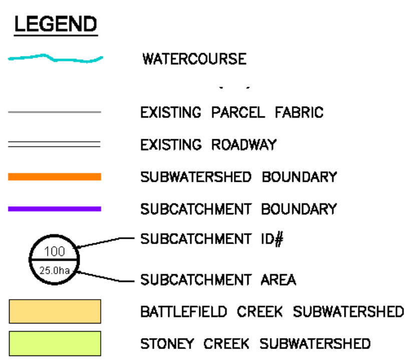
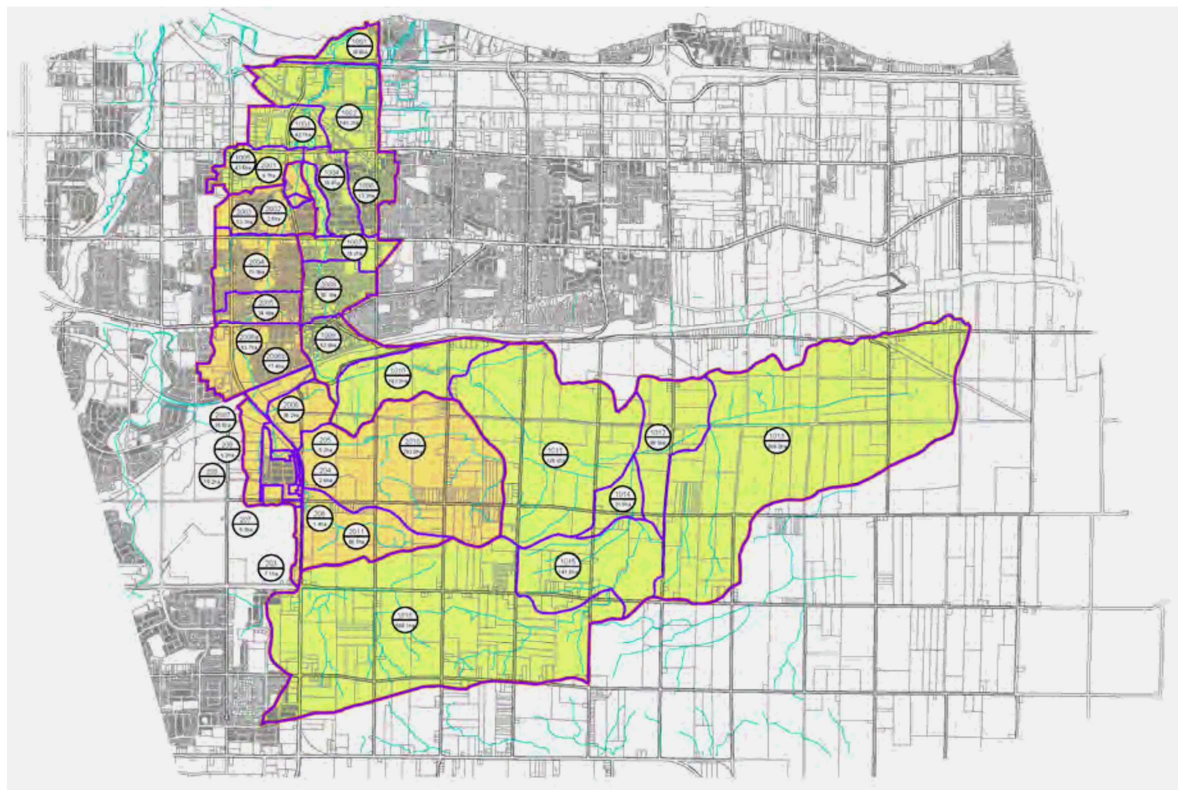
Hydrologic Assessment (Surface Water System)

- Hydrology is the science of the movement of water, derived from rain and snow on the watershed as runoff in creeks, ditches and storm sewers.
- Hydrologic models are numerical tools (computer-based) which are used to determine runoff rates and volumes from various land uses in response to a rainfall or snowmelt event.

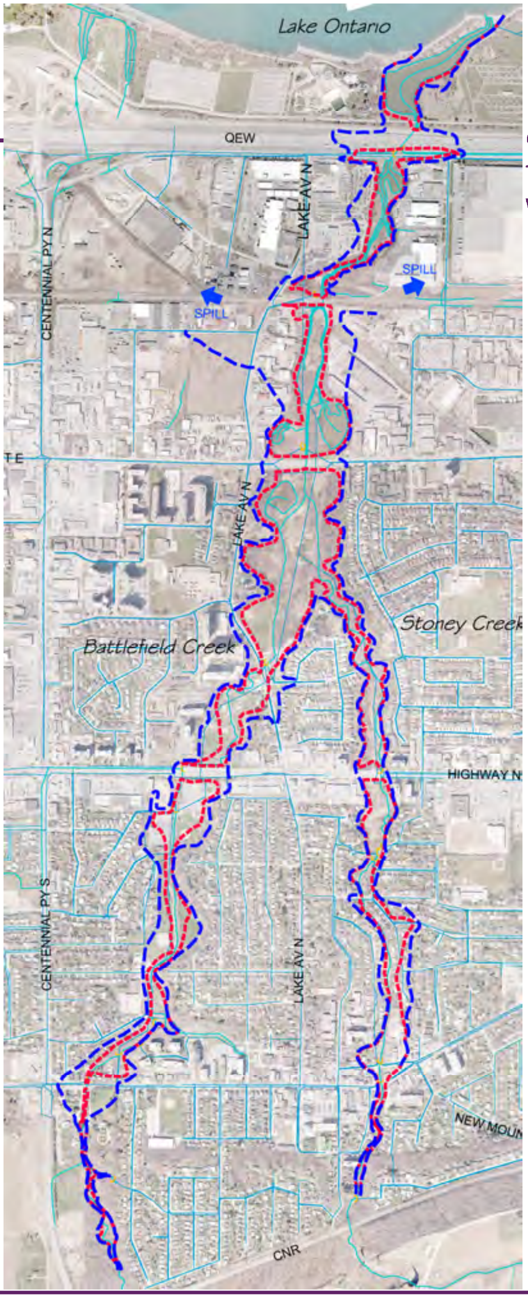




Baseline Inventories

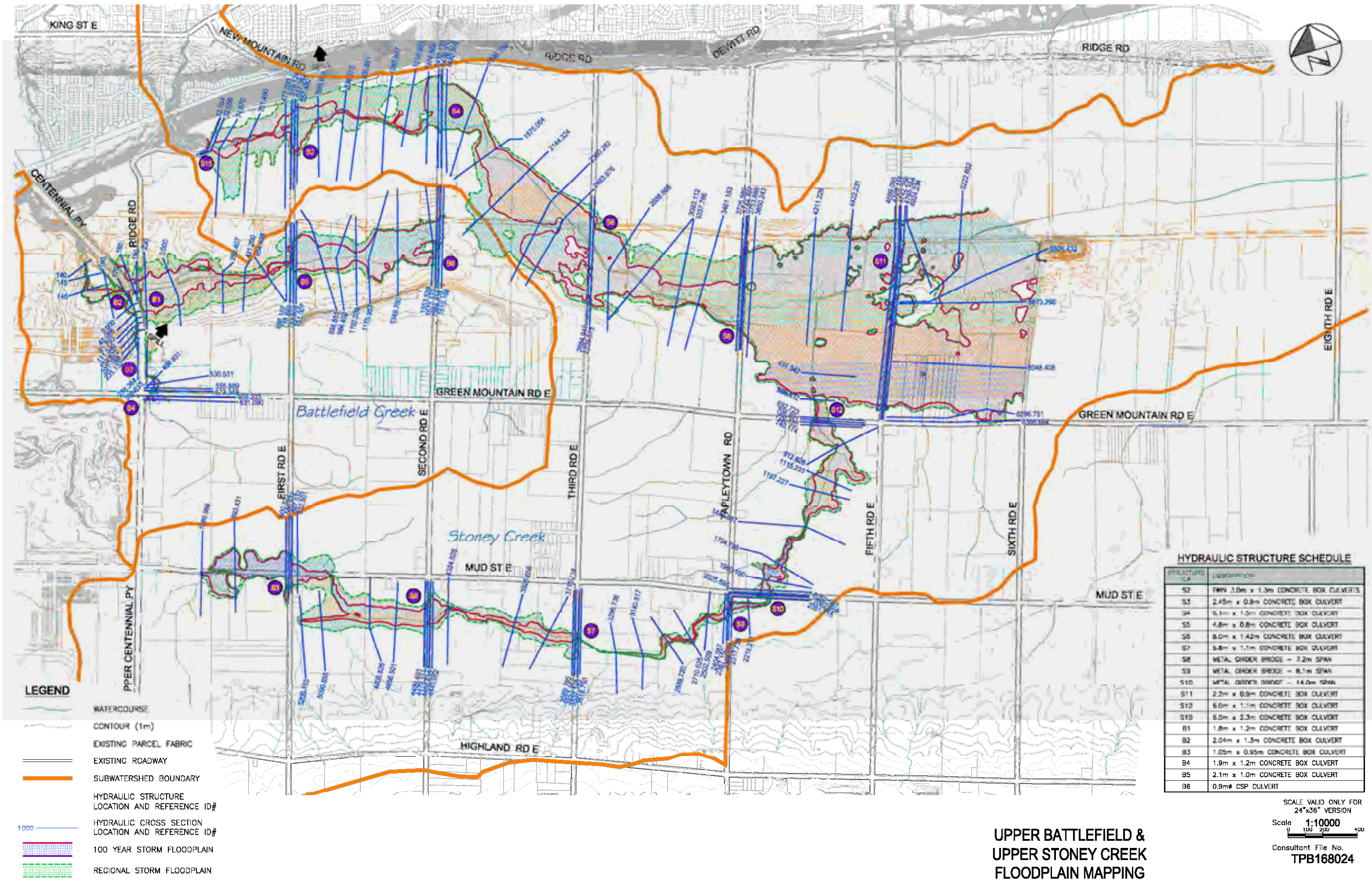
Hydraulic Assessment

- Hydraulics is the study of the flow of water and associated water levels and velocities in storm sewers, creeks and valleys, culverts and bridges, etc.
- Hydraulic models are numerical tools (computer-based) which are used to determine the velocity and depth of storm water runoff, specifically for this study in the Stoney Creek and Battlefield Creek reaches.



Baseline Inventories

Hydraulic Assessment (Preliminary)



HYDRAULIC STRUCTURE SCHEDULE

STRUCTURE I.D.	DESCRIPTION
S2	TWIN 3.0m x 1.3m CONCRETE BOX CULVERTS
S3	2.45m x 0.9m CONCRETE BOX CULVERT
S4	6.1m x 1.5m CONCRETE BOX CULVERT
S5	4.8m x 0.8m CONCRETE BOX CULVERT
S6	8.0m x 1.42m CONCRETE BOX CULVERT
S7	5.8m x 1.1m CONCRETE BOX CULVERT
S8	METAL GIRDER BRIDGE – 7.2m SPAN
S9	METAL GIRDER BRIDGE – 8.1m SPAN
S10	METAL GIRDER BRIDGE – 14.0m SPAN
S11	2.2m x 0.9m CONCRETE BOX CULVERT
S12	6.0m x 1.1m CONCRETE BOX CULVERT
S15	6.0m x 2.3m CONCRETE BOX CULVERT
B1	1.8m x 1.2m CONCRETE BOX CULVERT
B2	2.04m x 1.3m CONCRETE BOX CULVERT
B3	1.05m x 0.95m CONCRETE BOX CULVERT
B4	1.9m x 1.2m CONCRETE BOX CULVERT
B5	2.1m x 1.0m CONCRETE BOX CULVERT
B6	0.9mø CSP CULVERT

Baseline Inventories

Natural Environment

Fish Habitat and Aquatic Community Overview:

- Stoney Creek and Battlefield Creek above the Escarpment are low-gradient and mainly ditched through agricultural areas or along roads. The creeks are:
  - *broad and shallow watercourses;*
  - *heavily vegetated with emergent aquatic;*
  - *little evidence of groundwater inputs, and*
  - *minimal flow during the summer.*
- The fish community is comprised of non-migratory fishes that are tolerant of high water temperatures and low dissolved oxygen, typically found in isolated small shallow pools during summer and the same ice-covered pools and ponds during winter.

Fathead Minnow

Creek Chub

Northern Redbelly Dace

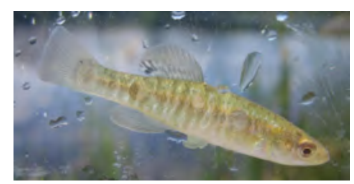
Central Mudminnow

Brown Bullhead

Brook Stickleback

Pumpkinseed

Green Sunfish



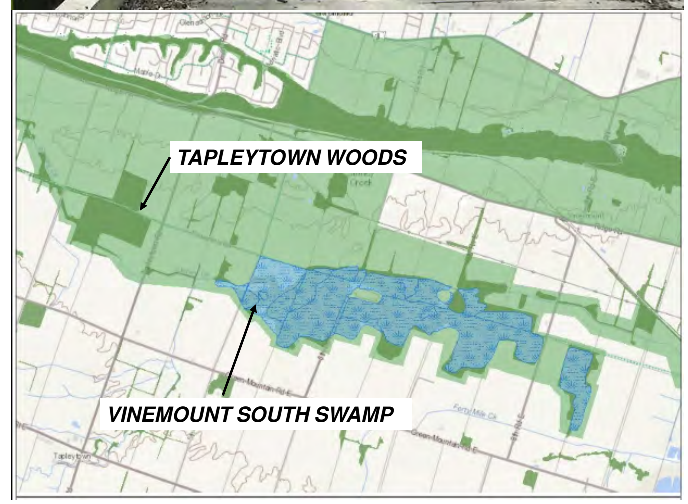
Banded Killifish

Baseline Inventories

Natural Environment

Terrestrial Ecology Overview:

- Terrestrial Ecology includes the study of land-based organisms and communities.
- The Stoney Creek and Battlefield Creek watershed above the Niagara Escarpment is primarily agricultural landscape with fragmented small woodlots connected by hedgerows.
- Three 'Natural Areas' have been identified by the Natural Area Inventory including: STCK-77Vinemount South Swamp (~69 ha), STCK-~38Tapleytown Woods (3~ha), and STCK-7.~(Un-named).
- Significant riparian habitat and hedgerows/woodlots located adjacent to area watercourses.
- Additional field work will be undertaken in 2017 to determine potential Species at Risk and other habitat considerations.



Baseline Inventories

Hydrogeology (Groundwater)

- The Stoney Creek and Battlefield Creek study area straddles three physiographic regions; (i) The Haldimand Clay Plain (ii) The Niagara Escarpment and (iii) the Iroquois Plain.
- The Hamilton Region Source Protection Area - Assessment Report (2015) indicates the eastern area above the escarpment, as well as the area below the escarpment, as a Highly Vulnerable Aquifer (more susceptible to contamination from surface sources) and the northern area above the escarpment as a significant groundwater recharge area that is susceptible to contamination.

- Creeks and area watercourses particularly in the upper watershed have limited baseflow due to groundwater contributions.

Problem and Opportunity Statement

Hamilton Conservation Authority
Healthy Streams...Healthy Communities!

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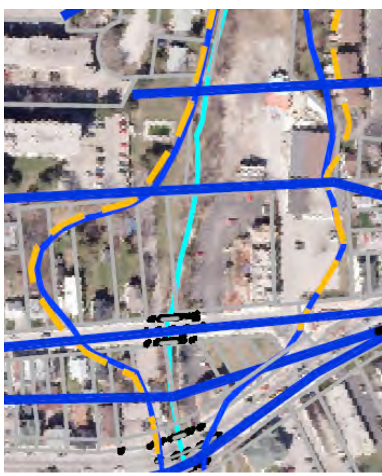
- The 2011 Class EA identified significant portions of the Lower Stoney Creek and Battlefield Creeks as being susceptible to flood and erosion risk.
- HCA has set a goal of creating a new conservation area in the Upper Stoney Creek and Upper Battlefield Creek watershed.
- Through detailed study and consultation, opportunities to provide flood and erosion impact management, through attenuation of runoff in existing and enhanced wetland areas, will be assessed and evaluated. These areas and locations for runoff storage will ultimately have the potential to become multi-use public spaces as part of a new conservation area.



Preliminary Alternatives

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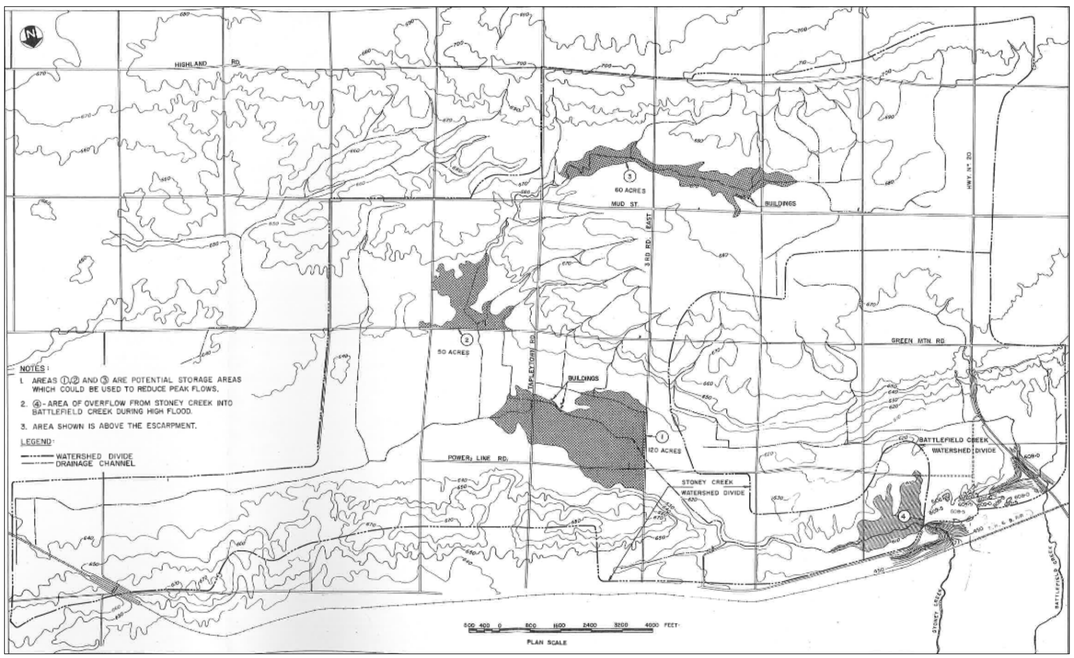
Flood and Erosion Control Storage Systems

1. Raise Roadways / Modify and Optimize Culvert Geometry (on-line storage)
2. Repurpose existing wetland systems (on-line / off-line storage)
3. Excavate storage areas and creating holding areas (off-line storage)
4. Combinations of off-line / on-line storage



1970 Fenco Flood and Erosion Control Study

Constructed Wetland System (City of London Dingman Creek wetland)

Preliminary Alternative Assessment

Preliminary alternatives will be evaluated considering four environments and various criteria specifically relevant to the study area, objectives and stakeholders:

Functional Environment	• Effectiveness of flooding and erosion mitigation • Constructability
Natural Environment	• Impacts/opportunities related to terrestrial ecology and fisheries
Social Environment	• Impacts/opportunities related to public use, safety, adjacent properties and structures, land use and recreation
Economic Environment	• Land Costs • Capital and maintenance cost for the storage systems

Next Steps

- Receive public comments by **April 12, 2017**
- Identification and evaluation of alternative methods and solutions
- Review potential for environmental impacts and residual effects
- Select preferred solution and implementation method
- PIC #2 (Fall 2017)

We Would Like To Hear From You

Please complete the comment sheet and place in the Comment Box or send your comments by email/fax/letter to either of the following Project Team members by **April 12, 2017.**

You can view tonight's information boards on our website:
https://conservationhamilton.ca/flood-and-erosion-control-study-stoney-creek-and-battlefield-creek/

Hamilton Conservation Authority

Mr. Scott Peck, MCIP, RPP
Director – Watershed Planning & Engineering
838 Mineral Springs Road
Ancaster ON L9G 4X1
Tel: 905.525.2181 ext. 130
Email: tspeck@conservationhamilton.ca

Amec Foster Wheeler
Environment & Infrastructure
Mr. Ron Scheckenberger, M.Eng., P.Eng.
Project Manager
3215 North Service Road, P.O. Box 220
Burlington ON L7N 3G2
Tel: 905.335.2353
Email: ron.scheckenberger@amecfw.com

Thank you for your participation

Flood and Erosion Control Study
Stoney Creek and Battlefield Creek
Conservation Ontario Class Environmental Assessment
Notice of Public Information Centre No. 2

THE STUDY

The Hamilton Conservation Authority (HCA) is conducting a study to investigate possible flood and erosion control alternatives for the Stoney Creek and Battlefield Creek watersheds. The focus is to investigate possible options above the escarpment that would help to alleviate the flooding and erosion occurring below the escarpment. The study area is shown on the attached map.

THE PROCESS

The study is being conducted in accordance with Conservation Ontario's procedures as outlined in the Class Environmental Assessment (EA) for Remedial Flood and Erosion Control Projects (2002, amended June 2013). The Class EA process includes public and agency consultation, characterization of the study area, evaluation of preliminary alternatives and determination of the potential environmental, social and economic effects of the proposed preferred alternative including identification of measures to mitigate any potential adverse impacts.

PUBLIC CONSULTATION

The first Public Information Centre was held March 28, 2017 and presented the existing conditions in the study area. Please join us at our second Public Information Centre to learn more about the study, the various alternatives being considered and the next steps in the study process. The Public Information Centre will provide an opportunity for you to view display boards, discuss the project with the HCA, consultant staff, and provide input into the planning process. A presentation will be given at 7:00 pm. Details are as follows:

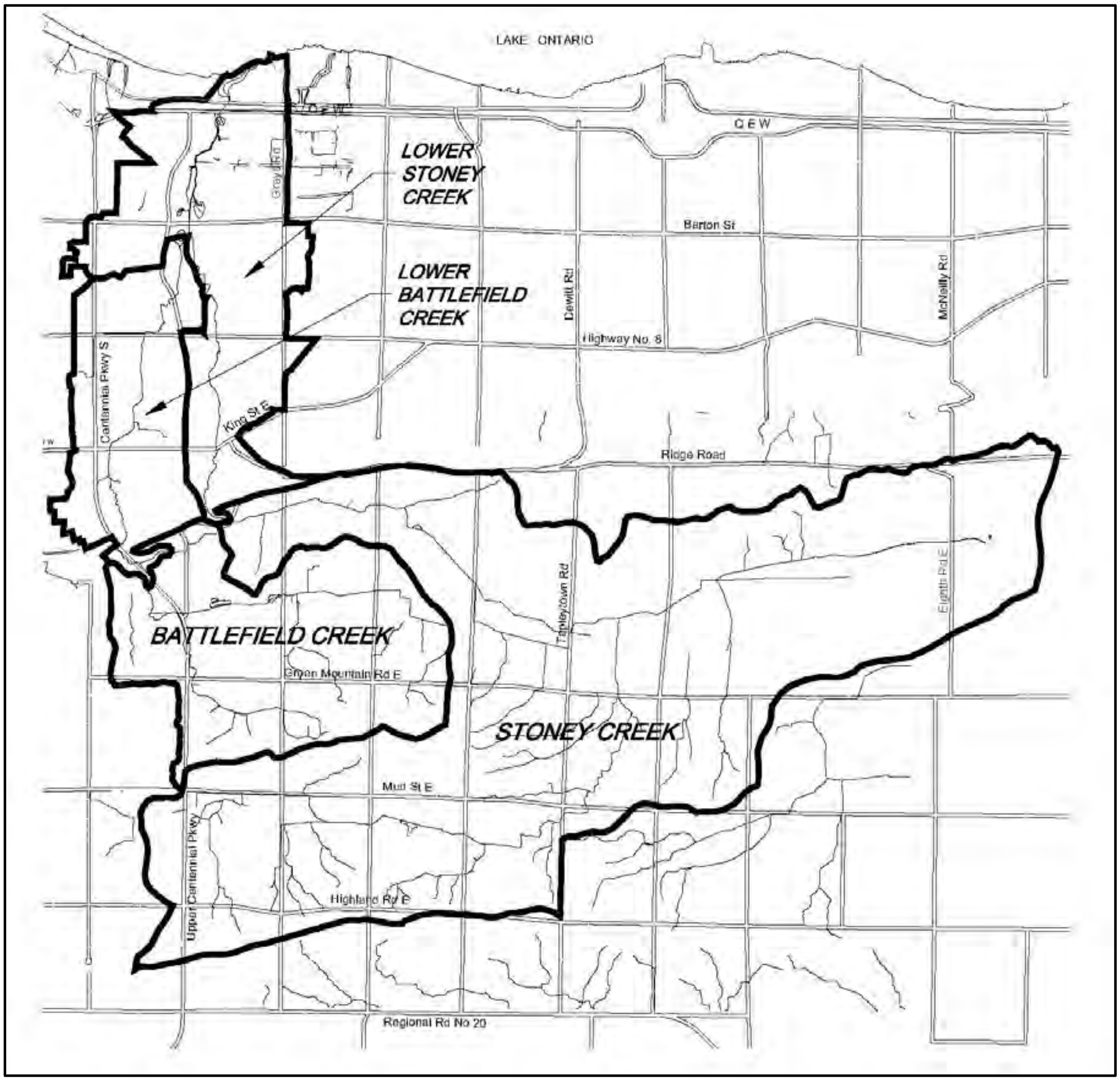
DATE: November 28, 2017
TIME: 6:00 p.m. to 8:00 p.m. (Presentation at 7:00 pm)
LOCATION: Croatian Community Centre
166 Green Mountain Rd E, Stoney Creek

Comments and information regarding the study will be collected to assist the HCA in meeting the requirements of the Class EA process. If you wish to be involved in this study, provide comments, ask questions, or receive information, please contact one of the project representatives identified below. Additional information on the project, as well as additional consultation opportunities will be made available as the study progresses.

Hamilton Conservation Authority

Mr. Scott Peck, MCIP, RPP
Deputy Chief Administrative Officer/
Director – Watershed Planning & Engineering
838 Mineral Springs Road
Ancaster ON L9G 4X1
Tel: 905.525.2181 ext. 130
Email: tspeck@conservationhamilton.ca

Amec Foster Wheeler
Environment & Infrastructure
Mr. Ron Scheckenberger, M.Eng., P.Eng.
Project Manager
3450 Harvester Road, Unit 100
Burlington ON L7N 3W5
Tel: 905.335.2353
Email: ron.scheckenberger@amecfw.com


LAKE ONTARIO
QEW
Gray Rd
LOWER STONEY CREEK
Barton St
LOWER BATTLEFIELD CREEK
Dewitt Rd
McNeilly Rd
Highway No. 8
Centennial Pkwy S
King St E
Ridge Road
Tapleytown Rd
Eighth Rd E
BATTLEFIELD CREEK
Green Mountain Rd E
STONEY CREEK
Mud St E
Upper Centennial Pkwy
Highland Rd E
Regional Rd No 20

East Escarpment Properties Mailing List								
Landowner	Property Address	Mailing Address	Mailing Address 2	Municipality	Postal Code	Phone Number	Phone Number2	Phone Number3

AGENCY MAILING LIST

Last Name	First Name	Title	Job Title	Organization	Street Address	City and Province	Postal Code	Contact Information	Link to Documents/ Webpages/ Email	Special Notes and Instructions
City of Hamilton Staff										
Cunliffe	Dave	Mr.	Fire Chief	Hamilton Fire Department	1227 Stone Church Road East	Hamilton, ON	L8W 2C6	905-546-2424 x3340	dave.cunliffe@hamilton.ca	**To be emailed a pdf copy of the mailout**
Girt	Eric	Mr.	Commander in Charge	Hamilton Police Service	155 King Street, Box 1060, LCD1	Hamilton, ON	L8N 4C1	905-546-4710	egirt@hamiltonpolice.on.ca	**To be emailed a pdf copy of the mailout**
DeJager	Shawn	Mr.	Senior Project Manager	Hamilton Fire Department	1227 Stone Church Road East, 3rd Floor	Hamilton, ON	L8W 2C6	905-546-4752	shawn.dejager@hamilton.ca	**To be emailed a pdf copy of the mailout**
Eisenberger	Fred	Mr.	Mayor	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4200	mayor@hamilton.ca	**To be emailed a pdf copy of the mailout**
Grice	Andrew	Mr.	Director, Water & Wastewater Operations	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x1461	andrew.grice@hamilton.ca	**To be emailed a pdf copy of the mailout**
Matthews-Malone	Betty	Ms.	Director of Operations	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x4622	betty.matthews-malone@hamilton.ca	**To be emailed a pdf copy of the mailout**
McKinnon	Dan	Mr.	General Manager	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905.546.2424 x5941	dan.mckinnon@hamilton.ca	**To be emailed a pdf copy of the mailout**
Bainbridge	Mark	Mr.	Acting Director, Hamilton Water	Public Works	78 James St. N., Suite 400	Hamilton, ON	L8R 2K4		mark.bainbridge@hamilton.ca	
Murdoch	Craig	Mr.	Director of Environmental Services	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x4490	craig.murdoch@hamilton.ca	**To be emailed a pdf copy of the mailout**
Norman	Robert	Mr.	Director, Strategic Planning	Public Works	77 James St. N., Suite 400	Hamilton, ON	L8R 2K3	905-546-2424 x2298	robert.norman@hamilton.ca	**To be emailed a pdf copy of the mailout**
Robichaud	Steve	Mr.	Director of Planning	Planning & Economic Development	71 Main Street West, 6th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4281	steve.robichaud@hamilton.ca	**To be emailed a pdf copy of the mailout**
Moore	Gary	Mr.	Director of Engineering Services	Public Works	77 James Street North, Suite 320	Hamilton, ON	L8R 2K3		gary.moore@hamilton.ca	
Murray	Chris	Mr.	City Manager	Hamilton City Hall	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5		chris.murray@hamilton.ca	
Sergi	Tony	Mr.	Senior Director, Growth Management	Planning & Economic Development	71 Main St W 6th flr	Hamilton, ON	L8P 4Y5	905-546-2424 x2274	tony.sergi@hamilton.ca	**To be emailed a pdf copy of the mailout**
Smith	Darrell	Mr.	Manager, Development Engineering	Planning & Economic Development	71 Main Street West, 5th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x1322	darrell.smith@hamilton.ca	**To be emailed a pdf copy of the mailout**
Thorne	Jason	Mr	General Manager	Planning & Economic Development	71 Main Street West, 7th Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4339	jason.thorne@hamilton.ca	**To be emailed a pdf copy of the mailout**
Councillors										
Conley	Doug	Mr.	Councillor, Ward 9	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x 2703	doug.conley@hamilton.ca	**To be emailed a pdf copy of the mailout**
Johnson	Brenda	Ms.	Councillor, Ward 1	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x2416	brenda.johnson@hamilton.ca	**To be emailed a pdf copy of the mailout**
Provinicial Authorities										
Cunningham	Robert	Mr.		Ministry of Agriculture and Food	1 Stone Rd. W., 2nd Floor	Guelph, ON	N1G 4Y2			
Van de Valk	Jackie	Ms.	Rural Planner - Central-West Ontario	Ministry of Agriculture and Food	6484 Wellington Road 7 - Unit 10	Elora, ON	NOB 1S0	519-846-3415	jackie.vandevalk@ontario.ca	
Environmental Assessment & Approvals Branch			E/A Project Co-ordination Section	Ministry of the Environment and Climate Change	2 St. Clair Ave. W. 14th Floor	Toronto, ON	M4V 1L5	MEA.NOTICES.EAAB@ontario.ca	MEA.NOTICES.EAAB@ontario.ca	**To be emailed a pdf ONLY FOR NOTICE OF PROJECT COMPLETION. (no hardcopy)**
Hagman	Ian	Mr.	District Manager, Guelph District Office	Ministry of Natural Resources and Forestry	1 Stone Rd. W.	Guelph, ON	N1G 4Y2	519-826-4931 Fax 519-826-4929	ian.hagman@ontario.ca	
Durst	Joad	Mr.	Resource Management Supervisor	Ministry of Natural Resources and Forestry	4890 Victoria Avenue North, P.O.Box 5000	Vineland, ON	L0R 2E0		joad.durst@ontario.ca	
Slattery	Barbara	Ms.	Environmental Assessment & Planning Co-ordinator	Ministry of the Environment and Climate Change	119 King St. W., 12th Floor	Hamilton, ON	L8P 4Y7	905-521-7864 Fax 905-521-7806 barbara.slattery@ontario.ca	barbara.slattery@ontario.ca	
Hatcher	Laura		Team Lead - Heritage Land Use Planning	Ministry of Tourism, Culture & Sport	401 Bay Street, 17th Floor	Toronto, ON	M7A 0A7	416-314-3108 Fax 416-314-7175 laura.e.hatcher@ontario.ca	laura.hatcher@ontario.ca	

