Prepared for:

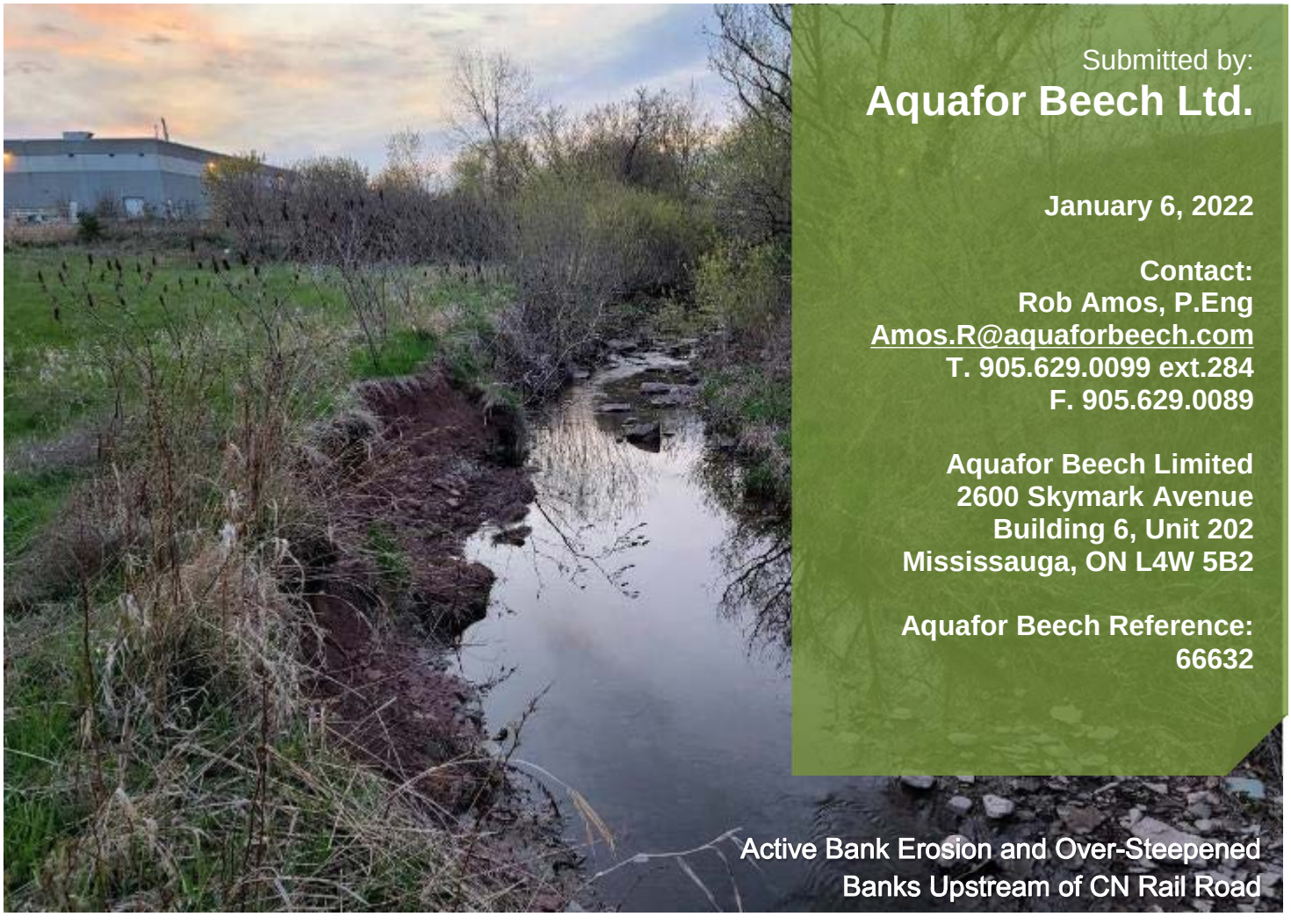
The Corporation of the City of Burlington
426 Brant Street
City Hall
Burlington, ON L7R 3Z7

Attn: Mr. Arif Shahzad, P.Eng

Tuck Creek Erosion Control Environmental Assessment

Harvester Road to Hydro Right of Way, Palmer Drive to CNR & Dundas Street to Headon Road

Project File Report



Active Bank Erosion and Over-Steepened Banks Upstream of CN Rail Road

Submitted by:
Aquafor Beech Ltd.

January 6, 2022

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66632

EXECUTIVE SUMMARY

Introduction

The Tuck Creek watershed has an area of about 10.6 km^2; its headwaters originate on the Niagara Escarpment and the watercourse drains to Lake Ontario running to the south-west of Walkers Line. Tuck Creek exhibits varying conditions throughout its length, ranging from an entirely natural state to portions which have undergone some degree of channelization.

The Burlington City-Wide Creeks Inventory and Erosion Assessment, completed in March 2016, highlighted numerous erosion risks and hazards, out of which one (1) site falls within this EA study. In response to the results from the City-wide study, the City of Burlington retained Aquafor Beech Limited to complete an erosion control Municipal Class Environmental Assessment for three (3) segments of Tuck Creek. The study area for this EA was defined as extending from Harvester Road to Hydro Right of Way (ROW), Palmer Drive to CN Rail, and Dundas Street to Headon Road.

Study Objectives

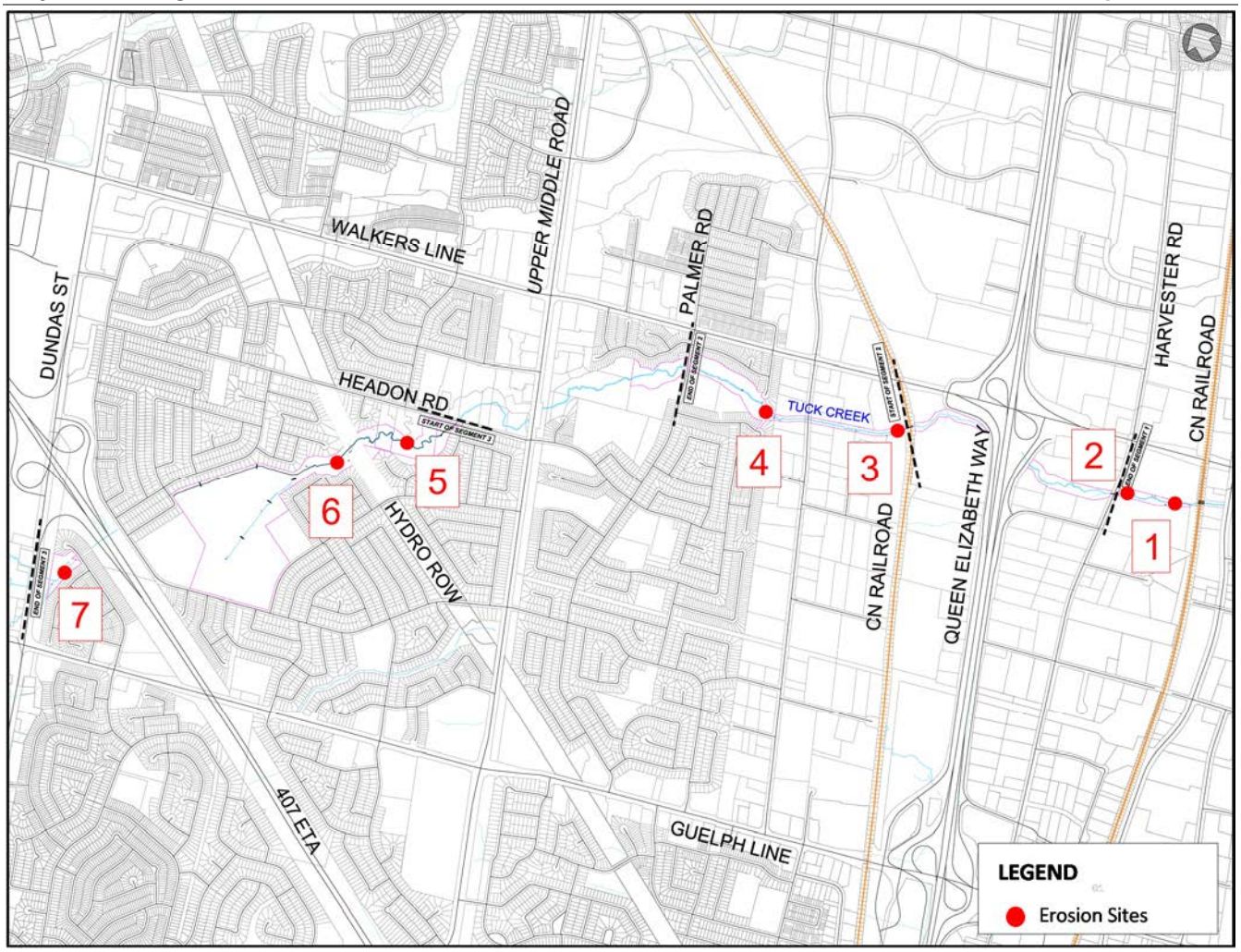
The intent of the study was to assess the existing conditions within the study area and develop alternatives to address the erosion hazards at identified sites. In developing these alternatives, the study team took into consideration the four principal objectives of the study:

- 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 First Nation Communities, regulatory agencies and stakeholders throughout the process, and
- Compliance with the Municipal Class EA process.

Phase I: Identification of Problems and Opportunities

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

- Replacement of failing bank protection treatments with new enhanced bank protection treatments;
- Channel widening and use of natural channel materials (bioengineering) where 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: Reach Scale Works*** – This alternative consists of a comprehensive approach, which is typically reach-based, to fully address erosion issues throughout the site.

A set of criteria were then developed to evaluate the alternatives on a site-by-site basis:

- Physical / Natural Environment
  - Mitigation of existing erosion risks;
  - Impacts to aquatic and/or terrestrial habitat;
- Technical and Engineering
  - Technical feasibility;

  - Flooding impacts
- Social / Cultural Environment
  - Parks and recreation
  - Community disruption;
  - Archaeological impacts;
- Economic Environment
  - Construction costs;
  - Operation and maintenance costs;
  - Life cycle costs;
  - Infrastructure protection.

Public Consultation

A Public Information Centre (PIC) was held on December 15, 2020. Due to the Public Health Emergency related to COVID-19, an Online Public Information Centre was held to the public. A series of presentation slides were presented which outlined the study background, problems, opportunities, alternatives, and the 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.

First Nations Consultation

This project has included consultation with the following communities who have been identified as potentially affected by the proposed project:

- Haudenosaunee Development Institute
- Huron-Wendat First Nations
- Six Nations of the Grand River
- Mississaugas of the Credit First Nations

Consultation included written correspondence with each community, as well as review of the Stage 1 Archaeological study. Each community responded noting their interest in participation through Field Liaison Representatives during onsite natural environment or archaeological fieldwork. The City of Burlington will accommodate these requests, which will occur at the detailed design phase of the project. The following sites will have Stage 2 Archeological assessments: Erosion Sites 1, 2, 4 and 5, and each project will have natural environment inventories.

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 seven (7) erosion sites are listed below:

- Erosion Site 1: Alternative 3 – Reach Scale Works
- Erosion Site 2: Alternative 3 – Reach Scale Works
- Erosion Site 3: Alternative 2 – Local Restoration Works
- Erosion Site 4: Alternative 3 – Reach Scale Works

- Erosion Site 5: Alternative 2 – Local Restoration Works
- Erosion Site 6: Alternative 3 – Reach Scale Works
- Erosion Site 7: Alternative 2 – Natural Design

Priority Ranking and Estimated Costs

The preferred alternatives have been prioritized into seven (7) projects and the estimated costs are summarized in the table below. The project prioritization is based on an erosion sites field scoring assessment. While the project cost estimates and time horizon are to provide the City with direction on project priorities, decisions on the actual order and implementation of projects should also give consider to 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	840 Walkers Line / Erosion Site 1 / Reach 1 / Length ~ 210m	City & Private	Bank erosion, erosion risk to storm outfall, and channel extending into private property	$925,000	0-2 years
2	CN Rail Road / Erosion Site 3 / Reach 2 / Length ~ 50m	City & Private	Degradation of existing erosion control structures, flow obstruction	$575,000	0-2 years
3	Harvester Road / Erosion Site 2 / Reach 1 / Length ~ 95m	City	Bank erosion, failing armourstone retaining wall, channel bifurcation	$1,100,000	2-5 years
4	Kettlebey Court / Erosion Site 4 / Reach 2 / Length ~ 160m	City	Bank erosion adjacent to private property, and sediment accumulation in front of storm outfall	$1,250,000	2-5 years
5	Ireland Park / Erosion Site 6 / Reach 3 / Length ~ 20m	City	Failed / failing grade control and erosion control structures, local bank erosion, barriers to fish passage	$120,000	2-5 years
6	Driftwood Park / Erosion Site 7 / Reach 3 / Length ~ 15m	City	Bank erosion adjacent to private property	$60,000	5-10 years
7	Hydro ROW / Erosion Site 5 / Reach 3 / Length ~ 45m	City	Degrading of armourstone retaining wall structures	$950,000	5-10 years

Conclusions and Recommendations

The preferred alternatives at Erosion Sites 1-7 achieve the study goals to reduce erosion and preserve/enhance fisheries. Following completion of this report, detailed design and construction will be undertaken to implement the preferred alternatives and remedy the identified problems.

Recommendations for site investigations and implementation measures should be taken into consideration during the detailed design and include the following items:

- Obtain easements / Permit to Enter where creeks encroach into privately owned property. Erosion Sites 1 and 3 requires temporary easements or permission to enter;
- Undertake a geotechnical investigation for Erosion Sites 2 and 6;
- Undertake utility locates where information is deemed necessary as part of a higher SUE Level (C/A) survey;
- Undertake a detailed topographic survey if additional information is deemed necessary to reflect the current site conditions;
- Prepare for DFO review and an IGF for MECP review as part of the detailed design process;
- Undertake Stage 2 Archaeological Assessments for Erosion Sites 1, 2, 4 and 5 as required;
- Engage First Nations for their field liaison representation during the Stage 2 Archaeological Assessments and natural environment inventories;
- 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 a fish collection permit from MNRF, and potentially a Species at Risk Permit from MNRF and a Letter of Advice from DFO.

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1 INTRODUCTION

1.1 Overview

The Tuck Creek watershed has an area of about 10.6 km^2, with headwaters originating on the Niagara Escarpment. The watercourse drains into Lake Ontario through the City of Burlington, flowing south-west of Walkers Line. Tuck Creek exhibits varying conditions throughout its length, having been urbanized and constrained to accommodate urbanization, notably within residential neighborhoods and mixed-use commercial land use.

Tuck Creek is comprised of multiple headwater tributaries which join to form a single main branch north of Upper Middle Road. The channel exhibits varying conditions throughout its length, ranging from an entirely natural state to portions which have undergone channelization. The watershed soils are primarily loams and clay loams with relatively low infiltration capacities. Tuck Creek has only two minor tributaries that converge near the upstream end of the creek within Ireland and Driftwood Park.

Within the urban boundary, Tuck Creek exhibits erosion and flooding issues. A previous City-Wide Creeks Inventory and Erosion Assessment (2016) identified numerous erosion risks and hazards which are further elaborated on 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 Municipal Class Environmental Assessment (EA) services to complete the Tuck Creek Erosion Control EA study, providing further insight into the existing conditions and risks along the corridor.

The EA study area is divided into three (3) sections: Harvester Road to Hydro Right of Way (ROW), Palmer Drive to CN Rail, and Dundas Street to Headon Road. This EA has been carried out to identify and address the channel erosion and slope destabilization within the Tuck Creek, addressing risks to 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 as at risk. The general extents of the study area are presented in **Figure 1-1**.

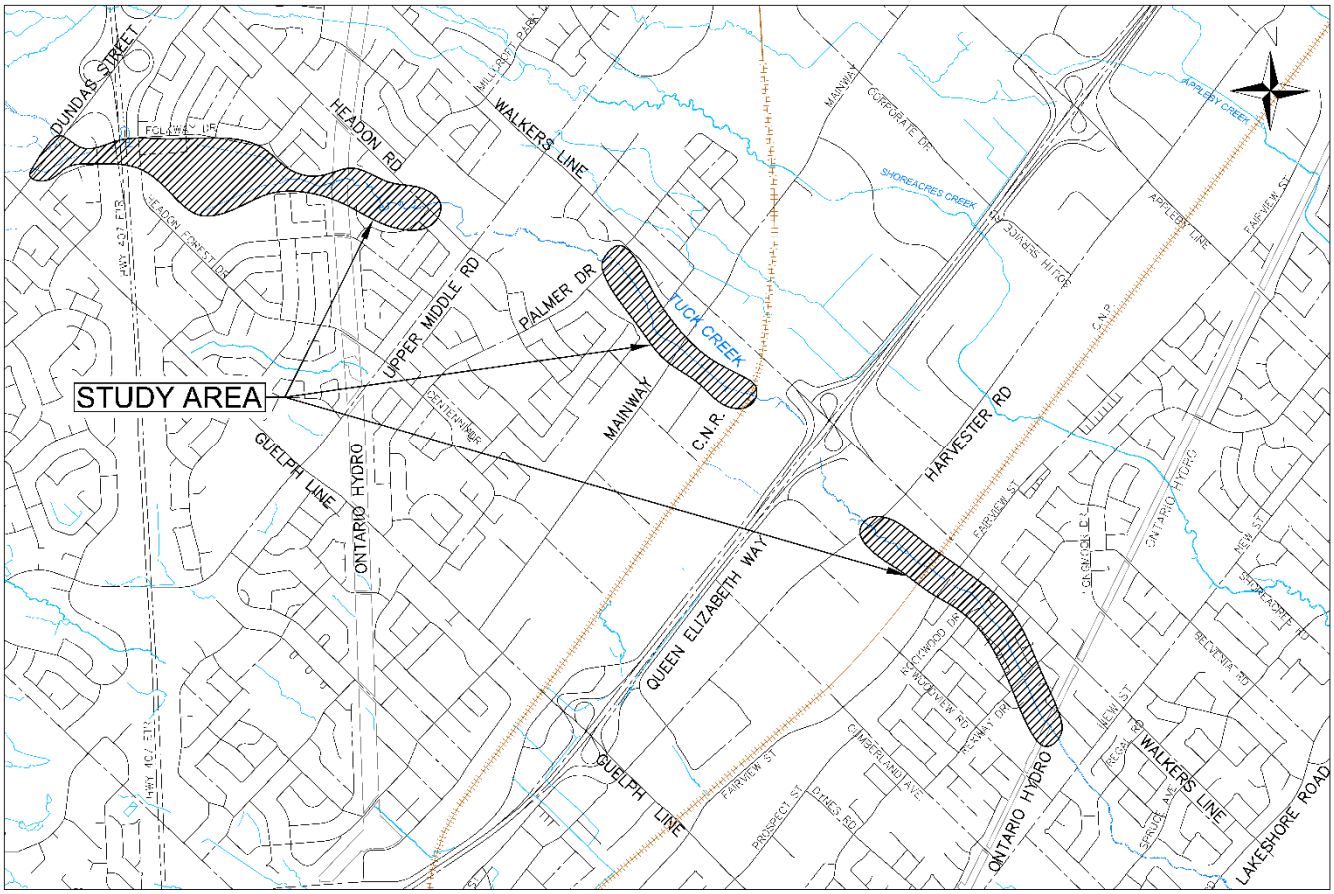


Figure 1-1: Study Area Map

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 MECP 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 (implementation) to follow. This Project File is intended to fulfill the consultation and documentation requirements of a Class EA Schedule B project by addressing the erosion related issues along Tuck Creek, and providing additional site-specific information to refine the development of the preferred solution.

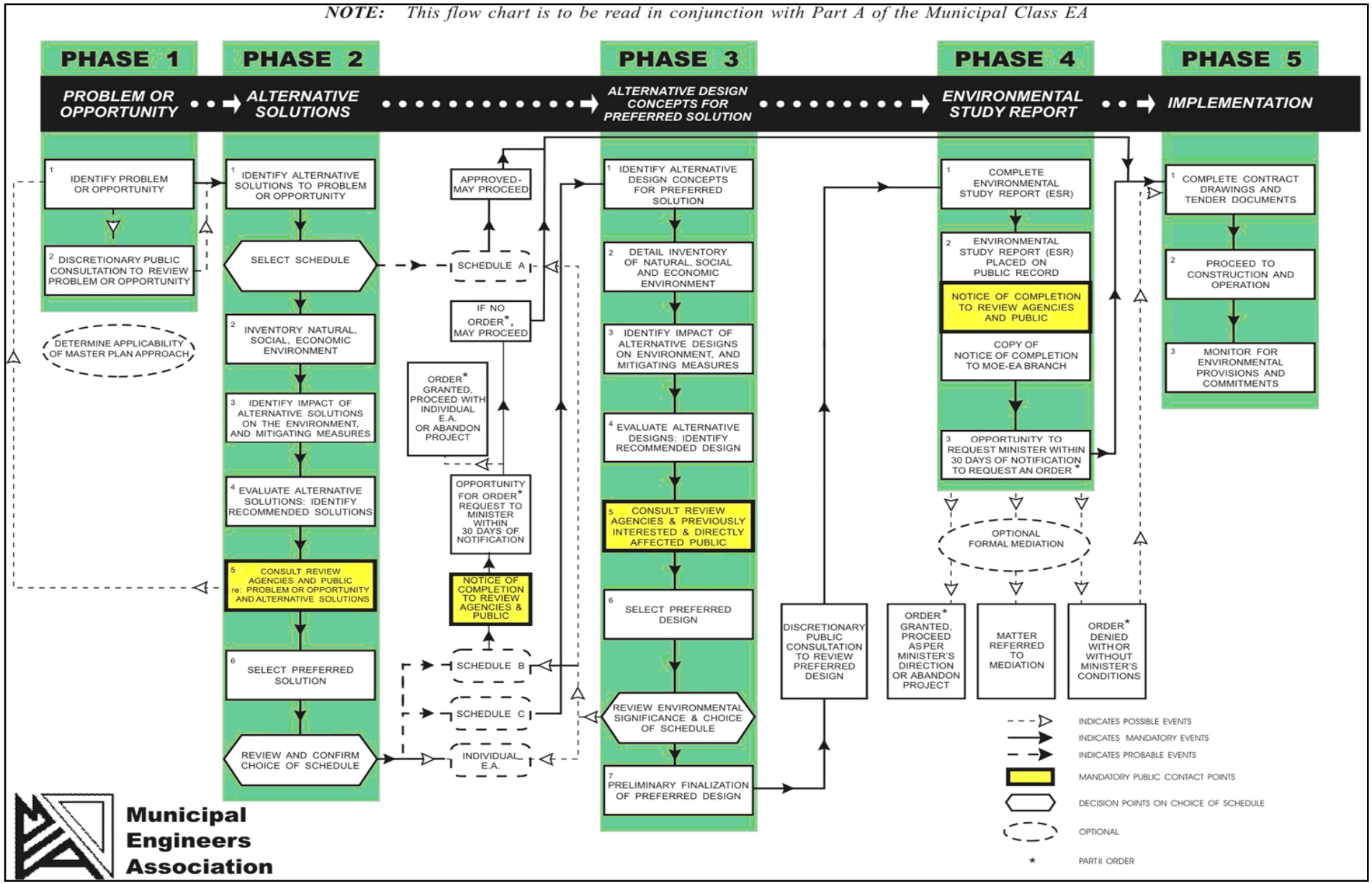


Figure 1-2: Municipal Class Environmental Assessment Planning and Design Process

1.3 Study Team

The consultant team for the Tuck Creek Erosion Control EA is led by Aquafor Beech Limited and included: ASI for archaeological assessment. A summary of specific areas of expertise are provided below:

- Robert Amos – Project Manager
- Sachet Siwakoti – Project Coordinator and Engineer
- Julie Scott – Ecology Lead
- Darcy Laframboise – ISA Certified Arborist
- Graham Eby – Aquatic Biologist
- Palka Sharma – Drafting Technician
- Lisa Meritt – Archaeology Project Manager (ASI)

1.4 Background Study

The City-wide Creek Inventory and Erosion Assessment was completed in 2016, which identified ten erosion sites ranking from low priority to moderate priority. However, only one (x1) erosion site is identified in the City-Wide Creek Inventory and Erosion Assessment study. The remaining sites identified in the City-Wide Creek Inventory study do not fall under the scope of this EA study area. 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 located immediately upstream of the Hydro Corridor and downstream of Headon Forest Drive. This straightened channel is attempting to meander outflanking a concrete weir, and is causing the continual upheaval of the cable Crete lining.

The information provided in the City-wide Creek Inventory was used as the basis for the EA study and the identified risks and opportunities were included in the analysis and evaluation of alternatives throughout this assessment.

1.5 Study Purpose and Primary Tasks

The primary objective of the study is to assess the existing conditions of Tuck 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 Tuck 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

The Tuck Creek watershed has an area of about 10.6 km^2, draining into Lake Ontario through the City of Burlington south-west of Walkers Line. Tuck Creek consists of headwater tributaries, originating on the Niagara Escarpment, which joins to form a single main branch north of Upper Middle Road. Tuck Creek exhibits varying conditions throughout its length, having been highly urbanized and constrained to accommodate urbanization particularly within residential neighborhoods and mixed-use commercial land use. This EA focuses on three reaches of Tuck Creek. The cumulative length of the study area is 5 km in channel length from Hydro Right of Way to Harvester Road, CN Rail to Palmer Drive, and Dundas Street to Headon Road. The creek is confined to a corridor ranging from 20m – 35m wide, with private residential properties lining the top of the slope. At the upstream end of the study area towards Dundas Street land use is a combination of mixed commercial, light industrial, as well as open parkland.

To accommodate urban growth, sections of Tuck Creek were historically channelized with intermittent engineered treatments implemented, including gabion lining, vegetated embankments, and concrete weir structures. Under these conditions, where creeks have been channelized and confined, issues with respect to erosion are prevalent. Aquafor has performed a detailed investigation and the key issues observed within the study area are summarized below:

- Erosion of private properties including property lines, fences, yards;
- Bank erosion where channel planform migration (and erosion) is evident;
- Lowering of channel beds;
- Deterioration of erosion control structures;
- Undermining and undercutting of erosion control structures;
- Watercourse enlargement and widening;
- Creation of barriers to fish migration.

