Prepared for:

The Corporation of the City of Burlington

426 Brant Street
City Hall
Burlington, ON L7R 3Z7

Attn: Mr. Arif Shahzad, P.Eng

Appleby Creek Erosion Control Environmental Assessment

Project File Report – Final

Submitted by:

Aquafor Beech Ltd.

August 20th, 2020

Contact:
Rob Amos, P.Eng
Amos.R@aquaforbeech.com
T. 905.629.0099 ext.284
F. 905.629.0089

Aquafor Beech Limited
2600 Skymark Avenue
Building 6, Unit 202
Mississauga, ON L4W 5B2

Aquafor Beech Reference:
66390



Bank Scouring and Bed Lowering Upstream of Spruce Avenue

EXECUTIVE SUMMARY

Introduction

The Appleby Creek watershed comprises a drainage area of 12.1km^2, with the headwaters originating on the Niagara Escarpment and the channel conveying through the City of Burlington to Lake Ontario. Appleby Creek exhibits varying conditions throughout its length, ranging from hardened and channelized sections to extended reaches that are still in natural state.

Over the last ~60 years, urbanization has led to a change in hydrologic regime of Appleby Creek, which has resulted in areas of channel modification and erosion hazard risks. The Burlington City-Wide Creek Inventory and Erosion Assessment (2016), highlighted one (1) high priority site and four (4) moderate priority sites within the corridor between Lake Ontario and South Service Road.

In response to the findings and recommendations of the City-Wide study, the City of Burlington retained Aquafor to complete an erosion control Municipal Class Environmental Assessment (EA) for Appleby Creek. The study area for this EA was defined as extending from Lake Ontario to South Service Road.

Study Objectives

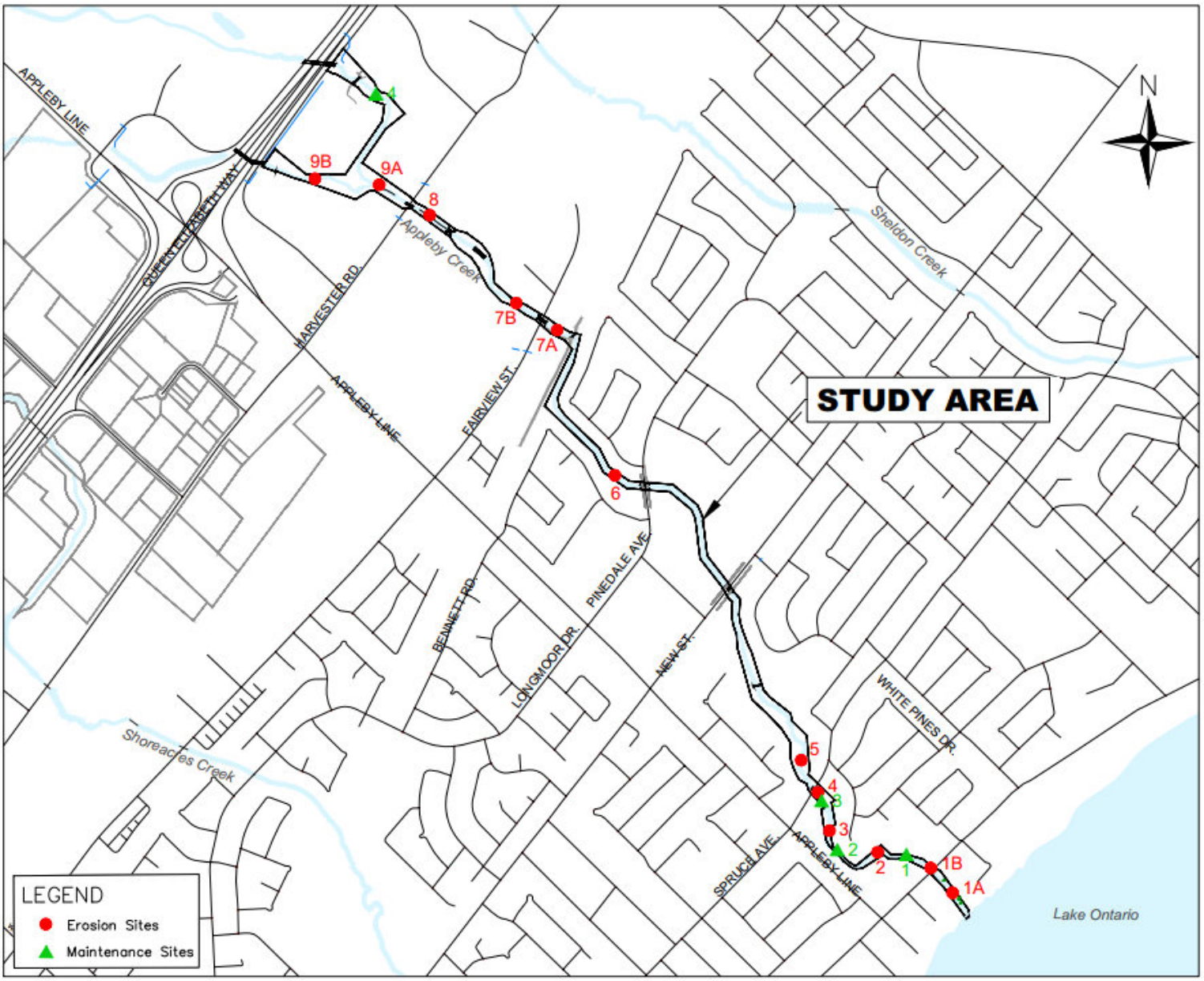
The intent of the study was to assess the existing conditions within the study area and develop alternatives to address the erosion hazards at identified sites. In developing these alternatives, the study team took into consideration the four principal objectives of the study:

- Protection of the environment (reduction in erosion and flooding and preservation / enhancement of fisheries habitat),
- Minimization of disruption to existing residents during construction,
- Engagement of regulatory agencies and stakeholders throughout the process, and
- Compliance with the Municipal Class EA process.

Phase I: Identification of Problems and Opportunities

Problems of erosion and flooding are present in the Appleby Creek study area. These issues are a result of urbanization within the watershed, which is typically associated with increased hydrologic conditions due to an increase in runoff volume and a shorter time of peak for flows. Historically, sections of Appleby Creek were channelized to accommodate urban growth with intermittent engineered treatments including gabion lining, vegetated embankments, and concrete weirs / drop control structures. As the channel adjusts to modified hydrology, and as engineered treatments deteriorate, bank erosion often occurs and poses risks to municipal infrastructure, roadway embankments, private properties, as well as the natural environment.

Based on desktop study and field investigations, twelve (12) erosion sites and four (4) maintenance sites were identified within the study area. The figure below illustrates the approximate location of erosion and maintenance sites.



Urbanization within the watershed has limited the opportunities to address the problems, as development has often occurred within the floodplain and the width of the creek corridor is often restricted. In considering the constraints on the physical extents, several opportunities have been investigated, including:

- Replacement of failing bank protection treatment with permanent bank protection treatments;
- Channel widening and use of natural channel materials (bioengineering) property constraints allow;
- Natural channel design;
- Enhancement of aquatic habitat;
- Improvement of riparian cover through planting of native trees and shrubs.

Phase II: Evaluation of Alternative Solutions

Three (3) alternatives were developed to address the erosion concerns at each of the identified erosion sites, including:

- ***Alternative 1: Do Nothing*** – This alternative involves leaving the site as it is and allowing erosional processes to continue within the watercourse corridor;
- ***Alternative 2: Local Restorative Works*** – This alternative consists of localized channel bank and/or bed work to address erosion issues at the site;
- ***Alternative 3: Comprehensive Reach Scale Works*** – This alternative consists of a comprehensive approach, which is typically reach-based, to address erosion issues at the site.

A set of criteria was thereafter developed to evaluate the alternatives on a site by site basis:

- Physical / Natural Environment
  - Potential to reduce stream bank and stream bed erosion;
  - Potential to reduce flooding risks;
  - Potential to improve aquatic habitat;
  - Potential of negative impacts to aquatic habitat during construction;
  - Potential to improve terrestrial habitat;
  - Potential of negative impacts to terrestrial habitat during construction;
- Social / Cultural Environment
  - Aesthetics / recreation;
  - Compatibility with adjacent land use;
  - Community disruption;
- Technical and Engineering
  - Ease of implementation;
  - Agency acceptance;
  - City acceptance;
  - Technical feasibility;
- Economic Environment
  - Construction costs;
  - Operation and maintenance costs;
  - Life cycle costs;
  - Infrastructure protection.

Each criterion was evaluated for the three alternatives at each identified erosion site and assigned a score. The alternatives that are ranked with highest total scores include Alternative 2 (Local Restorative Works) for Erosion Site 3, 4, 6, 8 and 9A, and Alternative 3 (Comprehensive Reach Based Works) for Erosion Site 1A, 1B, 2, 5, 7A, 7B and 9B.

Public Consultation

A Public Information Centre (PIC) was held on February 19, 2019 at the Appleby Ice Centre (1201 Appleby Line) in Burlington, with a total of 14 attendees signed in. A series of posters was presented which outlined the study background, problems, opportunities, alternatives, and preliminary alternative evaluation. In general, attendees were in support of the preliminary

preferred alternatives for each erosion site. Conservation Halton was also consulted throughout the study and their comments and inputs are considered and incorporated into the project.

Selection of Preferred Alternatives

Based on the results of the alternative evaluation and consultation with the City and the public, the preferred alternatives for the twelve erosion sites are listed below:

- Erosion Site 1A: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 1B: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 2: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 3: Alternative 2 – Local Restoration Works
- Erosion Site 4: Alternative 2 – Local Restoration Works
- Erosion Site 5: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 6: Alternative 2 – Local Restoration Works
- Erosion Site 7A: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 7B: Alternative 3 – Comprehensive Reach Based Works
- Erosion Site 8: Alternative 2 – Local Restoration Works
- Erosion Site 9A: Alternative 2 – Local Restoration Works
- Erosion Site 9B: Alternative 3 – Comprehensive Reach Based Works

Priority Ranking and Estimated Costs

The preferred alternatives have been prioritized into nine (9) projects and the estimated costs are summarized in the table below. The project prioritization is based on erosion sites field scoring and property ownership interests. While the project cost estimates and time horizon are to provide the City direction on project priorities, decisions on the actual order and implementation of project should consider overall City priorities, budgets, and stakeholder interests.

Project Priority Ranking for Erosion Sites

Priority No.	Project Name / Erosion Site / Reach / Length	Property Ownership	Risk and Opportunities	Cost Estimates	Planning Horizon
1	Go Station / Erosion Site 8 / Reach 6 / Length ~ 145 m	City	Failed / failing grade control and erosion control structures, fish barrier	$1,160,000	0-2 years
2	Lakeshore Road / Erosion Site 1A & 1B / Reach 1 / Length ~ 150 m	City & Private	Erosion of bridge abutment, storm outfall, and channel banks into private property	$525,000	0-2 years
3	South Service Road / Erosion Site 9A & 9B / Reach 7 / Length ~ 340 m	City & Private	Failed grade control structure, local bank erosion adjacent to private property	$1,190,000	2-5 years

Priority No.	Project Name / Erosion Site / Reach / Length	Property Ownership	Risk and Opportunities	Cost Estimates	Planning Horizon
4	Oval Court and Centennial Bikeway / Erosion Site 7A, Reach 5 & 7B, Reach 6 / Length ~ 500 m	City	Local bank erosion, failing gabion baskets, erosion risk to storm outfall and paved trail.	$2,500,000	2-5 years
5	Linwood Crescent / Erosion Site 3 / Reach 2 / Length ~ 100 m	Private & private with City easements	Failing grade control structure, fish barrier, local bank erosion	$220,000	2-5 years
6	Spruce Avenue / Erosion Site 5 / Reach 3 / Length ~ 280 m	City & Private	Bank erosion	$980,000	5-10 years
7	Sheraton Road / Erosion Site 6 / Reach 5 / Length ~ 80 m	City	Local bank erosion	$120,000	5-10 years
8	5031 & 5039 Lakeshore Road / Erosion Site 2 / Reach 2 / Length ~ 150 m	Private with City easements	Bank erosion	$525,000	5-10 years
9	Spruce Avenue Bridge and Road Embankment / Erosion Site 4 / Reach 2 / Length ~ 35 m	City	Local bank erosion, risk of exposing bridge footing	$90,000	5-10 years

In addition, the study identified four (4) maintenance projects, for which phasing and estimated cost are summarized in table below. The maintenance projects are recommended to be undertaken in conjunction with erosion projects where the sites coincide in order to achieve cost-savings. However, actual implementation order would be dependent on the City's Operation and Maintenance Department's budgets and overall projects.

Project Phasing for Maintenance Sites

Site No.	Project Name	Reach No.	Property Ownership	Site Description	Cost Estimates	Recommendation
1	5031 & 5039 Lakeshore Road Woody Debris Removal	2	Private with City Easement	Removal of fallen trees and woody debris	$15,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 8 (Erosion Site 2) as these two projects are in the location.

Site No.	Project Name	Reach No.	Property Ownership	Site Description	Cost Estimates	Recommendation
2	Appleby Line	2	Private with City Easement	Replacement of missing sewer back-flow cover	$10,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 5 (Erosion Site 3) as the extent is immediately downstream of Erosion Site 3.
3	South Service Road	2	City	Exposed armourstone wall toe protection maintenance	$90,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 9 (Erosion Site 4) as these two projects are in the location.
4	South Service Road Woody Debris Removal	7	City	Removal of fallen trees and woody debris	$30,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 3 (Erosion Site 9A & 9B) as these two projects are in the location.

Conclusions and Recommendations

Urbanization, in concert with Appleby Creek's erosional processes have resulted in a number of hazards and risks along the length of the creek corridor. The preferred alternatives at the twelve erosion sites achieve the study goal to reduce erosion and enhance / preserve terrestrial and aquatic habitat. Following the completion of this study, detailed design and construction will be undertaken to implement the preferred alternatives and remedy the identified problems. Additional site investigations and implementation measures are recommended to be taken during detailed design, including:

- Obtain easements / Permit to Enter where creek traverses private properties;
- Undertake a geotechnical investigation;
- Undertake a utility locate where information is deemed necessary as part of a higher SUE Level survey;
- Undertake a detailed topographic survey if additional information is deemed necessary to reflect the current states at sites;
- Undertake Stage 2 and 3 Archaeological Assessment;
- Complete a geomorphic analysis of channel hydraulics and tractive forces;

- Determine appropriate construction staging and erosion and sediment controls; and
- Prepare for DFO review and IGF for MECP reviews when the detailed design takes place;
- Obtain approvals from Conservation Halton and fish collection permit from MNRF, and potentially Species at Risk Permit from MNRF and a Letter of Advice from DFO.

TABLE OF CONTENTS

EXECUTIVE SUMMARY i

1 INTRODUCTION 1

1.1 Overview 1
1.2 Municipal Class Environmental Assessment Process 2
1.3 Background Study 6
1.4 Study Purpose and Primary Tasks 8

2 IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES 9

2.1 Identification of Problems 9
2.1.1 Erosion Site 1A – Bank Erosion, Failed Bridge Abutment Protection and Undermined Storm Outfall 12
2.1.2 Erosion Site 1B – Failed Bridge Abutment Protection and Undermined Storm Outfall 13
2.1.3 Erosion Site 2 – Meander Bend Erosion 14
2.1.4 Erosion Site 3 – Deteriorating Terrafix Channel Bed and Bank Erosion 15
2.1.5 Erosion Site 4 – Exposed Spruce Avenue Bridge Footing with Oversteepened Slope 16
2.1.6 Erosion Site 5 – Active Bank Erosion and Unstable Slope 17
2.1.7 Erosion Site 6 – Bank Erosion into Natural Trail 18
2.1.8 Erosion Site 7A – Active Bank Erosion in Close Proximity to Private Property and Trail 19
2.1.9 Erosion Site 7B – Active Bank Erosion in Close Proximity to Private Property .. 20
2.1.10 Erosion Site 8 – Deteriorating Gabion Baskets and Concrete Weirs 21
2.1.11 Erosion Site 9A – Failed Grade Control Structure and Active Bank Erosion 22
2.1.12 Erosion Site 9B – Active Bank Erosion Along the West Branch 23
2.1.13 Maintenance Sites 24
2.2 Opportunities 24

3 SITE SPECIFIC INVENTORIES 26

3.1 Topographic Surveys 26
3.2 Geomorphic Assessment 27
3.2.1 Reach 1 – Lake Ontario to Lakeshore Road 29
3.2.2 Reach 2 – Lakeshore Road to Spruce Avenue 30
3.2.3 Reach 3 – Spruce Avenue to New Street 32
3.2.4 Reach 4 – New Street to Pinedale Avenue 34
3.2.5 Reach 5 – Pinedale Avenue to Fairview Street 35
3.2.6 Reach 6 – Fairview Street to Harvester Road 36
3.2.7 Reach 7 – Harvester Road to South Service Road 37

3.3 Erosion and Maintenance Sites Inventory and Scoring 39
3.3.1 Erosion and Maintenance Sites Inventory 39
3.3.2 Erosion Sites Field Scoring Methodology 41
3.3.3 Erosion Sites Field Scoring Results 43
3.4 Storm Sewer Outfall Inventory 44
3.5 Hydrologic and Hydraulic Assessment 46
3.5.1 Hydrology 46
3.5.2 Hydraulics 46
3.5.3 Spill Area 49
3.6 Source Water Protection 49
3.7 Geology and Soils 52
3.8 Natural Heritage Assessment 53
3.8.1 Background Information Review 54
3.8.2 Policy Review 54
3.8.2.1 Regional Natural Heritage System 54
3.8.2.2 Conservation Halton Policies 56
3.8.2.3 DFO Self-Assessment 57
3.8.2.4 Endangered Species Act 58
3.8.3 Existing Conditions 58
3.8.4 Botanical Resources 59
3.8.4.1 Vegetation Communities 59
3.8.4.2 Vascular Plants 68
3.8.4.3 Tree Inventory 68
3.8.4.4 Butternut 74
3.8.5 Terrestrial Wildlife 76
3.8.5.1 Bat Maternity Roosts 76
3.8.5.2 Breeding Birds 85
3.8.5.3 Snakes and Anurans 88
3.8.5.4 Incidental Wildlife and Site Observations 88
3.8.6 Aquatic Ecology Assessment 89
3.8.6.1 Aquatic Habitat 89
3.8.6.2 Stream Classification and Fish Communities 102
3.8.7 Species-at-Risk and Other Species of Conservation Concern 103
3.8.8 Significant Wildlife Habitat 112
3.8.9 Linkages and Corridors 113
3.9 Archaeological and Cultural Heritage Assessment 113
3.10 Utilities 115
3.11 Socio-Economic Environment 117
3.11.1 Land Use 117
3.11.2 Transportation 118

3.11.3 Ownership 119

4 EVALUATION OF ALTERNATIVE SOLUTIONS 120

4.1 Description of Alternatives 120
4.1.1 Erosion Site 1A 120
4.1.2 Erosion Site 1B 121
4.1.3 Erosion Site 2 121
4.1.4 Erosion Site 3 121
4.1.5 Erosion Site 4 122
4.1.6 Erosion Site 5 122
4.1.7 Erosion Site 6 122
4.1.8 Erosion Site 7A & Erosion Site 7B 122
4.1.9 Erosion Site 8 123
4.1.10 Erosion Site 9A 123
4.1.11 Erosion Site 9B 124
4.2 Evaluation Criteria 124
4.3 Evaluation of Alternatives 126
4.4 Public and Agency Consultation 126
4.4.1 Notice of Commencement 126
4.4.2 Public Information Centre (PIC) 127
4.4.3 Halton Conservation Authority 127
4.4.4 Additional Input from Fairview Street & Oval Court Landowners 128
4.5 Selection and Description of the Preferred Alternative 129
4.6 Preliminary Design of the Preferred Alternative 130

5 EROSION AND MAINTENANCE SITES PRIORITY RANKING AND PROJECT PHASING 132

5.1 Prioritization and Project Phasing 132
5.2 Impact Assessment and Mitigation Measures 135
5.2.1 Vegetation Loss to Significant Woodlands and Private Lands 135
5.2.2 Impacts to Breeding Birds 136
5.2.3 Aquatic Communities 137
5.2.4 Species-at-Risk and other Species of Conservation Concern 137
5.2.4.1 Endangered Bats 137
5.2.4.2 Barn Swallow 138
5.2.4.3 Black-crowned Night-heron 138
5.2.4.4 Canada Warbler 138
5.2.4.5 Eastern Wood-pewee 139
5.2.4.6 Butternut 139
5.2.4.7 Snapping Turtle 139

5.2.4.8 Monarch....139
5.2.5 Impacts to Significant Wildlife Habitat....139
5.2.6 Impacts to Water Quality during Construction....140
5.2.7 Linkages and Corridors....140

6 IMPLEMENTATION PROGRAMS....146

6.1 Considerations at Detailed Design....146
6.1.1 Hydraulic Assessment....146
6.1.2 Geotechnical Investigations....146
6.1.3 Utilities Confirmation....146
6.1.4 Natural Heritage System....147
6.1.4.1 General Mitigation Measures....148
6.1.5 Stage 2 and 3 Archaeological Assessment....149
6.1.6 Easement / Permit to Enter Acquisition....150
6.2 Environmental Approvals and Permitting....150
6.3 Construction Services....151
6.4 Monitoring Program....151
6.5 As-Constructed Drawings and Analysis....155

7 CONCLUSIONS AND RECOMMENDATIONS....156

7.1 Conclusions....156
7.2 Recommendations....156

8 REFERENCES....158

LIST OF FIGURES

Figure 1-1: Study Area Map....2
Figure 1-2: Municipal Class Environmental Assessment Planning and Design Process....5
Figure 2-1: Erosion and Maintenance Sites within Appleby Creek....11
Figure 3-1: Delineated Management Reaches within the Appleby Creek Study Area....28
Figure 3-2: Framework for Field Scoring of Erosion Sites....41
Figure 3-3: Storm Outfall Location Map....45
Figure 3-4: Regulatory Floodlines within the Study Area....47
Figure 3-5: City of Burlington Intake Protection Zones (HHSPC, 2017)....51
Figure 3-6: Physiography of Study Area (Chapman and Putnam, 1984)....52
Figure 3-7: Bedrock Geology of the Study Area in the City of Burlington (Ontario Geological Survey, 1991)....53
Figure 3-8: RNHS as identified by the Region of Halton, with the limits of the study area (adapted from the Region of Halton OP Map 1G, 2018)....55
Figure 3-9: Ecological Land Classification Map 1 of 4....60
Figure 3-10: Ecological Land Classification Map 2 of 4....61
Figure 3-11: Ecological Land Classification Map 3 of 4....62
Figure 3-12: Ecological Land Classification Map 4 of 4....63
Figure 3-13: Candidate Bat Maternity Roosting Sites 1 of 5....77
Figure 3-14: Candidate Bat Maternity Roosting Sites 2 of 5....78
Figure 3-15: Candidate Bat Maternity Roosting Sites 3 of 5....79
Figure 3-16: Candidate Bat Maternity Roosting Sites 4 of 5....80
Figure 3-17: Candidate Bat Maternity Roosting Sites 5 of 5....81
Figure 3-18: Aquatic Habitat Assessment Sites and Erosion Sites....91
Figure 3-19: APB-1 - D/S looking D/S....96
Figure 3-20:APB-1 - D/S looking U/S....96
Figure 3-21: APB-1 - U/S looking D/S....96
Figure 3-22: APB-1 - U/S looking U/S....96
Figure 3-23: APB-2 - D/S looking D/S....97
Figure 3-24: APB-2 - D/S looking U/S....97
Figure 3-25: APB-2 - U/S looking U/S....97
Figure 3-26: APB-2 - U/S looking U/S....97
Figure 3-27: APB-3 - D/S looking D/S....98
Figure 3-28: APB-3 - D/S looking U/S....98
Figure 3-29: APB-3 - U/S looking D/S....98
Figure 3-30: APB-3 - U/S looking U/S....98
Figure 3-31: APB-4 - D/S looking D/S....99
Figure 3-32: APB-4 - D/S looking U/S....99
Figure 3-33: APB-4 - U/S looking D/S....99
Figure 3-34: APB-4 - U/S looking U/S....99
Figure 3-35: APB-6 - D/S looking D/S....100
Figure 3-36: APB-6 - D/S looking U/S....100
Figure 3-37: APB-6 - U/S looking D/S....100
Figure 3-38: APB-6 - U/S looking U/S....100
Figure 3-39: APB-7 - D/S looking D/S....101
Figure 3-40: APB-7 - D/S looking U/S....101
Figure 3-41: Results of the Archaeological Property Inspection 1....114
Figure 3-42: Results of the Archaeological Property Inspection 2....114

Figure 3-43: Results of the Archaeological Property Inspection 3 115
Figure 3-44: Land use within the City of Burlington (City of Burlington, 2017) 118
Figure 3-45: Transportation Facilities within the City of Burlington (City of Burlington, 2017) 119
Figure 4-1: Land Dedication to City 128
Figure 5-1: Natural Heritage Features 1 of 4 142
Figure 5-2: Natural Heritage Features 2 of 4 143
Figure 5-3: Natural Heritage Features 3 of 4 144
Figure 5-4: Natural Heritage Features 4 of 4 145

LIST OF TABLES

Table 1-1: Summary of Erosion Sites from Creeks Inventory and Erosion Assessment Study (2016) 6
Table 3-1: Summary of Erosion and Maintenance Sites by Reach 39
Table 3-2: Erosion Site Scoring Detailed Evaluation Criteria 42
Table 3-3: Erosion Sites Field Scoring Results 43
Table 3-4: Flows at different nodes along the Appleby Creek 46
Table 3-5: Summary of HEC-RAS Model Results 48
Table 3-6: Ecological Land Classification Descriptions 64
Table 3-7: Erosion Site 1A and 1B Tree Inventory Summary 69
Table 3-8: Erosion Site 2 Tree Inventory Summary 70
Table 3-9: Erosion Site 3 Tree Inventory Summary 70
Table 3-10: Erosion Site 4 Tree Inventory Summary 71
Table 3-11: Erosion Site 5 Tree Inventory Summary 71
Table 3-12: Erosion Site 6 Tree Inventory Summary 72
Table 3-13: Erosion Site 7A and 7B Tree Inventory Summary 73
Table 3-14: Erosion Site 8 Tree Inventory Summary 73
Table 3-15: Erosion Site 9A and 9B Tree Inventory Summary 74
Table 3-16: Butternut Status and Implications 75
Table 3-17: Candidate *Myotis* spp. Maternity Roost Sites 82
Table 3-18: Candidate Tri-colored Bat Maternity Roost Sites 83
Table 3-19: Breeding Bird Survey Results 86
Table 3-20: Incidental Wildlife Observations 89
Table 3-21: OSAP Summaries 92
Table 3-22: Results from CH Fish Community Sampling 102
Table 3-23: SAR and SOCC Survey Methodologies 104
Table 3-24: SAR and SOCC Screening Exercise 106
Table 3-25: Summary of Existing Utilities within the Study Area 116
Table 4-1: Alternative Evaluation Criteria 124
Table 4-2: Category Weighting Factors 125
Table 4-3: Ranking Scheme for Criteria Evaluation of Each Alternative 126
Table 4-4: Evaluation Scoring Summary 126
Table 5-1: Project Priority Ranking for Erosion Sites 133
Table 5-2: Project Phasing for Maintenance Sites 134
Table 6-1: Monitoring, Targets, and Adaptive Management Actions for Restoration Plantings 153

LIST OF PHOTOS

Photo 2-1:Manicured Lawn on Private Property Experiencing Bank Erosion....12
Photo 2-2: Temporary Timber Crib Wall on the East Bank....12
Photo 2-3: Mature Trees Rooting Network Providing Resistance to Erosion....12
Photo 2-4: Failed Bridge Abutment Protection....13
Photo 2-5: Undermined Storm Outfall Structure....13
Photo 2-6: Undermined Tree Roots and Exposed Shale Bedrock....13
Photo 2-7: Eroded Outer Bank with Near Vertical Slope, Exposed Shale Bedrock....14
Photo 2-8: Undermined Trees with Exposed Roots and Leaning into the Creek....14
Photo 2-9: Failed Rip-Rap at Toe of Bank....14
Photo 2-10: Double Concrete Weir with Deteriorating Terrafix Bed....15
Photo 2-11: Exposed Fence Post Foundation and Tree Roots Due to Erosion....15
Photo 2-12: Bank Erosion with Evidence of Planform Adjustment....15
Photo 2-13: Oversteepened Unstable Slope Downstream of the Bridge....16
Photo 2-14: Exposed Footings with Lowered Shale Bedrock....16
Photo 2-15: Lowered Channel Bed Exposing Bridge Footing Border....16
Photo 2-16: Bank Scour and Bed Down-Cutting....17
Photo 2-17: Undermined Trees and Exposed Tree Roots Due to Erosion....17
Photo 2-18: Trees Leaning into Creek....17
Photo 2-19: Bank Erosion Upstream of Storm Outfall....18
Photo 2-20: Active Bank Erosion into Trail....18
Photo 2-21: Rip-Rap Deposit in the Creek....18
Photo 2-22: Longitudinal and Transverse Cracks Along Centennial Bikeway....19
Photo 2-23: Bank Erosion at Meander Bend....19
Photo 2-24: Gabion-Lined Channel....19
Photo 2-25: Active Bank Erosion in Close Proximity to Private Property....20
Photo 2-26: Gabion Baskets Failed at Base Level, Upstream of Storm Outfall....20
Photo 2-27: Deteriorating Gabion Baskets Emptying at Base Level....20
Photo 2-28: Deteriorating Concrete Weir and Failed Gabion Baskets....21
Photo 2-29: Failed Gabion Deposited in the Creek....21
Photo 2-30: Looking upstream at the Gabion Lined Channel....21
Photo 2-31: Failed Gabion and Terrafix Grade Control Structure, Looking Downstream....22
Photo 2-32: Failed Gabion and Terrafix Grade Control Structure, Looking Upstream....22
Photo 2-33: Scoured and Over-Steepened North Bank....22
Photo 2-34: Over-Steepened Slope Due to Erosion, Adjacent to Private Property....23
Photo 2-35: Hydro Pole in the Creek....23
Photo 2-36: Intermittent Gabion Lined Bank and Woody Debris Jam....23
Photo 2-37: Fallen Tree Across the Creek (MS 1)....24
Photo 2-38: Missing Storm Sewer Back-Flow Cover (MS 2)....24
Photo 2-39: Exposed Armourstone Wall Toe Protection (MS 3)....24
Photo 2-40: Woody Debris Obstructing Flows (MS 4)....24
Photo 3-1: Confluence with Lake Ontario with Crib Wall Erosion Protection Measure....29
Photo 3-2: Detached Bedrock Particles Deposited on Channel Bed and Bank Erosion....29
Photo 3-3: Channel Planform Looking Upstream....30
Photo 3-4: Deep Scour Pool Downstream of Bridge with Fallen Trees....30
Photo 3-5: Banks Protected Boulder Toe and Armourstone Wall, Exposed Shale Bedrock....31
Photo 3-6: Terrafix Lined Channel Bed with Concrete Blocks / Armourstone Retaining Wall....31
Photo 3-7: Erosion at Outer Meander Bend....31

Photo 3-8: Double Concrete Weirs 31
Photo 3-9: Looking Downstream at Wide Low Flow Channel with Good Floodplain Access ..32
Photo 3-10: Undermined Bank Slope and Armourstone Toe Protection 32
Photo 3-11: Channel Bed Lowering Showing Soil Stratification at Downstream Segment 33
Photo 3-12: Channel with Leaning Trees.....33
Photo 3-13: Channel Base Level Lowering with Under-Cutting Banks 33
Photo 3-14: Pedestrian Bridge Crossing at Pinedale Park.....33
Photo 3-15: Riprap Deposits on Shale Bedrock, Creating Low Flow Channel with Minor Headcut 33
Photo 3-16: New Street Bridge and Back-Water Storm Outfall.....33
Photo 3-17: New Street Bridge Crossing, Exposed Shale Bedrock & Gabion Retaining Wall 34
Photo 3-18: Gabion Baskets with Grouted Concrete Toe Protection 34
Photo 3-19: Riprap-Lined Channel Bed 35
Photo 3-20: Channel Cross Section View.....35
Photo 3-21: Minor Bank Erosion into Natural Path 36
Photo 3-22: Channel Cross Section View.....36
Photo 3-23: Channel Cross Section View.....36
Photo 3-24: Gabion Lined Channel Bank.....36
Photo 3-25: Intermittent Natural Channel Corridor.....37
Photo 3-26: Gabion Baskets Failing at Base Level.....37
Photo 3-27: Channel Corridor within GO Station 37
Photo 3-28: Deteriorating Grade Control Structures 37
Photo 3-29: Channel Bypassing Failed Grade Control Structure.....38
Photo 3-30: Channel Confluence Point.....38
Photo 3-31: Channel Cross Section View, East Branch.....39
Photo 3-32: Wood Debris Obstructing Channel Conveyance, East Branch.....39
Photo 3-33:Channel Cross Section View, West Branch.....39
Photo 3-34: Bank Erosion Leading to Exposed Tree Roots, West Branch 39

LIST OF APPENDICES

Appendix A – Existing Conditions Plan and Profile Drawings
Appendix B – Storm Sewer Outfall Inventory and Mappings
Appendix C – Natural Environment Information
Appendix D – Archaeological and Cultural Heritage Assessment Report
Appendix E – Detailed Alternative Evaluations
Appendix F – Public Consultation
Appendix G – Conceptual Design Drawings for the Preferred Alternatives

1 INTRODUCTION

1.1 Overview

The Appleby Creek watershed comprises a drainage area of 12.1km^2; with the headwaters originating on the Niagara Escarpment and the channel conveying through the City of Burlington to Lake Ontario. Appleby Creek exhibits varying conditions throughout its length, ranging from hardened and channelized sections to extended reaches that still exhibit natural tendencies.

Over the last ~60 years, urbanization has led to a change in hydrologic regime of Appleby Creek, which has resulted in areas of channel modification and erosion. The Burlington City-Wide Creeks Inventory and Erosion Assessment (2016) identified numerous erosion risks and hazards which are further elaborated in **Section 1.3**. In response to the results from the City-Wide Erosion Assessment, the City of Burlington (City) retained Aquafor to provide comprehensive engineering, geomorphic, ecological and Environmental Assessment (EA) services to complete the Appleby Creek Erosion Control EA study, providing further insight into the existing conditions and risks along the corridor.

In this regard, this EA has been carried out to identify and address the channel erosion and slope destabilization within the Appleby Creek corridor from South Service Road to Lake Ontario, addressing risks to the City's infrastructure, adjacent private properties, and public safety. This Project File documents the development of alternative erosion mitigation strategies and the process used to determine the preferred restoration alternative intended to provide long-term protection for the infrastructure and properties identified at risk. The general extents of study area are presented in Figure 1-1.

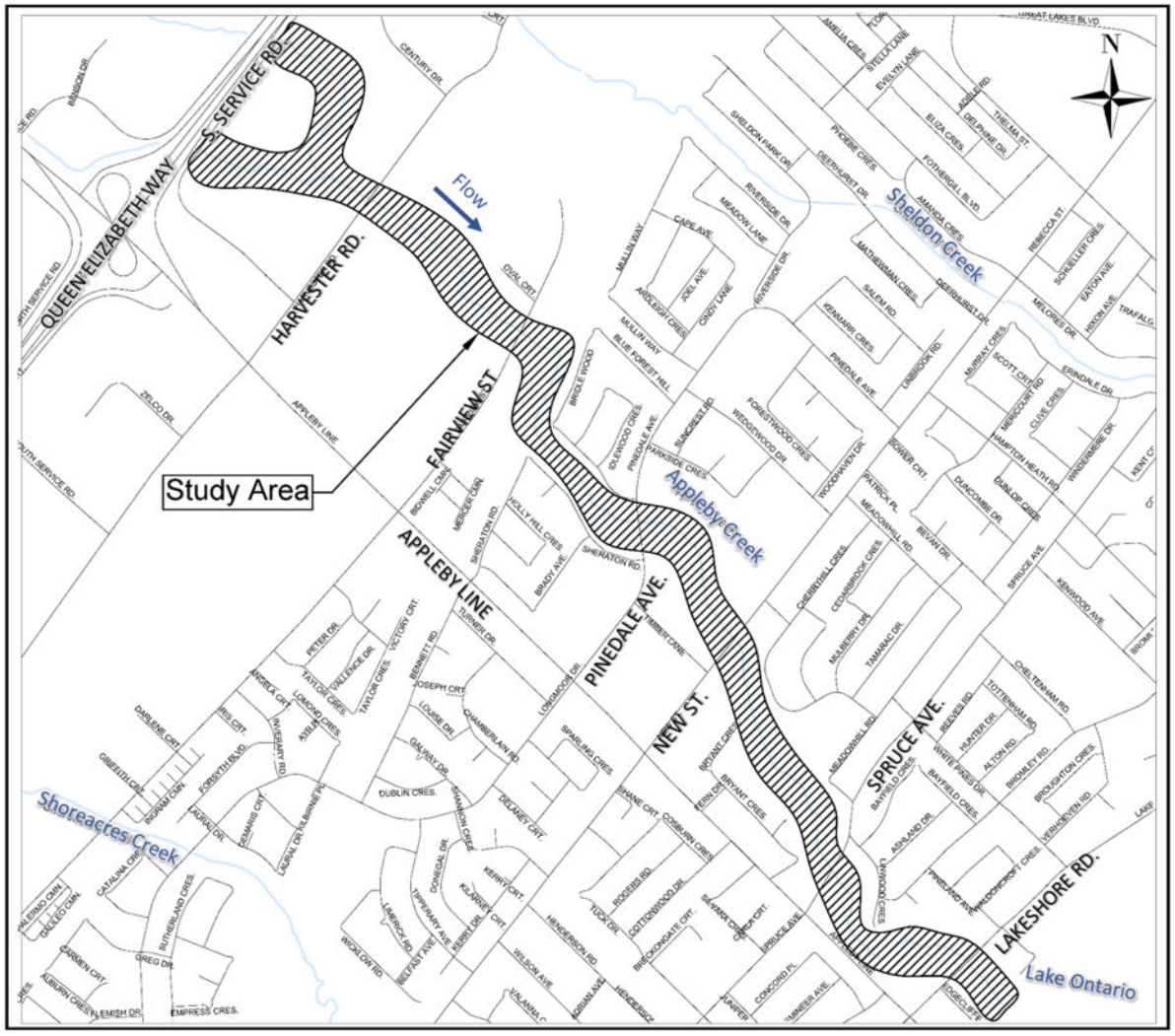


Figure 1-1: Study Area Map

1.2 Municipal Class Environmental Assessment Process

The Environmental Assessment Act (EAA) was proclaimed into law by the Province of Ontario in 1976 to ensure that proponents consider the environmental impacts of their proposals prior to commencement and with public transparency. The “environment” as defined by the EAA is understood broadly to include the biophysical, socio-cultural, built and economic environments and the interrelationships between them. The EAA applies primarily to public sector undertakings and extends to private sector projects where designated under regulation.

The EAA draws a distinction between “individual” and “class” environmental assessments (EA). Individual EA’s are prepared for large, complex projects in which significant environmental impacts are foreseeable. A “Terms of Reference” are devised which outline the EA process, and the final EA document is submitted to the Ministry of the Environment, Conservation and Parks (MECP) for approval. Alternatively, a Class EA is a streamlined approval process for a group of routine undertakings with predictable environmental impacts. Once a Class EA planning document is approved by MOE, all projects of this type are pre-approved provided that they adhere to its design. In this fashion, the Class EA process expedites approval for smaller, recurring projects.

The Municipal Class EA, which is followed here, outlines how municipal infrastructure projects are planned in accordance with the EAA. The Municipal Class EA is consistent with the EAA's five key principles for successful planning:

1. Consultation with affected parties early on and throughout the process, such that the planning process is a cooperative venture;
2. Consideration of a reasonable range of alternatives, both the functionally different "alternatives to" and the "alternative methods" of implementing the solution;
3. Identification and consideration of the effects of each alternative on all aspects of the environment;
4. Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects; and
5. Provisions of clear and complete documentation of the planning process followed, to allow "traceability" of decision-making with respect to the project.

The accompanying flow chart (Figure 1-2) illustrates the process followed in the planning and design of projects covered by this Class EA. The five phases, as defined in the flow chart, are summarized in the document as follows:

Phase 1: Identify the problem or deficiency.

Phase 2: Identify alternative solutions to the problem, by taking into consideration the existing environment, and establish the preferred solution taking into account public and agency review and input. At this point, identify approval requirements (e.g., Ontario Water Resources Act, Lakes and Rivers Improvement Act, and Environmental Protection Act) and determine the appropriate schedule for the project and proceed through the appropriate phases (Figure 1.2).

Phase 3: Examine alternative methods of implementing the preferred solution, based upon the existing environment, public and government agency input, anticipated environmental effects, and methods of minimizing negative effects and maximizing positive effects.

Phase 4: Document, in an Environmental Study Report, a summary of the rationale and the planning, design, and consultation process of the project as established throughout the above phases, and make such documentation available for scrutiny by review agencies and the public.

Phase 5: Complete contract drawings and documents, and proceed to construction and operation; monitor construction for adherence to environmental provisions and commitments. Where special conditions dictate, also monitor the operation of the completed facilities.

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

The Municipal Engineers Association's Class EA document classifies projects as Schedule A, A+, B or C depending on their level of environmental impact and public concern.

Schedule A: Projects are generally routine operational and maintenance activities and upgrade projects. These projects are generally small, pose limited adverse environmental impacts, and are pre-approved without the requirement for public consultation.

Schedule A+: Projects are also pre-approved small projects with minimal adverse environmental impacts; however, the public is to be advised prior to project implementation. The public has the opportunity to comment to municipal councils, but there is no appeal to MOE on these projects as they are pre-approved.

Schedule B: Projects with greater potential for environmental impact thereby requiring notification of the public and relevant review agencies. Examples include stormwater ponds, river crossings, expansion of water or sewage plants beyond their rated capacity, and new or expanded outfalls and intakes. Schedule 'B' projects require completion of Phases 1 and 2 of the Municipal Class EA process.

Schedule C: Projects that pose major environmental impacts and are therefore subject to the full scope of the Municipal Class EA planning, notification and documentation procedures. Examples include storage tanks and tunnels with disinfection, anything involving chemical treatment or expansion beyond a water or sewage plants rated capacity. Schedule 'C' projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 implementation.

This study has been determined as Schedule B project by the City and therefore follows Phase 1 and 2 of the planning and design process with Phase 5 to follow at a subsequent phase. This Project File is intended to fulfill the consultation and documentation requirements of Class EA Schedule B project, addressing the erosion issue of the Appleby Creek, providing additional site-specific information in order to refine the preferred solution.