First Nations

Durand	Tina	Ms.	Secretary Political Sector	Huron-Wendat Nation Council	255 Place Chef Michel-Laveau	Wendake, QC	G0A 4V0	418-843-3767 1-877-712-3767 Fax: 418-842-1108	tina.durand@cnhw.qc.ca	
General	Paul	Mr.	Lands & Resources	Six Nations Eco-Centre	1721 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-0330 pgeneral@sixnations.ca	pgeneral@sixnations.ca	**Email Notices**
Bomberry	Lonny	Mr.	Director of Lands & Resources	Six Nations of the Grand River Territory	P.O. Box 5000, 2498 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-2201 Fax: 519-445-4208	kcave@sixnations.ca	
Hill	Leroy	Hohahes	Secretary to Haudenosaunee Conferacy Chiefs Council	Haudenosaunee Chiefs Council	2634 6th Line RR2	Oshweken, ON	N0A 1M0	(519) 753-0665 Fax (519) 753-3449	utt@onwirednetworks.com;resource1749@execulink.com	
LaForme	Mark	Mr.	Director, Department of Consultation and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Tel: (905) 768-4260 Fax: (905) 768-9751 Cell: (289) 527-6577 Email: Mark.Laforme@Newcreditfirstnation.com, doca@newcreditfirstnation.com	Mark.Laforme@Newcreditfirstnation.com;doca@newcreditfirstnation.com	**Email Notices**
Sault	Fawn		Manager, Department of Consultaiton and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Fawn.sault@newcreditfirstnation.com	Fawn.sault@newcreditfirstnation.com	**2nd point of contact for missisaugas of new credit first nation, contact if cannot reach Mark Laforme**
Utilities										
Ardelli	Terri	Ms.	Land Analyst, Urban Development	TransCanada Pipelines	450-1st Street S.W.	Calgary, AB	T2P 5H1	403-920-7370 Fax 403-920-2329 terr_ardelli@transcanada.com	terri_ardelli@TransCanada.com;terri-ardelli@TransCanada.com	
Blakely	John	Mr.	Senior Right-of-Way Agent	Enbridge Pipelines Inc.	801 Upper Canada Drive P.O	Sarnia, ON	N7W 1A3	(519)339-0507	john.blakely@enbridge.com	
Carello	Jack	Mr.	Manager, Utilities East	Canadian Pacific Railway	1290 Central Parkway West,	Mississauga, ON	L5C 4R3	Phone: 905-803-3417	Jack_Carello@cpr.ca	
Greco	Enzo	Mr.	Construction Project Manager	Union Gas	918 South Service Road	Stoney Creek, ON	L8E 5M4	Phone: (289) 649-2061 Cell: (905) 741-8395 Email: egreco@uniongas.com	egreco@uniongas.com	
Harten	Ron	Mr.	General Manager, Hamilton Community Energy	Hamilton Utilities Corporation	The Textile Building 10 George Street Suite 300	Hamilton, ON	L8P 1C8	Ron.Harten@hamiltonucorp.com	Ron.Harten@hamiltonucorp.com	
Oriotis	Jim	Mr.		Hydro One	483 Bay Street, North Tower 15th Floor	Toronto, ON	M5G 2P5	jim.oriotis@hydroone.com	jim.oriotis@hydroone.com	
Lane	Paul	Mr.		Sun Canadian Pipeline	830 Highway 6 North P.O. Box 470	Waterdown, ON	L0R 2H0	905-689-6641 x136 Fax 514-395-5613 plane@sun-canadian-com	plane@sun-canadian.com	
Leppert	Randy	Mr.	Planning Lead Hand Niagara/Hamilton	Cogeco Cable Inc	7170 McLeod Rd	Niagara Falls, ON	L2G 3H5	Phone: 289-296-6228 Cell: 905- 351-3771 randy.leppert@cogeco.com	randy.leppert@cogeco.com	
Linder	Stefan	Mr.	Manager, Public Works Design & Construction	CN	4 Welding Way off Administration Road	Vaughan, ON	L4K 1B9	905-669-3264 email: Stefan.Linder@cn.ca	Stefan.Linder@cn.ca	
Milano	Bruno	Mr.	Planner/Designer	Source Cable	1090 Upper Wellington St	Hamilton, ON	L9A 3S6	Work # 905-318-4663 Cell # 905-971-2762	bruno@sourcecable.ca	
Mitchell	Colleen	Ms.	Land Agent - Eastern Pipeline Operations	Imperial Oil Products & Chemical Division	100 - 5th Concession Rd. E.	Waterdown, ON	L0R 2H1	1-888-242-6660 x242 colleen.m.mitchell@esso.com	colleen.m.mitchell@esso.com	
Newman	Ann	Ms.	Crossings Co-ordinator, Eastern Region	Enbridge Pipelines Inc.	801 Upper Canada Drive P.O Box 128	Sarnia, ON	N7W 1A3	(519)339-0503	ann.newman@enbridge.com	
Ontario Power Generation	Sir/Madam				700 University Avenue	Toronto, ON	M5G 1X6	416-592-2555	webmaster@opg.com	
Jakubowski	Mark	Mr.	Acting Manager of Capital Projects	Horizon Utilities Corporation	55 John St. N., 6th Floor	Hamilton, ON	L8R 3M8		mark.jakubowski@horizonutilities.com	
Sutton	Eleanor	Ms.		Bell Canada	20 Hunter St. W.	Hamilton, ON	L8N 3H2	(905) 577-6093	eleanor.sutton@bell.ca	
Winkley	John	Mr.	Regional Director - Marketing	Southern Ontario Railway	241 Stuart St. W.	Hamilton, ON	L8N 3P9		john.winkley@gwrr.com	

Britton, Matthew

From:	France, Michelle
Sent:	Thursday, November 23, 2017 9:35 AM
To:	Chipps, Steve; Campbell, Candice
Subject:	FW: [External] November 28th 2017 - Notice of Public Information Centre No. 2
Attachments:	image001.png; ATT00001.htm; 17-11-09_NComm_StoneyCreek.pdf; ATT00002.htm

FYI

Michelle France
Receptionist
Direct: +1 (905) 335-2353
www.woodplc.com

wood.

From: Eastern Region Crossing [mailto:est.reg.crossing@enbridge.com]
Sent: Thursday, November 23, 2017 9:34 AM
To: michelle.france@woodplc.com
Subject: FW: [External] November 28th 2017 - Notice of Public Information Centre No. 2

Good Morning,

I have reviewed the attached work and Enbridge Pipelines Inc. does not have any assets in the area

Thank you

Amy Robinson
519-339-0517
—
enbridge.com
Integrity. Safety. Respect.

From: John Blakely
Sent: Wednesday, November 22, 2017 5:50 PM
To: Ann Newman
Cc: Amy Robinson
Subject: Fwd: [External] November 28th 2017 - Notice of Public Information Centre No. 2

FYI

Sent from my iPhone

Begin forwarded message:

> **From:** "France, Michelle" <michelle.france@woodplc.com>
> **Date:** November 22, 2017 at 1:48:42 PM EST

To: Undisclosed recipients:;
Subject: [External] November 28th 2017 - Notice of Public Information Centre No. 2

Good afternoon,

Please see the attached Notice of Public Information in regards to the Flood and Erosion Control Study for Stoney Creek and Battlefield Creek.

Regards,

Michelle France
Receptionist
Direct: +1 (905) 335-2353
www.woodplc.com

Public Information Centre No. 2

Stoney Creek and Battlefield Creek
Flood and Erosion Control Project
East Escarpment Watershed Restoration Program
Conservation Ontario Class Environmental Assessment

Hamilton Conservation Authority

Healthy Streams...Healthy Communities!

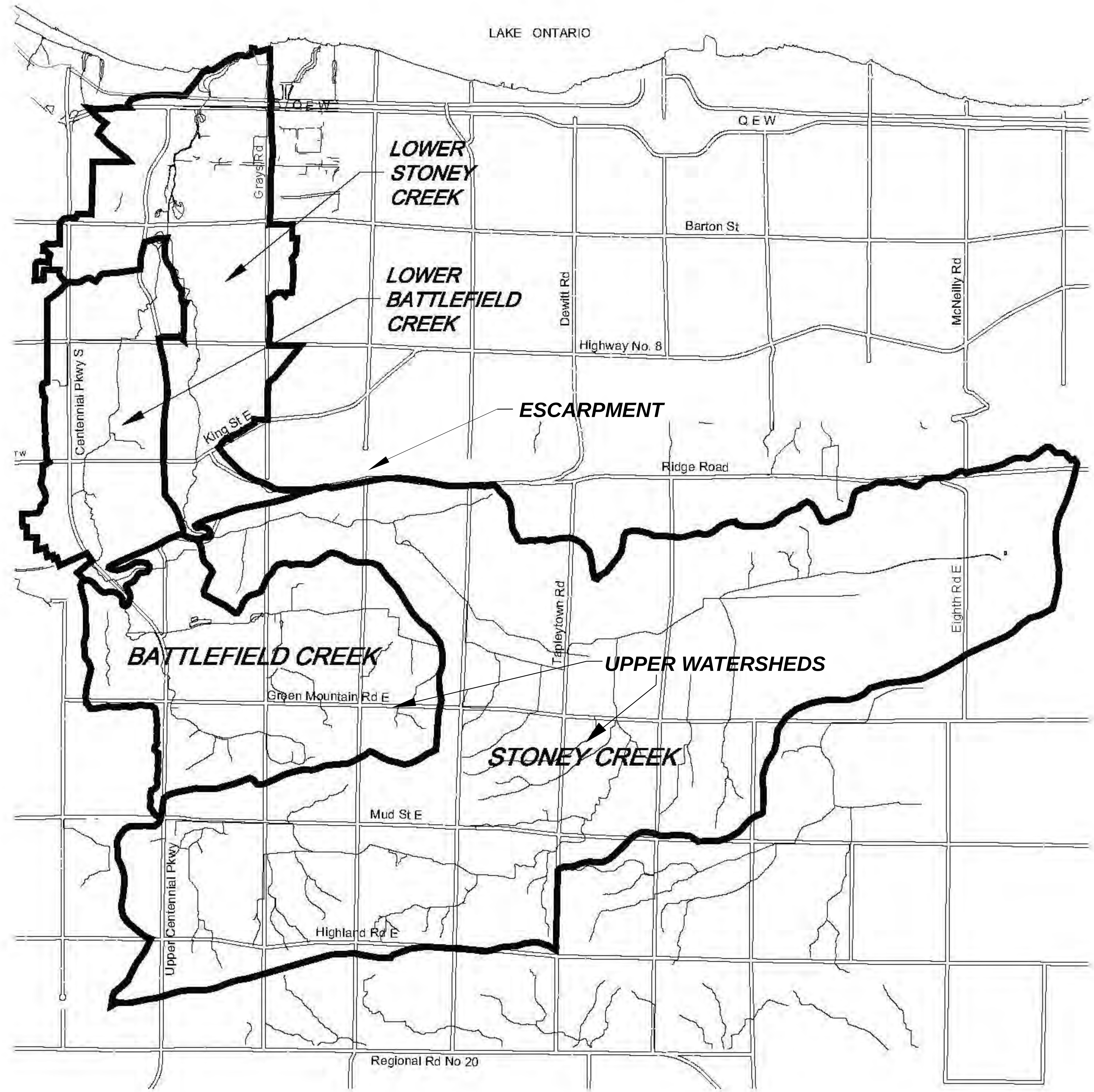
amec foster wheeler

Date: November 28, 2017 / Location: Croatian Community Centre / Time: 6:00 p.m. to 8:00 p.m.

Preliminary Preferred Solution

Study Area

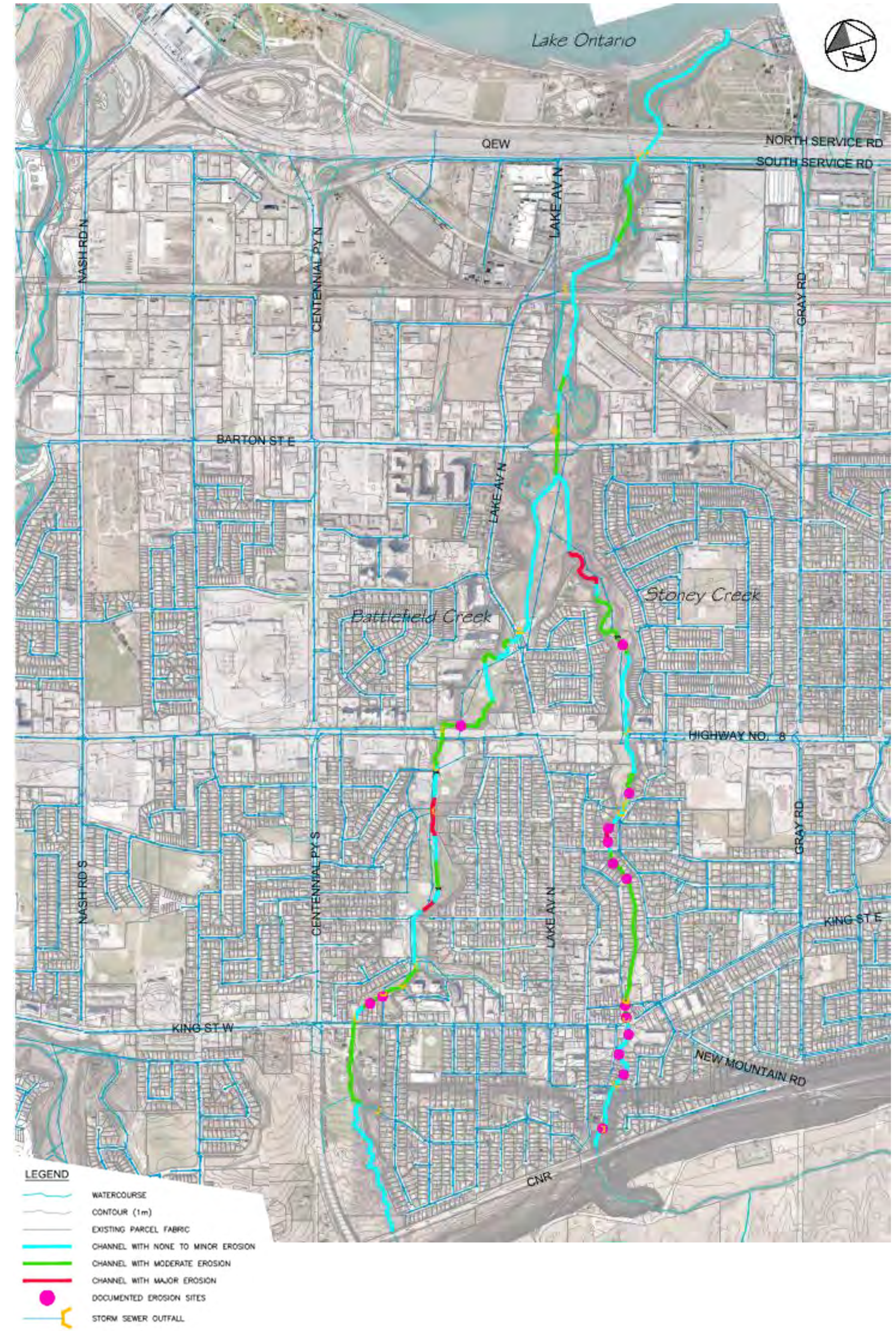
The Study area includes the erosion-prone Lower Stoney Creek and Battlefield Creek watersheds as well as the vast headwater above the escarpment.



Project Overview

Study Background and Purpose

- In 2011, the Hamilton Conservation Authority (HCA) and the City of Hamilton prepared a Class Environmental Assessment (EA) for the Lower Stoney Creek and Lower Battlefield Creek (sections of the watershed below the escarpment) which identified areas that were susceptible to flooding and erosion.
- As part of that study, the feasibility of storage based solutions located above the escarpment to address flood and erosion risk in the lower reaches was assessed and considered for further study.



Project Overview

Study Goal

- In 2015, the HCA released a Discussion Paper entitled "East Escarpment Conservation Area" which expressed the goal:
  - *" To create a new conservation area in the east end of the City of Hamilton, specifically the Upper Stoney Creek and Upper Battlefield Creek watersheds above the Escarpment to provide natural hazard attenuation, natural heritage enhancements and recreation opportunities."*

Project Overview

Study Objectives

- To utilize the floodplain areas of Upper Battlefield and Upper Stoney Creeks to retain water to provide flood attenuation to reduce flood and erosion risks both above and below the Niagara Escarpment.
- To enhance and enlarge existing wetland areas and to create new wetland areas to provide enhanced wetland hydrologic function to reduce the impacts of high water events and provide water to area watercourses during low flow periods.
- To restore the natural features and functions of the watercourses in the subject area.
- To restore, enhance and enlarge the natural heritage features associated with the floodplains, wetlands and watercourses of the area.

Conservation Ontario Class EA Approach

Hamilton Conservation Authority
Healthy Streams...Healthy Communities!

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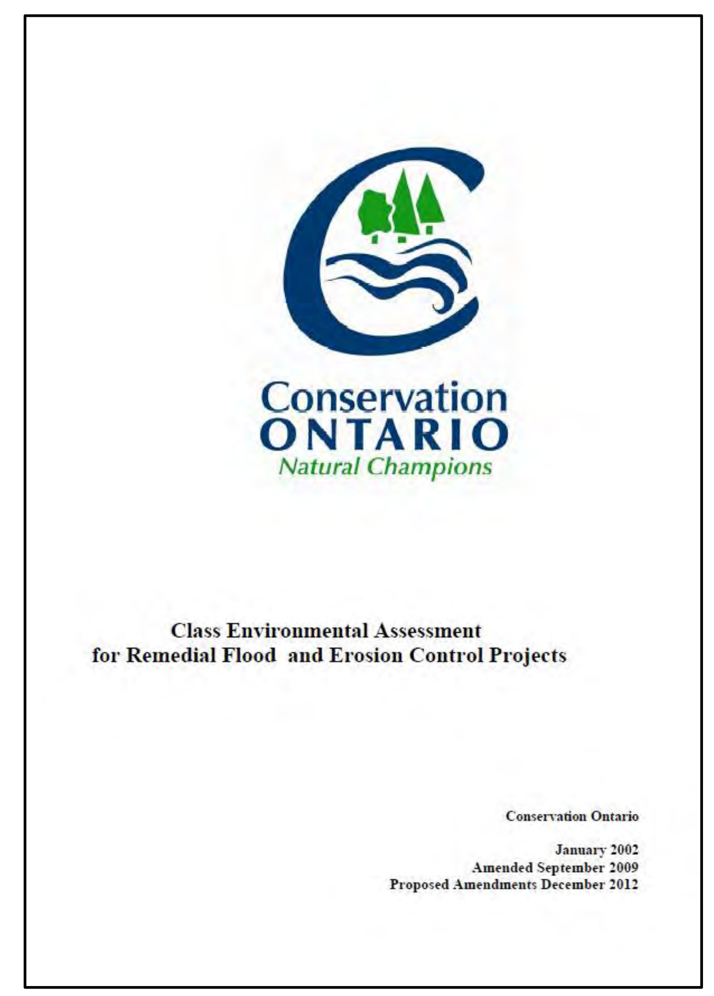
- This study follows the process outlined in: Conservation Ontario's Class Environmental Assessment for Remedial Flood and Erosion Control Projects
- The process provides a project planning and design framework for proponents (Conservation Authorities like Hamilton Conservation Authority) to ensure they meet the requirements of the Provincial Environmental Assessment Act.



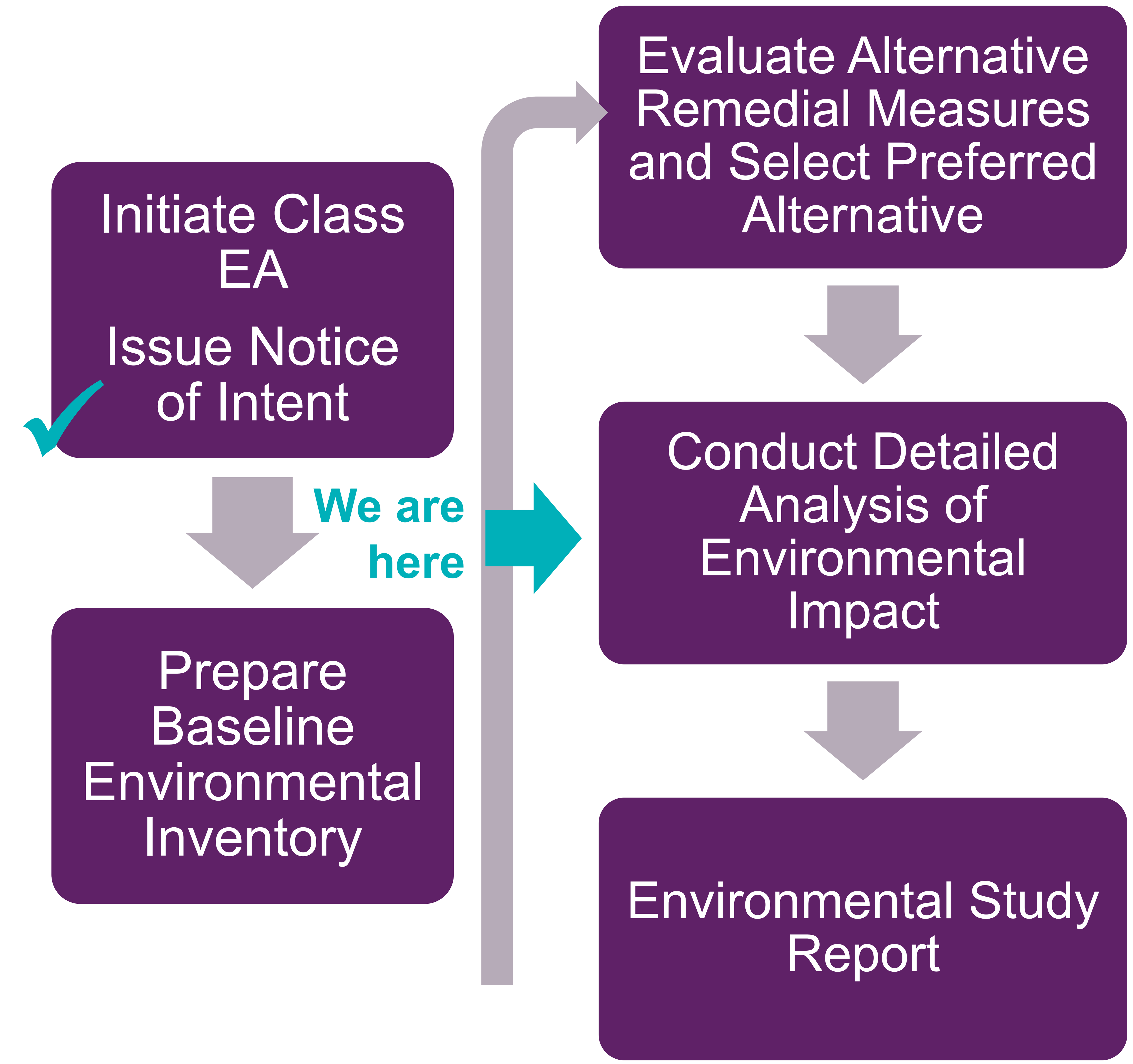
Conservation ONTARIO
Natural Champions

Class Environmental Assessment
for Remedial Flood and Erosion Control Projects

Conservation Ontario

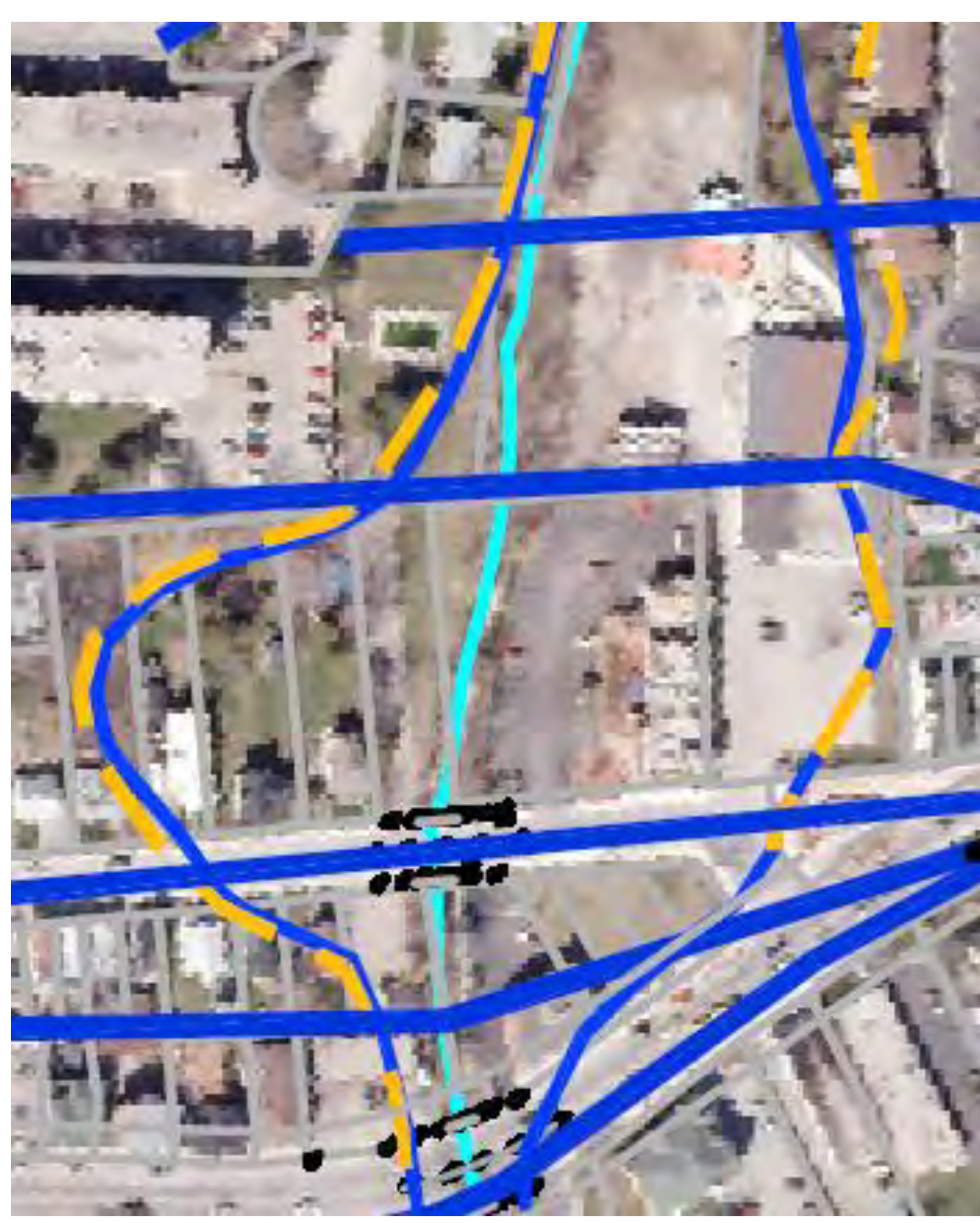
January 2002
Amended September 2009
Proposed Amendments December 2012

- Consultation is required with all stakeholders including the public and agency partners at all stages.



Problem and Opportunity Statement

- The 2011 Class EA identified significant portions of the Lower Stoney Creek and Battlefield Creeks as being susceptible to flood and erosion risk.
- HCA has set a goal of creating a new conservation area in the Upper Stoney Creek and Upper Battlefield Creek watershed.
- Through detailed study and consultation, opportunities to provide flood and erosion impact management, through attenuation of runoff in existing and enhanced wetland areas above the Escarpment, have been assessed and evaluated. These areas and locations for runoff storage would ultimately have the potential to become passive use public spaces as part of a new conservation area.



Alternative Assessment

Flood and Erosion Control Alternatives

In 2011, the Hamilton Conservation Authority (HCA) and the City of Hamilton prepared a Class Environmental Assessment (EA) for the Lower Stoney Creek and Lower Battlefield Creek.

Alternatives considered for flood mitigation included:

1. Flow conveyance upgrades (channels, floodplains, culverts and bridges)
2. Roadway profiles adjustments to reduce flooding
3. Flood proofing of buildings
4. Elimination/reduction of culvert blockages
5. Off-line and/or on-line flood storage systems

Alternatives considered for erosion mitigation included:

1. Local creek protection works to address/ prevent erosion
2. Reach-scale channel works
3. Off-line and/or online erosion storage systems

The flood and erosion control alternatives considered directly as part of this Class EA are online flood and erosion storage systems.

