Schedule B Class Environmental Assessment – Project File

Mathers Drive Stream & Valley Wall Erosion

submitted by:
Aquafor Beech Ltd.

in association with
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# Table of Contents

1 INTRODUCTION ............................................................................................................................. 4
  1.1 Overview of Study and Problem .................................................................................................... 4
  1.2 The Environmental Assessment Process ..................................................................................... 4

2 PHASE 1 – PROBLEM IDENTIFICATION ......................................................................................... 7
  2.1 Problem Identification ................................................................................................................ 7
  2.2 Study Objective .......................................................................................................................... 9

3 PHASE 2 – SITE SPECIFIC INVENTORIES ..................................................................................... 10
  3.1 Detailed Topographic / Total Station Survey ................................................................................. 10
  3.2 Geomorphic and Erosion Assessment .......................................................................................... 12
  3.3 Storm Sewer Infrastructure Identification and Assessment ......................................................... 16
  3.4 Hydraulic Characterization ......................................................................................................... 16
    3.4.1 Hydrologic Assessment ........................................................................................................ 17
    3.4.2 Existing HEC-RAS Model .................................................................................................... 18
  3.5 Species At-Risk Screening ......................................................................................................... 19
  3.6 Arborist Assessment .................................................................................................................... 20
  3.7 Aquatic/Fisheries Assessment and Review .................................................................................. 21
  3.8 Slope Stability Assessment ......................................................................................................... 21
  3.9 Archaeological Assessment ......................................................................................................... 25
  3.10 Land Ownership and Easements ............................................................................................... 26

4 DEVELOPMENT OF THE PREFERRED SOLUTION ...................................................................... 28
  4.1 Description of Alternatives ......................................................................................................... 28
    4.1.1 Alternative No.1 - Do Nothing ............................................................................................. 28
    4.1.2 Alternative No. 2 – Local Restoration within Existing Alignment ........................................ 30
    4.1.3 Alternative No. 3 – Major Realignment & Restoration of Channel ...................................... 32
  4.2 Evaluation of Alternatives ......................................................................................................... 34
  4.3 Notice of Commencement, Stakeholder Consultation and Public Information Centre .............. 36

5 Selection and description of preferred alternative ........................................................................ 38
  5.1 Selection of Preferred Alternative .............................................................................................. 38
  5.2 Description of Preferred Alternative .......................................................................................... 38
  5.3 Conceptual Design of Preferred Alternative ................................................................................ 38
  5.4 Construction Timing ................................................................................................................... 38
  5.5 Preliminary Cost Estimate .......................................................................................................... 39

6 IMPLEMENTATION PLAN ............................................................................................................. 40
  6.1 Notice of Completion .................................................................................................................. 40
List of Figures