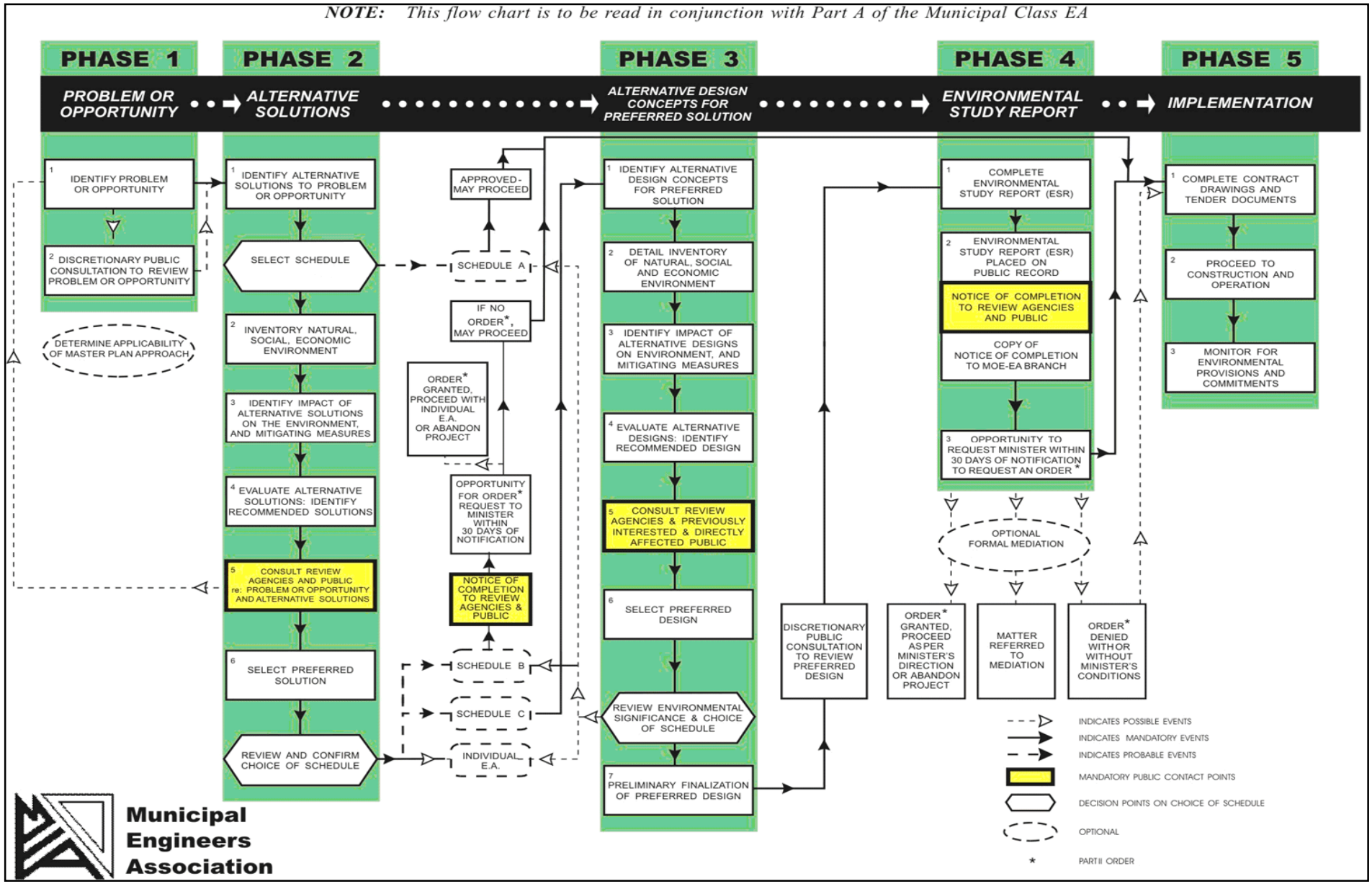


Figure 1-2: Municipal Class Environmental Assessment Planning and Design Process

1.3 Background Study

Varying degrees of erosion has taken place along Appleby Creek as a result of both natural processes and urbanization. The evolution of a watercourse, when constrained by surrounding development, requires intervention and return of the watercourse to previous conditions, or removal of the constraint.

The City-wide Creek Inventory and Erosion Assessment (2016) identified seven (x7) erosion sites ranging from low priority to moderate priority, with a brief overview of the inventory from the report summarized below.

Table 1-1: Summary of Erosion Sites from Creeks Inventory and Erosion Assessment Study (2016)

No.	Photo	Site Description
1		The site is in Reach A1 (from Lake Ontario to Lakeshore Blvd). The creek banks are eroding and any attempts at bank stabilization (i.e. concrete and concrete rubble) have failed. The east bank at the mouth of Appleby Creek has a narrow buffer of land owned by the City, but private property is at risk <1m from the top of bank closer to Lake Ontario.
2		The site is located in Reach A3 immediately downstream of Spruce Avenue and generally consists of the armourstone wall and miscellaneous treatments on the west side of the creek. The creek banks are generally eroding and the existing armourstone wall is undermining. The transition from the bridge to the retaining wall is eroding as well.
3		The site is located at the lower end of Reach A3 as the creek transitions into Reach A2 (artificial channel) and consists of open channel with generally eroding banks and stream transition. The creek banks are generally eroding due to the poor transition to the artificial channel.

No.	Photo	Site Description
4		The site is located upstream of Spruce Avenue and downstream of New Street. A number of concrete blocks have blocks have dislodged and mobilized downstream. The pedestrian bridge is located in Reach A4, approximately half way between Spruce Avenue and New Street. The channel at the bridge has eroding banks. Both sides of the creek have a park-like setting.
5		This site is located on Appleby Creek Reach A5, north of Pinedale Avenue. In general, the creek in this reach is a rip rap lined channel but has indications that the channel has initiated some meandering. The channel meandering process has resulted in creek bank erosion and point bar deposition. The erosion process will impact private property and the local pathway.
6		This reach is located downstream of Fairview Street at the pedestrian foot bridge within the hydro-electric corridor. The entire reach consists largely of failed and failing gabion stream bank lining. Where gabion treatment is absent, the creek banks are eroding.
7		The reach is located upstream of Harvester Road and consists of open channel and control structure with generally eroding banks and failing gabion/Terrafix structure treatments.

The information provides the basis for this study and the identified risks and opportunities were included in the analysis and evaluation of alternatives throughout this study.

1.4 Study Purpose and Primary Tasks

The primary objective of the study is to assess the existing conditions of Appleby Creek within the study area and provide recommendations to reduce erosion and protect the natural heritage in the area. As part of the environmental assessment process this study will also assess and evaluate erosion mitigation opportunities in light of mitigating biophysical, socio-cultural, built and economic environments to the Appleby Creek study area.

The primary tasks which were undertaken as part of this study and the associated chapters in which information is provided are summarized below:

Chapter 1 – Provide study background and define the study purpose;

Chapter 2 – Define the problems and opportunities associated with the study;

Chapter 3 – Establish existing environmental and social conditions;

Chapter 4 – Present and evaluate the alternative solutions, select the preferred alternative and present conceptual designs for the preferred alternative;

Chapter 5 – Present the prioritization of erosion and maintenance sites and project phasing;

Chapter 6 – Provide implementation considerations; and

Chapter 7 – Provide conclusions and recommendations.

2 IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

2.1 Identification of Problems

Appleby Creek, with a drainage area of approximately 12.1km^2, is one of the most prominent watercourses draining Burlington from the Niagara Escarpment to Lake Ontario, and has been identified as a key feature in the Regional Natural Heritage System. The section of Appleby Creek within the study area, including over 5km of channel length from the QEW to Lake Ontario, has been confined to a corridor ranging from 15 – 40m wide, with residential properties primarily lining the top of slope, with some commercial and industrial landuse as well as the Metrolinx GO Station at the upstream end.

This corridor width is less constrained than some of Burlington's adjacent watercourses, notably Tuck Creek and Roseland Creek, and in turn maintains a higher level of natural integrity. However, urbanization has led to a change in hydrologic regime of Appleby Creek, which in combination with development constraints has created a watercourse which poses a variety of risks and conditions which require intervention. Due to urbanization and increase in impermeable surfaces, infiltration of precipitation has been reduced and the volume of runoff reaching the receiving waterbody has increased. Additionally, watershed surface roughness has decreased and thus, compounded by the use of storm sewers, runoff reaches receiving waterbodies more rapidly. The overall change to the hydrology is an increase in runoff volume and reduction in time to peak flows. This is typically referred to as urban hydromodification. Within the study area and upstream areas, much development occurred prior to the early 1980s which pre-dates the use of stormwater management techniques.

To accommodate urban growth, sections of Appleby Creek were historically channelized in the 1970's and 1980's with intermittent engineered treatments implemented, including gabion lining, vegetated embankments, and concrete weirs / drop control structures. Under these conditions, where creeks have been channelized and confined, issues with respect to erosion are prevalent. Aquafor has performed a detailed forensic investigation and the key issues observed are summarized below:

- erosion of private properties including property lines, fences, yards;
- deterioration of erosion control structures;
- lowering of channel beds;
- undermining and undercutting of erosion control structures;
- watercourse enlargement and widening;
- exacerbation of erosion rates within the unlined channel segments or in areas where erosion naturally occurs; and
- creation of barriers to fish migration.

These issues have posed risks to municipal infrastructure, roadway embankment, private properties, as well as the natural environment (fish habitat and water quality).

Twelve areas of risks were identified within the study area based on the field investigation, with the general proximity illustrated in Figure 2-1. Descriptions and photos of each erosion site are included in the sub-sections below. These twelve sites include five of the seven erosion sites identified in the City-Wide Creek Inventory and Erosion Assessment study. One of the excluded

sites is site 2 (see Table 1-1), where the existing armourstone wall is being undermined. Since the base of the armourstone wall is still buried, the level of risk at this site is determined to be low and this site is identified as a maintenance site (refer to **Section 2.1.13** for details). The other excluded erosion site is site 4 for which there are some minor bank erosion at the pedestrian bridge between New Street and Spruce Avenue. The site condition was evaluated against the remainder of reaches, and it was determined that the current site condition would not require restoration works. However, routine monitoring should be undertaken should any extreme rainfall event occur and result in further channel erosion at this location.

While significant deterioration of some of the channelization treatments has been inventoried along Appleby Creek, other sections are well preserved and are with limited erosion hazards. Four maintenance sites with minor issues that require maintenance actions to prevent future erosion and flooding hazards were also identified and detailed in **Section 2.1.13**.

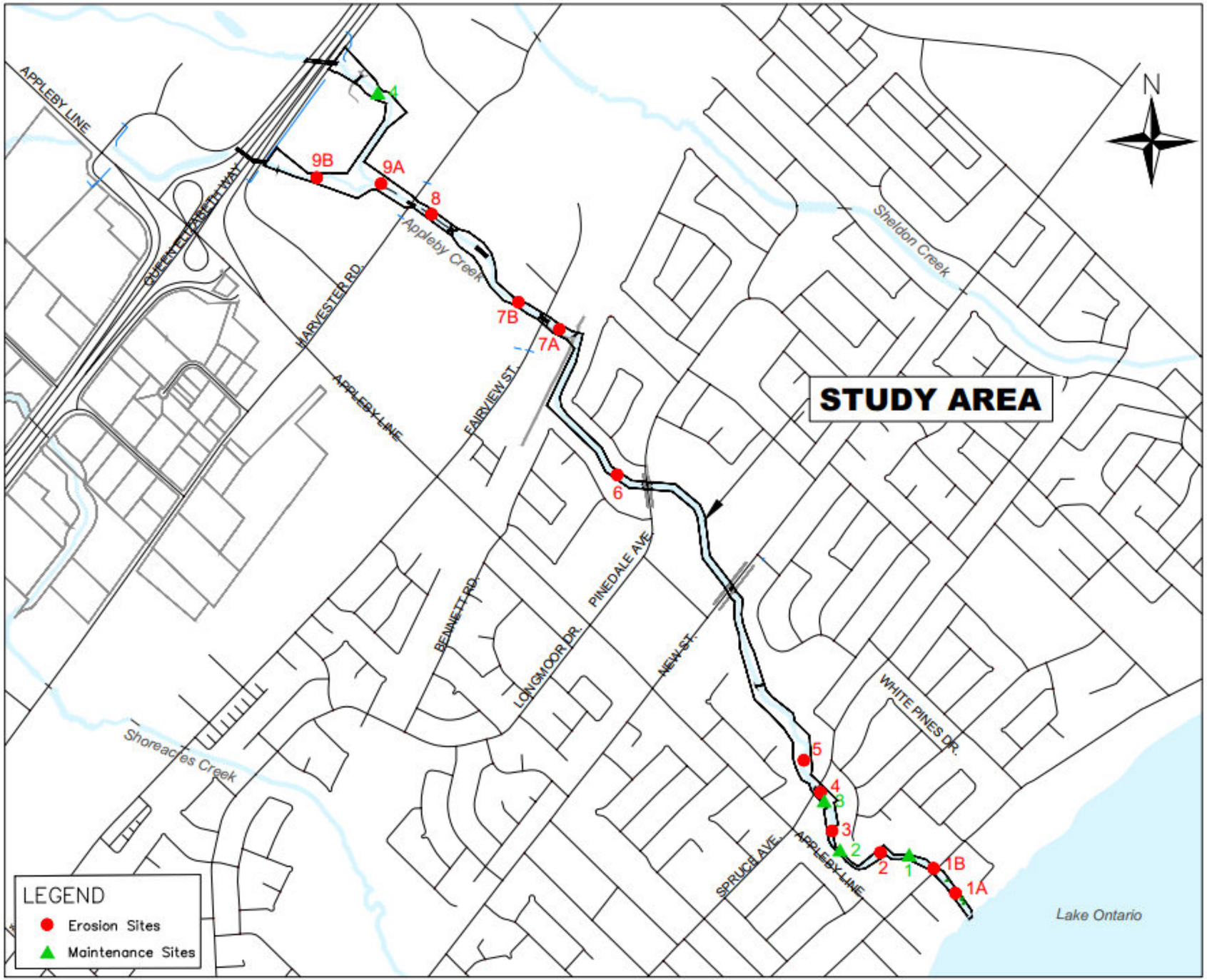


Figure 2-1: Erosion and Maintenance Sites within Appleby Creek

2.1.1 Erosion Site 1A – Bank Erosion, Failed Bridge Abutment Protection and Undermined Storm Outfall

At Erosion Site 1A, Appleby Creek is actively eroding along both sides of the creek which creates risks to private properties. The majority of the west bank is manicured lawn with no protection against erosion; whereas the east bank consists of some mature trees along the bank which provides increased resistance to erosion as a result of the rooting network. Nevertheless, minor exposed and undermined tree roots and leaning trees are observed, which are the indication of erosion. The east bank at the mouth of Lake Ontario has experienced extensive erosion under tidal effect and has a temporary erosion control measure (timber crib wall) to protect the private property.



Photo 2-1:Manicured Lawn on Private Property Experiencing Bank Erosion



Photo 2-2: Temporary Timber Crib Wall on the East Bank



Photo 2-3: Mature Trees Rooting Network Providing Resistance to Erosion

2.1.2 Erosion Site 1B – Failed Bridge Abutment Protection and Undermined Storm Outfall

At the Lakeshore Road crossing (Erosion Site 1B), bridge abutment protection has failed. Base level lowering is evident based on undermined storm outfall headwall and tree roots, downcutting creek banks, and exposed shale bedrock. The erosion poses risk to private property, municipal infrastructure and potentially public safety.



Photo 2-4: Failed Bridge Abutment Protection



Photo 2-5: Undermined Storm Outfall Structure



Photo 2-6: Undermined Tree Roots and Exposed Shale Bedrock

2.1.3 Erosion Site 2 – Meander Bend Erosion

Erosion Site 2 is located at a meander bend south-west of Bromley Park within Reach 2, where the channel is migrating out of the City property parcel onto private properties. Active erosion is evident as trees with exposed roots are leaning into the creek, and the outer bank is near-vertical. Shale bedrock is exposed within the area, which is subject to future weathering. Further upstream of the large meander bend, previous rip-rap treatment to control the channel along a fenceline has failed, as shown in Photo 2-9.



Photo 2-7: Eroded Outer Bank with Near Vertical Slope, Exposed Shale Bedrock



Photo 2-8: Undermined Trees with Exposed Roots and Leaning into the Creek



Photo 2-9: Failed Rip-Rap at Toe of Bank

2.1.4 Erosion Site 3 – Deteriorating Terrafix Channel Bed and Bank Erosion

Along Erosion Site 3, issues and risks consist of deteriorating channel engineering, with two concrete weirs providing grade control. The double weir and interlocking concrete bed configuration have created a fish passage barrier, warranting opportunities for fish habitat improvement. Upstream of the weirs, the creek is actively eroding the outer bank, extending into private properties, with a failing fenceline. Further upstream, planform adjustment is evident as point bar formation and well-defined meander bend were found, shifting the centre of creek easterly towards adjacent private property.



Photo 2-10: Double Concrete Weir with Deteriorating Terrafix Bed



Photo 2-11: Exposed Fence Post Foundation and Tree Roots Due to Erosion



Photo 2-12: Bank Erosion with Evidence of Planform Adjustment

2.1.5 Erosion Site 4 – Exposed Spruce Avenue Bridge Footing with Oversteepened Slope

At Erosion Site 4, the creek is actively scouring the toe of valley slope, creating an over-steepened slope condition near the Spruce Avenue bridge. Trees are actively being undermined and falling into the channel, with limited development beyond the top of slope as the parcel is owned by the City of Burlington. Along the opposing bank where a residential property has been historically protected by a large armourstone wall, channel incision has eroding the toe of the structure and requires reinstatement to limit risks of undermining. Under Spruce Avenue, an open bottom culvert is set on concrete footings, in which the upper half has been exposed. There are no signs of the footings being undermining presently.



Photo 2-13: Oversteepened Unstable Slope Downstream of the Bridge



Photo 2-14: Exposed Footings with Lowered Shale Bedrock



Photo 2-15: Lowered Channel Bed Exposing Bridge Footing Border

2.1.6 Erosion Site 5 – Active Bank Erosion and Unstable Slope

Active erosion along Erosion Site 5 has led to excessive channel enlargement, tree roots exposure and undermining as shown in the photos below. The exposure causes the overburden and shale bed to be more susceptible to weathering and erosion. As a result, the channel has widened especially at the meander bends, leaving tree roots overhanging and causing trees to fall into the creek. The underlying limestone layer, which is more resistant to erosion, has also weathered and been eroded over time and defines the current low flow channel. The creek condition including water quality and fish habitat will continue to degrade without intervention and pose risk to adjacent private properties along Bryant Crescent.



Photo 2-16: Bank Scour and Bed Down-Cutting



Photo 2-17: Undermined Trees and Exposed Tree Roots Due to Erosion



Photo 2-18: Trees Leaning into Creek

2.1.7 Erosion Site 6 – Bank Erosion into Natural Trail

At Erosion Site 6, the rip-rap material originating from upstream channel-lining treatment has been deposited on the channel bed, diverting the flow towards the bank and causing exacerbated bank erosion. The creek is eroding into an informal natural trail on the south bank and poses risk to both public safety and private property.



Photo 2-19: Bank Erosion Upstream of Storm Outfall



Photo 2-20: Active Bank Erosion into Trail



Photo 2-21: Rip-Rap Deposit in the Creek

2.1.8 Erosion Site 7A – Active Bank Erosion in Close Proximity to Private Property and Trail

Erosion Site 7A includes intermittent gabion baskets in poor conditions and failed gabion baskets at some locations. Due to the deterioration, the gabion baskets can no longer provide the intended level of protection for adjacent private properties and the bikeway overtime. Additionally, bank erosion is observed at meander bends that are not lined with gabion baskets.



Photo 2-22: Longitudinal and Transverse Cracks Along Centennial Bikeway



Photo 2-23: Bank Erosion at Meander Bend



Photo 2-24: Gabion-Lined Channel

2.1.9 Erosion Site 7B – Active Bank Erosion in Close Proximity to Private Property

Erosion Site 7B also consists of bank erosion and intermittent gabion baskets in poor conditions with failed gabion baskets at some locations. In comparison to Erosion Site 7A, this site is more confined with private properties without much floodplain relief opportunities. As a result, erosion is more evident, including encroachment of unprotected bank towards property fence, failing gabion baskets upstream and downstream of the storm outfall as well as other locations.



Photo 2-25: Active Bank Erosion in Close Proximity to Private Property



Photo 2-26: Gabion Baskets Failed at Base Level, Upstream of Storm Outfall



Photo 2-27: Deteriorating Gabion Baskets Emptying at Base Level

2.1.10 Erosion Site 8 – Deteriorating Gabion Baskets and Concrete Weirs

Erosion Site 8 consists of deteriorating and / or failed gabion baskets and concrete weirs. Rip-raps have been released from the deteriorating gabion baskets, accumulating downstream in the middle of the creek. Moreover, a section of gabion baskets was pulled out during previous floods and deposited in the creek downstream, obstructing the flow. The concrete weirs are also in poor conditions with some being undercut and perched. The deterioration will continue without intervention and create risk to public safety as this section of Appleby Creek traverses the Appleby Go Station parking lots.



Photo 2-28: Deteriorating Concrete Weir and Failed Gabion Baskets



Photo 2-29: Failed Gabion Deposited in the Creek



Photo 2-30: Looking upstream at the Gabion Lined Channel

2.1.11 Erosion Site 9A – Failed Grade Control Structure and Active Bank Erosion

Erosion Site 9A consists of a mass failure of a gabion structure, historically constructed to provide erosion and flood control upstream of Harvester Road. The remnants of this structure have created a deep scour pool downstream of the structure. The flow is split by the deposited rip-rap and Terrafix blocks, scouring and undermining the bank. Further upstream, the creek is also actively eroding the bank, creating an over-steepened condition and posing risks of slope failure to adjacent private properties. Continuing upstream of this structure, there is an extended length of gabion lined channel which is at risk of undermining as a result of this grade control failure.



Photo 2-31: Failed Gabion and Terrafix Grade Control Structure, Looking Downstream



Photo 2-32: Failed Gabion and Terrafix Grade Control Structure, Looking Upstream



Photo 2-33: Scoured and Over-Steepened North Bank

2.1.12 Erosion Site 9B – Active Bank Erosion Along the West Branch

Erosion Site 9B involves active erosion along the west branch of Appleby Creek. The corridor is confined by private properties without much flood relief opportunities. In turn, erosion has over-steepened slopes overtime and posing risks of slope failure to adjacent private properties. A number of woody debris are formed in the creek limiting the flow conveyance and posing flooding risks.



Photo 2-34: Over-Steepened Slope Due to Erosion, Adjacent to Private Property



Photo 2-35: Hydro Pole in the Creek



Photo 2-36: Intermittent Gabion Lined Bank and Woody Debris Jam

2.1.13 Maintenance Sites

In addition to the erosion sites, four maintenance sites are identified (see Figure 2-1 for locations). The details of each maintenance site (MS) are listed below followed by photo illustrations:

- MS 1 – removal of fallen trees and woody debris
- MS 2 – replacement of missing sewer back-flow cover
- MS 3 – exposed armourstone wall toe protection maintenance
- MS 4 – removal of fallen trees and woody debris



Photo 2-37: Fallen Tree Across the Creek (MS 1)



Photo 2-38: Missing Storm Sewer Back-Flow Cover (MS 2)



Photo 2-39: Exposed Armourstone Wall Toe Protection (MS 3)



Photo 2-40: Woody Debris Obstructing Flows (MS 4)

2.2 Opportunities

In light of the existing conditions within the study area, there are several opportunities to control erosion issues, protect municipal infrastructure and private properties while improving riparian habitat:

- Replacement of failing gabion baskets with alternative bank treatment including armourstone, vegetated stone bank treatment, rock toe protection, and/or vegetated banks;
- Protection of municipal infrastructure assets and private properties with minor channel realignment and erosion control measures;
- Restoration of watercourse floodplain access through cutting back of channel banks where applicable;
- Enhancement of aquatic and terrestrial habitat through removal of fish barriers and placement of rounded substrate, rib structures, and riparian plantings.

In considering the possible alternatives for the stabilization and rehabilitation of Appleby Creek within the study area, the above-listed opportunities were investigated.

3 SITE SPECIFIC INVENTORIES

To address Phase 2 of the EA process, site specific studies were conducted to inform the consideration of alternatives, and support the evaluation resulting in the preferred alternative. A summary of site-specific inventories are provided below.

3.1 Topographic Surveys

At the onset of the field assessment, a broad scale survey was undertaken to define the topographic features within the study area, including the identified reaches of Appleby Creek corridor, storm sewer infrastructure, and the culvert crossings. The survey was completed in sufficient detail for the purposes of geomorphic analysis, hydraulic modelling, and preliminary design. The key parameters of the survey included:

- Longitudinal profile of the Appleby Creek within the study area, surveying the channel thalweg;
- Cross-sections perpendicular to the channel at representative reaches and extended in sufficient detail beyond the top of bank for undertaking hydraulic analysis;
- Municipal infrastructure including the storm sewer outfalls, sewer manholes, and the culvert crossings;
- Mature vegetation potentially impacted because of the restoration or implementation; and
- Potential construction access routes.

The survey was completed using a combination of a total station and GPS techniques to confirm accuracy that geodetic elevations is consistent with City horizontal controls and overlays the basemapping provided by the City, which includes property parcels and contours.

The topographic information was compiled into planform and profile mappings, which highlight the locations with existing erosion issues, as well as the depth of the channel in comparison to the depth of the sanitary trunk sewer. The plan and profiles can be found in Appendix A.

Upon review of the channel and sewer profiles, the risks of undermining are apparent wherever there is limited elevation differential between the channel bed and sewer. Typically, a minimum channel bed cover of 1.5m is preferred over a sewer obvert, however, due to channel degradation the sewer cover is less than 1 m in some cases.

3.2 Geomorphic Assessment

As mentioned previously, Appleby Creek is one of the main watercourses in the City of Burlington and a key feature in the Regional Natural Heritage System, with a drainage area of approximately 12.1 km^2. The total watercourse length is approximately 14 km with an average longitudinal slope of 0.015 m/m. The watercourse falls through an elevation difference of approximately 200m. Approximately 65% of the watershed is developed.

When completing a geomorphic assessment, it is common practice to divide or segment the watercourse into sections of similar channel form, floodplain access, adjacent land use, and valley setting, referred to as reaches. Reaches within the study extents have been delineated into seven (7) management reaches as shown in Figure 3-1, totaling a length of approximately 4 km of from Lake Ontario to South Service Road.

Moreover, when undertaking a stream restoration study at a scale consistent with this EA, consideration of separate restoration plans or alternatives for each reach enables a design methodology which is specifically refined to address the channel characteristics and risks of that reach.

A fluvial geomorphic field assessment was completed in Fall 2018 to gain a better understanding of the system. The catchments within the study area are urbanized, leading to an increase in runoff volume and peak flows. As a result, vertical and horizontal erosion and undermined municipal infrastructure are present, in addition to the deterioration of erosion control measures. The existing fluvial conditions for each reach have been summarized in the sections below, accompanied with photographic illustrations.

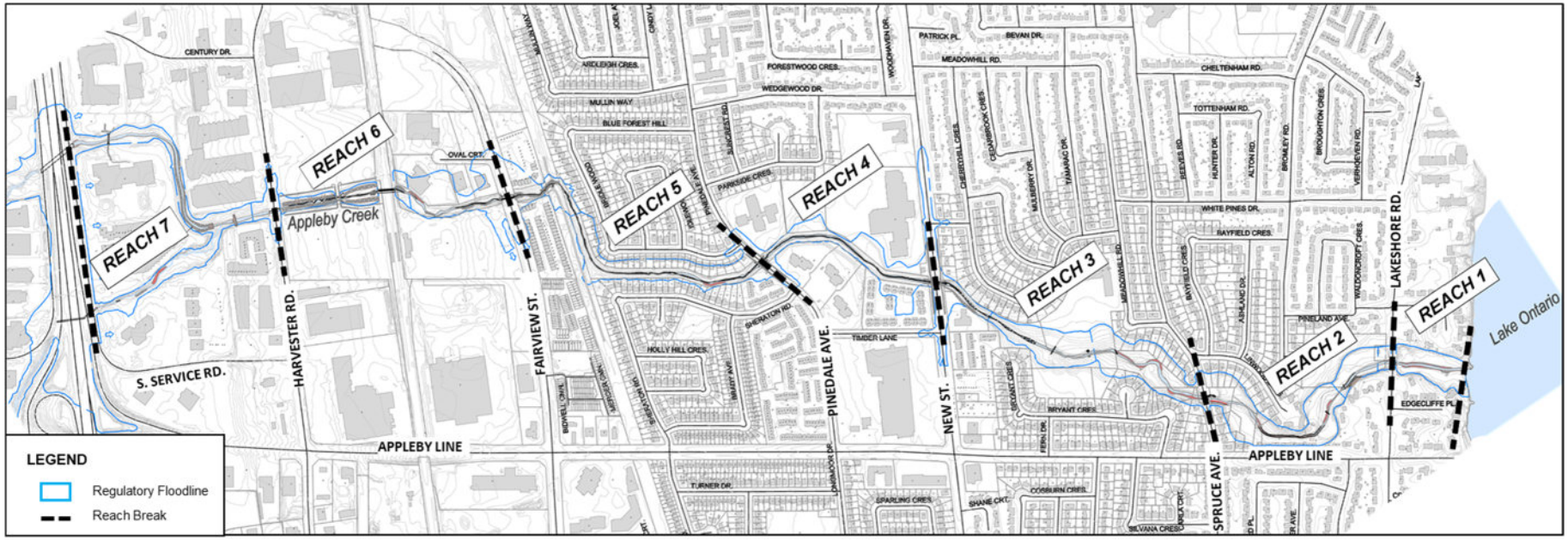


Figure 3-1: Delineated Management Reaches within the Appleby Creek Study Area

3.2.1 Reach 1 – Lake Ontario to Lakeshore Road

Reach 1 extends from the confluence with Lake Ontario to Lakeshore Road bridge crossing. Along this segment of channel, active erosion is evident based on exposed tree roots and leaning trees. A timber crib wall was installed to limit erosion near the confluence and protect the private property. However, vegetation failed to establish fully before high water conditions occurred and material loss is observed.

The channel has good access to the floodplain and the riparian corridor is vegetated, predominantly with grasses and mature trees. The riparian corridor provides shade to most of the width of the low flow channel. The channel bed material is comprised of deposition of material transported from upstream including angular rock (i.e., riprap), fragmented bedrock pieces, gravels and finer materials.

In terms of geomorphic process, continued scouring at the bridge abutment and downstream of the bridge is expected, which will eventually result in failure of the adjacent slopes without intervention. Also, widening of the channel will occur as part of the creek's natural process in combination with the tidal effects from the lake. In turn, this erosion issue has been identified as Erosion Site 1A.

In addition to the photos concerning Erosion Site 1A and 1B presented in **Section 2.1.1** and **Section 2.1.2**, photographic compilation of the reach existing conditions is shown below.



Photo 3-1: Confluence with Lake Ontario with Crib Wall Erosion Protection Measure



Photo 3-2: Detached Bedrock Particles Deposited on Channel Bed and Bank Erosion



Photo 3-3: Channel Planform Looking Upstream



Photo 3-4: Deep Scour Pool Downstream of Bridge with Fallen Trees

3.2.2 Reach 2 – Lakeshore Road to Spruce Avenue

Reach 2 extends from Lakeshore Road to Spruce Avenue, and the contributing area consists of residential lands and parks. Intermittent engineering works, including armourstone retaining wall, boulder toe protection, as well as approximately 150 m of Terrafix lined channel, are found in-between the natural setting.

At the downstream section of the reach, the creek has access to the floodplain with a flat and wide low flow channel. The banks are well vegetated with mature trees and shrubs, which provide high roughness and resistance to erosion. Intermittent erosion control and slope stabilization measures including roundstone toe protection and armourstone wall are in fair to good conditions. However, the roundstone at the toe of bank are sitting on exposed shale bedrock, which makes the material more subjective to movements during large flood flows. The shale bedrock is not only exposed but also lowering, proven by the undermined storm outfall headwall (see Photo 2-5). The storm outfall headwall will continue to deteriorate without intervention. In turn, the rehabilitation of the infrastructure is included as part of the alternatives for Erosion Site 1B. There are also a few fallen trees crossing the creek, which may be potential flow obstructions during large flood flows. As a result, this site is also identified as Maintenance Site 1 for fallen tree removals.

The middle section is confined to a narrow corridor between low density residential housings. To protect the private properties from erosion, the channel banks are lined with concrete blocks and armourstone ranging from 1 – 3.5 m high. The retaining wall is in good condition; however, the rectangular-shaped channel with near vertical walls provides no floodplain access during frequent flood flows. This limits the opportunities for energy dissipation and flow velocity decrease and increases erosion risk downstream. The channel bed is also engineered with Terrafix blocks and two concrete weirs, providing grade control and vertical migration control. The channel bed is also collecting fractured shale bedrock and limestone materials transported from upstream.

The channel upstream of the weir transitions into a more natural setting. The creek has a fair to good access to floodplain, and the riparian corridor is well-vegetated which provide high roughness. Nevertheless, eroded and undercut banks, point bar and undermined armourstone

wall toe protection are found in this section, suggesting bank erosion, aggradation, degradation and planimetric form adjustment. The shale bedrock is exposed at most the section, with native materials deposited at some locations.

Select photos were compiled below to further describe the conditions within the reach, highlighting some of the problems to be addressed through the Environmental Assessment and design stages.



Photo 3-5: Banks Protected Boulder Toe and Armourstone Wall, Exposed Shale Bedrock



Photo 3-6: Terrafix Lined Channel Bed with Concrete Blocks / Armourstone Retaining Wall



Photo 3-7: Erosion at Outer Meander Bend



Photo 3-8: Double Concrete Weirs



Photo 3-9: Looking Downstream at Wide Low Flow Channel with Good Floodplain Access



Photo 3-10: Undermined Bank Slope and Armourstone Toe Protection

3.2.3 Reach 3 – Spruce Avenue to New Street

This reach can be divided into two distinct segments. The upstream segment is historically straightened to be within the narrow corridor confined by low to medium density residential lands. The channel bed is predominantly comprised of riprap materials washed off from upstream with some gravels and sand, deposited on shale bedrock. The deposition has created a back-water effect just downstream of New Street, potentially reducing the capacity of an adjacent storm outfall. The deposits also create a concentrated low flow channel on shale bedrock, exacerbating local bed lowering and creating some minor headcut. Nevertheless, the channel has frequent access to densely vegetated floodplain and only minor erosion is observed with no evidence of active or excessive erosion.

The creek transitions into a more sinuous channel including a full meander wave length and contacts each valley slope. Active erosion is evident within this segment, shown by near vertical outer meander bends, overhanging tree roots, inclining trees, and exposed shale bedrock and limestone layers. Although hydraulic scour is not the dominant erosional process to shale and limestone bedrock, the exposure of bedrock has led to more susceptibility to bedrock weathering and further bedrock lowering, which is demonstrated by the penetrated limestone layer underneath the shale bedrock layer. Typically, bedrock lowers at a rate of 5~10m / 100yr. Nevertheless, active erosional process within this reach may accelerate the process.

The large shear stress that this segment is experiencing could be the result of the straightened upstream channel, providing little flow and energy dissipation. Therefore, the unprotected outer bends are experiencing erosion which is also encroaching adjacent private properties and will lead to loss of lands if no intervention is undertaken. The overall channel consists of wide and shallow low flow channels on exposed shale bedrock, with limited access to floodplain. As a result, further channel incision and bank erosion are expected.

Select photos to illustrate the existing reach conditions are included below.



Photo 3-11: Channel Bed Lowering Showing Soil Stratification at Downstream Segment



Photo 3-12: Channel with Leaning Trees



Photo 3-13: Channel Base Level Lowering with Under-Cutting Banks



Photo 3-14: Pedestrian Bridge Crossing at Pinedale Park



Photo 3-15: Riprap Deposits on Shale Bedrock, Creating Low Flow Channel with Minor Headcut



Photo 3-16: New Street Bridge and Back-Water Storm Outfall

3.2.4 Reach 4 – New Street to Pinedale Avenue

Through Reach 4, Appleby Creek is an urban creek with a vegetated riparian corridor. As discussed above the creek has been channelized, and has been straightened through the entire study area, which restricts the development of natural morphology. There are several long, course riffles/runs, and several short and shallow pools, which is characteristic of many channelized, urban, watercourses in southern Ontario. The low flow channel is wide and shallow, with much of the coarse bed material protruding through the water.

The channel is generally disconnected from the floodplain, as it is confined to the channelized corridor. There are small sections of the channel adjacent to the school yards that do provide some floodplain relief.

The bed material is predominantly comprised of angular rock (i.e., riprap), and sand, which is expected to be outwash from roads. A noticeable amount of the channel bed is composed of contribution materials from historic river treatment, including concrete at the New Street bridge inlet and masonry bricks and blocks. Large slumps of riprap were noted at several locations throughout the reach, and algae growth was prevalent throughout the reach.

The riparian corridor is vegetated, predominantly with grasses and shrubs, and some mature trees. The corridor is not maintained and there is a large “No Cut” zone upstream of New Street. The riparian corridor provides shade to the majority of the width of the low flow channel. The riparian corridor was observed to be significantly rougher than the channel or overbanks.

Some minor bank erosion was observed, however there was no evidence of active or excessive erosion. While there was evidence of exposed tree roots, there were very few leaning trees, indicating that the channel is not experiencing active lateral erosion. There were several outfalls that appeared to be buried, which might be evidence of aggradation. Some small debris jams were noted.

Select photos which illustrate the existing reach condition are shown below.



Photo 3-17: New Street Bridge Crossing, Exposed Shale Bedrock & Gabion Retaining Wall



Photo 3-18: Gabion Baskets with Grouted Concrete Toe Protection



Photo 3-19: Riprap-Lined Channel Bed



Photo 3-20: Channel Cross Section View

3.2.5 Reach 5 – Pinedale Avenue to Fairview Street

The general channel morphology of Reach 5 is very similar to Reach 4. There is limited development of natural morphology, however there are some long riffles/runs and shallow pools. Deeper pools have developed at the outlets of the Pinedale Avenue and Fairview Road bridges, resulting from scour. The low flow channel is slightly narrower in Reach 5; however, the general form is still wide and shallow.

The channel is almost completely disconnected from the floodplain. Even through the hydro-corridor, where the grassy park could provide safe, low risk floodplain relief, the channel is still confined to the corridor and does not appear to have any significant floodplain relief.

The bed material through Reach 5 is the same as Reach 4, predominantly angular foreign stone (i.e., riprap), masonry materials and sand. Some fractured shale deposition was observed between the pedestrian bridge and Fairview Road. Also, more channel vegetation was observed through Reach 2, mainly in the form of grasses.

The riparian corridor through Reach 5 presents more encroachment and some sections of the corridor have been completely manicured. The corridor still provides a significant amount of roughness, and several small debris jams were observed, which could be a result of yard waste dumping. Again, the riparian corridor was observed to be significantly rougher than the channel or overbanks.

More localized erosion was observed along the banks of the channel. At one location the erosion has migrated to the footpath that runs along the bank between the hydro corridor and Pinedale Avenue. Other localized areas of erosion appeared to be associated with areas of encroachment, and lawn mowing. Failing gabions were observed between the pedestrian bridge and Fairview Road. The gabions are expected to have been placed to protect the Trans-Northern pipeline and the Centennial Bikeway trail from erosion. The gabions have rusted out at the bottoms and are slumping into the channel.

Photographic compilation of the reach existing conditions is shown below.



Photo 3-21: Minor Bank Erosion into Natural Path



Photo 3-22: Channel Cross Section View



Photo 3-23: Channel Cross Section View



Photo 3-24: Gabion Lined Channel Bank

3.2.6 Reach 6 – Fairview Street to Harvester Road

While Reach 6 does exhibit several of the same characteristics as Reaches 4 and 5; having been straightened and confined to a narrow corridor, there are several differences. The valley corridor is much steeper and the channel is completely disconnected from the floodplain.

The bed material in this reach is predominantly exposed and fractured shale bedrock, and there is limited riprap or masonry material except at locations where localized bank treatments have been placed (e.g., Fairview Road bridge inlet). The native bed material seems to have allowed for a more natural morphology to form throughout Reach 6, with an obvious riffle-pool pattern, and more meandering of the low flow channel within the valley. The low flow channel is narrower than previous reaches, and generally has deeper flow.

The riparian corridor is completely unmaintained, and dense trees and shrubs have filled the valley. Small woody debris jams were noted throughout the reach. Tree and shrub roots were observed along the channel bed and appeared to be providing some grade control to the channel.

Erosion was observed at several locations. As noted above, the valley is very steep, and there were several locations of bank and valley erosion, some within the shale bedrock. There are several sections of gabions that are in a deteriorated sate; in particular at the storm sewer outlet for the Appleby GO station parking lot and the gabion weir at the inlet of the Fairview Road bridge. It is expected that the gabion weir at Fairview Road was intended to protect the 300mm watermain that crosses the channel at that location, however half of the weir has completely emptied and the other half is now creating a fish barrier.

Select photos to further demonstrate the site conditions are included below.



Photo 3-25: Intermittent Natural Channel Corridor



Photo 3-26: Gabion Baskets Failing at Base Level



Photo 3-27: Channel Corridor within GO Station



Photo 3-28: Deteriorating Grade Control Structures

3.2.7 Reach 7 – Harvester Road to South Service Road

This most upstream reach consists of a west branch and east branch, which confluent at approximately 120m upstream of Harvester Road bridge crossing. Reach 7 exhibits some similar characteristics as Reach 6 as this reach has also been straightened and confined to a narrow corridor at some locations. There are also several major differences amongst the two branches and the section downstream of confluence. The valley corridor along the two

upstream branches is steeper than the corridor within the main branch. However, most of the channel within the reach still has floodplain access, except for some locations with engineered bank treatments. The riparian corridor is unmaintained and filled with dense trees and shrubs, which provide resistance to erosion and roughness to channel. Small woody debris jams were noted at multiple locations within the reach.

The bed material in this reach varies between native gravel deposits and engineered interlocking Terrafix blocks or rip rap material from failing / failed bank protection structures. The native bed material within west branch seems to have allowed for a more natural morphology to form, with some obvious riffle-pool features and more meandering of the low flow channel within the valley. The east branch and main branch low flow channels are relatively straight.

Erosion was observed at several locations throughout the reach. As noted previously, the gabion and concrete weir grade control structure on the main branch has failed, creating deep scour pool immediately downstream of the weir and steep bank erosion. The structure remains has redirected the flow towards the banks, which allows the creek to further erode the unprotected banks. Minor bank erosion is noted at the east branch; however, previous bank protection treatment (i.e. gabion baskets and rip-rap toe protection) as well as dense vegetation is providing protection against erosion. Steeper slopes and exposed tree roots are more noticeable at the west branch, which shows the process of bank erosion and potential risks to adjacent private properties.

Photographic compilation of the reach existing conditions is shown below



Photo 3-29: Channel Bypassing Failed Grade Control Structure



Photo 3-30: Channel Confluence Point



Photo 3-31: Channel Cross Section View, East Branch



Photo 3-32: Wood Debris Obstructing Channel Conveyance, East Branch



Photo 3-33:Channel Cross Section View, West Branch



Photo 3-34: Bank Erosion Leading to Exposed Tree Roots, West Branch

3.3 Erosion and Maintenance Sites Inventory and Scoring

3.3.1 Erosion and Maintenance Sites Inventory

The Erosion Sites and Maintenance Sites discussed in **Section 2.1** have been summarized in the table below, which also details the encompassing reach, type of problems, potential risks, and field level risk assessment (i.e. High, Medium, Low).