Alternative Assessment

Hamilton Conservation Authority
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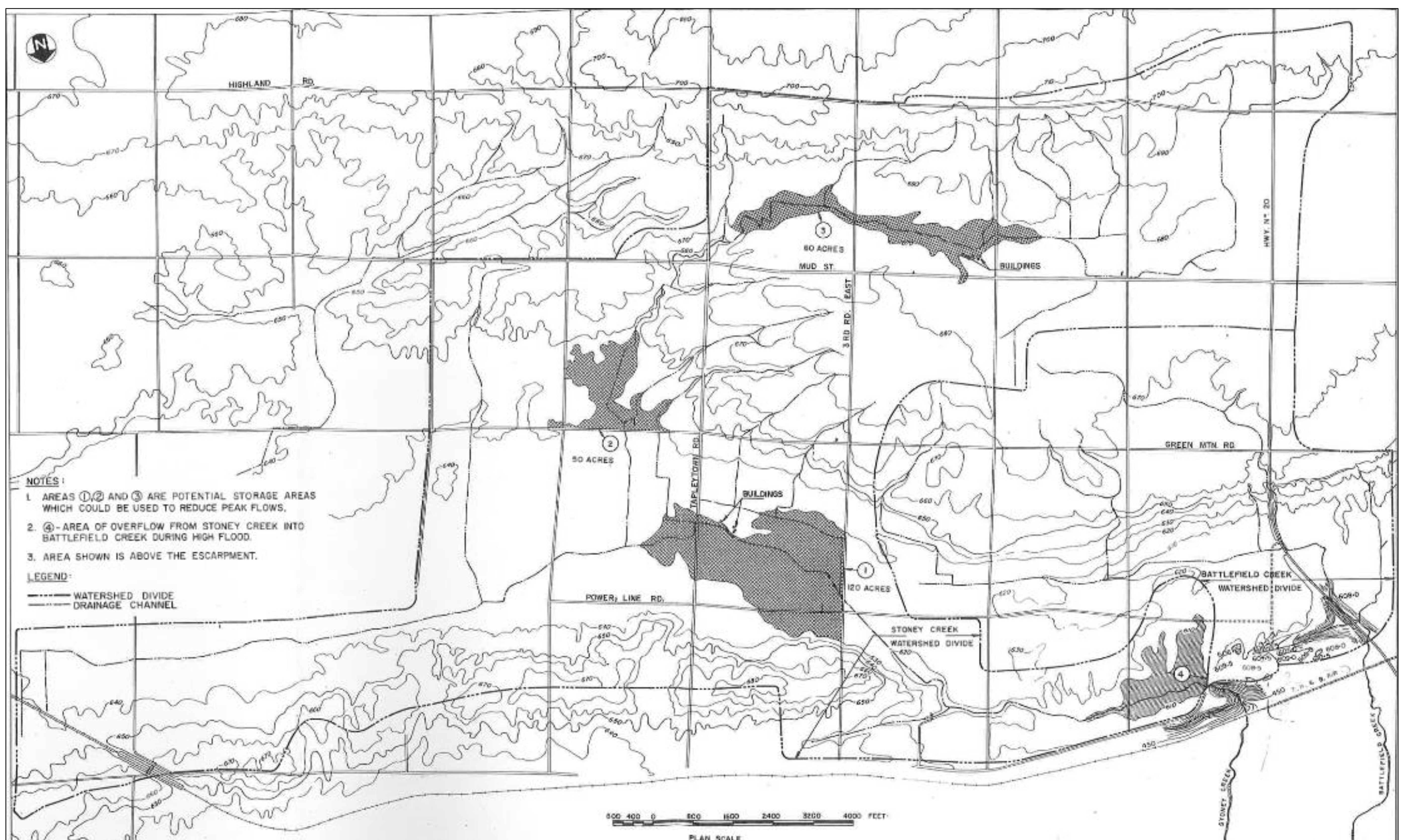
Approaches for Flood and Erosion Control Storage Systems

1. Raise Roadways / Modify and Optimize Culvert Geometry (on-line storage)
2. Repurpose existing wetland systems (on-line / off-line storage)
3. Excavate storage areas and creating holding areas (off-line storage)
4. Combinations of off-line / on-line storage

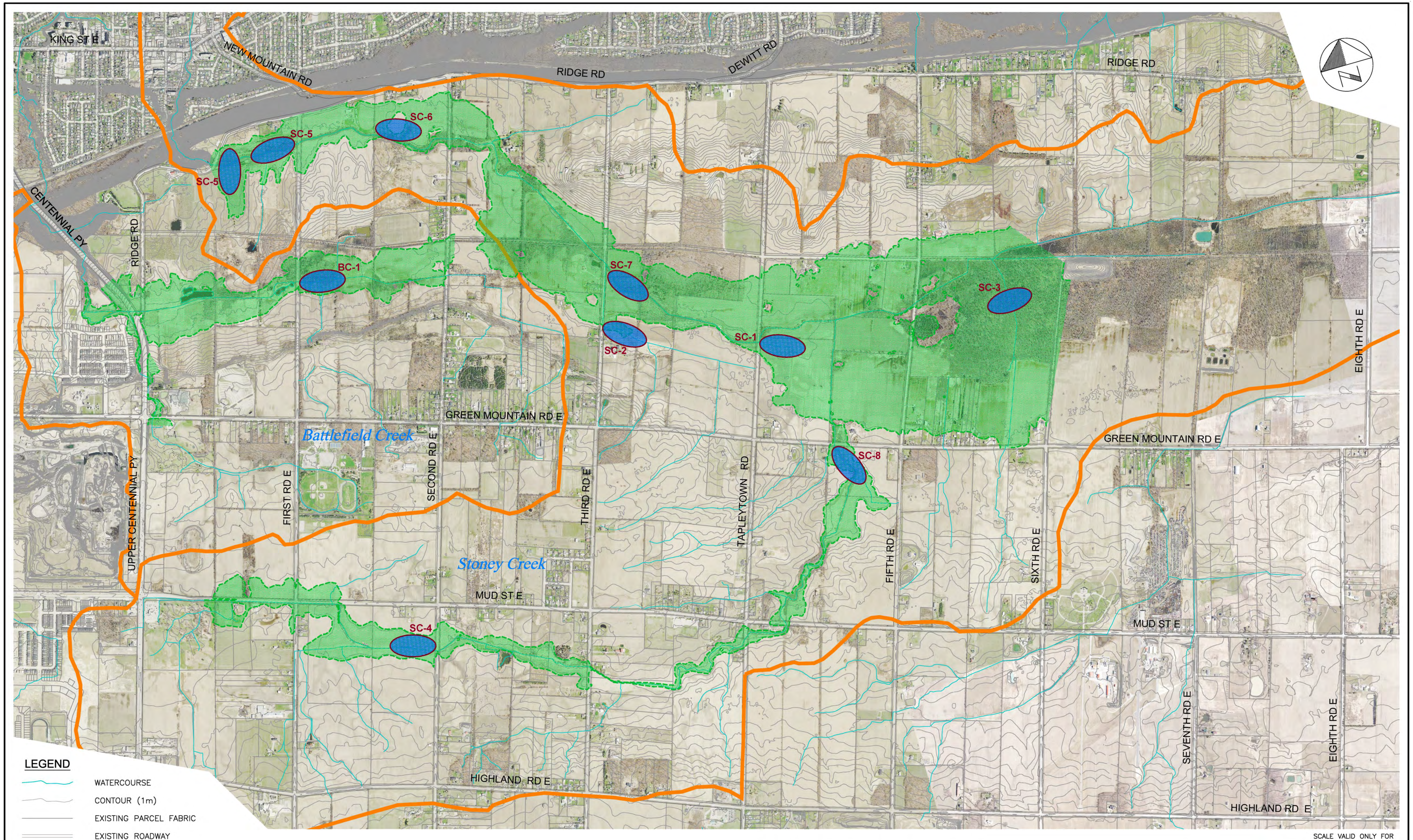


1970 Fenco Flood and Erosion Control Study

Constructed Wetland System (City of London Dingman Creek wetland)

Alternative Assessment

Potential Locations for Flood and Erosion Control Storage Systems



FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK CLASS EA HAMILTON CONSERVATION AUTHORITY	ALTERNATIVE FLOOD AND EROSION STORAGE AREAS	amec foster wheeler	Scale 1:10000 (0 100 200 400) Consultant File No. TPB168024 Figure No. 14

Alternative Assessment

Alternatives have been evaluated considering four environmental categories and various evaluation criteria specifically relevant to the study area, objectives and stakeholders:

Category	Criteria
Functional Environment	• Effectiveness of flooding and erosion mitigation • Constructability
Natural Environment	• Impacts/opportunities related to terrestrial ecology and fisheries
Social Environment	• Impacts/opportunities related to public use, safety, adjacent properties and structures, land use and recreation
Economic Environment	• Land Costs • Capital and maintenance cost for the storage systems

Alternative Assessment

Evaluation/ Screening of Potential Storage Sites

Evaluation Category	Evaluation Criteria	Battlefield Creek Site	Stoney Creek Sites							
		BC-1	SC-1	SC-2	SC-3	SC-4	SC-5	SC-6	SC-7	SC-8
Functional	Effectiveness of Flooding Mitigation	✓	✓	X	X	X	✓	X	✓	X
	Effectiveness of Erosion Mitigation	✓	✓	X	X	X	✓	X	✓	✓
	Constructability	✓	X	X	X	✓	X	X	X	✓
Natural	Terrestrial Ecology Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fisheries Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
Social	Public Use Impacts/Opportunities	✓	✓	X	✓	X	✓	X	✓	✓
	Safety Impacts/ Opportunities	✓	X	✓	✓	✓	✓	✓	✓	✓
	Adjacent Property Impacts/Opportunities	X	X	✓	X	✓	✓	X	✓	✓
	Land Use Impacts/Opportunities	✓	X	X	X	X	X	✓	✓	X
	Recreation Impacts/Opportunities	✓	✓	✓	✓	✓	✓	✓	✓	✓
Economic	Land Costs	✓	X	X	X	X	✓	✓	X	X
	Capital Costs	X	X	✓	✓	✓	X	✓	X	✓
	Maintenance Costs	X	X	✓	X	✓	X	✓	X	X
Carry Forward (Yes/No)		✓	X	X	X	X	✓	X	✓	✓

Legend: Negative: X, Positive: ✓

Not Carried Forward	Carried Forward

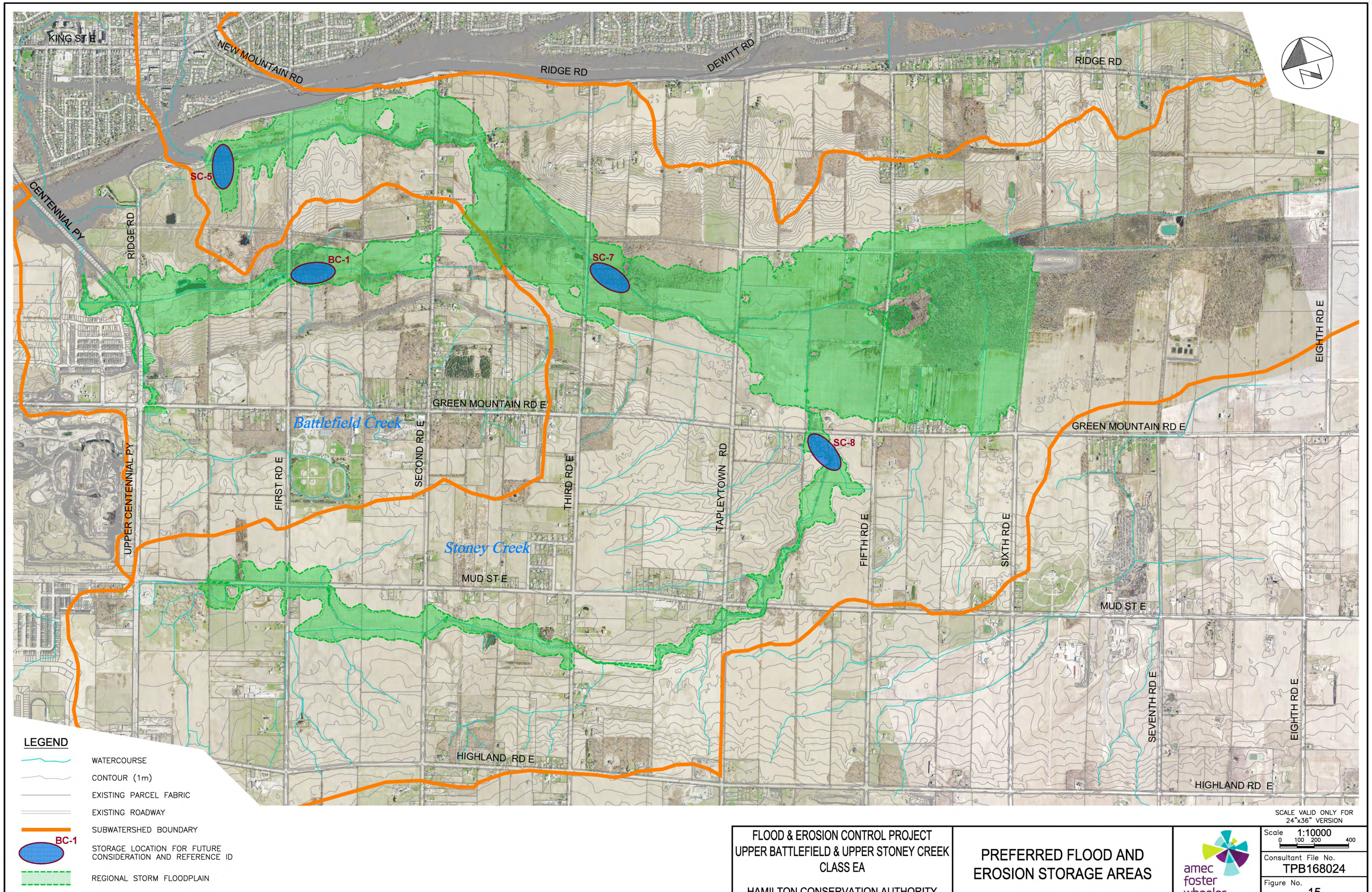
Alternative Assessment

Preliminary Preferred Flood and Erosion Control Storage Systems

- **Battlefield Creek Site 1 (BC-1):**
  - *Significant erosion and flood control storage potential*
  - *Hamilton Conservation Authority controlled lands*
  - *Significant opportunity for terrestrial ecology and fishery habitat enhancements*
- **Stoney Creek Site 5 (SC-5):**
  - *Significant erosion and flood control storage potential*
  - *Partially Hamilton Conservation Authority controlled lands*
  - *Significant opportunity for terrestrial ecology enhancements*
  - *Significant opportunity for public recreational use*
- **Stoney Creek Site 7 (SC-7):**
  - *Moderate erosion and flood control storage potential*
  - *Moderate opportunity for terrestrial ecology enhancements*
  - *Significant opportunity for public recreational use*
- **Stoney Creek Site 8 (SC-8):**
  - *Low to moderate erosion and flood control storage potential*
  - *Significant opportunity for terrestrial ecology enhancements*
  - *Moderate opportunity for public recreational use*

Alternative Assessment

Preliminary Preferred Flood and Erosion Control Storage Systems



Alternative Assessment

Summary of Results for Preliminary Preferred Flood and Erosion Control Systems

- Four (4) flood and erosion control sites: BC-1, SC-5, SC-7 and SC-8; each would allow for wetland creation, terrestrial and fishery habitat improvements and public recreational usage
- Reduced downstream property and building flooding for all storms up to and including the 100 year event
- Duration of erosive flows reduced by 32% and 27% for Battlefield Creek and Stoney Creek respectively

Properties and Buildings Removed from Risk

	Scenario	Storm Event:						
		2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	Regional Storm
Properties	Existing	1	14	33	62	78	102	194
	With Flood Control Systems	0	9	19	38	41	52	194
	Removed from Risk	1	5	14	24	37	50	0
Buildings	Existing	0	2	2	7	11	46	116
	With Flood Control Systems	0	1	2	2	2	10	116
	Removed from Risk	0	1	0	5	9	36	0

Alternative Assessment

Implementation of Flood and Erosion Control Storage Systems

- Implementation considerations and process:
  - *Topographic survey of lands*
  - *Mapping of terrestrial habitats, including species at risk*
  - *Mammal and amphibian inventories*
  - *Fisheries habitat mapping*
  - *Groundwater, soils and bedrock detailed assessment*
  - *Cultural heritage and Archaeological assessments*
  - *Design storage system layout and grading, including modified road profile and berming*
  - *Design storage system outlet – culvert (s), flow control structures*
  - *Determine potential impacts to adjacent lands and establish mitigating measures*
  - *Design wetland and terrestrial habitat enhancements*
  - *Design trail systems, boardwalks, parking, servicing and recreational land uses*
  - *Determine staging*

Alternative Assessment

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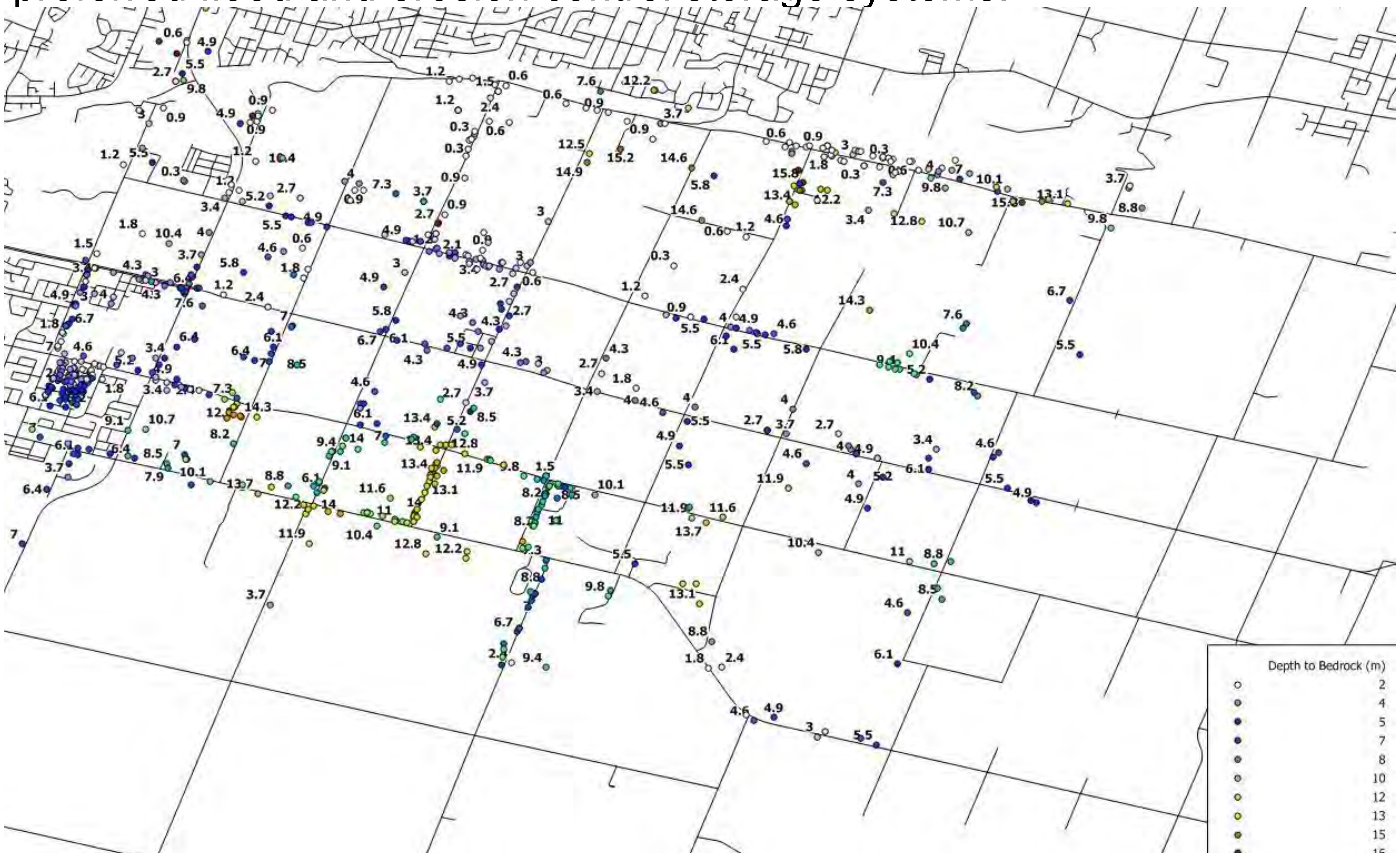
Implementation of Flood and Erosion Control Storage Systems

- Implementation would include detailed assessment of depth to bedrock within the preferred flood and erosion control storage systems.



Next Steps

- Receive public comments by **December 22, 2017**
- Incorporate public and agency input into alternative assessment
- Select preferred solution and implementation method
- Prepare and file Class Environmental Assessment Report

We Would Like To Hear From You

Please complete the comment sheet and place in the Comment Box or send your comments by email/fax/letter to either of the following Project Team members by **December 22, 2017.**

You can view tonight's information boards on our website:
https://conservationhamilton.ca/flood-and-erosion-control-study-stoney-creek-and-battlefield-creek/

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Thank you for your participation

Appendix B

Hydraulics and Culvert Inventory

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B1 – Ridge Road (May 20th, 2016)

Photo Inventory Abbreviations:

U/S – Upstream, view or extent
D/S – Downstream, view or extent
EXT – Extent, either upstream or downstream of the culvert
LB – Left bank (consistent with downstream orientation)
RB – Right bank (consistent with downstream orientation)
CSP – Corrugated Steel Pipe
Conc. – Concrete
A/S – Armourstone
w/ – With
Veg – Vegetation
Med – Medial (bar)
OB – Overbank

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B1 – Ridge Road (May 20th, 2016)

Photo 1: U/S EXT – U/S view from road of conc. culvert and channel

Photo 2: U/S EXT – D/S view of conc. culvert and grassy medial bars

Photo 3: U/S EXT – U/S view of tree lined channel

Photo 4: U/S EXT – D/S view of conc. culvert with grassy medial bars

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B1 – Ridge Road (May 20th, 2016)

Photo 5: U/S EXT – U/S view from road showing slight culvert skew

Photo 6: D/S EXT – D/S view from road of meandering channel to B2

Photo 7: D/S EXT – D/S view from road showing slight culvert skew

Photo 8: D/S EXT – U/S view of conc. culvert extent

Photo 9: D/S EXT – D/S view of narrow meandering grassy channel leading to B1

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B2 – Upper Centennial Pkwy (May 20th, 2016)

Photo 1: U/S EXT – D/S view of closed conc. culvert

Photo 2: U/S EXT – U/S view of dense veg channel from B1 to B2

Photo 3: U/S EXT – U/S view from road of culvert skew

Photo 4: D/S EXT – D/S view from road of headwall at road elevation

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B2 – Upper Centennial Pkwy (May 20th, 2016)

Photo 5: D/S EXT – D/S view of angled creek exiting culvert

Photo 6: D/S EXT – U/S view of conc. culvert with headwall

Photo 7: D/S EXT – U/S view in culvert, changes from closed to open

Photo 8: D/S EXT – D/S LB view of redone tributary on LB from B3

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B3 – Upper Centennial Pkwy (May 30th, 2016)

Photo 1: U/S EXT – D/S view of conc. box culvert with shale deposits

Photo 2: U/S EXT – U/S view of dry shale channel with grassy veg

Photo 3: U/S EXT – U/S view of dry shale channel with grassy veg

Photo 4: U/S EXT - Upward view from culvert of elevation to road

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B3 – Upper Centennial Pkwy (May 30th, 2016)

Photo 5: U/S EXT – U/S view from road of paved chute to culvert

Photo 6: D/S EXT – D/S view from road of paved chute to culvert

Photo 7: D/S EXT – U/S view of conc. culvert with damaged footings

Photo 8: D/S EXT – D/S view of river rock patch and grassy channel

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B3 – Upper Centennial Pkwy (May 30th, 2016)

Photo 9: D/S EXT – U/S view of river rock causing scour pool at culvert

Photo 10: U/S EXT – D/S view from private driveway culvert leading to U/S culvert

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B4 – Green Mountain Road (May 24th, 2016)

Photo 1: U/S EXT – U/S view from road of conc. culvert slight skew

Photo 2: U/S EXT – U/S view of vegetated channel, RB is golf course

Photo 3: U/S EXT – D/S view of conc. box culvert, with A/S banks

Photo 4: U/S EXT – U/S view of dry dense vegetated channel

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B4 – Green Mountain Road (May 24th, 2016)

Photo 5: U/S EXT – U/S view showing slight skew

Photo 6: D/S EXT – D/S view from road of culvert leading into pool

Photo 7: D/S EXT – D/S LB view of hill on LB leading to Centennial

Photo 8: D/S EXT – D/S RB view of marsh like pooled RB

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B4 – Green Mountain Road (May 24th, 2016)

Photo 9: D/S EXT – U/S view of closed conc. culvert

Photo 10: D/S EXT – D/S view of channel leading to wide pooled area

Photo 11: D/S EXT - RB view of another culvert contributing to pooling

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B5 – First Road East (May 20th, 2016)

Photo 1: U/S EXT – U/S view from road of culvert and channel

Photo 2: U/S EXT – U/S view of slightly skewed channel to culvert

Photo 3: U/S EXT – D/S view of conc. culvert with grassy medial bar

Photo 4: U/S EXT – U/S view of defined channel ~ 20m from culvert

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B5 – First Road East (May 20th, 2016)

Photo 5: D/S EXT – D/S view from road of culvert and channel

Photo 6: D/S EXT – D/S view of channel leading to a private pond

Photo 7: D/S EXT – U/S view of conc. culvert, heavy silted channel

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B6 – Second Road East (May 20th, 2016)

Photo 1: U/S EXT – U/S view from road of CSP culvert

Photo 2: U/S EXT – D/S view of circle CSP culvert with pooled water

Photo 3: U/S EXT – U/S view from road showing culvert skew

Photo 4: D/S EXT – D/S view from road of culvert, narrow channel

Stoney Creek HCA Study – Culvert Inventory
Battlefield Creek – B6 – Second Road East (May 20th, 2016)

Photo 5: D/S EXT – D/S view from road showing culvert skew

Photo 6: D/S EXT – U/S view of slightly bent CSP culvert

Photo 7: D/S EXT – D/S view of channel and large flat overbank zones

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S1 – Ridge Road (May 24th, 2016)

Photo 1: U/S EXT – U/S view from road of CSP culvert, dry channel

Photo 2: U/S EXT – U/S view of undefined dry channel

Photo 3: U/S EXT – D/S view of CSP culvert (arch or sed. filled circle)

Photo 4: U/S EXT – U/S view of undefined dry channel

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S1 – Ridge Road (May 24th, 2016)

Photo 5: D/S EXT – D/S view of dry culvert storm channel

Photo 6: D/S EXT – D/S view of dry channel along residential property

Photo 7: D/S EXT – U/S view of damaged CSP culvert

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S2 – First Road East (May 24th, 2016)

Photo 1: U/S EXT – U/S view from road of dual conc. culvert

Photo 2: U/S EXT – U/S view of stagnant channel with algae growth

Photo 3: U/S EXT – D/S view of dual conc. culvert, blocked by debris

Photo 4: D/S EXT – D/S view from road of dual conc. culvert & channel

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S2 – First Road East (May 24th, 2016)

Photo 5: D/S EXT – D/S RB view of wide grassy meandering channel

Photo 6: D/S EXT – U/S RB view of dual conc. culvert, med bar on LB

Photo 7: D/S EXT – U/S view of culverts, LB culvert blocked by med bar

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S4 – Second Road East (May 24th, 2016)

Photo 1: U/S EXT – U/S view from road of culvert and ditch channel

Photo 2: U/S EXT – U/S view of roadside grassy ditch channel

Photo 3: U/S EXT - RB view of connected ditch w/ flow along First Rd

Photo 4: U/S EXT – D/S view of the conc. culvert with sediment deposit

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S4 – Second Road East (May 24th, 2016)

Photo 5: D/S EXT – D/S view from road of culvert and ditch channel

Photo 6: D/S EXT – D/S view of roadside grassy ditch channel

Photo 7: D/S EXT – RB view of dry connection ditch along First Rd

Photo 8: D/S EXT – U/S view of the conc. culvert with sediment deposit

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S4 – Second Road East (May 24th, 2016)

Photo 1: U/S EXT – U/S view from road of large conc. box culvert

Photo 2: U/S EXT – D/S view of conc. box culvert with grassy med bars

Photo 3: U/S EXT – U/S view of wide stagnant channel with algae

Photo 4: D/S EXT – D/S view from road of wide densely veg channel

Photo 5: D/S EXT – U/S view of conc. box culvert with grassy medial bars on RB

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S5 – Second Road East (May 27th, 2016)

Photo 1: U/S EXT – U/S view from road of culvert and open channel

Photo 2: U/S EXT – U/S view of open channel, flat overbank zones

Photo 3: U/S EXT – D/S view of conc. culvert, stagnant water

Photo 4: D/S EXT – D/S view from road of culvert, undefined channel

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S5 – Second Road East (May 27th, 2016)

Photo 5: D/S EXT – D/S view of undefined, densely vegetated channel

Photo 6: D/S EXT – U/S view of conc. culvert, stagnant water, silt bed

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S6 – Third Road East (May 24th, 2016)

Photo 1: U/S EXT – U/S RB view from road showing creek skew

Photo 2: U/S EXT – U/S view from road of culvert, stagnant channel

Photo 3: U/S EXT – D/S view of large conc. culvert with algae

Photo 4: D/S EXT – D/S view from road showing culvert & creek skew

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S6 – Third Road East (May 24th, 2016)

Photo 5: D/S EXT – D/S view of wide stagnant channel

Photo 6: D/S EXT – D/S view of large woody debris blocking flow

Photo 7: D/S EXT – U/S LB view of conc. culvert

Photo 8: D/S EXT – U/S view of conc. culvert and algae growth

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S7 – Third Road East (May 27th, 2016)

Photo 1: U/S EXT – U/S view from road showing culvert skew

Photo 2: U/S EXT – U/S view of dry, grassy, braiding channel

Photo 3: U/S EXT – D/S view of conc. culvert

Photo 4: U/S EXT – D/S LB view of conc. wing wall on LB w/ no skew

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S7 – Third Road East (May 27th, 2016)

Photo 5: D/S EXT – D/S view from road of culvert and channel

Photo 6: D/S EXT – D/S view of ponding, grassy braiding channel

Photo 7: D/S EXT – U/S view of conc. culvert, slightly damaged

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S8 – Tapleytown Road (May 30th, 2016)

Photo 1: U/S EXT – U/S view from road of bridge barrier & channel

Photo 2: U/S EXT – U/S RB view of sharp bend in narrow channel

Photo 3: U/S EXT – U/S view of narrow roadside channel

Photo 4: U/S EXT – D/S view of large pool, conc. walls, metal top

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S8 – Tapleytown Road (May 30th, 2016)

Photo 5: D/S EXT – D/S view from road of bridge barrier and channel

Photo 6: D/S EXT – D/S view of grassy med bars in front of culvert

Photo 7: D/S EXT – U/S view of culvert, grassy medial bars

Photo 8: D/S EXT – U/S view of medial bars slightly blocking flow

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S8 – Tapleytown Road (May 30th, 2016)

Photo 9: D/S EXT – D/S view of open, clear channel

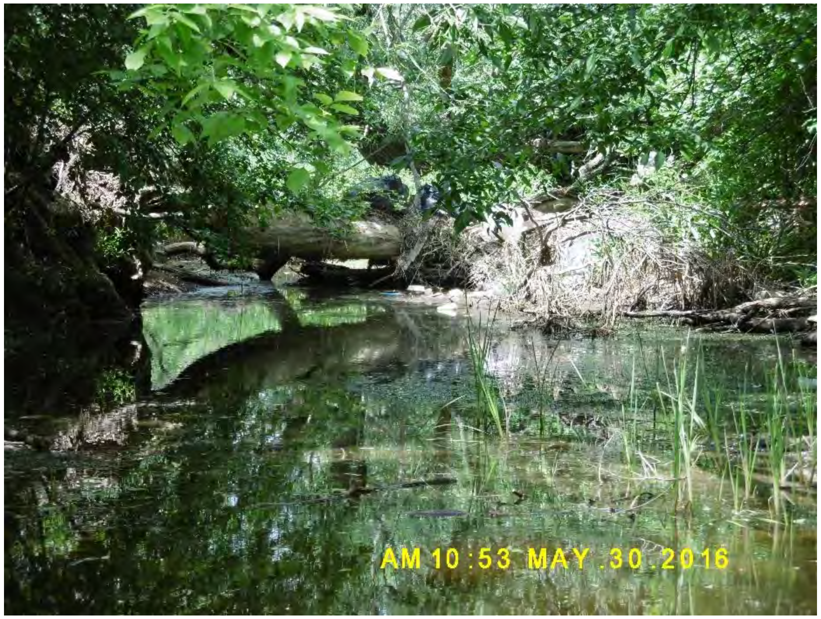


Photo 10: D/S EXT – D/S view of fallen tree and debris blocking flow

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S9 – Tapleytown Road (May 27th, 2016)

Photo 1: U/S EXT – U/S view from road of bridge barrier and channel

Photo 2: U/S EXT – U/S view from road of narrow channel, grassy OB

Photo 3: U/S EXT – D/S view of culvert, angle beneath road changes

Photo 4: U/S EXT – D/S view of culvert and grassy LB

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S9 – Tapleytown Road (May 27th, 2016)