Figure 1-1. Project Location Map ................................................................. 4
Figure 1-2. Municipal Class Environmental Assessment Planning and Design Process ......... 6
Figure 2-1: Study area of Mathers Stream, showing limits of private properties and City’s easement ....... 7
Figure 2-2: Storm sewer outlet at the upstream extent of Mathers Stream from Maple Drive .............. 8
Figure 2-3: Storm sewer outlet between 14 and 16 Mathers Drive ................................................. 8
Figure 2-4: An example of one of the outflanked, gabion, grade-control structure ............................ 8
Figure 2-5: An example of one of the deteriorating gabion structures, compromising downstream storm outfall .... 8
Figure 2-6: Erosion along valley wall undermined tree ................................................................. 8
Figure 2-7: Example of privately owned buildings along valley embankment .................................... 8
Figure 3-1. Topographic Survey Presented as Plan and Profile of Mathers Drive Creek ......................... 11
Figure 3-2: Aerial image of the study area from 1950, with redline showing City owned easement ........ 12
Figure 3-3: Aerial image of the study area from 1995 .................................................................... 13
Figure 3-4: Aerial image of the study area from 1995 .................................................................... 13
Figure 3-5. Approximate locations of erosion concerns within the study area ..................................... 15
Figure 3-6: Limits of HEC-RAS model developed for Mathers Stream hydraulic analysis .............. 17
Figure 3-7: Map of mature trees inventoried within the study area .................................................. 20
Figure 3-8: Upper Limits of Long Term Stable Slope Assessment (3H:1V slope) ............................... 22
Figure 3-9: Slope stability assessment at HEC-RAS station 191 (i.e., 8 Mathers Drive) ....................... 23
Figure 3-10: Slope stability assessment at HEC-RAS station 116 (i.e., 14 Mathers Drive and 107 Maple Drive) 23
Figure 3-11: Slope stability assessment at HEC-RAS station 60 (i.e., 22 Mathers Drive and 111 Maple Drive) . 24
Figure 3-12: Results of the Archaeological Assessment (ARA, 2016) .................................................. 25
Figure 3-13: Property and easement limits within the study area .................................................... 27
Figure 4-1: Bank slumping within Mathers Stream valley ............................................................... 28
Figure 4-2: Fracturing of the valley embankment within the Mathers Stream valley ......................... 28
Figure 4-3. Null Alternative – Do Nothing to Address Erosion Issue .............................................. 29
Figure 4-4: Example of armourstone rib structures .......................................................................... 30
Figure 4-5: Example of roundstone bed treatment ......................................................................... 30
Figure 4-6: Alternative No. 2 – Local Restoration within Existing Alignment ..................................... 31
Figure 4-7: Example armourstone channel in steep valley setting .................................................... 32
Figure 4-8: Example of armourstone channel with roundstone bed treatment .................................. 32
Figure 4-9: Alternative No. 3 – Major Realignment & Restoration of Channel .............................. 33
List of Tables

Table 3-1: Summary of Channel Geometry ...........................................................................................................14
Table 3-2: Return period flood flows for Mathers Stream sub-catchment .............................................................18
Table 3-3: Average of hydraulic results from the existing HEC-RAS model..........................................................18
Table 3-4: Summary of mature trees identified within the study area....................................................................20
Table 4-1: Ranking Scheme for Criteria Evaluation of Each Alternative ..............................................................34
Table 4-2: Evaluation of Alternatives....................................................................................................................35
Table 5-1: Preliminary Cost Estimate for the Preferred Alternative ......................................................................39

List of Appendices

Appendix A: Notice of Commencement & Stakeholder Consultation Record
Appendix B: HEC-RAS Results
Appendix C: Ministry of Natural Resources and Forestry Species at Risk Assessment
Appendix D: Detailed Tree Inventory
Appendix E: Archaeological Study
Appendix F: Information Provided at the PIC
Appendix G: Conceptual Design Drawings
1 INTRODUCTION

1.1 Overview of Study and Problem

Aquafor Beech Limited (Aquafor), was retained by the City of Hamilton to provide comprehensive engineering, geomorphic, ecological, and Environmental Assessment (EA) services to complete the Schedule B Municipal Class EA Mathers Drive Stream and Valley Wall Erosion project.

This Project File is intended to document the process used to determine the preferred restoration of the eroded Mathers Drive drainage channel within the City of Hamilton’s easement downstream of the Maple Drive crossing. The project will provide long-term protection against slope instability and channel erosion that will reduce the risk to public safety, prevent future property damage and mitigate excessive sediment inputs downstream. The general extents of the study area are presented Figure 1-1, confined to easements which extend through the rear lot of Mather Drive properties.

Figure 1-1. Project Location Map

1.2 The Environmental Assessment Process

The Environmental Assessment Act was legislated by the Province of Ontario in 1975 to ensure that an Environmental Assessment is conducted prior to the onset of development and development related (servicing) projects. Depending on the individual project or Master Plan to be completed, there are different processes that municipalities must follow to meet Ontario’s Environmental Assessment requirements.
The Municipal Class Environmental Assessment (MCEA, 2015) document defines Master Plans as long range plans which integrate infrastructure requirements for existing and future land use with environmental assessment planning principles. These plans examine a group of related projects in order to outline a framework for planning for subsequent projects and/or developments. At a minimum, Master Plans address Phases 1 and 2 of the Municipal Class Environmental Assessment process.

As the project being undertaken is defined as an Erosion project, the Schedule B process is applicable.