Table 3-1: Summary of Erosion and Maintenance Sites by Reach

Reach No.	Erosion / Maintenance Sites	Site Condition Descriptions	Risks to	Level of Risk
Reach 1	Erosion Site 1A	· Active bank erosion; and · Shale bedrock lowering.	Private property, municipal infrastructure, and aquatic habitat.	High

Reach No.	Erosion / Maintenance Sites	Site Condition Descriptions	Risks to	Level of Risk
	Erosion Site 1B	· Failed bridge abutment protection and deteriorating storm outfall headwall.	Municipal infrastructure	High
Reach 2	Erosion Site 2	· Active bank erosion, undermined trees; · Exposed Shale bedrock; and · Failed bank protection measures.	Private property and aquatic habitat.	Low
	Maintenance Site 1	· Fallen Trees	Channel conveyance	Low
	Erosion Site 3	· Active bank erosion resulting in undermined trees and exposed fence pole foundation; · Deteriorating Terrafix channel bed between concrete weirs; and · Existing fish barrier at the double concrete weir.	Private property and aquatic habitat.	Medium
	Erosion Site 4	· Active bank erosion and over-steepened slope, undermined trees; and · Shale bedrock lowering.	Municipal infrastructure and aquatic habitat	Low
	Maintenance Site 2	· Missing back-flow prevention covers for sewer outfalls within the concrete block wall reach.	Private properties due to sewer surcharging during extreme events	Low
	Maintenance Site 3	· Undermined armourstone concrete toe protection.	Municipal infrastructure	Low
Reach 3	Erosion Site 5	· Active bank erosion and over-steepened slope, undermined trees; · Shale bedrock lowering; and · Failed bank protection measures.	Private property and aquatic habitat.	Medium
Reach 4	n/a	n/a	n/a	n/a
Reach 5	Erosion Site 6	· Active bank erosion into natural trail; · Undermining of storm outfall; and · Riprap deposits in the creek.	Private property, public safety, municipal infrastructure and aquatic habitat	Medium
	Erosion Site 7A	· Active bank erosion in close proximity to private property; and · Failed gabion baskets adjacent to storm outfall and other locations.	Private property, municipal infrastructure and aquatic habitat	High
Reach 6	Erosion Site 7B	· Active bank erosion in close proximity to private property; and · Failed gabion baskets adjacent to storm outfall and other locations.	Private property, municipal infrastructure and aquatic habitat	High
	Erosion Site 8	· Gabion baskets in poor conditions, with failure at multiple locations;	Private property and aquatic habitat	High

Reach No.	Erosion / Maintenance Sites	Site Condition Descriptions	Risks to	Level of Risk
		· Failed and deteriorating concrete weirs; and · Gabion basket debris deposits in the creek, obstructing flow conveyance.		
Reach 7	Erosion Site 9A	· Failed gabion and Terrafix grade control structure.	Upstream and downstream creek stability and aquatic habitat	High
	Erosion Site 9B	· Active bank erosion resulting in over-steepened and unstable slopes; · Hydro poles inside the creek; and · Woody debris at multiple locations.	Private property, municipal infrastructure, aquatic habitat, and channel conveyance	High
	Maintenance Site 4	· Woody debris at multiple locations obstructing flow conveyance	Channel conveyance	Low

3.3.2 Erosion Sites Field Scoring Methodology

To standardize the erosion risks and environmental opportunities during the field assessments, a semi-quantitative technical scoring methodology was developed in consultation with the project team. Each erosion site was given a score out of 100, with larger scores representing sites with higher levels of erosion risk and / or higher degrees of environmental opportunity. Figure 3-2 and Table 3-2 summarize the technical scoring approach, including the evaluation criteria of each scoring component.

The erosion risk component includes an erosion index of 35% (distance, extent, stress, and erodibility) and a public health and safety index of 35% (type of risk). The environmental opportunity component includes opportunities to enhance riparian cover (15%) and opportunities to enhance aquatic habitat (15%). The total score out of 100 provides a semi-quantitative measure of risk and opportunity to guide subsequent decisions regarding stream restoration opportunities within the Appleby Creek study area.

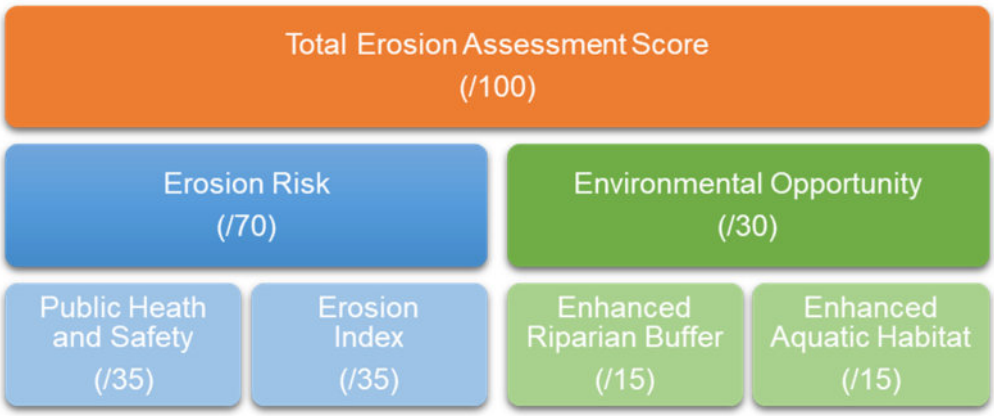


Figure 3-2: Framework for Field Scoring of Erosion Sites

Table 3-2: Erosion Site Scoring Detailed Evaluation Criteria

Parameter	Definition	Evaluation Criteria	
Erosion Risk Component			
Public Health and Safety (/35)			
Type of Risk	Identified the type of infrastructure that was closest to the Erosion Site	Critical Infrastructure (Buildings, Major Dams, Water or Gas Mains, Major Roads/Bridges, Sanitary Sewers and Maintenance Holes, Other Utilities)	35
		Minor Roads, Bridges and Paved Trails	30
		Private Property with Secondary Infrastructure (Deck, Pool, Shed, Septic Bed, Other Permanent Structure)	25
		Public Property with Secondary Infrastructure (Public Parking, Minor Dams or Weirs, Active Park Lands, Trail Types 2-4, Other)	15
		Open Space (Inactive)	0

Erosion Index (/35)			
Distance	Distance from top of bank to resource type	In channel	15
		0 – 2 m	12
		2 – 5 m	10
		5 – 10 m	5
		10– 20 m	2
		> 20 m	0
Extent	The spatial area encompassed by the erosion site	> 301 m^2	10
		201 – 300 m^2	8
		101 – 200 m^2	6
		50 – 100 m^2	4
		1 – 50 m^2	2

Stress	Stream energy and flow regime.	Stream Energy	Flow Regime		
			Flashy	Transitional	Undeveloped
		High	5	4	3
		Moderate	4	3	2
		Low	3	2	1

Erodibility	Physical characteristics of bank materials	High	5
		Moderate	3
		Low	1

Total Erosion and Risk Component Score	**/ 70**

Environmental Opportunity Component			
Enhance Riparian Cover (/15)			
Riparian Buffer	Evaluation of the quality of the surrounding riparian cover	Sensitive	0
		High Quality (i.e. dense, mature, native)	5
		Moderate Quality	10
		Low Quality (i.e. no buffer)	15

Enhance Aquatic Habitat (/15)					
Aquatic Habitat	General evaluation of the thermal regime of the system and evaluation of the	Thermal Regime/ Fish Community	Habitat Quality		
			High (Riffle-Pool, Natural Substrate)	Moderate (Mixed)	Low (Degraded Channel)

	quality of the channel bed to provided suitable habitat for fish or invertebrates	Coldwater / Intolerant	0	5	10
		Mixed / Moderately Tolerant	2	7	12
		Warmwater / Tolerant	5	10	15
Total Environmental Opportunity Component Score:					**/ 30**
TOTAL EROSION ASSESSMENT SCORE:					**/ 100**

3.3.3 Erosion Sites Field Scoring Results

The field scoring results for the nine identified erosion sites are presented in Table 3-3, with the detailed scoring methodology exemplified for Erosion Site 1.

Field scoring methods do not provide a definitive prioritization of erosion sites. Additional criteria such as property ownership have also been considered. Further classification and prioritization of the erosion sites are documented in **Section 5**, and implementation plans are outlined in **Section 6**.

Table 3-3: Erosion Sites Field Scoring Results

Reach No.	Site #	Erosion Risk Component						Environmental Opportunity Component			Total Score (/100)
		Type of Risk	Distance	Extent	Stress	Erodibility	Score (/70)	Riparian Buffer	Aquatic Habitat	Score (/30)	
Reach 1	1A & 1B	35	15	10	3	3	66	10	7	17	**83[1]**
Reach 2	2	25	2	4	4	3	38	5	2	7	**45**
	3	25	15	6	5	5	56	12	10	22	**78**
	4	0	15	6	4	5	30	8	7	15	**45**
Reach 3	5	25	15	10	4	5	59	5	10	15	**74**
Reach 5	6	15	5	4	4	3	31	12	4	16	**47**
Reach 6	7A (R5) & 7B (R6)	35	10	10	4	3	62	10	4	14	**76**
	8	35	15	10	5	1	66	15	12	27	**93**
Reach 7	9A & 9B	25	15	12	4	3	59	10	10	20	**79**

[1] Reach 1 Scoring Example (Reference to Table 3-2)

Parameter	Evaluation Criteria Description	Score
Erosion Risk Component		
Type of Risk	Risk to Critical Infrastructure	35
Distance	In-Channel	15
Extent	301 m^2	10
Stress	Flashy & Low	3
Erodibility	Moderate	3
Environmental Opportunity Component		
Riparian Buffer	Moderate Quality	10
Aquatic Habitat	Moderate & Mixed / Moderately Tolerant	7
	Total Score	**83**

3.4 Storm Sewer Outfall Inventory

During the creek walks, stormwater outfalls that drain directly into the creek were identified and inventoried. The approximate locations for identified storm outfalls are illustrated in Figure 3-3. Reach-scale storm outfall location maps as well as the inventory detailing sewer ownership, dimension, physical conditions and photos are attached in Appendix B.

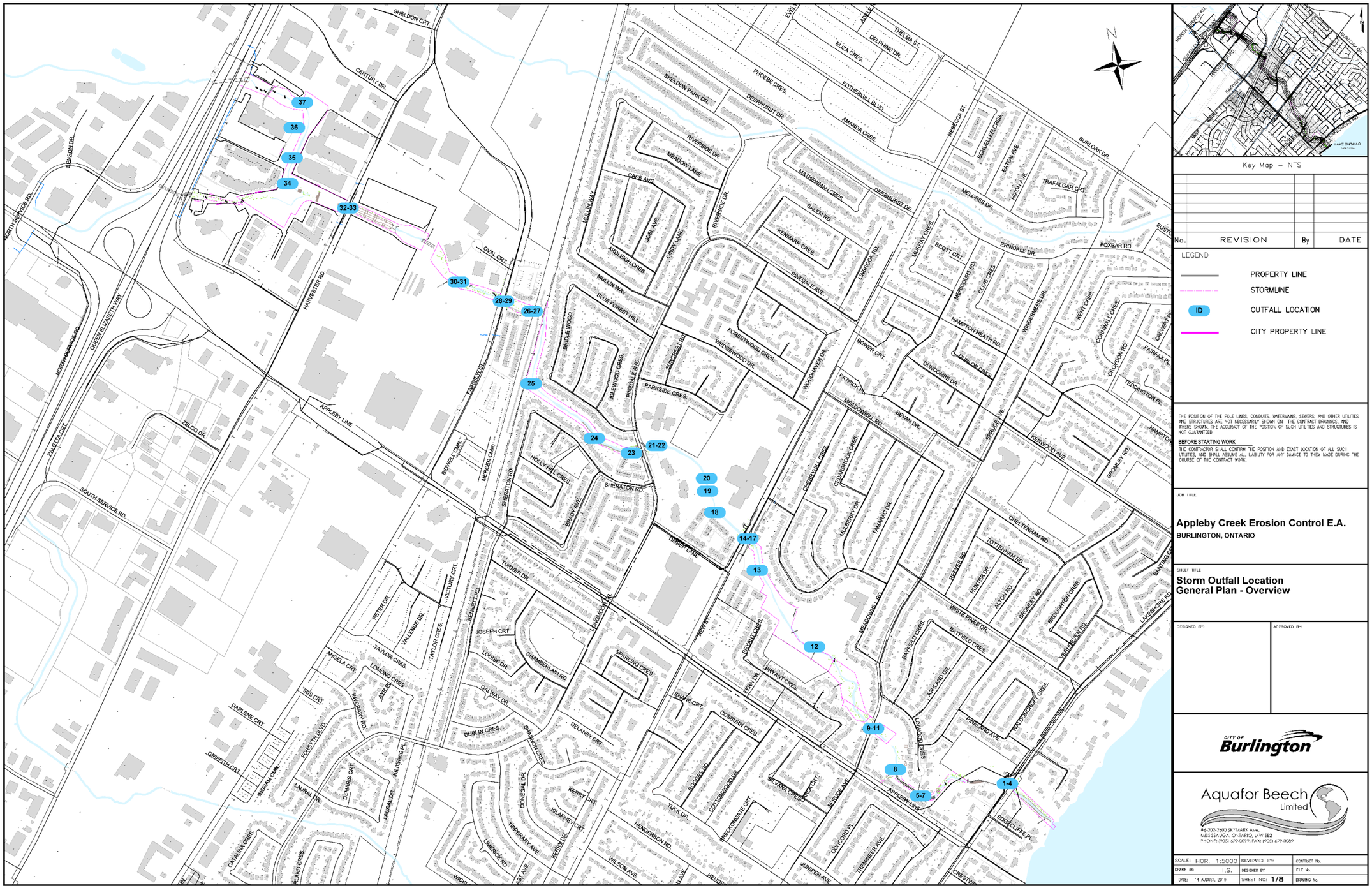


Figure 3-3: Storm Outfall Location Map

3.5 Hydrologic and Hydraulic Assessment

3.5.1 Hydrology

An existing hydrologic model for the Appleby Creek was developed during the Appleby Creek Flood Mitigation EA study (Aquafor Beech Ltd., 2019). The flows at different locations are derived from the Appleby Creek Flood Mitigation EA study into this study. The flows at different nodes along the Appleby Creek was computed using the HEC-RAS model for the full range of design storms events (i.e., 2-year to regional floods). Flows at different locations under various rainfall events are presented in Table 3-4 and the flow node locations are shown in Figure 3-4.

Table 3-4: Flows at different nodes along the Appleby Creek

Flow Node / Location	Flow (m^3/s)						
	Regional	100 Year	50 Year	25 Year	10 Year	5 Year	2 Year
Node 1 / Lakeshore Road	109	61	55	48	38	31	21
Node 2 / New Street	106	59	53	47	38	31	21
Node 3 / Longmoor Drive	101	57	51	45	35	30	20
Node 4 / Metrolinx Rail Corridor	93	54	48	42	34	28	19
Node 5 / Harvester Road	85	50	45	39	32	26	18

3.5.2 Hydraulics

Hydraulic modeling of the Appleby Creek study area was performed using the U.S. Army Corps of Engineers HEC-RAS model. The model was run under subcritical, steady state conditions.

The model developed for this study was derived from the model used as the base model for the Appleby Creek Flood Mitigation EA study (Aquafor Beech Limited, 2019). For this study, the model was updated to include the section of Appleby Creek from the South Service Road to Lake Ontario. Nine cross sections were established at the erosion site locations identified in the study.

The model geometry was refined using the topographic survey data collected to accurately reflect the existing erosional conditions at the Appleby Creek, and a ‘steady-state’ hydraulic analysis was carried out using the design storm presented in Table 3-4. The survey data characterized the existing conditions, supplementing the existing HEC-RAS with profile and cross sections in accordance with the Conservation Halton standards.

Figure 3-4 illustrate the cross-section locations within the study area and a summary of the hydraulics for all the cross sections are provided below in Table 3-5.

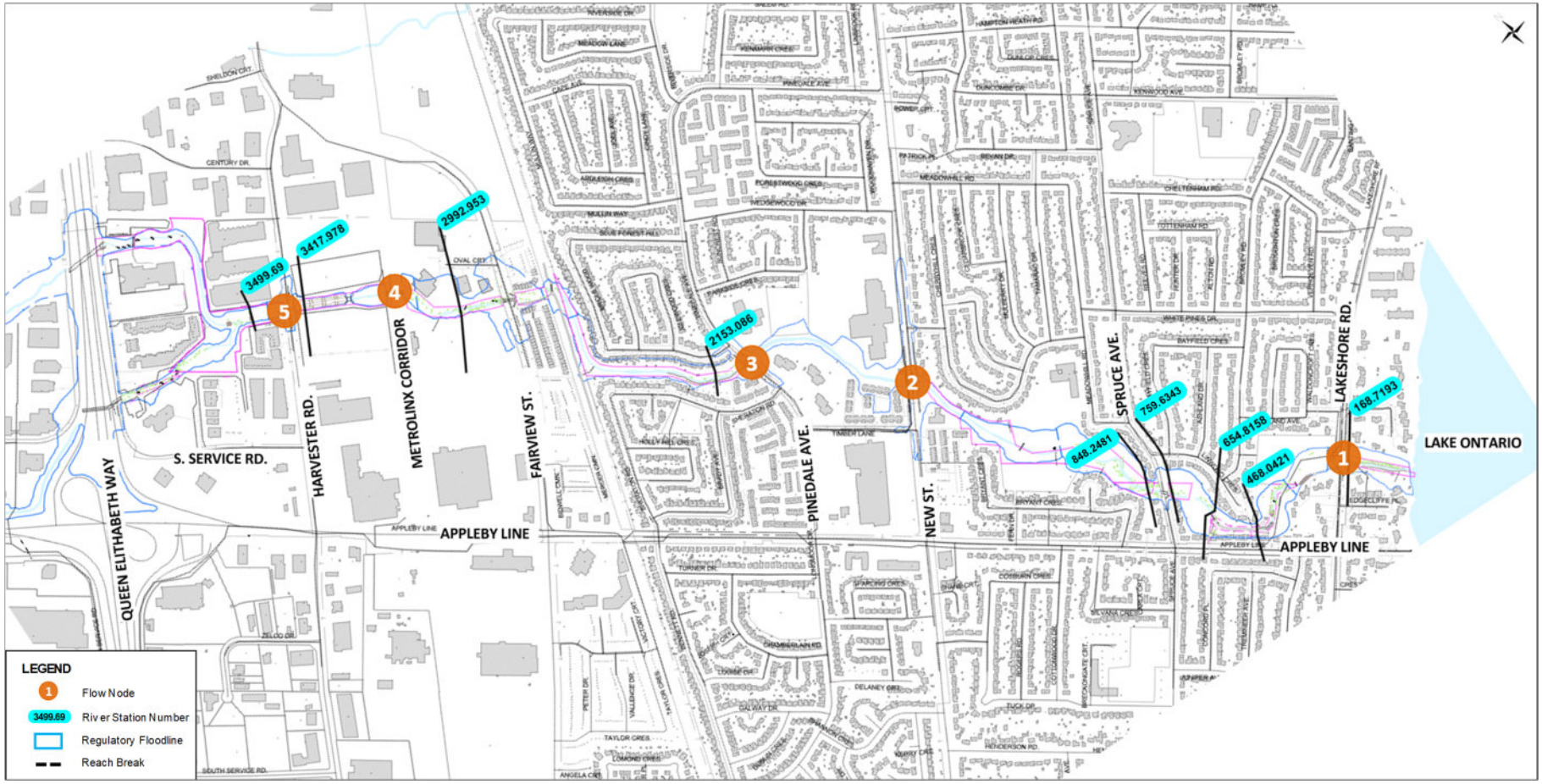


Figure 3-4: Regulatory Floodlines within the Study Area

Table 3-5: Summary of HEC-RAS Model Results

River Station	Erosion Site	Profile	Flow (m^3/s)	Channel Shear (N/m^2)	Velocity (m/s)		
					Channel	Left Overbank	Right Overbank
168.7193	1A and 1B	Regional	109	142.60	4.60	1.04	0.93
		100yr	61	81.63	3.35	0.69	0.58
		50yr	55	73.89	3.17	0.64	0.53
		25yr	48	68.90	3.02	0.58	0.47
		10yr	38	58.64	2.73	0.48	0.36
		5yr	31	51.51	2.51	0.41	0.27
		2yr	21	32.84	1.96	0.30	0.26
468.0421	2	Regional	109	54.9	2.91	0.43	0.53
		100yr	61	96.22	3.52	0.42	0.74
		50yr	55	93.17	3.43	0.38	0.73
		25yr	48	88.93	3.31	0.31	0.70
		10yr	38	85.62	3.16	0.14	0.68
		5yr	31	86.92	3.1	-	0.67
		2yr	21	73.76	2.76	-	0.58
654.8158	3	Regional	109	46.84	2.75	0.74	1.03
		100yr	61	50.18	2.67	0.61	1.28
		50yr	55	52.28	2.68	0.52	1.33
		25yr	48	55.24	2.7	0.37	1.41
		10yr	38	59.21	2.73	-	1.52
		5yr	31	58.63	2.66	-	1.57
		2yr	21	54.32	2.47	-	1.93
759.6343	4	Regional	109.00	148.36	4.60	0.88	0.30
		100yr	61.00	116.10	3.86	0.77	-
		50yr	55.00	112.74	3.77	0.74	-
		25yr	48.00	107.93	3.64	0.70	-
		10yr	38.00	98.02	3.40	0.63	-
		5yr	31.00	90.70	3.21	0.58	-
		2yr	21.00	76.55	2.84	0.48	-
848.2481	5	Regional	106	10.66	1.44	0.26	0.26
		100yr	59	14.26	1.53	0.27	0.24
		50yr	53	15.64	1.58	0.26	0.25
		25yr	47	16.17	1.58	0.25	0.26
		10yr	38	17.24	1.58	0.21	0.27
		5yr	31	17.19	1.53	0.29	0.29
		2yr	21	18.28	1.49	0.27	0.29
2153.086	6	Regional	93	56.97	2.65	0.86	0.67
		100yr	54	45.69	2.28	0.60	0.55
		50yr	48	40.40	2.13	0.56	0.52
		25yr	42	36.43	2.00	0.54	0.50

River Station	Erosion Site	Profile	Flow (m^3/s)	Channel Shear (N/m^2)	Velocity (m/s)		
					Channel	Left Overbank	Right Overbank
		10yr	34	38.17	1.99	0.54	0.49
		5yr	28	34.95	1.87	0.50	0.45
		2yr	19	53.72	2.15	0.56	0.50
2992.953	7A and 7B	Regional	93	134.11	3.85	0.98	1.35
		100yr	54	79.30	2.87	0.24	1.30
		50yr	48	72.61	2.72	0.24	1.27
		25yr	42	65.99	2.57	0.18	1.22
		10yr	34	59.48	2.39	-	1.16
		5yr	28	55.23	2.26	-	1.07
		2yr	19	48.68	2.04	-	0.94
3417.978	8	Regional	85	31.01	4.19	0.61	0.61
		100yr	50	25.85	3.62	0.51	0.51
		50yr	45	24.78	3.50	0.49	0.49
		25yr	39	23.00	3.33	0.46	0.47
		10yr	32	21.41	3.14	0.42	0.43
		5yr	26	19.68	2.95	0.38	0.39
		2yr	18	16.78	2.62	0.31	0.31
3499.69	9A and 9B	Regional	85	30.02	3.73	0.44	0.76
		100yr	50	24.18	3.19	0.36	0.62
		50yr	45	23.87	3.15	0.30	0.60
		25yr	39	23.34	3.09	0.20	0.56
		10yr	32	22.72	3.03	0.05	0.50
		5yr	26	21.42	2.90	-	0.45
		2yr	18	19.07	2.68	-	0.35

3.5.3 Spill Area

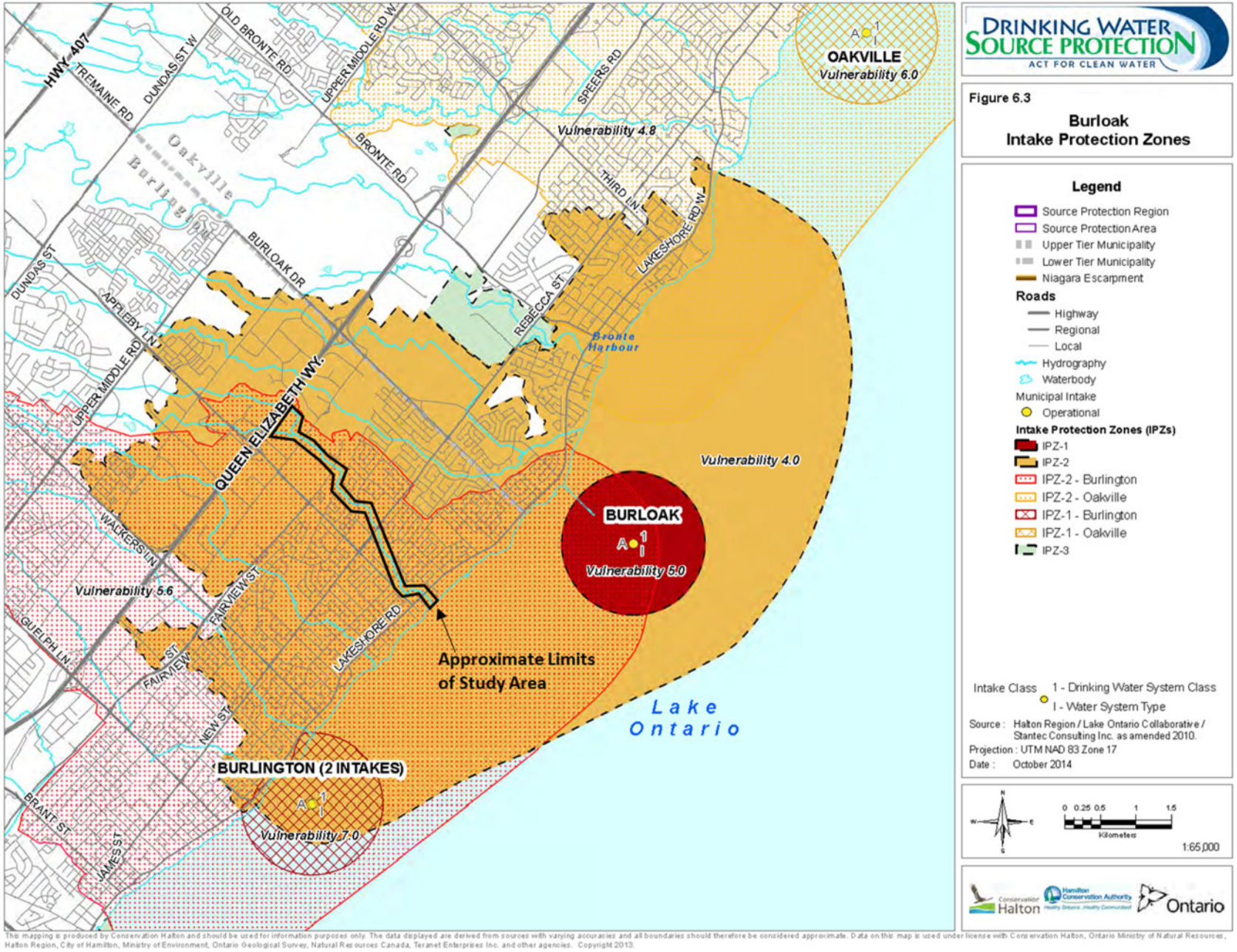
The regional flow is expected to exceed the channel capacity of the Appleby Creek and Spill into three locations: Fairview Street, Pinedale Avenue, and New Street. The road inundation is very infrequent, as the road is only expected to be overtopped under the regional flood condition.

3.6 Source Water Protection

In compliance with the Clean Water Act (2006), the Halton-Hamilton Source Protection Committee (HHSPC) has prepared the Halton Region Source Protection Area Assessment Report which supports the Source Protection Plan for Halton Region and Hamilton Region Source Protection Areas (2017).

According to the Assessment Report, the study area is within the source protection area. More specifically, it is within the surface water intake protection zone 2 (IPZ-2), which is an area upstream where a spill might reach the intake pipe before the plant operator can react (minimum time of 2 hours). Being in the IPZ-2 for both Burlington Water Purification Plant and Burloak Water Treatment Plant as illustrated in Figure 3-5, the study area is within a vulnerable area as

defined in the Clean Water Act, and any project activities that could be a threat to the sources of drinking water could be subject to the Halton Region's Source Protection Plan. The 22 prescribed drinking water threats stated in Section 1.1 (1) of the Ontario Regulation (O. Reg.) 287/07 which is under the Clean Water Act (2006) were examined, and none of the activities undertaken as part of this project is listed as the prescribed drinking water threats.



This mapping is produced by Conservation Halton and should be used for information purposes only. The data displayed are derived from sources with varying accuracies and all boundaries should therefore be considered approximate. Data on this map is used under license with Conservation Halton, Ontario Ministry of Natural Resources, Halton Region, City of Hamilton, Ministry of Environment, Ontario Geological Survey, Natural Resources Canada, Teranet Enterprises Inc. and other agencies. Copyright 2013.

Figure 3-5: City of Burlington Intake Protection Zones (HHSPC, 2017)

3.7 Geology and Soils

The physiography and surficial geology of the study area is illustrated in Figure 3-6. The City of Burlington is situated by the Niagara Escarpment, and Till Plain, with the study area extends over the Lake Iroquois Sand Plain, and Shale Plain as shown in Figure 3-6.

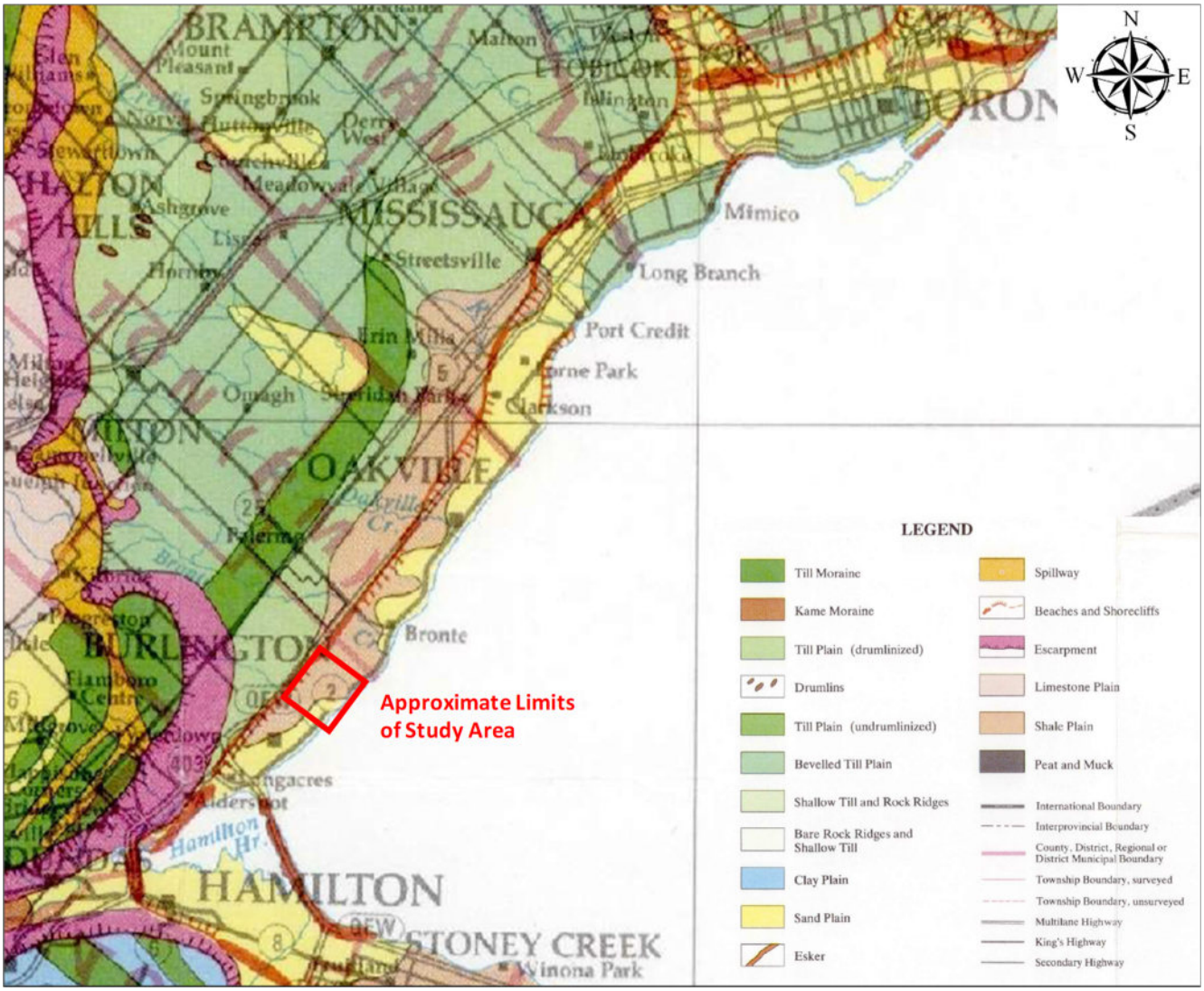


Figure 3-6: Physiography of Study Area (Chapman and Putnam, 1984)



Figure 3-7: Bedrock Geology of the Study Area in the City of Burlington (Ontario Geological Survey, 1991)

Based on Halton County Soils Report (Gillespie & Wicklund, 1971) identified the following soil types are characteristic of the study area:

- Chinguacousy Clam Loam-Rocky Phase soils, which are imperfectly drained and can be found on gently sloping landscapes where outcropping of shale bedrock is frequent.
- Jeddo Soils, which are poorly drained and found within depressional areas associated with undulating or rolling topography.

Upon inspection of the bed and banks where erosion has exposed lenses of stratigraphic layers, the top layer was generally identified as loose fill material with a topsoil, with an underlying layer of Halton Till which originated from glacial action on local rock material (Gillespie & Wicklund, 1971).

3.8 Natural Heritage Assessment

Aquafor completed ecological investigations in support of erosion control works to mitigate erosion along Appleby Creek between New Street and Fairview Street (**Figure 3-8**). The

purpose of this section is to identify the existing natural conditions, assess the potential impacts, and recommend mitigation measures for the preferred alternative as they relate to natural heritage resources. The findings of this report will be considered during the development of the detailed design. Lands subject to field studies completed include natural lands within the Appleby Creek Corridor on public property. Surrounding land use includes residential, institutional, and commercial uses.

3.8.1 Background Information Review

In preparation of this EA, the following background information was reviewed and incorporated where relevant:

- Natural Heritage Information Centre (NHIC)/Ministry of Natural Resources and Forestry (MNRF) database (online Make-a-Map);
- Region of Halton Official Plan (OP; 2015);
- Conservation Halton (CH) online flood mapping;
- CH policy documents;
- CH fisheries data;
- Halton Natural Areas Inventory Species Checklist document (2006);
- Avifaunal data (ebird.org);
- Soil maps and reports (Chapman & Putnam, 1984) and (Canada Department of Agriculture and the Ontario Agricultural College, 1971); and
- Historic and current aerial photography.

3.8.2 Policy Review

3.8.2.1 Regional Natural Heritage System

The Regional Natural Heritage System (RNHS), as defined by ROPA 38 of the Region of Halton's OP (2016), consists of the following:

1. areas so designated on Map 1;
2. the shoreline along Lake Ontario and Burlington Bay;
3. significant habitats of endangered species and threatened species not included in the designation on Map 1; and
4. Key Features, which include:
    a. significant habitat of endangered and threatened species,
    b. significant wetlands,
    c. significant coastal wetlands,
    d. significant woodlands,
    e. significant valleylands,
    f. significant wildlife habitat (SWH),
    g. significant areas of natural and scientific interest, and
    h. fish habitat.
5. enhancements to the Key Features including Centres for Biodiversity,
6. linkages,

7. buffers,
8. watercourses that are within a Conservation Authority Regulation Limit or that provide a linkage to a wetland or a significant woodland, and
9. wetlands other than those considered significant under Section 115.3(1)b).

The RNHS within the study area, illustrated on Map G1 of the OP (2018), is illustrated in Figure 3-8. As shown in this map, RNHS features are limited to the riparian corridor of Appleby Creek and include Key Features.

The study area includes Appleby Creek, which is a regulated watercourse by CH (See **Section 3.8.2.2)** and is part of a natural corridor that links to the Lake Ontario shoreline. This linkage may provide opportunities for fish, herpetofauna, birds, and small mammal dispersal throughout the corridor.

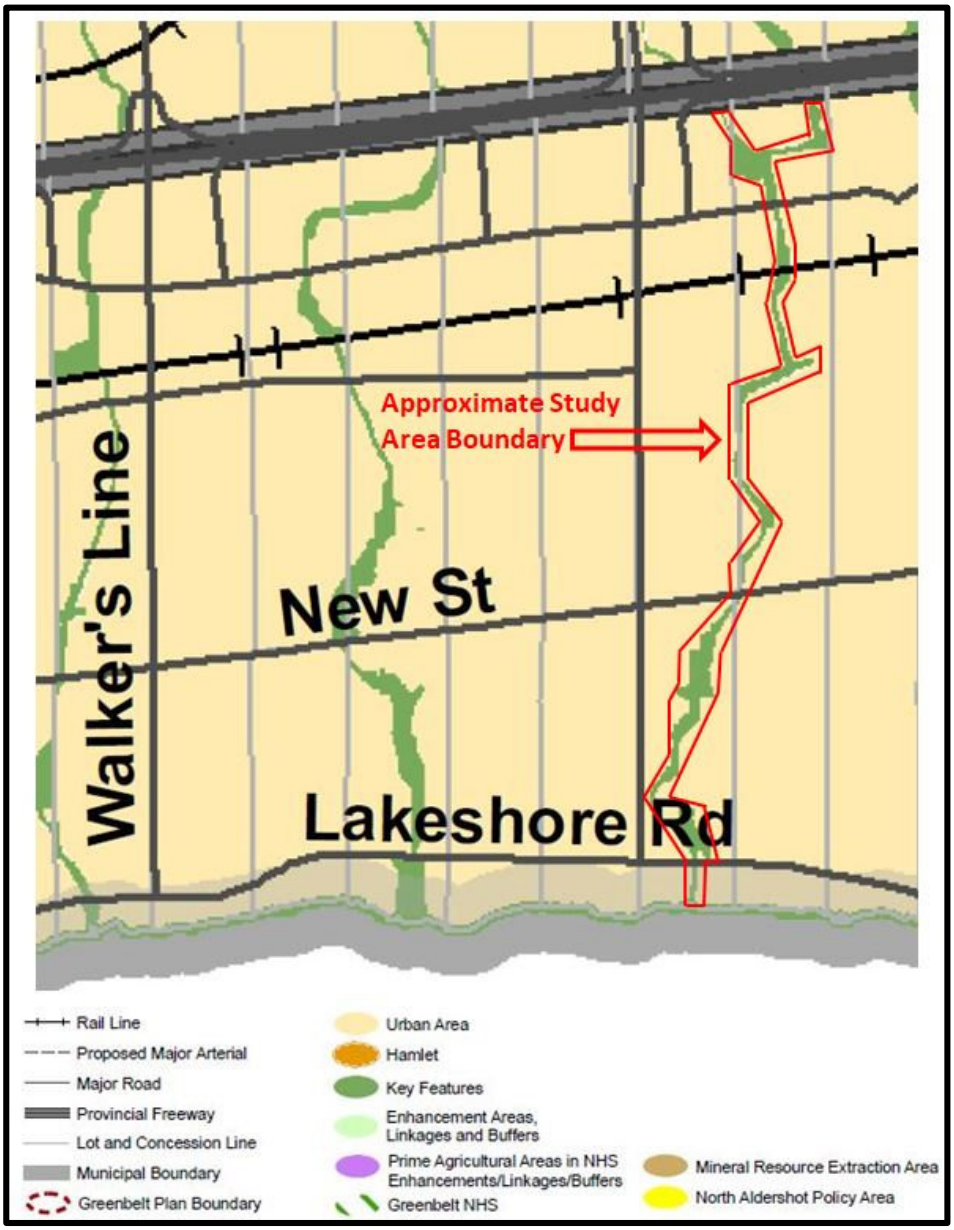


Figure 3-8: RNHS as identified by the Region of Halton, with the limits of the study area (adapted from the Region of Halton OP Map 1G, 2018)

3.8.2.2 Conservation Halton Policies

All watercourses and wetlands and their associated areas of interference are regulated by CH under the Development, Interference with Wetlands and Alteration to Shorelines and Watercourses Regulation (Ontario Regulation [O.Reg.] 162/06).

Prohibitions to development within regulated flood zones as prescribed by O. Reg. 162/06 are described as follows:

> **2.** (1) Subject to section 3, no person shall undertake development or permit another person to undertake development in or on the areas within the jurisdiction of the Authority that are,
>
> (b) river or stream valleys that have depressional features associated with a river or stream, whether or not they contain a watercourse, the limits of which are determined in accordance with the following rules:
>
> (i) where the river or stream valley is apparent and has stable slopes, the valley extends from the stable top of bank, plus an allowance not to exceed 15 metres, to a similar point on the opposite side,
>
> (ii) where the river or stream valley is apparent and has unstable slopes, the valley extends from the predicted long term stable slope projected from the existing stable slope or, if the toe of the slope is unstable, from the predicted location of the toe of the slope as a result of stream erosion over a projected 100-year period, plus an allowance not to exceed 15 metres, to a similar point on the opposite side,
>
> (iii) where the river or stream valley is not apparent, the valley extends the greater of,
>
> (A) the distance from a point outside the edge of the maximum extent of the flood plain under the applicable flood event standard, plus an allowance not to exceed 15 metres, to a similar point on the opposite side, and
>
> (B) the distance from the predicted meander belt of a watercourse, expanded as required to convey the flood flows under the applicable flood event standard, plus an allowance not to exceed 15 metres, to a similar point on the opposite side;
>
> (c) hazardous lands;
>
> (d) wetlands; or
>
> (e) other areas where development could interfere with the hydrologic function of a wetland, including areas within 120 metres of all provincially significant wetlands and wetlands greater than or equal to 2 hectares in size, and areas within 30 metres of wetlands less than 2 hectares in size. O. Reg. 162/06, s. 2 (1); O. Reg. 59/13, s. 1 (1).

After reviewing CH's online regulation mapping tool, all natural lands within the study area are regulated by CH, with the exception of the tableland in Bromley Park as they regulate 7.5 m from either the flooding or erosion hazard limit (whichever is more conservative). As such, development is prohibited within the regulated area unless it is determined by CH that the control of flooding, erosion, dynamic beaches, pollution is required or the conservation of land will not be affected by proposed works. CH Permits will be required for the proposed

development (fill, grading, watercourse alterations, structures, etc.) within the regulated area. Further consultation with CH is recommended to confirm detailed design requirements. Development permit appications will need to demonstrated that there will be no increase in flooding or erosion hazards or extension of regulated area on adjacent lands as a result of the works. Confirmation of an easement should be provided prior to Permit submission for works outside City property. If an easement does not exist, the landowner will need to submit the CH Permit application for works on their property

3.8.2.3 DFO Self-Assessment

The Department of Fisheries and Oceans Canada (DFO) is the governing authority and responsible party for the administration of the Federal *Fisheries Act*. Under this Act, Canada's marine and freshwater fisheries resources and their habitats are protected from the impact of human activities. It is the responsibility of any party undertaking projects near water bodies to work under the guiding principles of the DFO and the *Fisheries Act* to avoid causing serious harm to fish or fish habitat unless authorized by the Minister of Fisheries and Oceans Canada. This includes water bodies that support fish at any given time of any given year (Department of Fisheries and Oceans, 2016). As discussed in **Section 3.8.6**, Appleby Creek provides habitat to a number of fish species, including a number of rare and uncommon species in the Halton Region. The Fisheries Act requires that projects avoid causing serious harm to fish unless authorized by the Minister of Fisheries and Oceans Canada.