Photo 5: D/S EXT – D/S view from road of braiding grassy channel

Photo 6: D/S EXT – U/S view of culvert, large grassy bar blocking flow

Photo 7: D/S EXT – U/S view from main flow channel of culvert

Stoney Creek – S10 – Mud St E (May 27th 2016)

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S9 – Tapleytown Road (May 27th, 2016)

Photo 1: U/S EXT – U/S view from road of railing & grassy channel

Photo 2: U/S EXT – U/S view of braiding, densely vegetated channel

Photo 3: U/S EXT – D/S view of bridge-culvert w/ river rock banks

Photo 4: D/S EXT – D/S view from road of railing, meandering channel

Photo 5: D/S EXT – D/S view of narrow grassy meandering channel

Photo 6: D/S EXT – U/S view of bridge-culvert with ponding water

Photo 7: D/S EXT – U/S view of silt bed, ponding water beneath road

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S11 – Fifth Road East (May 30th, 2016)

Photo 1: U/S EXT – U/S view from road of culvert and channel

Photo 2: U/S EXT – U/S view of densely vegetated channel

Photo 3: U/S EXT – D/S view of conc. culvert w/ dense vegetation

Photo 4: D/S EXT – D/S view from road of culvert and channel location

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S11 – Fifth Road East (May 30th, 2016)

Photo 5: D/S EXT – D/S view of densely vegetated channel

Photo 6: D/S EXT – U/S view of damaged conc. culvert

Photo 7: D/S EXT – U/S view of damaged conc. culvert

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S12 – Green Mountain Road (May 30th, 2016)

Photo 1: U/S EXT – U/S view from road of culvert & grassy channel

Photo 2: U/S EXT – D/S view of culvert, woody-organic debris bed

Photo 3: U/S EXT – U/S view of channel, saturated silt bed

Photo 4 – U/S EXT – D/S view of conc. culvert

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S12 – Green Mountain Road (May 30th, 2016)

Photo 5: D/S EXT – D/S view from road of culvert and channel

Photo 6: D/S EXT – D/S view of wing wall skew, same on RB and LB

Photo 7: D/S EXT – D/S view of grassy meandering channel

Photo 8: D/S EXT – U/S view of conc. culvert with grassy medial bars

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S12 – Green Mountain Road (May 30th, 2016)

Photo 9: D/S EXT - LB view of wing wall geometry, same on RB

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S13 – Green Mountain Road (May 30th, 2016)

Photo 1: U/S EXT – U/S view from road of CSP & inlet conc. culvert

Photo 2: U/S EXT – U/S view of inlet conc. culvert with cobble pile

Photo 3: U/S EXT – D/S view of dry CSP culvert

Photo 4: D/S EXT – D/S view from road of culvert & straight channel

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S13 – Green Mountain Road (May 30th, 2016)

Photo 5: D/S EXT – D/S view of damaged CSP culvert, deep pool

Photo 6: D/S EXT – U/S view of damaged CSP culvert

Photo 7: D/S EXT – D/S view of river rock pile blocking flow

Photo 8: D/S EXT – U/S view of damaged CSP culvert

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S14 – Green Mountain Road (May 30th, 2016)

Photo 1: U/S EXT – U/S view from road of dual CSP culverts

Photo 2: U/S EXT – U/S view of dual CSP culvert with gravel fill

Photo 3: U/S EXT – D/S view of dual CSP culvert in dry roadside ditch

Photo 4: U/S EXT - LB view of ditch leading to other CSP culverts

Stoney Creek HCA Study – Culvert Inventory
Stoney Creek – S14 – Green Mountain Road (May 30th, 2016)

Photo 5: D/S EXT – D/S view from road of overgrown dry channel

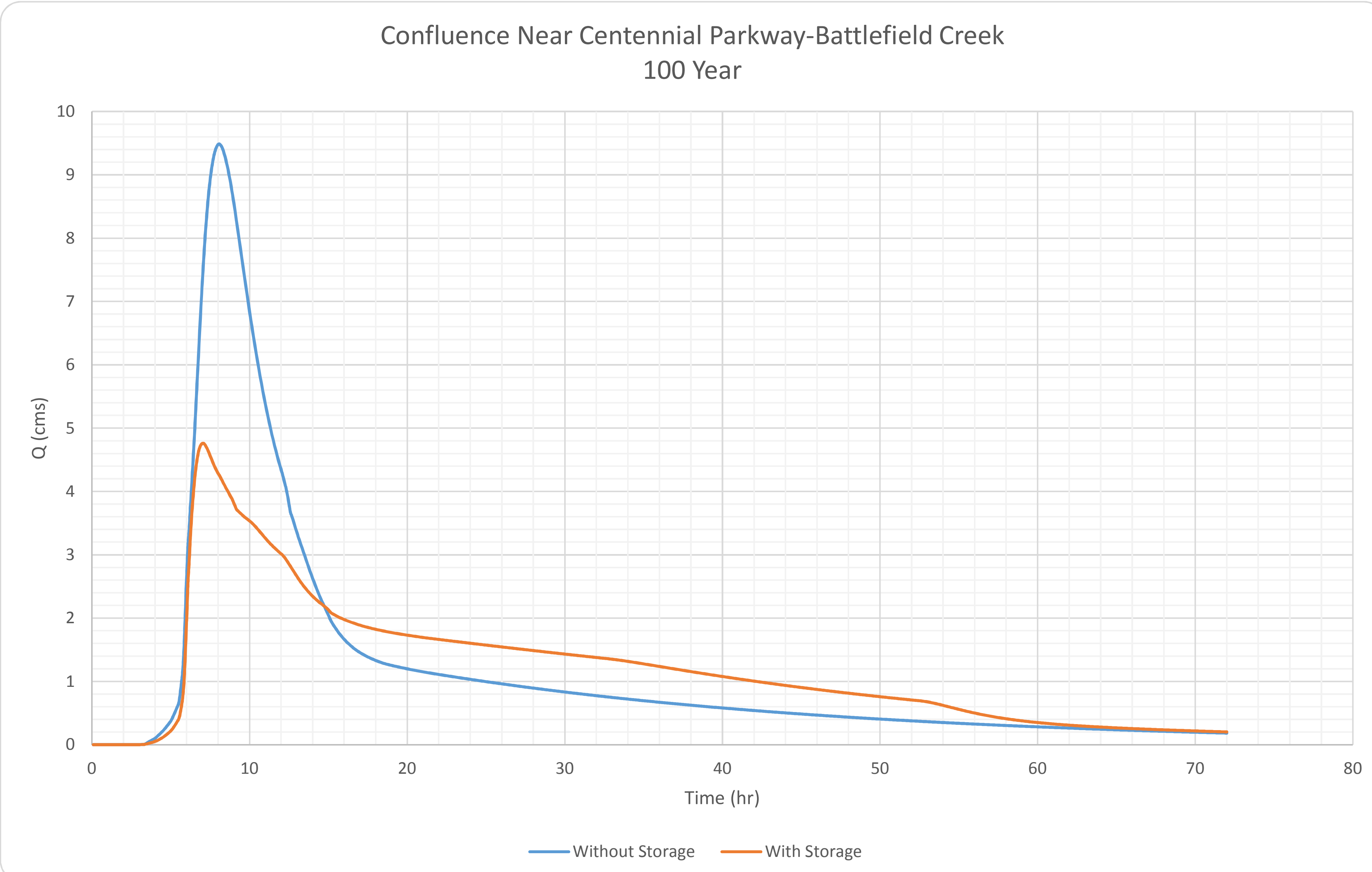
Photo 6: D/S EXT – D/S view of CSP culverts blocked by vegetation

Photo 7: D/S EXT - LB view of ditch leading to other CSP culverts

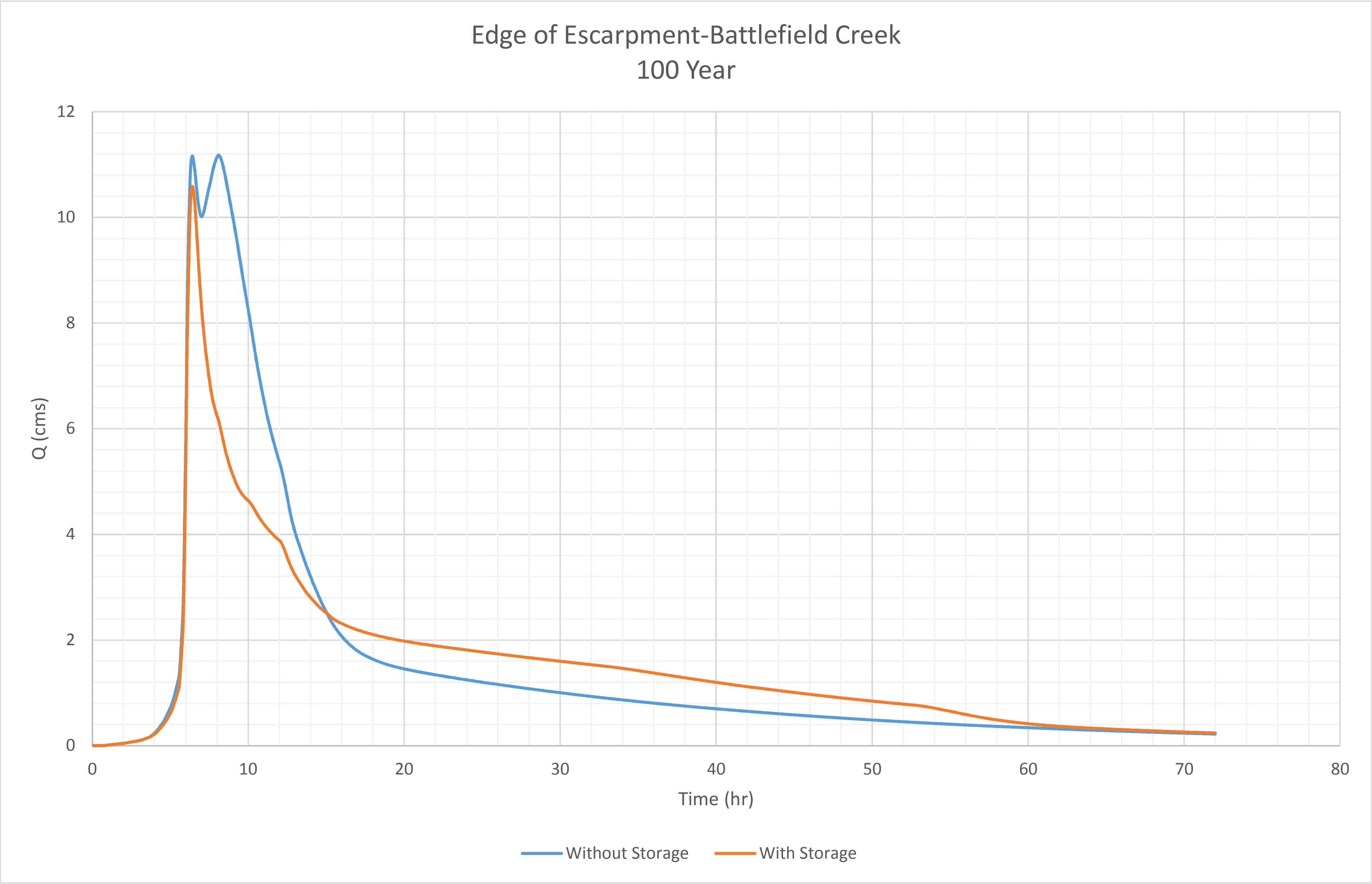
Photo 8: D/S EXT – U/S view of dry dual CSP culverts

Appendix C

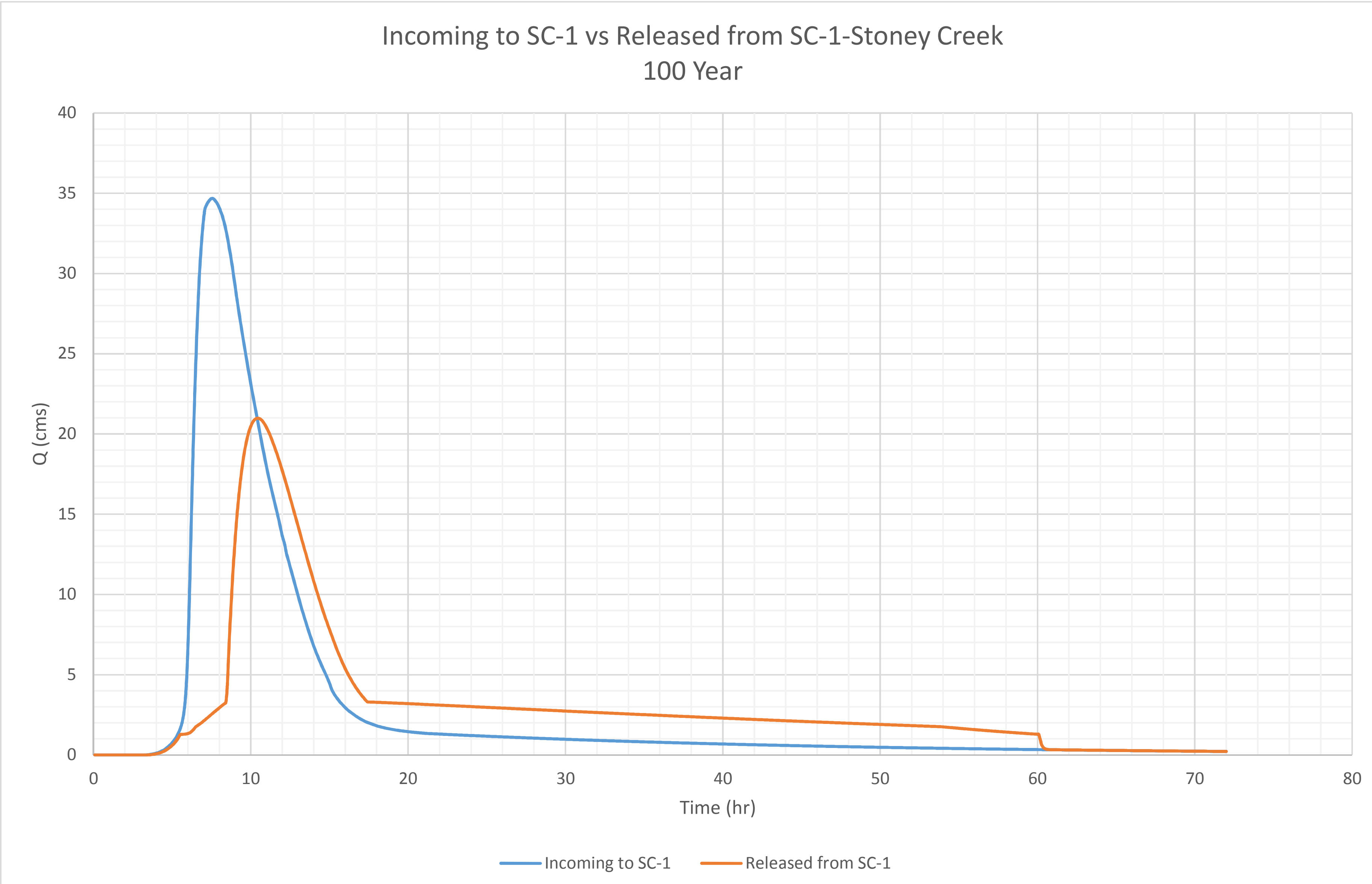
Hydrology and Hydraulics (CD)

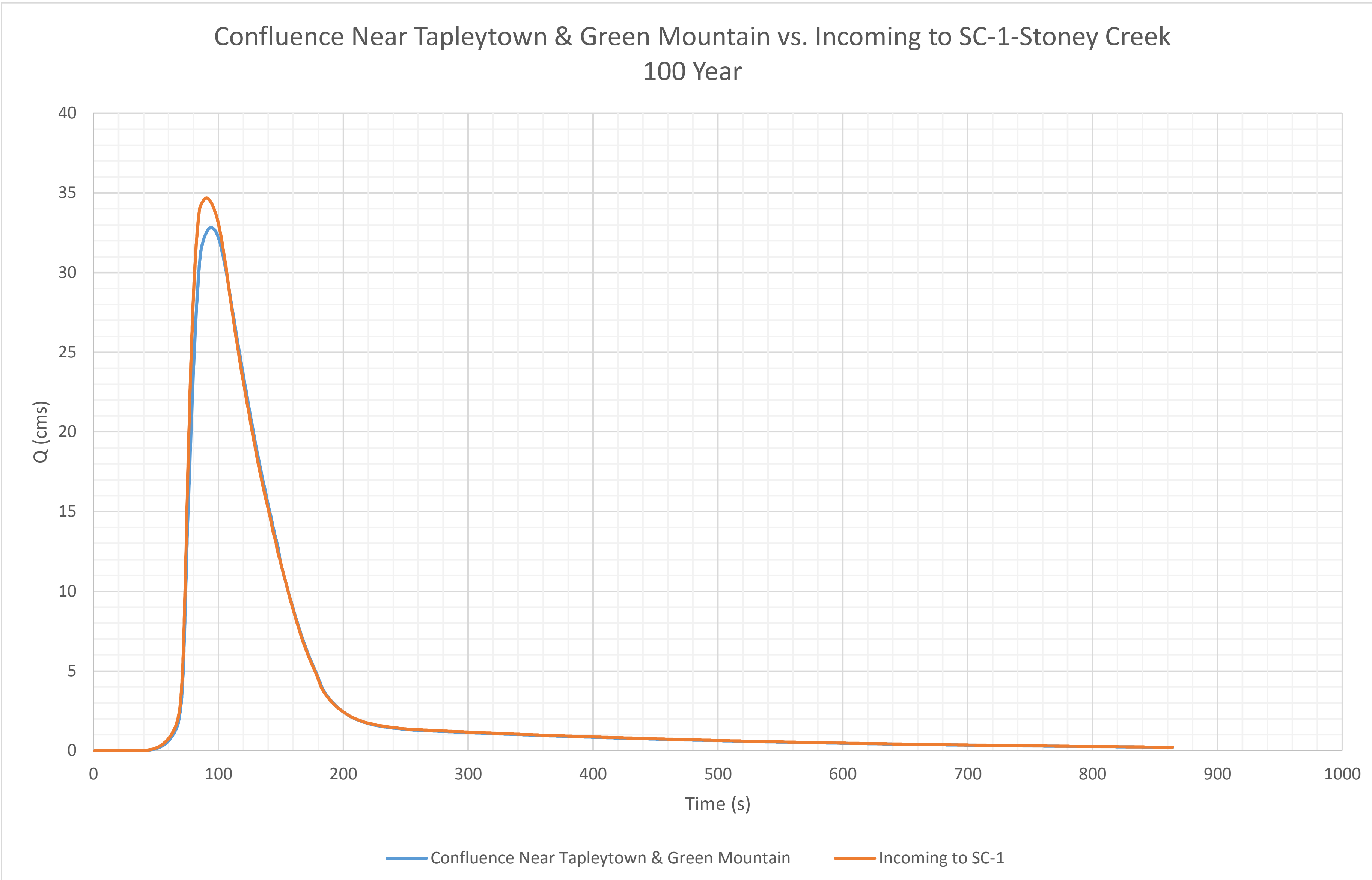


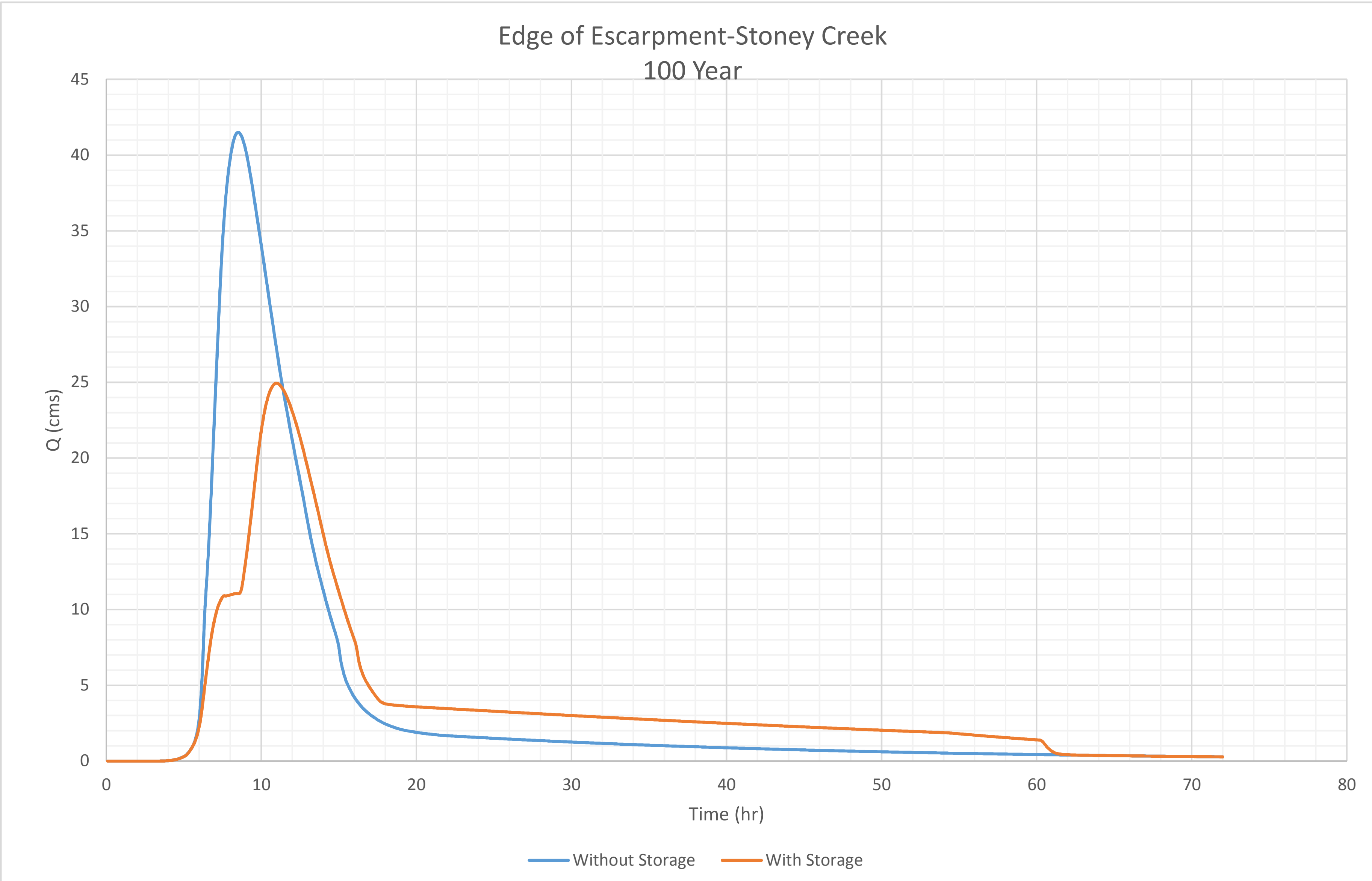
Confluence Near Centennial Parkway-Battlefield Creek
100 Year
Q (cms)
Time (hr)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
Without Storage
With Storage

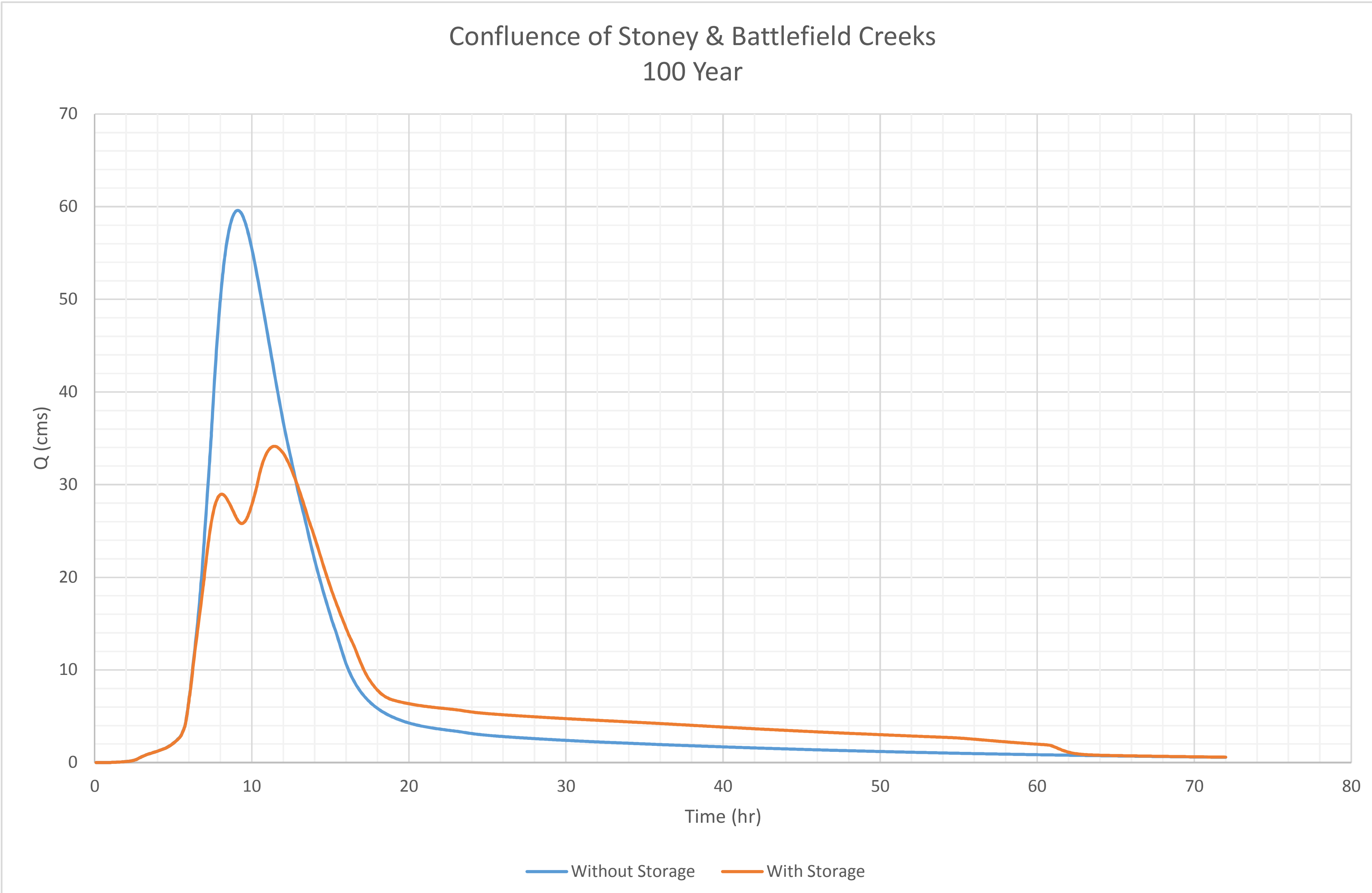


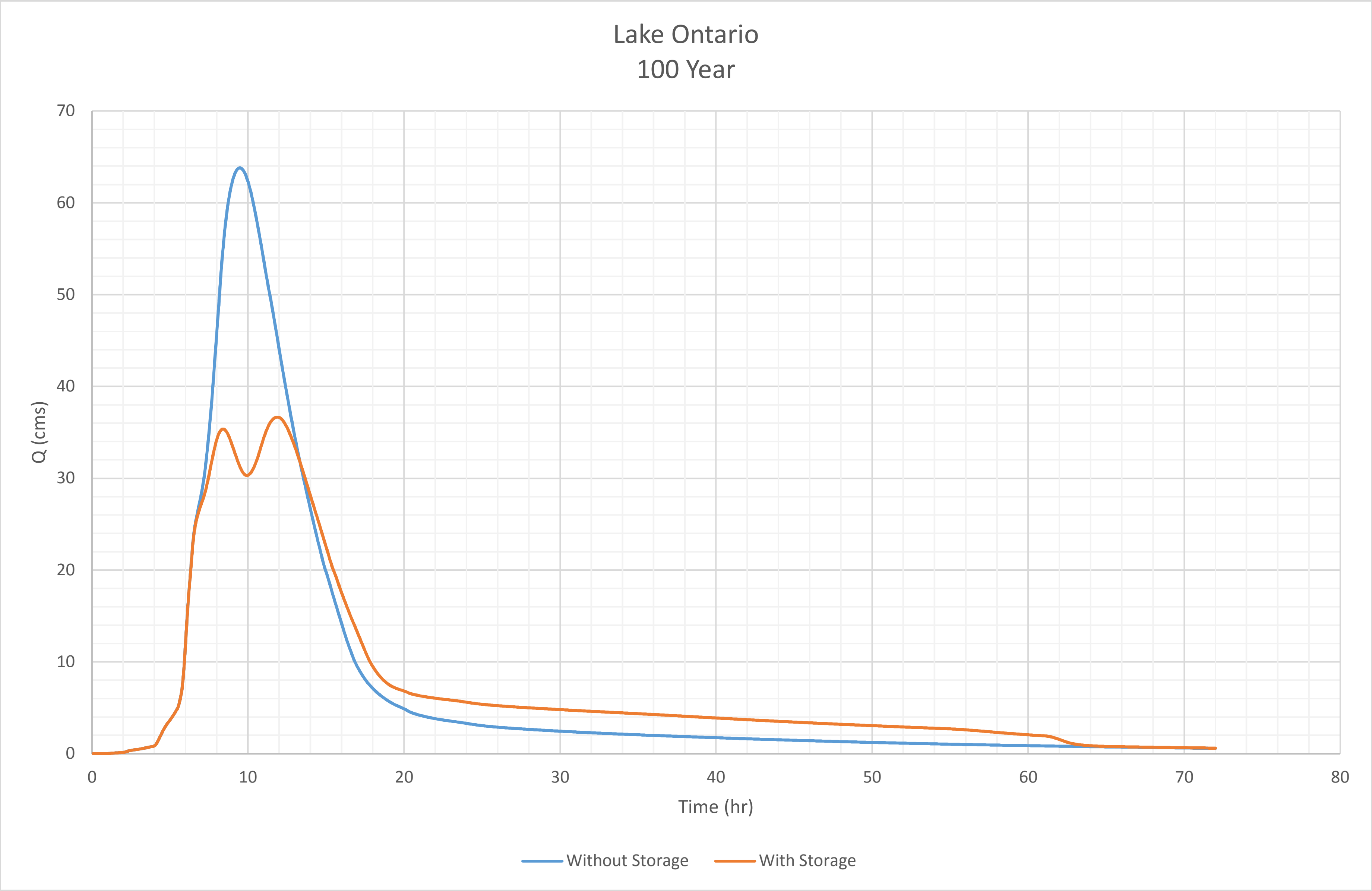
Edge of Escarpment-Battlefield Creek
100 Year
Q (cms)
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
Time (hr)
Without Storage
With Storage


Incoming to SC-1 vs Released from SC-1-Stoney Creek
100 Year
Q (cms)
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Time (hr)
Incoming to SC-1
Released from SC-1