A summary of the Class EA process and phases is provided below, with the accompanying flow chart (Figure 1-2) illustrating the process followed in the planning and design of projects covered by this Class Environmental Assessment:

**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, determine the appropriate Schedule for the undertaking and document decisions in a Project File for Schedule B projects, or proceed through the following phases for Schedule C projects.

**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 also classifies projects as Schedule A, A+, B or C depending on their level of environmental impact and public concern.

- Schedule ‘A’ projects are limited in scale, have minimal adverse environmental effects and generally include routine maintenance and operational activities. These projects are pre-approved and may proceed to implementation without following the full Class EA planning process.

- Schedule ‘A+’ projects have minimal adverse environmental effects and are pre-approved, however the public is to be advised prior to project implementation."

- Schedule ‘B’ projects have the potential for some adverse environment effects. Projects generally include improvements and minor expansions to existing facilities. These projects require completion of Phases 1 and 2 of the Class EA process, before proceeding to Phase 5 Implementation.

- Schedule ‘C’ projects have the potential for significant environment effects. Projects generally include the construction of new facilities and major expansions to existing facilities. These projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 Implementation.”
Figure 1-2. Municipal Class Environmental Assessment Planning and Design Process

NOTE: This flow chart is to be read in conjunction with Part A of the Municipal Class EA
2 PHASE 1 – PROBLEM IDENTIFICATION

2.1 Problem Identification

Between Mathers Drive and Maple Drive in Stoney Creek exists a confined, natural valley, with a small drainage feature, herein referred to as Mathers Stream. Erosion within Mathers Stream and along the valley wall have compromised the stability of the valley, leading to risk of failure and slumping. The valley is completely contained within private lands, and several residential houses are located at the top of the valley. The City owns an easement over some of the valley lands, for the purposes of accessing and maintaining their storm sewer infrastructure. The study area, easement and property limits are shown in Figure 2-1.

Mathers Stream originates from a storm sewer outlet at Maple Drive, which discharges to the valley floor (Figure 2-2). A second storm sewer also discharges to Mathers Stream, between 14 and 16 Mathers Drive (Figure 2-3). While Mathers Stream is wet all year, the majority of the flow within the creek is storm water runoff.

Throughout Mathers Stream there is a series of gabion baskets and grade control structures which were likely installed at the same time as the storm sewer infrastructure, with an attempt to protect the valley from erosion (Figure 2-4). The gabions have become outflanked, and are deteriorating and dispersing stone into the stream and there is excessive erosion surrounding the gabions and the storm sewer infrastructure (Figure 2-5).

The erosion along Mathers Stream has resulted in slumping and erosion within the valley. Currently the impacts of the erosion have been minor, with only trees falling into the valley (Figure 2-6), however there are several small buildings along the valley embankments that could be at risk (Figure 2-7). Furthermore, if the integrity and strength of the valley is compromised, the houses at the top of the valley wall could also be at risk in the long term.
Figure 2-2: Storm sewer outlet at the upstream extent of Mathers Stream from Maple Drive

Figure 2-3: Storm sewer outlet between 14 and 16 Mathers Drive.

Figure 2-4: An example of one of the outflanked, gabion, grade-control structure.

Figure 2-5: An example of one of the deteriorating gabion structures, compromising downstream storm outfall.

Figure 2-6: Erosion along valley wall undermined tree.

Figure 2-7: Example of privately owned buildings along valley embankment.
2.2 Study Objective

The objective of this study is to evaluate the existing conditions of Mathers Stream and determine the best approach to addressing this erosion within the valley.

The main focus of this study is to find a solution that will maintain and protect the private lands and the municipal storm sewer infrastructure. This solution will include erosion mitigation and prevention measures for Mathers Stream and the surrounding valley, if determined necessary.
3  PHASE 2 – SITE SPECIFIC INVENTORIES

To address Phase 2 of the EA process, site specific studies were conducted to support the design of the preferred alternative. A summary of site specific inventories are provided below.