A Self-Assessment was conducted to determine the need to apply for a Department of Fisheries and Oceans (DFO) Request for Review. The Assessment states that DFO Review is not required for restoration projects undertaken with the sole purpose of improving or repairing existing habitats including riparian planting, shoreline/bank stabilization, bio-engineering and creation of in-stream structure under the following conditions:

- no new temporary or permanent *fill* placed below the *high water mark*;
- any obstruction to fish passage will respect timing windows;
- work in water will be planned to respect timing windows;
- relevant measures to avoid harm are followed;
- criteria for all associated project activities are respected; and,
- no removal of riparian vegetation if the riparian area is identified as part of the critical habitat of an aquatic listed species at risk.

The Assessment defines *fill* as the deposit of materials or installation of structures resulting in the creation of land in a waterbody (i.e., what was wet is now dry). Furthermore, the assessment defines the *high water mark* as, 'The usual or average level to which the body of water rises at its highest point and remains for sufficient time as to leave a mark on the land' (Department of Fisheries and Oceans, 2016).

It is anticipated that works conducted as a part of this study will not meet the aforementioned criteria. Therefore, it is the opinion of Aquafor that DFO Review is necessary. Furthermore, in order to mitigate serious harm to fish and fish habitat and avoid contravention of the Federal *Fisheries Act*, design considerations should include the creation of fish habitat within Appleby Creek.

3.8.2.4 Endangered Species Act

The protection of species-at-risk (SAR) in Ontario is dictated primarily by the Endangered Species Act (ESA). The stated purposes of the ESA are:

1. *To identify species at risk based on the best available scientific information, including information obtained from community knowledge and aboriginal traditional knowledge.*
2. *To protect species that are at risk and their habitats, and to promote the recovery of species that are at risk.*
3. *To promote stewardship activities to assist in the protection and recovery of species that are at risk.*

The Committee on the Status of Species at Risk in Ontario (COSSARO) is tasked with identifying threats to species in Ontario and classifying those deemed at risk as extirpated, endangered, threatened or special concern. Endangered and threatened species receive recovery strategies, which offer science-based recommendations that aid in their protection and future recovery. These species are also protected from being killed, harmed or harassed (s. 9) and receive habitat protection (s. 10). Alternatively, special concern species receive management plans rather than recovery strategies and are not subject to species or habitat protection under the Act. Rather, their habitat is protected under the Planning Act.

A regulation specifying a species' habitat must be developed by the second anniversary (endangered) or third anniversary (threatened) of the date the species is officially listed. Before the habitat regulation has been devised, a general definition of habitat is employed and defined as:

> *"[A]n area on which the species depends, directly or indirectly, to carry on its life processes, including life processes such as reproduction, rearing, hibernation, migration or feeding"*

Any activity that constitutes harm to an endangered or threatened species or damages its habitat must receive approval from the MECP under section 17(2)(c) of the ESA or be eligible for a regulatory exemption as per the conditions laid out in O.Reg 242/08. In order to obtain a 17(2)(c) authorization proponents must demonstrate how an overall net benefit for the species will be attained, which often involves rehabilitation or restoration activities and monitoring.

Discussion of SAR screening and results is included in **Section 3.8.3**.

3.8.3 Existing Conditions

Characterization of the Natural Heritage System (NHS) relied upon field surveys and review of background information sources. The field studies outlined in the subsequent subsections characterize the existing biophysical conditions of the study area.

Physiography, commonly referred to as physical geography, is the study of the physical features of the earth's surface and the classification, mapping and grouping of landforms based on their geologic structures and age. According to *The Physiography of Southern Ontario* (Chapman & Putnam, 1984), the study area is situated within the Iroquois Plain, physiographic region of southern Ontario formed during the last glaciation when Lake Iroquois drained

eastward towards New York State. Features of this region include old shores, cliffs, bars, beaches, drumlins, and boulder pavements.

According to the *Soils of Halton County* (Canada Department of Agriculture and the Ontario Agricultural College, 1971), soils in the study area are described as Jeddo clay loam. Jeddo soils are poorly drained and found below the Niagara Escarpment in Burlington and Oakville. Found in low-lying depressions, the parent material is slightly stony calcareous clay till. Surface textures range from loam to clay-loam.

3.8.4 Botanical Resources

3.8.4.1 Vegetation Communities

Methods

Vegetation communities and flora within the study area were identified during field surveys completed on June 20 and 21, 2018 as well as June 19, 2019 to determine the presence of significant vegetation communities in the study area and to aid in the identification of significant wildlife habitat (SWH) and the habitats of potential SAR. Vegetation community assessments were completed in accordance with the *Ecological Land Classification (ELC) System for Southern Ontario: First Approximation and its Application* (Lee et al., 1998) survey protocol. The area search method was used to determine the boundaries of vegetation communities within the study area. A map of the vegetation communities is illustrated in Figure 3-9 to Figure 3-12. Vegetation community field sheets are contained in Appendix C.

Results

In total, nine vegetation communities are within the study area. Some of these communities are either complex communities (i.e. a pattern of two or more vegetation ecosites or types forming a mosaic (Lee et al., 1998)) or have inclusions (i.e. vegetation types less than 0.5 ha within a larger vegetation type). The vegetation communities within the study area are listed and described in Table 3-6; vegetation communities are mapped in Figure 3-9 to Figure 3-12.

Vegetation community field sheets and **photos of each vegetation community** are contained in Appendix C.



CITY OF Burlington

Legend

- WATERCOURSE
- VEGETATION COMMUNITY BOUNDARY

ID	CODE	DESCRIPTION
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest
2	FOD7 [CUW1]	Fresh – Moist Lowland Deciduous Forest - Mineral Cultural Woodland Complex
2 INC 1	CUP3	Coniferous Plantation (White Spruce)
3	CUW1 [FOD7]	Mineral Cultural Woodland - Fresh – Moist Lowland Deciduous Forest Complex
4	FOD9-1[FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest - Fresh – Moist Black Walnut Lowland Deciduous Forest Complex
5	CUW1	Mineral Cultural Woodland
5 INC 1	CUT1	Hawthorn Mineral Cultural Thicket
5 INC 2	CUM1	Dry – Moist Old Field Meadow
6	CUS1	Mineral Cultural Savannah
6 INC 1	MAM2-10	Forb Mineral Meadow Marsh
7	CUM1 [CUT1-1]	Mineral Cultural Meadow - Sumac Cultural Thicket Complex
7 INC 1	MAM2-10	Forb Mineral Meadow Marsh
8	CUW1	Mineral Cultural Woodland
8 INC 1	CUT1	Hawthorn / Buckthorn Mineral Cultural Thicket
8 INC 2	MAS2-1	Cattail Mineral Shallow Marsh
9	CUW1	Mineral Cultural Woodland
10	FOD 5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest

Figure:

Ecological Land Classification

0 80 160
Meters

Date: June 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: City of Burlington, Land Information Ontario

Aquafor Beech Limited

Figure 3-9: Ecological Land Classification Map 1 of 4



ID	CODE	DESCRIPTION
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest
2	FOD7 [CUW1]	Fresh – Moist Lowland Deciduous Forest - Mineral Cultural Woodland Complex
2 INC 1	CUP3	Coniferous Plantation (White Spruce)
3	CUW1 [FOD7]	Mineral Cultural Woodland - Fresh – Moist Lowland Deciduous Forest Complex
4	FOD9-1[FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest - Fresh – Moist Black Walnut Lowland Deciduous Forest Complex
5	CUW1	Mineral Cultural Woodland
5 INC 1	CUT1	Hawthorn Mineral Cultural Thicket
5 INC 2	CUM1	Dry – Moist Old Field Meadow
6	CUS1	Mineral Cultural Savannah
6 INC 1	MAM2-10	Forb Mineral Meadow Marsh
7	CUM1 [CUT1-1]	Mineral Cultural Meadow - Sumac Cultural Thicket Complex
7 INC 1	MAM2-10	Forb Mineral Meadow Marsh
8	CUW1	Mineral Cultural Woodland
8 INC 1	CUT1	Hawthorn / Buckthorn Mineral Cultural Thicket
8 INC 2	MAS2-1	Cattail Mineral Shallow Marsh
9	CUW1	Mineral Cultural Woodland
10	FOD 5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest

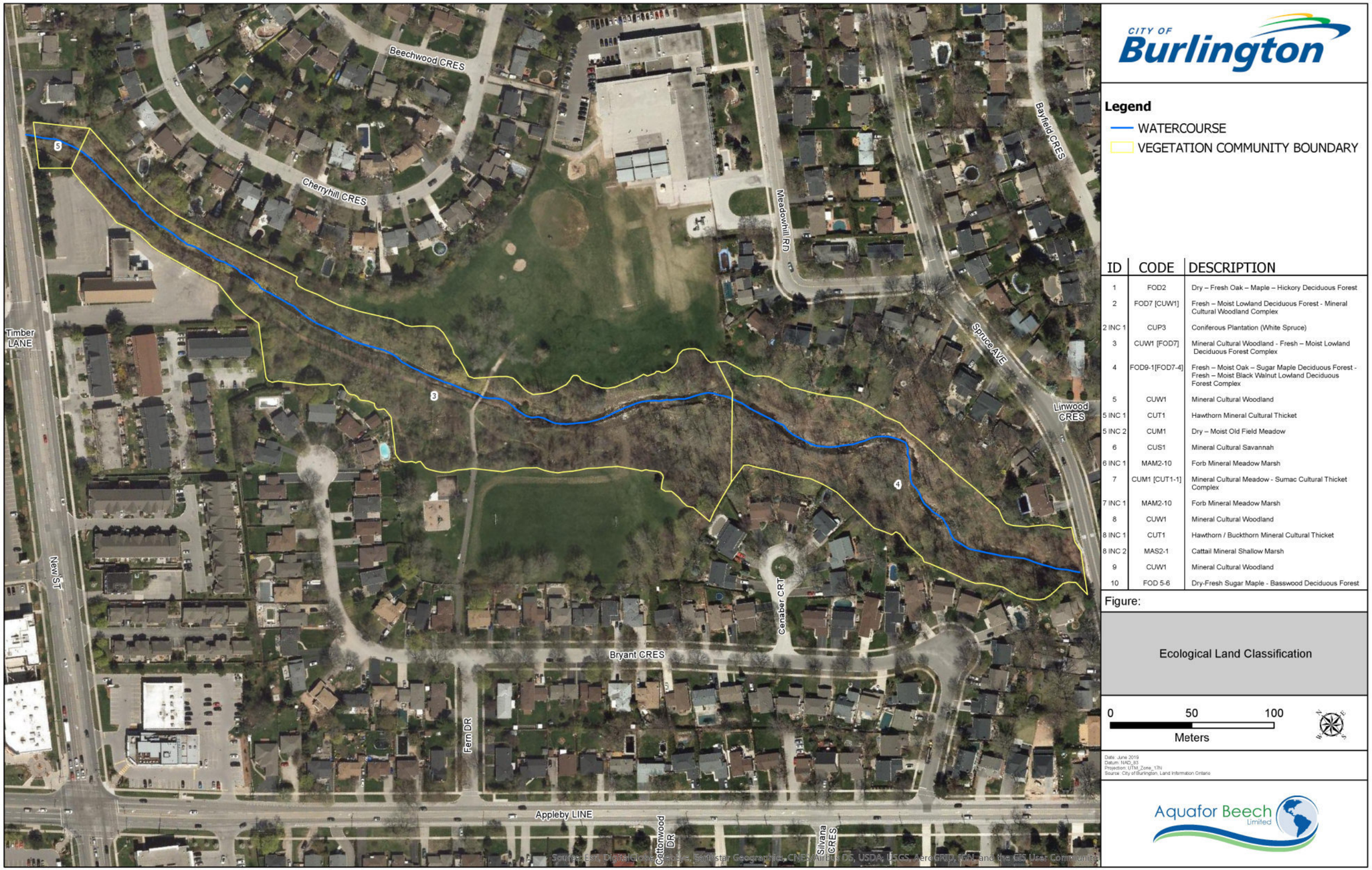
Figure:

Ecological Land Classification

0 75 150
Meters

Date: June 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: City of Burlington, Land Information Ontario

Figure 3-10: Ecological Land Classification Map 2 of 4



ID	CODE	DESCRIPTION
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest
2	FOD7 [CUW1]	Fresh – Moist Lowland Deciduous Forest - Mineral Cultural Woodland Complex
2 INC 1	CUP3	Coniferous Plantation (White Spruce)
3	CUW1 [FOD7]	Mineral Cultural Woodland - Fresh – Moist Lowland Deciduous Forest Complex
4	FOD9-1[FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest - Fresh – Moist Black Walnut Lowland Deciduous Forest Complex
5	CUW1	Mineral Cultural Woodland
5 INC 1	CUT1	Hawthorn Mineral Cultural Thicket
5 INC 2	CUM1	Dry – Moist Old Field Meadow
6	CUS1	Mineral Cultural Savannah
6 INC 1	MAM2-10	Forb Mineral Meadow Marsh
7	CUM1 [CUT1-1]	Mineral Cultural Meadow - Sumac Cultural Thicket Complex
7 INC 1	MAM2-10	Forb Mineral Meadow Marsh
8	CUW1	Mineral Cultural Woodland
8 INC 1	CUT1	Hawthorn / Buckthorn Mineral Cultural Thicket
8 INC 2	MAS2-1	Cattail Mineral Shallow Marsh
9	CUW1	Mineral Cultural Woodland
10	FOD 5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest

Figure 3-11: Ecological Land Classification Map 3 of 4



Figure 3-12: Ecological Land Classification Map 4 of 4

Table 3-6: Ecological Land Classification Descriptions

Polygon	Vegetation Community		Ranking		Description
	Code	Name	Global	Provincial	
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest	-	-	This mature forest community, located north of Lakeshore Blvd. on the right slope of Appleby Creek (looking upstream) adjacent to Bromley Park, is a remnant Oak – Maple – Hickory deciduous forest. Due to a high abundance of exotic and exotic invasive species, the vegetation community could not be classified further than Ecosite level. Not one tree species is more abundant than another in the community. Red Oak (*Quercus rubra*), Norway Maple (*Acer platanoides*), White Pine (*Pinus strobus*), and Shagbark Hickory (*Carya ovata*) are all occasionally represented in the canopy layer. The sub-canopy is primarily composed of Norway Maple, Black Walnut (*Juglans nigra*), Black Cherry (*Prunus serotina*), White Ash (*Fraxinus americana*), Sugar Maple (*A. saccharum*), and Hop Hornbeam (*Ostrya virginiana*). Many of the ash trees in the forest are dead or dying due to an infestation of Emerald Ash Borer (*Agrilus planipennis*). The understory layer is composed of an abundance of Norway Maple, with Black Cherry, Ironwood, Chokecherry (*P. virginiana*), and European Buckthorn (*Rhamnus cathartica*) associates. Garlic Mustard (*Alliaria petiolata*) is abundant in the ground layer, with English Ivy (*Hedera helix*), Yellow Avens (*Geum aleppicum*), Spotted Jewelweed (*Impatiens capensis*), Periwinkle (*Vinca minor*), and Jack-in-the-pulpit (*Arisaema atrorubens*) common associates. Deer and unofficial trails are scattered through the community leading to and from the park and creek. The soil composition is sandy clay loam (33 cm) over sandy clay (33 to >120 cm).
2	FOD7 [CUW1] (CUP3)	Fresh – Moist Lowland Deciduous Forest Complex: [Mineral Cultural Woodland] Inclusion: Coniferous Plantation (*White Spruce*)	- - -	- - -	Directly adjacent to Appleby Creek, north and south of Lakeshore Blvd. is a lowland deciduous forest and cultural woodland complex community. Due to disturbances (i.e. creek works, ash removals, and exotic invasive species), the community cannot be classified further. The canopy and sub-canopy layers are composed of Norway Maple, Crack Willow (*Salix* x *rubens*), Sugar Maple, Black Walnut, Black Cherry, White Elm (*Ulmus americana*), Eastern Cottonwood (*Populus deltoides*), and Basswood (*Tilia americana*). The understory is composed of Multiflora Rose (*Rosa multiflora*), Chokecherry, Riverbank Grape (*Vitis riparia*), Basswood, and White Elm. Goldenrods (*Solidago* spp.) and Great Burdock (*Arctium lappa*) are abundant in the ground layer, with Periwinkle, Garlic Mustard, Purple-flowering Raspberry (*Rubus odoratus*), White Sweet Clover (*Melilotus alba*), and Black Raspberry (*R. occidentalis*) associates. A small White Spruce (*Picea glauca*) plantation is located adjacent to the municipal driveway leading off Lakeshore Blvd. Four untested Butternuts (*Juglans cinerea*) are located in this polygon near the mouth of the watercourse (Figure 3-5). Butternuts and their habitat are both provincially and federally protected if they are determined to be genetically pure. For further information see **Section 3.5.7**.

Polygon	Vegetation Community		Ranking		Description
	Code	Name	Global	Provincial	
3	CUW1 [FOD7]	Mineral Cultural Woodland Complex: [Fresh – Moist Lowland Deciduous Forest]	- -	- -	This community represents the natural lands adjacent to Appleby Creek at Pinedale Park to the south side of New Street. The community fluctuates between an open woodland to a lowland deciduous forest. The woodland and forest have a similar composition of species, but the forest canopy is more closed due to clusters of Black Walnut, Norway Maple, and Black Locust (*Robinia pseudo-acacia*) scattered throughout the community. The canopy layer is abundant with Black Walnut. Associate species include Manitoba Maple (*A. negundo*), Norway Maple, Weeping Golden Willow (*Salix x sepulcralis*), and Eastern Cottonwood. The sub-canopy layer is composed of the same species as the canopy layer, but in a more even composition. The understory layer is composed of European Buckthorn, Tatarian Honeysuckle (*Lonicera tatarica*), Multiflora Rose, and Staghorn Sumac (*Rhus typhina*). Orchard Grass (*Dactylis glomerata*), goldenrods, grass (*Poa* sp.) are abundant in the ground layer. Garlic Mustard, Path Rush (*Juncus tenuis*), and Hedge Bindweed (*Fallopia dumetorum*) are also common. Many informal trails are in this community leading from Pinedale Public School. There is also a fire pit on the northwest corner of the official trail and pedestrian bridge. Exposed coir matting downstream of the pedestrian bridge suggests that restoration efforts were previously completed along the creek in this vegetation community.
4	FOD9-1 [FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest Complex: [Fresh – Moist Black Walnut Lowland Deciduous Forest]	G? G4?	S5 S2S3	This vegetation community is a complex of an oak-sugar maple forest (likely a historic remnant of the natural cover in the area) and a Black Walnut lowland forest that has thrived due to disturbances (e.g. land clearing, encroachment, previous restoration works, etc.). The upstream end of the community is more dominant with Black Walnut than the downstream end closer to Spruce Ave. **Due to the species composition and known disturbances within the Black Walnut lowland forest; this forest does not have the characteristics of the provincially rare S2S3 community, and should not be considered rare.** The community was classified as such due gaps in classifying communities using the ELC protocol. The oak-maple forest is composed of Red Oak, White Oak (*Q. alba*), Swamp White Oak (*Q. bicolor*), Sugar Maple, and Shagbark Hickory in the canopy and sub-canopy layers. The understory layer is composed of Red Oak, White Ash, Basswood, Ironwood, and Sugar Maple. An assortment of forbs and grasses compose the ground layer, including Orchard Grass, Yellow Avens, White Avens (*Geum canadense*), Jack-in-the-pulpit, Woodland Agrimony (*Agrimonia striata*), False Solomon's Seal (*Maianthemum racemosum*), False Sunflower (*Heliopsis helianthoides*), Spotted Crane's Bill (*Geranium maculatum*), and Wild Cucumber (*Echinocystis lobata*). **It is the opinion of Aquafor Beech Limited that the Fresh-Moist Oak-Sugar Maple Deciduous Forest should be used as a reference community for restoration plans**. Incidental wildlife observations in this community include Coyote (*Canis latrans*), juvenile Red-tailed Hawk (*Buteo jamaicensis*), Great Blue Heron (*Ardea herodias*), and Ebony Jewelwing (*Calopteryx maculata*). There is a fair amount of garden waste (e.g. leaf and lawn clippings) in this community from adjacent landowners. Mitigation measures to disturbances are discussed below in **Section 6**.
5	CUW1 (CUT1) (CUM1)	Mineral Cultural Woodland Inclusion: (*Hawthorn* Mineral Cultural Thicket) (Mineral Cultural Meadow)	- - -	- - -	The canopy and sub-canopy layers of the cultural woodland are comprised of Silver Maple (*A. saccharinum*), Norway Maple, Manitoba Maple, weeping willow (*Salix x sepulcralis*), Black Walnut (*Juglans nigra*), White Ash, and Black Locust. The understory is comprised of Manitoba Maple, Black Walnut, European Buckthorn, Multiflora Rose, honeysuckle species (*Lonicera* sp.), Red-osier Dogwood (*Cornus sericea*), Winged Euonymus (*Euonymus alatus*), and hawthorn (*Crataegus* spp.). The ground layer is comprised of Reed Canary Grass (*Phalaris arundinacea var. arundinacea*), asters (*Symphyotrichum* spp.), Canada Goldenrod (*Solidago canadensis*), Garlic Mustard (*Alliaria petiolata*), Blue Vervain (*Verbena hastata*), and Great Burdock. Ash tree removals, likely a result of the effects of the invasive insect pest Emerald Ash Borer, are evident throughout this community. Where ash trees have been removed, ash suckers and new ash seedlings are abundant. Areas where ash trees have been removed provide an opportunity for restoration and habitat improvements.

Polygon	Vegetation Community		Ranking		Description
	Code	Name	Global	Provincial	
6	CUS1 (MAM2-10)	Mineral Cultural Savannah Inclusion: (Forb Mineral Meadow Marsh)	- G?	- S4S5	This community is semi-natural. The substrate that comprises the vegetation community is mainly gabion baskets and concrete (See **Appendix A** for representative photos) as this section of Appleby Creek was constructed when the channel was moved from its historical position approximately 100 m east, which is now under the GO station's parking lot. The Common Reed (*Phragmites australis*) dominated meadow marsh is located at the downstream end towards the rail line. As a Cultural Savannah, the canopy land sub-canopy layers are sparsely populated with Black Locust, Black Walnut, and Norway Maple. The understory layer is comprised of Black Walnut, Norway Maple, European Buckthorn, Staghorn Sumac, and Gray Dogwood (*Cornus racemosa*). The ground layer is abundant with Canada Goldenrod, Hedge Bindweed, and Purple Loosestrife (*Lythrum salicaria*). Common associates in the ground layer include Common Teasel (*Dipsacus fullonum spp. sylvestris*) and Curly Dock (*Rumex crispus*). Incidental wildlife observations in this community include Mallard (*Anas platyrhynchos*), Red-winged Blackbird (*Agelaius phoeniceus*), and one Black-crowned Night-heron (*Nycticorax nycticorax*) foraging in the deep pools below broken concrete.
7	CUM1 [CUT1-1] (MAM2-10)	Mineral Cultural Meadow Complex: [Sumac Cultural Thicket] Inclusion: (Forb Mineral Meadow Marsh)	- - G?	- - S4S5	This community is also heavily influenced by channel realignment and is thus semi-natural. Gabion baskets are imbedded into the creek banks and compose approximately 4.5 m of the riparian zone from channel edge. Many of the gabion baskets along the channel in this community have failed (See **Appendix A** for representative photos). As this community is a complex of a meadow and thicket, trees comprising the canopy and sub-canopy layers are sparse. Species within these forest layers include Black Walnut, Norway Maple, Black Locust, and Manitoba Maple. Staghorn Sumac is abundant in the sub-canopy and understory layers. Also comprising the understory layer is Multiflora Rose, Pussy Willow (*Salix discolor*), White Mulberry (*Morus alba*), and European Buckthorn. The ground layer is dominated by Trailing Crown-vetch (*Coronilla varia*). Also plentiful is Canada Goldenrod, Riverbank Grape (*Vitis riparia*), Curly Dock, and Purple Loosestrife.
8	CUW1 (CUT1) (MAS2-1)	Mineral Cultural Woodland Inclusion: (*Hawthorn/Buckthorn* Mineral Cultural Thicket) (Cattail Mineral Shallow Marsh)	- - G5	- - S5	This community is located on the west branch of Appleby Creek, south of South Service Road. It is very likely this community was once a forest (i.e. > 60% canopy cover), but due to ash dieback and removals, the community was classified as a Cultural Woodland. This change in classification lends to opportunities for ecological restoration. Currently, the canopy layer is dominated by Black Walnut with Black Locust, Crack Willow, and Eastern Cottonwood (*Populus deltoides*) associates. The understory and ground layers are abundant with Green Ash (*Fraxinus pennsylvanica*). Other species in the understory layer include Black Walnut, Staghorn Sumac, European Buckthorn, and Gray Dogwood. Additional species in the ground layer include White Avens, Riverbank Grape, Black Raspberry (*Rubus occidentalis*), and Thicket Creeper (*Parthenocissus inserta*). There is a small remnant pocket of Bitternut Hickory (*Carya cordiformis*), Red Oak, and White Elm on the creek slope in the northern part of this community. These species are therefore suitable for restoration purposes in this community. Two inclusions are within the community as well: a hawthorn/buckthorn dominated Mineral Cultural Thicket and a Cattail Shallow Marsh. The marsh is located immediately downstream of the culvert under South Service Road. A very extensive fort has been built with pallets close to the creek in the middle of the community. No occupants were observed residing in the fort during surveys.

Polygon	Vegetation Community		Ranking		Description
	Code	Name	Global	Provincial	
9	CUW1	Mineral Cultural Woodland	-	-	The same ash die-off is evident in this community as vegetation community #8, which again explains the Cultural Woodland classification. The dead branches from mature ash trees have jammed the creek in a few areas near bridges and tight bends in the creek. Black Walnut is abundant in the canopy layer, with Green Ash, Manitoba Maple, Crack Willow, and Black Locust associates. The sub-canopy layer has the same species as the canopy layer, although in a slightly different composition, with Manitoba Maple abundant. The understory layer is composed of Green Ash, Manitoba Maple, Staghorn Sumac, European Buckthorn, and Privet (*Ligustrum vulgare*). The ground layer is abundant with Thicket Creeper and Spotted Jewelweed. Purple Loosestrife, Canada Thistle (*Cirsium arvense*), Dame's Rocket (*Hesperis matronalis*), and Reed Canary Grass are also in the ground layer.
10	FOD5-6	Dry-Fresh Sugar Maple Basswood Deciduous Forest	G5?	S5	This community's canopy and subcanopy are dominated by Sugar Maple with abundant Basswood (*Tilia americana*) and Green Ash. The canopy also has some Eastern White Pine (*Pinus strobus*), Shagbark Hickory, and Black Walnut where the subcanopy also contained Hop Hornbeam. There was minimal shrub layer cover (10-25% cover) of which is mostly Sugar Maple and Basswood saplings as well as Choke Cherry (*Prunus virginiana ssp. virginiana*), European Buckthorn, and Tatarian Honeysuckle. Typically, this community type does not have dense understory but several invasive garden escape species have established in this polygon, specifically Periwinkle and Lily-of-the-valley (*Convallaria majalis*), increasing the density of ground cover. This polygon abuts many manicured backyards that contain these species and there is abundant dumping of yard waste along the fence line. Other prevalent ground cover species include Garlic Mustard, Yellow Avens, and Canada Enchanter's Nightshade (*Circaea lutetiana ssp. canadensis*).

3.8.4.2 Vascular Plants

A botanical inventory was conducted in concert with vegetation community surveys on June 20 and 2t 2018 as well as June 19, 2019 to create an inventory of vascular plant species within the study area and to assess whether significant flora is present. The area search method was used to identify vascular plants in the study area. In total, 162 species were identified to species level with an additional 12 identified to genus. Of the 162 species, 80 (49.3%) are native; the remaining 82 (50.6%) are introduced.

One SAR plant, Butternut, was found; four individuals were located in polygon 2, with two additional located in the manicured portion of Bromley Park, north of Lakeshore Rd. Butternut is both provincially and federally endangered and has a provincial rank of "S2?". Only genetically pure Butternut and the associated habitat are subject to protection. The four individual Butternuts within polygon 2 have not been genetically tested but do exhibit phenotypic traits of pure Butternut. One of the Butternuts located in the Bromley Park (BN-5) was genetically tested in 2018 and no hybridity was detected (see **Section 3.8.7** for further details).

No regionally rare plant species were recorded during the botanical survey. There are only two species with a high coefficient of Conservatism (CC), greater than 7, which are Swamp White Oak and Eastern Hemlock (*Tsuga canadensis*) and the overall Floristic Quality Index (FQI) of 29.0 which is considered low (Keddy *et al.* 1993). Overall, where areas have been disturbed (e.g. encroachment, dumping, mowing, and previous channel works completed), species are typical of urban ravine environments are not particularly sensitive to disturbance. More sensitive upland species such as oaks, hickory, and Sugar Maple were recorded in remnant forests where disturbances seem to be localized.

An annotated list of the vascular plants recorded within the study area is contained in Appendix C.

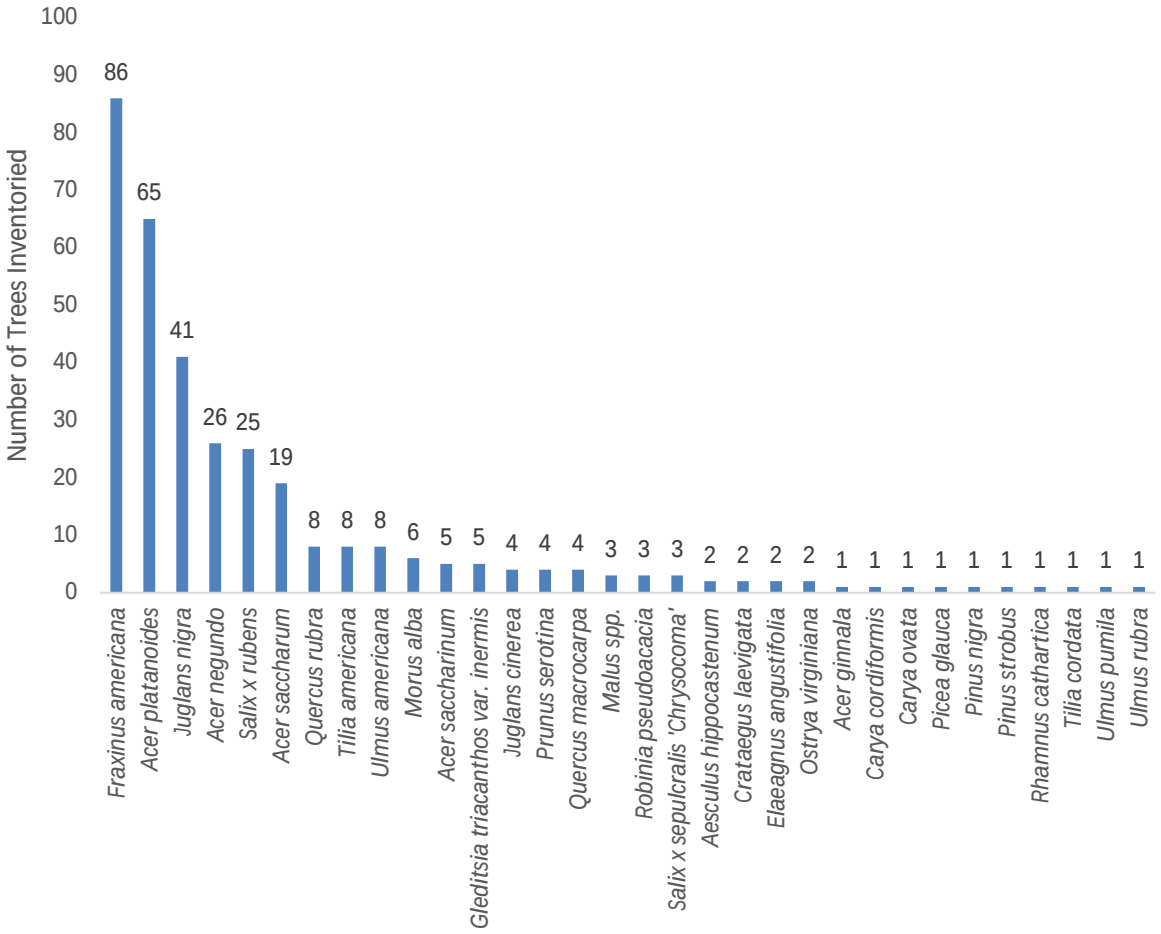
3.8.4.3 Tree Inventory

A tree inventory was undertaken by an ISA-certified arborist (D. Laframboise) from December 3-7, 2018 and May 22 and 23, 2019 to identify trees and large shrubs ≥ 10 cm diameter at breast height (DBH) that may be affected by proposed works at each site. The results of the tree inventory are as follows:

All Sites

Each individual tree was given a preservation priority status of low, moderate, or high. Trees, either native or non-native, which exhibited poor health, poor structure, and/or small size, and were deemed to be currently or potentially able to damage or interfere with existing structures were given low priority status. Trees, either native or non-native, which only moderately exhibited the previously-mentioned qualities were given moderate priority status. Trees of a high-quality species that exhibited good health, good condition, large size (generally over 30 cm DBH), and good growing conditions were given high priority status. Priority status designation was at the discretion of the arborist using the above-mentioned criteria. The full, annotated lists containing the results of each tree inventory, field sheets, and tree mapping are contained in Appendix C.

Overall, a total of 341 trees were inventoried which included 31 species; one identified to genus level only, 15 are non-native, and 15 are native. There were significantly more native trees, 219 trees, inventoried than non-native, 119 trees, with White Ash being the most abundant followed by Norway Maple.



Erosion Site 1A and 1B

A total of 71 trees representing ten species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level but one apple species. One species has federal and provincial significance, Butternut (*Juglans cinerea*). For further information on Butternut, refer to **Section 3.8.7**. Two of the White Ash exhibited evidence of Emerald Ash Borer but have healed over damage. Trees inventoried are summarized in Table 3-7.

Table 3-7: Erosion Site 1A and 1B Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	N	Public	1
Acer platanoides	Norway Maple	I	Public	37
Acer saccharinum	Silver Maple	N	Public	1
Aesculus hippocastenum	Horse Chestnut	I	Public	2
Fraxinus americana	White Ash	N	Public	15

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Juglans cinerea	Butternut	N	Public	4
Juglans nigra	Black Walnut	N	Public	1
Malus spp.	Apple Species		Public	1
Salix x rubens	Hybrid Crack Willow	I	Public	7
Ulmus americana	White Elm	N	Public	2
			TOTAL	**71**

Erosion Site 2

A total of thirty-three trees representing ten species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and eight species are native and two are non-native species. They are considered secure locally, provincially, and nationally. One White Ash has evidence of Emerald Ash Borer but has healed over damage and one Hybrid Crack Willow is significantly leaning over the channel. Trees inventoried are summarized in Table 3-8**.**

Table 3-8: Erosion Site 2 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	N	Private	1
Acer platanoides	Norway Maple	I	Private	6
Acer saccharum	Sugar Maple	N	Private	1
Fraxinus americana	White Ash	N	Private	9
Juglans nigra	Black Walnut	N	Private	5
Prunus serotina	Black Cherry	N	Private	1
Quercus rubra	Red Oak	N	Private	1
Salix x rubens	Hybrid Crack Willow	I	Private	2
Tilia americana	Basswood	N	Private	2
Ulmus americana	White Elm	N	Private	5
			TOTAL	**33**

Erosion Site 3

A total of six trees representing four species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and two species are non-native and two native species. They are considered secure locally, provincially, and nationally. Trees inventoried are summarized in Table 3-9**.**

Table 3-9: Erosion Site 3 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer saccharum	Sugar Maple	N	Private	2
Carya cordiformis	Bitternut Hickory	N	Private	1

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Morus alba	White Mulberry	I	Private	2
Salix x sepulcralis 'Chrysocoma'	Weeping Willow	I	Private	1
			TOTAL	**6**

Erosion Site 4

A total of fourteen trees representing seven species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and four species are native and three are non-native species. They are considered secure locally, provincially, and nationally. Trees inventoried are summarized in Table 3-10**.**

Table 3-10: Erosion Site 4 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	N	Private	1
Acer platanoides	Norway Maple	I	Private (1); Public (3)	4
Fraxinus americana	White Ash	N	Private	3
Juglans nigra	Black Walnut	N	Private	3
Morus alba	White Mulberry	I	Private	1
Salix x sepulcralis 'Chrysocoma'	Weeping Willow	I	Private	1
Tilia americana	Basswood	N	Public	1
			TOTAL	**14**

Erosion Site 5

A total of fifty-seven trees representing thirteen species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and ten species are native and three are non-native species. They are considered secure locally, provincially, and nationally. Trees inventoried are summarized in Table 3-11**.**

Table 3-11: Erosion Site 5 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer platanoides	Norway Maple	I	Private (3); Public (6)	9
Acer saccharum	Sugar Maple	N	Private (3); Public (13)	16
Carya ovata	Shagbark Hickory	N	Public	1
Fraxinus americana	White Ash	N	Private (7); Public (1)	8

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Juglans nigra	Black Walnut	N	Public	2
Ostrya virginiana	Hop Hornbeam	N	Public	2
Pinus nigra	Austrian Pine	I	Private	1
Pinus strobus	White Pine	N	Private	1
Prunus serotina	Black Cherry	N	Public	2
Quercus macrocarpa	Bur Oak	N	Public	3
Quercus rubra	Red Oak	N	Private (1); Public (4)	5
Robinia pseudoacacia	Black Locust	I	Public	3
Tilia americana	Basswood	N	Public	4
			TOTAL	**57**

Erosion Site 6

A total of twenty-six trees representing eleven species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and six species are native and five are non-native species. They are considered secure locally, provincially, and nationally. Trees inventoried are summarized in Table 3-12**.**

Table 3-12: Erosion Site 6 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer ginnala	Amur Maple	I	Private	1
Acer negundo	Manitoba Maple	N	Public	10
Acer platanoides	Norway Maple	I	Private (1); Public (3)	4
Acer saccharinum	Silver Maple	N	Private (3); Public (1)	4
Fraxinus americana	White Ash	N	Private	1
Juglans nigra	Black Walnut	N	Public	1
Morus alba	White Mulberry	I	Public	1
Picea glauca	White Spruce	N	Public	1
Quercus rubra	Red Oak	N	Private	1
Salix x sepulcralis 'Chrysocoma'	Weeping Willow	I	Public	1
Tilia cordata	Small-leaved Linden	I	Public	1
			TOTAL	**26**

Erosion Site 7A and 7B

A total of eighty-five trees representing fourteen species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level except one apple species and seven species are non-native and six are native species. They are all considered secure locally, provincially, and nationally. Naturally occurring Honeylocust are provincially rare

(S2) but the trees inventoried are the thornless variety that is often planted in urban landscapes which are not protected provincially. Trees inventoried are summarized in Table 3-13**.**

Table 3-13: Erosion Site 7A and 7B Tree Inventory Summary

Species Name			Location	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	N	Public	12
Acer platanoides	Norway Maple	I	Public	2
Crataegus laevigata	English Hawthorn	I	Public	2
Elaeagnus angustifolia	Russian Olive	I	Public	1
Fraxinus americana	White Ash	N	Public	41
Gleditsia triacanthos var. inermis	Thornless Honeylocust	I	Public	3
Juglans nigra	Black Walnut	N	Public	6
Malus spp.	Apple Species		Public	1
Morus alba	White Mulberry	I	Public	2
Prunus serotina	Black Cherry	N	Public	1
Quercus macrocarpa	Bur Oak	N	Public	1
Rhamnus cathartica	Common Buckthorn	I	Public	1
Salix x rubens	Hybrid Crack Willow	I	Public	11
Ulmus americana	White Elm	N	Public	1
			TOTAL	**85**

Erosion Site 8

A total of five trees representing three species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and all non-native. They are all considered secure locally, provincially, and nationally. As stated for Erosions Site 7, only naturally occurring Honeylocust are considered provincially rare (S2). The individuals at this site are the thornless variety that is often planted in urban landscapes and therefore are not protected. Trees inventoried are summarized in Table 3-14.

Table 3-14: Erosion Site 8 Tree Inventory Summary

Species Name			Location	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer platanoides	Norway Maple	I	Public	2
Gleditsia triacanthos var. inermis	Thornless Honeylocust	I	Public	2
Salix x rubens	Hybrid Crack Willow	I	Public	1
			TOTAL	**5**

Erosion Site 9A and 9B

A total of forty-four trees representing eleven species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level except one apple

species and five species are non-native and five are native species. They are all considered secure locally, provincially, and nationally. Trees inventoried are summarized in Table 3-15**.**

Table 3-15: Erosion Site 9A and 9B Tree Inventory Summary

Species Name			Location	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	N	Public	1
Acer platanoides	Norway Maple	I	Public	1
Elaeagnus angustifolia	Russian Olive	I	Public	1
Fraxinus americana	White Ash	N	Public	9
Juglans nigra	Black Walnut	N	Public	23
Malus spp.	Apple Species		Public	1
Quercus rubra	Red Oak	N	Public	1
Salix x rubens	Hybrid Crack Willow	I	Public	4
Tilia americana	Basswood	N	Public	1
Ulmus pumila	Siberian Elm	I	Public	1
Ulmus rubra	Slippery Elm	I	Public	1
			TOTAL	**44**

3.8.4.4 Butternut

An area search for Butternut was conducted in potentially suitable habitat within the study area in addition to botanical inventories on June 20th, 21st 2018 and Dec. 3rd-7th 2018. Six Butternuts were found; four within the area of disturbance and two within adjacent lands. The location of the Butternuts is depicted on Figure 3-12. One tree (BH-5) has been determined to be a pure Butternut based on the results of testing that were received October 24th, 2018. Genetic testing results are provided in Appendix C**.** The remaining trees have not been tested but have been assumed pure based on proximity to the confirmed pure tree and lack of physical characteristics suggesting hybridity. If confirmation of genetic purity is desired, a tree service would need to be hired to climb the trees and collect leaf samples for testing, as the trees are too tall to allow collection of samples from the ground.

A Butternut Heath Assessment (BHA) has been completed for four of the trees. If butternut tree removal is required, health assessment report submission to MECP is required as close as possible to the actual removal of a tree in order to have an accurate assessment of its health. See Table 3-16 for details of the Butternut Trees status. For supporting documentation see Appendix C.