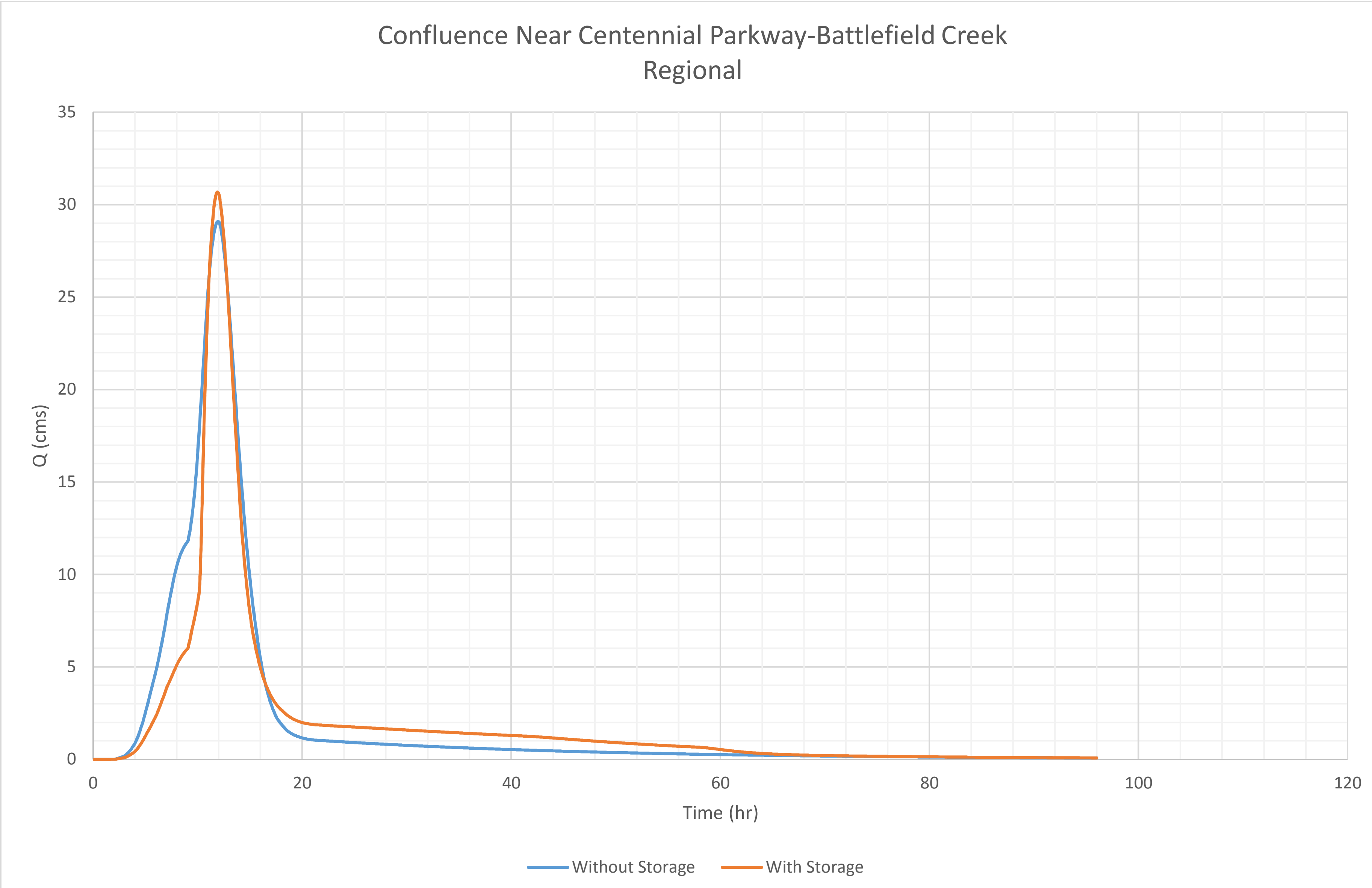

Confluence Near Tapleytown & Green Mountain vs. Incoming to SC-1-Stoney Creek
100 Year
Q (cms)
40
35
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
900
1000
Time (s)
Confluence Near Tapleytown & Green Mountain
Incoming to SC-1

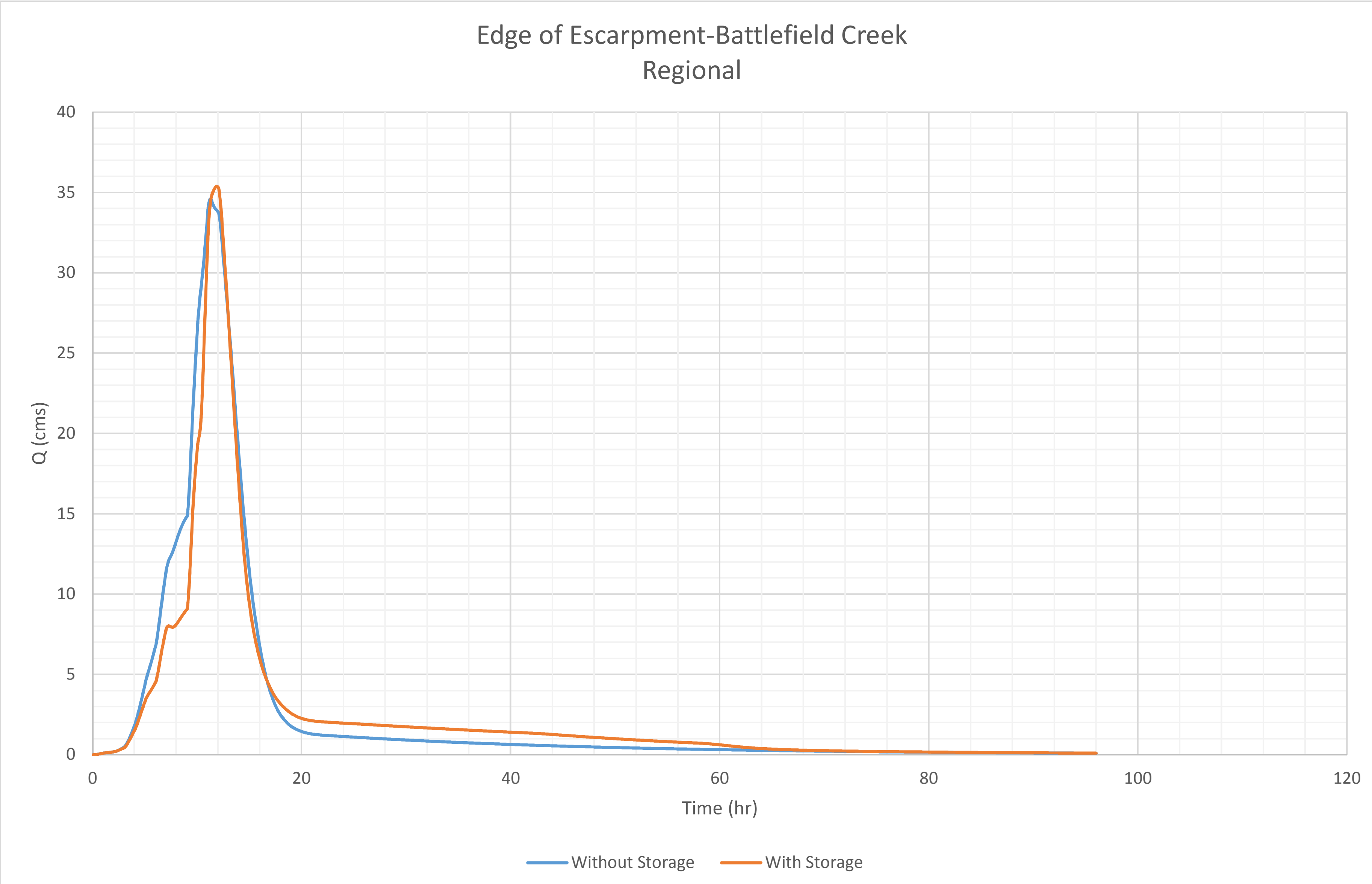

Edge of Escarpment-Stoney Creek
100 Year
Q (cms)
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
Time (hr)
Without Storage
With Storage

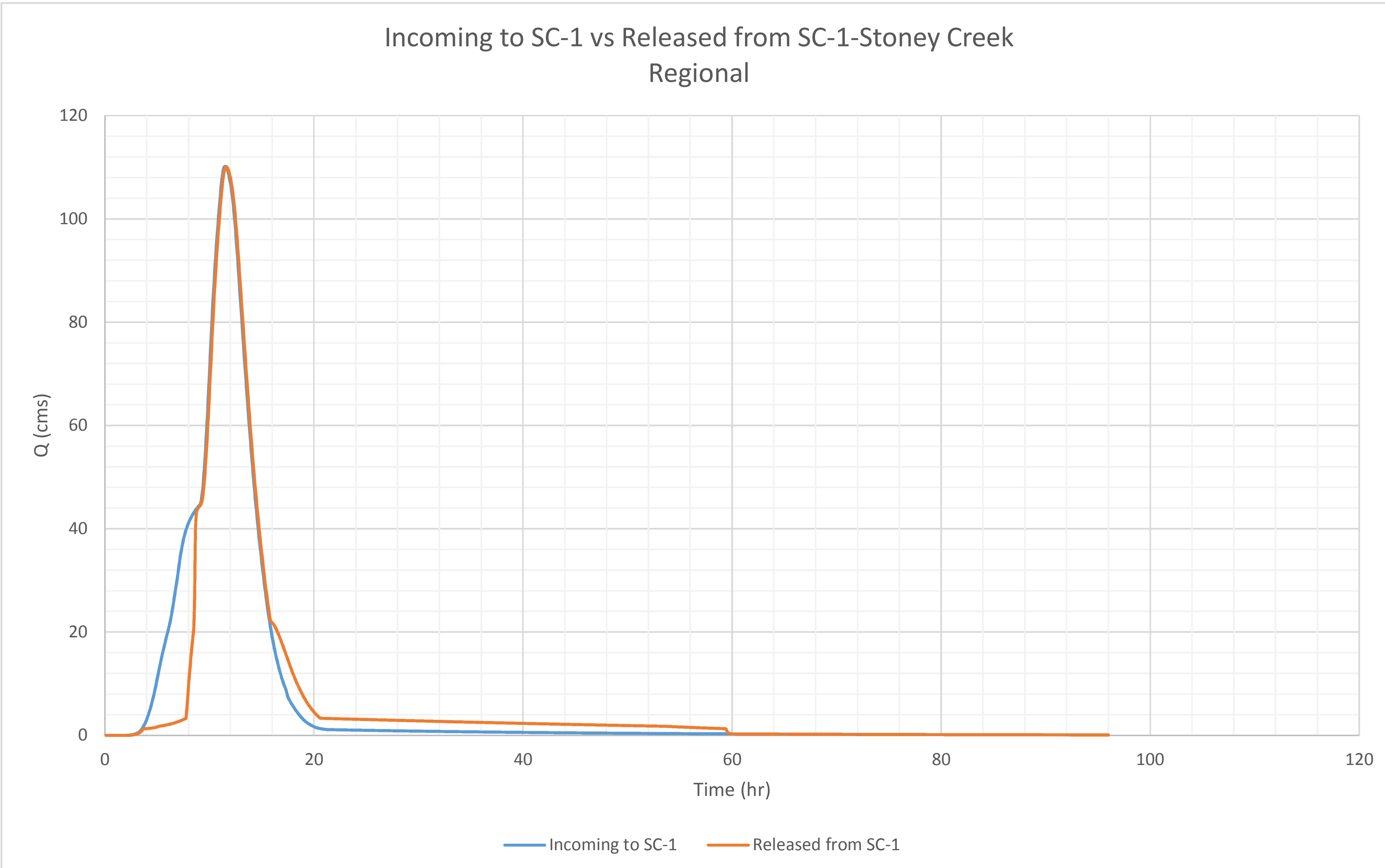

Confluence of Stoney & Battlefield Creeks
100 Year
Q (cms)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
Time (hr)
Without Storage
With Storage

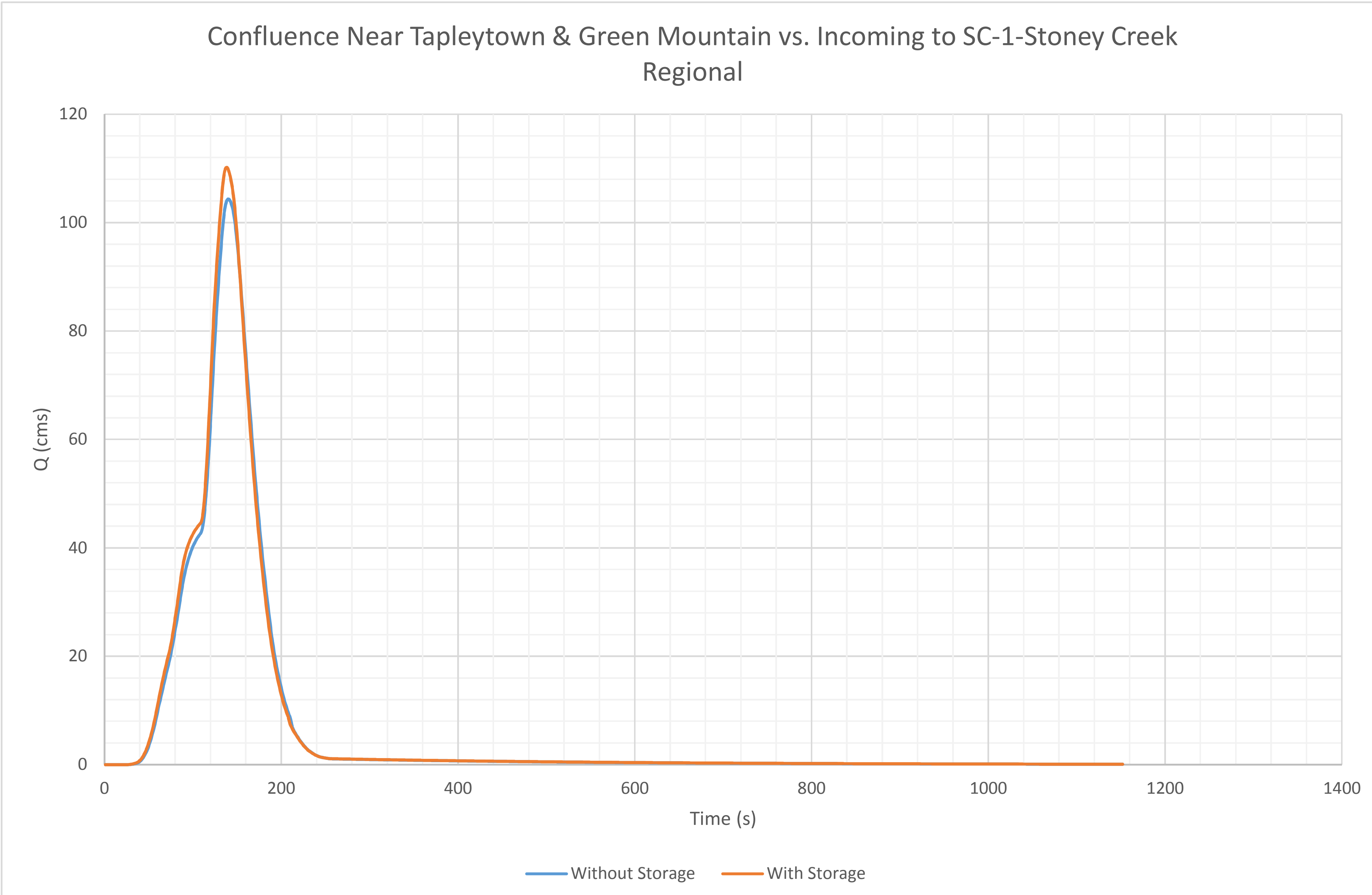


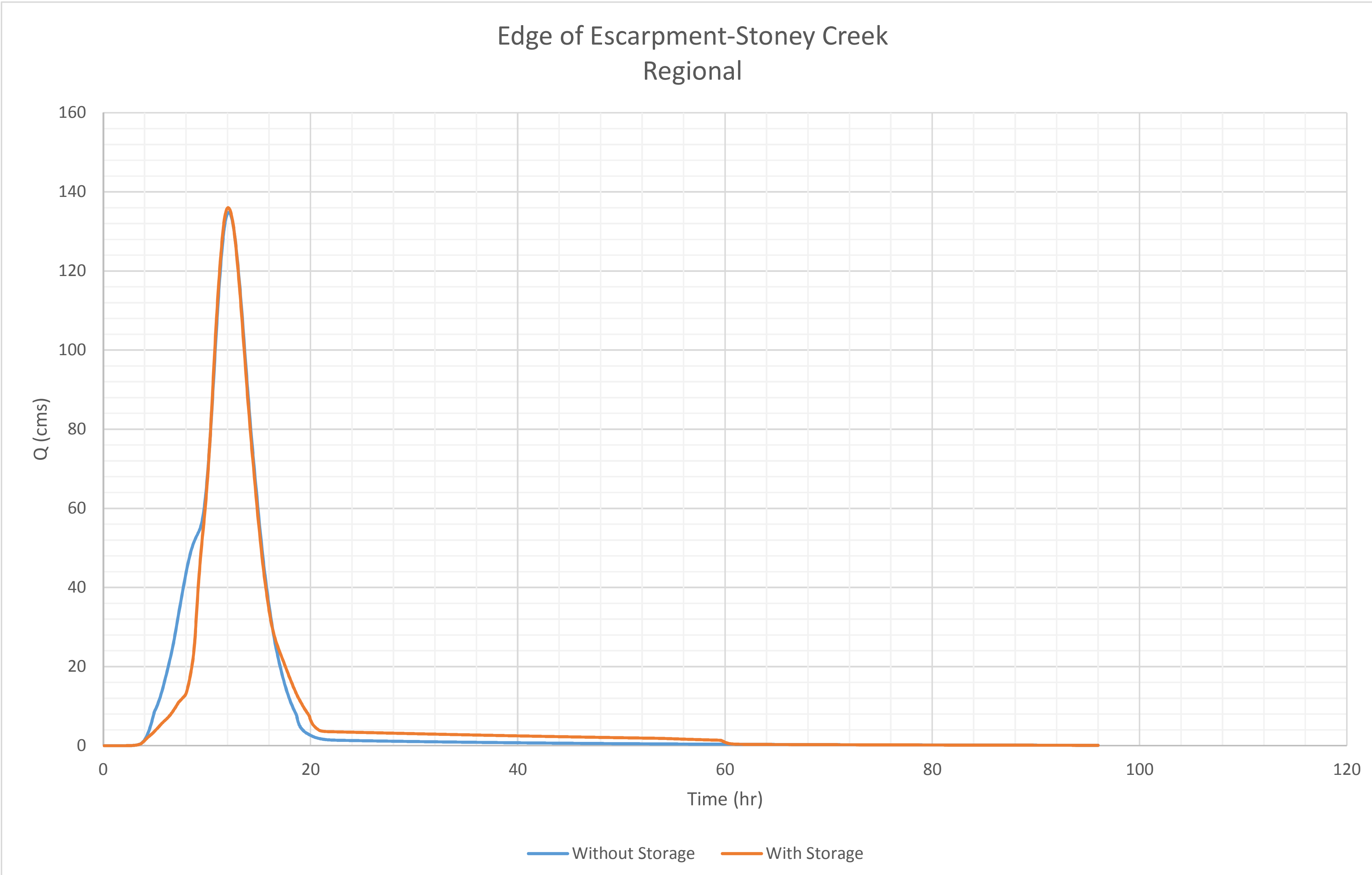
Lake Ontario
100 Year
Q (cms)
0
10
20
30
40
50
60
70
0
10
20
30
40
50
60
70
80
Time (hr)
Without Storage
With Storage

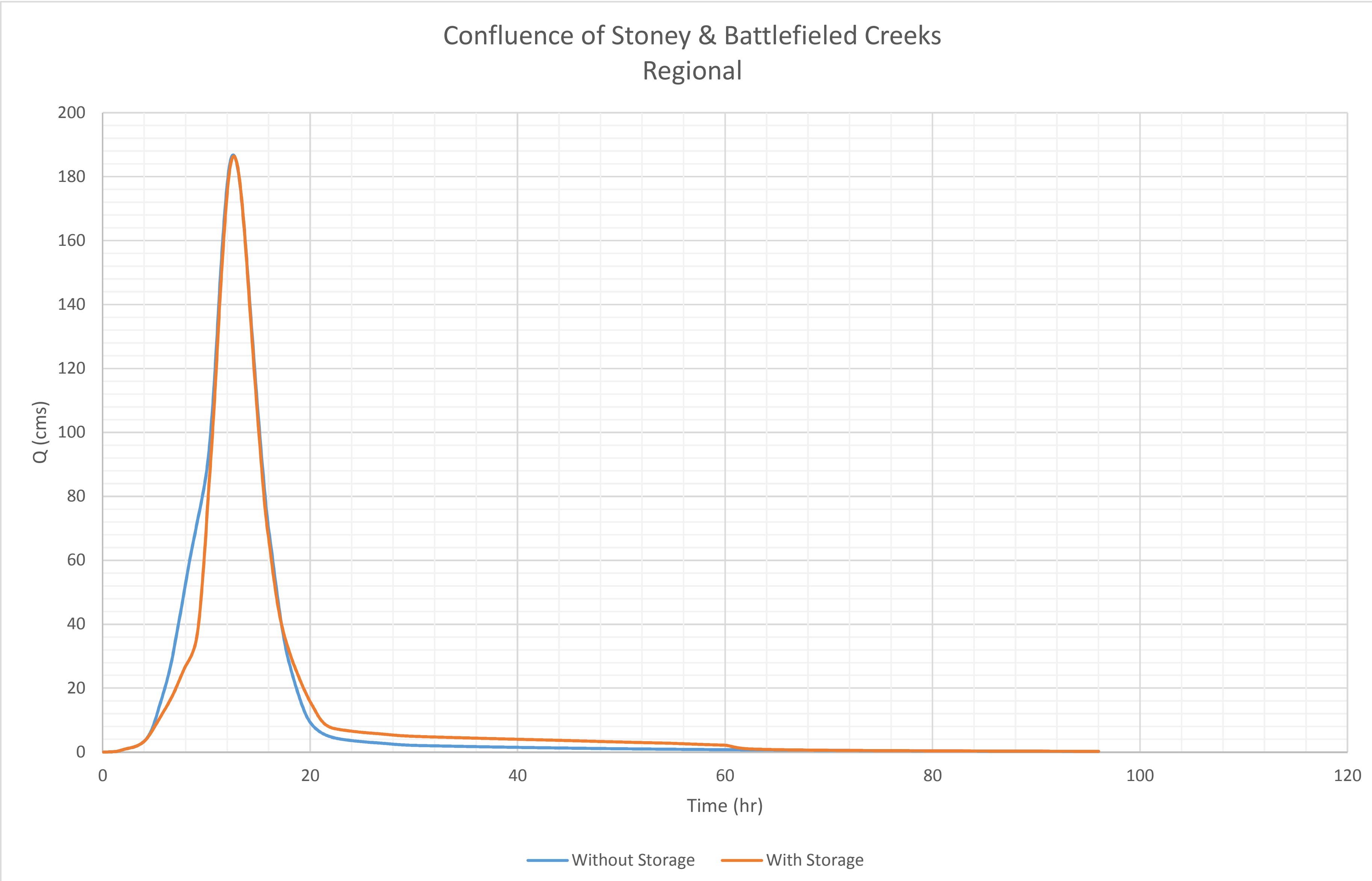

Confluence Near Centennial Parkway-Battlefield Creek
Regional
Q (cms)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
Time (hr)
Without Storage
With Storage

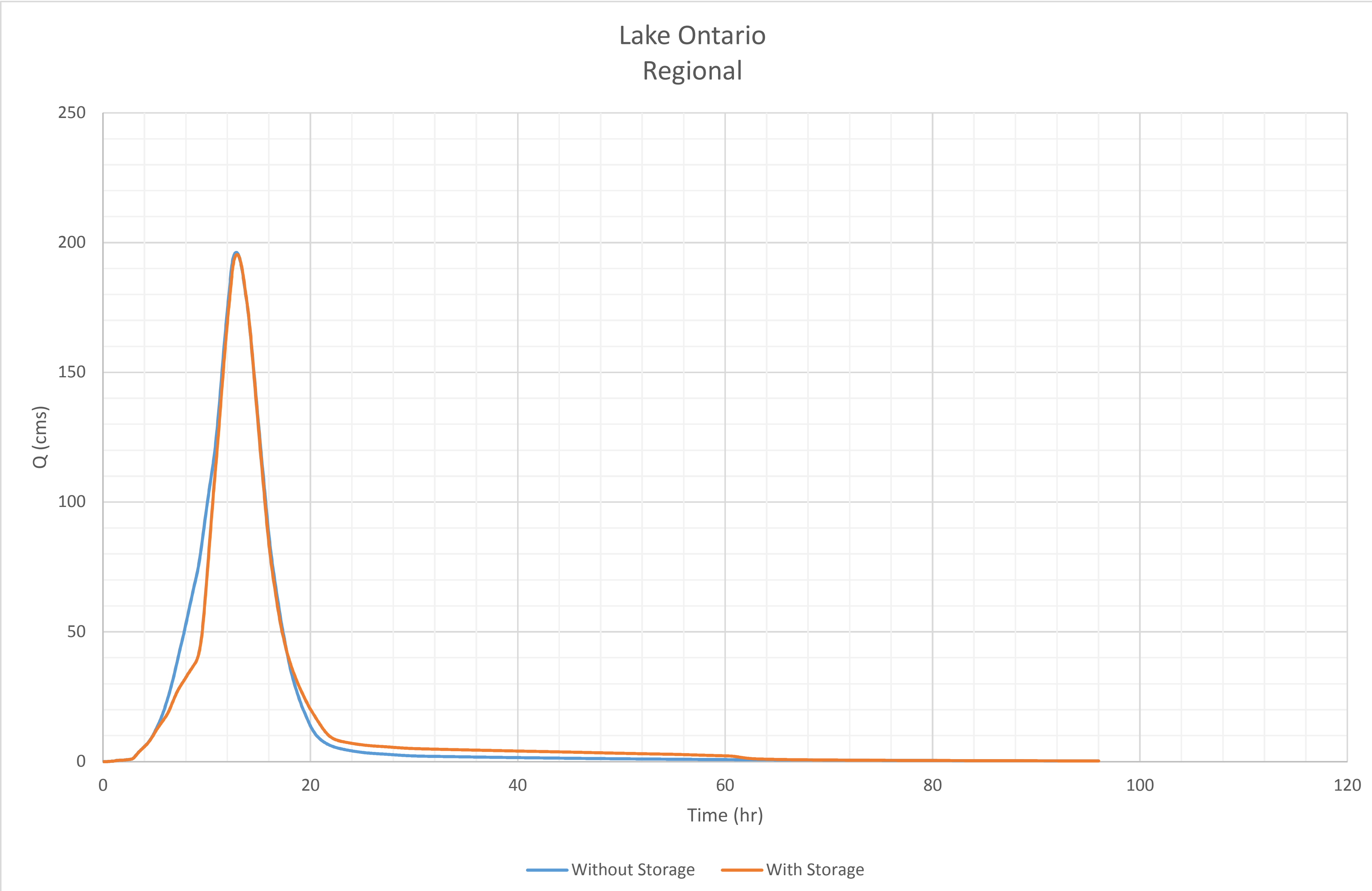

Edge of Escarpment-Battlefield Creek
Regional
40
35
30
25
20
15
10
5
0
Q (cms)
0
20
40
60
80
100
120
Time (hr)
Without Storage
With Storage


Incoming to SC-1 vs Released from SC-1-Stoney Creek Regional
Q (cms)
0
20
40
60
80
100
120
Time (hr)
0
20
40
60
80
100
120
Incoming to SC-1
Released from SC-1


Confluence Near Tapleytown & Green Mountain vs. Incoming to SC-1-Stoney Creek Regional
Q (cms)
0
20
40
60
80
100
120
Time (s)
0
200
400
600
800
1000
1200
1400
Without Storage
With Storage


Edge of Escarpment-Stoney Creek
Regional
160
140
120
100
80
60
40
20
0
Q (cms)
0
20
40
60
80
100
120
Time (hr)
Without Storage
With Storage


Confluence of Stoney & Battlefieled Creeks
Regional
Q (cms)
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
Time (hr)
Without Storage
With Storage


Lake Ontario
Regional
Q (cms)
250
200
150
100
50
0
0
20
40
60
80
100
120
Time (hr)
Without Storage
With Storage

Appendix D

Storage Location Photo Inventory

Floodplain Storage – Photo Inventory (July 25, 2016)

BC – 1 (First Road E)

Photo 1 – Downstream view of BC-1 concrete culvert.

Photo 2 – Upstream view of BC-1 concrete culvert.

Photo 3 – Northeast view of densely vegetated floodplain.

Photo 4 – East view of dense vegetation along upstream channel.

BC – 1 (First Road E)

Photo 5 – Southeast view of less dense vegetation, opens up to larger field.

SC – 1 (Tapleytown Road)

Photo 6 – Downstream view of SC-1 culvert.

Photo 7 – Upstream view of SC-1 culvert.

Photo 8 – Northeast view of large flat fields north of residential prop.

Photo 9 – Northeast view of large flat field and residential prop.

SC – 1 (Tapleytown Road)

Photo 10 – East view of large flat farm field and tree lined channel.

Photo 11 – Southeast view of large flat farm field.

Floodplain Storage – Photo Inventory (July 25, 2016)

SC – 2 (Third Road E)

Photo 12 – Northeast view of open field lined with trees.

Photo 13 – East view of open farm field.

Photo 14 – Southeast view of open field, residential property/farm behind trees.

Floodplain Storage – Photo Inventory (July 25, 2016)

SC – 3 (North of Green Mountain Road, East of Fifth Rd E)

Photo 15 – Northeast view from Fifth Rd E of open field leading to dense forest.

Photo 16 – Northwest view from Green Mountain Rd of open field leading to dense forest.

Photo 17 – Northeast view from Green Mountain Rd of open field leading to dense forest.

Floodplain Storage – Photo Inventory (July 25, 2016)

SC – 4 (Second Road E)

Photo 18 – Downstream view of SC-4 concrete culvert.

Photo 19 – Upstream view of SC-4 concrete culvert.

Photo 20 – Northwest view of open field floodplain.

Photo 21 – Southwest view of open field floodplain.

Floodplain Storage – Photo Inventory (Desktop)

SC – 5 (Ridge Road and First Road East)

Photo 22 – Storage area (Scenario 2) southeast of Ridge Road.

Photo 23 – Storage area (Scenario 1) south of Ridge Road

Photo 24 – Looking west at Stoney Creek from First Line Rd. E.

Photo 25 – Northwest view of storage area.

Floodplain Storage – Photo Inventory (Desktop)

SC – 6 (Second Road East and Ridge Road)

Photo 26 – Storage area west of Second Road East.

Photo 27 – Looking west at Stoney Creek at Second Road East

Photo 28 – Looking south at storage area from Ridge Road

Floodplain Storage – Photo Inventory (Desktop)

SC – 7 (Third Road East and Tapleytown Road East)

Photo 29 – Stoney Creek east of Third Line East

Photo 30 – Looking east to storage area from Third Road E.

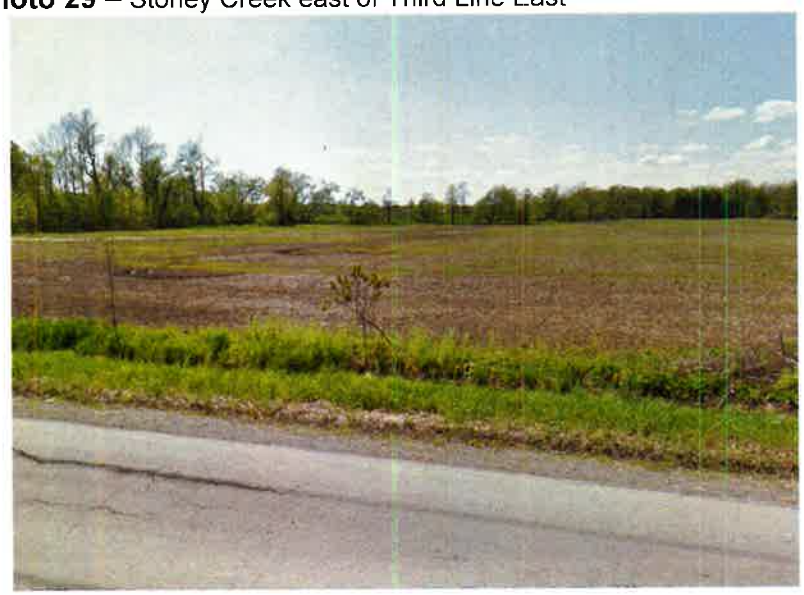


Photo 31 – Looking west from Tapleytown Road to storage area

Photo 32 – Looking west from Tapleytown Road E. at creek.