These issues represent risks to municipal infrastructure, roadway embankments, private properties, as well as the natural environment.

Seven (7) areas of risk were identified within the study area based on the field investigation, with the general proximity of these areas illustrated in Figure 2-1. Descriptions and photos of each erosion site are included in the sub-sections below. These seven (7) sites include one (1) of ten (10) erosion sites identified in the City-Wide Creek Inventory and Erosion Assessment study. The remaining sites identified in the City-Wide Creek Inventory study do not fall under the scope of this EA study area.

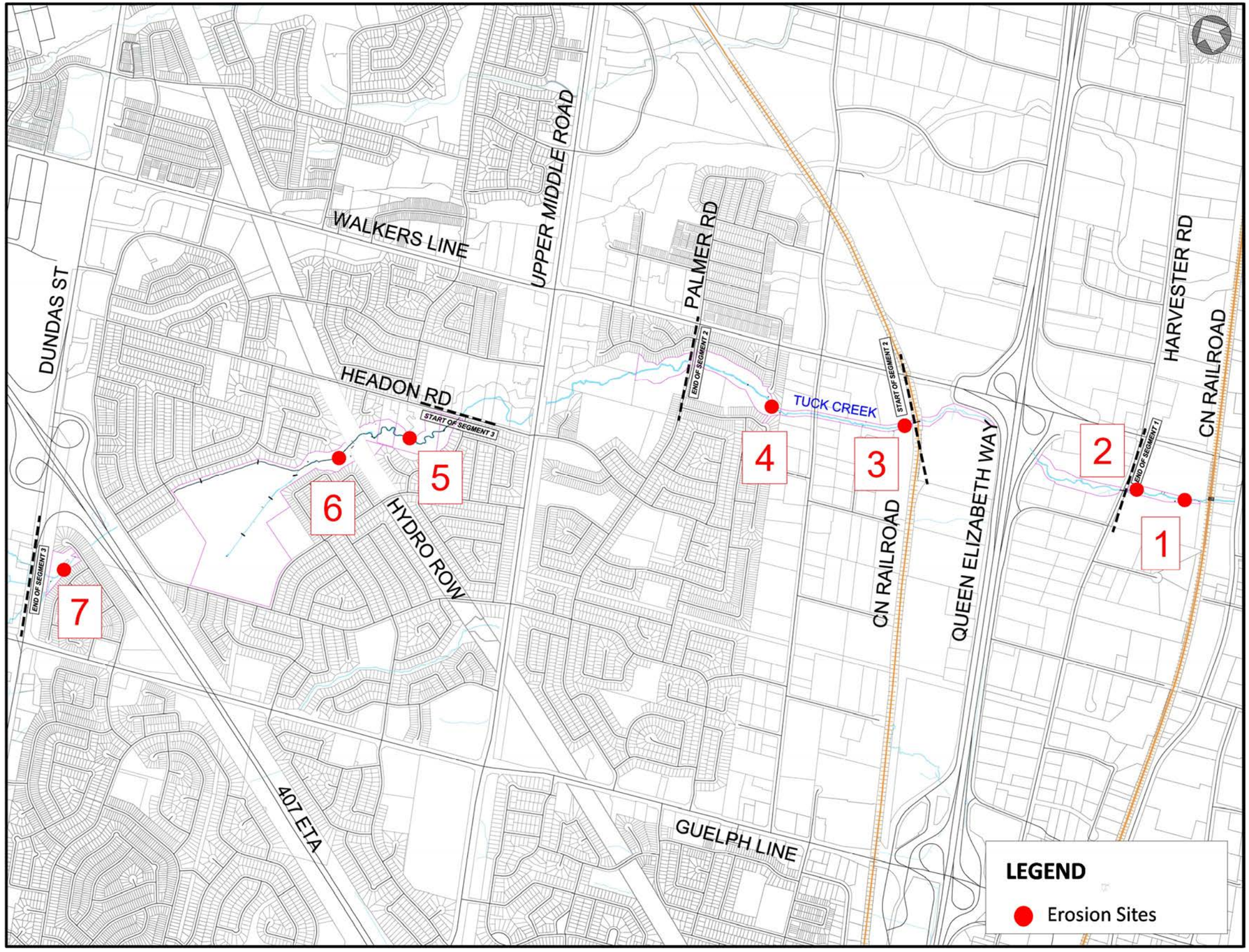


Figure 2-1: Erosion Sites within Tuck Creek

2.1.1 Erosion Site 1 – Active Bank Erosion, Deteriorated Outfall Headwall, and Failed Bank Protection

At Erosion Site 1, Tuck Creek is actively eroding along both sides of the creek creating risks to City infrastructure and private property. As a result of the ongoing erosion, the watercourse has encroached outside of the City owned corridor and into private property. The site is highly confined is without sufficient floodplain relief opportunities. The channel bed consists of riprap and detached shale particles. A City owned 1650mm ø storm outfall discharges perpendicular into Tuck Creek and is in a vulnerable state. The bank is recessed upwards of two (2) meters, leaving the concrete headwall exposed within the watercourse. Local private property owners have modified the creek banks in an attempt to mitigate active bank erosion by placing down large pieces of concrete debris. A drawing providing an overview of the existing site conditions is included on the following page.



Photo 2-1: Deteriorating 1650 mm Outfall Headwall due to Erosion



Photo 2-2: Active Bank Erosion and Over-Steepened Banks



Photo 2-3: Failed Bank Protection Using Concrete Debris placed by Local Landowners

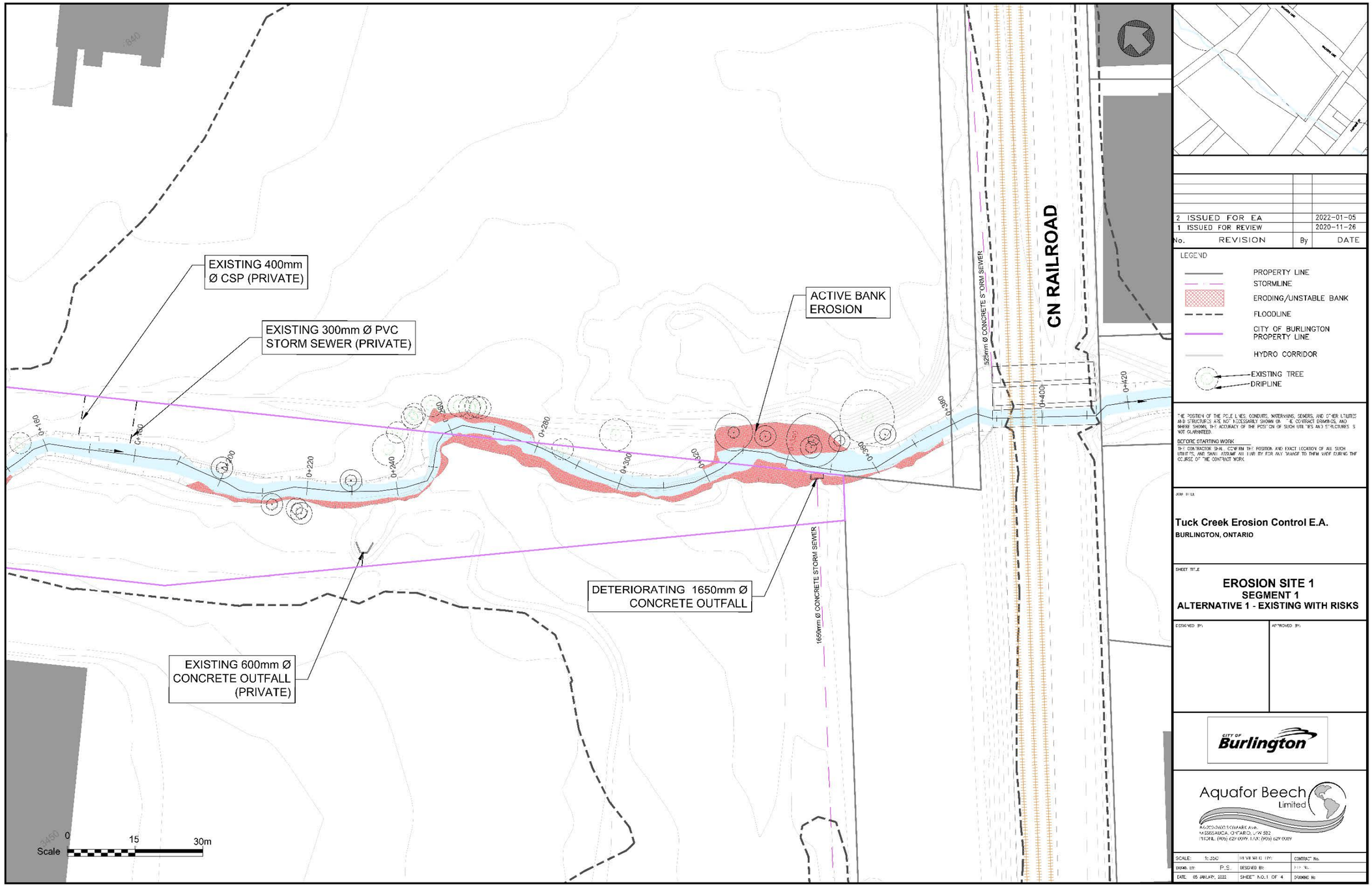


Figure 2-2: Erosion Site 1 – Existing Conditions

2.1.2 Erosion Site 2 – Bank Erosion, Failing Armourstone Wall and Bifurcated Channel

Erosion Site 2 is located immediately downstream of Harvester Road. The channel has bifurcated creating a large island filled with sediment and vegetation downstream of the Harvester Road crossing. The accumulation of the material downstream of Harvester Road was formed likely after the August 2014 storm, as the accumulated materials were transferred from upstream channel works. The material behind the local armourstone wall designed to protect the road embankment has washed out and hollowed out due to large flows overtopping the retaining wall. The armourstone wall was is assumed to be constructed without proper drainage. Without intervention, the armourstone retaining wall will eventually fail putting the road crossing at risk. A drawing providing an overview of the existing site conditions is included on the following page, with site photos illustrating existing conditions provided below.



Photo 2-4: Eroded Outer Bank Along the Eastern Bank towards the Private Property



Photo 2-5: Erosion Behind Failing Armourstone Wall



Photo 2-6: Bifurcated Channel and Evidence of Channel Planform Adjustment

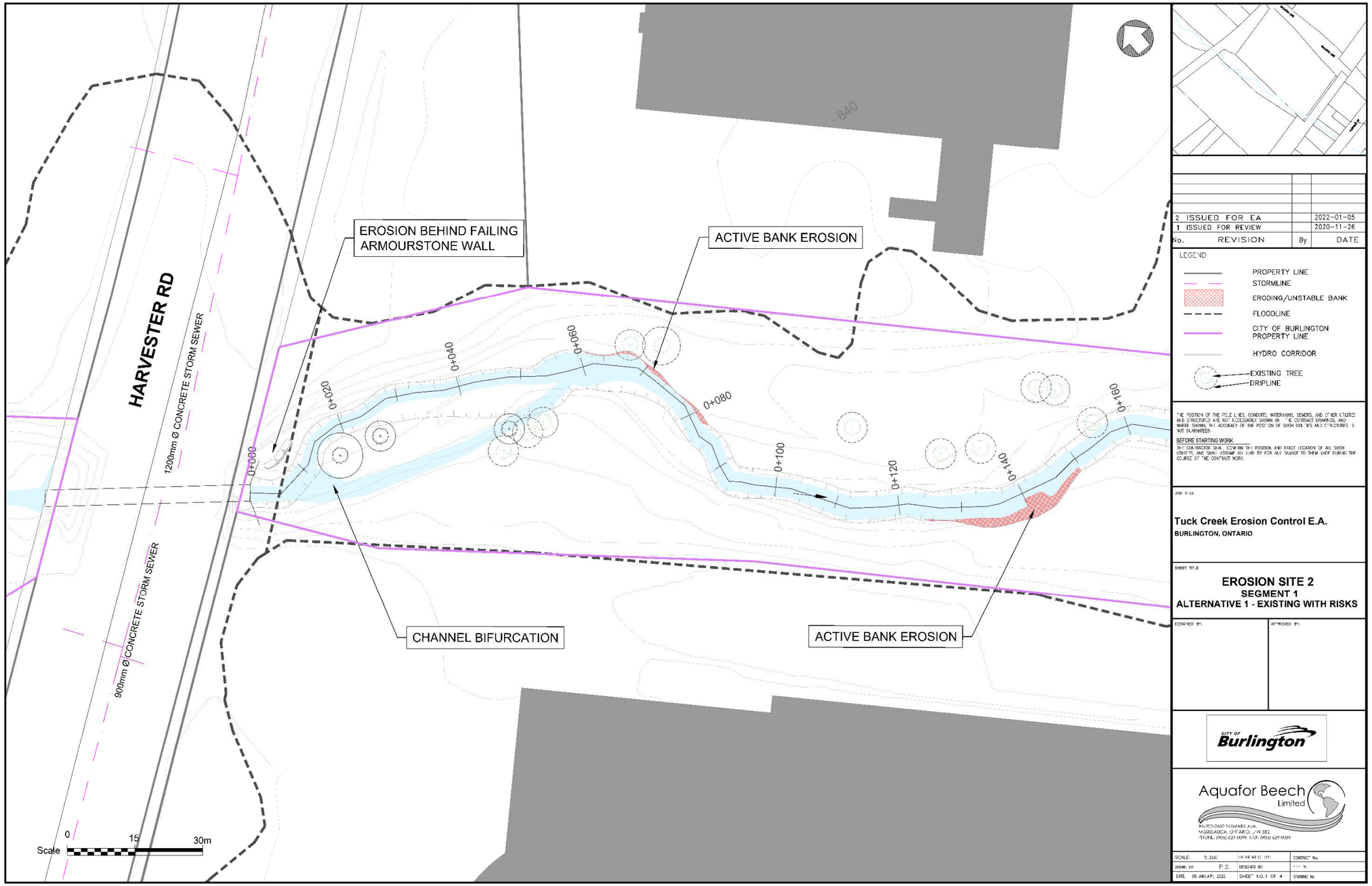


Figure 2-3: Erosion Site 2 – Existing Conditions

2.1.3 Erosion Site 3 – Deteriorating Gabion Basket Wingwall, Channel Bed, and Active Bank Erosion

Erosion Site 3 is located south of Mainway Drive and north of the CN Railway. The watercourse is within a City-owned parcel, upstream of the railway. Historically the channel was straightened and infilled up to the top of slope. On either side of the CN Railway crossing old gabion baskets were built as a retaining wingwall. These gabion baskets wingwall have a concrete lined toe at the base to prevent washout of materials during large flood events. The south gabion baskets wingwall on top have started to rupture and gabion basket has begun fail. The natural channel bed material is infilled with concrete rubble debris, which having been deposited on top of a rip-rap lined channel is promoting bed incision in the unarmored sections. A segment of the channel is actively migrating towards the westerly bank, forming a meander bend upstream of the railway and putting hydro transmission pole at risk.



Photo 2-7: Failing Gabion Basket Wingwall and Stones Emptying at Higher Level



Photo 2-8: Deteriorated Channel Bed Due to Concrete Rubble Debris Deposit



Photo 2-9: Bank Erosion with Evidence of Planform Adjustment & at-Risk Hydro Pole

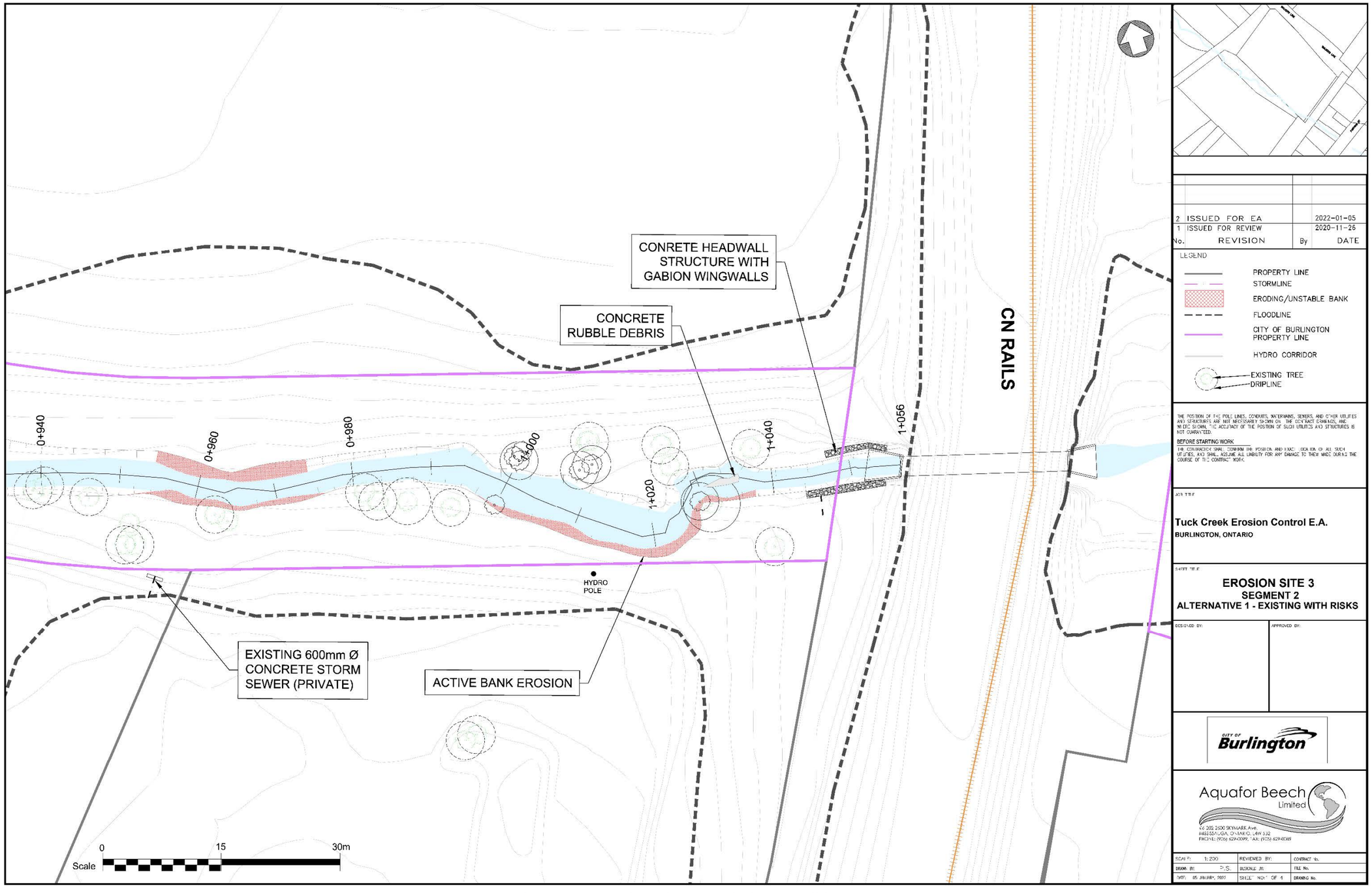


Figure 2-4: Erosion Site 3 – Existing Conditions

2.1.4 Erosion Site 4 – Deteriorating Terrafix Channel Bed and Bank Erosion

Erosion Site 4 is located at the downstream end of the Lansdown Park. The creek is in active contact with the valley slope adjacent to the 3482 Ketelbey Court creating a notable risk to the fence line of the private property. The channel bed predominantly consists of red shale bedrock, and the channel is actively eroding towards the oversteepened slope. Twin storm outfall discharge directly into the creek, where large sediment has accumulated in front of the outfalls. A drawing providing an overview of the existing site conditions is included on the following page, with site photos illustrating existing conditions provided below.



Photo 2-10: Eroded Outer Bank with Near Vertical Slope



Photo 2-11: Accumulated Sediment Infront of Twin Storm Outfall



Photo 2-12: Oversteepened Slope, Undermined Trees and Exposed Tree Roots Due to Erosion

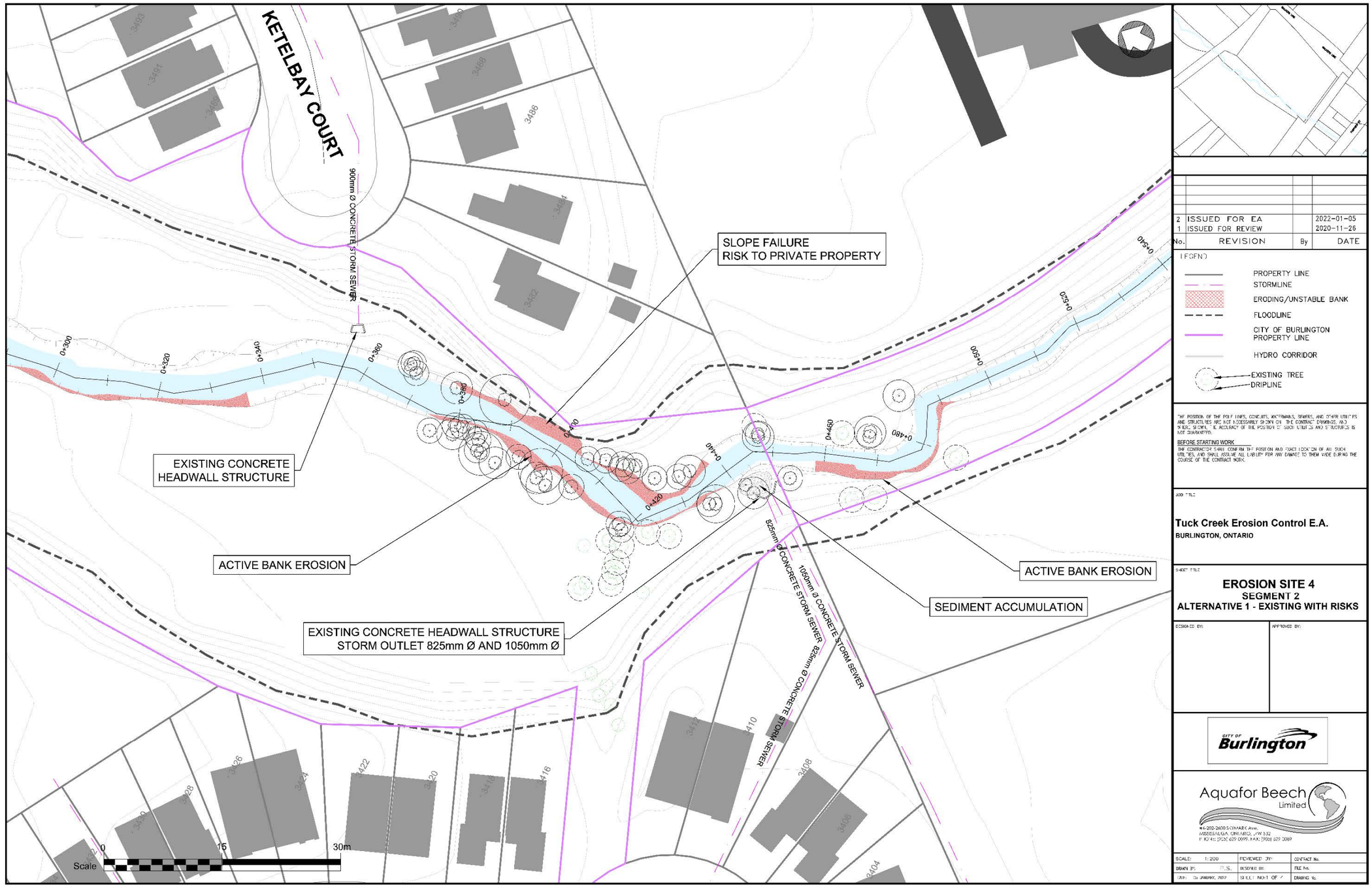


Figure 2-5: Erosion Site 4 – Existing Conditions

2.1.5 Erosion Site 5 – Deteriorating Armourstone Wall

Erosion Site 5 is located upstream of Headon Road, adjacent to a town house complex. This erosion site is within the upstream section of a meander bend. This section of watercourse has historically had erosion control measures applied, within a sinuous and wide natural channel valley. Large irregular sized armourstone retaining walls were placed on both side of the creek to protect the townhouse community adjacent to the watercourse. The armourstone retaining wall is in a deteriorating condition and a few stones have started leaning towards the creek. This partial failure was likely caused by irregular sized stones and lack of proper drainage behind the wall. A drawing of the existing site conditions is included on the following page.