Table 3-16: Butternut Status and Implications

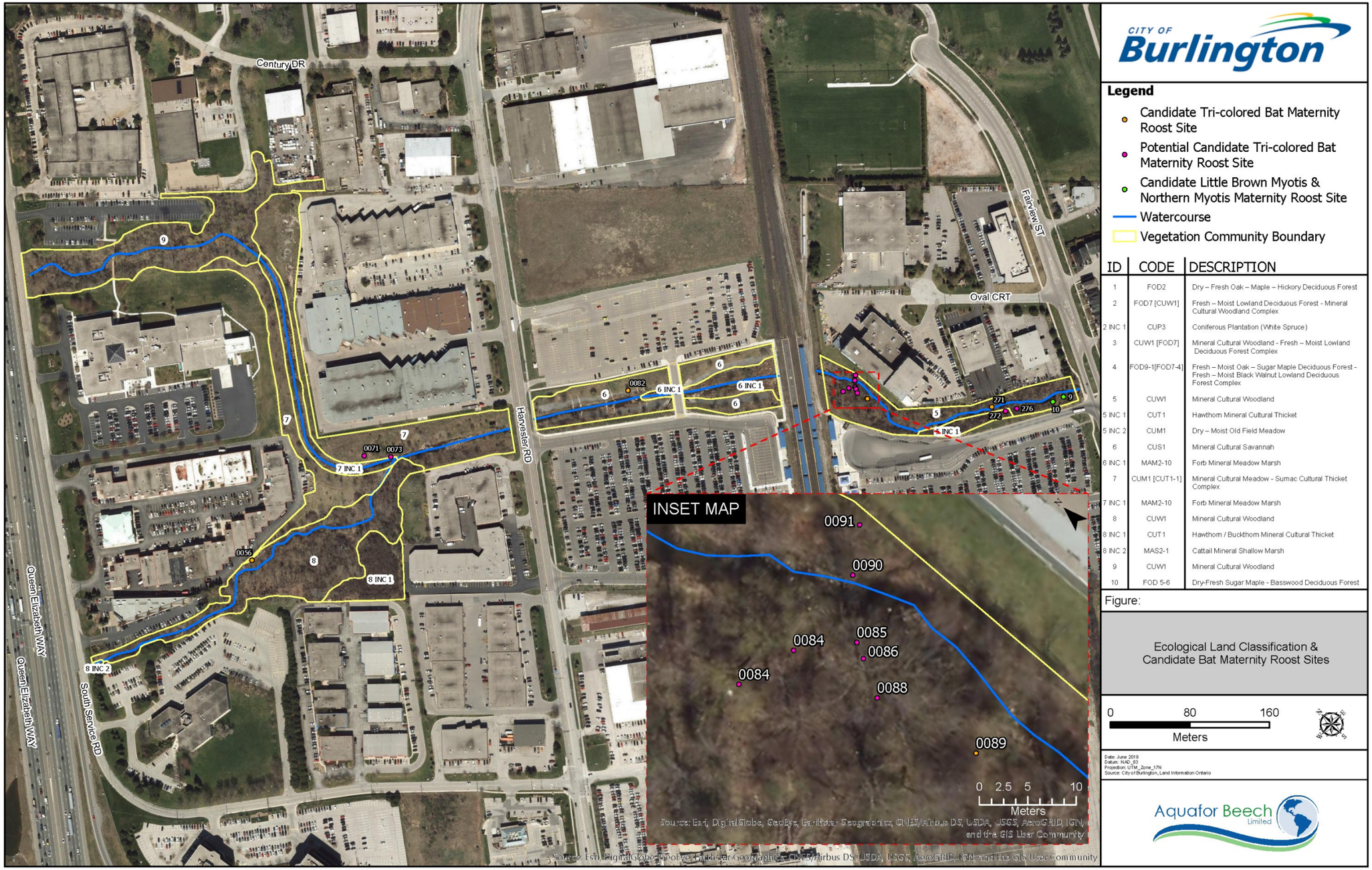
ID	Status	Implications
BN-1	The results of a Butternut Health Assessment identified this tree as **Category 2** ("retainable").	Per O.Reg. 242/08 under the ESA, up to 10 Category 2 trees may be removed without a permit following the 30-day review period by the MECP. However, the project must be registered with the MECP and the proponent must undertake Butternut planting (plus maintenance and monitoring of seedlings) following certain ratios and planting requirements. Genetic testing may be done to confirm the purity of the trees. If trees are determined to be hybrids than they are not protected under the ESA and should be compensated for in the same manner as all other trees that are to be negatively impacted by this project. However, the trees did not evidence strong visual hybridity indicators and are in proximity to a known pure tree, so there is a good chance these trees are also pure.
BN-2	The results of a Butternut Health Assessment identified this tree as **Category 2** ("retainable").	
BN-3	The results of a Butternut Health Assessment identified this tree as **Category 1** ("non-retainable")	Per O.Reg. 242/08 under the ESA, Category 1 trees may be removed without a permit following the 30-day review period by the MECP.
BN-4	A site visit on June 27th, 2019 determined that this tree was removed after it uprooted and fell into the watercourse.	No implications.
BN-5 (Adjacent lands)	Genetic testing was completed for this tree and confirmed that the **tree is a genetically pure Butternut**. A full BHA was not completed but based on preliminary observations the certified assessor is confident this tree is **Category 2** ("retainable").	See implications described above for Category 2 trees. This tree is located partially on private property (on the fenceline with Bromley Park) and therefore could not be accessed fully to complete the full requirements of a BHA. However, it is a very large, healthy tree (100% live crown, few visible cankers), and the certified Butternut Health Assessor who completed the review is confident the tree is Category 2.
BN-6 (Adjacent lands)	The results of a Butternut Health Assessment identified this tree as **Category 2** ("retainable").	See implications described above for Category 2 trees.

3.8.5 Terrestrial Wildlife

The results of surveys to identify terrestrial wildlife within the study area are described below.

3.8.5.1 Bat Maternity Roosts

Phase 1 and 2 of the Guelph District MNRF's *Survey Protocol for Species at Risk Bats within Treed Habitats Little Brown Myotis, Northern Myotis & Tri-colored Bat* (OMNRF, 2017) was completed to identify candidate maternity roosting sites for Little Brown Myotis, Northern Myotis , and Tri-colored Bat. Little Brown Myotis "establishes maternity roosts within tree cavities and under loose or exfoliating bark, especially in wooded areas located next to water" and Northern Myotis "roosts within tree crevices, hollows and under the bark of live and dead trees, particularly when tree are located within a forest gap" (OMNRF 2017). To map candidate roosting habitat for these two species, surveys were completed on January 17th and 18th, 2019. Per the protocol, trees with a DBH 10 cm and greater in various states of decay with snag attributes (e.g., loose bark, knot holes, cracks, etc.) were identified and mapped. Unlike the two Myotis, Tri-colored Bat prefers to establish "maternity roosts within line and dead foliage within or below the canopy" preferably in Oak and Maple trees (OMNRF, 2017). As per the protocol, all Oaks with a DBH of greater than 10 cm and Maples with a DBH of 25 cm were classified as candidate maternity roost habitat. Maples with a DBH greater than 10 cm but less than 25 cm were classified as potential candidate maternity roost habitat. It is the experience of Aquafor Beech Limited that the Aurora District MNRF has adopted this protocol as the standard for identifying the habitat of endangered bats. Phases 3 and 4 of the protocol have not been completed to date. **In total, 17 candidate Little Brown Myotis and Northern Myotis trees occur in the surveyed area (**Table 3-17**). There were 66 candidate Tri-colored Bat maternity roost sites as well as an additional 61 potential candidate Tri-colored Bat maternity roost sites identified within and 10 m from anticipated disturbance areas (**Table 3-18**)**. The highest concentration of candidate Little Brown Myotis and Northern Myotis sites is between Pinedale Avenue and the Great Lakes Waterfront Trail. Candidate bat maternity roost sites are illustrated in Figure 3-14. Tri-colored Bat sites are throughout the watercourse with the highest concentrations in communities dominated by Maples and Oaks including ELC polygons 1, 4, and 10 (Figure 3-13 to Figure 3-17). Leaf-off maternity roost survey field sheets and tree inventory data is contained in Appendix C.



ID	CODE	DESCRIPTION
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest
2	FOD7 [CUW1]	Fresh – Moist Lowland Deciduous Forest - Mineral Cultural Woodland Complex
2 INC 1	CUP3	Coniferous Plantation (White Spruce)
3	CUW1 [FOD7]	Mineral Cultural Woodland - Fresh – Moist Lowland Deciduous Forest Complex
4	FOD9-1[FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest - Fresh – Moist Black Walnut Lowland Deciduous Forest Complex
5	CUW1	Mineral Cultural Woodland
5 INC 1	CUT1	Hawthorn Mineral Cultural Thicket
5 INC 2	CUM1	Dry – Moist Old Field Meadow
6	CUS1	Mineral Cultural Savannah
6 INC 1	MAM2-10	Forb Mineral Meadow Marsh
7	CUM1 [CUT1-1]	Mineral Cultural Meadow - Sumac Cultural Thicket Complex
7 INC 1	MAM2-10	Forb Mineral Meadow Marsh
8	CUW1	Mineral Cultural Woodland
8 INC 1	CUT1	Hawthorn / Buckthorn Mineral Cultural Thicket
8 INC 2	MAS2-1	Cattail Mineral Shallow Marsh
9	CUW1	Mineral Cultural Woodland
10	FOD 5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest

Figure:

Ecological Land Classification & Candidate Bat Maternity Roost Sites

0 80 160
Meters

Date: June 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: City of Burlington, Land Information Ontario

Aquafor Beech Limited

Figure 3-13: Candidate Bat Maternity Roosting Sites 1 of 5



Figure 3-14: Candidate Bat Maternity Roosting Sites 2 of 5

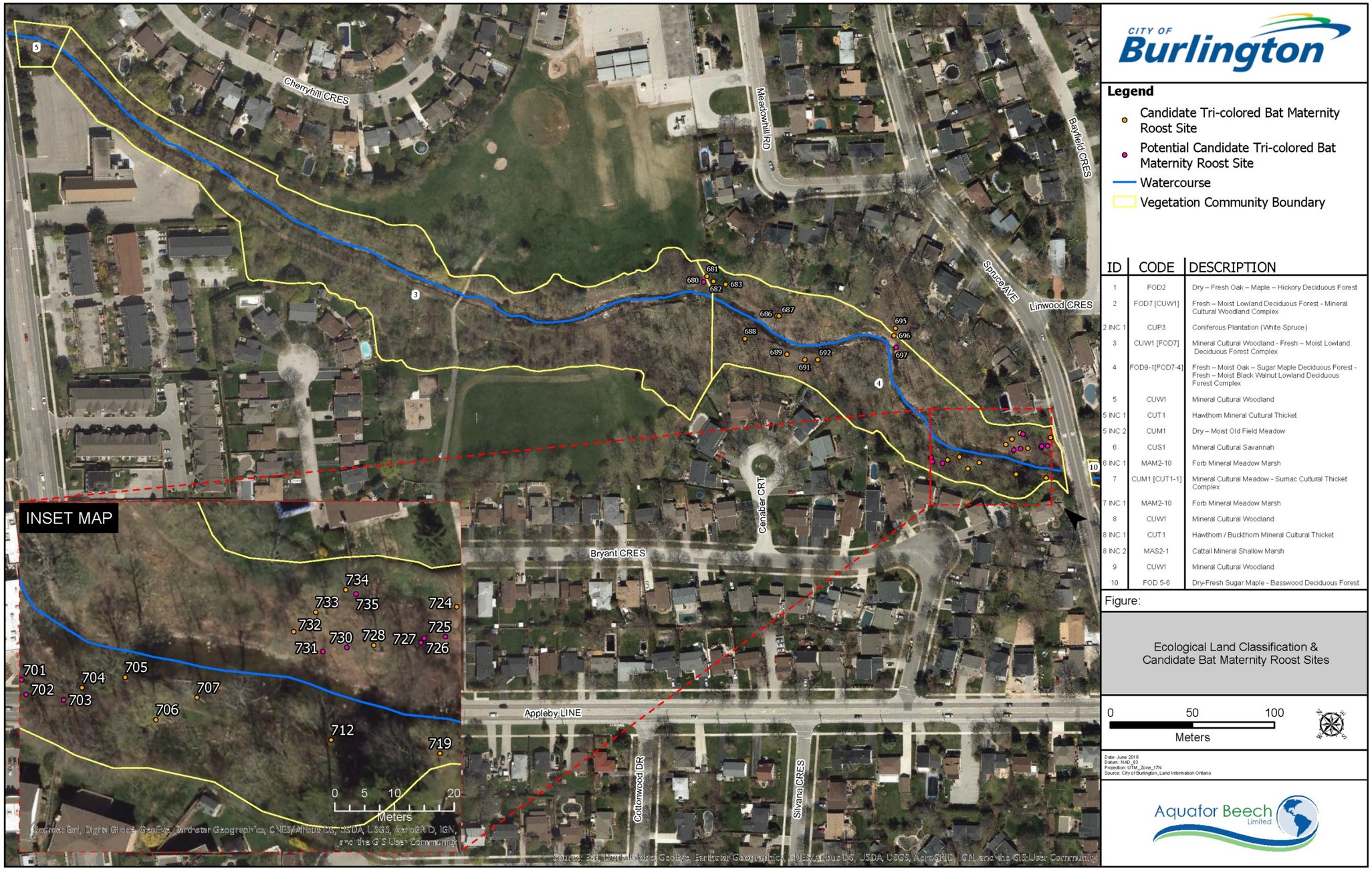


Figure 3-15: Candidate Bat Maternity Roosting Sites 3 of 5



Figure 3-16: Candidate Bat Maternity Roosting Sites 4 of 5



CITY OF Burlington

Legend

- Candidate Tri-colored Bat Maternity Roost Site
- Potential Candidate Tri-colored Bat Maternity Roost Site
- Butternut Locations
- Watercourse
- Vegetation Community Boundary

ID	CODE	DESCRIPTION
1	FOD2	Dry – Fresh Oak – Maple – Hickory Deciduous Forest
2	FOD7 [CUW1]	Fresh – Moist Lowland Deciduous Forest - Mineral Cultural Woodland Complex
2 INC 1	CUP3	Coniferous Plantation (White Spruce)
3	CUW1 [FOD7]	Mineral Cultural Woodland - Fresh – Moist Lowland Deciduous Forest Complex
4	FOD9-1[FOD7-4]	Fresh – Moist Oak – Sugar Maple Deciduous Forest - Fresh – Moist Black Walnut Lowland Deciduous Forest Complex
5	CUW1	Mineral Cultural Woodland
5 INC 1	CUT1	Hawthorn Mineral Cultural Thicket
5 INC 2	CUM1	Dry – Moist Old Field Meadow
6	CUS1	Mineral Cultural Savannah
6 INC 1	MAM2-10	Forb Mineral Meadow Marsh
7	CUM1 [CUT1-1]	Mineral Cultural Meadow - Sumac Cultural Thicket Complex
7 INC 1	MAM2-10	Forb Mineral Meadow Marsh
8	CUW1	Mineral Cultural Woodland
8 INC 1	CUT1	Hawthorn / Buckthorn Mineral Cultural Thicket
8 INC 2	MAS2-1	Cattail Mineral Shallow Marsh
9	CUW1	Mineral Cultural Woodland
10	FOD 5-6	Dry-Fresh Sugar Maple - Basswood Deciduous Forest

Figure:

Ecological Land Classification & Candidate Bat Maternity Roost Sites

0 12.5 25
Meters

Date: June 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: City of Burlington, Land Information Ontario

Aquafor Beech Limited

Figure 3-17: Candidate Bat Maternity Roosting Sites 5 of 5

Table 3-17: Candidate *Myotis* spp. Maternity Roost Sites

Site #	Species		DBH (cm)	Height Classł	Snag Attributes					Decay Class‡	Bat Notes	Location		
	Botanical Name	Common Name			Knot Hole(s)	Loose Bark	Cavity	Other snag within 10 m	Crack(s)			Easting	Northing	Margin of Error (m)
1	*Salix x sepulcralis*	Weeping Willow	>50	1	✓	✓		✓		1	4 stems fused at breast height; all stems above breast height >50 cm	601126	4802950	4.5
2	*Salix x sepulcralis*	Weeping Willow	18, 33.5, 56.2	1		✓	✓	✓		1	Cavity approx. 5 m off ground	601120	4802954	5
3	*Salix x sepulcralis*	Weeping Willow	>120	1	✓	✓	✓		✓	1	Large multi-stemmed weeping willow with various snag attributes	601045	4803015	4.7
4	*Acer saccharinum*	Silver Maple	52	1		✓				1		600899	4803043	6
5	*Salix x sepulcralis*	Weeping Willow	85	1		✓			✓	1		600876	4803056	6
6	*Acer saccharinum*	Silver Maple	86	1	✓	✓				1		600768	4803177	5.6
7	*Acer saccharinum*	Silver Maple	108	1	✓	✓				1		600676	4803273	4.3
8	*Acer saccharinum*	Silver Maple	44, 42, 38, 33	1		✓				1		600686	4803342	5.3
9	*Fraxinus americana*	White Ash	43, 37	1	✓	✓				5		600596	4803576	3.2
10	*Salix x rubens*	Hybrid Crack Willow	>100	1		✓			✓	2		600585	4803580	5
11	*Fraxinus americana*	White Ash	>80	1	✓	✓				3	in private property at fence line	600684	4803234	4.7
12	*Acer platanoides*	Norway Maple	32	2					✓	1		600737	4803187	6.2
13	*Acer negundo*	Manitoba Maple	45, 34.5	2	✓					2	Some tree stems removed previously	600761	4803164	4.4
14	*Acer platanoides*	Norway Maple	52	1		✓				1		600780	4803147	5.4
15	*Acer negundo*	Manitoba Maple	63	1			✓			1	Cavity approx. 3.5 m off ground	600873	4803032	5.9
16	*Acer negundo*	Manitoba Maple	65	1		✓			✓	1		600890	4803021	4.5
17	*Acer saccharinum*	Silver Maple	>100	1	✓	✓				1	5 stems fused together	601212	4802694	4.6

łHeight Class: 1 - Dominant (above canopy); 2 - Co-dominant (canopy height); 3 - Intermediate (just below canopy); 4 - Suppressed (well below canopy).

‡Decay Class: 1 - Healthy, live tree; 2 - Declining live tree, part of canopy lost; 3 - Very recently dead, bark intact, branches intact; 4 - Recently dead, bark peeling, only large branches intact; 5 - Older dead tree, 90% of bark lost, few branch stubs, broken top; 6 - Very old dead tree, advance decay, no branches, parts of the stem have rotted away.

Table 3-18: Candidate Tri-colored Bat Maternity Roost Sites

CANDIDATE TRI-COLORED BAT MATERNITY ROOST SITES (Information obtained from tree inventory)						
Status[1]	**Site**	**Tag #**	**Species Common Name**	**Species Botanical Name**	**DBH (cm)**	**Condition[2]**
C	1	788	Norway Maple	*Acer platanoides*	25	G
PC	1	789	Norway Maple	*Acer platanoides*	23	G
C	1	791	Norway Maple	*Acer platanoides*	28	F-G
PC	1	796	Norway Maple	*Acer platanoides*	23	G
PC	1	799	Norway Maple	*Acer platanoides*	17	F-G
PC	1	800	Norway Maple	*Acer platanoides*	16	F-G
PC	1	801	Norway Maple	*Acer platanoides*	13.5	F-G
PC	1	802	Norway Maple	*Acer platanoides*	20	F-G
PC	1	804	Norway Maple	*Acer platanoides*	22	F-G
C	1	808	Norway Maple	*Acer platanoides*	32	F-G
C	1	810	Norway Maple	*Acer platanoides*	41	F-G
C	1	813	Norway Maple	*Acer platanoides*	33	F-G
C	1	815	Norway Maple	*Acer platanoides*	37	G
PC	1	816	Norway Maple	*Acer platanoides*	17	F
PC	1	817	Norway Maple	*Acer platanoides*	14	F
PC	1	819	Norway Maple	*Acer platanoides*	13	F
C	1	820	Norway Maple	*Acer platanoides*	39	F-G
PC	1	823	Norway Maple	*Acer platanoides*	23	F
C	1	824	Norway Maple	*Acer platanoides*	32	F-G
C	1	825	Norway Maple	*Acer platanoides*	28	F-G
PC	1	827	Norway Maple	*Acer platanoides*	18	F-G
PC	1	828	Norway Maple	*Acer platanoides*	14.5	F-G
PC	1	829	Norway Maple	*Acer platanoides*	21	F-G
PC	1	830	Norway Maple	*Acer platanoides*	16	F
C	1	831	Norway Maple	*Acer platanoides*	42	G
C	1	832	Norway Maple	*Acer platanoides*	52	G
PC	1	833	Norway Maple	*Acer platanoides*	15	F-G
PC	1	834	Norway Maple	*Acer platanoides*	13	F
PC	1	837	Norway Maple	*Acer platanoides*	16	F
C	1	838	Norway Maple	*Acer platanoides*	46,30	G
C	1	839	Norway Maple	*Acer platanoides*	32,28,38	F-G(28), G
PC	1	842	Manitoba Maple	*Acer negundo*	16	F-G
C	1	844	Norway Maple	*Acer platanoides*	32,32	F-G
C	1	NT1-1	Norway Maple	*Acer platanoides*	50	G
C	1	NT1-2	Silver Maple	*Acer saccharinum*	~60	F
C	1	783	Norway Maple	*Acer platanoides*	35	F-G
PC	1	784	Norway Maple	*Acer platanoides*	18	F-G
C	1	NT2-1	Norway Maple	*Acer platanoides*	~30,~15	F-G
C	1	NT2-2	Norway Maple	*Acer platanoides*	~35	F-G
PC	2	758	Sugar Maple	*Acer saccharum*	18	G
PC	2	773	Norway Maple	*Acer platanoides*	19	F
C	2	774	Norway Maple	*Acer platanoides*	50	G
C	2	775	Norway Maple	*Acer platanoides*	43	G
PC	2	776	Norway Maple	*Acer platanoides*	11	F-G
PC	2	778	Manitoba Maple	*Acer negundo*	20	F
C	2	780	Red Oak	*Quercus rubra*	20	G
PC	2	781	Norway Maple	*Acer platanoides*	16	G
PC	2	782	Norway Maple	*Acer platanoides*	11	F-G
PC	4	748	Sugar Maple	*Acer saccharum*	(19,9)	F
PC	4	750	Sugar Maple	*Acer saccharum*	15	F

CANDIDATE TRI-COLORED BAT MATERNITY ROOST SITES (Information obtained from tree inventory)						
Status[1]	**Site**	**Tag #**	**Species Common Name**	**Species Botanical Name**	**DBH (cm)**	**Condition[2]**
PC	4	738	Norway Maple	*Acer platanoides*	14	F-G
PC	4	739	Norway Maple	*Acer platanoides*	19	G
PC	4	740	Norway Maple	*Acer platanoides*	15	G
C	4	741	Manitoba Maple	*Acer negundo*	39	F
PC	4	743	Norway Maple	*Acer platanoides*	22	G
PC	5	680	Norway Maple	*Acer platanoides*	17	F
C	5	681	Red Oak	*Quercus rubra*	19	G
C	5	682	Sugar Maple	*Acer saccharum*	44	F-G
C	5	683	Norway Maple	*Acer platanoides*	30	F-G
C	5	686	Sugar Maple	*Acer saccharum*	([21,31],[21,14,19,33]) @1.7m	F-G
C	5	687	Sugar Maple	*Acer saccharum*	45	F-G
C	5	688	Red Oak	*Quercus rubra*	[51,43,32]	F-G
C	5	689	Bur Oak	*Quercus macrocarpa*	42	G
C	5	691	Bur Oak	*Quercus macrocarpa*	38	G
C	5	692	Red Oak	*Quercus rubra*	60	F-G
C	5	695	Sugar Maple	*Acer saccharum*	30	G
C	5	696	Red Oak	*Quercus rubra*	21	F-G
PC	5	697	Sugar Maple	*Acer saccharum*	16	F-G
PC	5	701	Sugar Maple	*Acer saccharum*	21	G
PC	5	702	Sugar Maple	*Acer saccharum*	18	G
PC	5	703	Sugar Maple	*Acer saccharum*	13	G
C	5	704	Sugar Maple	*Acer saccharum*	30	F
C	5	705	Sugar Maple	*Acer saccharum*	42	F
C	5	706	Sugar Maple	*Acer saccharum*	35	G
C	5	707	Bur Oak	*Quercus macrocarpa*	12.5	F
C	5	712	Sugar Maple	*Acer saccharum*	29	F
C	5	719	Sugar Maple	*Acer saccharum*	47	F-G
C	5	724	Norway Maple	*Acer platanoides*	25	G
PC	5	725	Norway Maple	*Acer platanoides*	13.5	F-G
PC	5	726	Norway Maple	*Acer platanoides*	12	G
PC	5	727	Norway Maple	*Acer platanoides*	19	G
C	5	728	Sugar Maple	*Acer saccharum*	48	G
PC	5	730	Norway Maple	*Acer platanoides*	12	G
PC	5	731	Norway Maple	*Acer platanoides*	12	G
C	5	732	Sugar Maple	*Acer saccharum*	33	G
C	5	733	Sugar Maple	*Acer saccharum*	38	F-G
C	5	734	Red Oak	*Quercus rubra*	31	G
PC	5	735	Norway Maple	*Acer platanoides*	11	F-G
C	6	658	Silver Maple	*Acer saccharinum*	100 @1m	F-G
C	6	659	Silver Maple	*Acer saccharinum*	~50,45,40,30,30,25,20	F-G
PC	6	662	Manitoba Maple	*Acer negundo*	11	F-G
C	6	665	Manitoba Maple	*Acer negundo*	38	F
PC	6	666	Manitoba Maple	*Acer negundo*	13	F
C	6	667	Manitoba Maple	*Acer negundo*	46	F-G
C	6	668	Manitoba Maple	*Acer negundo*	65	F-G
C	6	669	Norway Maple	*Acer platanoides*	34	F-G
C	6	670	Norway Maple	*Acer platanoides*	31	G
C	6	671	Silver Maple	*Acer saccharinum*	38,26	F-G
C	6	672	Norway Maple	*Acer platanoides*	19,24,20,22,10	F-G
C	6	673	Manitoba Maple	*Acer negundo*	36	G
PC	6	674	Manitoba Maple	*Acer negundo*	10.5	F-G

CANDIDATE TRI-COLORED BAT MATERNITY ROOST SITES (Information obtained from tree inventory)						
Status[1]	**Site**	**Tag #**	**Species Common Name**	**Species Botanical Name**	**DBH (cm)**	**Condition[2]**
PC	6	675	Manitoba Maple	*Acer negundo*	19	G
PC	6	676	Manitoba Maple	*Acer negundo*	12	G
C	6	677	Manitoba Maple	*Acer negundo*	(24,12)	F-G
C	6	NT7-1	Amur Maple	*Acer ginnala*	22,10,12,11	F-P
PC	6	NT7-2	Norway Maple	*Acer platanoides*	22	F-G
C	6	NT7-4	Silver Maple	*Acer saccharinum*	~40,35,30,30	F-G
C	6	NT7-5	Red Oak	*Quercus rubra*	~28	F-G
PC	7	0084	Manitoba Maple	*Acer negundo*	21	F-P
PC	7	0085	Manitoba Maple	*Acer negundo*	18	P
PC	7	0086	Manitoba Maple	*Acer negundo*	14	F
PC	7	0088	Manitoba Maple	*Acer negundo*	17,12,18	F
C	7	0089	Manitoba Maple	*Acer negundo*	27	F-G
PC	7	0090	Manitoba Maple	*Acer negundo*	14	F-G
PC	7	0091	Manitoba Maple	*Acer negundo*	15	G
C	7	271	Manitoba Maple	*Acer negundo*	30	F-P
PC	7	272	Manitoba Maple	*Acer negundo*	15	F-G
PC	7	276	Manitoba Maple	*Acer negundo*	(13,10)	F
PC	7	292	Manitoba Maple	*Acer negundo*	(13,14,17)	F-G
C	7	294	Norway Maple	*Acer platanoides*	33	G
PC	7	296	Manitoba Maple	*Acer negundo*	23	F-G
C	7	657	Norway Maple	*Acer platanoides*	30	F-G
C	7	NT8-21	Bur Oak	*Quercus macrocarpa*	18	G
C	8	0082	Norway Maple	*Acer platanoides*	27	G
C	9	0056	Red Oak	*Quercus rubra*	30,22	F-G
PC	9	0071	Norway Maple	*Acer platanoides*	23	G
PC	9	0073	Manitoba Maple	*Acer negundo*	13	G

1: C - Candidate maternity roost habitat; PC – Potential candidate maternity roost habitat
2: Health Condition: G - Good; F - Fair; P - Poor; D – Dead

3.8.5.2 Breeding Birds

Two breeding bird surveys were conducted within the study area on June 4, 2018 and June 26, 2018 by a qualified avian biologist. The surveys were conducted in accordance with the Ontario Breeding Bird Atlas (Cadman, 2007) protocol, occurring more than fifteen (15) days apart during the core breeding season, within 5 hours of dawn and in favourable weather. Each survey was conducted by walking parallel to the creek within the riparian corridor, with observations recorded at each road crossing and via 10-minute point counts 250 m apart throughout the rest of the area. Approximate crossing locations (denoted by purple pins), point count locations (denoted by yellow pins), and location coordinates are illustrated in Appendix C. All birds seen and heard were recorded, as was any evidence of breeding, as applicable. Breeding evidence was used to assign a breeding status (confirmed, probable, possible, and observed). The breeding evidence codes and their abbreviations are also contained in Appendix C.

Results

A total of 35 species were encountered during the two surveys, as listed in Table 3-19. Of the 35 species, breeding was confirmed for one, probable for 13 and possible for 16. The remaining five species were observed with no evidence of breeding. One of the 35 species could not be identified, and is indicated as ‘Bird sp.’ – this single bird was observed only briefly and with no breeding evidence (presumed migrant).

Table 3-19: Breeding Bird Survey Results

Species Name		Highest Breeding Evidence	Ranking			
Common Name	Binomial Name		S Rank	Halton*	SARA	ESA
Alder Flycatcher	*Empidonax alnorum*	**Poss (S)**	S5B, SZN	Common	-	-
American Crow	*Corvus brachyrhychos*	**Obs (X)**	S5B, SZN	Abundant	-	-
American Goldfinch	*Spinus tristis*	**Prob (T)**	S5B, SZN	Abundant	-	-
American Redstart	*Setophaga ruticilla*	**Poss (S)**	S5B, SZN	Common	-	-
American Robin	*Turdus migratorius*	**Prob (T)**	S5B, SZN	Abundant	-	-
Baltimore Oriole	*Icterus galbula*	**Prob (T)**	S5B, SZN	Common	-	-
Black-capped Chickadee	*Poecile atricapillus*	**Prob (T)**	S5	Abundant	-	-
Black-crowned Night-Heron	*Nycticorax nycticorax*	**Prob (T)**	S3B, SZN	Uncommon	-	-
Blue Jay	*Cyanocitta cristata*	**Poss (H)**	S5	Abundant	-	-
Canada Goose	*Branta canadensis*	**Obs (X)**	S5B, SZN	Abundant	-	-
Cedar Waxwing	*Bombycilla cedrorum*	**Poss (H)**	S5B, SZN	Common	-	-
Chipping Sparrow	*Spizella passerina*	**Poss (S)**	S5B, SZN	Common	-	-
Common Grackle	*Quiscalus quiscula*	**Prob (P)**	S5B, SZN	Abundant	-	-
Downy Woodpecker	*Picoides pubescens*	**Poss (H)**	S5	Common	-	-
European Starling	*Sturnus vulgaris*	**Poss (H)**	SNA	Abundant	-	-
Eastern Wood-Pewee	*Contopus virens*	**Poss (S)**	S5B, SZN	Common	-	-
Gray Catbird	*Dumetella carolinensis*	**Poss (S)**	S5B, SZN	Common	-	-
Great Crested Flycatcher	*Myiarchus crinitus*	**Poss (S)**	S5B, SZN	Common	-	-
House Sparrow	*Passer domesticus*	**Prob (P)**	SNA	Abundant	-	-
Killdeer	*Charadrius vociferous*	**Poss (H)**	S5B, SZN	Common	-	-
Mallard	*Anas platyrhynchos*	**Prob (P)**	S5B, SZN	Abundant	-	-

Species Name		Highest Breeding Evidence	Ranking			
Common Name	**Binomial Name**		**S Rank**	**Halton***	**SARA**	**ESA**
Mourning Dove	*Zenaida macroura*	**Poss (S)**	S5B, SZN	Abundant	-	-
Northern Cardinal	*Cardinalis cardinalis*	**Prob (T)**	S5	Common	-	-
Northern Flicker	*Colaptes auratus*	**Poss (H)**	S5B, SZN	Common	-	-
Red-bellied Woodpecker	*Melanerpes carolinus*	**Poss (H)**	S4	Uncommon	-	-
Red-breasted Nuthatch	*Sitta canadensis*	**Poss (H)**	S5B, SZN	Uncommon	-	-
Red-eyed Vireo	*Vireo olivaceus*	**Prob (T)**	S5B, SZN	Abundant	-	-
Red-winged Blackbird	*Agelaius phoeniceus*	**Conf (FY)**	S5B, SZN	Abundant	-	-
Ring-billed Gull	*Larus delawarensis*	**Obs (X)**	S5B,S4N	Abundant	-	-
Rock Pigeon	*Columba livia*	**Obs (X)**	SNA	Abundant	-	-
Song Sparrow	*Melospiza melodia*	**Prob (T)**	S5B, SZN	Abundant	-	-
Tree Swallow	*Tachycineta bicolor*	**Poss (S)**	S5B, SZN	Abundant	-	-
Warbling Vireo	*Vireo gilvus*	**Prob (T)**	S5B, SZN	Common	-	-
Yellow Warbler	*Setophaga petechia*	**Prob (T)**	S5B, SZN	Common	-	-
Unidentified sp.	*Unidentified sp.*	**Obs (X)**	-	-	-	-

*Halton Natural Areas Inventory (2006)

Of the 35 species, 29 have a rank of S5, indicating that they are Secure (common, widespread or abundant), while one has a rank of S4 or Apparently Secure (uncommon but not rare; some cause for long-term concern due to declines or other factors) and one has a rank of S3 or Apparently Vulnerable (vulnerable within a particular state or province because it is rare or uncommon, or because it is found only in a restricted range, or because other factors make it vulnerable to extinction). Three introduced species (European Starling, House Sparrow, and Rock Pigeon) are assigned a rank of SNA or Not Applicable, meaning they are not a suitable target for conservation activities. The single unidentified species was not assigned ranks due to the lack of species confirmation.

Suitable nesting locations for Barn Swallow, along with evidence of past nest building was observed under the Lakeshore Road crossing, however no birds were observed during either site visit. It is assumed that the nests were abandoned before completion and are currently

uninhabited, although nesting could occur at this location again in future. Barn Swallow is designated as Threatened under the ESA (2007) and SARA (2002).

A single singing Eastern Wood-pewee was observed during the latter surveys in the woodlots in Bromley Park, north of Lakeshore Road (heard from point count PC11). Eastern Wood-pewee is designated as Special Concern under the ESA (2007) and SARA (2002).

The Black-crowned Night-heron was observed foraging in Appleby Creek near the Appleby GO Station. It is believed this species is foraging in the study area only; evidence of breeding was not observed. As an S3 ranked species, the habitat of the Black-crowned Night-heron is considered SWH.

It is the opinion of Aquafor Beech Limited that the study area is likely not a significant migratory stopover area for birds due to a lack of high-quality habitat (e.g., canopy cover, native food sources, etc.), the high level of disturbance in the study area (e.g., encroachment and recent ash tree removal), and observations during surveys not indicating a high number of birds in the study area.

3.8.5.3 Snakes and Anurans

The presence of calling anurans (i.e., frogs and toads) was surveyed according to the protocol of the Marsh Monitoring Program (Bird Studies Canada, 2003). The protocol requires three surveys occurring at least fifteen days apart, between April 15 and June 30, that meet minimum nighttime temperature requirements and start a half hour after sunset.

To determine the presence of significant snake species and their habitats within the study area, an active hand search was completed following the Milksnake Survey Protocol (MNRF, 2013). Per the protocol, three survey days are required between late April and late June during warm days between 8°C and 25°C. Each survey day is to be separated by at least two weeks and spread out over the survey period. Active hand searches focused on key habitats, such as under rocks, logs, and other objects that may provide cover.

No anurans or snakes were observed during the surveys mentioned above. Furthermore, no structures that may be used as hibernacula for snakes were observed within the study area. It should be noted that the areas adjacent to school may be a deterrent to snakes due to frequent trampling by school children.

3.8.5.4 Incidental Wildlife and Site Observations

Wildlife and/or traces of wildlife (e.g., tracks, scat, sheds, vocalizations, etc.) observed incidentally during all field surveys are detailed in Table 3-20, below. All species observed are common locally and to the province, and considered tolerant of urban environments. As mentioned above, anurans and snakes were not identified during targeted surveys. Given the degraded condition of the study area, it is likely that only common urban species such as Eastern Chipmunk (*Tamias striatus*), Red Squirrel (*Sciurus vulgaris*), Eastern Cottontail (*Sylvilagus floridanus*), Striped Skunk (*Mephitis mephitis*), Eastern Garter Snake (*Thamnophis sirtalis sirtalis*), and the domestic house cat (*Felis catus*) may be found with any reliability in the study area.

Table 3-20: Incidental Wildlife Observations

Species Name		Ranking				
Scientific Name	**Common Name**	**G Rank**	**S Rank**	**SARA**	**ESA**	**Halton Region**
Picoides villosus	Hairy Woodpecker	G5	S5	-	-	Common
Spinus tristis	American Goldfinch	G5	S5B	-	-	Abundant
Poecile atricapillus	Black-capped Chickadee	G5	S5	-	-	Abundant
Procyon lotor	Northern Raccoon	G5	S5	-	-	Common
Sciurus carolinensis	Gray Squirrel	G5	S5	-	-	Common
Turdus migratorius	American Robin	G5	S5B	-	-	Abundant
Sylvilagus floridanus	Eastern Cottontail	G5	S5	-	-	Common
Canis latrans	Coyote	G5	S5	-	-	Common

3.8.6 Aquatic Ecology Assessment

An assessment of the aquatic communities and species within the study area are detailed in the subsections below. Within the study area, Appleby Creek varies greatly in morphology and faces a number of challenges associated with anthropogenic disturbances. The channel is confined within a narrow riparian corridor surrounded by residences, schools and motorways. Sections of the creek have been straightened and hardened while others show signs of well sorted substrate with potential fish habitat. Overall, Appleby Creek has been assessed using a number of indices and has been shown to have a healthy stream rating of poor to fair (Lee, 2017). A more detailed assessment follows, further supporting this stream rating, however noting potential for habitat improvements.

3.8.6.1 Aquatic Habitat

Aquatic habitat was assessed using Ontario Stream Assessment Protocol (OSAP) Version 10 by certified Aquafor Beech Limited biologists in June of 2019. A map detailing the assessment sites in respect to the Erosion Sites is shown in Figure 3-18. Sites were chosen to best represent the condition of Appleby Creek adjacent to erosion sites discussed above.

In summary:

- Site limits were located using OSAP Section 1: Modules 1 and 2 (Defining Site Boundaries and Key Identifiers; Screening Level Site Documentation);
- Habitat features, including barriers to fish movement and other channel disturbances, were recorded using OSAP Section 1: Module 3 (Assessment Procedures for Site Features Documentation);
- Depth, wetted width, habitat type, instream cover, instream vegetation, riparian vegetation, width/depth ratio, bank stability, substrate, and entrenchment were assessed using OSAP Section 4: Modules 2 and 3 (Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions; and Channel Entrenchment).

OSAP data was summarized using Flowing Waters Information Systems (FWIS) and is outlined in Table 3-21 with associated habitat photos found in Figure 3-19 through Figure 3-40. OSAP field sheets are presented in full in Appendix C.

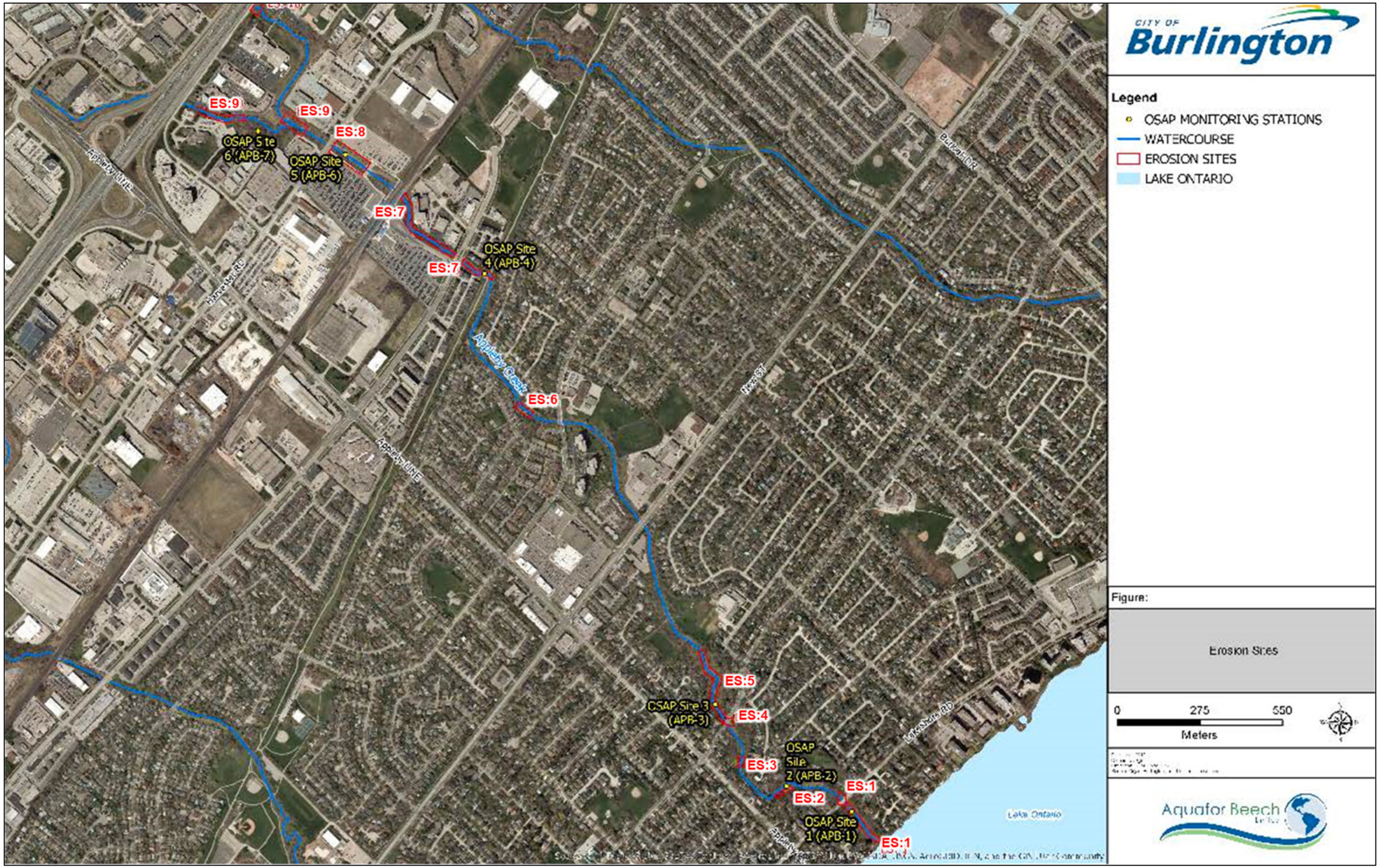


Figure 3-18: Aquatic Habitat Assessment Sites and Erosion Sites

Table 3-21: OSAP Summaries

Habitat Characteristics			General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
Site	**Study Reach**	**Erosion Site**								
APB-1	**1**	**1A**	Permanent	APB-1 was the furthest, most downstream site located approximately 100 m upstream of Lake Ontario and 30 m downstream of Lakeshore Road.	Site length was 41.7 m. Minimum wetted width at the time of sampling was 8 m, and the average wetted width was 10.19 m. The average depth was 442.17 mm and the maximum depth sampled was 960 mm.	This site was consistent in depth and habitat, consisting almost entirely of a long, deep, and slow-moving run. The water elevation is at the same elevation as the Lake Ontario water level. Instream cover was moderate, consisting of macrophytes, unembedded round rocks, some unembedded flat rocks, with some large woody material and macrophytes contributing to in-stream cover. Vegetation was sparse, consisting only of macrophytes with some terrestrial vegetation contributing to instream habitat due to high lake levels and therefore a high site water level.	This site mainly consisted of sand, gravel and cobble with some larger cobbles found throughout. Both the mean point particle size and mean maximum particle size was sand. The maximum particle size was 530 mm. The substrate was poorly sorted.	The left bank consisted of mainly fines while the right held larger cobbles (rip-rap), with evidence of stabilization efforts observed throughout. Nine undercuts fell on sampled transects, ranging from 90 mm – 780 mm, the largest of which was observed at the downstream extent on the right bank.	Very little instream vegetation was present throughout this site, consisting of 10% macrophytes. Riparian vegetation was also poorly distributed, with five transects having forested zones within 1 m, four of which were on the right bank which have been maintained by adjacent landowners. Left bank observed more rooted vegetation although almost entirely consisting of mowed lawn.	A number of road crossings fall upstream of this site which could be sources of contaminants, including Lakeshore Road, which observed two large storm sewer outlets. Adjacent land use consisted of maintained yards adjacent to residential homes. A log jam was present at the downstream end of the site although should not be considered a fish barrier. Fish were observed throughout this site, with many large Common carp observed.
APB-2	**2**	**2**	Permanent	APB-2 was located approximately 150 m upstream of Lakeshore Road and 350 m downstream of Spruce Avenue.	Site length was 49 m. Minimum wetted at the time of sampling was 6 m, and the average wetted width was 6.38 m. The average depth was 202.72 mm and the maximum depth sampled was 625 mm. One point sampled fell on an island.	This site was evenly distributed between shallow riffles and medium depth runs, with one large pool observed mid-site. The highest hydraulic head observed was 70 mm while the average was 16.37 mm, indicating moderate to high flow for the size of the stream. Instream cover was moderate to high, consisting mainly of unembedded flat rocks. Vegetation was extremely sparse, consisting only macrophytes though limited due to the substrate composition.	This site mainly consisted larger pieces of flat rock which likely originated from broken shale entering the stream from bank and bed erosion. Some points observed throughout the site, mainly in the deep pool observed mid site, consisted of consolidated clay and/or bedrock. The substrate was poorly sorted.	The left bank consisted of well distributed substrate, located on the inside lobate bar and therefore within a deposition zone. The right bank observed much finer material with evidence of erosion throughout. Nine undercuts fell on sampled transects, ranging from 80 mm – 650 mm, the largest and most of which was observed on the right bank.	Very little instream vegetation was present throughout this site, consisting of 3.3% macrophytes. Riparian vegetation was also poorly distributed, with four transects having forested zones within 1 m. Right bank observed more rooted vegetation with erosion present up to the forested area behind the residential area and with the park.	A number of road crossings fall upstream of this site which could be sources of contaminants, including Spruce Avenue. Adjacent land use consisted of parkland up to 100 m with maintained yards adjacent to residential homes beyond. No barriers were observed throughout the site. Two migratory Rainbow trout were observed at the time of assessment, indicating high connectivity to this site and potentially beyond.