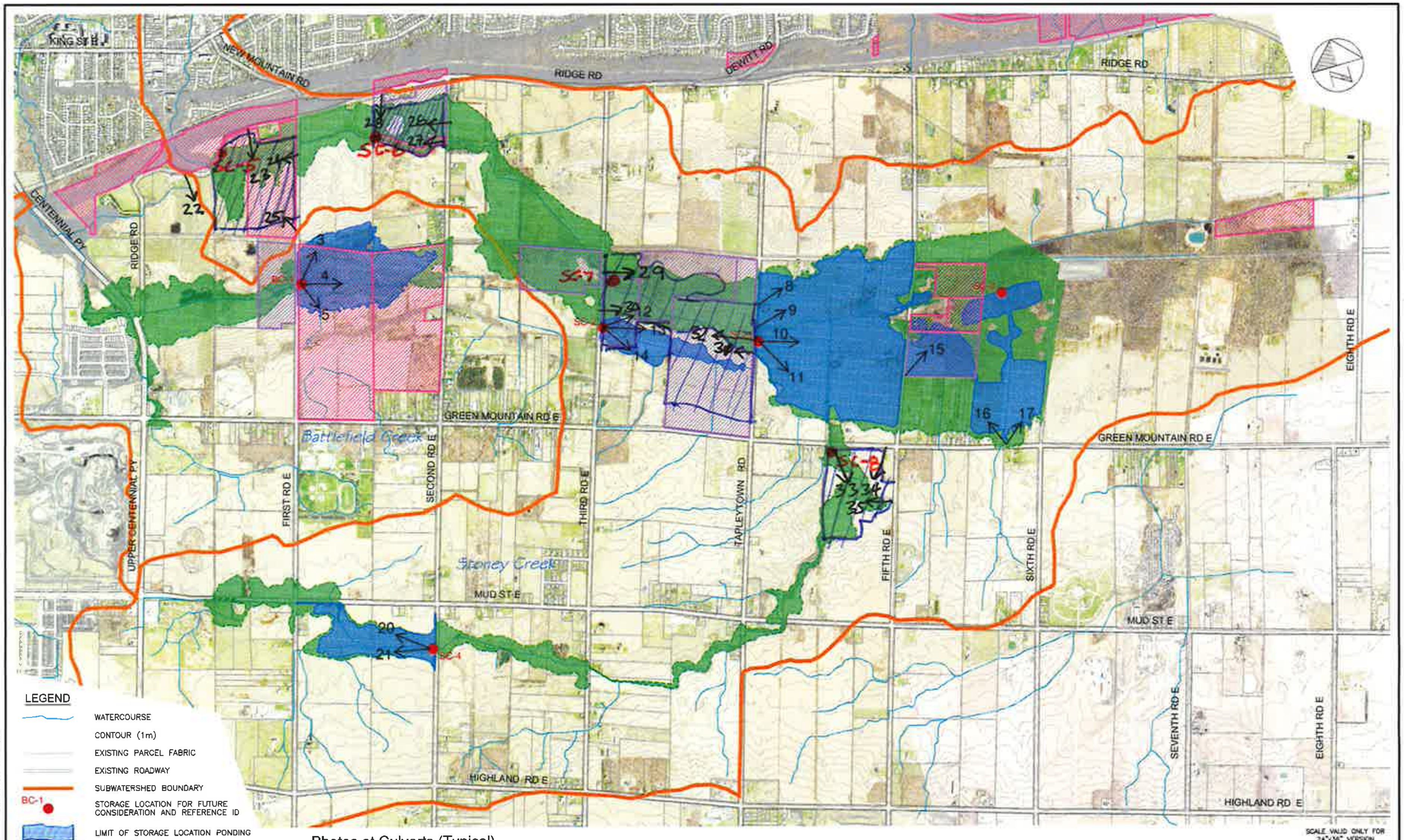
Floodplain Storage – Photo Inventory (Desktop)

SC – 8 (Green Mountain Road East and Fifth Road East)

Photo 33 – Looking south at storage area from Green Mountain Road East.

Photo 34.Looking south at storage area from Green Mountain Road East.

Photo 35 – Looking west from Fifth Road East to storage area



FEASIBILITY STUDY FLOOD & EROSION CONTROL PROJECT UPPER BATTLEFIELD & UPPER STONEY CREEK

HAMILTON CONSERVATION AUTHORITY

STORAGE AREAS, REGIONAL FLOODPLAIN AND AUTHORITY PROPERTIES

amec foster wheeler

Scale 1:10000

Consultant File No. TPB168024

Figure No. 2B

Appendix E

Critical Erosion Flow Assessment

1 STONEY/BATTLEFIELD EROSION THRESHOLD RESULTS

1.1 Battlefield Creek

Results based on Komar (1987) and Yang (1973) and Lane (1955) methods, the average critical discharge was 1.93 m^3/s. Tables 1-3 contain a summary of the physical and hydraulic characteristics of the measured cross-sections and erosion threshold results.

Table 1 Physical Cross-Section Summary at Upstream Battlefield Creek

	XS-1	*XS-2*	*XS-3*	*Average*
Bankfull Width (m)	6.00	5.40	7.60	**6.33**
Average Bankfull Depth (m)	0.44	0.30	0.47	**0.40**
Maximum Bankfull Depth (m)	0.67	0.43	0.73	**0.61**
Bankfull Width:Depth	13.76	17.93	16.23	**15.97**
Cross-sectional Area (m^2)	2.62	1.63	3.52	**2.59**
Wetted Perimeter (m)	6.42	5.69	7.91	**6.67**
Hydraulic Radius (m)	0.41	0.29	0.44	**0.38**
Left Bank Angle (^{o})	22.9	45.0	25.0	**30.97**
Right Bank Angle (^{o})	51.0	33.7	11.3	**31.99**
Left Bank Height (m)	0.38	0.20	0.28	**0.29**
Right Bank Height (m)	0.37	0.20	0.20	**0.26**
Left Bank Wetted Perimeter (m)	0.98	0.40	0.67	**0.68**
Right Bank Wetted Perimeter (m)	0.48	0.36	1.02	**0.62**

Table 2 Hydraulic Cross-Section Summary at Upstream Battlefield Creek

	XS-1	XS-2	XS-3	Average
Bankfull Discharge (m^3/s)	9.17	4.06	14.12	**9.11**
Average Bankfull Velocity (m/s)	3.14	2.33	3.32	**2.93**
Maximum Bankfull Velocity (m/s)	4.24	3.00	4.95	**4.06**
Average Shear Velocity [u*] (m/s)	0.41	0.35	0.43	**0.40**
Reynolds Number	16416	13752	28571	**19580**
Reynolds Flow Type	Rough	Rough	Rough	**-**
Froude Number	1.52	1.36	1.55	**1.48**
Froude Flow Type	Super-critical	Super-critical	Super-critical	**-**
Stream Power (W/m)	3867	1711	5954	**3844**
Stream Power per unit Width (W/m^2)	644	317	783	**581**
Average Shear Stress (N/m^2)	172	121	187	**160**
Maximum Shear Stress (N/m^2)	247	162	300	**236**
Left Bank Shear Stress (N/m^2)	126	80	130	**112**
Right Bank Shear Stress (N/m^2)	115	78	139	**110**
Critical Particle Diameter for Analysis (m)	0.04	0.04	0.07	**0.05**

Table 3 Threshold Summary of Upstream Battlefield Creek

		XS-1	XS-2	XS-3	Average
Komar (1987)	Critical Discharge (m^3/s)	1.11	0.94	2.40	**1.48**
	Critical/Bankfull Discharge	12.13%	23.25%	16.98%	**17%**
	Maximum Depth (m)	0.28	0.24	0.39	**0.30**
	Average Depth (m)	0.18	0.17	0.25	**0.20**
	Maximum Velocity	1.58	1.52	2.21	**1.77**
	Average Velocity	1.02	1.08	1.44	**1.18**
Yang (1973)	Critical Discharge (m^3/s)	1.60	1.35	3.49	**2.15**
	Critical/Bankfull Discharge	17.47%	33.36%	24.76%	**25%**
	Maximum Depth (m)	0.32	0.27	0.44	**0.34**
	Average Depth (m)	0.22	0.19	0.29	**0.23**
	Maximum Velocity	1.87	1.79	2.62	**2.09**
	Average Velocity	1.28	1.27	1.75	**1.43**
Lane (1955)	Critical Discharge (m^3/s)	1.77	0.85	3.84	**2.15**
	Critical/Bankfull Discharge	19.36%	20.94%	27.19%	**22%**
	Maximum Depth (m)	0.33	0.23	0.45	**0.34**
	Average Depth (m)	0.23	0.16	0.30	**0.23**
	Maximum Velocity	1.96	1.45	2.73	**2.05**
	Average Velocity	1.37	1.02	1.85	**1.41**

1.2 Stoney Creek

Results based on Komar (1987) and Yang (1973) methods, the average critical discharge was 7.53 m^3/s. Tables 4-6 contain a summary of the physical and hydraulic characteristics of the measured cross-sections and erosion threshold results.

Table 4 Physical Cross-Section Summary at Upstream Stoney Creek

	XS-1	*XS-2*	*XS-3*	*XS-4*	*XS-5*	*Average*
Bankfull Width (m)	11.40	11.10	9.90	9.30	9.90	**10.32**
Average Bankfull Depth (m)	0.90	0.80	1.12	1.14	0.89	**0.97**
Maximum Bankfull Depth (m)	1.12	1.26	1.60	1.41	1.03	**1.28**
Bankfull Width:Depth	12.71	13.79	8.85	8.13	11.13	**10.92**
Cross-sectional Area (m^2)	10.22	8.93	11.08	10.64	8.81	**9.93**
Wetted Perimeter (m)	12.30	11.91	10.87	10.39	10.76	**11.25**
Hydraulic Radius (m)	0.83	0.75	1.02	1.02	0.82	**0.89**
Left Bank Angle (^{o})	36.3	45.0	37.9	48.0	49.0	**43.23**
Right Bank Angle (^{o})	64.9	45.0	41.2	46.5	49.8	**49.47**
Left Bank Height (m)	0.66	0.30	0.70	1.00	0.69	**0.67**
Right Bank Height (m)	0.64	0.30	0.70	1.00	0.71	**0.67**
Left Bank Wetted Perimeter (m)	1.13	0.42	1.14	1.35	0.91	**0.99**
Right Bank Wetted Perimeter (m)	0.71	0.42	1.25	1.29	0.93	**0.92**

Table 5 Hydraulic Cross-Section Summary at Upstream Stoney Creek

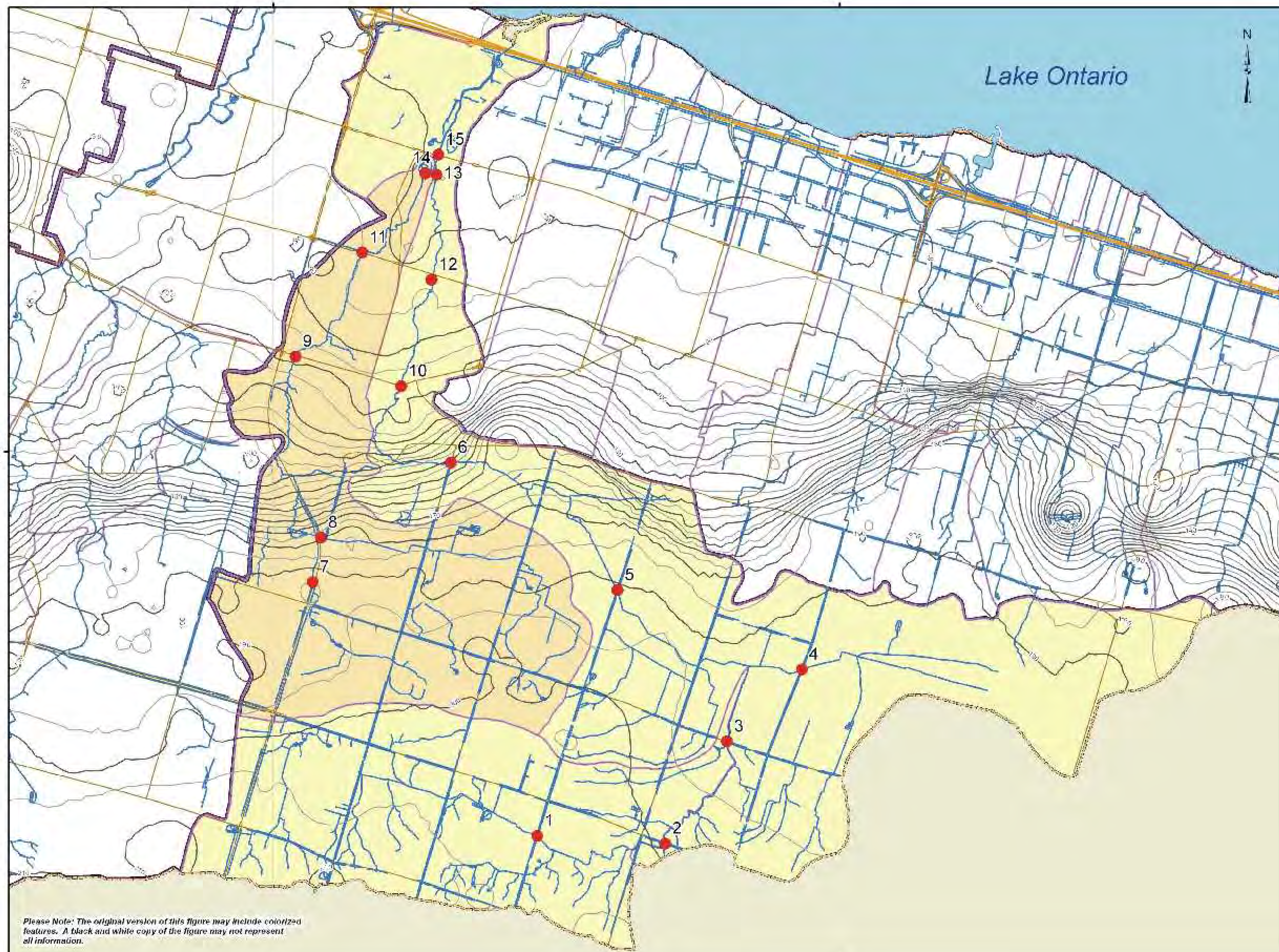
	XS-1	*XS-2*	*XS-3*	*XS-4*	*XS-5*	*Average*
Bankfull Discharge (m^3/s)	49.36	40.15	70.51	66.40	42.22	**53.73**
Average Bankfull Velocity (m/s)	4.53	4.03	5.44	5.58	4.47	**4.81**
Maximum Bankfull Velocity (m/s)	5.68	6.47	8.01	7.17	5.38	**6.54**
Average Shear Velocity [u*] (m/s)	0.52	0.49	0.57	0.58	0.51	**0.54**
Reynolds Number	17972	26020	42648	68369	50939	**41190**
Reynolds Flow Type	Rough	Rough	Rough	Rough	Rough	**-**
Froude Number	1.53	1.44	1.64	1.66	1.51	**1.56**
Froude Flow Type	Super-critical	Super-critical	Super-critical	Super-critical	Super-critical	**-**
Stream Power (W/m)	15980	12997	22825	21497	13668	**17393**
Stream Power per unit Width (W/m^2)	1402	1171	2306	2311	1381	**1714**
Average Shear Stress (N/m^2)	269	243	330	331	265	**288**
Maximum Shear Stress (N/m^2)	353	406	515	455	333	**412**
Left Bank Shear Stress (N/m^2)	186	132	231	236	180	**193**
Right Bank Shear Stress (N/m^2)	168	132	234	235	181	**190**
Critical Particle Diameter (m)	0.04	0.05	0.08	0.12	0.10	**0.08**

Table 6 Threshold Summary of Upstream Stoney Creek

		XS-1	*XS-2*	*XS-3*	*XS-4*	*XS-5*	*Average*
Komar (1987)	Critical Discharge (m^3/s)	3.74	6.17	6.68	7.29	6.70	**6.11**
	Critical/Bankfull Discharge	7.58%	15.37%	9.47%	10.97%	15.86%	**12%**
	Maximum Depth (m)	0.47	0.74	0.72	0.63	0.53	**0.62**
	Average Depth (m)	0.33	0.35	0.45	0.51	0.43	**0.41**
	Maximum Velocity	1.56	3.02	2.57	2.18	1.94	**2.26**
	Average Velocity	1.01	1.27	1.49	1.72	1.54	**1.41**
Yang (1973)	Critical Discharge (m^3/s)	5.19	8.56	9.54	11.24	10.22	**8.95**
	Critical/Bankfull Discharge	10.50%	21.32%	13.53%	16.93%	24.22%	**17%**
	Maximum Depth (m)	0.52	0.81	0.81	0.73	0.61	**0.70**
	Average Depth (m)	0.37	0.41	0.52	0.59	0.51	**0.48**
	Maximum Velocity	1.83	3.43	3.05	2.75	2.45	**2.70**
	Average Velocity	1.22	1.60	1.84	2.17	2.01	**1.77**

Appendix F

Environmental Conditions Assessment Documentation



Stoney Creek / Battlefield Creek Groundwater Study

LEGEND

- Baselfow Observation
- Road (Collector)
- Highway / Expressway
- River / Stream
- Static Water Level Contour (5m Intervals)
- StudyArea
- Subwatersheds
- Battlefield Creek Watershed
- Stoney Creek Watershed
- Other Watersheds
- OpenWater

Scale: 1:35,000

500 0 500 1,000

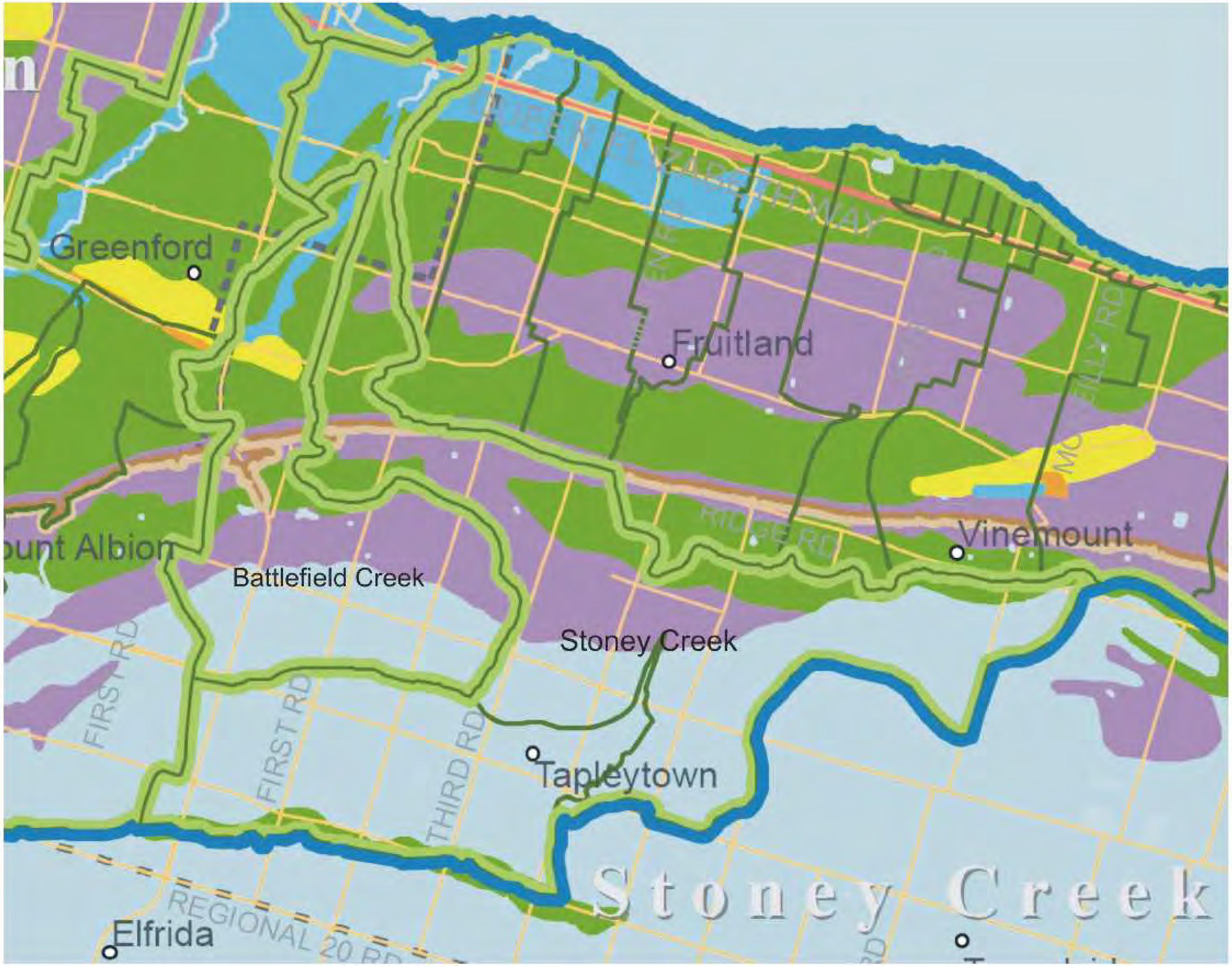
Meters

REFERENCES:

Base Data - Ministry of Natural Resources, 2008; Conservation Halton - Hamilton Conservation Authority, 2009.

Projection: UTM Zone 17N, NAD 83

Figure GW-1



Stoney Creek / Battlefield Creek Groundwater Study

Legend

- Study Area
- Hamilton Conservation Authority
- Watersheds
- Subwatersheds
- Lower Tier Municipalities
- Upper Tier Municipalities
- Niagara Escarpment

Roads

- Highway
- Regional
- Water Bodies

Surficial Geology - Material

- Paleozoic Bedrock
- Precambrian Bedrock
- Clay
- Diamicton
- Fill
- Gravel
- Organic Deposits
- Sand
- Silt

Source: Watershed Characterization Report
Prepared by: Source Water Protection Halton-Hamilton Region

Figure GW-2

October 2009

20090003_StoneyBattlefield

Appendix F1. Species at Risk Screening for Stoney Creek Restoration Feasibility sites, Stoney Creek

1 – no suitable habitat within 120 metres of the site.
2 – potential habitat present within 120 metres but species not detected in 2017 using MNRF-endorsed protocols.
3 – potential habitat present within 120 metres but species not surveyed for using MNRF-endorsed protocols.
4 – potential habitat within 120 metres but no property access; further surveys required.
5 – species detected in 2017; see report for details.
6 – species not detected in 2017 but known records from the general area; see report for details.
7 – no field surveys undertaken; potential for species unknown; further study required

SPECIES	SAR Designation	Status in City of Hamilton & Surrounding Areas (to July 2017)	Key Habitats Used By Species	Status at Stoney Creek Feasibility sites and adjacent lands (within 120 metres)										Notes
				BC-1	SC-1	SC-2	SC-3	SC-4	SC-5 A	SC-5 B	SC-6	SC-7	SC-8	
Jefferson Salamander (*Ambystoma jeffersonianum*)	Endangered	Known to Occur	Inhabits deciduous and mixed deciduous forests with suitable breeding areas which generally consist of ephemeral (temporary) bodies of water that are fed by spring runoff, groundwater, or springs.	3, 4	1	1	3, 4	1	3	1	1	1	1	MNRF database lists this species, likely from the Devil's Punchbowl Escarpment ESA. Note that Vinemount South Swamp ESA (SC-3) does not list it.
BIRDS														
Acadian Flycatcher (*Empidonax virescens*)	Endangered	Known to Occur	Generally requires large areas of mature, undisturbed forest; avoids the forest edge; often found in well wooded swamps and ravines.	1	1	1	2	1	3	1	1	1	1	No records from area (MNRF/NHIC databases and ESA summaries).
Bald Eagle (*Haliaeetus leucocephalus*)	Special Concern	Known to Occur	Prefers deciduous and mixed-deciduous forest; and habitat close to water bodies such as lakes and rivers; they roost in super canopy trees such as pine.	1	1	1	1	1	1	1	1	1	1	
Bank Swallow (*Riparia riparia*)	Threatened (federal only)	Known to Occur	Low areas along rivers, streams, coasts or reservoirs; nest in natural bluffs and eroding streamside banks, also sand and gravel quarries and road cuts	1	1	1	1	1	7	1	1	1	1	Listed for Devil's Punchbowl Escarpment ESA (SC-5 A).
Barn Owl (*Tyto alba*)	Endangered	Known to Occur	Generally prefers low-elevation, open country; often associated with agricultural lands, especially pasture. Nests are located in buildings, hollow trees and cavities in cliffs.	1	1	3	1	1	1	1	1	1	1	Only considered nesting sites (e.g. buildings), not foraging habitat (which is found around SC-1, and SC-4, 5 A, 5 B, 6, 7, and 8).
Barn Swallow (*Hirundo rustica*)	Threatened	Known to Occur	Prefers farmland, lake/river shorelines, wooded clearings, urban populated areas, rocky cliffs, and wetlands. They nest inside or outside buildings; under bridges and in road culverts; on rock faces and in caves, etc.	2	2	2	1	5	3	3	3	3	3	For SC-4, there are no structures for nesting within 120 metres; the birds seen were foraging only (low quality foraging habitat). For BC-1, SC-1, SC5, SC-6, and SC-7, there is foraging habitat only; SC-2 and SC-8 have foraging and nesting habitat.

Appendix F1. Species at Risk Screening for Stoney Creek Restoration Feasibility sites, Stoney Creek

Black Tern (*Childonias niger*)	Special Concern	Known to Occur	Generally prefers freshwater marshes and wetlands; nests either on floating material in a marsh or on the ground very close to water.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Bobolink (*Dolichonyx oryzivorus*)	Threatened	Known to Occur	Generally prefers open grasslands and hay fields. In migration and in winter uses freshwater marshes and grasslands.	**1**	**1**	**1**	**1**	**2**	**7**	**7**	**7**	**7**	**7**	Birds were nesting in the meadow immediately north of the SC-3 woods (beyond 120 m). See report for details.
Canada Warbler (*Wilsonia canadensis*)	Threatened (federal) / Special Concern (provincial)	Suspected to Occur	Generally prefers wet coniferous, deciduous and mixed forest types, with a dense shrub layer. Nests on the ground, on logs or hummocks, and uses dense shrub layer to conceal the nest.	**1**	**1**	**1**	**2**	**1**	**3**	**1**	**1**	**7**	**1**	Listed for Devil's Punchbowl Escarpment ESA (SC-5 A).
Cerulean Warbler (*Dendroica cerulea*)	Endangered (federal) / Threatened (provincial)	Historically Known to Occur	Generally found in mature deciduous forests with an open understorey; also nests in older, second-growth deciduous forests	**1**	**1**	**1**	**2**	**1**	**7**	**1**	**1**	**7**	**1**	No records from area (MNRF/NHIC databases and ESA summaries).
Chimney Swift (*Chaetura pelagica*)	Threatened	Known to Occur	Historically found in deciduous and coniferous, usually wet forest types, all with a well developed, dense shrub layer; now most are found in urban areas in large uncapped chimneys.	**1**	**1**	**1**	**2**	**1**	**3**	**1**	**1**	**1**	**1**	No structures with chimneys within 120 metres of SC-3. Listed for Devil's Punchbowl Escarpment ESA (SC-5 A).
Common Nighthawk (*Chordeiles minor*)	Threatened (federal) / Special Concern (provincial)	Known to Occur	Generally prefers open, vegetation-free habitats, including dunes, beaches, recently harvested forests, burnt-over areas, logged areas, rocky outcrops, rocky barrens, grasslands, pastures, peat bogs, marshes, lakeshores, and river banks. This species also inhabits mixed and coniferous forests. Can also be found in urban areas (nests on flat roof-tops).	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Eastern Meadowlark (*Sturnella Magna*)	Threatened	Known to Occur	Generally prefers grassy pastures, meadows and hay fields. Nests are always on the ground and usually hidden in or under grass clumps.	**1**	**1**	**1**	**1**	**2**	**7**	**7**	**7**	**7**	**7**	Birds were nesting in the meadow immediately north of the SC-3 woods (beyond 120 m).
Eastern Whip-poor-will *(Caprimlugus vociferus)*	Threatened	Known to Occur	Generally prefers semi-open deciduous forests or patchy forests with clearings; areas with little ground cover are also preferred. In winter they occupy primarily mixed woods near open areas.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Eastern Wood-Pewee (*Contopus virens*)	Special Concern	Known to Occur	Found in deciduous, mixed woods, or pine plantations; also found in mature woodlands, urban shade trees, roadsides, and orchards; usually found in clearings and forest edges.	**2**	**2**	**1**	**5**	**1**	**3**	**3**	**3**	**3**	**3**	A common and widespread species in southern Ontario and within the City of Hamilton. Not protected by the ESA (2007).
Golden-winged Warbler (*Vermivora chrysoptera*)	Special Concern	Known to Occur	Generally prefers areas of early successional vegetation, found primarily on field edges, hydro or utility right-of-ways, or recently logged areas.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Henslow's Sparrow *(Ammodramus henslowii)*	Endangered	Historically Known to Occur	Generally found in old fields, pastures and wet meadows. They prefer areas with dense, tall grasses, and thatch, or decaying plant material.	**1**	**1**	**1**	**1**	**1**	**7**	**7**	**7**	**7**	**7**	Not likely as extirpated from Region.