Photo 2-13: Deteriorating Armourstone Wall



Photo 2-14: Installation of Armourstone Wall without Proper Drainage



Photo 2-15: Failing Armourstone Wall falling in towards the Creek

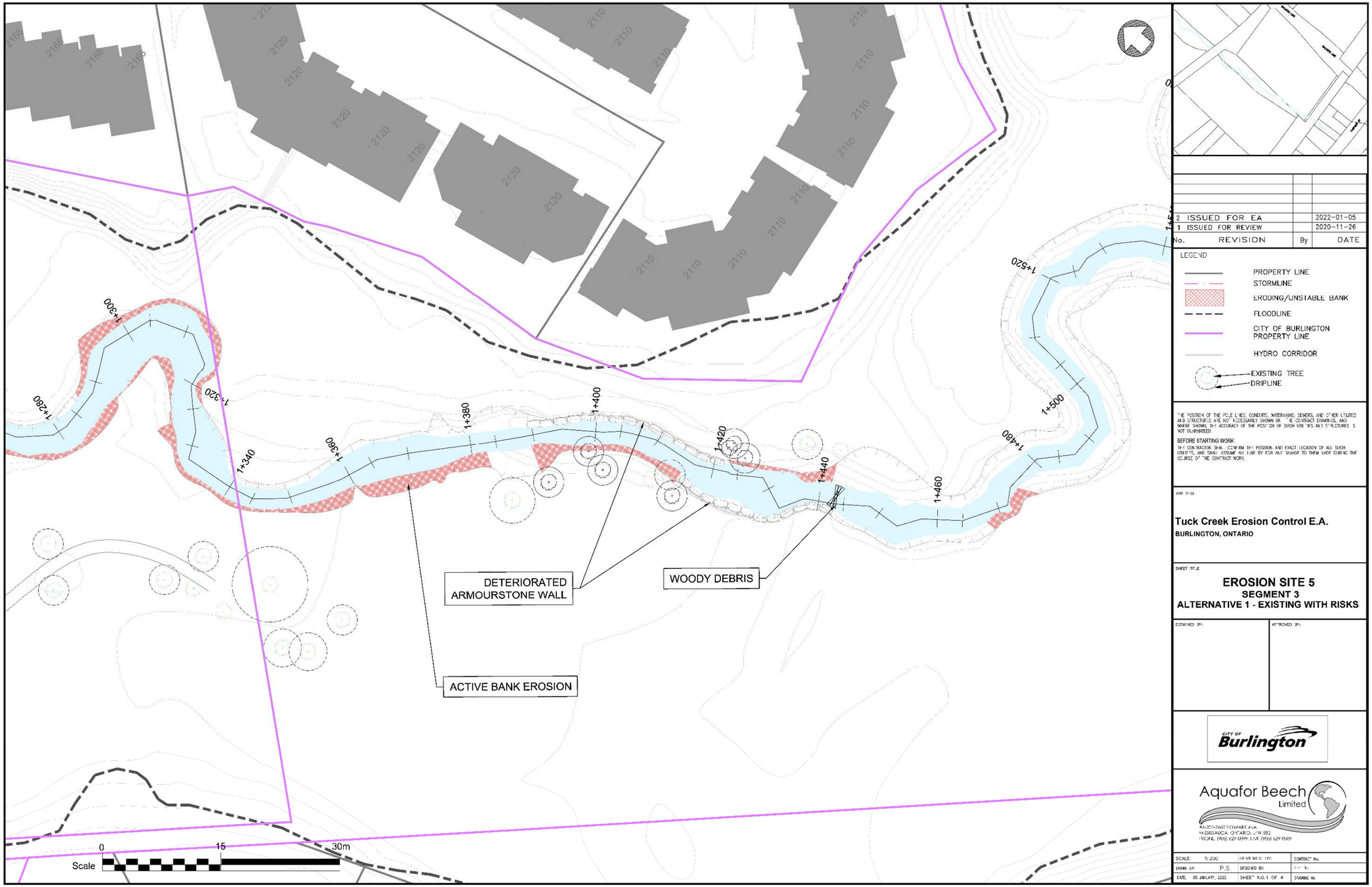


Figure 2-6: Erosion Site 5 – Existing Conditions

2.1.6 Erosion Site 6 – Failed Terrafix Channel Bed and Concrete Weir, and Bank Erosion

Erosion Site 6 is located upstream of the hydro corridor and downstream of Ireland Park. The residential developments are set beyond the top of slope adjacent to the erosion site. During the channelization of Tuck Creek, a series of grade control structures were installed along this segment of Tuck Creek, and the grade control structure within this erosion site is the most downstream of those structures. If this downstream grade control structure fails it could have a domino effect overtime because the failed structure would likely create a knick-point or head cut that would eventually propagate further upstream undermining the upstream grade controls. The grade control structure is comprised of a concrete Terrafix blocks lining which has failed and a concrete weir that has become outflanked and is no longer functioning as intended. The upstream channel banks have eroded and reformed the creeks planform.



Photo 2-16: Active Erosion and Outflanked Banks with Evidence of Planform Adjustment



Photo 2-17: Failed Terrafix Block and Concrete Weir



Photo 2-18: Woody Debris Jam in the Channel

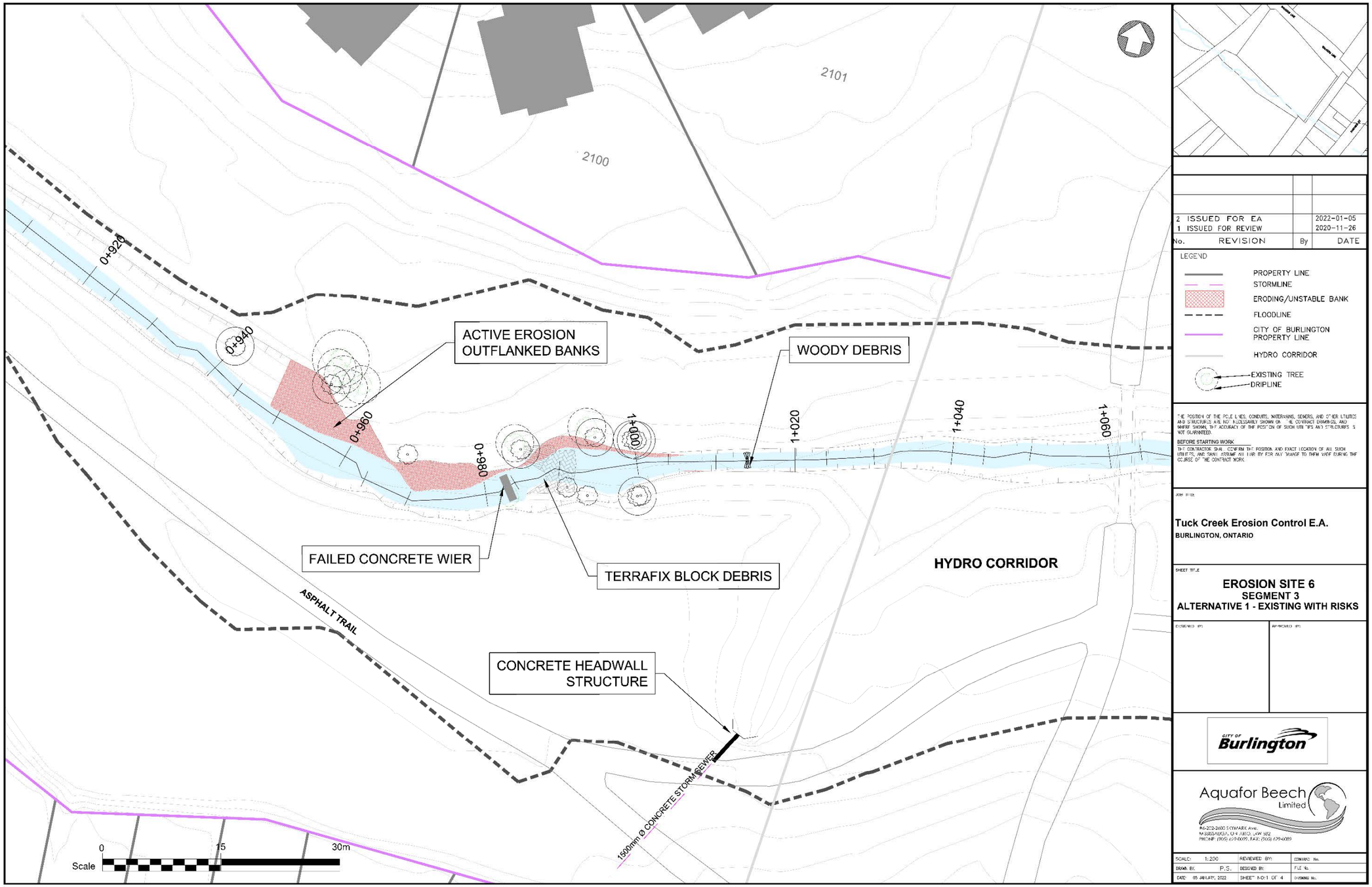


Figure 2-7: Erosion Site 6 – Existing Conditions

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

Erosion Site 7 is located adjacent to Driftwood Park. The outer bend of the channel is eroding and has diverted flow towards the banks of the Autumn Hill Crescent private properties causing exacerbated bank erosion. This erosion site currently poses relatively low risk to the private properties; however, without intervention, over time the banks will continue to erode, and will eventually create a significant risk to the adjacent private properties if left unmitigated. A drawing providing an overview of the existing site conditions is included on the following page.



Photo 2-19: Active Bank Erosion in Close Proximity to Private Property



Photo 2-20: Looking Downstream of the Erosion Site



Photo 2-21: Looking Upstream of the Erosion Site

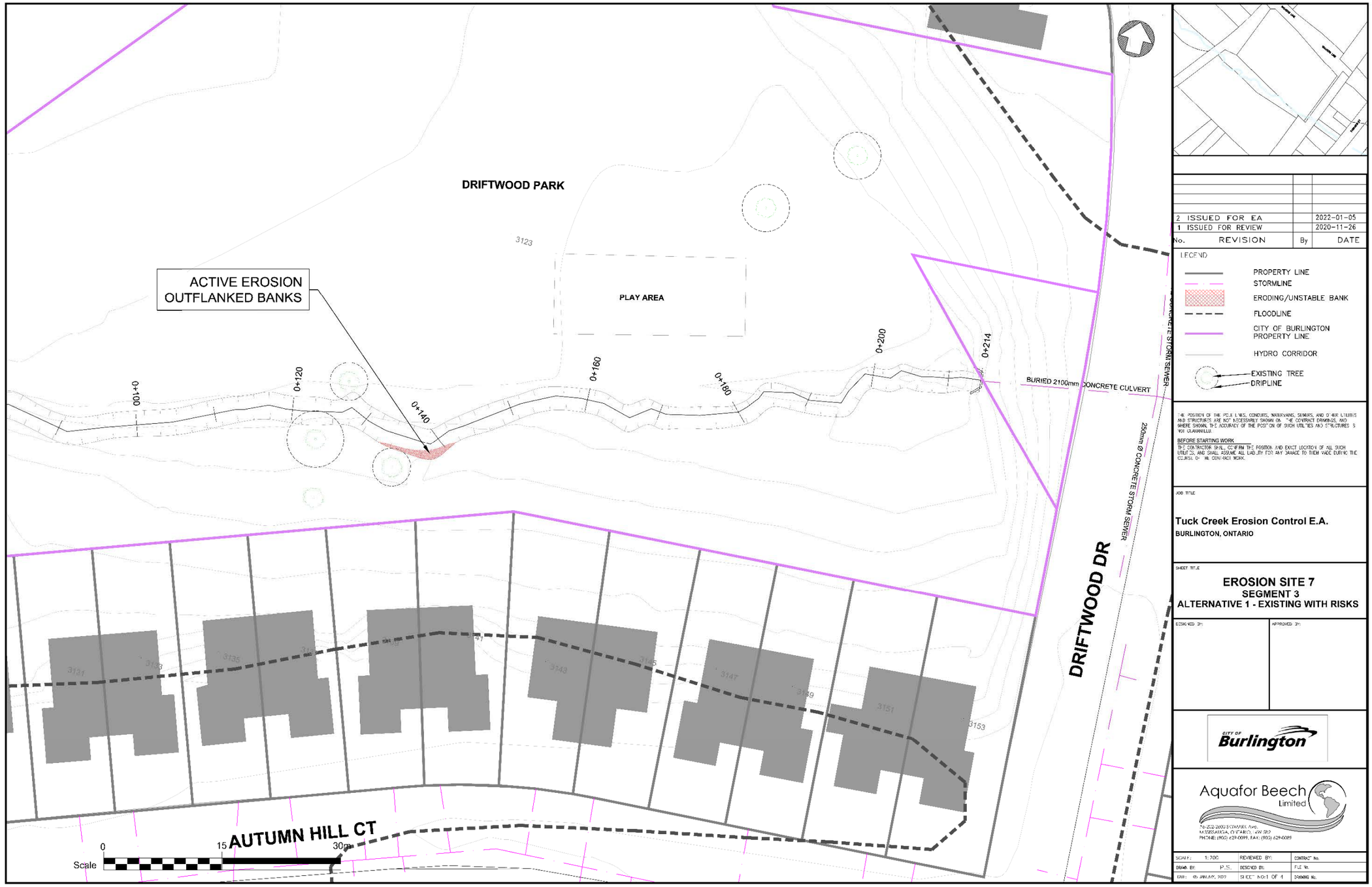


Figure 2-8: Erosion Site 7 – Existing Conditions

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 also improving riparian habitat:

- Replacement of failing gabion baskets with alternative bank treatments including armourstone, vegetated stone bank treatments, rock toe protection, and/or vegetated banks;
- Protection of municipal infrastructure assets and private properties through minor channel realignment and erosion control measures;
- Restoration of floodplain access by cutting back channel banks where feasible;
- Restoring the channel banks and bed with softer soil bioengineering approaches and minimizing harder engineering approaches;
- 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 Tuck 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 of alternatives, ultimately resulting in the selection of a preferred alternative for each erosion site. A summary of site-specific inventories completed in support of this EA 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 the Tuck Creek corridor, storm sewer infrastructure and all relevant 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 Tuck 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 storm sewer outfalls, sewer manholes, and culvert crossings;
- Mature vegetation potentially impacted because of the planned restoration or implementation of the preferred design; and
- Potential construction access routes.

The survey was completed using a combination of total station and GPS techniques to confirm accuracy by ensuring that geodetic elevations were consistent with City horizontal controls and that survey results aligned well with the base mapping provided by the City, which included 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 any sanitary trunk sewers or other municipal infrastructure. The plan and profile drawings can be found in Appendix A.

3.2 Geomorphic Assessment

As part of the stream erosion inventory and assessment for Tuck Creek within the City of Burlington, about 5 kilometers of the creek were walked to visually assess the channel and the surrounding area. The reach delineation was confirmed and refined in the field during creek walks to fully account for geomorphically significant changes in channel conditions.

This fluvial geomorphic field assessment was completed in Fall 2020 to gain a better understanding of the system. During the field walk, existing conditions within Tuck Creek were noted, and erosion site identification and photographic inventory collection for watercourse reach conditions were completed. The extent of the reaches are shown on Figure 3-1. Erosion is present throughout the study area. Naturally, some erosion is expected in a natural watercourse; however, erosion can be exacerbated by urbanization within a catchment area through channelization of the watercourse and changes in the rainfall-runoff response due to increased imperviousness. The existing fluvial conditions for each reach have been summarized in the sections below, accompanied by photographic illustrations.

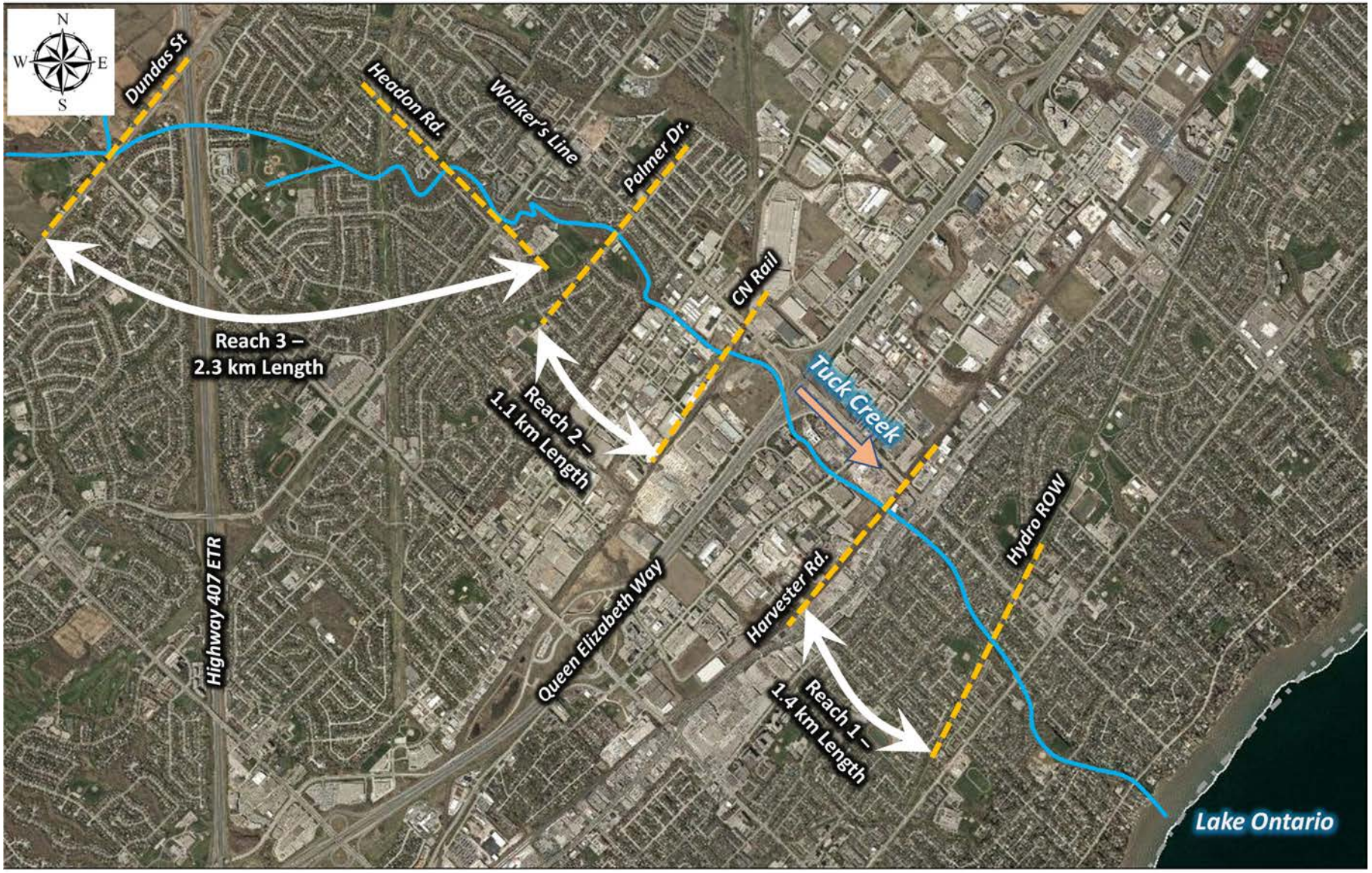


Figure 3-1: Delineated Management Reaches within the Tuck Creek Study Area

3.2.1 Reach 1 – Hydro Right of Way (RoW) to Harvester Road

Reach 1 extends from the Hydro Right of Way to Harvester Road bridge crossing. This reach of Tuck Creek has been historically channelized and straightened to extend through a narrow (~20m) City of Burlington owned corridor, from the Hydro RoW to Fowler / Commerce Court. Along this section, private residential properties line the top of the slope, with a wide variety of specific uses subject to each property. Some sections of the riparian corridor through Reach 1 are characterized by extensive encroachment with fully manicured banks maintained by the private property owners.

Along this reach, private property encroachment is widespread with numerous fence lines extending into the City property, coupled with widely varied ground conditions ranging from manicured grasses to thickly wooded areas. Immediately downstream of Fairview Street, the channel extends through a private commercial property. North of Fairview, the channel passes through a narrow corridor, and also crosses the CN Railway Bridge. Shale bedrock is exposed on the channel bed and banks. The channel is moderately incised and widened as a result of urbanization in the watershed. There are no engineered bank treatments within the Reach 1 of the study area.

In addition to the photos concerning Erosion Site 1 and 2 presented in Section 2.1.1 and 2.1.2, select photos of the reach's existing conditions are shown below.



Photo 3-1: Riprap Lined Channel with Dense Riparian Overbank Between Hydro RoW & Rexway.



Photo 3-2. Riprap Application with Manicured Banks Maintained by Private Properties Near Rockwood.



Photo 3-3. Limited Riprap with Active Bank Erosion Near Fowler Court.



Photo 3-4. Unlined Channel with Exposed Shale Bedrock Downstream of Harvester Road.

3.2.2 Reach 2 – CN Rail to Palmer Drive

Reach 2 extends from the northerly CN Rail crossing extending up through Lansdown Park to Palmer Drive. This reach has been channelized and confined to a narrow corridor from the CN Rail line to upstream of Mainway, at which point the channel extends through to Palmer Drive through an open parkland. Beyond the limits of the City corridor, however, the adjacent land use is defined as mixed commercial and light industrial.

Some of these segments have been protected by a variety of channel treatments and stabilization measures. Most notable is the limited riprap application allowing for a more natural bedform, which is primarily composed of detached shale particles. This condition also includes areas of mass bank slumping where channel planform migration (and erosion) is evident.

Along this reach, erosion on the outside of the meander bend from the meander bend movement is notable. Exposed tree roots are prevalent within the eroded banks and some fallen trees were visible. The watercourse has only intermittent access to its floodplain. Planform adjustment is also occurring as a result of urban hydromodification which drives channel widening and downcutting in response to higher peak flows, greater runoff volumes, and more frequent flow events.

A Photographic compilation of the reach's existing conditions is provided below.



Photo 3-5. Bank Erosion at Palmer Drive Looking Downstream



Photo 3-6. Looking Upstream of Mainway Road



Photo 3-7. Large Concrete Fish Barrier, Upstream of CN Rail Crossing



Photo 3-8. Bank Erosion on outside of Meander Bend, Upstream of CN Rail Crossing

3.2.3 Reach 3 – Headon Drive to Dundas Street

This reach extends from Headon Drive to Dundas Street. Downstream of Headon Road, much of the channel has been historically lined with armourstone consistent with the standard engineering practices of the 1990s. Where this section of channel is not engineered, there is a range of conditions including a wide riparian corridor with limited erosion hazard risks, as well as segments in which the channel is actively maintained through Ireland park, where flows are significantly less, however, erosion and channel risks still exist.

The creek transitions into a more sinuous channel including a full meander wave length that contacts each valley slope between the segment upstream of Headon Road and the Hydro right of way. Photos concerning Erosion Site 5 presented in Section 2.1.5 indicate active erosion is evident within this segment, as evidenced by a failed engineered armourstone wall. Within this section of the creek, the riparian corridor is unmaintained and filled with dense trees and shrubs, which provide resistance to erosion and roughness to the channel. Small woody debris jams were noted at a few locations within the reach.

Tuck Creek has only two minor tributaries that converge near the upstream end of the creek within Ireland and Driftwood Park. Upstream of Hydro right of way, the channel has been straightened and confined to a narrow corridor to accommodate for Ireland Park. The valley corridor along the branches is steeper than the corridor within the main branch. Within Ireland Park, where the channel has been channelized, a series of grade control structures are inset along the length of the channel to facilitate channel gradient reduction. The Terrafix blocks and concrete weir grade control structure have failed and flow is currently being redirected towards the banks, which is causing exacerbated erosion rates along the unprotected banks. Select photos to further demonstrate the site conditions are included below.



Photo 3-9. Bank Stabilization Works at Headon Road



Photo 3-10. Natural Riparian Corridor filled with Dense Trees and Shrubs



Photo 3-11. Failed Terrafix Block Channel, Upstream of Headon Road & Hydro Corridor Multiuse Path



Photo 3-12. Dense Vegetation along the Banks Providing Shade to the Channel Upstream of Driftwood Drive.

3.3 Erosion Sites Inventory and Scoring

3.3.1 Erosion Sites Inventory

The Erosion 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 result (i.e., High, Medium, Low).

Table 3-1: Summary of Erosion Sites by Reach

Reach No.	Erosion Sites	Site Condition Descriptions	Risks to	Level of Risk
Reach 1	Erosion Site 1	· Active bank erosion · Deteriorating storm outfall headwall · Creek encroaching private property	Private property, City owned 1650mm ø concrete storm outfall, terrestrial habitat, and degraded aquatic habitat	High
	Erosion Site 2	· Active bank erosion · Erosion behind failing armourstone wall · Channel bifurcation likely due to accumulation of materials transferred from upstream during the August 2014 storm	Armourstone retaining wall, and degraded aquatic habitat	High
Reach 2	Erosion Site 3	· Active bank erosion · Gabion basket wingwall failure due to loss of stones at the higher level · Hydro pole is located adjacent to outflanked south bank · Aquatic habitat is degraded due to channel rubble debris deposit	Private property, gabion basket, hydro pole, terrestrial habitat, and degraded aquatic habitat	Medium
	Erosion Site 4	· Active bank erosion, undermined trees, slope failure posing risk to fenceline of 3482 Ketelbey Court private property · Sediment accumulated in front of storm sewer	Fenceline of 3482 Ketelbey Court property, 825mm and 1050mm ø concrete storm sewer, terrestrial habitat, and degraded aquatic habitat	Medium
Reach 3	Erosion Site 5	· Active bank erosion · Woody debris jam in the channel · Deteriorated armourstone wall	Properties located on the north side, and terrestrial habitat.	Low
	Erosion Site 6	· Active bank erosion and outflanked banks · Failed concrete weir and Terrafix block debris · Woody debris jam in the channel	Concrete weir/ Terrafix block, terrestrial habitat, and degraded aquatic habitat	Low
	Erosion Site 7	· Active bank erosion and outflanked banks	3139, 3141 and 3143 Autumn Hill Court	Low

Reach No.	Erosion Sites	Site Condition Descriptions	Risks to	Level of Risk
		· Creek encroaching 3139, 3141 and 3143 Autumn Hill Court private properties · Public safety is a concern as Driftwood Park is located adjacent to the erosion site	private properties and public safety	

3.3.2 Erosion Sites Field Scoring Methodology

To standardize the erosion risks and environmental opportunities evaluated 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 Tuck Creek study area.

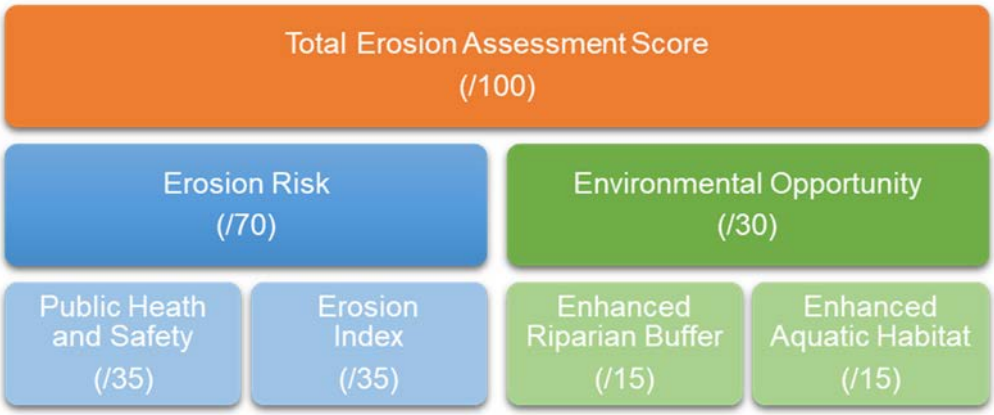


Figure 3-2: Framework for Field Scoring of Erosion Sites

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 quality of the channel bed to provided suitable habitat for fish or invertebrates	Thermal Regime/ Fish Community	Habitat Quality		
			High (Riffle-Pool, Natural Substrate)	Moderate (Mixed)	Low (Degraded Channel)
		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 seven (7) 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	1	35	15	10	3	3	66	10	7	17	**83**
	2	30	12	8	5	3	58	10	7	17	**75**
Reach 2	3	30	15	4	4	5	58	10	12	22	**80**
	4	25	15	6	4	5	55	5	10	15	**70**
Reach 3	5	15	10	4	3	1	33	5	7	12	**45**
	6	15	15	6	5	5	46	10	12	22	**68**
	7	25	12	2	4	5	48	10	5	15	**63**

Erosion Site 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. A total of 38 storm outfall were inventoried during the creek walk. Reach-scale storm outfall location maps as well as the inventory detailing sewer ownership, dimension, physical conditions and photos are attached in Appendix B.