Habitat Characteristics			General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
Site	**Study Reach**	**Erosion Site**								
APB-3	**3**	**5**	Permanent	APB-3 was located approximately 50 m upstream of Spruce Avenue and 650 m downstream of New Street.	Site length was 54.3 m. Minimum wetted width at the time of sampling was 5 m, and the average wetted width was 7.26 m. The average depth was 80.1 mm and the maximum depth sampled was 230 mm.	This site was consistent in depth and habitat, consisting almost entirely of a shallow, wide runs flowing over exposed bedrock. Instream cover was minimal due to the high percentage of bedrock. Vegetation was also very sparse, consisting only of some filamentous algae.	This site mainly consisted almost entirely of exposed bedrock (93% of all points fell on exposed bedrock). Any particles observed were found in small, slow moving runs.	Both banks consisted mainly of fine silts and sands with some larger cobbles observed throughout. The left bank observed a large stretch of extremely entrenched bank near the top of the site, with the largest undercut observed here (650 mm). Other undercuts ranged from 80 mm – 380 mm.	Little to no instream vegetation was present throughout this site due to the substrate composition. Riparian vegetation was also poorly distributed, with five transects having forested zones within 1 m on either bank. The left bank observed no rooted vegetation throughout the site while the right bank observed 6 of 10 transects with up to 100 percent of the bank consisting of rooted vegetation.	A number of road crossings fall upstream of this site which could be sources of contaminants, including New Street. Adjacent land use consisted of a small strip of parkland is found adjacent to the site. Maintained yards adjacent to residential homes were observed encroaching almost directly upon the left bank near the downstream extent. No barriers were observed throughout the site.
APB-4	**5**	**7A**	Permanent	APB-4 was located approximately 90 m downstream of Fairview Street. The site was immediately upstream of a pedestrian bridge.	Site length was 49.8 m. Minimum wetted width at the time of sampling was 3 m, and the average wetted width was 4.14 m. The average depth was 185.83 mm and the maximum depth sampled was 445 mm.	This site was fairly evenly distributed between riffles and medium depth runs, with some large pools. The highest hydraulic head observed was 75 mm while the average was 7.48 mm, indicating moderate to high flow for the size of the stream. Instream cover was moderate to high, consisting mainly of unembedded flat rocks. Vegetation was sparse, consisting only macrophytes though limited due to the substrate composition. Areas of historic bank stabilization efforts were observed throughout, mainly on the left bank due to the adjacent pedestrian trail.	This site mainly consisted larger pieces of flat rock which likely originated from broken shale entering the stream from bank and bed erosion, similar to that of the downstream site APB-2. Substrate that consisted of unembedded round rock was likely attributed to failing gabion structures observed throughout. The substrate was poorly sorted.	Both banks consisted mainly of fine silts and sands. Particles that were observed to be larger were mainly contributed to by the bank stabilization efforts (gabion structures). Both banks observed large undercut areas, with 9 of 10 transects observing undercuts on either bank ranging from 80 mm – 650 mm. The largest undercut and the highest number of undercut areas was observed on the right bank, the bank that did not observed evidence of historic bank stabilization.	Very little instream vegetation was present throughout this site, consisting of 14% filamentous algae and 16% macrophytes. Riparian vegetation was also poorly distributed, with much of the vegetation observed on the right bank opposite of the bank stabilization gabion structures and the adjacent pedestrian path.	A number of road crossings fall upstream of this site which could be sources of contaminants, including Fairview Street and the GO Train line. Adjacent land use consisted of high-density housing with a small, well-used paved pedestrian trail running on the left bank. No barriers were observed throughout the site.

Habitat Characteristics			General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
Site	**Study Reach**	**Erosion Site**								
APB-6	**6**	**8**	Permanent	APB-6 was located approximately 170 m upstream of the GO Train line crossing and 50 m downstream of Harvester Road.	Site length was 46.2 m. Minimum wetted width at the time of sampling was 3.7 m, and the average wetted width was 4.98 m. The average depth was 158.42 mm and the maximum depth sampled was 500 mm.	This site was consistent in depth and habitat, consisting almost entirely of a shallow, wide runs flowing over exposed bedrock. Pools were limited to areas immediately downstream of two failed concrete rib structures. Near the upstream extent of the site, habitat consisted of a deep, slow-moving run that can be directly attributed to the furthest most upstream failing rib structure which was observed to be acting as a weir structure. Instream cover was minimal due to the high percentage of bedrock with much of the cover limited to the upstream reach and areas immediately adjacent to overhanging terrestrial vegetation. In-stream vegetation was also very sparse, consisting only of some filamentous algae.	This site mainly consisted almost entirely of exposed bedrock and concrete remnants. Any particles observed were found in small, slow moving runs like that observed near the upstream extent of the site.	Both banks observed historic engineering in the form of an almost entirely gabion lined riparian zone. Undercuts were observed on both banks, ranging from 80 to 650, with the largest and highest number of undercuts observed on the right bank attributed to a failed concrete rib structure and failed gabion structures.	Very little instream vegetation was present throughout this site, with the near entirety contributed to by filamentous algae. Riparian vegetation was very poorly distributed due to the gabion lined riparian area.	A number of road crossings fall upstream of this site which could be sources of contaminants, including Harvester Road and Highway 403. Adjacent land use consisted of parking for the GO Train Station. Two significant barriers to fish movement were observed throughout the site which had resulted from failed concrete rib structures. The lowest barrier at the downstream extent was the largest with the perched height observed at 2 m and the jumping height observed at 1 m.
APB-7	**7**	**9B**	Permanent	APB-7 was the furthest most upstream site and was located approximately 250 m upstream of Harvester Road and 275 m downstream of Highway 403. A confluence of two branches of Appleby Creek was	Site length was 40.4 m. Minimum wetted width at the time of sampling was 1.4 m, and the average wetted width was 2.22 m. The average depth was 95.11 mm and the maximum depth sampled was 230 mm.	Habitat observed at this site, similar to those discussed above, were fairly consistent. Consistency in habitat can be attributed to historic engineering and realignment observed throughout. Much of the site consisted of medium depth runs with some shallower kick-points observed as riffles. Very little pool habitat was observed with one small area of refuge observed at the upstream extent. Instream cover was mainly limited to the downstream reach, extending mid site where rip-rap from	From the downstream extent to mid-site, substrate consisted of engineered material (rip-rap), while the upstream extent was observed as an area of deposition consisting mainly of fine silts and sands.	The left bank observed historic bank stabilization efforts with rip-rap lined banks extending through much of the site. The right bank observed some bank stabilization near the downstream extent. Seven transects observed an undercut bank ranging from 40 mm – 310 mm. The largest undercut was observed at the upstream extent on the right bank. Both banks	Little to some instream vegetation was observed throughout, mainly consisting of filamentous algae (47.8%) and rooted macrophytes (28.3%). Riparian vegetation was poorly distributed due to rip-rap lined banks. The right bank contributed most of the rooted vegetation.	This site, being the furthest most upstream site was the closest to the Highway 403 crossing which likely contributed as a source of contaminants. Adjacent landuse consisted mainly of industrial buildings with a well forested area spanning up to 100 m beyond the top of bank. A well-used, unofficial pedestrian trail was observed to cross the site with a makeshift

Habitat Characteristics			General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
Site	Study Reach	Erosion Site								
				located approximately 15 m downstream of the site. It was located in the western branch.		adjacent bank stabilization contributed unembedded, round rock as cover. In-stream vegetation was also very present, consisting mainly of filamentous algae with some macrophytes observed throughout near the right bank.		observed evidence of erosion.		bridge. No barriers were observed throughout the site. Small, unidentifiable minnows were observed near the upstream extent of the site within the pool and woody material.



Figure 3-19: APB-1 - D/S looking D/S



Figure 3-20:APB-1 - D/S looking U/S



Figure 3-21: APB-1 - U/S looking D/S



Figure 3-22: APB-1 - U/S looking U/S



Figure 3-23: APB-2 - D/S looking D/S



Figure 3-24: APB-2 - D/S looking U/S



Figure 3-25: APB-2 - U/S looking U/S



Figure 3-26: APB-2 - U/S looking U/S



Figure 3-27: APB-3 - D/S looking D/S



Figure 3-28: APB-3 - D/S looking U/S



Figure 3-29: APB-3 - U/S looking D/S



Figure 3-30: APB-3 - U/S looking U/S



Figure 3-31: APB-4 - D/S looking D/S



Figure 3-32: APB-4 - D/S looking U/S



Figure 3-33: APB-4 - U/S looking D/S



Figure 3-34: APB-4 - U/S looking U/S



Figure 3-35: APB-6 - D/S looking D/S



Figure 3-36: APB-6 - D/S looking U/S



Figure 3-37: APB-6 - U/S looking D/S



Figure 3-38: APB-6 - U/S looking U/S



Figure 3-39: APB-7 - D/S looking D/S



Figure 3-40: APB-7 - D/S looking U/S

3.8.6.2 Stream Classification and Fish Communities

Results from CH's summer water temperature monitoring as part of a Long-Term Monitoring Program (LEMP) show that the thermal classification of Appleby Creek within the study area is that of a Cool-Warm thermal regime. This classification is based on protocols modified by Chu *et al.* (2009). Also completed as a part of the LEMP by CH was fish community sampling. The sampling took place within the study reach in 2016, 2014 and 2012 using a backpack electrofisher and by following protocols outlined by the Ontario Stream Assessment Protocol. Results from the community sampling can be seen in Table 3-22.

Table 3-22: Results from CH Fish Community Sampling

Species Name		Ranking					Count
Common Name	**Scientific Name**	**G Rank**	**S Rank**	**COSEWIC**	**COSSARO**	**Halton**	
Blacknose Dace	*Rhinichthys atratulus*	G5	S5	-	-	HU	1
Brassy Minnow	*Hybognathus hankinsoni*	G5	S5	-	-	HR	2
Brook Stickleback	*Culaea inconstans*	G5	S5	-	-	HR	24
Carps and Minnows	*Cyprinidae*	-	-	-	-	-	3
Creek Chub	*Semotilus atromaculatus*	G5	S5	-	-	-	286
Fathead Minnow	*Pimephales promelas*	G5	S5	-	-	-	10
Goldfish	*Carassius auratus*	G5	SNA	-	-	-	1
Green Sunfish	*Lepomis cyanellus*	G5	S4	NAR	NAR	HR	47
Largemouth Bass	*Micropterus salmoides*	G5	S5	-	-	HU	1
Lepomis sp.	*Lepomis sp.*	-	-	-	-	-	8
Longnose Dace	*Rhinichthys cataractae*	G5	S5	-	-	HU	22
Pumpkinseed	*Lepomis gibbosus*	G5	S5	-	-	HU	4
Threespine Stickleback	*Gasterosteus aculeatus*	G5	S4	-	-	HR	2
White Sucker	*Catostomus commersoni*	G5	S5	-	-	-	34

Table 3-22 indicates that the study area within Appleby Creek is dominated by warmwater and coolwater species, further supporting the Cool-Warm theremal regime classification. Fish community sampling results were also analyzed by CH using a modified Index of Biotic Integrity (IBI) which allows for the characterization and classification of a stream's health. According to

these results, Appleby Creek ranges from poor to fair (Lee, 2017) with opportunities for aquatic habitat improvements. As discussed above in **Section 3.8.6.1**, Common Carp (*Cyprinus carpio*) and migratory Rainbow Trout (*Oncorhynchus mykiss*), along with many other unidentifiable fish species were observed near the downstream extent of the study area. Furthermore, small unidentifiable minnows were observed near the upstream extent of the study area.

Improvements vary in form and function, ranging from superficial changes to intensive restoration. Superficial changes that could see improvements in fish passage and flow mitigation include the removal of barriers, such as the one observed upstream of the Fairview Street Crossing and adjacent to the GO Station Parking lot between Harvester Road and the GO Line (Reach 6, Site APB-6). Barrier removal would not only improve fish passage for species such as the migratory Rainbow trout observed but improve flow and reduce the risk of blockages. Other superficial changes could include the removal of dead and downed debris as much of it will enter the creeks and increase the risk of blockages. Plantings along the banks could provide shade and help regulate stream temperatures. More intensive restoration efforts include but are not limited to channel improvements such that reintroduce a naturalized and sinuous stream bed. Areas like the hardened and straightened section(s) of the New Street crossing (Reach 4), the area adjacent to the GO Station Parking lot between Harvester Road and the GO Line (Reach 6, APB-6), and the sediment deprived reach observed upstream of Spruce Avenue (Reach 3, Site APB-3) could benefit from such efforts as flow mitigation would occur and improved aquatic habitat would be reintroduced.

3.8.7 Species-at-Risk and Other Species of Conservation Concern

For the purpose of this Study, SAR are defined as species listed as Endangered (END), Threatened (THR), or Special Concern (SC) under the provincial Endangered Species Act (ESA) and/or the federal Species at Risk Act (SARA). Other Species of Conservation Concern (SOCC) are those with Global ranks of G1-G3 and/or Subnational/Provincial ranks of S1-S3.

Species listed provincially as Endangered and Threatened receive regulatory protection for themselves and their general or specific habitat under the ESA:

- General Habitat: an area on which a species depends directly or indirectly to carry out its life processes (under clause 2(1)(b) of the ESA) or,
- Regulated Habitat: the area prescribed for a species in a habitat regulation (under clause 2(1)(a) of the ESA). A habitat regulation may prescribe an area as the habitat of a species by describing the boundaries of the area, the features of the area, or by describing the area in any other manner. Regulated habitat may be smaller or larger than general habitat. As well, unlike the general habitat of a species, regulated habitat may include areas currently unoccupied by the species, such as areas where the species formerly occurred or areas where there is the potential for the species to become re-established. These areas are commonly referred to as “recovery habitat”.

The habitat of Special Concern species and SOCC does not receive regulatory protection under the ESA but is considered significant wildlife habitat (SWH) and is thus protected under municipal policy and the PPS.

Aquafor Beech Limited conducted a number of field surveys and consulted secondary information sources to assess the presence of SAR and SOCC within the study area. As part

of the assessment, Aquafor Beech Limited solicited natural heritage information from the Aurora District MNRF as well as the MNRF's NHIC Make-a-Map online database. The Aurora MNRF indicates that Eastern Meadowlark (*Sturnella magna*), Bank Swallow (*Riparia riparia*), Barn Swallow (*Hirundo rustica*), Peregrine Falcon (*Falco peregrinus*), Canada Warbler (*Cardellina canadensis*), and Wood Thrush (*Hylocichla mustelina*) have previously been recorded in the study area (MNRF, 2018). The MNRF also states the *Myotis* spp. and *Perimyotis* sp. bats have the potential to occur within the study area. A review of the NHIC online database produced historic records for Red-necked Grebe (*Podiceps grisegena*), Northern Bobwhite (*Colinus virginianus*), Eastern Wood-pewee (*Contopus virens*), and American Chestnut (*Castanea dentata*) within 1 km of the study area. In addition to species provided by secondary sources, Aquafor Beech Limited conducted field surveys for Monarch (*Danaus plexippus*), Butternut (*Juglans cinerea*) and Snapping Turtle (*Chelydra serpentina* – special concern) as this species is known to inhabit potentially suitable habitat in urban areas.

Table 3-23 contains the descriptions of the methodologies used to identify candidate SAR and their habitats within the study area.

Table 3-23: SAR and SOCC Survey Methodologies

<table>
<tr><th>Species</th><th>Methodology</th><th>Survey Date</th></tr>
<tr><td>Eastern Small-footed Myotis</td><td rowspan="4">See Section 3.8.5.1 for a description of the methodology used to identify candidate bat maternity roost sites.</td><td rowspan="4">Jan. 17 & 18 2019</td></tr>
<tr><td>Little Brown Myotis</td></tr>
<tr><td>Northern Myotis</td></tr>
<tr><td>Tri-coloured Bat</td></tr>
<tr><td>Bank Swallow</td><td>See Section 3.8.5.2 for the survey methodology for breeding birds. In addition to BBS, the banks of Appleby Creek were visually inspected for active and remnant Bank Swallow nests.</td><td rowspan="10">June 4 & 26 2018</td></tr>
<tr><td>Barn Swallow</td><td>See Section 3.8.5.2 for the survey methodology for breeding birds. In addition to BBS, the undersides of bridges were visually inspected for inactive and remnant Barn Swallow nests.</td></tr>
<tr><td>Black-crowned Night-heron</td><td rowspan="9">See Section 3.8.5.2 for the survey methodology for breeding birds.</td></tr>
<tr><td>Canada Warbler</td></tr>
<tr><td>Eastern Meadowlark</td></tr>
<tr><td>Eastern wood-pewee</td></tr>
<tr><td>Northern Bobwhite</td></tr>
<tr><td>Peregrine Falcon</td></tr>
<tr><td>Red-necked Grebe</td></tr>
<tr><td>Wood Thrush</td></tr>
</table>

Species	Methodology	Survey Date
Butternut	An area search for butternut was conducted in potentially suitable habitat within the study area in addition to botanical inventories. One tree found in Bromley Park was tested for genetic purity and three trees along watercourse were evaluated by a Butternut Health Assessor (BHA). See Section 3.5.4.4. for further details.	Areas Search: June 20, 21 2018, Dec. 3-7 2018
American Chestnut	An area search for American chestnut was conducted in potentially suitable habitat within the study area in addition to botanical inventories.	June 20, 21 2018 Dec. 3-7 2018
Snapping Turtle	An area search was conducted to identify potentially suitable nesting (i.e., sandy and gravelly substrates away from water), foraging (i.e., watercourses with emergent vegetation and other opportunities to feed), and dispersal habitat (i.e., watercourses within natural lands) within natural lands in the study area.	All surveys dates
Monarch	An area search was conducted for potentially suitable habitat within the study area, with a focus on milkweed (*Asclepias* spp.), the larval host plant of this species.	All surveys dates

Species included in the screening assessment include those provided by secondary sources and those documented via direct observations by Aquafor Beech Limited. A total of 18 SAR and SOCC are included in the screening assessment. Using this aggregated list of SAR, Aquafor Beech Ltd. cross-referenced the habitat needs of each species with the habitat conditions present within the study area and adjacent lands.

A consolidated list of all potential SAR and other SOCC within the study area and an assessment of each species' presence within the study area is presented below in Table 3-24. Detailed summaries of the species that have the potential to occur within the study are presented following the screening exercise. Correspondence with the MNRF is contained in Appendix F.

Table 3-24: SAR and SOCC Screening Exercise

Species Name		Ranking					Data Source	Habitat Requirementsł	Assessment of Species Occurrence at or Near Subject Property
Scientific Name	Common Name	SARA*	ESA*	G-Rank	S-Rank	Halton Region			
Myotis leibii	Eastern Small-footed Myotis	END	END	G4	S2S3	-	MNRF	Maternity roosts: primarily under loose rock on exposed rock outcrops, crevices and cliffs, and occasionally in buildings, under bridges and highway overpasses and under tree bark. In the winter, these bats hibernate, most often in caves and abandoned mines that stay above 0°C.	**Potentially Present:** Potentially suitable maternity roosting sites (i.e. trees in various states of decay with snag attributes and trees large enough to support Tri-colored bat) are present within the study area. A total of 17 candidate *Myotis* spp. maternity roosting sites and 66 candidate and 61 potential candidate *Perimyotis* sp. were identified during surveys (see **Figure 3-13** to **Figure 3-17**). Wintering hibernacula (i.e. caves, mines, and old foundations) are not present within the study area.
Myotis lucifugus	Little Brown Myotis	END	END	G3	S4	Common	MNRF	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).	
Myotis septentrionalis	Northern Myotis	END	END	G1G2	S3	Common	MNRF	Northern long-eared bats are associated with cavities of large diameter trees, but occasionally associated with structures such as barns and attics. Overwintering habitat: Caves and mines that remain above 0°C.	
Perimyotis subflavus	Tri-coloured Bat	END	END	G2G3	S3?	-	MNRF	Overwintering habitat: Caves and mines that remain above 0°C. Maternal roosts: Can be in trees or dead clusters of leaves or arboreal lichens on trees. May also use barns or similar structures.	
Riparia riparia	Bank Swallow	THR	THR	G5	S4B	Common	MNRF	It nests in a wide variety of naturally and anthropogenically created vertical banks, which often erode and change over time including aggregate pits and the shores of large lakes and rivers.	**Not Present**: Potentially suitable habitat is not present within the study area and species was not recorded during BBS.
Hirundo rustica	Barn Swallow	THR	THR	G5	S4B	Common	MNRF	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, or on rock faces and caves.	**Potentially Present:** Suitable nesting locations for Barn Swallow, along with evidence of past nest building was observed under the Lakeshore Road crossing, however no birds were observed during either site visit.
Nycticorax nycticorax	Black-crowned Night-heron	-	-	G5	S3B, SZN	Uncommon	Aquafor Beech Limited	Generally found within wetlands such as cattail marshes, lakeshores, and slow moving rivers as this species primarily preys on fish, amphibians, and aquatic invertebrates (Bezener, 2000). Colonial nesting occurs in trees or shrubs.	**Confirmed Present:** This species was observed during both breeding bird survey dates feeding downstream of the Appleby GO Station, outside of proposed disturbance areas. It is not believed this species is breeding as no nests were observed within or adjacent to the study area. It is the opinion of Aquafor Beech Limited that this individual is using the creek corridor as foraging habitat only.

Species Name		Ranking					Data Source	Habitat Requirementsł	Assessment of Species Occurrence at or Near Subject Property
Scientific Name	**Common Name**	**SARA***	**ESA***	**G-Rank**	**S-Rank**	**Halton Region**			
Cardellina canadensis	Canada Warbler	THR	SC	G5	S4B	Rare	MNRF	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.	**Present**: According to eBird.org, three observations of this species (i.e. May 24th, August 20th, and August 24th 2018) were made downstream of Pinedale Avenue in vegetation community #5 (i.e. Mineral Cultural Woodland). Given that the characteristics of this woodland are unsuitable for breeding, it is the opinion of Aquafor Beech Limited that this species is likely using the Appleby Creek corridor as a migratory stopover area and foraging habitat only.
Sturnella magna	Eastern Meadowlark	THR	THR	G5	S4B	Common	MNRF	Generally prefers grassy pastures, meadows and hay fields. Nests are always on the ground and usually hidden in or under grass clumps.	**Not Present**: Potentially suitable habitat is not present within the study area and species was not recorded during BBS.
Contopus virens	Eastern Wood-Pewee	SC	SC	G5	S4B	Common	Aquafor Beech Limited	Associated with deciduous and mixed forests. Within mature and intermediate age stands it prefers areas with little understory vegetation as well as forest clearings and edges.	**Confirmed Present**: A single singing male was recorded during the second BBS in vegetation community #1 (i.e. Dry – Fresh Oak – Maple – Hickory Deciduous Forest). This forest community is suitable breeding habitat for this species; therefore it is the opinion of Aquafor Beech Limited that this forest is candidate breeding habitat.
Colinus virginianus	Northern Bobwhite	END	END	G4G5	S1	Rare Visitor	NHIC (1904)	Generally inhabits a variety of edge and grassland type - habitats including non-intensively farmed agricultural lands.	**Not Present**: Potentially suitable habitat is not present in large quantities within the study area suitable for this species.
Falco peregrinus	Peregrine Falcon	SC	SC	G4	S3B	Casual	MNRF	Generally nest on tall, steep cliff ledges adjacent to large waterbodies; some birds adapt to urban environments and nest on ledges of tall buildings, even in densely populated downtown areas.	**Not Present**: Potentially suitable habitat is not present within the study area and species was not recorded during BBS.
Podiceps grisegena	Red-necked Grebe	-	NAR	G5	S3B,S4N	Uncommon	NHIC (1991)	This species generally prefers extensive marshes with emergent vegetation around lakes and ponds (Bezener, 2000). According to NHIC (2018), there are approximately 200 birds in Ontario. The breeding range consists of several locations across Northern Ontario and the Luther Marsh in Southern Ontario.	**Not Present**: Potentially suitable habitat is not present within the study area. This species is known to breed in the Luther Marsh in Southern Ontario. The records from NHIC is considered historic.
Hylocichla mustelina	Wood Thrush	THR	SC	G4	S4B	Common	MNRF	Nests mainly in second-growth and mature deciduous and mixed forests, with saplings and well-developed understory layers. Prefers large forest mosaics, but may also nest in small forest fragments.	**Not Present:** Species was not recorded during BBS.
Castanea dentata	American Chestnut	END	END	G4	S1S2	Uncommon	NHIC	Moist to well-drained forests on sand, occasionally heavy acid soils.	**Not Present:** This species was not identified during botanical surveys.

Species Name		Ranking					Data Source	Habitat Requirementsł	Assessment of Species Occurrence at or Near Subject Property
Scientific Name	Common Name	SARA*	ESA*	G-Rank	S-Rank	Halton Region			
Juglans cinerea	Butternut	END	END	G4	S2?	Common	MNRF	Generally grows in rich, moist, and well-drained soils often found along streams. It may also be found on well-drained gravel sites, especially those made up of limestone. It is also found, though seldomly, on dry, rocky and sterile soils. In Ontario, the Butternut generally grows alone or in small groups in deciduous forests as well as in hedgerows. MNRF considers Butternut habitat includes suitable lands within 50 m of a Butternut tree.	**Confirmed Present**: Six Butternut trees are within the study area: two are in Bromley Park, the other four are below Lakeshore Blvd. on the east bank of Appleby Creek near Lake Ontario. One tree in the park was genetically tested and determined to be a pure Butternut. The remaining five trees (not tested for purity yet) were assessed. Three are category 2, one is category 1, and one fell over the watercourse and has been removed.
Chelydra serpentina	Snapping Turtle	SC	SC	G5	S3	Common	Aquafor Beech Limited	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. Snapping turtles often take advantage of man-made structures for nest sites, including roads (especially gravel shoulders), dams and aggregate pits.	**Potentially Present**: Potentially suitable foraging and dispersal habitat is present within the Appleby Creek corridor in the study area. Potentially suitable nesting habitat is not present within the study area.
Danaus plexippus	Monarch	SC	SC	G4	S2N, S4B	Common	Aquafor Beech Limited	Exist primarily wherever milkweed and wildflowers exist; abandoned farmland, along roadsides, and other open spaces.	**Confirmed Present**: Adults of this species was recorded during field investigations foraging on wildflowers in vegetation community 4

*Species ranking for SARA and ESA are as follows: EXT – Extinct, EXP – Extirpated, END – Endangered, THR – Threatened, SC – Special Concern, NAR – Not-at-Risk, and DD – Data Deficient
łHabitat Requirements were provided by the MNRF unless otherwise sourced.

Confirmed and potential SAR and SOCC within the study area include the following:

Bats (Myotis and Perimyotis spp.) – Potentially Present

According to the Guelph District MNRF Office's *Survey Protocol for Species at Risk Bats within Treed Habitats* (MNRF, 2017), "any coniferous, deciduous, or mixed wooded ecosite, including treed swamps, that includes trees at least 10 cm [DBH] should be considered suitable maternity roost habitat". In accordance with this definition, potentially suitable habitat within the study area includes all treed habitats within the study area. Endangered bat species in Ontario currently receive general habitat protection, which means the area in which a species requires to fulfill its life processes. This may include the vegetation community they are found within for breeding, rearing young, and feeding.

As detailed in **Section 3.8.5.1**, 127 potentially suitable maternity roosting sites (66 candidate and 61 potential candidate trees) for several *Myotis* spp. bats and 17 candidate *Perimyotis* sp. sites are present within the study area.

As Endangered species, bats and their habitat are protected under the Endangered Species Act (ESA, 2007).

Barn Swallow – Potentially Present

Barn Swallows prefer 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, or on rock faces and caves. All potential nesting structures were checked for the presence of nests during the breeding bird surveys and none were found. There is

Suitable nesting locations for Barn Swallow, along with evidence of past nest building was observed under the Lakeshore Road crossing, however no birds were observed during either site visit. Suitable nesting locations for Barn Swallow, along with evidence of past nest building was observed under the Lakeshore Road crossing, however no birds were observed during either site visit.

Black-crowned Night-heron – Confirmed Present

This wetland species prefers lakeshores, slow-moving rivers, cattail and bulrush shallow marshes where it can forage for fish, amphibians, aquatic invertebrates, and young birds. It is distinguished by a black cap and back, white cheeks, neck, and underbelly. It has a large black bill, red eyes, and yellow legs. During breeding, two white plumes extend from the cap.

This species resides mainly in Southern Ontario. According to NHIC (2018), there were forty-four (44) documented breeding colonies between 2001 and 2005 and a significant northward range expansion since between 1981 and 1985. Sites used for colonies are somewhat ephemeral as a number of previously documented colonies are no longer extant, although the population has not changed significantly (NHIC, 2018).

A single bird was observed on both breeding bird survey dates foraging in the creek on both sides of the Appleby GO Station. It is not believed this species is breeding within or adjacent to the study area as no nest(s) were observed and no other individuals were documented during surveys. The site was therefore concluded to provide foraging habitat only. As a provincially

rare species (i.e. S3B), Black-crowned Night-heron and its habitat qualify as SWH (see **Section 3.8.8**). SWH is protected under the City of Burlington's OP.

Canada Warbler

The Canada Warbler is a small, bright yellow-bellied songbird with a black band across its chest and blue-gray uppers. As a migratory species, it winters in South American and summers in Ontario's deciduous, mixed, and coniferous wet forests with a dense understory of shrubs (Government of Ontario, 2018). The dense understory shields this ground-nester from predators. Nests are usually on or close to the ground on mossy logs or roots, often close to stream banks or on hummocks. The primary breeding range in Ontario is in the Boreal forest along the Canadian Shield.

Threats to this species include habitat degradation and fragmentation, and a reduction in shrub-dense forests. In its winter habitat, deforestation is a major threat to this species (Government of Ontario, 2018).

This species was not recorded during BBS, however there are three observations on eBird.org off Pinedale Avenue in vegetation community #5 (i.e. Mineral Cultural Woodland). Given that the characteristics of this woodland are unsuitable for breeding, it is the opinion of Aquafor Beech Limited that this species is likely using the Appleby Creek corridor as a migratory stopover area and foraging habitat only.

As a species of Special Concern, Canada Warbler and its habitat qualify as SWH. SWH is protected under the City of Burlington's OP.

Eastern Wood-pewee

The Eastern Wood-pewee occurs throughout Southern Ontario, breeding most often in deciduous forests with an open understory, with a preference for nest sites near clearings and forest edges. In general, the size of forest fragments does not appear to be an important factor in habitat selection for this species, though the presence of residential developments surrounding woodlots does appear to decrease the likelihood that Eastern Wood-pewee will be present. The presence of dead branches that are used as hunting perches may be an additional habitat need (COSEWIC, 2012).

Threats contributing to the decline of this species are not fully understood. Forest fragmentation of itself does not appear to be a major factor since the size of forest fragments was not found to significantly affect nest site selection. However, the overall amount of forest cover on the landscape and the proximity of human development to remaining woodlots may both influence habitat suitability.

Eastern Wood-pewee was observed at point count 11 during BBS completed in 2018 in Bromley Park. The vegetation community at this location is potentially suitable nesting habitat for this species. As a species of Special Concern, this species and its habitat qualify as SWH (see **Section 3.8.8**). SWH is protected under the City of Burlington's OP.

Butternut

Butternut is a short-lived (<75 years), mast-bearing tree in the walnut family (Juglandaceae). It is frequently found along floodplains, streambanks, and ravine slopes, but can occur in a wide variety of other conditions; it is more common in areas with underlying limestone and is generally absent from regions with acidic soil such as the granite-dominated areas of the Canadian Shield. Butternut is intolerant of shade and tends to be found either as a mature canopy tree or in or in openings and edges (COSEWIC, 2017).

Butternut is currently designated as Endangered and receives general habitat protection under the ESA. The primary threat to Butternut is an introduced exotic fungal pathogen, *Sirococcus clavigignenti-juglandacearum* ("Butternut canker"). Infection generally occurs through wounds, broken branches or leaf scars, causing twig dieback and eventual tree mortality. The most obvious sign of infection is a black, oozing canker on the stem or twigs. Potential habitat for Butternut occurs throughout the subwatershed study area.

The provincial Butternut Recovery Strategy (Poisson & Ursic, 2013) recommends that a minimum radius of 25 m from the base of the stem of all Butternuts be considered protected habitat. However, it also recommends that this protection only be applied to healthy trees (i.e., trees which are not affected by the canker to the degree they are classed as "non-retainable" by a Butternut Health Assessment). The MNRF's interim guidance on general habitat for Butternut under the ESA (2015) confirms that a 25 m radius from each tree should be considered Category 1 habitat which protects the critical root zone and other functions that support the life of that individual, but further adds that suitable areas from 25-50 m of a tree should be considered Category 2 habitat necessary for nut dispersal and seedling establishment. Aquafor Beech therefore recommends a 50 m radius around each retainable Butternut be protected as habitat.

Six Butternut trees are within the study area: Two in Bromley Park adjacent to a residential property and the utilities building, the other four are on the east bank of Appleby Creek south of Lakeshore Road. One has been tested and determined to be genetically pure. Of the trees that are likely to be impacted, either their habitat or the individual tree, three are category 2 and one is category 1. Before detailed design, the remaining trees should be tested for hybridity and MECP consultation should commence.

Snapping Turtle (Chelydra serpentina) – Potentially Present

Snapping turtles prefer slow-moving water such as in ponds, sloughs, shallow marshes, river edges, and slow streams with a soft mud bottom and dense aquatic vegetation, and are known to tolerate heavily urbanized waterbodies such as storm water management ponds, irrigation canals, and golf course ponds.

Potentially suitable foraging and dispersal habitat is present within the Appleby Creek corridor. Potentially suitable nesting habitat (i.e., sandy or gravelly soils) was not found within the study area.

As a provincial species of Special Concern, Snapping Turtle and its habitat qualify as SWH. SWH is protected under the City of Burlington's OP.

Monarch

The Monarch butterfly is currently listed as Special Concern both provincially and federally and therefore receives no regulatory protection. However, COSEWIC recently reassessed the Monarch as Endangered in 2016, citing declines of greater than 50% in the last decade. The primary threats facing the Eastern North American Monarch population include the degradation and loss of overwintering habitat in Mexico, the widespread use of pesticides and herbicides throughout their breeding grounds, climate change, severe weather events, succession and/or conversion of breeding and nectaring habitat, and the impacts of bark beetles on overwintering habitat (COSEWIC, 2016).

Monarch butterfly habitat consists of open areas that support its larval host plant milkweed (*Asclepias* spp.) and other wildflowers. Such habitat is common in Southern Ontario and includes cultural meadows, gardens, roadsides, and other disturbed lands. Accordingly, the designation of monarch as Special Concern mainly reflects its vulnerability to the loss of overwintering areas in Mexico rather than habitat-related concerns in Ontario (COSEWIC, 2016).

Larval host plants of this species (i.e. *Asclepias* spp.) were identified in low numbers during the botanical inventory in vegetation communities 6, 7, and 9 (communities located north of the Appleby GO Station). Nectaring plants for adult monarchs are scattered throughout the study area.

As a provincial species of Special Concern, Monarch and its habitat qualify as SWH. SWH is protected under the City of Burlington's OP.

3.8.8 Significant Wildlife Habitat

The province has provided guidance for the identification and assessment of Significant Wildlife Habitat (SWH). In Burlington, the primary document to use to identify SWH is the Technical Guide for Ecoregion 7E (Government of Ontario, 2015). The full assessment of SWH is contained in Appendix C. Although migratory stopover SWH types are candidate within the study area, it should be noted that the quality of these SWH types is generally poor given fragmentation, canopy tree removals, and encroachment, but may be improved through restoration and habitat enhancement (e.g. tree planting, removing disturbances such as the various types of encroachment, and diversifying foraging foods for birds). The following candidate SWH types within the study area include the following:

Bat Maternity Colonies - Candidate

As discussed in **Section 3.8.5.1**, seventy-seven candidate maternity roost sites and an additional 61 potential candidate sites are present within and 10 m from anticipated disturbance areas.

Migratory Butterfly Stopover Areas - Candidate

The study area is within the Appleby Creek corridor, which is connected to Lake Ontario and is greater than 10 ha in overall size. The study area is approximately 1.7 km from the lake. Although natural lands in the study area is candidate, the flora species within the study area are not favourable to high quality habitat for butterflies. Opportunities for habitat improvement are discussed in **Section 5.2.5**.

Landbird Migratory Stopover Areas - Candidate

The study area is approximately 1.7 km from Lake Ontario and is part of the continuous Appleby Creek corridor, which is greater than 5 ha in overall size. Although natural lands in the study area are candidate, the flora species within the study area are not favourable to provide high quality habitat for migratory birds. Opportunities for habitat improvement are discussed in **Section 5.2.5**.

Special Concern and Rare Wildlife Species – Candidate/Confirmed

All Special Concern and provincially rare (S1-S3) plant and animal species' habitats are considered SWH. Snapping turtle (SC, S3) has the potential to occur within Appleby Creek and its woodland corridor, and Black-crowned Night-heron is confirmed foraging south of the Appleby Go Station.

3.8.9 Linkages and Corridors

Linkages are used by wildlife for many aspects of their life cycles including foraging, dispersal, nesting, etc. The Appleby Creek corridor within the study area is a direct link to the Lake Ontario shoreline, although the semi-natural features in the study area are functioning as islands in an urban landscape, and are not connected to an extensive natural heritage system east and west. Currently, disturbances such as ash tree removal and encroachment has degraded the ecological form and function of the Appleby Creek corridor by removing terrestrial and aquatic habitat. Additionally, exotic invasive species within the corridor outcompete native species for resources and habitat. There are opportunities improve the form and function of the Appleby Creek corridor by removing the abovementioned disturbances within the corridor.

Under normal to high flow events, Spruce Avenue, New Street, Pinedale Avenue, Fairview Street, the rail line overpass, and Harvester Road present barriers to some terrestrial wildlife movement (e.g., small and medium-sized mammals) as the flooded creek reduces any terrestrial benches that may be present under these structures. At each crossing, during high flow events, there is no natural terrestrial connection between the upstream and downstream riparian areas; the roads are the only way to cross for terrestrial species.

3.9 Archaeological and Cultural Heritage Assessment

Stage 1 archaeological assessment was undertaken by Archaeological Services Inc. (ASI) in May 2019. The assessments included review of background research and property inspection as a part of Appleby Creek Erosion Control Municipal Class Environmental Assessment to assess if there is potential to impact significant lands.

The Stage 1 assessment determined that 10 previously registered archaeological sites are locate within one kilometer of the Study area. The property inspection determined that parts of the Study Area exhibit archaeological potential. These results prompted the Study Area as archaeological potential and these lands require Stage 2 archaeological assessment by test pit survey. Figure 3-41, Figure 3-42 and Figure 3-43 below show the results of archaeological inspection of the property. The complete Archaeological Assessment study report is included in Appendix D.