3.1  Detailed Topographic / Total Station Survey

At the onset of the field assessments, a detailed total station survey was undertaken to accurately define the topographic features within the study area, including the surrounding valley and storm sewer infrastructure. The survey was completed in sufficient detail for the purposes of geomorphic analysis, hydraulic modelling, and detailed design. The key parameters of the survey included:

- Longitudinal profile of Mathers Stream, surveying the channel alignment;
- Cross-sections perpendicular to the channel and extended in sufficient detail beyond the top of bank for undertaking hydraulic analysis;
- Municipal infrastructure including the storm sewer headwall structure and sewer manholes and catch basins where available on Mathers Drive;
- Mature trees potentially impacted as a result of the restoration or implementation; and
- Potential construction access routes.

The survey was completed using a combination of a total station and GPS techniques in order to confirm accuracy of survey consistent with UTM NAD 83 Zone 17 projection, and geodetic elevations consistent with City horizontal controls, and overlays the base-mapping provided by the City, which includes property parcels, building limits, storm sewer network alignment, and contours.

The topographic information was compiled into a planform and profile as shown in Figure 3-1, which highlights the confined nature of the Mathers Stream.
Figure 3-1. Topographic Survey Presented as Plan and Profile of Mathers Drive Creek
3.2 Geomorphic and Erosion Assessment

Aquafor’s fluvial geomorphologist inspected the site to gain an understanding of the existing conditions and provide an understanding of the hydrologic and hydraulic processes. Additionally, a desktop investigation of historic aerial imagery and the topographic survey data was completed to evaluate the channel dimensions and understand the changes that are occurring within the system.

Mathers Stream is a small drainage feature within a confined valley setting. The valley is very steep which creates a narrow floodplain for the stream. The channel bed is dominantly composed of organic, till material, but there are a variety of manmade bed treatments (e.g., concrete, interlocking stone, riprap, roundstone) scattered through the study reach. At the downstream extent of the study reach, fine sediment deposits were observed, and are expected to be a result of the erosion of the channel and valley.

The valley hosts a dense, mature forest throughout the floodplain, with minimal to no undergrowth. There is extensive organic deposition and fallen trees and limbs. The tree roots at the channel are shallow and appear to be providing limited grade control to the stream.

Aerial imagery from 1950 and 1995 - 2015 was reviewed, with select years presented below in Figure 3-2 to Figure 3-4. The imagery shows that the previous land use was agricultural in the 1950’s. In the mid 1990’s the land were developed into a low-density residential neighbourhood, which was undertaken by the former City of Stoney Creek. No imagery was available for the years between 1950 and 1995 for review. It was also noted that there has been no new development within the study area between 1995 to present. Due to the extensive tree cover and narrowness of the creek, an assessment of the channel migration could not be completed.

![Figure 3-2: Aerial image of the study area from 1950, with redline showing City owned easement (ARA, 2016)](image-url)
Figure 3-3: Aerial image of the study area from 1995 with redline showing approximate limit of City owned easement (City of Hamilton Maps, http://map.hamilton.ca, accessed March 24, 2017)

Figure 3-4: Aerial image of the study area from 1995 with redline showing approximate limit of City owned easement (City of Hamilton Maps, http://map.hamilton.ca, accessed March 24, 2017)
The topographic survey data was reviewed, to assess the geometry of the channel. Representative metrics were measured from the data to characterise the Mathers Stream and try to gain insight into the underlying erosional issues.

The longitudinal profile and cross sections of Mathers Stream show that the upstream extent of the stream is very steep and confined, and become less steep and wider at the downstream extent of the study reach. A noticeable decrease in the channel slope occurs downstream of the Mathers Drive storm outlet, which also coincides with the approximate location that the valley starts to widen. A summary of channel parameters for the study area upstream and downstream of the Mathers outfall is provided below in Table 3-1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value [Average (Minimum - Maximum)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Width</td>
<td>5.0 m (3.6 - 6.2 m) 5.2 m (2.4 - 9.1 m)</td>
</tr>
<tr>
<td>Channel Depth</td>
<td>1.8 m (1.2 - 2.8 m) 1.7 m (0.5 - 3.0 m)</td>
</tr>
<tr>
<td>Valley Width</td>
<td>20 m (17 - 24 m) 36 m (29 - 51 m)</td>
</tr>
<tr>
<td>Valley Depth</td>
<td>5.4 m (2.9 - 7.9 m) 9.5 m (8.7 - 10.0 m)</td>
</tr>
<tr>
<td>Slope</td>
<td>10% (2.6% - 16%) 4% (3.0% - 4.8%)</td>
</tr>
<tr>
<td>Meander Length</td>
<td>12 - 32 m 78 m</td>
</tr>
<tr>
<td>Sinuosity</td>
<td>1.1 1.1</td>
</tr>
</tbody>
</table>