3.5 Hydrologic and Hydraulic Assessment

3.5.1 Hydrology

The flows at different nodes along Tuck Creek were computed using a 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 3-3.

Table 3-4: Flows at Different Nodes Along the Tuck Creek

Flow Node / Location	Flow (m^3/s)						
	Regional	100 Year	50 Year	25 Year	10 Year	5 Year	2 Year
Node 1 / Dundas Street	28.6	13.8	11.7	9.7	7.1	5.3	3.1
Node 2 / Palmer Road	81	38.9	33.5	29.2	23.4	19.9	13.6
Node 3 / Harvester Road	108.1	51.2	45.9	40.1	33.8	28.1	20.4

3.5.2 Hydraulics

A HEC-RAS model of the Tuck Creek was provided by Conservation Halton, which was used to compute the existing hydraulic assessment of the erosion sites within the study area. The name of the model provided was “TuckCreek.prj”, and the flow file used within the model was titled “Updated Flow from Hydrology Model”. The base model was run under all flood scenarios using the subcritical flow regime, and steady state conditions.

The summary of the existing hydraulics for cross sections within the study area are provided in Table 3-5 below, with Figure 3-3 illustrating the regulatory floodline for Tuck Creek.

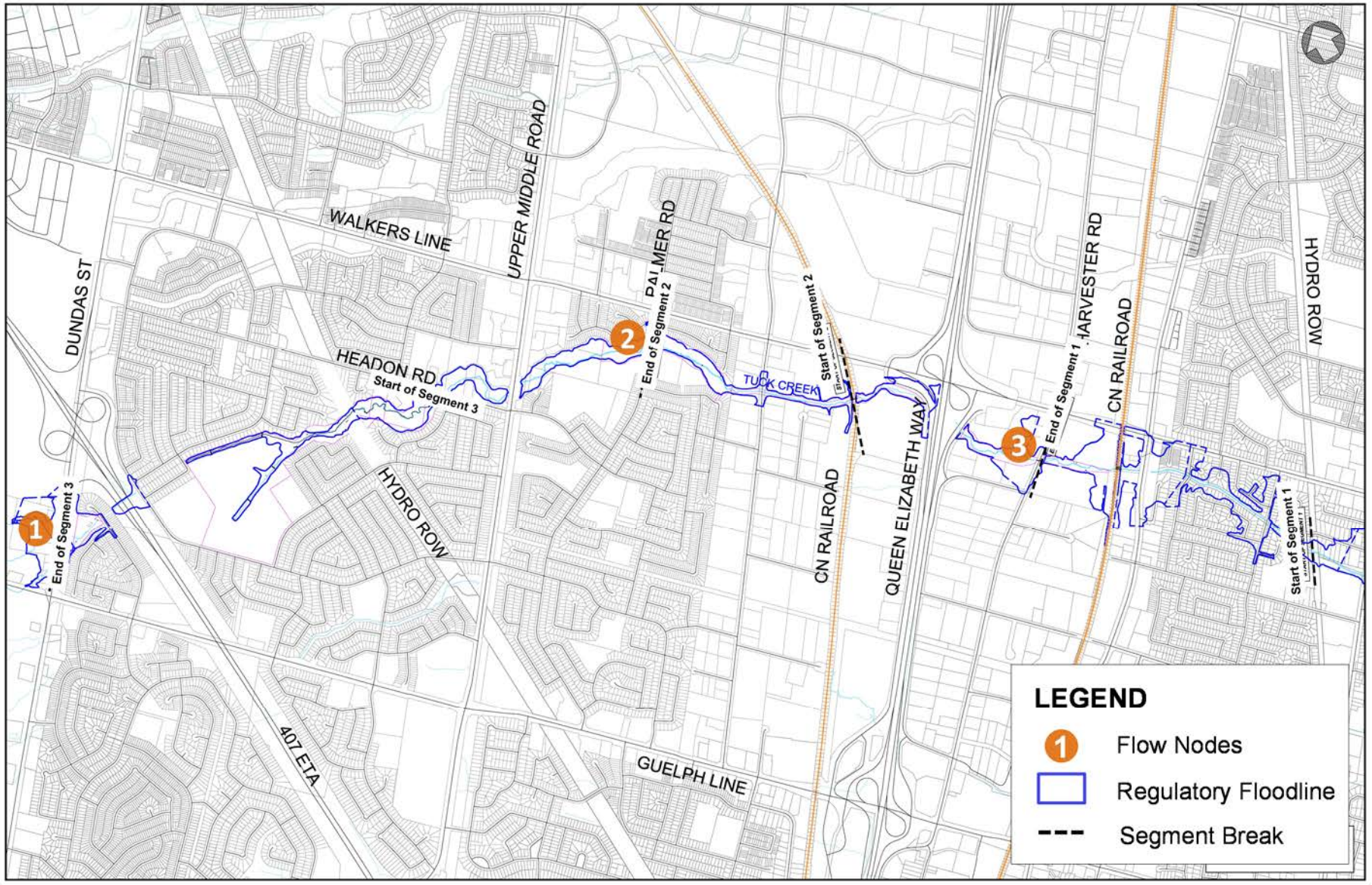


Figure 3-3: Regulatory Floodlines within the Study Area

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

Erosion Site	River Station	Profile	Q Total (m^3/s)	W.S. Elev (m)	Shear Chan (N/m^2)	Vel Chnl (m/s)
1	2595	Regional	108.4	101.66	125.88	3.67
	2595	100 Yr	50.5	101.08	101.24	3.13
	2595	50 Yr	46.1	100.97	108.53	3.21
	2595	25 Yr	40.8	100.88	106.14	3.14
	2595	10 Yr	33.2	100.73	99.51	2.99
	2595	5 Yr	28	100.61	96.35	2.89
	2595	2 Yr	20.6	100.41	91.47	2.73
	2595	Low Flow	0.4	99.35	23.57	0.93
2	2811	Regional	108.4	103.79	96.27	3.09
	2811	100 Yr	50.5	103.31	61.79	2.34
	2811	50 Yr	46.1	103.26	58.16	2.26
	2811	25 Yr	40.8	103.19	53.89	2.15
	2811	10 Yr	33.2	103.08	47.59	1.99
	2811	5 Yr	28	103	42.07	1.85
	2811	2 Yr	20.6	102.83	34.06	1.63
	2811	Low Flow	0.4	101.62	4.65	0.47
3	3897	Regional	96	121.75	13.62	1.35
	3897	100 Yr	44.4	120.81	7.31	0.95
	3897	50 Yr	39.5	120.59	7.34	0.94
	3897	25 Yr	34.3	119.82	13.86	1.24
	3897	10 Yr	28.2	119.43	15.91	1.29
	3897	5 Yr	23.8	119.1	18.77	1.37
	3897	2 Yr	16.6	118.54	25.15	1.48
	3897	Low Flow	0.4	117.05	29.71	1.11
4	4510	Regional	88.7	126.64	104.12	2.93
	4510	100 Yr	41.4	126.21	43.38	1.83
	4510	50 Yr	36.2	126.29	29.35	1.51
	4510	25 Yr	30.9	125.91	41.18	1.73
	4510	10 Yr	25.4	125.58	54.52	1.91
	4510	5 Yr	21.1	125.14	121.77	2.63
	4510	2 Yr	14.5	124.96	107.88	2.38
	4510	Low Flow	0.4	124.24	8.54	0.55
5	6340	Regional	79.7	140.57	41.11	2.85
	6340	100 Yr	39.1	140.12	30.56	2.39
	6340	50 Yr	33.5	140.03	28.66	2.3
	6340	25 Yr	28.3	139.93	26.69	2.2
	6340	10 Yr	23.4	139.75	29.59	2.29
	6340	5 Yr	19.5	139.5	37.51	2.52
	6340	2 Yr	13.6	139.24	27.91	2.12
	6340	Low Flow	0.4	137.89	1.78	0.42

Erosion Site	River Station	Profile	Q Total (m^3/s)	W.S. Elev (m)	Shear Chan (N/m^2)	Vel Chnl (m/s)
6	6805	Regional	69	144.84	25.67	1.94
	6805	100 Yr	39.6	144.38	19.95	1.65
	6805	50 Yr	34	144.3	17.43	1.53
	6805	25 Yr	28.6	144.2	15.02	1.4
	6805	10 Yr	21.7	144.09	10.88	1.18
	6805	5 Yr	16.7	143.98	8.18	1.01
	6805	2 Yr	10.7	143.65	7.15	0.9
	6805	Low Flow	0.4	142.3	2.58	0.42
7	8188	Regional	28.7	164.3	0.22	0.2
	8188	100 Yr	13.8	162.34	0.32	0.22
	8188	50 Yr	11.7	161.76	0.48	0.26
	8188	25 Yr	9.7	161.4	0.56	0.28
	8188	10 Yr	7.1	160.91	0.73	0.3
	8188	5 Yr	5.3	160.56	0.97	0.32
	8188	2 Yr	3.1	160.07	2.47	0.45
	8188	Low Flow	0.4	159.54	17.1	0.92

Conservation Halton is currently in the process of updating the Flood Hazard Mapping of Tuck Creek. The study will comprehensively update flood hazard models (hydrology and hydraulics) and mapping of the Tuck Creek watershed. During the detailed design stage, the detailed hydraulic modelling assessment of the Tuck Creek erosion sites should be undertaken using the CH's updated georeferenced Tuck Creek HEC-RAS model.

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 Burlington Water Purification Plant as illustrated in Figure 3-4, 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 Halton Region's Source Protection Plan. The IPZ-1 (highlighted red in Figure 3-4 below) encompasses the area within one kilometer of an intake pipe. Tuck Creek drains in the IPZ-1, which is most vulnerable area and poses the highest risk to water entering the treatment plant. 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 are listed as prescribed drinking water threats.

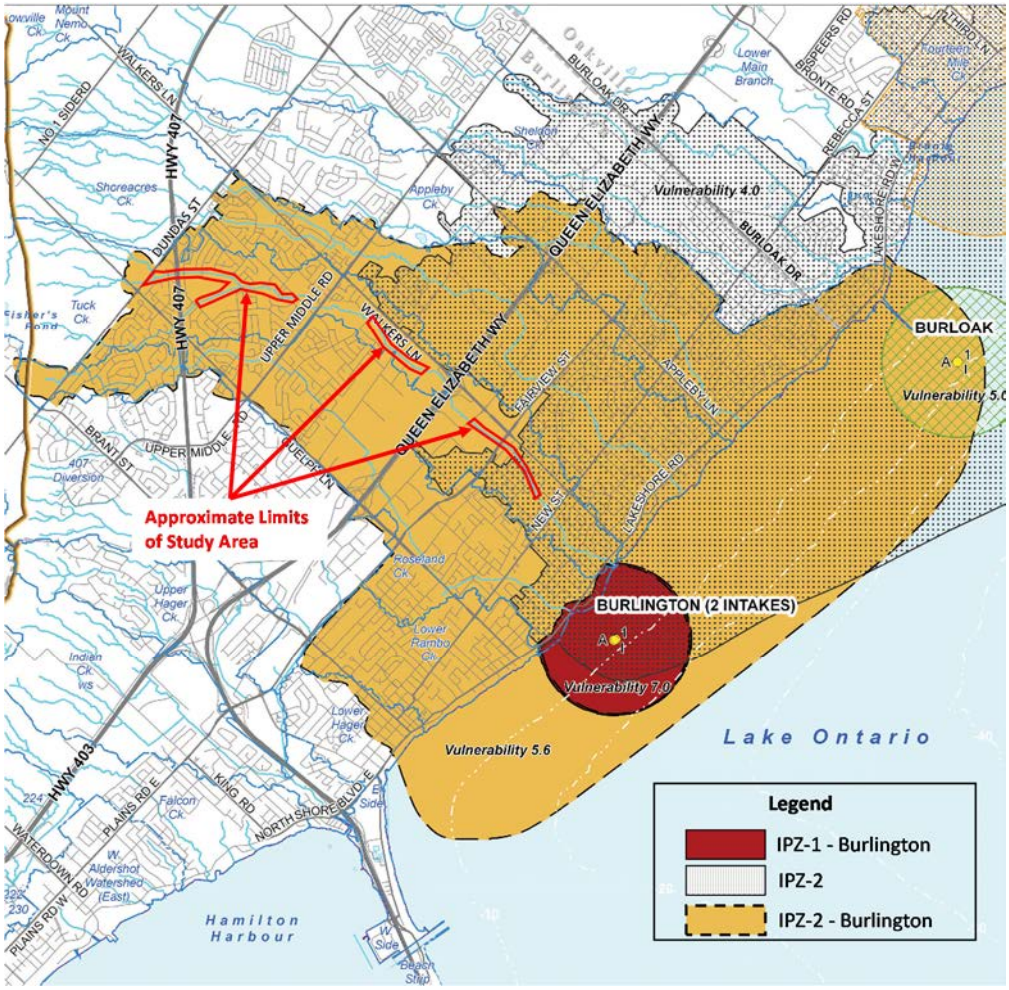


Figure 3-4: City of Burlington Intake Protection Zones (HHSPC, 2017)

3.7 Geology, Physiology, and Soils

The City of Burlington is situated by the Niagara Escarpment, Till Plain and Limestone Plain, with the study area extending over the Lake Iroquois Sand Plain, and Shale Plain as shown in Figure 3-5 and Figure 3-6.

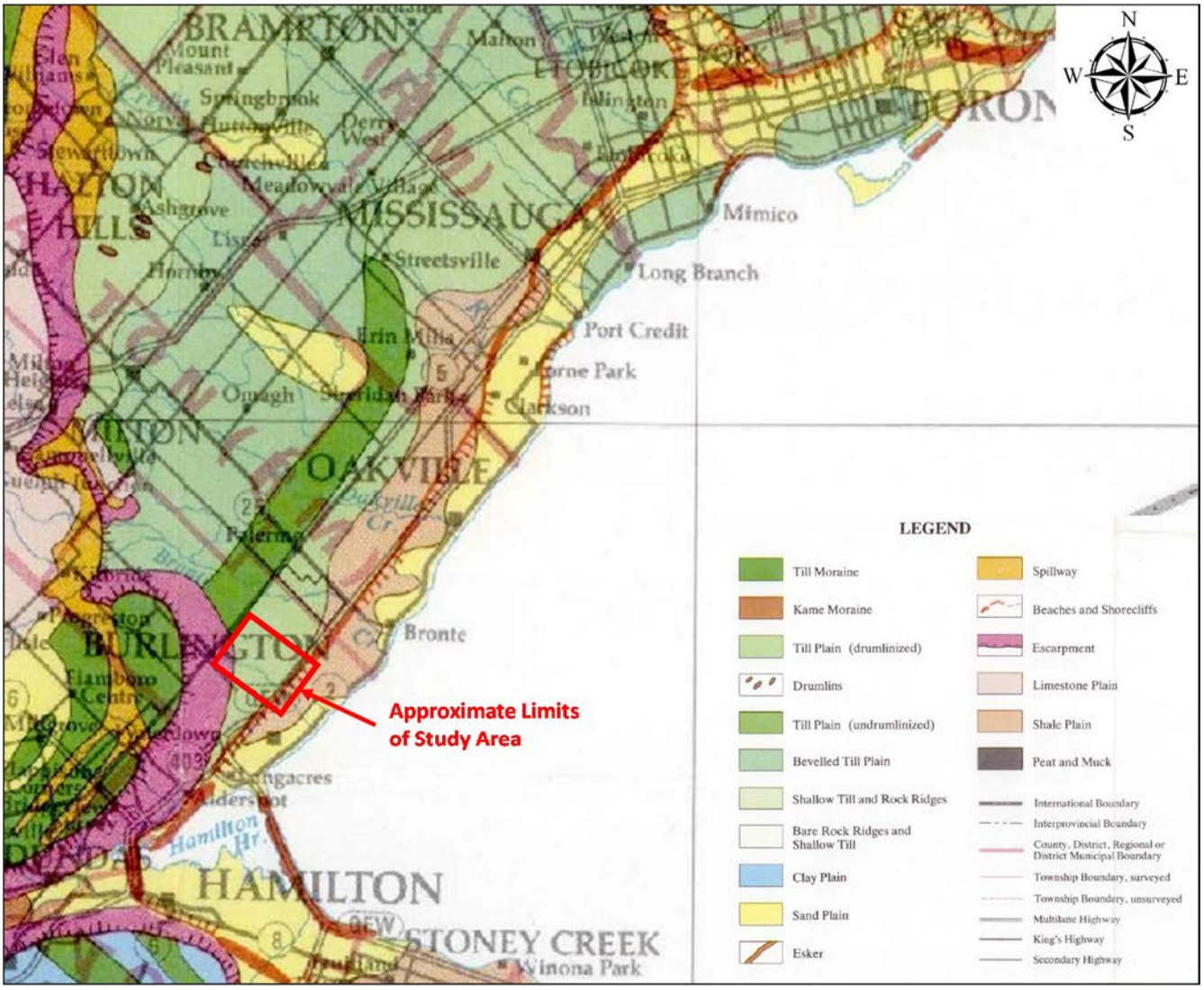


Figure 3-5: Physiography of Study Area (Chapman and Putnam, 1984)

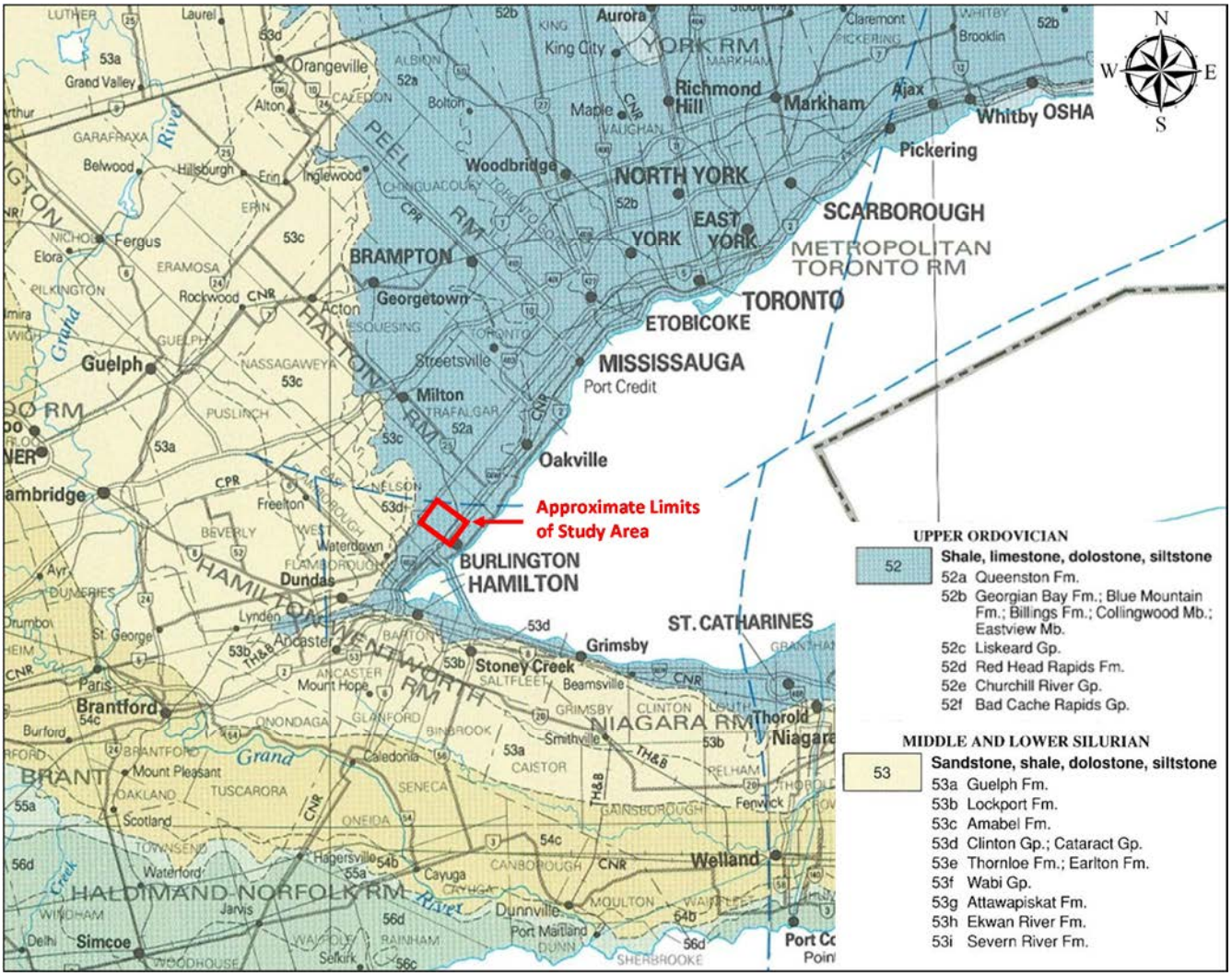


Figure 3-6: Bedrock Geology of the Study Area in the City of Burlington (Ontario Geological Survey, 1991)

Soils within the Tuck Creek watershed consist of Fox sandy loam, Chinguacousy clay loam, Brady sandy loam, Jeddo clay loam, and Oneida clay loam (Gillespie & Wicklund, 1971). The Fox sandy loam and Brady sandy loam are found at the downstream end of the watershed while the upstream portion consists of Chinguacousy clay loam, and Oneida clay loam. The watercourse bed is mainly located on Jeddo clay loam.

3.8 Natural Heritage Assessment

Aquafor completed ecological investigations throughout the natural lands in the Tuck Creek corridor in support of the proposed erosion control works; a detailed accounting of these investigations and their results has been provided in **Appendix C**. The following subsections provide a summary of key findings and constraints in order to characterize the existing ecological conditions of the study area and allow for the assessment of potential impacts and development of mitigation measures for the preferred alternative. The information detailed in the following subsections and in **Appendix C** will be considered during the development of the detailed design.

3.8.1 Background Information Review

Aquafor staff reviewed all available background data resources to obtain species lists, mapping, area designations, and other relevant information that would assist in the identification and assessment of ecological features and functions in the study area. Primary data sources included (but were not limited to):

- The Natural Heritage Information Centre (NHIC) database accessed via the online Make-a-Map: Natural Heritage Areas tool;
- Online 'citizen science' observation databases such as iNaturalist and eBird;
- Past study reports by Aquafor in the Tuck Creek corridor (Tuck Creek at Headon Road Species at Risk Summary Report, 2018; Tuck Creek at Billings and Harvester Spring Species Inventory, 2016; Tuck Creek Erosion Control Municipal Class EA, 2012);
- Halton Natural Areas Inventory (NAI), Volume 1: Site Summaries and Volume 2: Species Checklists (2006); and
- The Official Plans of Halton Region and the City of Burlington.

3.8.2 Existing Conditions

3.8.2.1 Vegetation Communities and Flora

Vegetation communities and flora within the study area were identified during field surveys completed in June and July, 2020, using the Ecological Land Classification (ELC) for Southern Ontario, First Approximation protocol (Lee et al, 1998). A total of 23 polygons were delineated along the Tuck Creek corridor, comprising 15 distinct vegetation community types. Community types ranged from disturbed woodlands and open meadows to deciduous forests containing mature species and moderate to high quality habitat. **Figure 3-7** through **Figure 3-10** illustrate the vegetation communities identified by Aquafor; a detailed description of each community and list of species observed within each polygon is provided in **Appendix C**.



Figure 3-7: Vegetation Communities (1 of 4)



Figure 3-8: Vegetation Communities (2 of 4)



Figure 3-9: Vegetation Communities (3 of 4)

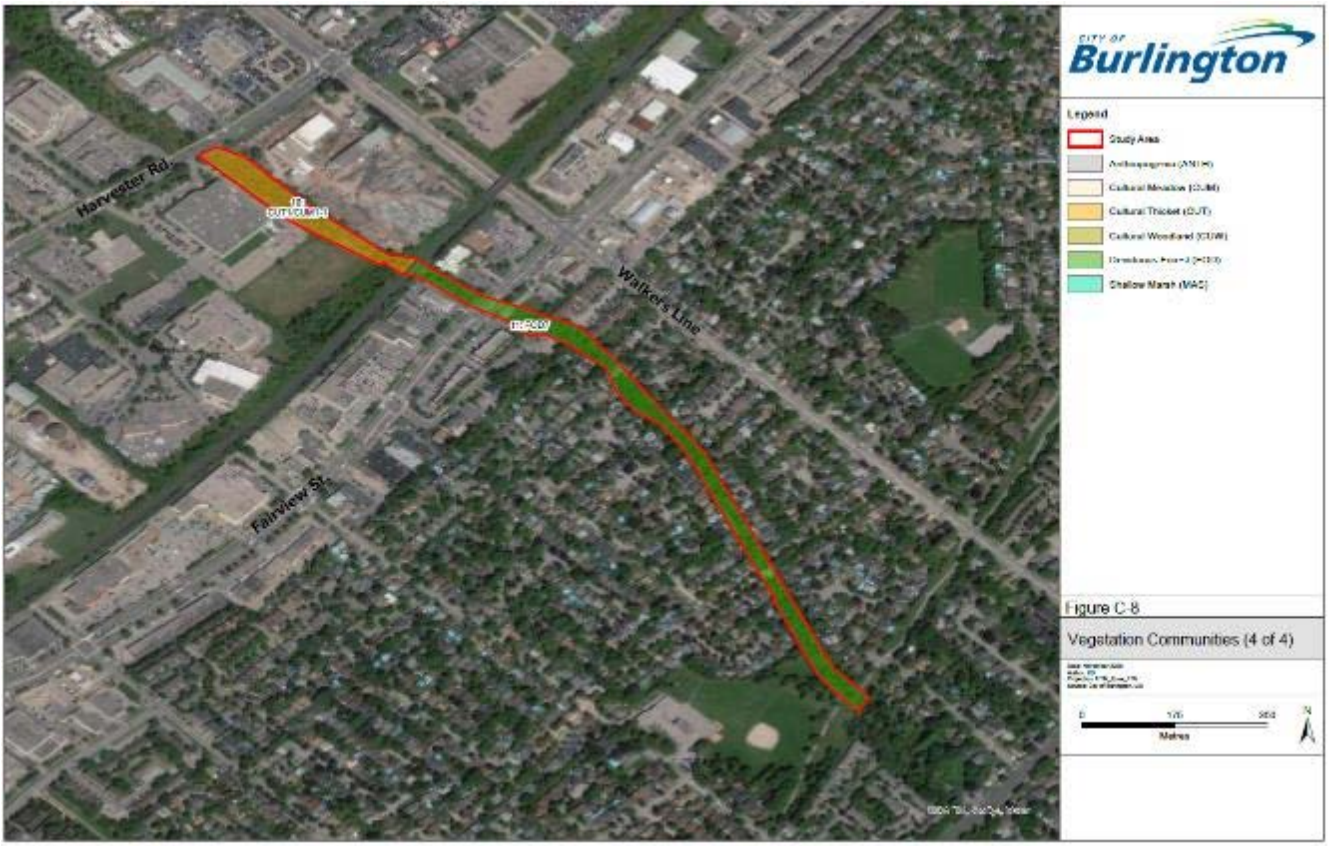


Figure 3-10: Vegetation Communities (4 of 4)

A total of 201 vascular plant species were identified within the study area, the majority of which are native to Ontario. Many species observed within the study area are non-native or considered disturbance-tolerant and common in urban environments, and all vegetation communities exhibit at least some evidence of human disturbance; however, some of the observed vegetation communities also retained features reminiscent of an intact undisturbed forest (e.g., Polygon 9 – FOD5-3, or Polygon 6 - FOD6-5).