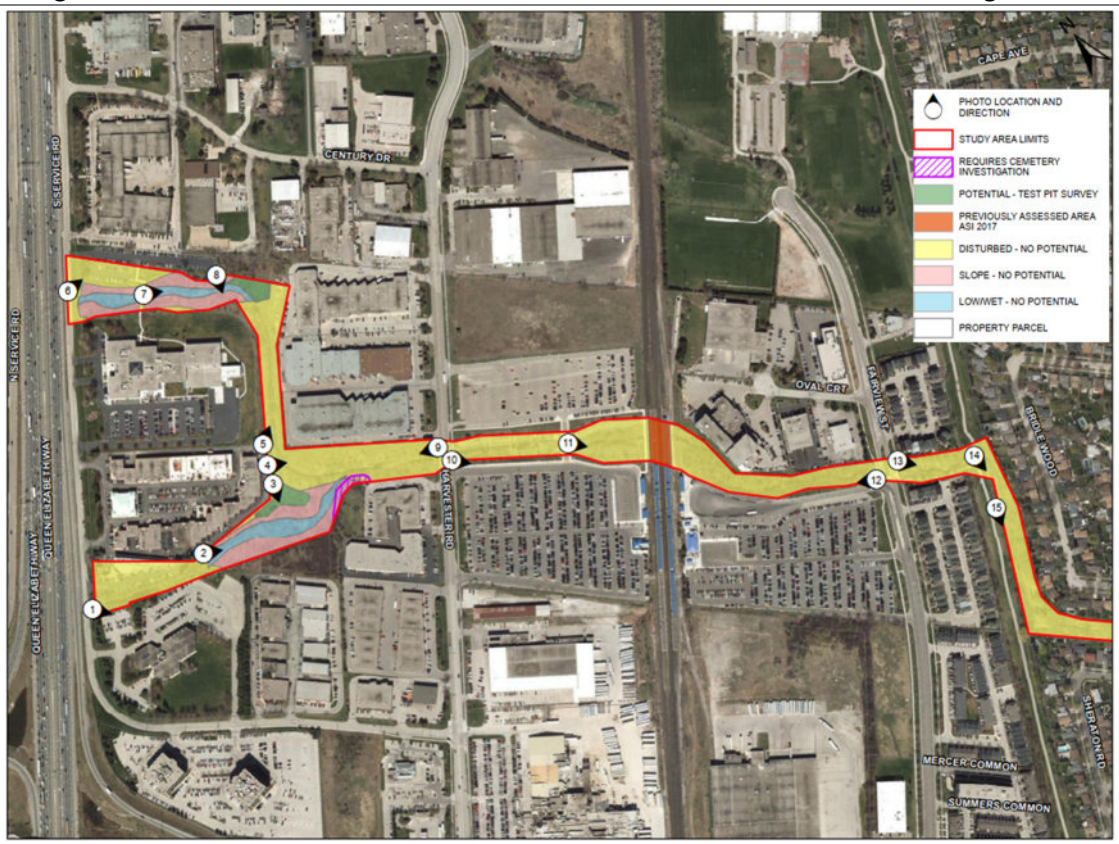


Figure 3-41: Results of the Archaeological Property Inspection 1



Figure 3-42: Results of the Archaeological Property Inspection 2



Figure 3-43: Results of the Archaeological Property Inspection 3

3.10 Utilities

Aquafor undertook a Subsurface Utility Engineering (SUE) Quality Level C and Quality Level D investigations, including detailed review of basemapping, as-built drawings and field survey of visible utilities, to identify utilities within the study area. This investigation was included as part of the EA evaluation, as relocation or replacement of utilities could be very costly or physically restrictive and could impact the preferred alternatives. The identified utilities include sanitary sewers (Region of Halton), storm outfalls (City and private), water mains (Region of Halton) communication conduits (Bell), gas mains (Union Gas), pipelines (Trans-Northern) and hydro (Hydro One) are listed in Table 3-25. Figures illustrating the approximate utility locations and size are attached in Appendix A.

Table 3-25: Summary of Existing Utilities within the Study Area

Reach No.	Erosion Sites	Utilities	Dimension and Material	Recommendation
Reach 1	1A	Storm	300mm ø Concrete	Potential Retrofit
	1A	Sanitary	200mm ø Concrete	Enhanced encasement or lowering
	1B	Sanitary	600mm ø CPP – Depth Unknown	Enhanced encasement or lowering
	1B	Sanitary	350mm ø AC - Depth Unknown	Enhanced encasement or lowering
	1B	Sanitary	450mm ø – Unknown Material	Enhanced encasement or lowering
	1B	Storm	675mm ø Concrete	Potential Retrofit
	1B	Pipeline	Size and Depth Unknown	Lowering or enhanced encasement
	1B	Watermain	300mm ø PVC	Lowering to increase cover
Reach 2	2	Sanitary	450mm ø – Unknown Material	Lowering or enhanced encasement
	3	Storm	1100 ø Concrete	Potential Retrofit
	4	Pipeline	Depth and Size Unknown	Lowering or enhanced encasement
	4	Watermain	300mm ø PVC	Lowering to increase cover
	4	Storm	450mm ø Concrete	Potential Retrofit
Reach 3	5	Storm	300mm ø Concrete	Potential Retrofit
Reach 4	-	Sanitary	375mm ø - Material Unknown	-
	-	Sanitary	500mm ø Polyethylene & PVC - Depth	-
	-	Sanitary	Unknown	-
	-	Storm	1050mm ø Concrete	-
	-	Storm	375 mm ø Concrete	-
	-	Storm	1200mm ø Concrete	-
	-	Watermain	375mm ø PVC	-
	-	Watermain	750mm ø CPP	-
	-	Drain	500mm ø Private Concrete Drain	-
	-	Drain	500mm ø Private Concrete Drain	-
	-	Pipeline	Size and Depth Unknown	-
Reach 5	-	Storm	1050mm ø Concrete	-
	-	Storm	575mm ø Concrete	-

	6	Storm	250mm ø Concrete	Potential Retrofit
	6	Storm	1050mm ø Concrete	Potential Retrofit
	-	Storm	750mm ø Concrete	-
	-	Watermain	300mm ø PVC	-
	7A	Storm	250mm ø – Material Unknown	Potential Retrofit
Reach 6	-	Pipeline	Size and Depth Unknown	-
	-	Pipeline	Size and Depth Unknown	-
	-	Sanitary	900mm ø Concrete	-
	-	Watermain	500mm ø CPP	-
	-	Watermain	300mm ø DI	-
	7B	Pipeline	Size and Depth Unknown	Lowering or enhanced encasement
	7B	Storm	1800mm ø Material Unknown	Potential Retrofit
Reach 7	-	Sanitary	300mm ø VC	-
	-	Watermain	300mm ø DI	-
	9B	Pipeline	Size and Depth Unknown	Lowering or enhanced encasement
	9B	Storm	350mm ø Material Unknown	Potential Retrofit

3.11 Socio-Economic Environment

3.11.1 Land Use

As noted in the Burlington Official Plan (City of Burlington, 2010), initial settlement in what is now the City of Burlington occurred along Lake Ontario and proceeded northward. Urban growth and expansion have been continuous in Burlington since the 1950s. At present, development within the Appleby Creek watershed extends approximately to the limits of Highway 407 (see Figure 3-44).

South of South Service Road and north of GO transit train tracks, land use is categorized as general employment and corridor for business. The area is categorized as "mixed use" and for employment, south of the GO transit train line and south of Fairview Street. Similarly, in the area east of the Appleby Creek between south of the Sheraton Road and north of New Street, medium to high density residential property are classified. The land use is predominantly low-density residential between New Street and Lake Ontario (Figure 3-44).

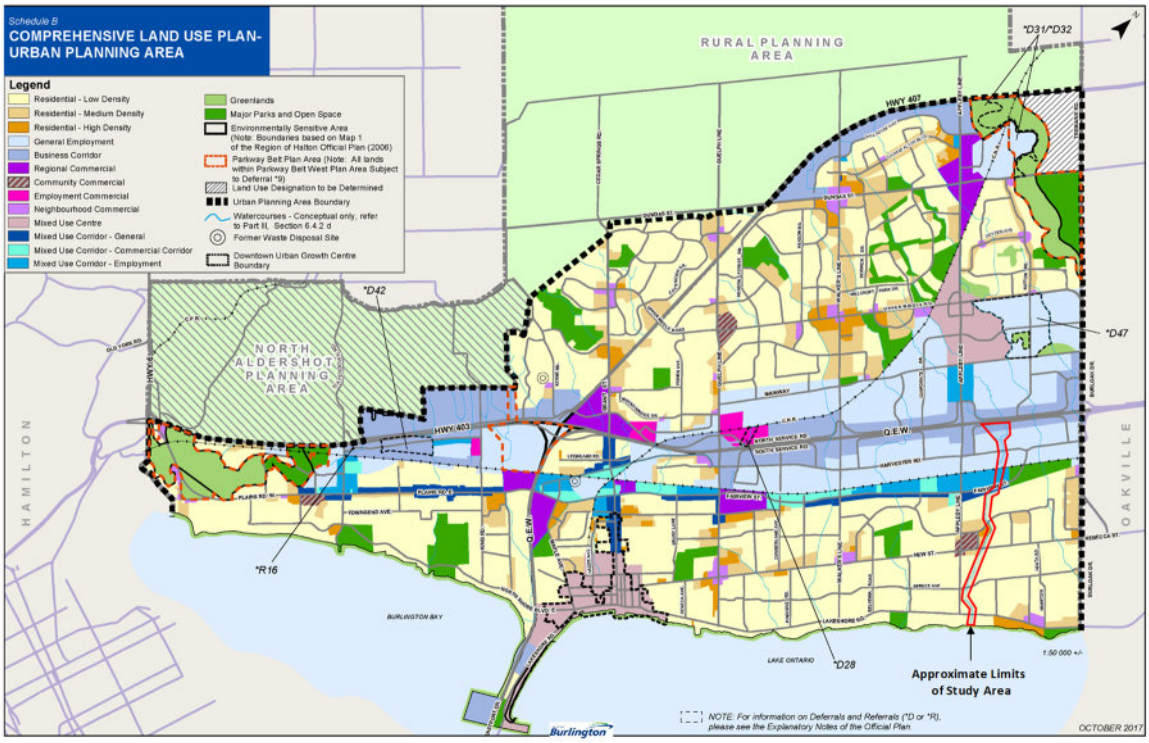


Figure 3-44: Land use within the City of Burlington (City of Burlington, 2017)

3.11.2 Transportation

Within the Appleby Creek watershed, major transportation corridors are the Queen Elizabeth Way, Highway 407, and two Canadian National Railway lines. Highway 407 is categorized as a Provincial Freeway, Harvestor Road east of Appleby Line as a multi-purpose arterial road, while Fairview Street east of Appleby Line is categorized as a small arterial road. Within the City of Burlington Official Plan (City of Burlington, 2010) New Street and Lakeshore Road within the study area are classified as a minor arterial road (Figure 3-45).

A right-of-way hydro corridor traverses through Appleby Creek south of Fairview Road. Also, within the hydro corridor are the Trans-Northern pipeline and the Centennial Bikeway trail. While there are several other utilities in the region of study area, significant utility corridors do not pass through the study area.

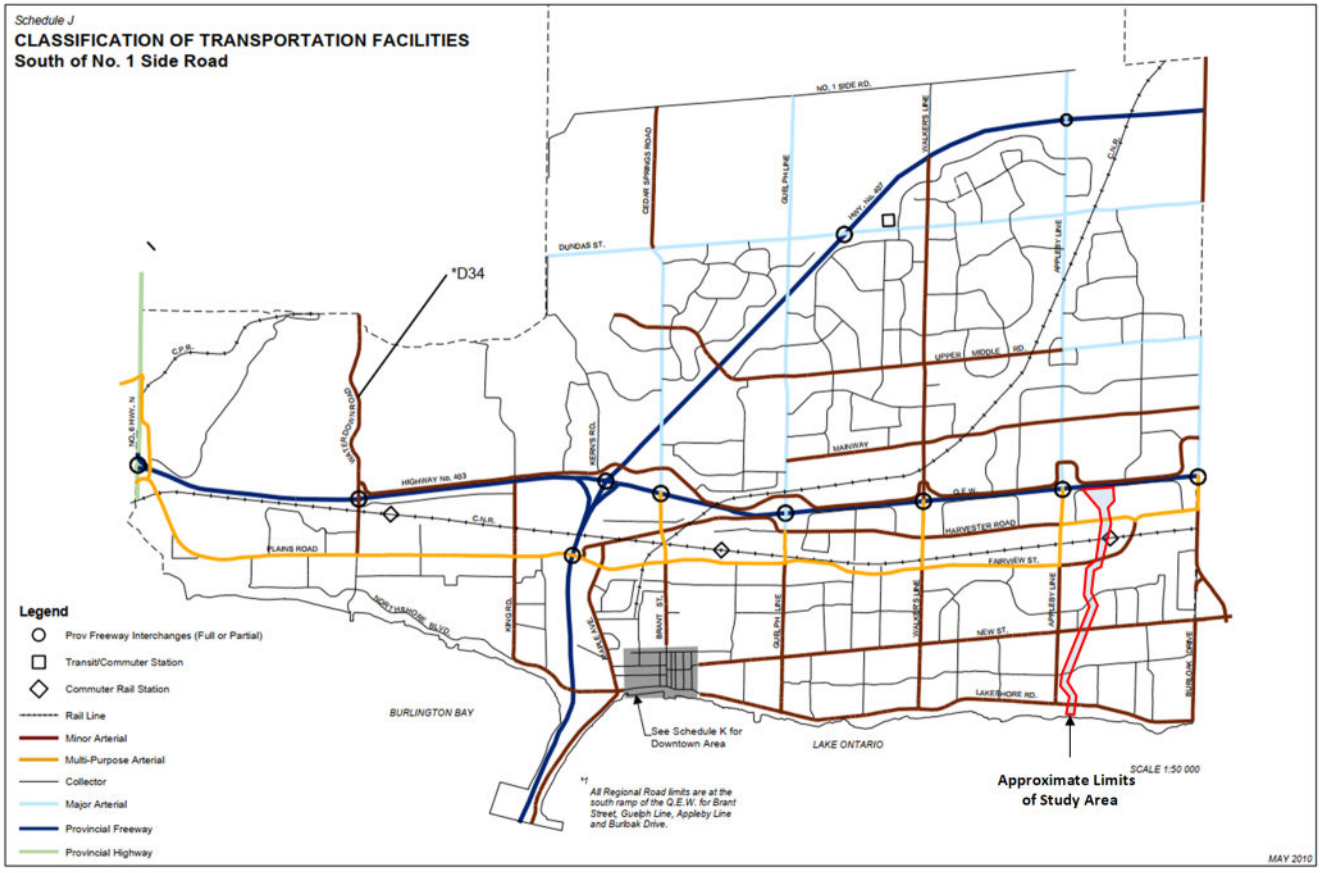


Figure 3-45: Transportation Facilities within the City of Burlington (City of Burlington, 2017)

3.11.3 Ownership

Within the study areas, majority of Appleby Creek is contained to City owned lands or lands with permanent easements. However, some segments of the creek in Reach 2, 3, 5 and 7 are on private property. The corridor is very narrow and leaves little room for natural channel processes. At some locations (i.e. Erosion Site 1 within Reach 1 and Erosion Site 5 within Reach 3), the creek was originally contained within City's land and is now encroaching onto private lands. Should erosion control works to be undertaken, land acquisition or easement negotiation may be required. Detailed ownerships are illustrated on the existing conditions maps attached in Appendix A.

4 EVALUATION OF ALTERNATIVE SOLUTIONS

A series of alternatives was developed for this study to specifically address erosion concerns documented in the nine (9) erosion sites as identified in **Section 2.1**. These alternatives are described below with specifics dependant on each particular site.

- **Alternative 1: Do Nothing** – This alternative involves leaving the site as it is and allowing erosional processes to continue within the watercourse corridor. Under this alternative, it should be expected that maintenance, or possibly emergency works, may have to be undertaken to address damage to property or infrastructure caused by the continued erosion. Damage from erosion may occur gradually over time or suddenly due to a high magnitude flood event.

- **Alternative 2: Local Restorative Works** – This alternative consists of localized channel bank and/or bed work to address erosion issues at the site. While it is understood that local erosion protection works may require ongoing maintenance, occasional repairs, or eventual replacement, this alternative is often still preferred to limit the economic cost and the environmental damage of large-scale channel engineering and stream restoration works.

- **Alternative 3: Comprehensive Restorative Works** – This alternative consists of a comprehensive approach, which is typically reach-based, to address erosion issues at the site. Reach-scale engineering focuses on minimizing the risks of erosion and flooding in highly constrained urban watercourses. This alternative will apply a combination of "hard" channel engineering approaches for erosion control and natural channel techniques to mimic natural channel features such as riffles and pools to enhance creek riparian.

4.1 Description of Alternatives

4.1.1 Erosion Site 1A

Alternative 1: Do Nothing – Private properties at Erosion Site 1A will continue to be at risk from horizontal and vertical erosion. Ongoing risks include loss of property within the Reach 1, continued degradation of water quality and aquatic habitat, damage to existing municipal infrastructure, and potential exposure of sanitary crossing.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, which is approximately 10m of minor channel realignment with riffle-pool features from immediately downstream of the bridge. The proposed works would limit the potential risks within the City property, mitigate risks to private properties and municipal infrastructure (sanitary sewer crossing). The remainder of the channel will remain as it is.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 150m downstream of Lakeshore Road bridge, including roundstone bank protection with enhanced vegetation buffer, ~10m minor channel realignment and bank and bed protection using roundstone riffles and pools just downstream of the bridge. A permanent erosion protection on the east bank at the mouth of the lake will replace the existing temporary erosion control measure (timber crib wall).

4.1.2 Erosion Site 1B

Alternative 1: Do Nothing – Bridge abutment and a stormwater outfall at Erosion Site 1B will continue to be at risk from horizontal and vertical erosion.

Alternative 2: Local Restoration Works – This alternative would provide temporary restorations to the high risk areas including the storm outfall and bridge abutment. Roundstones and boulders will be installed in front of the storm outfall at the bridge abutment. The proposed works would reduce risks to municipal infrastructure and public safety.

Alternative 3: Comprehensive Reach Scale Works – This comprehensive alternative would include 1) recessing the storm outfall and retrofitting the headwall with grouted boulder toe protection; and 2) installing a terrestrial clay bench at the Lakeshore Road bridge abutment to provide protection using a softer engineering approach and enhance terrestrial potentials. The Proposed works would smoothly tie into existing channel.

4.1.3 Erosion Site 2

Alternative 1: Do Nothing – Private properties at Erosion Site 2 will continue to be at risk from erosion and failure of existing erosion control works. Ongoing risks include loss of property within the affected reach, continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including bank protection treatment at select eroded locations along the channel.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 150m of bank works at lower section of Reach 2, and tie into existing armourstone walls. The works would apply natural channel techniques and include roundstone bank protection with enhanced vegetation buffer.

4.1.4 Erosion Site 3

Alternative 1: Do Nothing – Private properties at Erosion Site 3 will continue to be at risk from erosion. Ongoing risks include loss of property within the affected reach, continued degradation of water quality and aquatic habitat, and potential impacts to downstream channel works.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including removal of deteriorating double concrete, installation of boulder cascade structure for grade control and fish passage, and approximately 100m of bank works to protect the outer meander bends with boulders and large cobble stone material. The restorative works will tie into existing concrete block walls downstream of the site. Native tree and shrub would be planted to restore all disturbed areas.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 250m of channel works, including 1) removing existing “hard” engineered channel; 2) replacing with natural channel design using armourstone, boulders and cobble stone materials; 3) replacing the concrete weir and Terrafix channel bed with roundstone riffle-pools to promote fish passage.

4.1.5 Erosion Site 4

Alternative 1: Do Nothing – The Spruce Avenue road embankment, City's land property and public safety will continue to be at risk from erosion. Ongoing risks include loss of property within the affected reach, potential exposure of bridge footing, continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including bank protection treatment at the steep road embankment using boulders and cobble stone material. The bridge footing would be protected from erosion.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 85m of bank works, and tie into restoration limit of Erosion Site 3. The works include re-stabilizing the steep slope with boulders, roundstone material, and native trees and shrubs planting. The bridge footing would be protected from erosion.

4.1.6 Erosion Site 5

Alternative 1: Do Nothing – Private properties along the creek will continue to be at risk from erosion. Ongoing risks include loss of property within the affected reach, continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including bank protection treatment at select eroded locations along the channel.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 280m of bank works, including 1) channel realignment to re-centralize the creek within City property and mitigate risks to private properties; 2) boulders and roundstone bank protection to limit erosion; and 3) storm outfall retrofit into the bank works. This alternative would include extensive removal and restoration of vegetation on the affected areas.

4.1.7 Erosion Site 6

Alternative 1: Do Nothing – City's land property, municipal infrastructure, natural path and public safety will continue to be at risk from erosion. Ongoing risks include loss of property within the affected reach, deterioration to the storm outfall headwall, and continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including bank protection treatment at select eroded locations along the channel and removal of riprap deposits within the creek.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 180m of bank works, including bank protection using boulders and large cobble stone material, as well as removal of riprap deposits within the creek.

4.1.8 Erosion Site 7A & Erosion Site 7B

Alternative 1: Do Nothing – City's land property, municipal infrastructure, private property and public safety will continue to be at risk from erosion and failure of existing erosion control structures. Ongoing risks include loss of property within the affected reach, deterioration to the

storm outfall headwall, continued degradation of water quality and aquatic habitat, as well as potential impacts to downstream reaches.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including undermined / failed sections of the gabion basket erosion controls and areas of bank erosion and slope failure. The local erosion areas would be restored with armourstone retaining walls.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale bank and bed protection works (approximately 150m at Erosion Site 7A and 300m at Erosions Site 7B), including removal of existing gabion baskets, installation of armourstone retaining wall, roundstone riffle-pool features and in-creek vegetation buffer, retrofit of existing storm outfall into the restorative bank works. The integrated channel widening design between Fairview Street and Metrolinx Corridor would allow for flood relief, which will also tie into the recommendation from the Appleby Creek Flood EA study (i.e. widen the Fairview Street bridge). Slopes above the armourstone wall will be restored with native trees and shrubs.

4.1.9 Erosion Site 8

Alternative 1: Do Nothing – Private property and public safety will continue to be at risk from erosion and failure of existing erosion control structures. Ongoing risks include flow obstruction, continued degradation of water quality and aquatic habitat, as well as potential impacts to downstream reaches.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including 1) removal of existing concrete weirs and gabion baskets; 2) approximately 150m of bank and bed protection works using armourstone retaining wall; and 3) grouted boulder grade control structures with riffle-pool features and in-creek vegetation buffers. Slopes above the armourstone wall will be restored with native trees and shrubs. The proposed restoration works will not only address erosion issues but also promote fish passage and enhance aquatic and terrestrial habitat.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for the reach between Harvester and Metrolinx Corridor, using natural channel techniques to restore the channel with armourstone, boulders, cobble materials, riffles and pools and lin-creek vegetation buffer.

4.1.10 Erosion Site 9A

Alternative 1: Do Nothing – This alternative will leave the creek as is. Ongoing risks include loss of property, erosion migration to both upstream and downstream reaches, as well as continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – This alternative would apply a softer engineering approach to restore approximately 60m of channel bed and banks, which would include replacing failed grade control structure with grouted boulder grade control structures with riffle-pool features and in-creek vegetation buffer. All slopes above the top of bank will be restored with native trees and shrubs.

Alternative 3: Comprehensive Reach Scale Works – This alternative consists of approximately 120m of channel and bed works, including the works proposed as part of the local restoration alternative and the bank restoration will be extended and tie into the Harvester Rd culvert at the downstream and the confluence at the upstream. The alternative will provide opportunities for reach-scaled restoration and enhancement.

4.1.11 Erosion Site 9B

Alternative 1: Do Nothing – Banks will continue to be susceptible to erosion and private property will continue to be at risk. Other ongoing risks include loss of property, flow obstruction, continued degradation of water quality and aquatic habitat, as well as potential impacts to downstream reaches.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high risk areas, including areas of eroded banks and steep slopes.

Alternative 3: Comprehensive Reach Scale Works – Apply reach-scale engineering for approximately 280m of bank and bed protection works along the west branch, using armourstone, boulders and large cobble stone material. All slopes above the top of bank will be restored with native trees and shrubs.

4.2 Evaluation Criteria

As a part of the Municipal Class Environmental Assessment Process, each alternative must be evaluated based on a set of physical, natural, social, cultural, economic environment, as well as technical and engineering considerations. These set of criteria were developed by Aquafor and reviewed by the City of Burlington. The list of criteria and the associated scoring is presented in Table 4-1.

Table 4-1: Alternative Evaluation Criteria

Criteria Category	Criteria	Description
Physical / Natural Environment	Potential to Reduce Stream Bank and Stream Bed Erosion	Greater reduction of erosion risks, slope failures, and loss of public and private properties/parklands
	Potential to Reduce Flooding Risks	Greater reduction of localized flooding risks to public and/or private lands for longer time by implementing the alternative scores higher
	Potential to Improve Aquatic Habitat	Greater improvements to fish and aquatic habitat scores higher, including substrate, overhanging vegetation, turbidity, and passage/connectivity
	Potential Impacts to Aquatic Habitat During Construction	Less disruption to fish and aquatic habitat during construction scores higher
	Potential to Improve Terrestrial Habitat	Greater improvements to terrestrial habitat scores higher, including loss and replacement of vegetation and natural corridor connectivity

Criteria Category	Criteria	Description
	Potential Impacts to Terrestrial Habitat During Construction	Less disruption to the terrestrial habitat during construction scores higher
Technical and Engineering	Ease of Implementation	Potential impact to the surrounding infrastructure (e.g., sewers, watermains, gas, roads) during and after constructions
	Agency Acceptance	Greater likelihood that regulatory authorities will support the alternative scores higher
	City Acceptance	Greater compliance with existing City plans, policies, and bylaw requirements scores higher
	Technical Feasibility	Greater technical feasibility relative to other alternatives scores higher
Social / Cultural Environment	Aesthetics / Recreation	Greater improvements to the aesthetics of the creek corridor and how the alternative impacts recreational use of the corridor. Tree plantation and natural looking alternative scores higher
	Compatibility with Adjacent Land Use	Greater compatibility with the land use of adjacent properties (e.g., softer approach will be preferred in the residential and parklands compared to hard-engineered structure) scores higher
	Community Disruption	Less disruption the surrounding community and residents scores higher
Economic Environment	Construction Costs	Lower construction cost relative to other alternatives scores higher
	Operation and Maintenance Costs	Lower operations and maintenance costs relative to other alternatives scores higher
	Life Cycle Costs	Lower life cycle costs relative to the other alternatives scores higher
	Infrastructure Protection	Greater protection of existing infrastructure for a longer time scores higher

A weighting factor was assigned to each category presented in Table 4-1, which ensured that each category was valued appropriately, regardless to the number of criteria within the category. The weighting factors used for this evaluation are shown in Table 4-2.

Table 4-2: Category Weighting Factors

Category	Weighting Factor	Maximum Points for Category
Physical / Natural Environment Criteria	0.30	30
Social / Cultural Environment Criteria	0.20	20
Technical and Engineering Criteria	0.20	20
Economic Environment Criteria	0.30	30
TOTAL	**1**	**100**

For each criteria item, a score was applied ranging from 0 to 5 (Table 4-3), where:

- 0 = Unfavourable, no improvement or negative impact
- 3 = Acceptable
- 5 = Favourable, most improvement or most positive impact

Table 4-3: Ranking Scheme for Criteria Evaluation of Each Alternative

Ranking Scale							
No / Negative Impact	0	1	2	3	4	5	**Ideal / Most Positive Impact**

4.3 Evaluation of Alternatives

For each alternative and each Erosion Site, the criteria were evaluated, where higher scores relate to varying degrees of positive effect that an alternative, for the defined criterion, would have on the outcome. The sum of the criterion scores was determined for each alternative and the alternative with the highest score was deemed to be preferred.

A summary of scores for each of the Erosion Site are presented in Table 4-4.

Table 4-4 summarizes the results of the evaluation. Detailed evaluation matrix for each Erosion Site can be found in Appendix E.

Table 4-4: Evaluation Scoring Summary

Erosion Site	Alternative 1 – Do Nothing	Alternative 2 – Local Restoration Works	Alternative 3 – Comprehensive Reach Scale Works
Erosion Site 1A	51	54	58
Erosion Site 1B	51	57	59
Erosion Site 2	52	56	64
Erosion Site 3	47	69	51
Erosion Site 4	46	70	51
Erosion Site 5	45	59	60
Erosion Site 6	44	75	59
Erosion Site 7A	41	62	69
Erosion Site 7B	41	61	70
Erosion Site 8	46	72	51
Erosion Site 9A	38	66	57
Erosion Site 9B	38	59	64

4.4 Public and Agency Consultation

4.4.1 Notice of Commencement

The Notice of Commencement for the study was issued on July 16th, 2018.

4.4.2 Public Information Centre (PIC)

One public information meeting was held which included a display of poster boards and a question-and-answer session. The meeting was held on February 19, 2019 at the Appleby Ice Centre – Community Room 1, Arena A (1201 Appleby Line, Burlington), with a total of 14 attendees signed in.

The open house consisted of display board outlining the study purpose and background, as well as next steps. A copy of display boards was presented and is attached in Appendix F. The display board outlines the following items:

- The study area;
- The objective of the study and the purpose of the public information package;
- The Municipal Class EA – Schedule B process;
- The existing condition of the Appleby Creek within the study area;
- The problem and opportunities;
- The erosion and maintenance sites inventory identified within the study area;
- The evaluation criteria;
- The preliminary alternative solutions; and
- The next steps in the process.

A comment sheet was provided to the attendee to solicit input on the project, and obtain input on the information presented. The questions asked on the comment form included:

1. Do you have any information on the conditions of Appleby Creek within the study area that would be useful for the study team to know (i.e. evidence of erosion you may have observed)? If so, please tell us what they are.
2. Do you agree with the preliminary preferred alternatives? Why or why not?
3. Do you have any concerns about the potential impacts the preliminary preferred alternatives may have on the creek or adjacent properties?
4. Additional questions/comments?

No comment sheet was received; however, City and Aquafor staff provided responses and clarification to questions raised by the public during the PIC.

Sign in sheet, blank comment sheet, together with the PIC display boards are provided in Appendix F.

4.4.3 Halton Conservation Authority

Conservation Halton (CH) has been included throughout the entirety of this project as part of the technical review team, including attendance at key meetings and providing comments and feedback at interim stages throughout the project. Conservation Halton has included engineering, planning and ecology representation as part of the technical review team. Relevant comments and feedback from CH have been addressed and incorporated into the study where applicable, and these inputs are included in Appendix F**.**

4.4.4 Additional Input from Fairview Street & Oval Court Landowners

Branthaven Development Corporation and 5135 Fairview Holdings Inc., combined, own all the property along the eastern limit of Appleby Creek between Fairview Street and the railway line (Reach 3), along Oval Court. Input from these landowners was obtained through a phone conversation and letter prepared by Urbantech Consulting and Jennifer Lawrence and Associates representing the two landowners respectively, which suggests the following:

> *There may be an opportunity, through the re-development of lands east of Appleby Creek, between Fairview Street and the railway line, as part of the Mobility Hub development, to widen the watercourse corridor to assist in containing the extent of the floodplain east of Appleby Creek to provide for additional tableland for re-development. Such options should be explored further with the adjacent landowners and approval agencies as part of future re-development.*

The two firms provided further inputs regarding the study and subsequent meetings were coordinated. Inputs were considered where applicable. Additional meeting was held on December 12th, 2019 to discuss the erosion control alternatives at Fairview Street. Urbantech has proposed to dedicate a land for possible channel widening on the eastern limit of Appleby Creek as shown in Figure 4-1 below. Further opportunities to widen the channel could be taken into consideration during the detailed design stage.



Figure 4-1: Land Dedication to City

The letters and supplemental information prepared by Urbantech and Jennifer Lawrence and Associates are included in Appendix F.

4.5 Selection and Description of the Preferred Alternative

The preferred alternatives have been selected based on evaluation criteria, refined and confirmed through consultation with the City and the public, which are as follows:

Erosion Site 1A: Alternative 3 – Comprehensive Reach Based Works

Roundstone bank protection such as vegetated buttress would be applied to approximately 140m of channel downstream of Lakeshore Road bridge. Consider minor channel planform adjustment (channel realignment) and profile adjustment (riffles and pools) for approximately 10m downstream of the bridge to limit potential risks to private property. A permanent erosion protection on the east bank at the mouth of the lake will replace the existing temporary erosion control measure (timber crib wall).

Erosion Site 1B: Alternative 3 – Comprehensive Reach Based Works

The storm outfall upstream of Lakeshore Road would be recessed and retrofitted with grouted boulders toe protection. A terrestrial clay bench would be installed at the bridge crossing to protect bridge abutment and road embankment. The proposed works at both the outfall and bridge abutment will tie into existing channel smoothly.

Erosion Site 2: Alternative 3 – Comprehensive Reach Based Works

The comprehensive restoration works would be applied to approximately 150m of bank works at lower section of Reach 2, and tie into existing armourstone walls. The works would apply natural channel design such as vegetated buttress for bank protection. Restore slopes above top of bank with native tree and shrub plantings.

Erosion Site 3: Alternative 2 – Local Restoration Works

Local restoration works would include 1) removal of concrete double weirs; 2) restore fish passage using grouted boulder grade control structures with riffle-pool features; and 3) approximately 240m of bank stabilization works at the eroded outer meander bends with boulders and cobble stone materials; and 4) restoration of slopes above top of bank with native tree and shrub plantings.

Erosion Site 4: Alternative 2 – Local Restoration Works

Bank protection treatments this site include engineered bank stabilization using boulders and cobble stone material for toe protection. The bridge footing would be further investigated for risks of exposure.

Erosion Site 5: Alternative 3 – Comprehensive Reach Based Works

The comprehensive restoration works would involve both planform and profile adjustment for approximately 270m of channel. Works include 1) channel realignment to re-centralize the creek within City property and mitigate risks to private properties; 2) boulders and roundstone bank protection to limit erosion; 3) riffles and pools construction; and 4) storm outfall retrofit into the bank works. Based on the alternative scoring, similar score was given to Alternative 2 and Alternative 3. Through the discussions with Conservation Halton, the interest in limiting impacts to aquatic and terrestrial habitat, and the limiting the extent of channel realignment should be

minimized during the detailed design. The detailed design consideration to hybrid approach would include moderate removal and restoration of vegetation on the affected areas.

Erosion Site 6: Alternative 2 – Local Restoration Works

Local works including removal of riprap deposits within the creek, bank restoration with natural channel techniques such as vegetated buttress at select locations, and retrofit the storm outfall headwall into the bank treatments.

Erosion Site 7A: Alternative 3 – Comprehensive Reach Based Works

Approximately 150m of bank and bed protection works would be undertaken, including removal of existing failing / failed gabion baskets, installation of armourstone retaining wall, roundstone riffle-pool features and in-creek vegetation buffer, retrofit of existing storm outfall into the restorative bank works. Slopes above the armourstone wall will be restored with native trees and shrubs.

Erosion Site 7B: Alternative 3 – Comprehensive Reach Based Works

Approximately 300m of bank and bed protection works would be undertaken, including removal of existing failing / failed gabion baskets, installation of armourstone retaining wall, roundstone riffle-pool features and in-creek vegetation buffer, retrofit of existing storm outfall into the restorative bank works. The integrated channel widening design between Fairview Street and Metrolinx Corridor would allow for flood relief, which will also tie into the recommendation from the Appleby Creek Flood EA study (i.e. widen the Fairview Street bridge). Slopes above the armourstone wall will be restored with native trees and shrubs.

Erosion Site 8: Alternative 2 – Local Restoration Works

Local restoration works include 1) removal of existing concrete weirs and gabion baskets, 2) approximately 150m of bank and bed protection works using armourstone retaining wall; and 3) grouted boulder grade control structures with riffle-pool features and in-creek vegetation buffers. Slopes above the armourstone wall will be restored with native trees and shrubs. The proposed restoration works will not only address erosion issues but also promote fish passage and enhance aquatic and terrestrial habitat.

Erosion Site 9A: Alternative 3 – Local Restoration Works

The failed concrete and gabion grade control structure would be removed and replaced with grouted boulder cascade with riffle-pool features and in-creek vegetation buffers to promote fish passage and enhance aquatic habitat. All slopes above the top of bank will be restored with native trees and shrubs.

Erosion Site 9B: Alternative 3 – Comprehensive Reach Based Works

Approximately 280m of bank and bed protection works along the west branch would be undertaken, using armourstone, boulders and large cobble stone material. Minor channel realignment to limit risks to private properties. All slopes above the top of bank will be restored with native trees and shrubs.

4.6 Preliminary Design of the Preferred Alternative

Preliminary design drawing package for the preferred alternative including preliminary design, preliminary staging storage and access, erosion and sediment control, and restoration plans are included in Appendix G. Location of the erosion control structures, grade control measures and the length of each reach are highlighted in the general plan. Technical details will be refined through the detailed design process.

The conceptual drawings are typically of interest to the regulatory conservation authority (CH), in order to confirm the preferred alternative will be consistent with permitting requirements, and also highlighted through the public consultation program as being imperative to the study.

5 EROSION AND MAINTENANCE SITES PRIORITY RANKING AND PROJECT PHASING

5.1 Prioritization and Project Phasing

Based upon the understanding of the risks associated with the current conditions of Appleby Creek ravine, the preferred restoration alternatives have been prioritized into multiple projects. The project prioritization is based on erosion sites field scoring and property ownership.

Table 5-1 summarizes the information required to successfully implement the proposed measures, including project name, erosion site numbers, reach ID, length of channel works, risk and opportunities, EA Schedule, property ownership, cost estimate, and recommended time horizon for implementation. While the project cost estimates and time horizon are to provide the City direction on project priorities, decisions on the actual order and implementation of projects should consider overall City priorities, budgets, and stakeholder interests. For instance, the Appleby Creek Flood Environmental Assessment study (Aquafor Beech Limited, 2018) recommends bridge widening at Fairview Street which situates within the limit of Erosion Site 7 (Project 4). Therefore, City should consider integrating the implementation of the two projects for time and cost saving as well as minimizing disturbance.

A preliminary cost estimate for each project is also presented in the table. Each project cost estimate includes 15% for engineering design and approvals and a 15% contingency (rounded up to the nearest $1,000), but the total is exclusive of HST.

Note that cost estimates in Table 5-1**,** do not include the cost of land acquisition that may be considered in some cases (e.g., Projects 2 and 3). Longer-term projects, such Project 8 and 9 may require consideration of interim emergency works should channel conditions worsen before project implementation and inflation.

The project phasing and estimated costs associated with each maintenance site are detailed in Table 5-2. The maintenance projects are recommended to be undertaken with erosion projects where the sites coincide so that cost-savings could be achieved. However, actual implementation order would be dependent on the City's Operation and Maintenance Department's budgets and overall projects.

Table 5-1: Project Priority Ranking for Erosion Sites

Priority No.	Project Name	Erosion Sites	Reach	Field Scoring	Property Ownership	Approximate Length	Risk and Opportunities	EA Schedule	Cost Estimates	Planning Horizon
1	Go Station	8	6	93	City	145m	Failed / failing grade control and erosion control structures, fish barrier	B	$1,160,000	0-2 years
2	Lakeshore Road	1A & 1B	1	83	City & Private	150m	Erosion of bridge abutment, storm outfall, and channel banks into private property	B	$525,000	0-2 years
3	South Service Road	9A & 9B	7	79	City & Private	340m	Failed grade control structure, local bank erosion adjacent to private property	B	$1,190,000	2-5 years
4	Oval Court and Centennial Bikeway	7A & 7B	7A in Reach 5 7B in Reach 6	76	City	500m	Local bank erosion, failing gabion baskets, erosion risk to storm outfall and paved trail.	B	$2,500,000	2-5 years
5	Linwood Crescent	3	2	78	Private & private with City easements	100m	Failing grade control structure, fish barrier, local bank erosion	B	$220,000	2-5 years
6	Spruce Avenue	5	3	74	City & Private	280m	Bank erosion	B	$980,000	5-10 years
7	Sheraton Road	6	5	47	City	80m	Local bank erosion	B	$120,000	5-10 years
8	5031 & 5039 Lakeshore Road	2	2	45	Private with City easements	150m	Bank erosion	B	$525,000	5-10 years
9	Spruce Avenue Bridge and Road Embankment	4	2	45	City	35m	Local bank erosion, risk of exposing bridge footing	B	$90,000	5-10 years

Table 5-2: Project Phasing for Maintenance Sites

Maintenance Site	Project Name	Reach	Property Ownership	Site Description	Cost Estimates	Recommendation
1	5031 & 5039 Lakeshore Road Woody Debris Removal	2	Private with City Easement	Removal of fallen trees and woody debris	$15,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 8 (Erosion Site 2) as these two projects are in the location.
2	Appleby Line	2	Private with City Easement	Replacement of missing sewer back-flow cover	$10,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 5 (Erosion Site 3) as the extent is immediately downstream of Erosion Site 3.
3	South Service Road	2	City	Exposed armourstone wall toe protection maintenance	$90,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 9 (Erosion Site 4) as these two projects are in the location.
4	South Service Road Woody Debris Removal	7	City	Removal of fallen trees and woody debris	$30,000	This maintenance project to recommended to be carried out concurrently with Erosion Project No. 3 (Erosion Site 9) as these two projects are in the location.

5.2 Impact Assessment and Mitigation Measures

Potential impacts to nature heritage features and functions within the study area are described under the following subsections. Recommended mitigation measures relating to potential negative impacts to natural heritage features and functions are discussed, as well as general mitigation measures that should be applied regardless of the natural heritage feature(s) present. Environmental constraints have been provided on Figure 5-1 to Figure 5-4.

5.2.1 Vegetation Loss to Significant Woodlands and Private Lands

Vegetation loss in Significant Woodlands and vegetation on private property along Appleby Creek is required to accommodate access and construction works.

Recommended Mitigation Measures: To offset the loss of Significant Woodland cover; native trees, shrubs, and herbaceous species should be planted in disturbed areas. It is recommended that all vegetation removed is replanted in accordance with the City of Burlington's Public Tree By-law 68-2013 (City of Burlington, 2013). Section 1.17 of this By-law states:

> *Where a Public Tree(s) is to be removed and where its removal is not required due to age, health or other reasons in accordance with sound arboriculture principles, the applicant shall plant Tree(s) with the total combined diameter being equal to or greater than that of the Tree(s) to be removed. Where the total combined diameter of the Tree(s) to be planted is less than the total combined diameter of the Tree(s) removed, Council approval will be required.*

In addition, five (5) shrubs should be planted for every tree planted, and an herbaceous seed mix should be seeded over disturbed areas that reflect a native-species riparian corridor. **It is recommended that the Fresh-Moist Oak-Sugar Maple Deciduous Forest be used as a reference community for restoration plans** as this community is likely a remnant of the native forest cover before development in the area. It is also recommended that, where possible, efforts be made to improve wildlife habitat through the provision of habitat plantings, re-use of large diameter trees cut to accommodate construction, etc.

It is also recommended that a Certified Arborist prune branches of trees adjacent to construction zones that may interfere with construction. If tree roots are to be impacted by excavation processes, roots should be pruned before excavation according to standard arboricultural practices. Horizontal root protection measures, as designed by a Certified Arborist, should be used where machinery is required to drive within minimum tree protection zones.
Note that given the linear shape of natural areas in the study area and the location of anticipated disturbance areas on the edge of woodland communities; it is recommended that trees selected for replacement should be tolerant of full to partial sun, and salt tolerant. It is highly recommended that species selection should reflect a native lowland forest community. Disturbed vegetation communities should be seeded with herbaceous species appropriate to the respective vegetation community.

Areas where vegetation is to be removed on private properties must be restored following Conservation Halton's Landscaping and Tree Preservation Guidelines. This guideline outline species selection, planting density, and post-planting care requirements.

Best Management Practices for trees before, during, and after construction include the following:

Planning Phase

- It is recommended that a Certified Arborist completes an Arborist Report and Tree Protection Plan, complete with detailed tree inventory for areas of anticipated impact.

Design Phase

- Arborist Report and Tree Protection Plan complete with a detailed tree inventory, identification of tree injuries and removals (including area(s) of root zone impact, the prognosis for survival, structural stability, health, and vigour) and recommendations for mitigation including additional tree protection or redesign, as necessary;
- Planned areas for construction access, staging, material storage, etc.;
- Tree protection zone (TPZ) fencing and signage, trunk protection, etc.;
- Considerations: Root and Crown pruning (raising, reduction, etc.) to avoid damage by construction equipment;
- Grade changes, slope stabilization, etc.

Construction Phase

- Site supervision by a certified arborist and communication plan;
- Installation of Urban Forestry approved tree protection measures;
- Backfill techniques and considerations; and
- Tree care during construction.

Post-Construction Aftercare

- Monitoring;
- Irrigation;
- Aeration;
- Mulching;
- Wound treatment; and
- Fertilization (not recommended for at least one [1] year post-construction).

It should be noted that since the City has been removing dead ash throughout the Appleby Creek corridor, there is an opportunity to underplant most of the natural lands within the study area (on private and public properties, as applicable) with trees and shrubs to mitigate canopy and habitat loss.