King Rail (*Rallus elegans*)	Endangered	Historically Known to Occur	Freshwater and brackish marshes and rice fields.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Least Bittern *(Ixobrychus exilis)*	Threatened	Known to Occur	Generally located near pools of open water in relatively large marshes and swamps that are dominated by cattail and other robust emergent plants.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Louisiana Waterthrush *(Seiurus motacilla)*	Special Concern	Known to Occur	Generally inhabits mature forests along steeply sloped ravines adjacent to running water. Prefers clear, cold streams and densely wooded swamps.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Peregrine Falcon (*Falco peregrinus*)	Special Concern	Known to Occur	Mountain ranges, coastlines, river valleys, and increasingly in cities.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Records from area in MNRF database.
Prothonotary Warbler (*Protonotaria citrea*)	Endangered	Known to Occur	Generally found in the dead trees of flooded woodlands or deciduous swamp forests; Carolinian Zone	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	No records from area (MNRF/NHIC databases and ESA summaries).
Red-headed Woodpecker *(Melanerpes erythrocephalus)*	Threatened (federal) / Special Concern (provincial)	Known to Occur	Generally prefers open oak and beech forests, grasslands, forest edges, orchards, pastures, riparian forests, roadsides, urban parks, golf courses, cemeteries, as well as along beaver ponds and brooks.	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**7**	**7**	No records from area (MNRF/NHIC databases and ESA summaries).
Short-eared Owl *(Asio flammeus)*	Special Concern	Known to Occur	Generally prefers a wide variety of open habitats, including grasslands, peat bogs, marshes, sand-sage concentrations, old pastures and agricultural fields.	**1**	**1**	**1**	**1**	**3, 4**	**1**	**7**	**7**	**7**	**7**	
Wood Thrush (*Hylocichla mustelina*)	Special Concern (federal only)	Known to Occur	Breeds in mature deciduous and mixed forests, most commonly those with American beech, sweet gum, red maple, black gum, eastern hemlock, flowering dogwood, American hornbeam, oaks, or pines; nests less successfully in fragmented forests and suburban parks with enough large trees for a territory; ideal habitat includes trees over 50 feet tall, a moderate understory of saplings/shrubs, an open floor with moist soil and decaying leaf litter, and water nearby.	**2**	**1**	**1**	**5**	**1**	**3**	**1**	**1**	**3**	**1**	Recorded in 2017 breeding bird surveys in SC-3.
Yellow-breasted Chat *(Icteria virens)*	Endangered	Historically Known to Occur	Generally prefers dense thickets around wood edges, riparian areas, and in overgrown clearings.	**1**	**1**	**1**	**2, 6**	**1**	**1**	**1**	**1**	**7**	**1**	There is a record for 2002 from Vinemount South Swamp ESA (SC-3). Not likely from this part of the ESA as the habitat is not suitable. Not detected during breeding bird surveys.
FISH														
American Eel (*Anguilla rostrata*)	Endangered	Known to Occur	All fresh water, estuaries and coastal marine waters that are accessible to the Atlantic Ocean; 12-mile Creek watershed and Lake Ontario	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Grass Pickerel (*Esox americanus vermiculatus*)	Special Concern	Known to Occur	Generally occur in wetlands with warm, shallow water and an abundance of aquatic plants; occur in the St.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	

Appendix F1. Species at Risk Screening for Stoney Creek Restoration Feasibility sites, Stoney Creek

			Lawrence River, Lake Ontario, Lake Erie, and Lake Huron											
Redside Dace *(Clinostomus elongatus)*	Endangered	Known to Occur	Generally found in pools and slow-moving areas of small headwater streams with a moderate to high gradient.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Not listed in MNRF/NHIC databases or in the ESA summary for Vinemount South Swamp ESA (SC-3).
Silver Shiner *(Notropis photogenis)*	Threatened	Known to Occur	Generally prefer moderate to large, deep, relatively clear streams with swift currents, and moderate to high gradients.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
INSECTS														
Monarch *(Danaus plexippus)*	Special Concern	Known to Occur	Exist primarily wherever milkweed and wildflowers exist, such as abandoned farmland, along roadsides, and other open spaces.	**3, 4**	**3, 4**	**3, 4**	**1**	**3, 4**	**3**	**3**	**3**	**3**	**3**	Likely present at most of the sites at certain times of year, and likely breeds if Common Milkweed is present. Numbers likely not significant.
Mottled Duskywing (*Erynnis martialis*)	Endangered (federal only)	Known to Occur	Open woodland, barrens, prairie hills, open brushy fields, chaparral; larvae feed on New Jersey tea (*Ceanothus americanus*) and redroot (*Ceanothus herbaceus*).	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
West Virginia White (*Pieris virginiensis*)	Special Concern	Known to Occur	Generally prefer moist, deciduous woodlands; the larvae feed only on the leaves of the two-leaved toothwort (Cardamine diphylla), which is a small, spring-blooming plant of the forest floor.	**1**	**1**	**1**	**3**	**1**	**7**	**1**	**1**	**7**	**1**	Pre-1994 records for area from Ontario Butterfly Atlas (online). Not known if Common Toothwort is in these forests. If so, surveys required in late April to mid-May to determine status. Not listed in the ESA summary for Vinemount South Swamp (SC-3), athough none of the site visits from 1990 to 2002 were in late April to early May.
MAMMALS														
American Badger (*Taxidea taxus*)	Endangered	Known to Occur	Occurs primarily in grasslands and open areas with grasslands, which can include parklands, farms, and treeless areas; also found in forest glades and meadows, marshes, brushy areas, hot deserts, and mountain meadows.	**1**	**3, 4**	**3, 4**	**1**	**3, 4**	**7**	**7**	**7**	**7**	**7**	Can occur in agricultural areas and there are fairly recent records from this general area. Not listed for area in MNRF/NHIC databases or for the three ESAs (Vinemount South Swamp, Devil's Punchbowl Escarpment, and Tapleytown Woods). Confirmation would require property access to check for burrows within 120 m of all sites.
Eastern Small-footed Myotis (*Myotis leibii*)	Endangered	Known to Occur	Overwintering habitat: caves and mines that remain above 0 degrees Celsuis; Maternal roosts: primarily under loose rocks on exposed rock outcrops, crevices and cliffs, and occasionally in buildings, under bridges and highway overpasses, and under tree bark.	**3, 4**	**1**	**1**	**3, 4**	**1**	**3**	**1**	**1**	**3**	**1**	Habitat assessment refers to maternity roosts only (i.e., no overwintering habitat is known from any of the sites).

Little Brown Myotis (*Myotis lucifugus*)	Endangered	Known to Occur	Overwintering habitat: caves and mines that remain above 0 C; Maternal roosts: often associated with buildings (attics, barns, etc.). Occasionally found in trees (25-44 cm dbh).	**3, 4**	**1**	**1**	**3, 4**	**1**	**3**	**1**	**1**	**3**	**1**	Habitat assessment refers to maternity roosts only (i.e., no overwintering habitat is known from any of the sites).
Northern Myotis (*Myotis septentrionalis)*	Endangered	Known to Occur	Overwintering habitat: caves and mines that remain above 0 C; Maternal roosts: often asssociated with cavities of large diameter trees (25-44 cm dbh). Occasionally found in structures (attics, barns, etc.)	**3, 4**	**1**	**1**	**3, 4**	**1**	**3**	**1**	**1**	**3**	**1**	Habitat assessment refers to maternity roosts only (i.e., no overwintering habitat is known from any of the sites).
Tri-colored Bat (*Perimyotis subflavus*)	Endangered	Known to Occur	Overwintering habitat: caves and mines that remain above 0 degrees Celsius; Maternal roosts: can be in trees or dead clusters of leaves or arboreal lichens on trees. May also use barns or similar structures.	**3, 4**	**1**	**1**	**3, 4**	**1**	**3**	**1**	**1**	**3**	**1**	Habitat assessment refers to maternity roosts only (i.e., no overwintering habitat is known from any of the sites).
Woodland Vole (*Microtus pinetorum*)	Special Concern	Known to Occur	Occurs in deciduous forests, dry fields, and apple orchards, preferring wooded areas with high vertical vegetative stratification, also evergreen shrubs, ground cover, and old fallen logs. Most abundant in deciduous forests with moist, friable soils suitable for burrowing.	**3**	**1**	**1**	**3**	**1**	**3**	**1**	**1**	**3**	**1**	Fall trapping studies would be required to confirm presence.
MOLLUSCS (FRESHWATER MUSSELS)														
Eastern Pondmussel (*Ligumia nasuta*)	Endangered	Known to Occur	Generally inhabit sheltered areas of lakes or slow streams in substrates of fine sand and mud	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Lilliput (*Taxolasma parvum*)	Endangered	Known to Occur	Found in a variety of habitats including small to large rivers, wetlands, shallows of lakes, ponds and reservoirs. They are common in soft substrates with over 50% of the substrate type comprised of sand and a mud/muck/silt combination. Typically occur with or near Green Sunfish, Bluegill, White Crappie, and Johnny Darter	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Rainbow Mussel (*Villosa iris*)	Threatened	Known to Occur	Most abundant in shallow, well oxygenated reaches of small- to medium-sized rivers and sometimes lakes, on substrates of cobble, gravel,sand and occasionally mud.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
REPTILES														
Blanding's Turtle *(Emydonidea blandingii)*	Threatened	Known to Occur	Generally occurs in freshwater lakes, permanent or temporary pools, slow-flowing streams, marshes and swamps. Prefers shallow water that is rich in nutrients, organic soil and dense vegetation. Adults are generally found in open or partially vegetated sites, and juveniles prefer areas that contain thick aquatic vegetation including sphagnum, water lilies and algae. Overwintering	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	No records from area (MNRF/NHIC databases and ESA summaries).

			occurs in permanent pools that average about one metre in depth, or in slow-flowing streams.											
Eastern Hog-nosed Snake (*Heterodon platirhinos*)	Threatened	Known to Occur	Generally prefer habitats with sandy, well-drained soil and open vegetative cover, such as open woods, brushland, fields, forest edges and disturbed sites. The species is often found near water.	**3, 4**	**3, 4**	**3, 4**	**1**	**1**	**1**	**1**	**7**	**7**	**1**	MNRF/NHIC databases do not list this species. ESA summary for Vinemount South Swamp (surrounding SC-3) indicates that the soils are not suitable (i.e., poorly drained silty clay loam) so this species is not likely present throughout area.
Eastern Ribbonsnake *(Thamnophis sauritus)*	Special Concern	Known to Occur	Generally occurs along the edges of shallow ponds, streams, marshes, swamps, or bogs bordered by dense vegetation that provides cover. Abundant exposure to sunlight is also required, and adjacent upland areas may be used for nesting.	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**1**	**7**	**1**	Not listed in MNRF/NHIC databases or in the ESA summary for Vinemount South Swamp ESA (surrounding SC-3).
Northern Map Turtle (*Graptemys geographica*)	Special Concern	Known to Occur	Found in large rivers and lakes with slow-moving currents and soft bottoms	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	No records from area (MNRF/NHIC databases and ESA summaries).
Snapping Turtle (*Chelydra serpentina*)	Special Concern	Known to Occur	Generally inhabit shallow waters where they can hide under the soft mud and leaf litter. Nesting sites usually occur on gravely or sandy areas along streams. Can use man-made structures for nest sites, including roads (e.g. gravel shoulders), dams and aggregate pits.	**3, 4**	**3, 4**	**1**	**3**	**3, 4**	**3**	**3**	**3**	**3**	**3**	This species is common and widespread in the area and likely occurs at most, if not all, of the sites. As a Special Concern species, it mainly presents a constraint from a Significant Wildlife Habitat perspective.
Spiny Softshell (*Apalone spinifera*)	Threatened	Known to Occur	Found in rivers with soft bottoms, aquatic vegetation and sandbars or mudflats; also lakes or impoundments.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	
Vascular Plants														
American Chestnut (*Castanea dentata*)	Endangered	Known to Occur	Found in deciduous forest communities; this tree prefers arid forests with acid and sandy soils.	**3, 4**	**3, 4**	**1**	**3, 4**	**1**	**1**	**1**	**1**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
American Columbo (*Frasera caroliniensis*)	Endangered	Known to Occur	Most commonly associated with open deciduous forested slopes, thickets and clearings; grows in a variety of relatively stable habitats and on a wide variety of soils.	**3, 4**	**3, 4**	**1**	**3, 4**	**1**	**3**	**1**	**3, 4**	**3, 4**	**3, 4**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
American Ginseng (*Panax quinquefolius*)	Endangered	Known to Occur	Grows in rich, moist, undisturbed and relatively mature deciduous woods in areas of neutral soil (such as over limestone or marble bedrock).	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).

Broad Beech Fern (*Phegopteris hexagonoptera*)	Special Concern	Known to Occur	Generally inhabits shady areas of beech and maple forests where the soil is moist or wet.	**3, 4**	**3, 4**	**1**	**3, 4**	**1**	**1**	**1**	**1**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
Butternut (*Juglans cinerea*)	Endangered	Known to Occur	Generally grows in rich, moist, and well-drained soils often found along streams. Found on well-drained gravel sites, especially those made up of limestone, and seldomly on dry, rocky and sterile soils. Generally grows alone or in small groups in deciduous forests as well as in hedgerows.	**4**	**4**	**4**	**4, 6**	**4**	**4, 6**	**4**	**4**	**4, 6**	**4**	Could occur at all ten sites as all of them have streams and/or hedgerows. Listed in the MNRF and NHIC databases for general area. It is not listed in the summary for Vinemount South Swamp ESA (SC-3); listed as present at Tapleytown Woods ESA (SC-7) and Devil's Punchbowl Escarpment ESA (SC-5 A).
Eastern Flowering Dogwood (*Cornus florida*)	Endangered	Known to Occur	Generally grows in deciduous and mixed forests, in the drier areas of its habitat, although it is occasionally found in slightly moist environments; also grows around edges and hedgerows.	**1**	**1**	**1**	**3, 4**	**1**	**1**	**1**	**1**	**3, 4**	**1**	Not listed in the MNRF database; records in NHIC database. Not listed in the summary for Vinemount South Swamp (SC-3) and Tapleytown Woods (SC-7) ESAs. Listed for Devil's Punchbowl Escarpment ESA (SC-5 A).
Few-flowered Club-rush (*Trichophorum planifolium*)	Endangered	Known to Occur	Generally found in Dry Fresh Oak deciduous forests and Dry Fresh Oak-Maple-Hickory deciduous forests (only found on RBG property).	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
Green Dragon (*Arisaema dracontium*)	Special Concern	Known to Occur	Generally grows in damp deciduous forests and along streams.	**3, 4**	**1**	**1**	**3, 4**	**1**	**1**	**3, 4**	**3, 4**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in the summary for Vinemount South Swamp ESA (SC-3).
Hoary Mountain-Mint (*Pycnanthemum incanum*)	Endangered	Known to Occur	Oak savannas and prairies, dry sites.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
Red Mulberry (*Morus rubra*)	Endangered	Known to Occur	Generally grows in moist forest, including slopes and ravines of the Niagara Escarpment, and sand spits and bottom lands; can grow in open areas e.g. hydro corridors.	**3, 4**	**3, 4**	**1**	**3, 4**	**1**	**3, 6**	**4**	**1**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
Spotted Wintergreen (*Chimaphila maculata*)	Endangered	Known to Occur	Generally grow in sandy habitats in dry-mesic oak-pine woods.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	Not listed in the MNRF database; records in NHIC database. Not listed in any ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).
White Wood Aster (*Eurybia divaricata*)	Threatened	Known to Occur	Generally grows in open, dry, deciduous forests. It has been suggested that it may benefit from some disturbance, as it often grows along trails.	**1**	**1**	**1**	**3, 4**	**1**	**3, 4**	**3, 4**	**1**	**3, 4**	**1**	Not listed in the MNRF/NHIC databases nor in ESA summaries (Vinemount South Swamp, Tapleytown Woods, Devil's Punchbowl Escarpment).

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Acer negundo	Manitoba Maple		S5			N	0	-2			x		x
Acer platanoides	Norway Maple		SNA			I	0	5			x		
Acer saccharinum	Silver Maple		S5			N	5	-3	x		x		x
Acer saccharum	Sugar Maple		S5			N	4	3			x		x
Acer x freemanii	(Acer rubrum X Acer saccharinum)		SNA			I					x		x
Achillea millefolium	Common Yarrow		SNA			N					x	x	x
Alisma triviale	Northern Water-plantain		S5			N					x		
Alliaria petiolata	Garlic Mustard		SNA			I	0	0	x			x	x
Ambrosia artemisiifolia	Annual Ragweed		S5			N	0	3	x				x
Arctium minus	Common Burdock		SNA			I	0	5			x		x
Arisaema triphyllum	Jack-in-the-pulpit		S5			N	5	-2			x		
Asclepias incarnata	Swamp Milkweed		S5			N	6	-5			x		
Asclepias syriaca	Common Milkweed		S5			N	0	5			x		x
Barbarea vulgaris	Bitter Wintercress		SNA			I	0	0	x				x
Bidens frondosa	Devil's Beggarticks		S5			N	3	-3			x		
Bromus inermis	Awnless Brome		SNA			I	0	5	x			x	
Campanula rapunculoides	Creeping Bellflower		SNA			I	0	5			x		
Carex blanda	Woodland Sedge		S5			N	3	0					x
Carex crinita	Fringed Sedge		S5			N	6	-4			x		
Carex lupulina	Hop Sedge		S5			N	10	-4			x		
Carya ovata	Shagbark Hickory		S5			N	6	3					x
Cerastium arvense ssp. arvense	Field Chickweed		SNA			I	0	5			x	x	x
Circaea canadensis	Broad-leaved Enchanter's Nightshade		S5			N	3	3					x

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Cirsium arvense	Canada Thistle		SNA			I	0	3	x				
Cirsium vulgare	Bull Thistle		SNA			I	0	4	x		x		
Clematis virginiana	Virginia Virgin's-bower		S5			N	3	0			x		
Cornus racemosa	Gray Dogwood		S5			N	2	-2	x		x		x
Cornus stolonifera	Red-osier Dogwood		S5			N	2	-3			x		
Cosmos bipinnatus	Garden Cosmos		SNA			I	0	5				x	
Dactylis glomerata	Orchard Grass		SNA			I	0	3	x	x			
Daucus carota	Wild Carrot		SNA			I	0	5	x		x	x	x
Dipsacus fullonum	Fuller's Teasel		SNA			I	0	5	x		x		x
Dryopteris carthusiana	Spinulose Wood Fern		S5			N	5	-2			x		
Equisetum arvense	Field Horsetail		S5			N	0	0			x		
Erigeron annuus	Annual Fleabane		S5			N	0	1					x
Eupatorium perfoliatum	Common Boneset		S5			N	2	-4			x		
Fragaria virginiana	Wild Strawberry		S5			N	2	1			x		x
Frangula alnus	Glossy Buckthorn		SNA			I	0	-1			x		x
Fraxinus pennsylvanica	Green Ash		S4			N	3	-3	x	x	x	x	x
Galium aparine	Cleavers		S5			N	4	3					x
Galium mollugo	Smooth Bedstraw		SNA			I	0	5			x		
Geranium maculatum	Spotted Geranium		S5			N	6	3					x
Geum aleppicum	Yellow Avens		S5			N	2	-1			x		
Geum fragarioides	Barren Strawberry		S5			N	5	5					x
Glechoma hederacea	Ground Ivy		SNA			I	0	3			x		x
Hesperis matronalis	Dame's Rocket		SNA			I	0	5	x	x			
Impatiens capensis	Spotted Jewelweed		S5			N	4	-3			x		

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Iris versicolor	Harlequin Blue Flag		S5			N	5	-5			x		
Leucanthemum vulgare	Oxeye Daisy		SNA			I	0	5			x		x
Ligustrum vulgare	European Privet		SNA			I	0	1			x		
Lotus corniculatus	Garden Bird's-foot Trefoil		SNA			I	0	1				x	x
Lysimachia thyrsiflora	Water Loosestrife		S5			N	7	-5			x		
Lythrum salicaria	Purple Loosestrife		SNA			I	0	-5			x		x
Maianthemum stellatum	Star-flowered False Solomon's-seal		S5			N	6	1			x		
Malus pumila	Common Apple		SNA			I	0	5			x		
Medicago lupulina	Black Medic		SNA			I	0	1					x
Myosotis arvensis	Rough Forget-me-not		SNA			I	0	0			x		
Onoclea sensibilis	Sensitive Fern		S5			N	4	-3			x		
Parthenocissus quinquefolia	Virginia Creeper		S4?			N	6	1	x		x		x
Phalaris arundinacea	Reed Canary Grass		S5			N	0	-4	x	x	x	x	x
Phleum pratense	Common Timothy		SNA			I	0	3					x
Phragmites australis ssp. australis	European Reed		SNA			I							x
Plantago lanceolata	English Plantain		SNA			I	0	0			x		
Plantago major	Common Plantain		S5			N	0	-1			x		x
Poa pratensis ssp. pratensis	Kentucky Bluegrass		S5			N	0	1	x	x	x	x	x
Podophyllum peltatum	May-apple		S5			N	5	3			x		
Populus tremuloides	Trembling Aspen		S5			N	2	0			x		
Potentilla recta	Sulphur Cinquefoil		SNA			I	0	5			x		x
Prunus serotina	Wild Black Cherry		S5			N	3	3			x		
Quercus macrocarpa	Bur Oak		S5			N	5	1			x		x

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Quercus rubra	Northern Red Oak		S5			N	6	3					x
Ranunculus acris	Tall Buttercup		SNA			I	0	-2	x		x		x
Rhamnus alnifolia	Alderleaf Buckthorn		S5			N	7	-5			x	x	
Rhamnus cathartica	Common Buckthorn		SNA			I	0	3	x	x	x		x
Rhus typhina	Staghorn Sumac		S5			N	1	5	x		x		x
Rosa blanda	Smooth Rose		S5			N	3	3			x		x
Rubus idaeus ssp. idaeus	Common Red Raspberry		SNA			I			x		x		
Rubus occidentalis	Black Raspberry		S5			N	2	5					x
Salix bebbiana	Bebb's Willow		S5			N	4	-4	x		x	x	
Salix nigra	Black Willow		S4?			N	6	-5					x
Sambucus canadensis	Common Elderberry		S5			N	5	-2			x		
Securigera varia	Common Crown-vetch		SNA			I	0	5					x
Smilax tamnoides	Hispid Greenbrier		S4			N	6	0			x		
Solanum dulcamara	Climbing Nightshade		SNA			I	0	0			x		x
Sonchus arvensis ssp. arvensis	Field Sow-thistle		SNA			I	0	1		x	x		
Spiraea alba	White Meadowsweet		S5			N	3	-4			x		
Symphyotrichum novae-angliae	New England Aster		S5			N	2	-3	x		x		x
Symphyotrichum urophyllum	Arrow-leaved Aster		S4			N	6	5					x
Taraxacum officinale	Common Dandelion		SNA			I	0	3	x	x	x	x	x
Thalictrum pubescens	Tall Meadow-rue		S5			N	5	-2			x		
Tilia americana	American Basswood		S5			N	4	3					x
Toxicodendron radicans	Climbing Poison Ivy		S5			N	5	-1					x
Toxicodendron rydbergii	Rydberg's Poison Ivy		S5			N	0	0			x		x

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Trifolium pratense	Red Clover		SNA			I	0	2					x
Trifolium repens	White Clover		SNA			I	0	2					x
Triosteum aurantiacum	Orange-fruited Horse-gentian		S5			N	7	5					x
Tussilago farfara	Colt's-foot		SNA			I	0	3			x		x
Typha angustifolia	Narrow-leaved Cattail		SNA			I	3	-5					x
Typha latifolia	Broad-leaved Cattail		S5			N	3	-5				x	
Typha x glauca	(Typha angustifolia X Typha latifolia)		SNA			I	3	-5			x		
Ulmus americana	American Elm		S5			N	3	-2	x		x		x
Verbascum thapsus	Common Mullein		SNA			I	0	5				x	
Viburnum lentago	Nannyberry		S5			N	4	-1			x		x
Viburnum opulus ssp. opulus	Cranberry Viburnum		SNA			I	0	0			x		x
Viburnum recognitum	Smooth Arrowwood		S4			N	7	-2			x		
Vicia cracca	Tufted Vetch		SNA			I	0	5		x	x		
Vitis riparia	Riverbank Grape		S5			N	0	-2	x		x		x
Zanthoxylum americanum	Northern Prickley Ash		S5			N	3	5					x
Allium sp	Onion Species								x				
Amelanchier sp	Serviceberry Species										x		
Arctium sp	Burdock Species								x			x	
Crataegus sp	Hawthorn Species								x		x		x
Geum sp	Avens Species												x
Hieracium sp	Hawkweed Species												x
Lactuca sp	Lettuce Species												x
Lilium sp	Lily Species										x		x
Lonicera sp	Honeysuckle Species								x		x		x

Appendix F2. Vascular Plant List

Scientific Name	Common Name	COSEWIC	S-Rank	MNR	Hamilton	Native Status	CC	CW	SC-1	SC-2	SC-3	SC-4	BC-1
Rosa sp	Rose Species										x		x
Salix sp	Willow Species										x		
Solidago sp	Goldenrod Species								x		x		x

Appendix F2. Vascular Plant List

Parameter	Notes / Definition	Reference
Scientific Name, Common Name		**NHIC (Natural Heritage Information Centre). 2017.** Ontario Vascular Plant Species List.February 2017. Ontario Ministry of Natural Resources. https://www.ontario.ca/page/get-natural-heritage-information
COSEWIC	**Federal Status ;** **NAR** Not At Risk, a wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances; **SC** Special Concern, a wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats; **T** Threatened, a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction; **E** Endangered, a wildlife species facing imminent extirpation or extinction; **XT** Extirpated, a wildlife species that no longer exists in the wild in Canada, but exists elsewhere; **X** Extinct, a wildlife species that no longer exists.	**NHIC (Natural Heritage Information Centre). 2017.** Ontario Vascular Plant Species List.February 2017. Ontario Ministry of Natural Resources. https://www.ontario.ca/page/get-natural-heritage-information
S-Rank	**Provincial Status;** **SX** Presumed Extirpated; **SH** Possibly Extirpated (Historical); **S1** Critically Imperiled; **S2**Imperiled; **S3** Vulnerable; **S4** Apparently Secure; **S5** Secure; **SNR** Unranked; **SU** Unrankable (conflicting information about status or trends); **SNA** A conservation status rank is not applicable because the species is not a suitable target for conservation activities (e.g. an introduced species, or a species that has been recorded in Ontario but the observations were made at locations far outside the species' usual range); **S#S#** Range Rank (used to indicate any range of uncertainty about the status of the species or community). **S?** Not Ranked Yet; or if following a ranking, Rank Uncertain (e.g. S3?).	**NHIC (Natural Heritage Information Centre). 2017.** Ontario Vascular Plant Species List.February 2017. Ontario Ministry of Natural Resources. https://www.ontario.ca/page/get-natural-heritage-information
MNR Status	**Provincial Status;** **NAR** Not At Risk; **SC** Special Concern; **THR** Threatened; **END** Endangered; **EXP** Extirpated; **END-R** Endangered (Regulated)	**NHIC (Natural Heritage Information Centre). 2017.** Ontario Vascular Plant Species List.February 2017. Ontario Ministry of Natural Resources. https://www.ontario.ca/page/get-natural-heritage-information
Hamilton	**R** = Rare in the City of Hamilton (known from five or fewer sites); **U**= Uncommon in the City of Hamilton (known from six to ten sites)	**Goodban, A.G. 2003.** The Vascular Plants of Hamilton, Ontario. In Dwyer, J. (ed.) Nature Counts Project, Hamilton Natural Areas Inventory. Species Checklists. Hamilton Naturalist Club, Hamilton, Ontario, vol.2, pp.1-99.
Native Status	**N** native; **I** introduced	**NHIC (Natural Heritage Information Centre). 2014.** Ontario Vascular Plant Species List. April 2014. Ontario Ministry of Natural Resources. https://contrib.ontario.ca/environment-and-energy/get-natural-heritage-information; **Brouillet, L., F. Coursol, S.J. Meades, M. Favreau, M. Anions, P. Bélisle & P. Desmet. 2010+**. VASCAN, the Database of Vascular Plants of Canada. http://data.canadensys.net/vascan/ (consulted on 2017-06-22)
CC	Coefficient of Conservatism is a value (0 to 10) assigned to native species in Ontario based on its degree of fidelity to a specific vegetation community type. The lower this value, the more likely the plant is to be found in a wide variety of plant community types including disturbed sites. The presence of plants with a coefficient of conservatism of 9 or 10 indicates later-successional native plants that have undergone only minor disturbance.	**Oldham, M.J., W.D. Bakowsky and D.A. Sutherland. 1995.** Floristic Quality Assessment System for Southern Ontario., ONTdex. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Peterborough, Ontario.
CW	Coefficient of Wetness is a value (-5 to +5) assigned to species in Ontario based on how often it is to occur in wetland habitat. -5 Obligate Wetland; -3 Facultative Wetland; 0 Facultative; +3 Facultative Upland; +5 Obligate Upland	**Oldham, M.J., W.D. Bakowsky and D.A. Sutherland. 1995.** Floristic Quality Assessment System for Southern Ontario., ONTdex. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Peterborough, Ontario

Appendix F3: Breeding bird survey results for Stoney Creek Restoration Feasibility study, Stoney Creek

Common Name	Scientific Name	CONSERVATION STATUS				Covered by MBCA (Governmt of Canada 1994)	Area Sensitivity (OMNR, 2000)	Breeding Evidence (OBBA 2001) within 120 metres (adjacent lands) of station					NOTES
		National	Provincial		Local								
		COSEWIC Designation (COSEWIC 2016)	OMNRF Designation (OMNRF 2017)	Srank (NHIC 2016)	City of Hamilton - Based on N.A.I. (Schwetz 2014) Birds - (Smith 2014)			BC-1	SC-1	SC-2	SC-3	SC-4	
Mallard	*Anas platyrhynchos*	---	---	S5	common - ubiquitous	Y	---	---	---	---	---	X	Pair flew over on June 25
Ring-necked Pheasant	*Phasianus colchicus*	---	---	SNA	rare - widespread (introduced)	N	---	---	---	POSSIBLE	---	---	One heard on June 11
Wild Turkey	*Meleagris gallopavo*	---	---	S5	common - widespread; re-introduced	N	---	---	---	X	---	---	Small group seen foraging
Rock Pigeon	*Patagioena livia*	---	---	SNA	abundant - very widespread (introduced)	N	---	---	---	---	---	X	
Mourning Dove	*Zenaida macroura*	---	---	S5	abundant - ubiquitous	Y	---	PROBABLE	PROBABLE	POSSIBLE	---	POSSIBLE	
Yellow-billed Cuckoo	*Coccyzus americanus*	---	---	S4	rare - scattered	Y	---	---	---	---	POSSIBLE	---	One heard on June 25
Black-billed Cuckoo	*Coccyzus erythropthalmus*	---	---	S5	uncommon - very widespread	Y	---	---	---	---	POSSIBLE	---	One heard on June 11
Ruby-throated Hummingbird	*Archilochus colubris*	---	---	S5	uncommon - ubiquitous	Y	---	---	---	---	POSSIBLE	---	One male seen displaying on June 11
Killdeer	*Charadrius vociferus*	---	---	S5	abundant - ubiquitous	Y	---	POSSIBLE	POSSIBLE	PROBABLE	---	PROBABLE	
Spotted Sandpiper	*Actitis macularius*	---	---	S5	common - ubiquitous	Y	---	---	---	---	---	POSSIBLE	
Ring-billed Gull	*Larus delawarensis*	---	---	S5	abundant - very restricted	Y	---	---	---	---	---	X	
Great Blue Heron	*Ardea herodias*	---	---	S4	uncommon - scattered	Y	---	---	X	---	---	---	
Green Heron	*Butorides virescens*	---	---	S4	uncommon - widespread	Y	---	---	X	---	---	---	
Turkey Vulture	*Cathartes aura*	---	---	S5	uncommon - widespread	N	---	---	X	---	---	---	
Red-tailed Hawk	*Buteo jamaicensis*	NAR	NAR	S5	common - ubiquitous	N	---	---	POSSIBLE	POSSIBLE	---	---	
Red-bellied Woodpecker	*Melanerpes carolinus*	---	---	S4	uncommon - very widespread	Y	---	---	---	---	PROBABLE	---	At least three territorial males
Downy Woodpecker	*Picoides pubescens*	---	---	S5	common - ubiquitous	Y	---	PROBABLE	---	POSSIBLE	POSSIBLE	---	
Hairy Woodpecker	*Picoides villosus*	---	---	S5	uncommon - very widespread	Y	AS	---	---	---	POSSIBLE	---	Drumming male on June 11; female seen June 11
Northern Flicker	*Colaptes auratus*	---	---	S4	common - ubiquitous	Y	---	---	POSSIBLE	---	POSSIBLE	X	
American Kestrel	*Falco sparverius*	---	---	S4	uncommon - very widespread	N	---	---	---	---	---	POSSIBLE	One male seen at distance on June 25
Eastern Wood-Pewee	*Contopus virens*	SC	SC	S4	common - very widespread	Y	---	---	---	---	PROBABLE	---	Two territorial birds heard on both dates.
Willow Flycatcher	*Empidonax traillii*	---	---	S5	common - very widespread	Y	---	---	---	---	POSSIBLE	---	
Great Crested Flycatcher	*Myiarchus crinitus*	---	---	S4	common - very widespread	Y	---	---	---	---	PROBABLE	---	
Eastern Kingbird	*Tyrannus tyrannus*	---	---	S4	abundant - ubiquitous	Y	---	PROBABLE	---	---	PROBABLE	---	Pair seen at each location
Warbling Vireo	*Vireo gilvus*	---	---	S5	common - very widespread	Y	---	---	POSSIBLE	---	---	---	
Red-eyed Vireo	*Vireo olivaceus*	---	---	S5	common - ubiquitous	Y	---	POSSIBLE	---	---	PROBABLE	---	
Blue Jay	*Cyanocitta cristata*	---	---	S5	abundant - ubiquitous	N	---	POSSIBLE	---	PROBABLE	PROBABLE	---	
American Crow	*Corvus brachyrhynchos*	---	---	S5	common - ubiquitous	N	---	---	POSSIBLE	X	POSSIBLE	X	
Horned Lark	*Eremophila alpestris*	---	---	S5	common - very widespread	Y	---	---	PROBABLE	POSSIBLE	---	PROBABLE	
Tree Swallow	*Tachycineta bicolor*	---	---	S4	abundant - very widespread	Y	---	---	PROBABLE	---	PROBABLE		
Barn Swallow	*Hirundo rustica*	THR	THR	S4	common - ubiquitous	Y	---	---	---	---	*	X	* SC-3 - several birds present in meadow directly to north of woods; SC-4 - one pair to southwest and three birds to northwest. All sightings beyond adjacent lands.
Black-capped Chickadee	*Poecile atricapillus*	---	---	S5	abundant - ubiquitous	Y	---	---	---	---	CONFIRMED	---	Fledged young observed.
White-breasted Nuthatch	*Sitta carolinensis*	---	---	S5	common - very widespread	Y	AS	---	---	---	PROBABLE	---	
House Wren	*Troglodytes aedon*	---	---	S5	common - ubiquitous	Y	---	POSSIBLE	PROBABLE	---	CONFIRMED	---	Nest located (in nest box along boardwalk).
Wood Thrush	*Hylocichla mustelina*	THR	SC	S4	common - ubiquitous	Y	---	---	---	---	PROBABLE	---	Two territorial birds heard on both dates.
American Robin	*Turdus migratorius*	---	---	S5	abundant - ubiquitous	Y	---	PROBABLE	PROBABLE	CONFIRMED	PROBABLE	---	
Gray Catbird	*Dumetella carolinensis*	---	---	S4	abundant - ubiquitous	Y	---	PROBABLE	PROBABLE	---	PROBABLE	---	
Northern Mockingbird	*Mimus polyglottos*	---	---	S4	uncommon - widespread	Y	---	---	---	POSSIBLE	---	POSSIBLE	Single birds heard singing on June 25 only.
European Starling	*Sturnus vulgaris*	---	---	SNA	abundant - ubiquitous (introduced)	N	---	---	PROBABLE	CONFIRMED	---	---	