Of the introduced species documented in the study area, European Buckthorn (*Rhamnus cathartica*), Garlic Mustard (*Alliaria petiolata*), Goutweed (*Aegopodium podagraria*), Norway Maple (*Acer platinoides*), European Privet (*Ligustrum vulgare*), Purple Loosestrife (*Lythrum salicaria*), Black Locust (*Robinia pseudoacacia*), Multiflora Rose (*Rosa multiflora*), Periwinkle (*Vinca minor*) and European Swallow-wort (a.k.a. Dog strangling Vine - *Vincetoxicum rossicum*) are considered invasive species.

None of the observed plant species are a provincially- or federally-protected Species at Risk (SAR). One of the observed species is considered provincially rare (ranked S3): Pignut Hickory (*Carya glabra*), observed in Polygon 9. Twenty-two species considered regionally rare or uncommon were also documented (see **Appendix C** for full listing), and seven species with a high Coefficient of Conservatism (i.e., species that tend to be intolerant of anthropogenic disturbance) were also observed. The Floristic Quality Index for the study area overall was calculated as 36.7 or “medium”, likely due to the high number of introduced species and disturbed nature of many of the vegetation communities. As this FQI represents the entirety of the study area, a higher FQI is expected in individual communities that resemble intact forests, such as Polygons 6 and 9, as these communities contain a higher proportion of plant species less tolerant to disturbance.

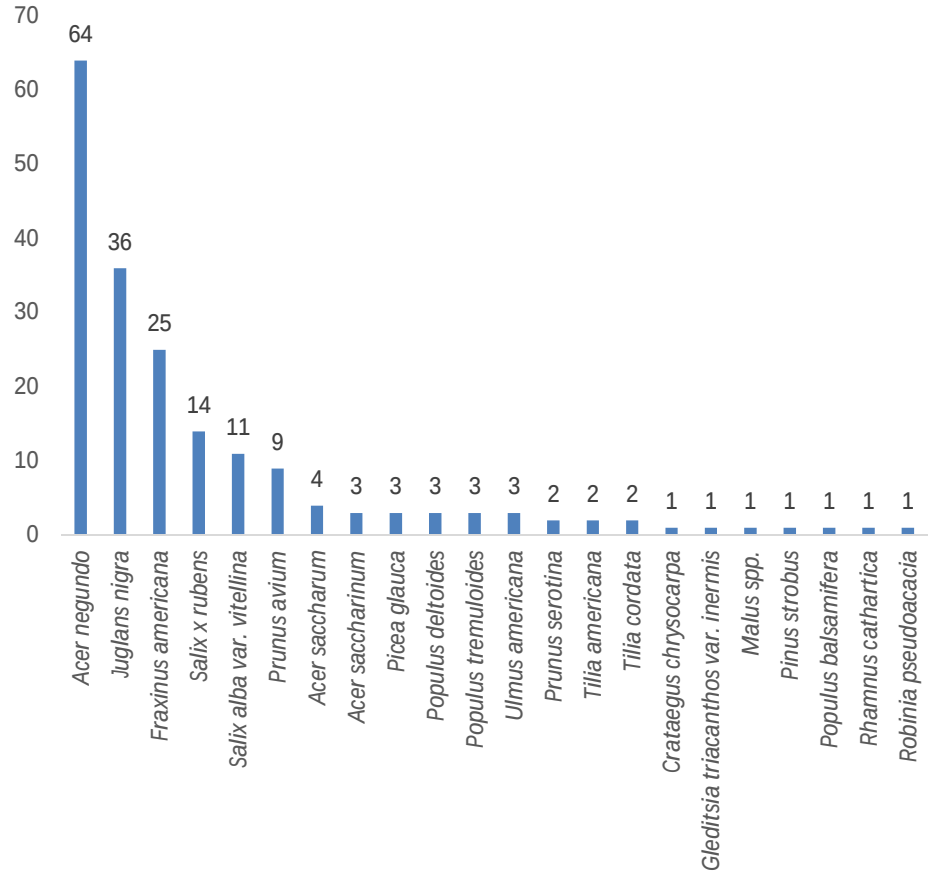
3.8.2.2 Tree Inventory

A tree inventory was undertaken by an ISA-certified arborist (D. Laframboise) from October 2-3, 2020 to identify trees and large shrubs ≥ 10cm 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 30cm 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 191 trees were inventoried which included 22 species; one identified to genus level only, nine (9) are non-native, and thirteen (13) are native. There were slightly more non-native trees, 104 trees, inventoried than native, 87 trees with Manitoba maple (*Acer negundo*) being the most abundant followed by Black Walnut (*Juglans nigra*).



Erosion Site 1

A total of twenty-four (24) trees representing ten (10) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to the species level of which five are native and five, non-native. They are considered secure locally, provincially, and nationally. The only white ash exhibited evidence of Emerald Ash Borer and is dead. Trees inventoried are summarized in Table 3-6.

Table 3-6: Erosion Site 1 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Acer negundo	Manitoba Maple	I	Public	14
Fraxinus americana	White Ash	N	Public	1
Pinus strobus	White Pine	N	Public	1
Populus balsamifera	Balsam Poplar	N	Public	1
Populus deltoides	Eastern Cottonwood	N	Public	1
Prunus avium	Wild Cherry	I	Public	1
Salix alba var. vitellina	Golden Willow	I	Public	1
Salix x rubens	Hybrid Crack Willow	I	Public	2
Tilia cordata	Small-leaved Linden	I	Public	1

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Ulmus americana	White Elm	N	Public	1
			TOTAL	**24**

Erosion Site 2

A total of fourteen (14) trees representing six (6) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level of which four are native and two, non-native. They are considered secure locally, provincially, and nationally. The cottonwood, silver maple and white spruce were found to be previously planted, staked, and secured. They have been left untended and are growing into the planting wires resulting in girdling and causing deformation of the trunk. Trees inventoried are summarized in Table 3-7.

Table 3-7: Erosion Site 2 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Acer negundo	Manitoba Maple	I	Public	3
Acer saccharinum	Silver Maple	N	Public	2
Juglans nigra	Black Walnut	N	Public	2
Picea glauca	White Spruce	N	Public	3
Populus deltoides	Eastern Cottonwood	N	Public	2
Salix x rubens	Hybrid Crack Willow	I	Public	2
			TOTAL	**14**

Erosion Site 3

A total of thirty-one (31) trees representing six (6) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level of which three are native and three, non-native. They are considered secure locally, provincially, and nationally. Of the six white ash present all exhibited evidence of Emerald Ash Borer with three dead and three in relatively good condition with trunk wounds from the borer healing. Two of the willows are being undercut by bank erosion and a forked trunk of one has broken away from the other and fallen into the channel. Trees inventoried are summarized in Table 3-8.

Table 3-8: Erosion Site 3 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Acer negundo	Manitoba Maple	I	Public	10
Crataegus chrysocarpa	Fireberry Hawthorn	N	Public	1
Fraxinus americana	White Ash	N	Public	6
Juglans nigra	Black Walnut	N	Public	5
Salix alba var. vitellina	Golden Willow	I	Public	5
Salix x rubens	Hybrid Crack Willow	I	Public	4
			TOTAL	**31**

Erosion Site 4

A total of sixty-four (64) trees representing ten (10) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level of which seven are native and three, non-native. They are considered secure locally, provincially, and nationally. Of the five white ash present all exhibited evidence of Emerald Ash Borer with three dead and two in relatively good condition with trunk wounds from the borer healing. Four Manitoba maple lean steeply over the channel with one almost horizontal. Trees inventoried are summarized in Table 3-9.

Table 3-9: Erosion Site 4 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	I	Public	33
Acer saccharinum	Silver Maple	N	Public	1
Acer saccharum	Sugar Maple	N	Public	4
Fraxinus americana	White Ash	N	Public	5
Juglans nigra	Black Walnut	N	Public	5
Populus tremuloides	Trembling Aspen	N	Public	3
Prunus serotine	Black Cherry	N	Public	1
Salix alba var. vitellina	Golden Willow	I	Public	3
Salix x rubens	Hybrid Crack Willow	I	Public	6
Tilia americana	Basswood	N	Public	1
Ulmus americana	White Elm	N	Public	2
			TOTAL	**64**

Erosion Site 5

A total of thirty-three (33) trees representing six (6) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level of which four are native and two, non-native. They are considered secure locally, provincially, and nationally. Of the six white ash present all exhibited evidence of Emerald Ash Borer and all are dead. Three black walnut are being undercut by bank erosion and have extensive exposed roots. Trees inventoried are summarized in Table 3-10.

Table 3-10: Erosion Site 5 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	**Common Name**	**Native Status**		
Acer negundo	Manitoba Maple	I	Public	3
Fraxinus americana	White Ash	N	Public	6
Juglans nigra	Black Walnut	N	Public	19
Prunus avium	Wild Cherry	I	Public	3
Prunus serotina	Black Cherry	N	Public	1
Tilia Americana	Basswood	N	Public	1
			TOTAL	**33**

Erosion Site 6

A total of nineteen (19) trees representing seven (7) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level, except one apple species. Of the seven species, two are native and five, non-native. They are considered secure locally, provincially, and nationally. Of the six white ash present all exhibited evidence of Emerald Ash Borer and all are dead. Three black walnut are being undercut by bank erosion and have extensive exposed roots. Trees inventoried are summarized in Table 3-11

Table 3-11: Erosion Site 6 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Fraxinus americana	White Ash	N	Public	6
Juglans nigra	Black Walnut	N	Public	4
Malus spp.	Apple	I	Public	1
Prunus avium	Wild Cherry	I	Public	5
Rhamnus cathartica	Common Buckthorn	I	Public	1
Salix alba var. vitellina	Golden Willow	I	Public	1
Tilia cordata	Small-leaved Linden	I	Public	1
			TOTAL	**19**

Erosion Site 7

A total of six (6) trees representing six (6) species were inventoried within and 10 m from anticipated areas of disturbance. All trees were identified to species level and two are native and four, non-native. They are considered secure locally, provincially, and nationally. Naturally occurring Honeylocust are provincially rare (S2) but the tree inventoried is the thornless variety that is often planted in urban landscapes which are not protected provincially. The only white ash present exhibits evidence of Emerald Ash Borer and is in poor condition with 70% crown dieback. Four of the six individuals are planted trees in a park setting with only the Manitoba maple and black walnut appearing natural. Trees inventoried are summarized in Table 3-12.

Table 3-12: Erosion Site 7 Tree Inventory Summary

Species Name			Ownership	Number of Trees
Scientific Name	Common Name	Native Status		
Acer negundo	Manitoba Maple	I	Public	1
Fraxinus americana	White Ash	N	Public	1
Gleditsia triacanthos var. inermis	Honey Locust	I	Public	1
Juglans nigra	Black Walnut	N	Public	1
Robinia pseudoacacia	Black Locust	I	Public	1
Salix alba var. vitellina	Golden Willow	I	Public	1
			TOTAL	**6**

3.8.2.3 Migratory Birds

Aquafor staff completed breeding bird surveys on June 4 and June 25, 2020, and incidental observations of birds were recorded during all site visits. Bird species reported from the area via background resources were also considered in Aquafor's assessment of the site. A master list of bird species observed in or reported for the study area, along with additional details of Aquafor's breeding bird surveys, is provided in **Appendix C**.

In total, 33 bird species were documented during breeding bird surveys, consisting mainly of species that are typical of suburban areas and remnant habitats in southern Ontario. Most of the species observed are common and widespread, and do not have any habitat sensitivities or special requirements. However, two of the documented species, Barn Swallow (*Hirundo rustica*) and Eastern Wood-pewee (*Contopus virens*), are designated SAR and will be discussed further in **Section 3.8.3**. Further, a pair of nesting Cooper's Hawks (*Accipiter cooperii*) were observed incidentally and confirmed via discussions with area residents, in woodlands near Palmer Drive; additionally, confirmed raptor nesting indicates the presence of Significant Wildlife Habitat as discussed further in **Section 3.8.4**.

3.8.2.4 Amphibians and Reptiles

Calling surveys for frogs and toads were completed at selected roadside survey locations throughout the study area on April 6, May 25, and June 22 using the Marsh Monitoring Program protocol. Full survey details and results are provided in **Appendix C**. In summary, very low numbers of Spring Peeper (*Pseudacris crucifer*) and Green Frog (*Lithobates clamitans*) were documented in the northernmost portion of the study area (likely associated with roadside wetland pockets along Dundas St. and the Highway 407 interchange), and no frogs were heard calling from the remaining survey stations. The survey results did not indicate the presence of significant amphibian breeding habitat in the study area.

Aquafor surveyed for snakes in the study area by walking transects in suitable habitat and visually monitoring potential basking sites; hand searching (i.e., lifting flat rocks and other cover materials to search for snakes sheltering beneath) was also completed where conditions were suitable. No snakes were observed by Aquafor during these surveys, nor were any documented incidentally on other dates. However, background information indicated the presence of common species Eastern Gartersnake (*Thamnophis sirtalis sirtalis*), and Dekay's Brownsnake (*Storeria dekayi*) in the vicinity of the study area, as well as federally-listed Special Concern species Eastern Milksnake (*Lampropeltis triangulum*), and suitable habitat conditions for these species are present in the study area, so individuals could be present themselves even though they were not detected during surveys.

3.8.2.5 Bat Habitat

Phase 1 and 2 of the MNRF's Survey Protocol for Species at Risk Bats within Treed Habitats (2017) was completed to identify candidate maternity roosting sites for Ontario's four Endangered bat species. Potential habitat trees that were identified include primarily standing dead or dying trees ("snags"), live trees with cavities, loose bark, or similar features, and large-diameter oaks and maples (particularly those with dead or dying clusters of leaves). A total of 170 trees with potential habitat features for *Myotis* species bats and 152 trees with features suitable for Tricolored Bat were identified throughout the Tuck Creek corridor, and associated woodlands (although please note that there is some overlap between the two categories); see

Appendix C for full details and mapping. The habitat of Endangered bats has implications under the *Endangered Species Act* and therefore impacts related to proposed tree removal must be quantified and assessed in consultation with the MECP.

3.8.2.6 Other Terrestrial Wildlife

Mammal species observed incidentally by Aquafor staff throughout the study area include: Eastern Cottontail (*Sylvilagus floridanus*), Eastern Grey Squirrel (*Sciurus carolinensis*), Red Squirrel (*Tamiasciurus hudsonicus*), Raccoon (*Procyon lotor*), and Striped Skunk (*Mephitis mephitis*). All of these are very common species in urban and suburban southern Ontario habitats. Similarly common species such as Eastern Chipmunk (*Tamias striatus*) are also highly likely to be present even though they were not directly observed.

A wide variety of insects were also observed in the study area, including the provincially rare (S2-ranked) River Bluet (*Enallagma anna*) and regionally rare Fragile Forktail (*Ischnura posita*). These two species were observed in association with Polygons 8 and 6, respectively, and would use Tuck Creek and the associated riparian area as breeding and foraging habitat.

3.8.2.7 Aquatic Habitat and Fisheries

Aquatic habitat characteristics were investigated within the Tuck Creek study area using the Ontario Stream Assessment Protocol (OSAP), Version 10 (Stanfield, 2017), which included review of:

- Bank characteristics;
- Stream width (wetted and bankfull);
- Instream cover (e.g., woody debris, undercut banks, boulders, vegetation);
- Riparian cover (vegetation composition, quality and width); and
- Physical barriers to fish movement (e.g., woody or debris jams, knickpoints, etc.).

Full details of the results of field investigations are provided in **Appendix C**. In brief, Tuck Creek and its contributing tributaries provide a variety of aquatic habitats, varying in functionality throughout the reaches. The majority of the study area falls within the urban city centre of Burlington, with surrounding land use consisting of medium- to high-density residential, commercial, and industrial areas with some well-used parkland and recreational areas throughout. Several major roads and rail crossings were observed throughout the site, including Highways 403 and 407, and both the GO Rail line and the CN Rail line. As such, most of the study area has undergone realignment and past engineering attempts to accommodate for development and crossings, leading to a heavily urban-impacted watercourse with highly altered and degraded habitat. Not surprisingly, the highest quality habitat was observed in the reaches bordered by wide riparian corridors consisting of well-established forests (in the vicinity of erosion areas 4 and 5). Areas where riparian clearing and channel straightening have been carried out (e.g., in association with Ireland Park) likely contribute to downstream disturbance and potentially increased stream temperatures.

Despite these observations, fish and other aquatic life were observed throughout the entire system, suggesting that the demonstrated conditions provided integral habitat to a number of fish communities. Aquatic Resource Area (ARA) information provided by the Land Information Ontario (LIO) database shows that the Tuck Creek study area provides warmwater habitat for a community dominated by urban adaptive, common and largely tolerant species, such as

Blacknose Dace (*Rhinichthys atratulus*), Creek Chub (*Semotilus atromaculatus*), Fathead Minnow (*Pimephales promelas*), and White Sucker (*Catostomus commersonii*). Invasive species such as Goldfish (*Carassius auratus*) were also recorded throughout. Reaches downstream of Spruce Avenue and outside of the study area near Lake Ontario show more diversity, with coldwater migratory species such as Chinook Salmon (*Oncorhynchus tshawytscha*), Rainbow Trout (*Oncorhynchus mykiss*), and Brown Trout (*Salmo trutta*) recorded. Diversity could be impacted throughout the watershed due to instream barriers, changes in aquatic habitat and compounding impacts from adjacent landuse development.

In general, aquatic habitat was observed throughout the study area as both direct and contributing fish habitat. Tuck Creek and its contributing tributaries should be regarded as key features to fish habitat within the subwatershed and protected under the Federal *Fisheries Act*.

3.8.3 Species at Risk (SAR) and Provincially Rare Species

A full list of SAR and provincially rare species that either were observed during Aquafor's field investigations or which resulted from the review of background resources is provided in **Appendix C** along with the assessment of their potential presence in the study area based on habitat suitability. The species listed below were determined through the SAR screening process to either be present in the study area (per direct observation by Aquafor staff or confirmed, recent records from other sources) or to potentially be present based on habitat suitability and proximity to prior occurrences.

Plants

- Pignut Hickory (S3) - confirmed present by Aquafor staff along the valley slope adjacent to Lansdown Park.

Birds

- Barn Swallow (THR) - observed by Aquafor staff foraging in Lansdown Park, although nesting habitat (structures) is not present in the project study area.
- Black-crowned Night-heron (S3) - observed by Aquafor staff foraging in the creek near the Harvester Rd. crossing; nesting habitat is not present.
- Eastern Wood-pewee (SC) - observed by Aquafor staff during breeding bird surveys; suitable nesting habitat is present in association with erosion area 4.
- Red-headed Woodpecker (federally THR, provincially SC) - not observed during breeding bird surveys, but previously documented by the Ontario Breeding Bird Atlas for the area at large; suitable habitat is present in the study area.
- White-eyed Vireo (S2) - not observed during breeding bird surveys, but recent records are present for the area at large and suitable habitat is present.
- Wood Thrush (federally THR, provincially SC) - not observed during breeding bird surveys, but recent records are present for the area at large and suitable habitat is present.
- Yellow-breasted Chat (END) - not observed during breeding bird surveys, but previously documented by the Ontario Breeding Bird Atlas for the area at large; suitable habitat is present in the study area.

Mammals

- Bats (END) - suitable habitat for Ontario's four SAR bat species is present in wooded portions of the study area.

Reptiles

- Eastern Milksnake (federally SC) - noted for the area at large via background information, and suitable habitat is present throughout the study area.

Invertebrates

- River Bluet (S2) - confirmed present by Aquafor in Tuck Creek near Lansdown Park; breeding habitat expected to be present in the watercourse and foraging habitat in the riparian zone.
- Monarch (SC) - confirmed present in the study area at large via recent iNaturalist records; potential to breed in areas containing milkweed plants and forage throughout open habitats.
- Hentz's Orbweaver (S3S4) - confirmed present in the vicinity (Ireland Park) via recent iNaturalist records; suitable moist woodland habitat is present in the study area.
- Tiger Bee Fly (S3S4) - confirmed present in the vicinity (Lansdown Park) via recent iNaturalist records; suitable habitat is present in the study area

3.8.4 Significant Wildlife Habitat

Aquafor reviewed the MNRF's Significant Wildlife Habitat (SWH) Criteria Schedules for EcoRegion 7E and applied the relevant criteria to the study area in order to identify potentially significant habitat features or areas. The following five categories of SWH are considered relevant to the current study:

- Bat Maternity Colonies:
- The presence of cavity trees and similar features that provide potential habitat for roosting bats was discussed previously in this report. Wooded habitats within the study area provide suitable conditions to potentially support maternity colonies of Silver-haired Bat and Big Brown Bat, and are therefore considered Candidate SWH in this category. It should be noted that this habitat type directly overlaps with SAR bat habitat (discussed above) and that mitigation/protection measures for the two are therefore likely to be the same moving forward.

- Landbird Migratory Stopover Areas: Woodland habitat associated with the Tuck Creek corridor north and south of Palmer Drive meets the size and location criteria for this SWH category, and multiple regionally-uncommon or regionally-rare migrant songbird species were documented in this area via background information sources. These areas are therefore considered Candidate SWH.

- Woodland Raptor Nesting Habitat: A Cooper's Hawk nesting territory was documented in the woodlot between Palmer Dr. and Mainway, via direct observation of the species and discussion with area residents. SWH for Cooper's Hawk, as defined by the provincial criteria, includes a radius of 100 m around the nest location; as the nest was not pinpointed during field investigations, the entire community containing the territory has been identified as candidate SWH pending further refinement.

- Seeps and Springs: Iron staining, a common sign of groundwater seepage, was documented in one location at Driftwood Park. The provincial SWH criteria require two

seeps/springs to confirm the significance of habitat; as the site was not exhaustively surveyed for the presence of seeps, it is considered candidate SWH pending further review.

- Special Concern and Provincially Rare Species: Aquafor documented SC species Eastern Wood-pewee and S2 species River Bluet along the creek corridor off Lansdown Park. SWH associated with these species would include habitat elements that support the species' survival, so in this case habitat features that are considered important include the forest plants and structure (to support nesting by Eastern Wood-pewee) as well as the aquatic environment and herbaceous riparian vegetation (to support the nymph and adult life stages of River Bluet). Aquafor also confirmed one mature, healthy Pignut Hickory (an S2 species), along the upper slopes of the same section of valley corridor, within vegetation community polygon 9. Although no young Pignut Hickory were directly observed in the surrounding areas, it is likely that a viable seed bank is present in the area, particularly including polygon 9 community and adjacent polygon 8. All habitat within these communities should be considered SWH to account for existing or potential individuals.

  Additional Special Concern species Monarch and Wood Thrush were reported in the area via background resources. Wood Thrush has similar habitat requirements as Eastern Wood-pewee and was reported in the same vicinity, so any consideration of SWH for Wood Thrush would overlap with that of Eastern Wood-pewee. Monarch is largely a habitat generalist that is found as often in urban gardens as in natural meadows; the presence of small meadow patches or low numbers of milkweed stems is not considered highly significant for the survival of the species.

From the above, it is noted that multiple SWH categories have been applied to the woodland corridor adjacent to Lansdown Park, between Palmer Drive and Mainway, which is associated with erosion area 4 (plus, by association, the contiguous wooded area to the north of Palmer Drive, although that section of the creek corridor was outside of the study are and not investigated in detail as part of this EA). Mapping illustrating the locations of the SWH discussed above is provided in Appendix C, along with a full discussion of other SWH categories which were not considered relevant to this study.

3.8.5 Linkages and Corridors

Tuck Creek forms a mostly contiguous corridor from Lake Ontario through the City of Burlington. For the most part, this corridor is narrow and closely constrained by the adjacent development; in the northern part of the City, some larger isolated woodlands are present along the stream corridor, and outside of the City to the north, there remain larger areas of natural habitat connected to the watercourse. The function of the overall stream corridor to provide connectivity between these northern habitats and Lake Ontario is limited by the presence of barriers, primarily roads, and the scarcity of habitat in the southern portions. The riparian corridor undoubtedly provides some local function for wildlife migration. There is no apparent connectivity between the Tuck Creek corridor and other natural habitats in adjacent watersheds.

3.8.6 Policy Review and Overview of Environmental Approvals

3.8.6.1 Regional Natural Heritage System

The Regional Natural Heritage System (RNHS) is "a system of connected natural areas and open space to preserve and enhance the biological diversity and ecological functions within Halton" (Halton Region Official Plan, office consolidation June 2018). The RNHS includes:

1. areas so designated on Map 1 [*see* ***Figure 3-11***];
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,
    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 [*as a Key Feature, above*].