5.2.2 Impacts to Breeding Birds

The natural corridor of Appleby Creek is breeding habitat for birds. There is the potential to harm and/or disturb birds nesting in vegetation within and adjacent to disturbance areas.

Recommended Mitigation Measures: To mitigate negative impacts to breeding birds, tree removals are recommended to occur outside of the breeding bird nesting period for forest birds in Burlington (i.e., April 10 to August 12). If site works must occur during the generalized nesting period, it is recommended that a qualified avian ecologist must conduct an active nest survey immediately prior to tree removal. It is further recommended that that the proponent establishes temporary Nest Protection Zones for any nests, which will remain in place until all young birds

have fledged as confirmed by a qualified wildlife biologist. These measures will ensure that site alteration does not contravene the federal *Migratory Birds Convention Act* (2010), which protects the nests of most breeding bird species in Ontario.

As the study area is highly disturbed, and native species are generally lacking, it is recommended that disturbance areas are planted with native trees, shrubs, and herbaceous species that may provide cover and food sources for birds throughout the year. For further discussion regarding planted materials for birds, see *Impacts to Significant Wildlife Habitat* (**Section 5.2.5**), below.

5.2.3 Aquatic Communities

As fish are in all reaches of Appleby Creek, there is the potential to harm fish and fish habitat during construction. Construction activities may also impact the quality of fish habitat by reducing water quality from sedimentation.
Fish habitat may be improved by removing the fish barrier observed 2 m upstream of the crossing at Fairview St.

Recommended Mitigation Measures: It is recommended that removed vegetation is compensated by planting native tree, shrub and herbaceous species. Erosion and sediment controls should be used to prevent siltation into the creek. As all reaches will likely require dewatering, fish rescues should be conducted in accordance with the cold-water timing window (outside of September 15 to June 30) to reduce harm to aquatic species. As per CH's EA checklist, where lands are available to achieve a 30 m fisheries setback from bankfull, all efforts should be made to restore this setback with native vegetation to provide water quality and quantity benefits to the creek.

5.2.4 Species-at-Risk and other Species of Conservation Concern

Recommended mitigation measures related to potential impacts to Endangered and Threatened species known or suspected to occur within the study area are presented below.

5.2.4.1 Endangered Bats

Tree removals may remove candidate bat maternity roosting sites.

Recommended Mitigation Measures: At the detailed design stage, it is recommended that candidate bat maternity roost sites are cross referenced with proposed tree removals to determine if trees selected for removal are also candidate bat maternity roost sites. Endangered bat species in Ontario currently receive general habitat protection, which means the area in which a species requires to fulfill its life processes. This may include the vegetation community they are found within for breeding, rearing young, and feeding. Trees should not be removed until surveys for candidate bat maternity roost sites have been completed and an Information Gathering Form (IGF) has been submitted to the MECP for review. Suitable hibernation sites (i.e. mines and caves) are not present within the study area. If suitable trees must be removed permitting under the ESA may be required and will likely require the installation of bat condos or bat rocket boxes as a part of compensation.

5.2.4.2 Barn Swallow

Habitat regulated by the MECP includes up to 200 m of a Barn Swallow nest, including the following categories:

Category 1: Nest (lowest tolerance to alteration)
Category 2: Area within 5 m of the nest (moderate tolerance to alteration)
Category 3: Area between 5 m and 200 m of the nest (highest tolerance to alteration)

Generally, activities within Category 1 or 2 habitat zones are most heavily regulated as they are critical to nest success and most susceptible to disturbance. Examples of activities considered invasive to Barn Swallow nesting include modifications to structures (e.g. bridges or buildings) where nests are found, and/or involve activities that would disturb or remove Barn Swallow nests.

Recommended Mitigation Measures: Effects to Barn Swallow can be minimized by avoiding activities that could harm actively nesting birds, such as removing or modifying structures outside of the breeding season (generally May to August), or taking preventative measures to dissuade birds from entering the structure and building nests before the breeding bird season (e.g. install tarp or netting). Any activity that cannot avoid impacts to Barn Swallow are likely to require permitting under the ESA.

5.2.4.3 Black-crowned Night-heron

Vegetation removal and construction within Appleby Creek may disrupt foraging opportunities for herons. As this species is only foraging within the study area and anticipated disturbance areas are contained to mainly within bridge footprints, it is not believed works will disturb a significant portion of Black-crowned Night heron foraging habitat.

Recommended Mitigation Measures: Addition to the bird-sensitive timing window mentioned above all disturbed natural areas should be restored with species native to the vegetation community disturbed and enhanced with plant species preferred by birds. For Black-crowned Night-heron, it is recommended cattails (*Typha* spp.) and bulrushes (*Schoenoplectus* spp.) are incorporated into the restoration plan where possible. A fish rescue should be conducted to exclude fish from work areas so that herons are not tempted to forage within disturbance areas.

5.2.4.4 Canada Warbler

Vegetation removal and construction within Appleby Creek may disrupt foraging opportunities for Canada Warbler.

Recommended Mitigation Measures: Addition to the bird-sensitive timing window mentioned above, it is recommended that access and staging areas are restricted to existing paved surfaces as much as possible to reduce the amount of vegetation removed. Foraging opportunities may be enhanced by planting insect-loving native tree species such as oaks (*Quercus* spp.), willows (*Salix* spp.), and maples (*Acer* spp.) and underplanting with a variety of native shrubs. As this species gleans insects from trees and the ground, downed woody debris may be incorporated into restoration plans to enhance foraging opportunities and encourage insect growth.

5.2.4.5 Eastern Wood-pewee

Vegetation removal and construction within Appleby Creek may disrupt foraging and nesting opportunities for Eastern Wood-pewee.

Recommended Mitigation Measures: Addition to the bird-sensitive timing window mentioned above, it is recommended that staging and access routes are located away from Bromley Park and associated woodlands as much as possible to avoid disturbance to Eastern Wood-pewee.

5.2.4.6 Butternut

Proposed works may be within the regulated area of Butternut, potentially harming this species and/or its habitat.

Recommended Mitigation Measures: It is recommended an IGF is completed for all Endangered and Threatened species within or potentially within the study area and submitted to the MECP for review. As works will likely be within the regulated area for Butternut, the MECP should be consulted before detailed design to avoid project delays.

5.2.4.7 Snapping Turtle

Potentially suitable foraging and dispersal habitat is present for snapping turtles within the Appleby Creek corridor. There is the potential for habitat loss due to vegetation removals to accommodate proposed works. If watercourses are dewatered, this action may temporarily limit turtle movement within the creek corridor.

Mitigation Measures: All efforts to minimize riparian zones impacted should be exercised. It is recommended that staging and access areas be contained to existing roads (i.e. New Street, Pinedale Ave., and Fairview St.). Restoration of disturbed lands/vegetation is recommended as a measure to mitigate potential negative impacts to snapping turtle habitat. It is also recommended that dewatered areas be subject to fish and wildlife rescues in accordance with MECP protocols.

5.2.4.8 Monarch

Although the larval host plant of this species is in low numbers within the study area (i.e. milkweed), vegetation removal to accommodate works may remove potentially suitable breeding and foraging habitat for Monarchs.

Recommended Mitigation Measures: All staging, storage, and access routes should be located outside of the NHS as much as possible to reduce the amount of vegetation removed. It is recommended that restoration plans include milkweed (*Asclepias* spp.) and other native wildflowers suitable to the vegetation community disturbed to mitigate habitat loss. Furthermore, vegetation should be removed before May 1st to reduce the chance of harming the butterfly as it migrates from its wintering habitat.

5.2.5 Impacts to Significant Wildlife Habitat

Recommended mitigation measures related to potential impacts to SWH types known or suspected to occur within the study area are presented below.

Bat Maternity Roost Colonies

See *Endangered Bats* (**Section 5.2.4.1**) above.

Migratory Butterfly Stopover Areas & Landbird Migratory Stopover Areas

Proposed works require vegetation removal, which is potentially suitable habitat for migratory butterflies and birds.

Recommended Mitigation Measures: To mitigate the loss of potentially suitable stopover habitat for butterflies and birds, it is recommended that butterfly host plants and early and late fruiting native vegetation for birds are used in restoration plantings. Host plants for target butterflies include milkweed (*Asclepias* spp.) for monarchs, asters (Asteraceae) for painted lady, and nettles (Urticaceae) for red admiral. For birds, a variety of dogwoods (*Cornus* spp.), viburnums (*Viburnum* spp.), serviceberries (*Amelanchier* spp.), oaks (*Quercus* spp.), grape (*Vitis riparia*), and staghorn sumac (*Rhus typhina*) are a few species appropriate to be planted in the study area.

Special Concern and Rare Wildlife Species

Special Concern and rare wildlife species confirmed or potentially present within the study area include Black-crowned Night-heron, Canada Warbler, Eastern Wood-pewee, Snapping Turtle, and Monarch. For a discussion on the impacts to these species, see **Species-at-Risk and other Species of Conservation Concern** above.

5.2.6 Impacts to Water Quality during Construction

There is the potential impact to water quality due to construction site runoff and drainage and general construction activities. During construction, there is risk of potential sediment release into the watercourse.

Recommended Mitigation Measures: Efforts should be made mitigate surface water runoff to the creek to provide water quality and quantity benefits to the creek. To comply with the Provincial Policy Statement, channel works should be completed in the dry to project water quality. Erosion and Sediment Control (ESC) plan will be developed to mitigate the risk. Possible measures include, but not limited to, the sure of bio degradable erosion control media, siltation fences or biodegradable longs, check and coffer dams, mud mats etc. Inspection of Erosion and Sediment Control (ESC) measures should be completed regularly during the construction process to ensure that ESC measures are functioning as intended and to address any immediate concerns. Similarly, monitoring of erosion control works should be completed following any flooding event to ensure that ESC measures are not compromised as a result of the event. These activities will be confirmed during the detailed design phase of the project before implementation and will be reviewed and approved by Conservation Halton as part of its permit process.

5.2.7 Linkages and Corridors

The Appleby Creek corridor links to Lake Ontario's shoreline south of Lakeshore Blvd. As the study area is within 5 km of Lake Ontario, natural lands within the study area likely act as a migratory stopover area for birds and butterflies, and a potential spawning area for fish, including salmonids.

Recommended Mitigation Measures: To mitigate habitat loss to accommodate construction works, it is recommended disturbed areas are planted with native species, including potential food sources for eastern wood-pewee (e.g., seasonal berries and seeds), butterflies (e.g., host plants and nectaring plants for adults), and other migratory fauna (e.g., native fruits and seeds throughout the seasons). It is also recommended that habitat features such as woody debris, rocks, etc. are retained on the landscape to maintain ecological features and habitat functions. Barriers to fish movement should be removed to improve aquatic habitat connectivity. Invasive species within disturbance areas should be removed and disposed of in landfill. Planted areas should be managed for sprouting invasive species until planted materials have become established.

To enhance the linkage connection along Appleby Creek, it is recommended that the new bridge designs include a terrestrial bench that will accommodate medium sized mammals (i.e. the largest likely animals within the natural area such as raccoon and skunk) during normal flows. Crossing structures such as terrestrial benches are able to alleviate road mortality impacts for many species and allow for the natural migration of animals safely. Refer to CH's *Road Ecology Best Management Practices* (Conservation Halton, 2018) document for design criteria for new structures.

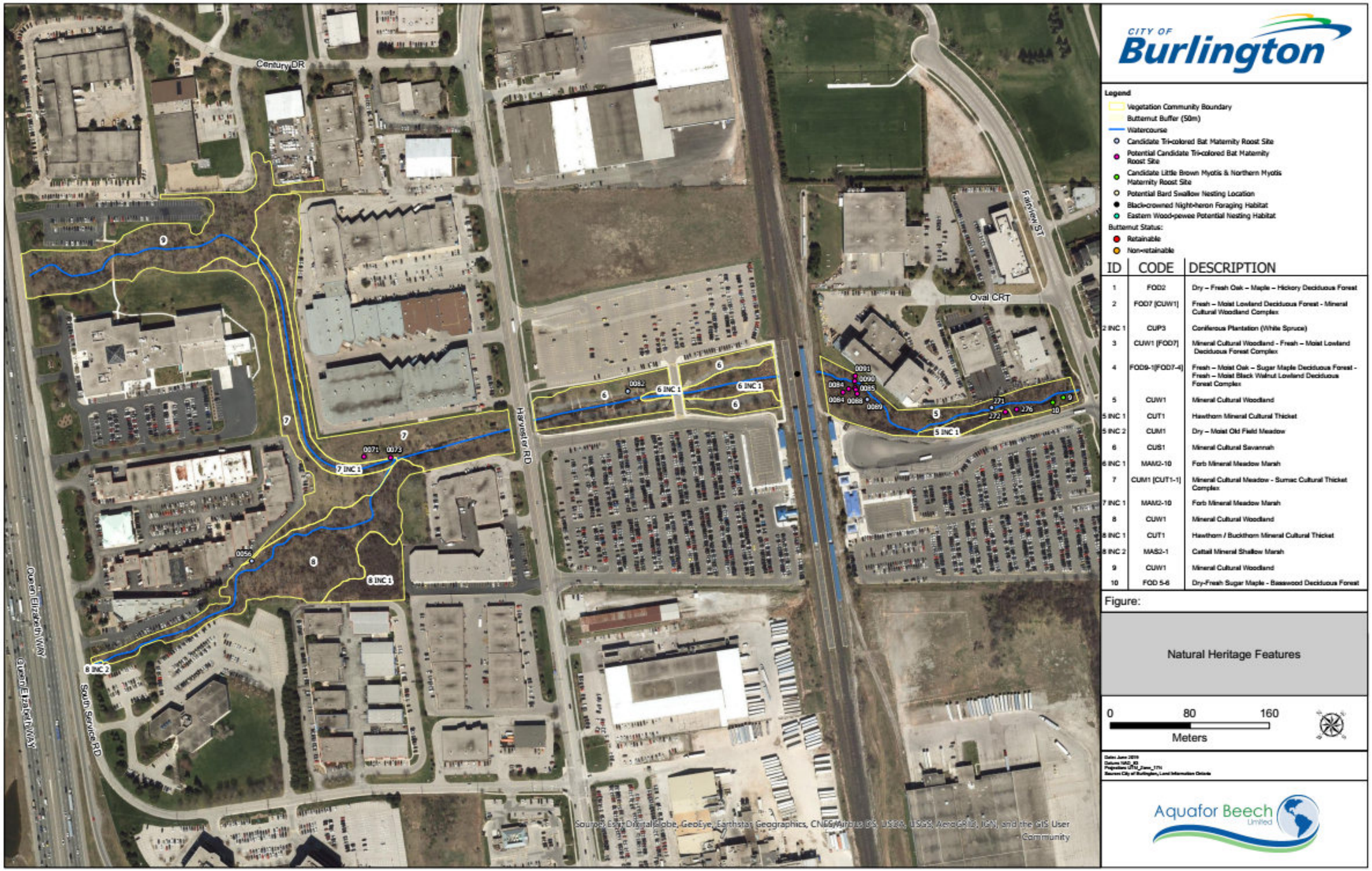


Figure 5-1: Natural Heritage Features 1 of 4



Figure 5-2: Natural Heritage Features 2 of 4

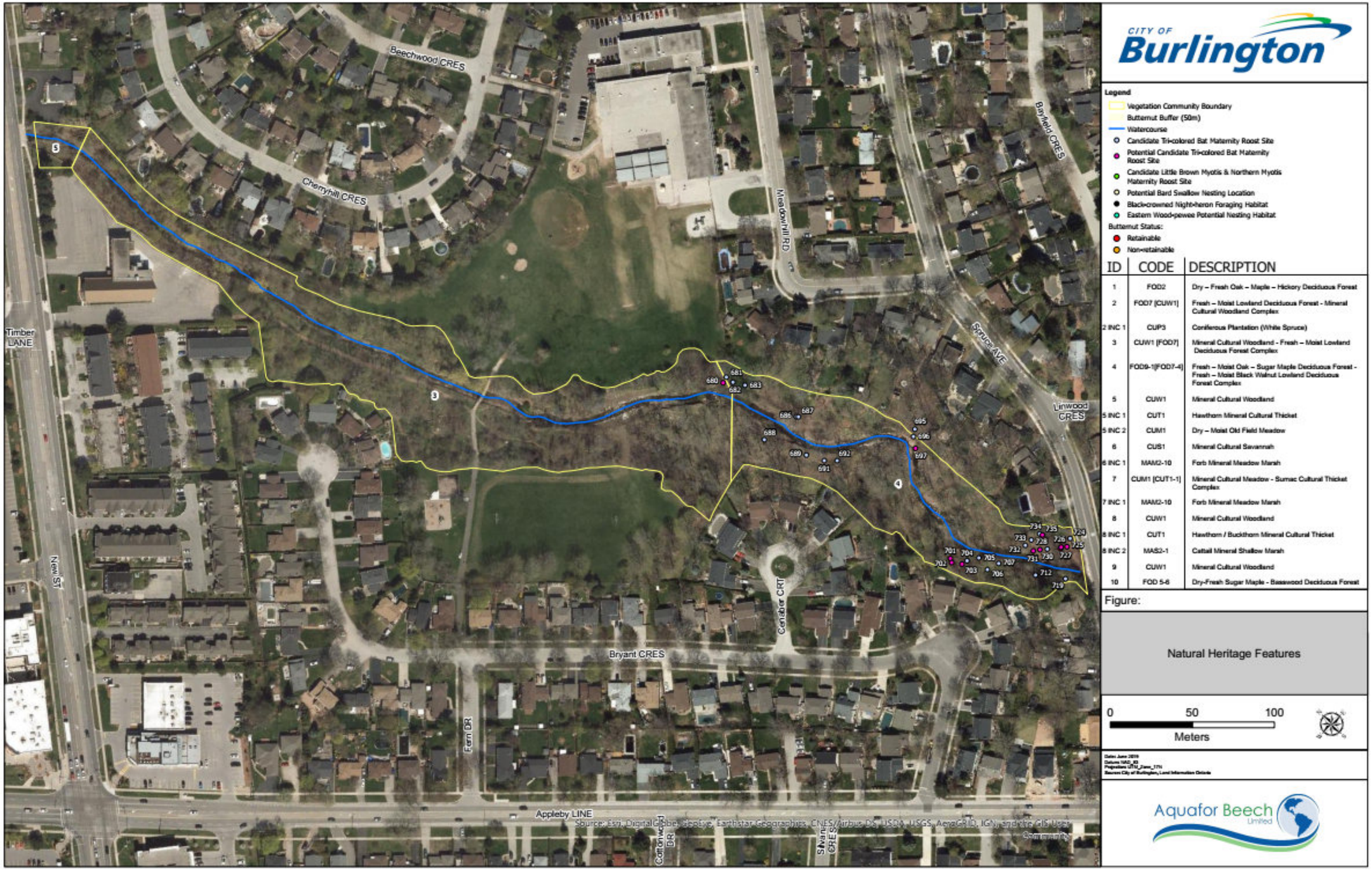


Figure 5-3: Natural Heritage Features 3 of 4



Figure 5-4: Natural Heritage Features 4 of 4

6 IMPLEMENTATION PROGRAMS

6.1 Considerations at Detailed Design

Upon completion of the EA, each project will require a detailed design process prior to construction. The detailed design will include additional technical investigations and inventories, with the primary deliverable a design package used for construction. This package will be subject to regulatory review and permitting. A brief overview of additional inventories and design package is summarized below.

For each project a detail design package will include the preparation of 60%, 90% and final design drawings for review by the City, CH and relevant stakeholders. A detail design package will include the following components:

- General plan (detailing structure, property lines and services);
- Site plan (including site access, staging and stockpile area delineation);
- Plan and profile drawings (detailing location of existing utilities and existing bridge);
- Erosion and sediment control plan (as per the Erosion and Sediment Guidelines for Urban Construction, GGHACA);
- Landscape restoration plan (including tree removal, preservation and planting plan);
- Storm outfall restoration plan;
- Sanitary sewer protection plan; and
- Associated design brief

As part of the design process, additional inventories and plans will be required to further inform the design.

6.1.1 Hydraulic Assessment

A hydraulic assessment of the proposed conditions would be undertaken and the results would be included in the associated design briefs. Computation of peak velocities for bank full and peak floods shall be included and incorporated into evaluation of the proposed remedial measures. The assessment will be used to confirm that no negative flooding impacts will result from the proposed works, a condition of the CH permit, and to size the material for the channel bed.

6.1.2 Geotechnical Investigations

Geotechnical investigations are recommended for Erosion Site 3, 7, 8 and 9 to assess the potential impacts of the proposed restoration works on the private property parking lots and stability and foundation requirements for the proposed armourstone retaining walls.

6.1.3 Utilities Confirmation

As discussed in **Section 3.10**, there are several utilities that might be impacted by the construction of the preferred alternatives. The utility identifications that were undertaken for this EA were done at a high level and involved reviewing GIS data, mapping and as-built drawings. Further investigation will be required to confirm the impact to the utilities.

Relocating or realigning utilities can be spatially restrictive, timely and potentially expensive; because of this it is recommended that the City initiate communications with the utility owners at the early stages of the detailed design. Communications will help confirm the location/existence of the utility, and get an understanding as to whether further steps (e.g., day lighting with HydroVac services) will be required.

By starting this process at the onset of the detailed design, this will allow for the utility modifications to be undertaken prior to the bridge reconstruction or to be well integrated into the construction staging.

6.1.4 Natural Heritage System

The following mitigation measures described in the impact assessment should be considered as a part of the detailed design and have been summarized below.

- An IGF should be completed for all Endangered and Threatened species within or potentially within the study area and submitted to the MECP for review before the detailed design phase to avoid project delays;
- Tree removals are recommended to occur outside of the breeding bird nesting period for forest birds in Burlington (i.e., April 10 to August 12). If site works must occur during the generalized nesting period, it is recommended that a qualified avian ecologist must conduct an active nest survey immediately prior to tree removal;
- All vegetation removed is replanted in accordance with the City of Burlington's Public Tree By-law 68-2013 (City of Burlington, 2013). Trees not exempt from compensation (see Section 6.1 for details) must be replaced with total combined diameter equal to or greater than that of the trees being removed; five (5) shrubs should be planted for every tree planted; and herbaceous seed mix should be seeded over disturbed areas that reflect a native-species riparian corridor;
- Restoration plans should be modeled after Fresh Moist Sugar Maple Deciduous Forest and trees selected for replacement should be tolerant of full to partial sun, and salt tolerant;
- Any Butternuts and their habitat that may be impact negatively should be tested for hybridity and MECP should be consulted before any work occurs within regulated area of a pure Butternut;
- Candidate maternity roost sites are cross referenced with proposed tree removals to determine if trees selected for removal are also candidate bat maternity roost sites. Trees should not be removed until surveys for candidate bat maternity roost sites have been completed and an Information Gathering Form (IGF) has been submitted to the MECP for review;
- All impacted natural areas should be restored with species native to the vegetation community disturbed and enhanced with plant species preferred by wildlife:

    - For Black-crowned Night-heron, it is recommended cattails (*Typha* spp.) and bulrushes (*Schoenoplectus* spp.) are incorporated into the restoration plan for disturbed areas where possible;
    - For Canada Warbler, foraging opportunities may be enhanced by planting insect-loving native tree species such as oaks (*Quercus* spp.), willows (*Salix* spp.), and maples (*Acer* spp.) and underplanting with a variety of native shrubs;

- For Monarchs and other butterflies, include milkweed (*Asclepias* spp.) for Monarchs, asters (Asteraceae) for painted lady, and nettles (Urticaceae) for red admiral;
- For landbirds including Eastern Wood-peewee, a variety of dogwoods (*Cornus* spp.), viburnums (*Viburnum* spp.), serviceberries (*Amelanchier* spp.), oaks (*Quercus* spp.), grape (*Vitis riparia*), and staghorn sumac (*Rhus typhina*) other native wildflowers suitable to the vegetation community disturbed to mitigate habitat loss;

- Dewatered areas must be subject to fish and wildlife rescues in accordance with MNRF protocols and should be conducted accordance with the warm-water timing window, July 1 to March 31;
- Areas used for access and staging should be restricted to paved surfaces as much as possible to minimize vegetation removal;
- Staging and access routes should be located away from Bromley Park and associated woodlands as much as possible to avoid disturbance to Eastern Wood-pewee;
- Vegetation should be removed before May 1st to reduce the chance of harming Monarchs as they migrate from its wintering habitat;
- Habitat features such as woody debris, rocks, etc. are retained on the landscape to maintain ecological features and habitat functions;
- Barriers to fish movement should be removed to improve aquatic habitat connectivity;
- Invasive species within disturbance areas should be removed and disposed of in landfill;
- Planted areas should be managed for sprouting invasive species until planted materials have become established;
- New bridge designs include a terrestrial bench that will accommodate medium sized mammals (i.e. the largest likely animals within the natural area such as raccoon and skunk) during normal flows; and
- Branches and roots should be pruned by a Certified Arborist prior to construction.

6.1.4.1 General Mitigation Measures

In addition to the mitigation measures that are specific to potential impacts, the following mitigation measures outlined below represent standard best practices and are not specific to any type of valued natural heritage feature or function. Rather, they may apply to some or all of the natural heritage features and/or functions and are to be implemented regardless of the results of further biophysical studies undertaken in support of the proposed works.

Erosion and Sediment Control

Erosion and sedimentation control techniques are necessary precautions to minimize sediment entry into surrounding creeks and/or storm sewer pipes. Installation of construction fencing and erosion & control silt fence are required well in advance of construction activities. Construction fencing and access routes shall be clearly delineated and appropriate setbacks maintained from private property for the duration of construction works. Sediment and erosion control measures should remain in place until vegetation has become established.

Sediment and erosion control measures should also act as wildlife exclusion fencing to prevent small mammals and herpetofauna from entering disturbance areas.

Public lands should be restored with woody vegetation as a part of bank stabilization efforts.

Potential sources for sedimentation related to construction activities include sediments disturbed and deposited by construction vehicles and blowing sand and dust. The following mitigating measures are proposed:

- Place sediment traps to receive storm runoff during construction;
- Provide tire washing facilities for construction vehicles that exit the sites;
- Install silt fencing along the perimeters of the work sites where appropriate to prevent migration of sediment-laden storm runoff;
- Cover exposed excavated material to prevent erosion by rain and wind; and
- Water or other dust suppressants to be employed during construction to control release of dust particles to the air.

Erosion and sediment control plan and the selection of appropriate measures will be addressed during the detailed design stage. The erosion and sediment controls indicated are the minimum that are required. It is necessary to ensure that all erosion and sediment control measures are functional prior to and throughout the duration of construction.

Fuel Spills

Fuel spills may occur during the onsite refueling of construction equipment, and may potentially contaminate surface and groundwater as well as soils. Recommended mitigation measures include the following:

- Refueling in designated areas outside of the NHS;
- Spill containment for on-site storage tanks; and
- Spill clean-up contingency plan.

Landowner Stewardship

As described in **Section 3.5.4.1**, dumping and encroachment is prevalent within the study area, especially in Reach 2. It is recommended that landowner stewardship is enacted for landowners adjacent to Appleby Creek. Stewardship programming/messaging should focus on dumping, tree cutting of City trees, and the benefits of landscaping with native species. Refuse within the creek corridor should be collected, removed, and disposed of appropriately.

Tree removals on private property within the NHS were documented on January 18 2019, west of Bromley Park. It is recommended the City of Burlington and/or Halton Region work with private landowners who removed trees on their property within the NHS to develop a restoration plan so that tree loss (and thus canopy cover and habitat) is compensated. This will not be included in the detailed design. Due to the low habitat quality currently within the Appleby Creek corridor, and the presence of invasive exotic species, it is not recommended that forests are left solely to reforest naturally.

6.1.5 Stage 2 and 3 Archaeological Assessment

The Stage 1 report recommends the following with respect to Stage 2 and 3 archaeological assessment:

1. The archaeological potential lands require Stage 2 archaeological assessment by test pit survey at five meters intervals, if impacted, prior to any proposed construction activities.
2. The Mount Vernon Pioneer Cemetery lies within the study area as exhibited by Figure 11 of Appendix D. All cemetery lands should be avoided by the project designs and a Stage 3 Cemetery Investigation will be required, where feasible, on any lands impacted by the project designs within 10 meters of the cemetery property to confirm the presence or absence of unmarked graves.

    a. A Stage 3 cemetery investigation entails the mechanical removal of topsoil around the cemetery, under the supervision of a licensed archaeologist. The exposed subsoil will then be shovel-shined and thoroughly examined for the presence of burial shafts.
    b. Any impacted lands at the top of the slope will require Stage 2 test pit survey prior to the Cemetery investigation to identify any near surface finds.

6.1.6 Easement / Permit to Enter Acquisition

The proposed design and construction access / staging areas involve works on private properties that the City currently do not have easements, including Erosion Site 1, 2, 3, 5, 7, and 9. Should erosion control works to be undertaken, land acquisition or easement negotiation may be required.

6.2 Environmental Approvals and Permitting

Prior to construction it will be necessary to coordinate environmental approvals and permits necessary to complete the intended works. At this time, it is Aquafor's understanding that reviews or approvals from CH, MNRF, DFO, and the City's may be required. A brief summary of permits and approvals is included below:

As detailed in **Section 3.8.2.3**, permits from the City of Burlington will be required prior to tree removals. As the proposed development is within lands regulated by the CH, a permit from the Authority will be required to support the development. Additionally, a DFO Review is needed to comply with provincial policy.

CH – O. Reg. 166/06 Permit - This typically involves two submissions (70% & 95% design), and will include supporting design brief information.

DFO – Assessment under the Federal Fisheries Act – A certified fisheries biologist will complete a Self-Assessment based on the detailed design for the proposed works. Based on similar experiences, at minimum a Letter of Advice may will be required from DFO.

MNRF 17(2) (b / c) Species at Risk Permit – Depending on the results of the IGF and further field investigations, MNRF will confirm whether a SAR permit may be required.

City of Burlington – Site Alternation and Tree Removal Permits – All approvals from the City's Capital Works and Parks Department will be required, which will regulate excavation / fill and disposal of earth from any lands within the City and provide guidance to tree protection and restoration.

6.3 Construction Services

All tender documentation will be completed applicable to the City of Burlington or CH standards, with Special Provisions and Schedule of Quantities with refined engineering cost estimates provided. The package will include Project Descriptions, Special Provisions, Specifications, Form of Tender and a Schedule of Prices. The final detailed design drawings will be issued as a set of contract drawings with the completed tender package. The contract drawings will be stamped by a professional engineer, signed, and labeled “Issued for Tender” complete with all necessary material and performance specifications. Aquafor will typically assist the City during the tendering and procurement period as required, providing responses and clarification to bidders during the procurement process.

Inspection and administration services during construction under the guidance of a professional engineer (or geomorphologist) who has been integrated in the design and well versed in similar construction projects. Tasks undertaken as part of the supervision role will include:

- Attend regular (bi-weekly) progress meetings, including pre-construction meeting, prepare and distribute meeting minutes within 3 days of the meeting;
- Respond to inquiries and request for information from external agencies, public stakeholders;
- Preparation of progress payment certificates and recording material quantities as they arrive to site;
- Overseeing the day-to-day construction and providing interpretation of the drawings;
- Ensuring that contractor’s methodology complies with requirements of design;
- Monitor the traffic control measures to ensure they are consistent with traffic control plans;
- Inspect all layout and construction work to ensure compliance with the contract specifications and drawings;
- Provide advice to the contractor regarding the interpretation of the contract drawings and specifications and the preparation of supplemental details, instruction and clarifications as required;
- Notify the contractor of any deficiencies in the construction of the work, instructing the contractor to take appropriate corrective measures, confirm and report results of the corrective measures during construction. The deficiency list will be maintained and coordination of rectification throughout the 2-year maintenance period;
- Review, monitor and ensure compliance with contractor environmental conditions (i.e. Erosion and Sediment Control Plan).
- Preparation and issuance of substantial Performance certificate and recommendations; and
- Undertake a complete and thorough inspection of the contractor’s work and prepare a report which lists all outstanding deficiencies at the end of the warranty period and coordinate and ensure that contractor corrects all warranty deficiencies expeditiously and to the satisfaction of the City.

6.4 Monitoring Program

It is recommended that a monitoring plan be implemented which shall document the success of restoration plantings. The primary goals of the monitoring plan is to ensure that new plant material can reach the free to grow stage, and to identify potential need for adaptive

management measures. The free to grow (FTG) stage is defined as the point at which 90% of woody plantings have surpassed the average height of adjacent grasses and forbs, and presumably will not be outcompeted.

Table 6-1 lists the key restoration performance measures recommended for inclusion in the monitoring plan, along with frequency and duration of monitoring activities, and adaptive management actions related to each performance measure. Each monitoring parameter is to be included in a monitoring plan which is recommended to occur in years 1, 3, and 5 post-construction, subject to monitoring results. Additional monitoring at year 10 may be required if monitoring results in years 1-5 do not provide reasonable confidence that the restoration plantings will succeed over the long term. It is recommended that a minimum of five (5) permanent vegetation monitoring plots be established for monitoring, with locations to be confirmed as part of the approvals for the restoration plan (e.g. in consultation with the City of Burlington, Region of Halton, and Conservation Halton).

Table 6-1: Monitoring, Targets, and Adaptive Management Actions for Restoration Plantings

Performance Measures	Location	Targets	Potential Outcomes	Adaptive Management Actions
Survival: Quantitative assessment of the establishment and survivorship of planted woody and herbaceous material. The survivorship of woody material should be assessed according to each size category of plan material used.	· Throughout site · Permanent monitoring plots	75% survival rate for planted material.	≥75% of planted material has survived.	· Report findings; no further action required.
			<75% of planted material has survived.	· Investigate causes of plant mortality and document findings. · Remediate causes of plant mortality. · Replace planting material as required within warranty period.
			Unbalanced survivorship among some plant types and/or species.	· Investigate causes of unbalanced survivorship and document findings. · Remediate causes of imbalance. · Provide mitigation measures such as increased rodent protection, invasive species removal, etc. · Replace planting material within warranty period.
Growth Rate: Quantitative assessment of the growth rate (e.g. last year's growth) of planted woody material. Growth rate should be assessed according to each size category of plan material used.	· Throughout site · Permanent monitoring plots	Establish and achieve varied height and cover targets to achieve structural diversity.	Structural diversity evident after 5 years.	· Report findings; no further action required.
			Unbalanced growth performance of some plant species and/or sizes. Structural diversity not evident after 5 years.	· Investigate causes of unbalanced survivorship and document findings. · Remediate causes of imbalance. · Provide mitigation measures such as increased rodent protection, invasive species removal, competition control, etc.
Free to Grow (FTG) Performance: Quantitative assessment of the percentage of woody plants that achieve FTG status.	· Throughout site · Permanent monitoring plots	FTG status achieved within 5 years after planting.	FTG status achieved within 5 years.	· Report findings; no further action required.
			FTG status not achieved within 5 years.	· Investigate possible causes of poor performance; document findings. · Remediate causes. · Provide mitigation measures such as increased rodent protection, invasive species removal, competition control, mulching, etc.

Performance Measures	Location	Targets	Potential Outcomes	Adaptive Management Actions
Invasive Species: Invasive species have the potential to outcompete planted material and negatively affect the structural diversity and ecology of the RNHS. Several invasive species, such as Garlic Mustard, Periwinkle, and European Buckthorn, have been identified on site.	· Throughout site · Permanent monitoring plots	Less than 5% of planted areas colonized by invasive species.	<5% of restored areas colonized by invasive species.	· Report findings; no further action required.
			≥5% of restored areas colonized by invasive species.	· Document, map, and photograph incident location(s); describe and map details of current extent. · Advise applicable review agencies of findings within 2 weeks of discovery. · Assess the risk of the species spreading. · Undertake invasive species removals as soon as possible. · Report observations and follow-up actions. · Monitor outcomes of control measures.
Erosion: Quantitative and qualitative measurement of erosion sites, especially near watercourse.	· Throughout site	Erosion location and severity identified and addressed.	Erosion sites and erosion severity identified.	· Document, map, and photograph incident location(s); describe details. · Remediate cause(s) of erosion. · Report observations and follow-up actions. · Advise applicable review agencies of findings within 2 weeks of discovery. · Monitor outcomes of control measures.
Disturbance and Encroachment: Encroachments and disturbance (e.g. dumping, unauthorized trails, vandalism, etc.) should be documented and mapped.	· Throughout site	Encroachments identified and addressed.	Encroachments within restoration areas identified.	· Document, map, and photograph incident location(s); describe details. · Identify potential negative impacts. · Report observations and follow-up actions. · Advise applicable review agencies of findings within 2 weeks of discovery. · Monitor outcomes of control measures.

6.5 As-Constructed Drawings and Analysis

This task will set baseline conditions following construction, which will enable future monitoring and comparative analysis. Specifically, Aquafor will undertake an as-built survey of completed channel works (plan, profile, and cross sections) to verify implementation of design within reasonable tolerances. As-constructed drawings, together with a report summarizing pre- and post-construction conditions would be provided. The report would comment on significant deficiencies found with recommendations for correction or adaptive management as required.

The HEC model shall be updated to match as-built conditions (should the comparative analysis to the design highlight differential condition), Aquafor will update the HEC model accordingly to confirm no negative impacts to flooding.

7 CONCLUSIONS AND RECOMMENDATIONS

This study was carried out as a Schedule B project under the Class Environmental Assessment for Municipal Water and Wastewater Projects and is subject to the requirements of the Environmental Assessment Act. This document provides relevant information with respect to Phases I and II of the Environmental Assessment Process. Subsequent phases of the process will involve completion of contract drawings and documents for all proposed works together with appropriate monitoring requirements.

7.1 Conclusions

Changes to the hydrologic regime resulting from urbanization within the watershed have led to erosion issues within Appleby Creek as well as degradation to the natural heritage system. Seven erosion sites were identified within the City-wide Creek Inventory and Erosion Assessment (Water's Edge, March 2016) as low to moderate priority. This study investigated these sites and identified a total of twelve erosion sites and four maintenance sites. A series of remedial alternatives were developed for each erosion sites, evaluated systematically to determine the preferred alternative. The process included public consultation as well as consultation with other stakeholders. The preferred alternative for each site has been developed and selected to achieve the study goals of reducing erosion as well as preserving / enhancing terrestrial and aquatic habitat. The remedy of erosion sites has also been prioritized based on level of risks and property ownership, which is listed as follows:

- Project 1: Erosion Site 8 – Local Restoration Works;
- Project 2: Erosion Site 1A & 1B – Comprehensive Reach Scale Works;
- Project 3: Erosion Site 9A – Local Restoration Works, Erosion Site 9B - Comprehensive Reach Scale Works;
- Project 4: Erosion Site 7A & 7B – Comprehensive Reach Scale Works;
- Project 5: Erosion Site 3 – Local Restoration Works;
- Project 6: Erosion Site 5 – Comprehensive Reach Scale Works;
- Project 7: Erosion Site 6 – Local Restoration Works;
- Project 8: Erosion Site 2 – Comprehensive Reach Scale Works; and
- Project 9: Erosion Site 4 – Local Restoration Works

Conceptual designs have been prepared for the preferred alternative at each site. Following completion of this report, detailed design and construction would be undertaken to implement the preferred alternatives and remedy of identified problems. The suggested implementation order should be integrated with considerations of the overall City priorities, budgets, and stakeholder interests.

7.2 Recommendations

During the study, recommendations for site investigations and implementation measures were identified. These items should be taken into consideration during the detailed design and include the following items:

- Obtain easements / Permit to Enter where creek traverses privately owned property;
- Undertake a geotechnical investigation;

- Undertake a utility locate where information is deemed necessary as part of a higher SUE Level survey;
- Undertake a detailed topographic survey if additional information is deemed necessary to reflect the current states at sites;
- Prepare for DFO review and IGF for MECP reviews when the detailed design takes place;
- Undertake Stage 2 and 3 Archaeological Assessment;
- Complete a geomorphic analysis of channel hydraulics and tractive forces;
- Determine appropriate construction staging and erosion and sediment controls; and
- Obtain approvals from Conservation Halton and fish collection permit from MNRF, and potentially Species at Risk Permit from MNRF and a Letter of Advice from DFO.

8 REFERENCES

Bezener, A. (2000). *Birds of Ontario.* Edmonton: Lone Pine Publishing.

Cadman, M. D. (2007). *Atlas of the Breeding Birds of Ontario, 2001-2005.* Toronto: Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Natur.

Canada Department of Agriculture and the Ontario Agricultural College. (1971). *Soils of Halton County.* Toronto: Ontario Deparment of Agriculture and Food.

Chapman, L., & Putnam, D. F. (1984). *The Physiogrpahy of Southern Ontario* (Vol. Third Edition). Ontario: Ontario Ministry of Natural Resources.

Chu, C., Jones, N. E., Piggott, A. R., & Buttle, J. M. (2009). *Evaluation of a Simple Method to Classify the Termal Characteristics of Streams Using a Nomagram of Daily Maximum Air and Water Temperatures.* Peterborough: AMerican Fisheries Society.

Clean Water Act - General, O. Reg 287/07, s.1.1(1). (n.d.).

Clean Water Act, S.O. 2006, c. 22. (n.d.).

Conservation Halton. (2018). *Native Species List.* Retrieved from https://www.conservationhalton.ca/uploads/native_species_list_aug2018.pdf

Conservation Halton. (2018). *Road Ecology Best Management Practices Quick Reference Guide.* Conservation Halton.

COSEWIC. (2016). *COSEWIC assessment and status report on the Monarch Danaus plexippus in Canada.* Ottawa: Committee on the Status of Endangered Wildlife in Canada. Retrieved from https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Department of Fisheries and Oceans. (2016, November 18). *Projects Near Water*. Retrieved from Fisheries and Oceans Canada: http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

Gillespie, J. E., & Wicklund, R. E. (1971). *The Soils of Halton County, Report No. 43 of the Ontario Soil Survey.*

Government of Ontario. (2018, 10 18). *Canada Warbler*. Retrieved 01 21, 2019, from Ontario.ca: https://www.ontario.ca/page/canada-warbler

Halton-Hamilton Source Protection Committee. (2017). *Assessment Report - Halton Region Source Protection Area.*

Lee, J. (2017, October 13). Email: Request for Digital Data for Appleby Creek Flood Mitigation EA. Burlington, Ontario, Canada.

Ministry of Transportation Ontario. (2009, June). Environmental Guide for Fish and Fish Habitat, Section 4: Field Investigations. St. Catharines, Ontario, Canada.

MNRF. (2017, November). Appleby Creek Flood Relief. Aurora, Ontario, Canada.

MNRF. (2018, July). Request for Information for the Appleby Creek Erosion Control EA, Town of Oakville. Aurora, Ontario, Canada.

NHIC. (2018, 12 16). Ontario Birds. Ontario, Canada.

OMNRF. (2017, April). Survey Protocol for Species at Risk Bats within Treed Habitats Little Brown Myotis, Northern Myotis & Tri-colored Bat. Guelph, Ontario, Canada: Ontario Ministry of Natural Resources and Forestry.

Water's Edge. (March 2016). *Creek Inventory and Erosion Assessment.*

Appendix A –

Existing Conditions Plan and Profile Drawings

Appendix B –

Storm Sewer Outfall Inventory and Mappings

Appendix C –

Natural Environment Information

Appendix D –

Archaeological and Cultural Heritage Assessment Report

Appendix E –

Detailed Alternative Evaluations

Appendix F –

Public Consultation

Appendix G –

Conceptual Design Drawings for the Preferred Alternatives