Appendix F3: Breeding bird survey results for Stoney Creek Restoration Feasibility study, Stoney Creek

Cedar Waxwing	*Bombycilla cedrorum*	---	---	S5	common - ubiquitous	Y	---	POSSIBLE	---	POSSIBLE	POSSIBLE	---	
House Sparrow	*Passer domesticus*	---	---	SNA	abundant - ubiquitous (introduced)	N	---	---	---	PROBABLE	---	---	
American Goldfinch	*Spinus tristis*	---	---	S5	abundant - ubiquitous	Y	---	PROBABLE	---	PROBABLE	POSSIBLE	POSSIBLE	
Common Yellowthroat	*Geothlypis trichas*	---	---	S5	common - ubiquitous	Y	---	PROBABLE	PROBABLE	---	---	POSSIBLE	
Yellow Warbler	*Setophaga petechia*	---	---	S5	abundant - ubiquitous	Y	---	POSSIBLE	PROBABLE	PROBABLE	PROBABLE	---	
Chipping Sparrow	*Spizella passerina*	---	---	S5	abundant - ubiquitous	Y	---	---	---	POSSIBLE	---	---	
Savannah Sparrow	*Passerculus sandwichensis*	---	---	S4	abundant - very widespread	Y	AS	---	POSSIBLE	---	---	PROBABLE	
Song Sparrow	*Melospiza melodia*	---	---	S5	abundant - ubiquitous	Y	---	POSSIBLE	POSSIBLE	PROBABLE	PROBABLE	POSSIBLE	
Northern Cardinal	*Cardinalis cardinalis*	---	---	S5	abundant - ubiquitous	Y	---	PROBABLE	PROBABLE	PROBABLE	PROBABLE	POSSIBLE	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	---	---	S4	common - ubiquitous	Y	---	---	---	---	PROBABLE	---	
Indigo Bunting	*Passerina cyanea*	---	---	S4	common - ubiquitous	Y	---	---	---	---	PROBABLE	---	
Bobolink	*Dolichonyx oryzivorus*	THR	THR	S4	uncommon - scattered	Y	AS	---	---	---	*	---	* Present in meadow immediately to north of woods (outside adjacent lands).
Red-winged Blackbird	*Agelaius phoeniceus*	---	---	S4	abundant - ubiquitous	N	---	PROBABLE	---	---	PROBABLE	PROBABLE	
Eastern Meadowlark	*Sturnella magna*	THR	THR	S4	uncommon - scattered	Y	AS	---	---	---	*	---	* Present in meadow immediately to north of woods (outside adjacent lands).
Common Grackle	*Quiscalus quiscula*	---	---	S5	abundant - ubiquitous	N	---	PROBABLE	X	POSSIBLE	X	X	
Brown-headed Cowbird	*Molothrus ater*	---	---	S4	abundant - ubiquitous	N	---	---	POSSIBLE	POSSIBLE	X	POSSIBLE	
Baltimore Oriole	*Icterus galbula*	---	---	S4	common - ubiquitous	Y	---	PROBABLE	---	---	PROBABLE	---	BC-1 - pair seen; SC-3 - territorial male

WEATHER AND SURVEY TIMES:

Breeding bird survey (BBS) 1 - June 11, 2017; 06:30 - 09:40; clear, southwest winds (beaufort 2 to 4), 20 - 26 °C

Breeding bird survey (BBS) 2 - June 25, 2017; 06:30 - 09:30; clear, southwest winds (beaufort 2 to 3), 14 - 18 °C

LEGEND:

COSEWIC: THR - Threatened; SC - Special Concerrn; NAR - assessed and deemed to be not at risk; --- = not assessed as population secure

OMNRF: THR - Threatened; Special Concern; NAR - assessed and deemed to be not at risk; --- = not assessed as population secure

Provincial Sranks: S4 - population apparently secure; S5 - population secure; SNA - non-native exotic

BCR 13: PS - Priority Species

Area Sensitivity: AS - Area Sensitive species

OBBA: X - species observed but not considered a potential breeder (e.g. flying over site only)

REFERENCES:

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. COSEWIC Species Assessments (detailed version), October 2016. http://www.cosewic.gc.ca/eng/sct0/rpt/ dsp_booklet_e.htm

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Appendix F4. Screening for Confirmed/Candidate SWH at Stoney Creek Restoration Feasibility Study sites, Stoney Creek - using Ecoregion 7E Criteria Schedule (Final version: OMNRF, January 2015)

Significant Wildlife Habitat (SWH) Type	ELC Categories indicated for SWH Type	BC-1	SC-1	SC-2	SC-3	SC-4	SC-5 A[1]	SC-5 B[1]	SC-6[1]	SC-7[1]	SC-8[1]
Seasonal Concentration Area of Animals											
Waterfowl Stopover and Staging Areas (Terrestrial)	CUM1; CUT1; plus evidence of spring (Mar – May) flooding; does not include agricultural fields	No	No	No	No	No	No	No	Unknown	No	No
Waterfowl Stopover and Staging Areas (Aquatic)	MAS1; MAS2; MAS3; SAS1; SAM1; SAF1; SWD1; SWD2; SWD3; SWD4; SWD5; SWD6; SWD7	No	No	No	Candidate	No	No	No	No	No	No
Shorebird Migratory Stopover Area	BB01; BB02; BBS1; BBS3; BBT1; BBT2; SDO1; SDS2; SDT1; MAM1; MAM2; MAM3; MAM4; MAM5	No	No	No	No	No	No	No	No	No	No
Raptor Wintering Area	One of FOD, FOM, FOC and one of CUM, CUT, CUS, CUW (20+ hectares); least disturbed sites 15+ hectares with adjacent woodlands; Bald Eagle: FOD, FOM, FOC, SWD or SWC on shoreline areas adjacent to large rivers or adjacent to lakes with open water	No	No	Candidate	No	No	Candidate	Candidate	Candidate	Candidate	No
Bat Hibernacula	Big Brown Bat/Tri-colored Bat only; CCR1; CCR2; CCA1; CCA2; does not include buildings	No	No	No	No	No	No	No	No	No	No
Bat Maternity Colonies	Big Brown Bat/Silver-Haired Bat only; all FOD, FOM, SWD, SWM; snags: 10+ per hectare AND 25+ cm DBH	Candidate	No	No	Candidate	No	Candidate	No	No	Candidate	No
Bat Migratory Stopover Area	Hoary, Eastern Red, and Silver-haired bats only. No specific ELC types. Long Point area is only location identified by MNRF to date.	No	No	No	No	No	No	No	No	No	No
Turtle Wintering Areas	Snapping/Painted Turtles: SW, MA, OA, SA; FEO and BOO; Northern Map Turtle: open water areas (e.g. deeper rivers, streams) and lakes with current can also be used as over-wintering habitat.	Candidate	No	No	Candidate	No	Unknown	Unknown	Unknown	Candidate	Unknown
Reptile Hibernaculum	Snakes: any ecosite except very wet ones; talus, rock barren, crevice, cave, and alvar site may be directly related.	Unknown	Unknown	Unknown	No	No	Unknown	Unknown	Unknown	Unknown	Unknown
Colonially - Nesting Bird Breeding Habitat (Bank and Cliff)	CUM1, CUS1, BLS1, CLO1, CLT1; CUT1; BLO1; BLT1; CLS1	No	No	No	No	No	Unknown	Unknown	No	No	No
Colonially - Nesting Bird Breeding Habitat (Tree/Shrubs)	SWM2; SWM3; SWM5; SWM6; SWD1; SWD2; SWD3; SWD4; SWD5; SWD6; SWD7; FET1	No	No	No	Candidate	No	No	No	No	No	No
Colonially - Nesting Bird Breeding Habitat (Ground)	MAM1; MAM2; MAM3; MAM4; MAM5; MAM6; MAS1; MAS2; MAS3; CUM; CUS; CUT	No	No	No	No	No	No	No	No	No	No
Migratory Butterfly Stopover Areas	Combination of field (CUM, CUS, CUT) and forest (FOC, FOD, FOM, CUT) of 10+ hectares AND within 5 km of Lake Ontario	No	No	No	No	No	Unknown	Unknown	Unknown	Unknown	No
Landbird Migratory Stopover Areas	FOC, FOM, FOD, SWC, SWM, SWD; 5+ ha AND within 5 km of Lake Ontario but if woodlands rare in area than 2-5 ha can be considered	Candidate	No	No	Candidate	No	Candidate	No	No	Candidate	No
Deer Winter Congregation Areas	FOC; FOM; FOD; SWC; SWM; SWD; typically 100+ ha but 50+ ha if woodlots rare in area; conifer plantations < 50 ha may be used. Identified by MNRF.	No	No	No	Candidate	No	Candidate	No	No	No	No
Rare Vegetation Communities											
Cliffs and Talus Slopes	TAO; TAS; TAT; CLO; CLS; CLT	No	No	No	No	No	Confirmed	No	No	No	No
Sand Barren	SBO1; SBS1; SBT1	No	No	No	No	No	No	No	No	No	No
Alvar	ALO1; ALS1; ALT1; FOC1; FOC2; CUM2; CUS2; CUT2-1; CUW2; 0.5+ ha	No	No	No	No	No	No	No	No	No	No
Old Growth Forest	FOD; FOC; FOM; SWC; SWD; SWM; 0.5+ ha	No	No	No	Confirmed	No	Candidate	No	No	Candidate	No
Savannah	TPS1; TPS2; TPW1; TPW2; CUS2. No minimum size; does not include remnants along railway ROWs.	No	No	No	No	No	No	No	No	No	No
Tallgrass Prairie	TPO1; TPO2	No	No	No	No	No	No	No	No	No	No

Significant Wildlife Habitat (SWH) Type	ELC Categories indicated for SWH Type	BC-1	SC-1	SC-2	SC-3	SC-4	SC-5 A[1]	SC-5 B[1]	SC-6[1]	SC-7[1]	SC-8[1]
Other Rare Vegetation Communities	S1, S2, or S3 vegetation communities	Candidate	No	No	Candidate	No	Unknown	Unknown	Unknown	Unknown	Unknown
Specialized Habitat for Wildlife											
Waterfowl Nesting Area	MAS1; MAS2; MAS3; SAS1; SAM1; SAF1; MAM1; MAM2; MAM3; MAM4; MAM5; MAM6; SWT1; SWT2; SWD1; SWD2; SWD3; SWD4	No	No	No	Candidate	No	No	No	No	No	No
Bald Eagle and Osprey Nesting, Foraging, and Perching Habitat	FOD; FOM; FOC; SWD; SWM; SWC; adjacent to riparian areas (rivers, lakes, ponds and wetlands)	No	No	No	No	No	No	No	No	No	No
Woodland Raptor Nesting Habitat	All forested ELC ecosites; also SWC, SWM, SWD, CUP3; 30+ ha with 4+ ha IF (200m buffer)	No	No	No	Candidate	No	Candidate	No	No	Candidate	No
Turtle Nesting Areas	MAM1; MAM2; MAM3; MAM4; MAM5; MAM6; SAS1; SAM1; SAF1; BOO1; FEO1	No	No	No	Unknown	No	Unknown	Unknown	Unknown	Unknown	Unknown
Seeps and Springs	Any forested ecosite within headwater area of stream	No	No	No	Candidate	No	No	No	No	No	No
Amphibian Breeding Habitat (Woodland)	FOC; FOM; FOD; SWC; SWM; SWD	Candidate	No	No	Candidate	No	No	No	No	Unknown	No
Amphibian Breeding Habitat (Wetlands)	SW, MA, FE, BO, OA, SA; typically 120 m + from woodlands (except American Bullfrog)	No	No	No	No	No	Unknown	Unknown	No	No	No
Woodland Area-Sensitive Bird Breeding Habitat	FOC, FOM, FOD, SWC, SWM, SWD; mature (60+ years), 30+ ha; IF (> 200 m from edge)	No	No	No	Candidate	No	Candidate	No	No	Candidate	No
Habitats for Species of Conservation Concern (not including END or THR species)											
Marsh Breeding Bird Habitat	MAM1; MAM2; MAM3; MAM4; MAM5; MAM6; SAS1; SAM1; SAF1; FEO1; BOO1; GRHE – all SW, MA, CUM1 sites	No	No	No	No	No	No	No	No	No	No
Open Country Bird Breeding Habitat	CUM1; CUM2; 30+ ha; not Class 1 or 2 agricultural lands or actively used for farming in last 5 years	No	No	No	No	No	Unknown	Unknown	Unknown	Unknown	Unknown
Shrub/Early Successional Bird Breeding Habitat	CUT1; CUT2; CUS1; CUS2; CUW1; CUW2; 10+ ha; not Class 1 or 2 agricultural lands or actively used for farming in last 5 years	No	No	No	No	No	Unknown	Unknown	Unknown	No	No
Terrestrial Crayfish	MAM1; MAM2; MAM3; MAM4; MAM5; MAM6; MAS1; MAS2; MAS3; SWT; SWD; SWM; CUM1 with inclusions of above MAM or swamp ecosites can be used by crayfish	No	No	No	Unknown	No	No	No	No	No	No
Special Concern and Rare Wildlife Species	SC and S1, S2, S3, and SH species	Candidate	Unknown	Unknown	Confirmed	Unknown	Candidate	Unknown	Unknown	Unknown	Unknown
Animal Movement Corridors											
Amphibian Movement Corridors	All ecosites associated with water	Candidate	No	No	Candidate	No	No	No	No	No	No

[1] Desktop assessments only

Definitions:

No – this SWH category is not present on site or within 120 metres of the site either because it does not meet habitat criteria and/or significance thresholds OR no indicator species were observed during 2017 field investigations (using appropriate protocols for detection).

Candidate – potential SWH is present on site or within 120 metres of the site; further field studies may be required to see if criteria are met.

Confirmed – SWH is present on site or within 120 metres of site (criteria regarding habitat, significance thresholds, and/or indicator species (numbers/diversity) confirmed by field investigations).

Unknown – status of SWH on site or within adjacent lands is unknown; further study is required.

1.0 Restoration Principles

Guidelines for specific terrestrial restoration measures for the preferred storage areas fit into the following restoration measures:

1. Buffer plantings;
2. Channel modifications;
3. Wetland creation; and
4. Utilizing existing wetlands in high water events.

Following is a description of the form and function of each of these techniques; this is meant to serve as an overview of the site-by-site recommendations

1.1 Buffer Plantings

Buffer plantings are a strip of continuous vegetation along the top of bank consisting of herbs and grasses, shrubs, and/or trees; see Figure 1 for a graphic representation of a buffer. Environment Canada's publication "How Much Habitat Is Enough?" (2004) recommends that 75% of the length of any watercourse should have a riparian buffer. Academic studies on buffer zone effectiveness have provided varying results, but in general found that a larger, more diverse buffer containing both woody and herbaceous species is more effective than a narrow, herbaceous-dominated buffer. Buffers with dense herbaceous layers (i.e. dense grass) will filter more sediments than those with an open understory (i.e. shrub cover). Nutrient uptake by vegetation will be most effective when the plants are actively growing, so a mix of different types of plants is best (plants which mature at different points of the season) (Haycock et al 1997) ("Buffer zone must provide enough friction to slow flows to improve efficiency of particulate trapping and provide leaf litter to help assimilate the trapped nutrients and toxic materials"). The character of soils and groundwater movement can also affect the effectiveness of buffers (Haycock et al 1997). For buffers to function optimally, water must flow as sheet flow rather than highly focused flow (i.e. rills, gullies), allowing for effective removal of particulates, dissolved nutrients, and toxic materials (Haycock et al 1997). A diverse 10m buffer seems to be a minimum for effective removal of significant quantities of water-borne nitrogen and phosphorus as well as trapping wind-blown sprays.

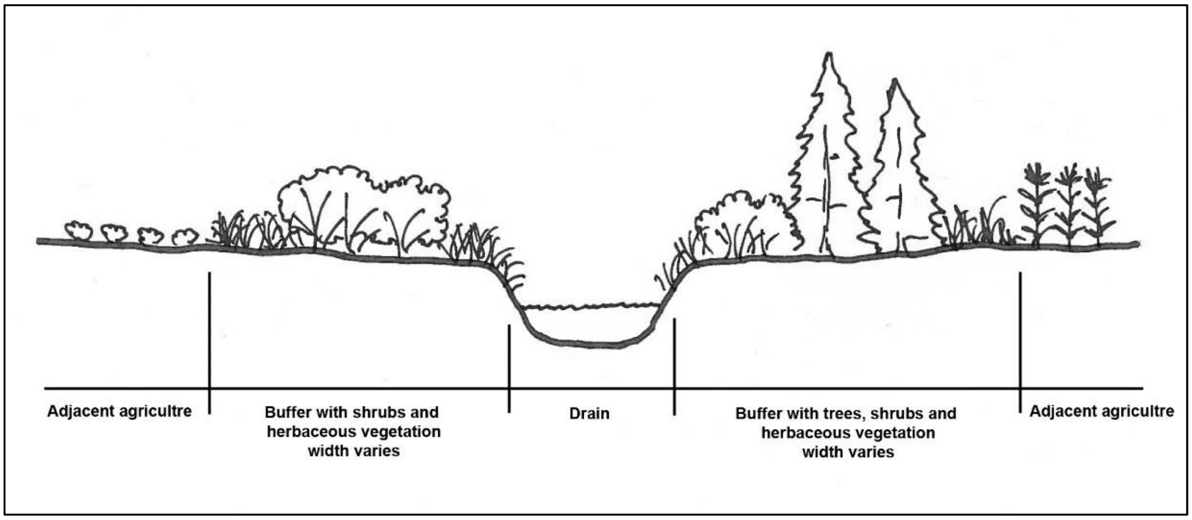

Figure 1: Buffer Plantings

Pros:

- Effective in reducing overland contaminant flow;
- If buffer is 10m or more wide, effective in reducing wind-blown contaminants (i.e. spray);
- Buffers are more effective for sediment removal when ground is flat;
- Buffer zone can provide shade, which cools the channel and is beneficial for some aquatic life forms;
- Can retain original channel size and shape;
- Easy to implement;
- Creates wildlife habitat;
- Relatively inexpensive; and
- Variety of planting techniques available for different cost and effort levels (herbaceous seed only, woody & herbaceous seed, seed with shrubs & tree plantings).

Cons:

- Reduces amount of land available for agriculture;
- Only effective for overland flow, not tile drainage flow;
- Effectiveness of buffers for sediment removal decreases over time as sediment accumulates;
- Maintenance may be required in order to remove accumulated sediment and/or stimulate dense herbaceous plant growth;
- No effectiveness on water quality in channel; and
- Easy for landowners to remove or reduce over time.

Buffer strips can be contentious in agricultural landscapes because they remove land from active production. Thus, it may be more effective to prioritize areas to receive buffer strips rather than recommending them everywhere. It is recommended that buffer strips be prioritized on the south and west sides of channels, as well as for channels with large catchment areas. The rationale for plantings on the south and west is that plantings on these sides will, in time, provide more shade (particularly in the hot afternoon sun) to the water's surface than plantings on the north and east sides. Also, the dominant winds in Stoney Creek are from the north-west, so establishing vegetation on these sides will reduce windblown contaminants into the channel. Channels with large catchment areas are a priority because they will contribute more water to the drain than small catchment areas, and so should be targeted for sediment and nutrient removal.

1.2 Channel Modifications

Channel modifications are reconstructed channels that mimic natural watercourses. This technique can include a buffer strip and/or riparian wetland shelf combined with either a typical straight channel or a sinuous natural channel design; see Figure 2 for a graphic representation of these designs. The buffer or riparian shelf is below the top of bank level and is intended to flood in high water events, providing a way to minimize water velocities and encourage sediment deposition. Constructing a sinuous channel will also minimize the water velocity in the channels and encourage deposition. The overall size of the modified channel as well as the natural channel design configuration would need to be designed by a water resources engineer and a fluvial geomorphologist.

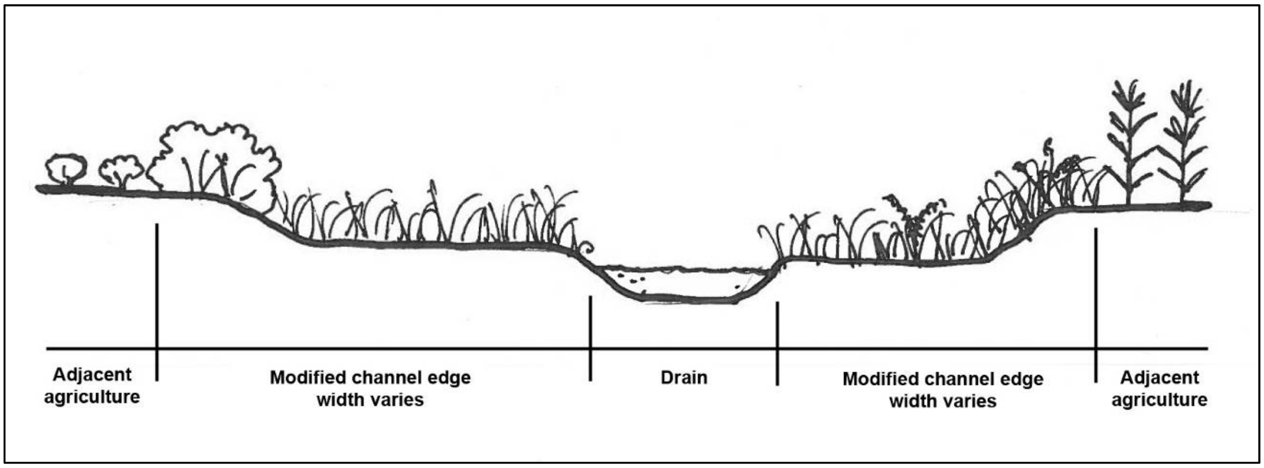

Figure 2: Channel Modifications

Pros:

- Increases wildlife habitat;
- Effective in reducing overland contaminant flow;
- Can keep typical municipal drain channel dimensions (flat bottom, steep banks) for low-flow channel;
- Use of natural channel design would slow down water velocities, which would result in more sediment and nutrient deposition in channel rather than at end of system;
- Provides an outlet for flood water energy; and
- Variety of planting techniques available for different cost and effort levels (herbaceous seed only, woody & herbaceous seed, seed with shrubs & tree plantings).

Cons:

- Reduces amount of land available for agriculture;
- Channel may be more difficult to maintain in future drain maintenance; and
- Excavation work is expensive.

Channel modifications may be contentious because they remove land from agricultural use, but they can be targeted to areas where they are most effective. Targeted areas would be in the lower half of the watershed, where more water is flowing and more sediment is present (“the most bang for the buck" approach). Several areas exist where land is already out of agricultural production and where the channel could be modified without greatly affecting the existing farmland.

1.3 Wetland Creation

This method involves the design and construction of a treatment wetland using the principles used for storm water management ponds; see Figure 3 for a graphic representation of this technique. The constructed wetlands would use a series of ponds to allow sediment to settle out of the water column and could also be designed to include a shallow marsh section to facilitate the uptake of nutrients. These constructed wetlands would be built adjacent to the drain and would be designed to admit water from the channel at a variety of water levels. The banks and land surrounding the wetlands could be planted with native species to provide wildlife habitat.

Pros:

- Increases wildlife habitat;
- Area impacted is very localized, can be achieved with one cooperative landowner rather than needing the input of many;
- Can use standardized storm water management pond design principles for water quality enhancement to reduce contaminant and sediment loads; and
- Can retain existing municipal drain channel and perform typical maintenance.

Cons:

- Requires a large amount of land permanently removed from agricultural production;
- Planting typically limited to seeding;
- Requires regular maintenance;
- No effectiveness in reducing overland contaminant flow; and
- Very expensive.

Wetland creation may be contentious because it requires the removal of a large area of land from agricultural use. They are best installed in the lower reaches of a watershed so that the maximum amount of water can pass through the system. Several areas exist where land is already out of agricultural production and where the channel could be converted to constructed wetland without greatly affecting the existing farmland.

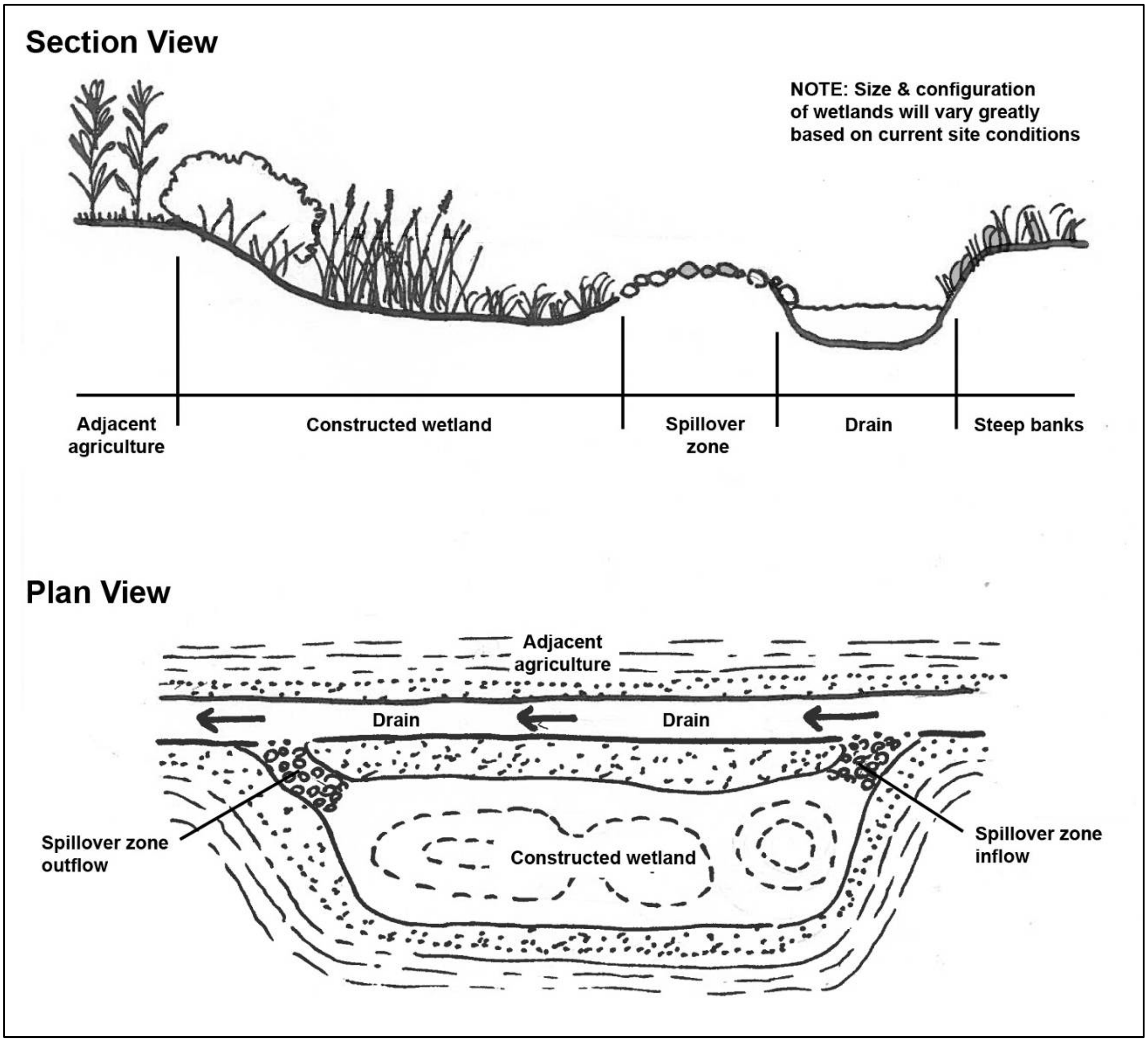

Figure 3: Constructed Wetlands

1.4 Utilizing Existing Wetlands in High Water Events

This technique involves diverting water from the channels during high water events into existing wetlands (forested and non-forested) and using these existing features to store and infiltrate this water. Wetlands lower in the watershed would be a higher priority for this technique because they would receive more water and would be more effective for treating.

Pros:

- Can keep typical municipal drain channel dimensions (flat bottom, steep banks);
- Provides an outlet for flood water energy;
- No impacts to farmland;
- Minimal re-planting or seeding should be necessary; and
- Low cost.

Cons:

- Possible damage to wetland ecosystem due to high water velocities in storm events;
- Possible damage to wetland ecosystem due to nutrient & pesticide loading;
- Possible damage to wetland ecosystem due to sediment loading; and
- Maintenance required on sediment trap if one is installed (recommended).

The major disadvantage of this technique is that the majority of the existing wetlands in the Stoney Creek and Battlefield Creek subwatersheds are forested swamps or swamp thickets, and the impacts of using these communities for this technique are not well studied. At a minimum, the system would have to be designed with a sediment trap at the upstream end before the water disperses into wetland so that sediment loading in the wetland is minimized. This technique would be much more effectively employed in areas where water can be diverted into more open wetland communities such as meadow marsh or shallow marsh.