The Regional OP notes that all known Key Features have been included on Map 1G (see **Figure 3-11**). The Tuck Creek corridor is shown to form a contiguous green line from Lake Ontario northwest through the city; per the information provided in the preceding sections, it includes multiple of the features/categories listed above, including significant wildlife habitat, a regulated watercourse, and fish habitat. It also includes Significant Woodland per the definition provided in the Regional OP, which is a woodland 0.5ha or larger that is wholly or partially within 50 m of a major creek. All of the larger woodland patches investigated by this study meet this criterion as they are within 50 m of Tuck Creek.

Relevant to the proposed works related to the current study, the Regional OP policies indicate that "essential watershed management and flood and erosion control projects either carried out or supervised by a public authority" are allowable within the RNHS.

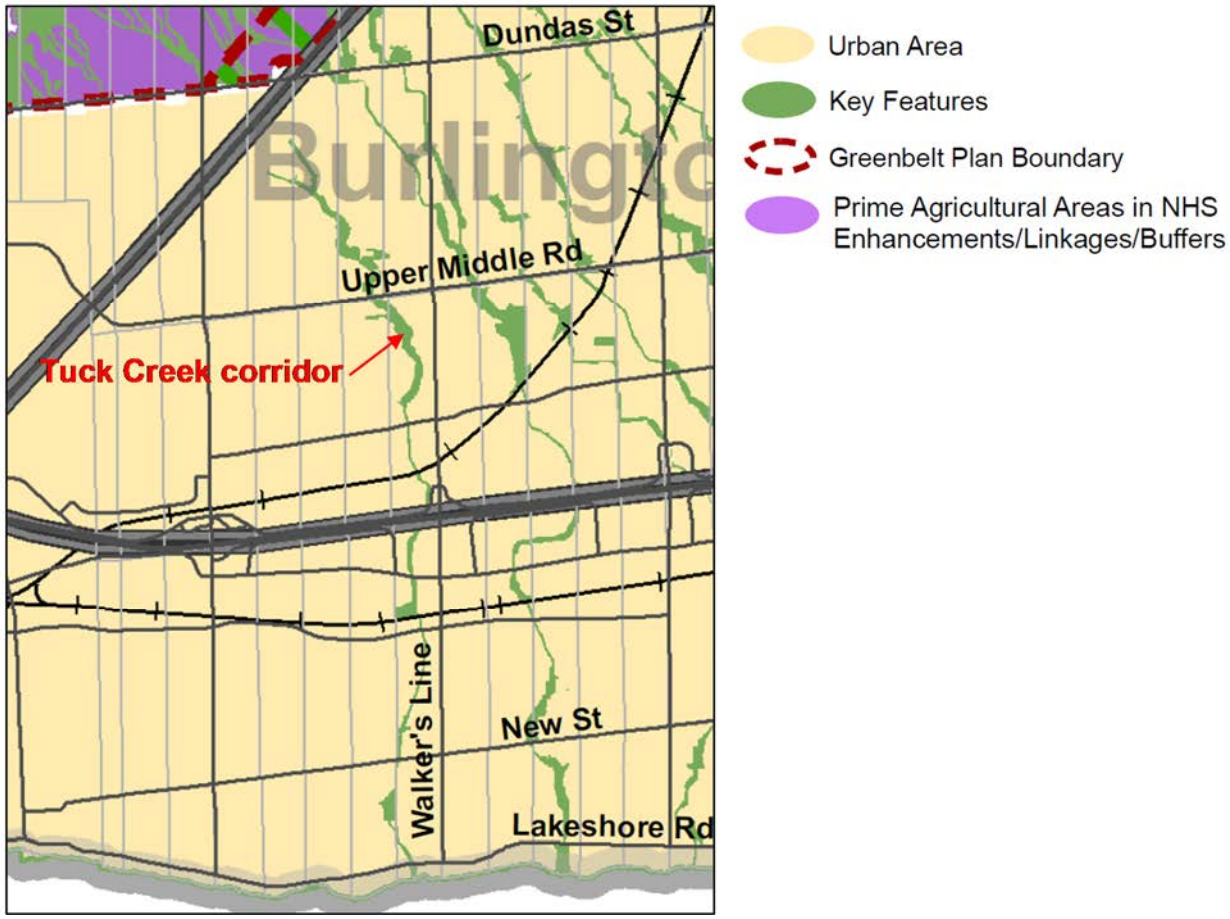


Figure 3-11: Excerpt of Halton Region Official Plan, Map 1G "Key Features within the Greenbelt and Regional Natural Heritage Systems"

3.8.6.2 Conservation Halton

All watercourses, wetlands, and flood/slope hazard areas are regulated by CH under the Development, Interference with Wetlands and Alteration to Shorelines and Watercourses Regulation (Ontario Regulation [O.Reg.] 162/06). Any proposed alteration of Tuck Creek, such as is proposed by this EA, will therefore need to be reviewed by CH to determine whether the control of flooding, erosion, dynamic beaches, pollution or the conservation of land will be affected by proposed works. A permit from CH under the aforementioned regulation will be needed to complete the proposed work.

3.8.6.3 DFO Self-Assessment

The federal *Fisheries Act* requires that projects avoid causing the death of fish and the harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near waterbodies that support fish at any time during any given year or are connected to waterbodies that support fish at any time during any given year. As noted above, records provided by LIO and observations made in the field by Aquafor staff support the claim that the study area within Tuck Creek contains fish at any time during any given year. The study area is also connected to waterbodies, such as the Lake Ontario, that support fish at any time during any given year. Therefore, the *Fisheries Act* applies to works conducted in or near water within the study area.

Upon completion of the detailed design for the channel works at the study site, the works should be cross-referenced with the DFO "Projects Near Water" online service to determine if a request for regulatory review under the federal *Fisheries Act* is required (Department of Fisheries and Oceans, 2016). Based on field investigations conducted by Aquafor staff and background information provided by LIO, the study area contains fish at any time during any given year, with a connection to waterbodies like Lake Ontario that support a diverse fish community at any time during any given year. It is therefore the opinion of Aquafor Beech Limited that a request for regulatory review by Fisheries and Oceans Canada will be required for works in or near water in the Tuck Creek study area. It is recommended that the proponent exercise the measures listed by Fisheries and Oceans Canada to avoid contravention with the Federal *Fisheries Act* and exercise due diligence by further mitigating accidental death of fish and the harmful alteration, disruption or destruction of fish habitat.

3.8.6.4 Endangered Species Act

Species at Risk that were potentially found or confirmed within the study area were previously discussed in **Section 3.8.3**. Under the *Endangered Species Act* (ESA), Endangered and Threatened species and their habitat receive regulatory protection, and any proposed impacts to those species must be discussed with the MECP via the submission of an Information Gathering Form (IGF) which provides the MECP with details of the proposed works and potential impacts and allows them to make a determination of the appropriate next steps (e.g., letter of advice and recommended mitigation, project registration under a regulatory exemption, or permit application).

Special Concern species and their habitat do not receive regulatory protection under the ESA. However, important habitat features/area for these species would be considered Significant Wildlife Habitat (see **Section 3.8.4**) and therefore fall under the RNHS.

3.9 Archaeological and Cultural Heritage Assessment

A Stage 1 archaeological assessment was undertaken by Archaeological Services Inc. (ASI) in October 2020. The assessments included review of background research and property inspection as a part of Tuck Creek Erosion Control Municipal Class Environmental Assessment to assess if there is potential to impact significant lands.

The Stage 1 assessment determined that 26 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 and these lands require Stage 2 archaeological assessment by test pit survey. Stage 2 Archaeological Assessment is required for Erosion Sites 1, 2, 4 and 5. The remainder of the study area does not retain archaeological potential on account of deep and extensive land disturbance, low and wet conditions, slopes in excess of 20 degrees or being previously assessed and these lands do not require further archaeological assessment. Figure 3-12 to Figure 3-17 below show the results of archaeological inspection of the property. The complete Archaeological Assessment study report is included in Appendix D.



Figure 3-12: Results of the Archaeological Property Inspection - 1



Figure 3-13: Results of the Archaeological Property Inspection - 2



Figure 3-14: Results of the Archaeological Property Inspection - 3



Figure 3-15: Results of the Archaeological Property Inspection - 4

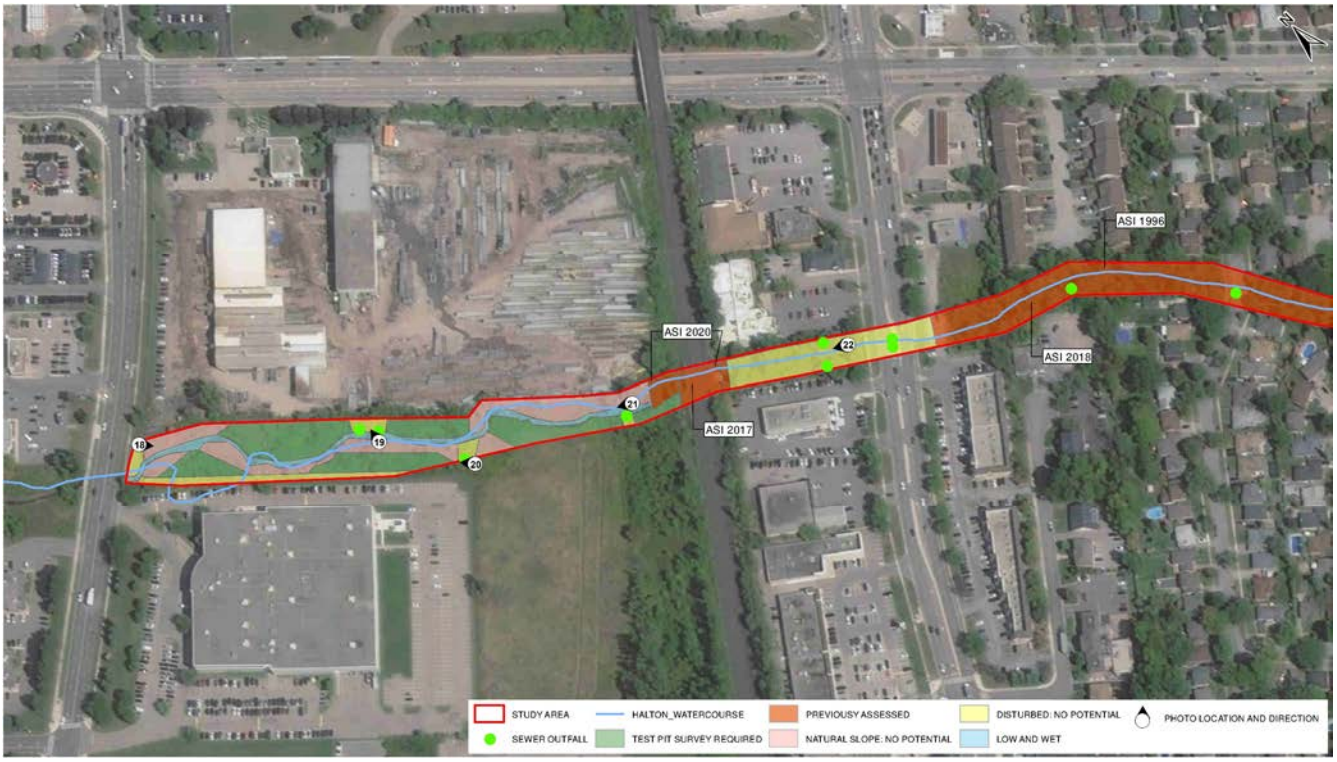


Figure 3-16: Results of the Archaeological Property Inspection - 5



Figure 3-17: Results of the Archaeological Property Inspection - 6

3.10 Utilities

Aquafor undertook 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. The identified utilities include storm outfalls (City and private), which are listed in Table 3-13. Figures illustrating the approximate utility locations and size are attached in Appendix A.

Table 3-13: Summary of Existing Utilities within the Study Area

Reach No.	Erosion Sites	Utilities	Dimension and Material	Recommendation
Reach 1	1	Storm	1650 mm ø Concrete	Recess and Retrofit with New Headwall
		Storm	600 mm ø Concrete	Recess and Retrofit
	2	N/A	N/A	N/A
Reach 2	3	N/A	N/A	N/A
	4	Storm	1050 mm ø Concrete	Scour Pool and Transition into New Channel
		Storm	825 mm ø Concrete	Scour Pool and Transition into New Channel
		Storm	900 mm ø Concrete	Scour Pool and Transition into New Channel
Reach 3	5	N/A	N/A	N/A
	6	N/A	N/A	N/A
	7	N/A	N/A	N/A

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 Tuck Creek watershed extends approximately to the limits of Dundas Street (see Figure 3-18).

South of Dundas Street and north west of Headon Road, land use is predominantly low to medium density residential and major parks and open space. The major parks located within this area are Driftwood Park north of Highway 407 and Ireland Park south of Highway 407. The area is categorized as low and medium density residential, and for employment, south of Palmer Drive and north of CN Rail. Similarly, the area south of Harvester Road and north of Centennial Bikeway is categorized as a mixed-use commercial and employment corridor, as well as low density residential (Figure 3-18).

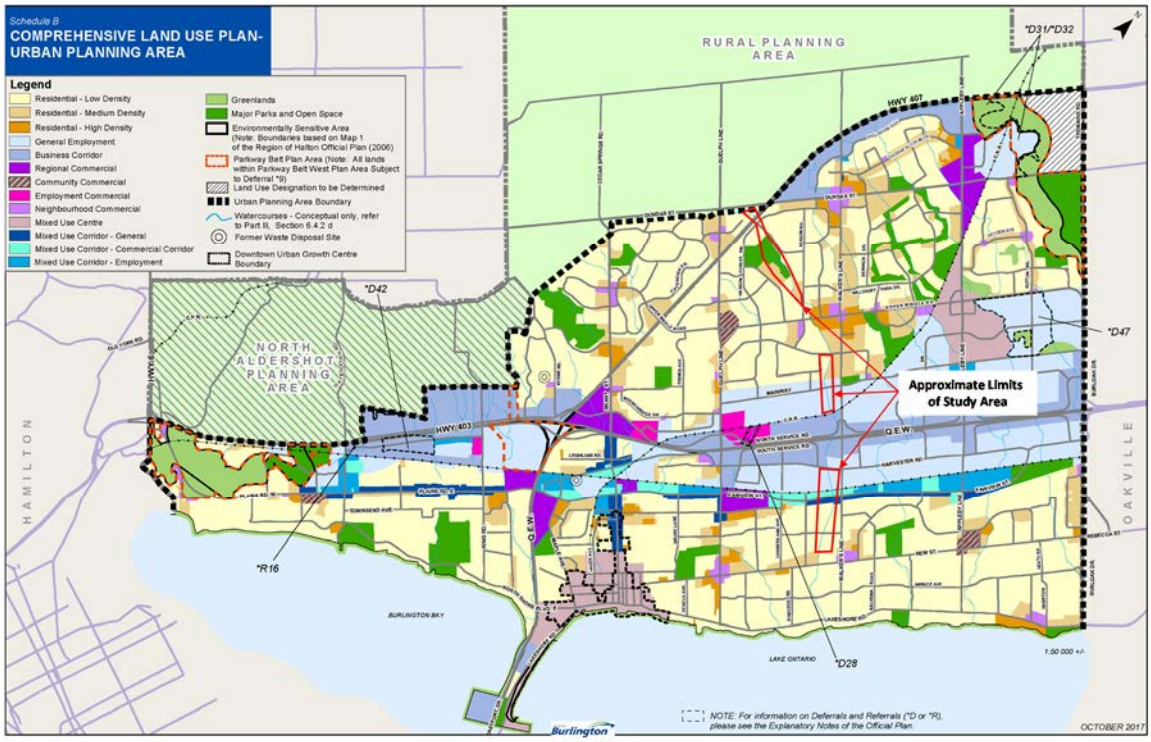


Figure 3-18: Land use within the City of Burlington (City of Burlington, 2017)

3.11.2 Transportation

Within the Tuck Creek watershed, major transportation corridors are the Highway 407, Queen Elizabeth Way (QEW), Dundas Street and two Canadian National Railway lines. Highway 407 and QEW are categorized as a Provincial Freeways and Dundas Street as a major arterial. Within the City of Burlington Official Plan (City of Burlington, 2010), Upper Middle Road, Harvester Road and North Service Road within the study area are classified as minor arterial roads (Figure 3-19).

A Right-of-way hydro corridor traverses through Tuck Creek south of Highway 407 and Rexway Drive. Also, within the hydro corridor are the Trans-Northern pipeline and the Centennial Bikeway trail. While there are several other utilities in the surrounding region, additional significant utility corridors do not pass through the study area.

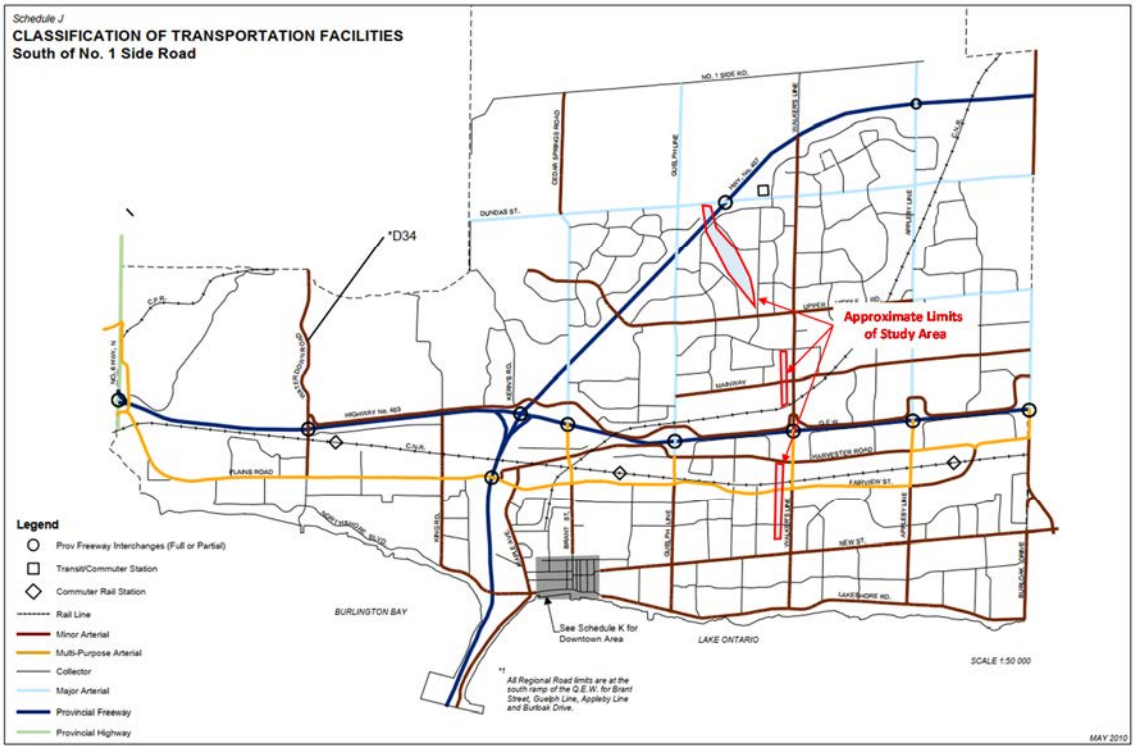


Figure 3-19: Transportation Facilities within the City of Burlington (City of Burlington, 2017)

3.11.3 Ownership

Within the study areas, the majority of Tuck Creek is contained to City owned lands or lands with permanent easements. The corridor is very narrow and leaves little room for natural channel processes. At one location (i.e., Erosion Site 1), the watercourse in on the privately owned property. Land acquisition or permanent easement is encouraged for Erosion Site 1. In addition, in order to undertake the proposed works at Erosion Site 3, private property easements will be required to access the site from the Landmark Road. Should erosion control work to be undertaken, land acquisition or temporary easement negotiation may be required. Land ownership details 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 seven (7) erosion sites as identified in **Section 2.1**. These alternatives are described in general below with specifics related to on each particular site following thereafter.

- **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 Restoration 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: Reach Scale 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 the riparian environment.

4.1 Description of Alternatives

4.1.1 Erosion Site 1

Alternative 1: Do Nothing – City property, municipal infrastructure, private property and public safety will continue to be at risk from erosion and the continued failure of existing erosion control structures. Ongoing risks include loss of property within the affected reach, deterioration of the 1650 mm ø concrete storm outfall, continued degradation of water quality and aquatic habitat, as well as potential impacts to the CN Rail Road crossing downstream.

Alternative 2: Local Restoration Works – Apply local erosion protection works at high-risk areas, including bank protection treatments at select eroded locations along the channel using vegetated buttresses, recess and retrofit the storm outfall with a new headwall and regrade and restore the channel slope.

Alternative 3: Reach Scale Works – Apply reach-scale engineering for approximately 210 meters of channel works, including 1) channel planform realignment to re-centralize the creek within City property and mitigate risks to private properties 2) installation of a vegetated buttress on both banks using boulders and round stone bank protection to prevent lateral erosion; and 3) recess, re-align to direct flows downstream at an angle, and retrofit storm outfall with new headwall integrated into the bank works. This alternative would also provide a natural channel

design with riffle-pool morphology to enhance the riparian environment while providing protection to aquatic habitat.

4.1.2 Erosion Site 2

Alternative 1: Do Nothing – City property, municipal infrastructure, private property and public safety will continue to be at risk from erosion and the failure of existing erosion control structures. Ongoing risks include loss of property within the affected reach, deterioration to the armourstone retaining wall, 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 20 meters immediately downstream of Harvester Road, including bank protection using a buried armourstone wall on the north bank, while also constructing a vegetated buttress on both banks. This design would also include diversion of flow towards the north branch, and clearing of the medial bar debris and infill, as well as regrading and restoration of the south branch.

Alternative 3: Reach Scale Works – Apply reach-scale bank and bed protection works approximately 95 meters downstream of Harvester Road, including 1) installation of a buried armourstone wall on both banks with vegetated buttress to prevent toe erosion, 2) removal of medial bar debris and channel realignment with typical round stone riffle-pool morphology, and 3) restoration of channel banks with enhanced vegetative buffer to enhance the riparian environment while also providing protection to aquatic habitat.

4.1.3 Erosion Site 3

Alternative 1: Do Nothing – City property, public safety and the CN Rail crossing will continue to be at risk from erosion and further degradation 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 for a length of 50 meters, including 1) minor channel realignment with typical round stone riffle-pool morphology, 2) removal of concrete debris from the channel bed, 3) regrade and restore the outflanked banks with the installation of a vegetated buttress on the south bank, and 4) restoration of channel banks with enhanced vegetative buffer to improve riparian cover while also providing protection to aquatic habitat.

Alternative 3: Reach Scale Works – Apply reach-scale engineering works for 60 meters immediately upstream of the CN Rail crossing, including channel realignment with typical round stone riffle-pool morphology, removal of gabion wingwalls and regrading and restoration of the outflanked south bank with the installation of vegetated buttress along the 60 meters of south bank and 10 meters upstream of the CN rail crossing on the north bank.

4.1.4 Erosion Site 4

Alternative 1: Do Nothing – This alternative will leave the creek as is. City infrastructure, private property and public safety will continue to be at risk from erosion. Ongoing risks include slope failure and potential loss of private property, sediment accumulation in front of the twin concrete storm outfall, as well as continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works for 70 meters along the north bank adjacent to Ketelbey Court, including bank protection using vegetated buttress, removal of sediment in front of the twin storm outfall and transition into existing channel with the creation of a scour pool.

Alternative 3: Reach Scale Works – Apply reach-scale bank and bed protection works for approximately 160 meters, including 1) channel planform realignment to re-centralize the creek within City property and mitigate risks to private property; 2) channel restoration with typical round stone riffle-pool morphology, 3) removal of sediment in front of twin storm outfall, and establish the smooth transition of the 900 mm ø storm sewer and twin storm sewer outfall into the existing channel via the creation of scour pool reconfigured to direct flows downstream at an angle, and 4) restoration of channel banks and infilling the old channel with an enhanced vegetative buffer to improve the riparian environment while also providing protection to aquatic habitat.

4.1.5 Erosion Site 5

Alternative 1: Do Nothing – City property and public safety will continue to be at risk from erosion and further degradation of the armourstone retaining wall 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 for a length of 45 meters along both banks, including bank protection encompassing 1) removing, salvaging, and resetting of existing armourstone wall in a revetment alignment, 2) removal of wooden debris from the channel, and 3) restoration of banks with enhanced vegetative buffer to enhance creek riparian cover while also providing protection to aquatic habitat.

Alternative 3: Reach Scale Works – Apply reach-scale bank and bed protection works for a length of approximately 130 meters, including 1) channel realignment with typical round stone riffle-pool morphology, 2) removal and disposal of failing armourstone wall, and 3) removal of wooden debris from the channel.

4.1.6 Erosion Site 6

Alternative 1: Do Nothing – City's property, municipal infrastructure, and public safety will continue to be at risk from erosion and further degradation of existing erosion control structures. Ongoing risks include flow obstruction and creation of a knick-point or head cut that could propagate further upstream, putting the series of upstream grade control structures at risk, while also allowing the continued degradation of water quality and aquatic habitat.

Alternative 2: Local Restoration Works – Apply local erosion protection works for 60 meters along the north bank and 20 meters on the south bank, including bed and bank protection using 1) removal of Terrafix block and replacement with rocky ramp, and 2) re-establishment of concrete weir, in addition to infilling and regrading the outflanked north bank.

Alternative 3: Reach Scale Works – Apply reach-scale bank and bed protection works for approximately 60 meters, including 1) removal of Terrafix blocks and rehabilitation of the channel with rocky ramp / pool morphology, and 2) removal of concrete weir, 3) restoration of banks with enhanced vegetative buffer to enhance creek riparian cover also while providing

protection to aquatic habitat, and 4) expanded riparian buffer between the asphalt trail and the watercourse.

4.1.7 Erosion Site 7

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

Alternative 2: Natural Design – Apply erosion protection works with a natural design approach with softer bio engineering techniques for approximately 15 meters, including 1) installation of rootwads and/or stumps for bank protection, and 2) Restoration and planting efforts to mimic existing vegetation.

Alternative 3: Engineered Design – Apply erosion protection works with an engineered design approach for approximately 15 meters, including 1) installation of armourstone retaining wall on the south bank, and 2) bank and bed protection with the creation of round stone riffle-pool morphology.

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, and 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 description of the scoring rationale is presented in Table 4-1.

Table 4-1: Alternative Evaluation Criteria

Criteria Category	Criteria	Description
Physical / Natural Environment Criteria	Mitigation of Existing Erosion Risks	Where existing erosion risks are substantial, close to the maximum score may be achievable. Where erosion risks are lower, maximum scores are not achievable. Higher Risk: Pending slope failure, potential loss of structures, potential impacts to critical infrastructure, etc. Lower Risk: Minor bed/bank erosion toward a naturalized area or non active use (vacant land), etc.
	Impacts to Aquatic and/or Terrestrial Habitat	Where existing aquatic habitat is of higher quality, maximum scores are not achievable and it is also possible to achieve a negative score where harm is expected. Where the existing channel is degraded, full of rubbish/debris, has barriers to fish passage etc., maximum scores may be achievable. The degree of improvement/mitigation or impact (negative score) is scored in the green box. Greater

Criteria Category	Criteria	Description
		improvements to fish and aquatic habitat would score higher. Improvements may be with respect to restoration of bed materials/substrates, riparian plantings, reduced turbidity, improved passage/connectivity. Scoring should also consider potential construction impacts (relative to existing conditions) where disruption is expected to result from construction. Where on-going degradation is expected under the do-nothing this could be considered a negative impact (negative score).
		Where existing terrestrial habitat is of higher quality, maximum scores are not achievable and it is also possible to achieve a negative score when harm is expected. Where there's rubbish/debris or minimal/low quality riparian vegetation, etc., maximum scores may be achievable. The degree of improvement/mitigation or impact (negative score) is scored in the green box. Greater improvements to terrestrial habitat score higher, including increased buffers, increased planting density, inclusion of key features (e.g., raptor poles), etc. Scoring should also consider potential construction impact relative to existing conditions as well as consider the loss of habitat for interim periods.
Technical and Engineering	Technical Feasibility	Less complexity of the Project: Consider permitting/coordination requirements with community members and stakeholders, etc.
		Less impacts to existing infrastructure (e.g., sewers, watermains, gas, roads)
	Flooding Impacts	Greater reduction of flooding risks to public and/or private lands for longer time scores higher
Social / Cultural Environment	Parks and Recreation	Opportunities which increase safety or utility of trails and/or outdoor recreational facilities would score higher (e.g., improvements to parkland, trails, etc.)
	Community Disruption	Compatibility of proposed works with adjacent properties (i.e., removal or addition of features which reduces utility for neighbouring lands scores lower). As an example, removal of mature vegetation adjacent residential properties would score lower.
		Less disruption to the surrounding community and residents scores higher (e.g., consideration of traffic/road closures, access impacts to shops, etc.)
	Archaeological Impacts	Less disturbance of areas with archaeological potential and cultural heritage resources scores higher

Criteria Category	Criteria	Description
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 of the number of sub-criteria presented within the larger category. The maximum points for each category for this evaluation are shown in Table 4-2.

Table 4-2: Category Weighting Factors

Category	Maximum Points for Category
Physical / Natural Environment Criteria	40
Technical and Engineering Criteria	15
Social / Cultural Environment Criteria	20
Economic Environment Criteria	25
TOTAL	**100**

For Physical / Natural Environment Criteria, a score was applied ranging from 0 to 20 for Mitigation of Existing Erosion Risk, and a score range of 0 to 10 was applied for Impacts to Aquatic and Terrestrial Habitat. Similarly, for Technical and Engineering Criteria, Social / Cultural Environment Criteria, and Economic Environment Criteria, 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. A 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 – Reach Scale Works
Erosion Site 1	40	63	67
Erosion Site 2	42	69	73
Erosion Site 3	43	83	78
Erosion Site 4	39	65	69
Erosion Site 5	46	69	58
Erosion Site 6	40	68	79
Erosion Site 7	45	77 (Natural Design)	66 (Engineered Design)

4.4 Public and Agency Consultation

4.4.1 Notice of Commencement

The Notice of Commencement for the study was issued on November 7th and 17th, 2019.

4.4.2 Public Information Centre (PIC)

Due to the ongoing Public Health Emergency related to COVID-19, one (1) Virtual Public Information meeting was held to inform residents and stakeholders of the study and to solicit their input with respect to priority restoration sites and erosion restoration alternatives. The PIC meeting included a web presentation and a question-and-answer session. The meeting was held on December 15, 2020.

The PIC consisted of a board outlining the study purpose and background, as well as next steps. A copy of the PIC boards presented 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 Tuck 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 could not be provided to the attendees as the PIC was held virtually, however, Aquafor and City obtained input and feedback on the evaluation of alternative solutions, and the selection of preferred solutions during the question-and-answer session. After the PIC,

additional feedback and comments were received through email from the attendees which are provided in Appendix F.

PIC display boards are provided in Appendix F.

4.4.3 Conservation Halton 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. Responses to comments have been addressed, with detailed responses summarized within the consultation appendix. Input from Conservation Halton has been carried forward through the recommendations of the preferred alternatives, specifically, with regards to use of natural materials and bioengineering as part of all erosion control measures.

4.4.4 First Nations Consultation

This project has included consultation with the following communities who have been identified as potentially affected by the proposed project:

- Haudenosaunee Development Institute
- Huron-Wendat First Nations
- Six Nations of the Grand River
- Mississaugas of the Credit First Nations

Consultation included written correspondence with each community, along with provision of the Notice of Study Commencement and Public Information Centre. Upon receipt of the written communication, responses were received which requested a review of the Stage 1 Archaeological study. This report was provided in draft format prior to submission to the M

Each community responded noting their interest in participation through Field Liaison Representatives during onsite natural environment or archaeological fieldwork. The City of Burlington will accommodate these requests, which will occur at the detailed design phase of the project. The following sites will have Stage 2 Archeological assessments: Erosion Sites 1, 2, 4 and 5, and each project will have natural environment inventories.

4.5 Selection and Description of the Preferred Alternative

The preferred alternatives were selected based on the evaluation criteria, and were then further refined and confirmed through consultation with the City and the public. The preferred alternatives are as follows:

Erosion Site 1: Alternative 3 – Reach Scale Works

The reach scale works would include 210 meters of channel works with the use of roundstone vegetated buttresses for bank protection. Is it suggested that consideration be given to channel planform adjustment to re-centralize the creek within City property, thereby helping to prevent encroachment of the creek into private properties This planimetric adjustment should be coupled with profile adjustment (riffles and pools) to enhance aquatic habitat conditions. Moreover, the 1650 mm ø storm outfall is to be recessed, re-aligned to direct flows downstream at an angle, and retrofitted with a new headwall and the private outfall storm runoff channel will be re-aligned to direct flows downstream at an angle and integrated within the proposed bank works. This alternative also includes restoration of slopes above top of bank with native trees and shrubs within the City owned portion of the corridor. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$. The use of construction/wood matting should be considered on the potential access route to have less impact(s) on riparian vegetation. The maintenance of a buffer between the watercourse and the employment/storage uses on site is encouraged.

A drawing illustrating the preferred alternative for Erosion Site 1 is included on the following page.

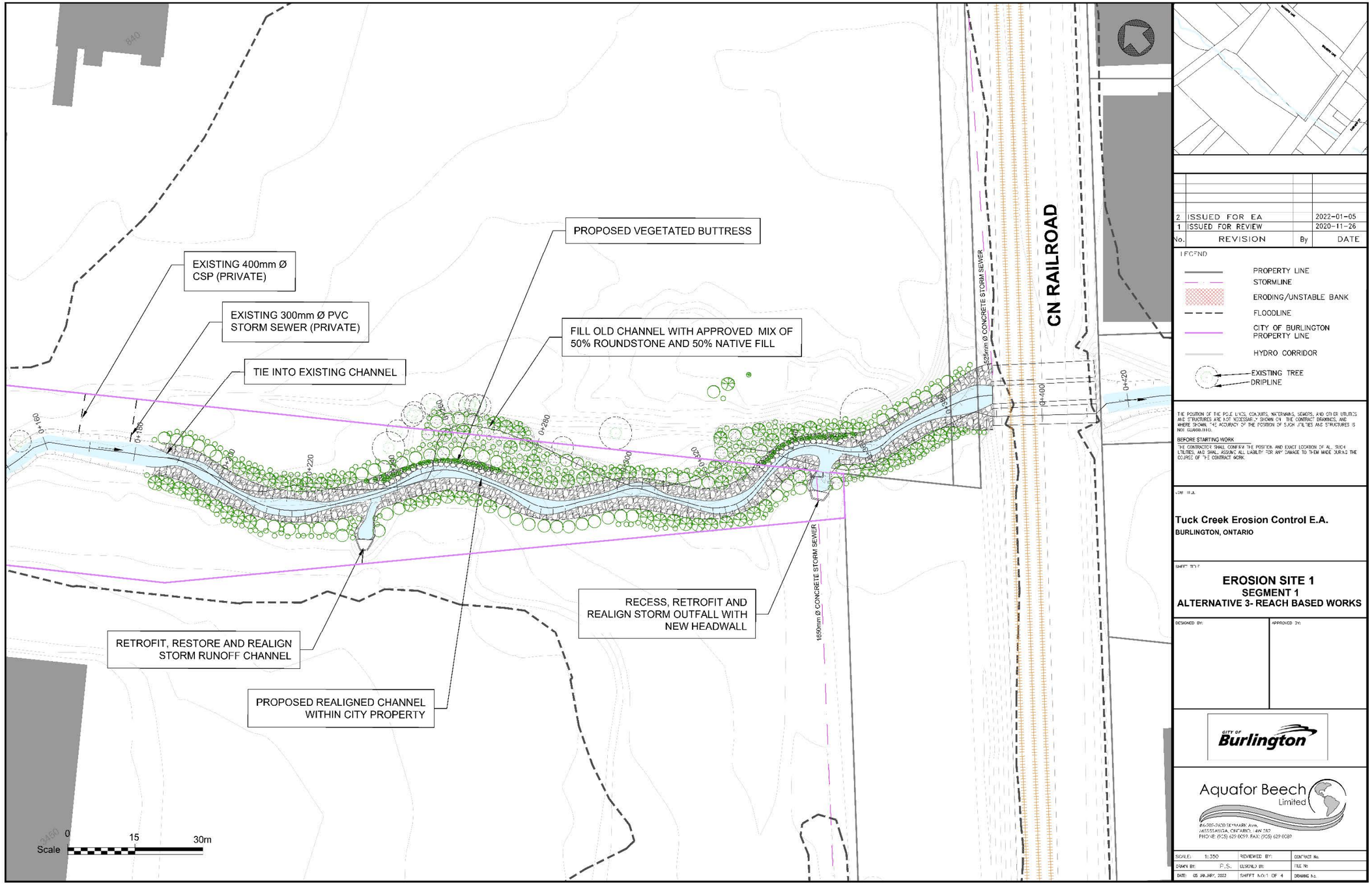


Figure 4-1: Conceptual Drawing of Preferred Alternative for Erosion Site 1 – Reach Scale Works

Erosion Site 2: Alternative 3 – Reach Scale Works

Approximately 95 meters of bank and bed protection works will be undertaken downstream of Harvester Road, including removal of the existing failing armourstone retaining wall, installation of a buried armourstone wall on both banks coupled with vegetated buttress to prevent toe erosion, removal of medial bar debris and channel realignment with implementation of typical round stone riffle-pool morphology. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$. The utilization of softer bioengineering approaches to help reduce scale of works (i.e., root wads, live staking, etc.) is recommended. Slopes above the armourstone wall and top of bank will be restored with native trees and shrubs.

A drawing illustrating the preferred alternative for Erosion Site 2 is included on the following page.

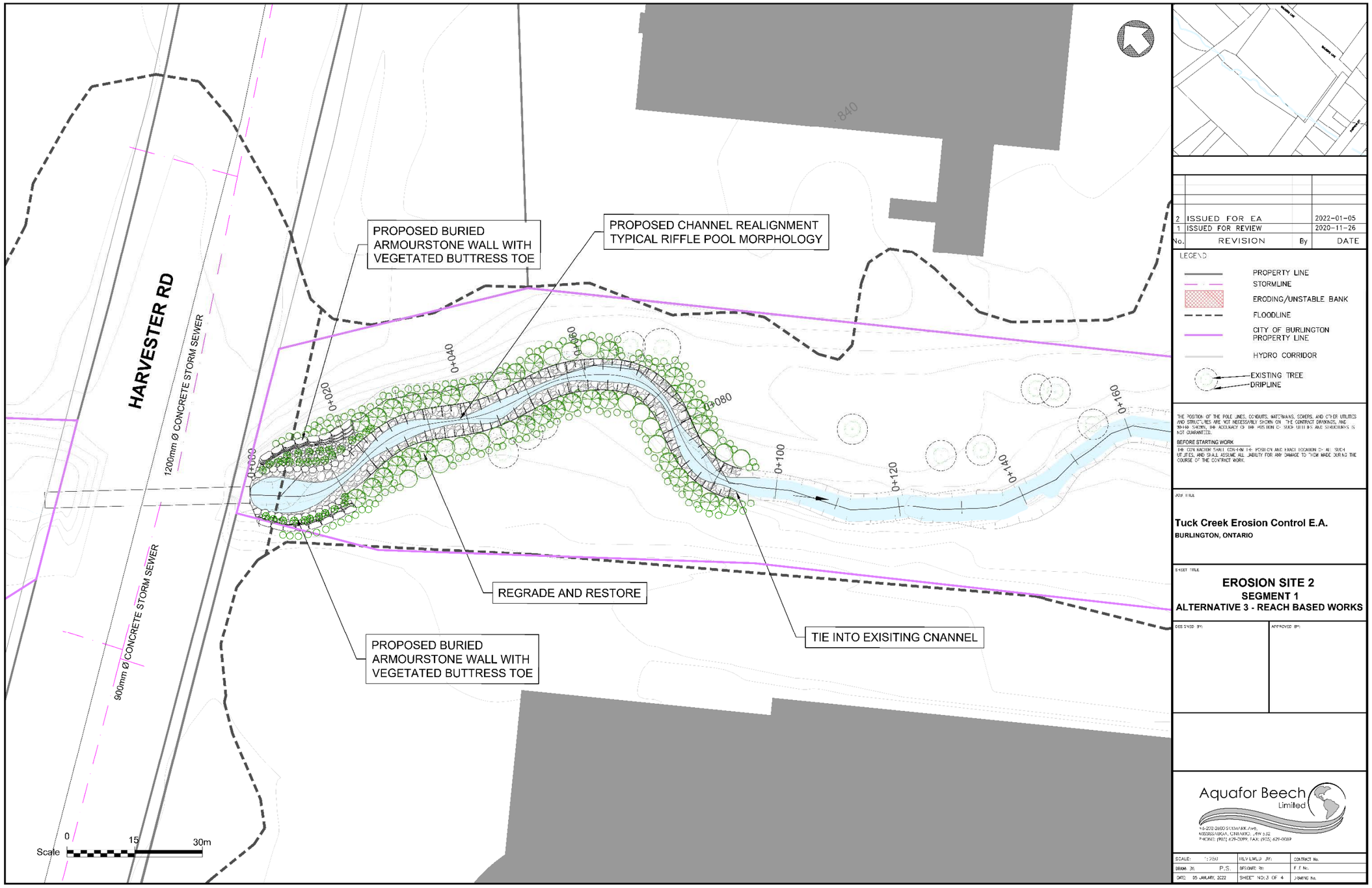


Figure 4-2: Conceptual Drawing of Preferred Alternative for Erosion Site 2 – Reach Scale Works

Erosion Site 3: Alternative 2 – Local Restoration Works

Local restoration works would include 1) removal of concrete debris from the channel bed to enhance an existing natural resource, 2) approximately 50 meters of bank stabilization works along the outer edge of the eroded meander bends with round stone vegetated buttresses, 3) regrade and restore outflanked banks, and 4) restore slopes above top the of the bank with native tree and shrubs within the City owned corridor. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$. The utilization of softer bioengineering approaches to help reduce scale of works (i.e., root wads, live staking, etc.) is recommended. As the access route is near the watercourse, it will require additional ESC measures to minimize additional erosion/sedimentation impacts.

A drawing illustrating the preferred alternative for Erosion Site 3 is included on the following page.

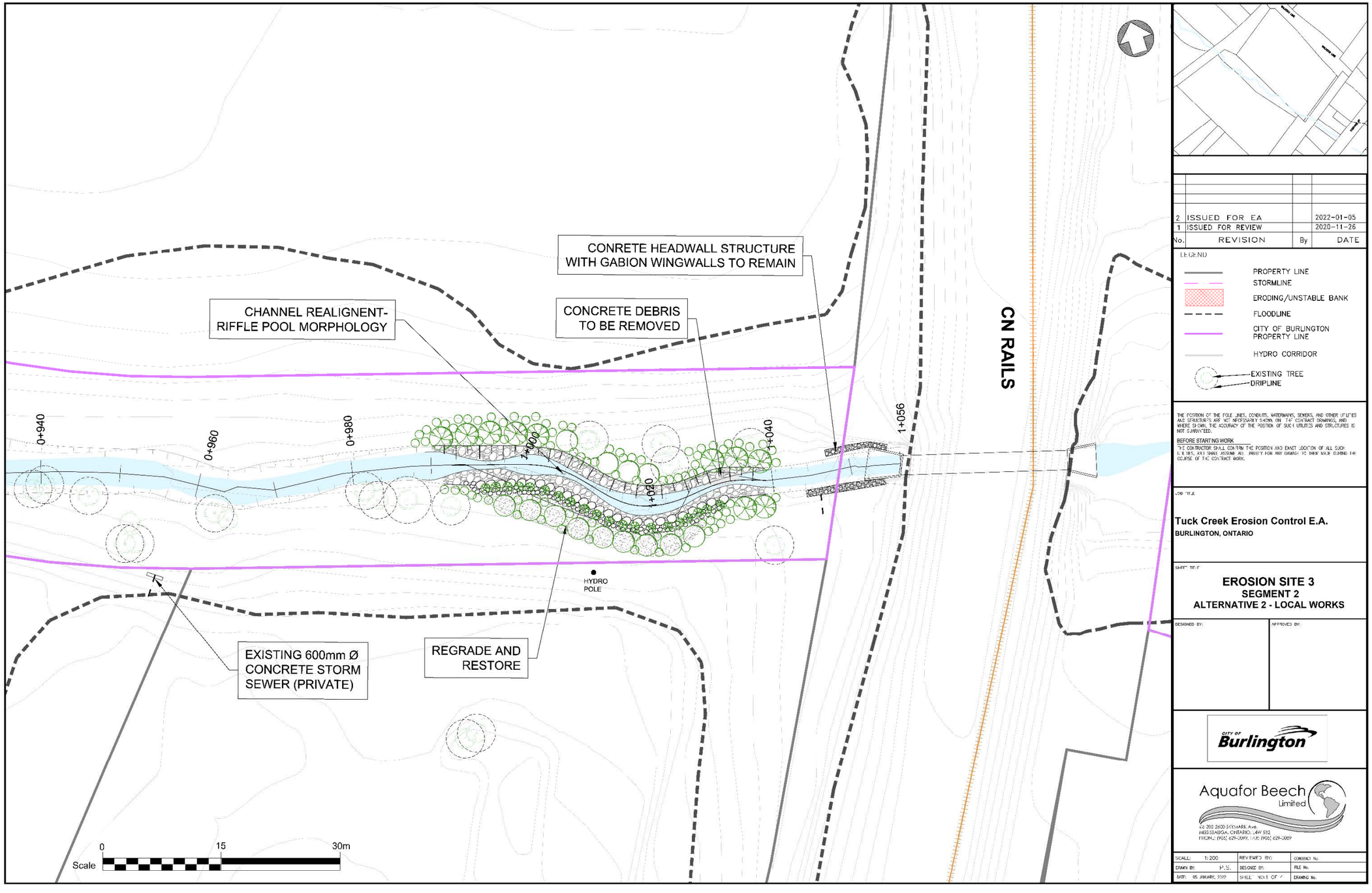


Figure 4-3: Conceptual Drawing of Preferred Alternative for Erosion Site 3 – Local Restoration Works

Erosion Site 4: Alternative 3 – Reach Scale Works

Reach-scale works would involve both planform and profile adjustment for approximately 160 meters of channel. This would include 1) channel planform realignment to re-centralize the creek within City property and mitigate risks to the fence line of the private property (3482 Ketelbey Court); 2) channel profile adjustment to establish typical round stone riffle-pool morphology, 3) removal of sediment in front of the twin storm outfall and establishment of a smooth transition for the 900 mm ø storm outfall and twin storm outfall into the existing channel through the creation of a scour pool reconfigured to direct flows downstream at an angle, and 4) restoration of channel banks and infilling of the old channel with an enhanced vegetative buffer to enhance riparian cover within the creek corridor. The use of existing substrate materials for the channel planform is highly encouraged. Coordination with the owners of 3482 Ketelbey Court is encouraged as opportunities to establish more deeper rooting vegetation in the vicinity of the top of bank to aid with stabilization of this embankment. The staging and storage area need to be placed such that there is minimal impact to the existing terrestrial habitat. The utilization of softer bioengineering approaches to help reduce scale of works is recommended. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$. This is specifically important due to the Confirmed and Candidate SWH and SAR bat habitat. The restoration plan should mimic existing habitat to encourage long term sustainability of habitat form and function.

A drawing illustrating the preferred alternative for Erosion Site 4 is included on the following page.

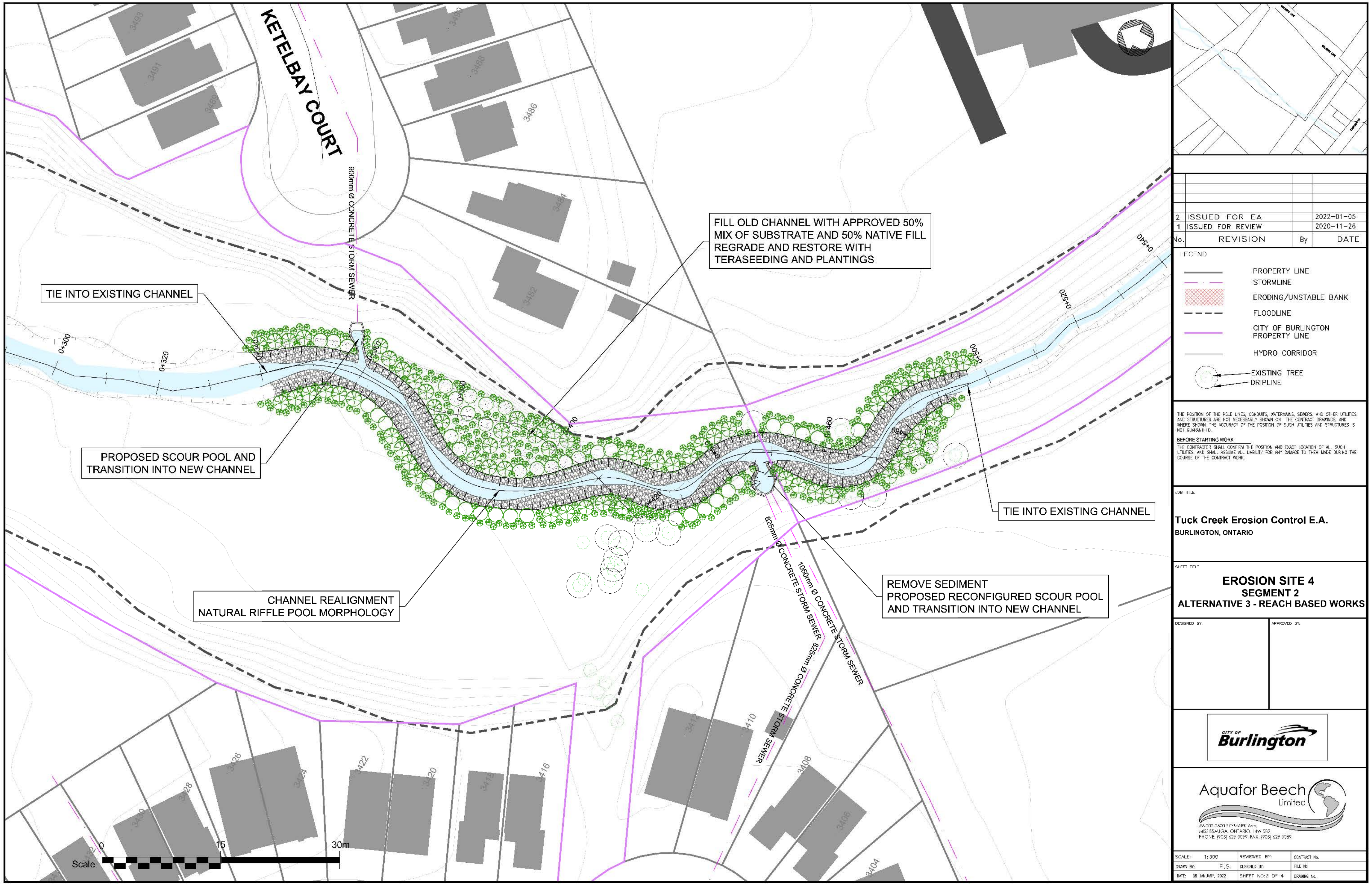


Figure 4-4: Conceptual Drawing of Preferred Alternative for Erosion Site 4 – Reach Scale Works

Erosion Site 5: Alternative 2 – Local Restoration Work

Approximately 45 meters of bed and bank protection works would be undertaken, including the removal and resetting of the existing armourstone wall in a revetment alignment to provide the long-term erosion protection to the adjacent properties. The utilization of softer bioengineering approaches to help reduce scale of works and address local erosion is recommended. The in-creek wooden debris jam would also be removed. Slopes above the revetment wall and top of the bank are to be restored with native trees and shrubs. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$. The use of existing community/informal trail is proposed for access to creek to avoid the removal of sensitive vegetation features.

A drawing illustrating the preferred alternative for Erosion Site 5 is included on the following page.

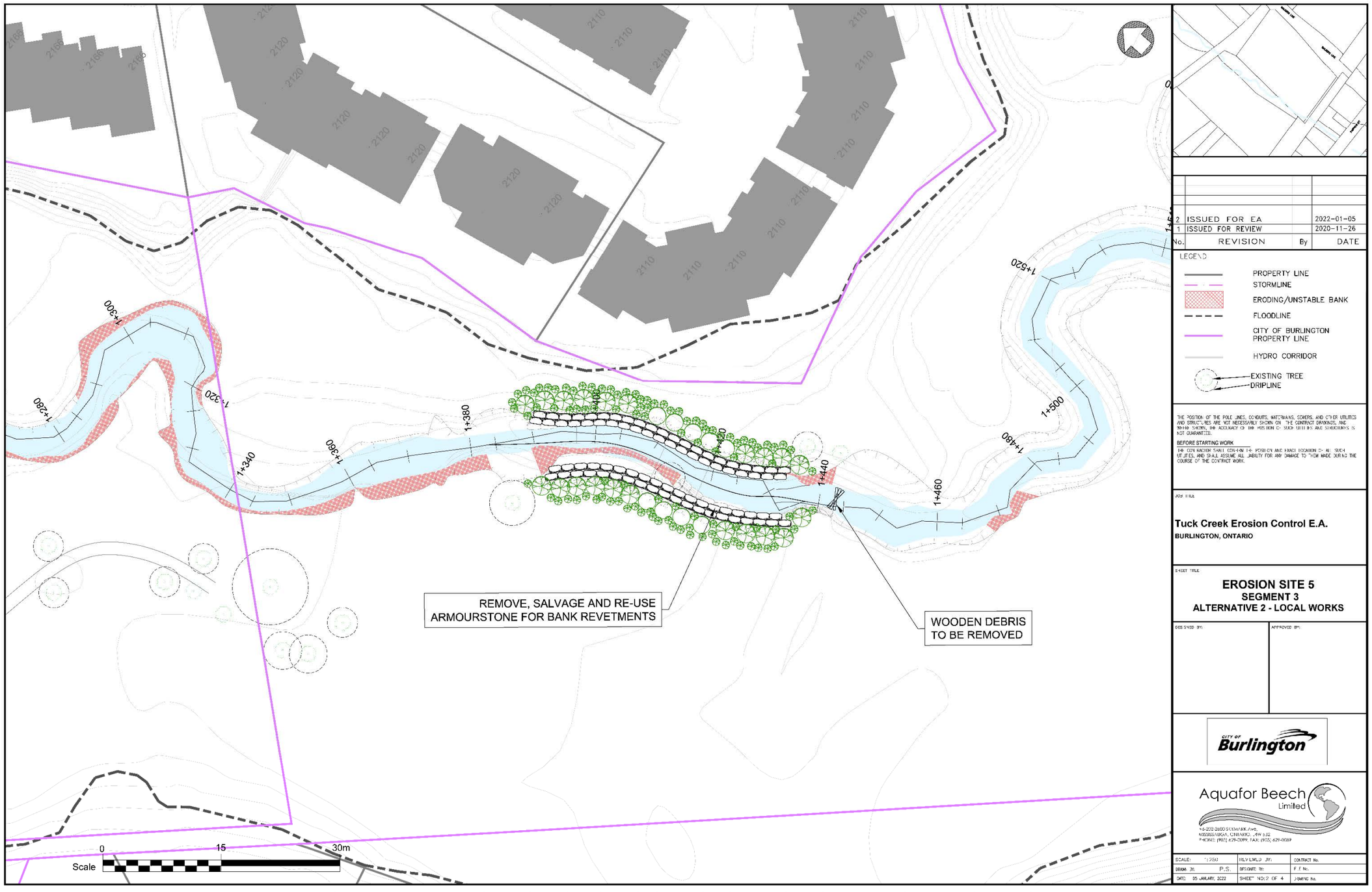


Figure 4-5: Conceptual Drawing of Preferred Alternative for Erosion Site 5 – Local Restoration Works

Erosion Site 6: Alternative 3 – Reach Scale Works

Reach-scale works would involve bank and bed protection works for approximately 60 meters, including 1) removal of Terrafix blocks and rehabilitation of the channel with rocky ramp / pool morphology, 2) removal of the concrete weir, 3) restore slopes above top of bank with native tree and shrubs within the City owned corridor, 4) expanded riparian buffer between the asphalt trail and the watercourse. The utilization of softer bioengineering approaches to help reduce scale of works and address local erosion is recommended. A dam and pump flow diversion method is recommended with a minimum pumping capacity of $1m^3/s$.

A drawing illustrating the preferred alternative for Erosion Site 6 is included on the following page.

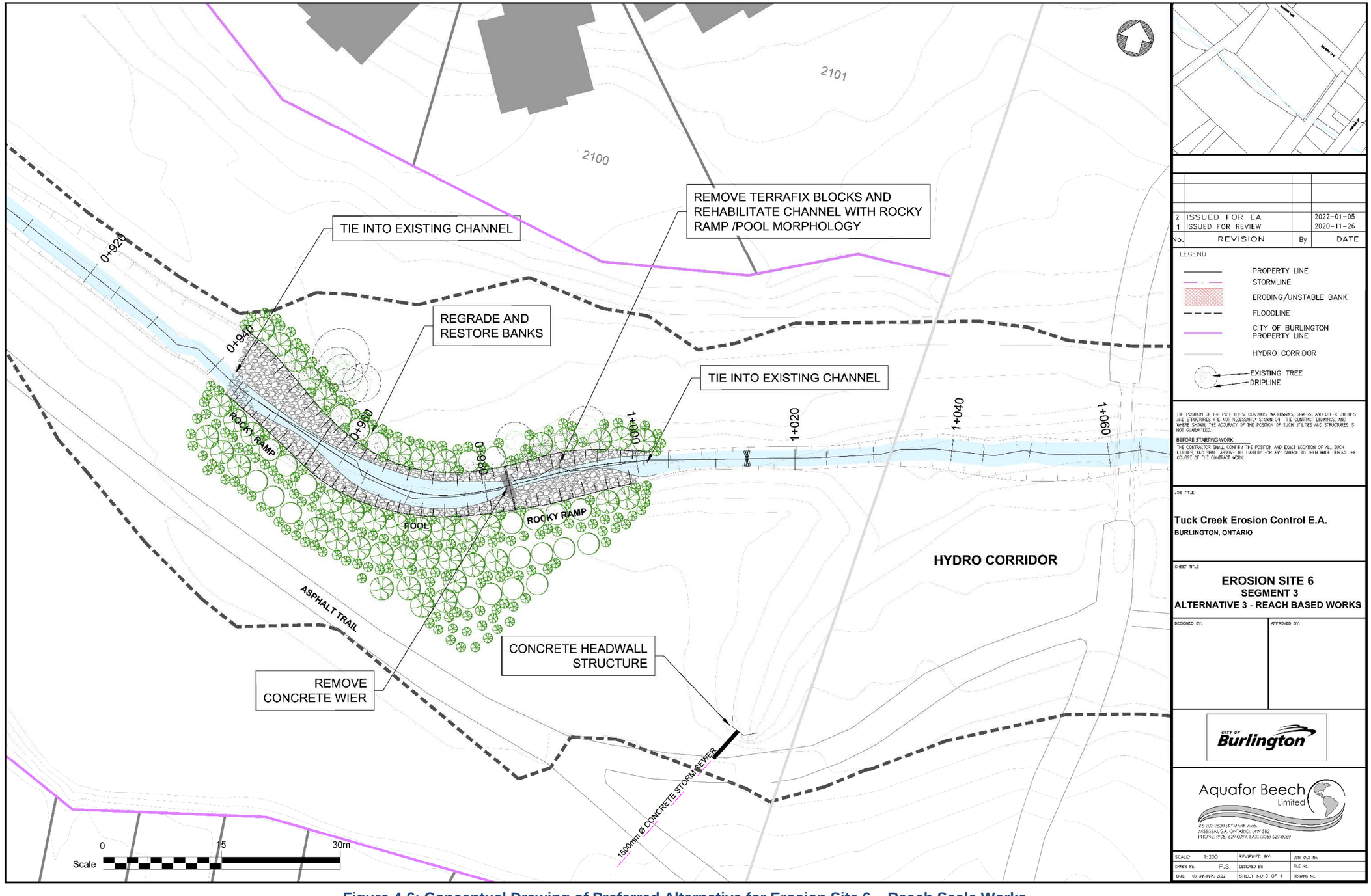


Figure 4-6: Conceptual Drawing of Preferred Alternative for Erosion Site 6 – Reach Scale Works

Erosion Site 7: Alternative 2 – Natural Design

This alternative involves natural design works including approximately 15 meters of bank stabilization works at the eroded outer meander bends with softer bioengineering techniques such as root wads and/or stumps. The Hamilton-Halton Stewardship Program and the Field and Stream Rescue Team could potentially undertake the restoration works using low impact equipment to minimize impacts on existing riparian vegetation. The proposed access route is located within identified riparian wetland. Therefore, efforts to re-route and minimize impacts to wetland's form and function during and post construction will need to be demonstrated. A site visit with CH staff to flag wetland boundary during the appropriate time of year should take place to determine the areas of impacts. The restoration plan and planting efforts will need to mimic existing vegetation to promote long-term sustainability of wetland post construction. In addition, slopes above top of bank, and within the City corridor, are to be restored with native trees and shrubs.

A drawing illustrating the preferred alternative for Erosion Site 7 is included on the following page.

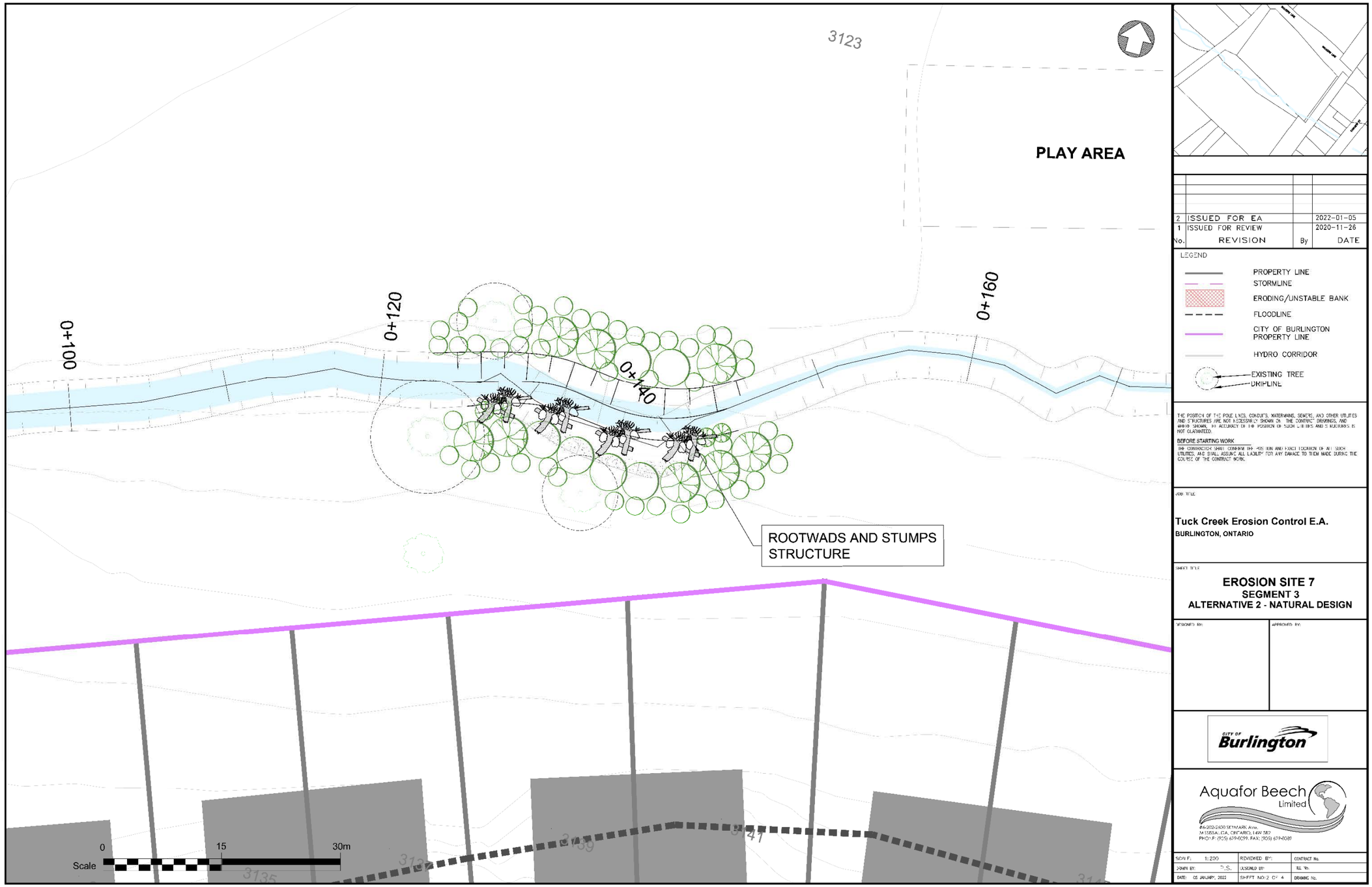


Figure 4-7: Conceptual Drawing of Preferred Alternative for Erosion Site 7 – Natural Design

4.6 Conceptual Design of the Preferred Alternative

Conceptual design drawing packages for the preferred alternatives are included in Appendix H. The 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.

These 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 helped facilitate the public consultation program by illustrating the importance of the proposed works to interested stakeholders.

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 Tuck Creek, the preferred restoration alternatives have been prioritized into multiple projects. The project prioritization is based on the erosion sites field scoring assessment and property ownership considerations.

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 tentative planning and budgeting purposes only, a feasible implementation plan for the recommended erosion mitigation projects is organized into 0-2, 2-5, and 5-10-years planning horizons. In addition, the City should also consider integrating the implementation of multiple projects based on City priorities and opportunities that arise with other departments, stakeholders, and private landowners 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., Erosion Site 1).

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	840 Walkers Line	1	1	83	City and Private	210m	Bank erosion, erosion risk to storm outfall, and channel into private property	B	$925,000	0-2 years
2	CN Rail Road	3	2	80	City & Private	50m	Degradation of existing erosion control structures, flow obstruction	B	$575,000	0-2 years
3	Harvester Road	2	1	75	City	95m	Bank erosion, failing armourstone retaining wall, channel bifurcation	B	$1,100,000	2-5 years
4	Kettlebey Court	4	2	70	City	160m	Bank erosion adjacent to private property, and sediment accumulation in-front of storm outfall	B	$1,250,000	2-5 years
5	Ireland Park	6	3	68	City	20m	Failed / failing grade control and erosion control structures, local bank erosion fish barrier	B	$120,000	2-5 years
6	Driftwood Park	7	3	63	City	15m	Bank erosion adjacent to private property	B	$60,000	5-10 years
7	Hydro ROW	5	3	45	City	45m	Degrading of armourstone retaining wall structures	B	$950,000	5-10 years

5.2 Impact Assessment and Mitigation Measures

5.2.1 Terrestrial Vegetation

Vegetation removal within the Tuck Creek corridor would be required to carry out the proposed works. This would include removal of trees and other plants from Significant Woodlands. The recommended design should seek to minimize the required removals to the greatest extent possible, particularly in woodlands adjacent to Erosion Sites 4 and 5 which have been associated with Significant Wildlife Habitat and species of conservation concern. All landscaping, restoration, and rehabilitation works within CH's regulated area will follow CH's most up-to-date landscaping guidelines.

A post-construction restoration plan including native trees, shrubs, and herbaceous plants will be required to compensate for the removed vegetation and promote the regeneration of natural habitats within the riparian corridor. The existing native deciduous forest communities that were identified within the study area (see **Appendix C** for details) should be used as a reference community for the restoration plan, as these communities are considered to be the closest representation of the forest cover that was present before the area was developed. Plant species providing wildlife habitat benefits (e.g., nut- or berry-producing plants, native wildflowers) are recommended to be included in the restoration plan. It is further recommended that opportunities to transplant regionally rare or uncommon plant species be investigated if such plants are located within the area of disturbance associated with the proposed works.

The City of Burlington's Public Tree By-law 68-2013 (City of Burlington, 2013), section 1.17, further states the following requirement:

> *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.*

It is also recommended that 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.

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

<u>Design Phase</u>

- An Arborist Report and Tree Protection Plan should be completed with a detailed tree inventory of the proposed area of impact, including 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-year post-construction).

Management of invasive plant species may be required both pre-construction (e.g.: collection and proper disposal of stems and other plant waste containing invasive species; use of clean equipment protocols to prevent the spread of seeds, stems, and other propagules throughout the site or between sites) and post-construction (e.g.: monitoring of invasive plant regeneration or incursion; targeted removal of invasive plants from the restoration areas).

5.2.2 Breeding Birds

Disturbance of natural habitats and the removal of vegetation from natural areas during the bird nesting season (typically considered April 1st to August 31st in southern Ontario) has the potential to damage or destroy active bird nests ("incidental take"), which is prohibited for most species under the federal *Migratory Birds Convention Act*. Vegetation clearing is therefore recommended to occur outside of this nesting window.

Removal of small areas of simple habitat or isolated trees within the nesting season may be permitted following the inspection of the area by a qualified biologist to confirm the absence of active nests. However, this allowance is not recommended for forested portions of the creek corridor as nest detectability in complex habitats is very low and the probability of incidental take is high. If an active nest is found in the construction work area at any time, work in the vicinity must cease and a protective buffer must be established around the nest until such time as the young birds have fledged or the nest is otherwise naturally abandoned.

5.2.3 Aquatic Communities

Fish habitat is present in Tuck Creek. Appropriate sediment and erosion controls must be used in all construction areas to prevent the transport of sediment into the creek. All reaches are expected to require the isolation and dewatering of in-water work areas, and therefore fish and wildlife rescue operations should be conducted prior to beginning work in the isolated areas. A

permit from the MNRF under the *Fish and Wildlife Conservation Act* will be required to compete the rescue.

Based on the observations discussed in **Section 3.8.2.7** and **Appendix C**, and on recommendations made by the MNRF In-water Work Timing Window Guidelines for Ontario's Southern Region, no in-water works should take place between March 1st and July 15th of any given year. With the presence of white sucker within the system, the spawning activity typically begins early spring. This restriction is aimed to protect the species found within the Tuck Creek study area during their vulnerable life stages of spawning and rearing and should be implemented to avoid contravention to the Federal *Fisheries Act*, among other mitigation measures.

5.2.4 Endangered and Threatened Species

Species at Risk which were found in or which have the potential to occur in the study area were previously listed in Section 3.8.3. For the majority of these, the potential for direct impacts can be avoided through minimizing vegetation disturbance and the observation of appropriate timing windows (such as the bird nesting timing window discussed above).

However, tree removals from woodlands and the related construction disturbance have the potential to impact roosting habitat for one or more of Ontario's Endangered bat species, and destruction of the habitat of an Endangered species has implications under the ESA. At the detailed design stage, the proposed area of disturbance should be cross-referenced with the location of potential bat habitat trees (provided in **Appendix C**) and the resulting habitat impacts must be reviewed by the MECP via the submission of an IGF to determine the appropriate actions under the ESA. Typical measures that are used to mitigate impacts include avoiding all vegetation clearing during the bat activity season (generally April 1st to September 30th) and the installation of artificial bat boxes ("rocket boxes") to compensate for removed habitat. However, the final requirements of the project are at the discretion of the MECP.

5.2.5 Species of Conservation Concern and Significant Wildlife Habitat

Multiple Special Concern, provincially rare, and/or regionally rare or uncommon species were documented in the study area, and the presence of important habitat features for these species also indicate the presence of Significant Wildlife Habitat. Construction disturbance associated with the proposed works could result in the direct mortality, injury, or displacement of the various species. Recommended mitigation measures include the following:

- Observe all timing windows related to wildlife activity and vegetation removal noted previously in this report.
- Minimize the required vegetation clearing to the greatest extent possible, particularly in woodlands associated with erosion areas 4 and 5.
- Enact a comprehensive restoration plan using native plant species that are consistent with the pre-existing habitat and monitor the disturbed areas post-construction to ensure that the desired vegetation community establishes on the site.
- Use comprehensive erosion and sediment controls to isolate in-water work areas and prevent the deposition of sediment in the creek, to avoid burying or otherwise impacting the nymph stages of rare damselfly species.
- Investigate the opportunity for transplanting or seed collection from any regionally rare plants that occur in the proposed construction areas.

- Identify the known Pignut Hickory location on tree protection plans, if applicable, and ensure no impacts to this tree or its root zone.
- Include a requirement in the project tender for the construction contractor to perform regular site inspection for the presence of wildlife and avoid/relocate wildlife as required to ensure animals are not harmed by construction activities or equipment.
- Consider the inclusion of wildlife habitat features (e.g., standing perches for raptors, recycled logs or branch piles on the ground) in the final design.

5.2.6 Impacts to Water Quality during Construction

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

Recommended Mitigation Measures: Efforts should be made to 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) plans will be developed to mitigate the risk. Possible measures include, but are not limited to, the application 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. Turbidity monitoring should be completed for both during and post construction activities. 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 proposed works are expected to result in temporary disturbance of wildlife movement in the vicinity of construction. However, this disturbance will be temporary and, following the completion of post-construction restoration, should not result in any long-term impacts to local wildlife movement or habitat connectivity. The proposed works do not include any bridge or culvert modification so improvement of wildlife road crossings is not applicable for this project.

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 the additional inventories and deliverables to be completed in support of the detailed 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 bridges);
- 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

A geotechnical investigation should be undertaken to determine the engineering properties of the existing soils for bank works. The details of the geotechnical investigation are to be determined by a qualified geotechnical engineer in consultation with the stream restoration consultant. Geotechnical investigations are recommended for Erosion Sites 2 and 6 to assess the potential impacts of the proposed restoration works.

Borehole logs containing appropriate and sufficient data should be prepared. Information from the boreholes is to be used for assessments of slope stability, soil properties for channel design, soil contamination, and any other geotechnical recommendations for engineered structures.

6.1.3 Utilities Confirmation

Further investigation will be required to confirm the impact to the utilities and underground services within the proposed restoration area. The utilities may include, but are not limited to, electricity, natural gas, cable television, telephone, water, sanitary sewer, and storm sewer.

6.1.4 Natural Heritage System

The mitigation measures discussed above in **Section 5.2** should be reviewed and further developed for implementation as part of the detailed design and construction tender. Agency consultation and related approvals should be pursued including, as required, the DFO Request for Review and MECP consultation regarding Endangered bats via the submission of an IGF.

6.1.4.1 General Mitigation Measures

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.

6.1.5 Stage 2 Archaeological Assessment

Stage 2 Archaeological Assessment is required for Erosion Sites 1, 2, 4, and 5. The Stage 1 report (ASI, 2020) recommends the following with respect to the Stage 2 archaeological assessment:

1. A portion of the Study Area exhibits archaeological potential. These lands require Stage 2 archaeological assessment by test pit survey at five-meter intervals, prior to any proposed impacts;
2. The remainder of the Study Area does not retain archaeological potential on account of deep and extensive land disturbance, slopes in excess of 20 degrees or being previously assessed. These lands do not require further archaeological assessment; and,
3. Should the proposed work extend beyond the current Study Area, further Stage 1 archaeological assessment should be conducted to determine the archaeological potential of the surrounding lands.

Engagement with the First Nations is recommended for the field liaison representation during the Stage 2 Archaeological Assessment;

6.1.6 Easement / Permit to Enter Acquisition

Within the study area, Tuck Creek is located on both public and private property. The proposed design and construction access / staging areas involve works on private properties for which the City currently do not have easements, including Erosion Sites 1 and 3. Should erosion control works 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 may be required. A brief summary of permits and approvals is included below:

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. 162/06 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. The consulting engineer 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 is well versed in similar construction projects is required. 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, an as-built survey of completed channel works (plan, profile, and cross sections) to verify implementation of design within reasonable tolerances should be undertaken. As-constructed drawings, together with a report summarizing pre- and post-construction conditions should be provided. The report should comment on significant deficiencies found with recommendations for correction or adaptive management as required.

The HEC-RAS model should be updated to match as-built conditions (should the comparative analysis to the design highlight differential condition), and the updated HEC-RAS model should be applied 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 Tuck Creek as well as degradation of the natural heritage system. Ten (10) erosion sites were identified within the City-wide Creek Inventory and Erosion Assessment (Water's Edge, March 2016) as low to high priority. Only one (1) site falls under the study area of this EA, therefore, this study investigated additional sites and identified a total of seven (7) erosion sites. A series of remedial alternatives were developed for each erosion site, and then 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 planned remediation of erosion sites has also been prioritized based on level of risks and property ownership. The list of prioritized projects from highest to lowest importance is as follows:

- Project 1: Erosion Site 1 – Reach Scale Works
- Project 2: Erosion Site 3 – Local Restoration Works
- Project 3: Erosion Site 2 - Reach Scale Works
- Project 4: Erosion Site 4 - Reach Scale Works
- Project 5: Erosion Site 6 - Reach Scale Works
- Project 6: Erosion Site 7 – Natural Design
- Project 7: Erosion Site 5 – Local Restoration Works

Conceptual designs have been prepared for the preferred alternative at each site. Following completion of this report, detailed design and construction will be undertaken to implement the preferred alternatives and remedy the identified problems. The suggested implementation order should be refined based on other considerations regarding 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 the creek traverses privately owned property. Erosion Sites 1 and 3 requires temporary easement;
- Undertake a geotechnical investigation for Erosion Sites 2 and 6;
- Undertake utility locates where information deficiencies have deemed it necessary as result of findings, or lack thereof, from a previous less intensive SUE Level survey;

- Undertake a detailed topographic survey if additional information is deemed necessary to reflect the current site conditions;
- Prepare for DFO review and an IGF for MECP review when the detailed design takes place;
- Undertake Stage 2 Archaeological Assessments for Erosion Sites 1, 2, 4 and 5 as required. The advice on compliance with legislation must be followed;
- Engage First Nations for their field liaison representation during the Stage 2 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.

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Appendix A –

Existing Conditions 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 –

First Nations Consultation

Appendix H –

Conceptual Design Drawings for the Preferred Alternatives