To compliment the assessment of the existing geomorphic conditions, an assessment of the erosion within the study area was also undertaken. Figure 3-5 shows a map of the approximate locations of erosional concerns documented along the channel and valley slopes, with photos of some of the locations.

It was noted that the erosion downstream of the Mathers Drive outlet was more severe than the erosion upstream. It can be seen from Figure 3-5 that there are more erosion sites downstream of the Mathers Drive outlet. Furthermore, the erosional areas downstream of the outlet extend over larger areas or created more extreme vertical cuts, as seen in the photos in Figure 3-5. Furthermore, the gabion grade control structures downstream of the Mathers Drive outfall are completely undermined, outflanked or deteriorated while fewer structures upstream of the outfall were outflanked or undermined.

The observed erosion is likely a result of the storm water contributions. Based on the extent of the erosion downstream of the Mathers Drive outlet, the storm water contributions from this outlet are having a large erosional impact, potentially indicating that this outlet has a much larger flow and/or velocity contribution than the outlet at the upstream extent of the study reach. It is Aquafor’s understanding that there are no storm water controls upstream of the outlet. The till material that makes up the channel bed and valley slopes is highly erodible under high velocities, and therefore results in scour, undermining of structures, bank erosion, and outflanking.
Figure 3-5. Approximate locations of erosion concerns within the study area
3.3 Storm Sewer Infrastructure Identification and Assessment

Aquafor’s engineer completed a site inspection of the storm sewer infrastructure within the study area to gain an understanding of how the network drains to Mathers Stream and to assess the structural integrity of the infrastructure.

Within the study area, two storm outfalls discharge to Mathers Stream; a 925 mm concrete sewer at the upstream extent of the creek, and a 600 mm concrete sewer between 14 and 16 Mathers Drive. A map of shows the outlet locations of the two sewers and the surrounding storm sewer network is provided in Appendix B.

The 925 mm sewer is connected to the road side ditch on Jenny Court. This ditch drains runoff waters from Ridge Road, a paved trail and the adjacent escarpment lands upstream of Jenny Court. The 600 mm sewer is the outlet for Mathers Drive and Plateau Place, and sections of Maple Drive and Hilts Drive.

At the upstream extent the 925 mm sewer is contained within a concrete headwall, flush with the river bed. There is no significant scour or erosion around the headwall, and the pipe appears to be in good condition at the outlet.

The 600 mm sewer discharges to a grated, overflow structure, in the middle of Mathers Stream. The stream has outflanked the overflow structure, resulting in erosion along the west side of the structure. The structure outlets to a concrete scour pad on the north (i.e., downstream) side of the overflow structure. The scour pad has become severely undermined due to excessive erosion at the outlet. The pipe appears to be in good condition at the outlet, with no evidence of cracking or deformity.

3.4 Hydraulic Characterization

Aquafor developed a hydraulic model to analyze the erosional forces within Mathers Stream. GeoHECRAS™ was used to import the topographic survey data and develop a one dimensional HEC-RAS model. The limits of the model extend to the limits of the study area. The limits of the model can be seen in Figure 3-6.
3.4.1 Hydrologic Assessment

A hydrologic assessment was necessary to determine the flows within Mathers Stream for the hydraulic assessment. This involved assessing the storm contributions and surrounding storm sewer network.

An area of approximately 24 ha drains to Mathers Stream, with approximately 7 ha being residential lands or impervious surfaces, 3 ha being forested, escarpment lands, and 14 ha being agricultural lands. The forested and agricultural lands are south of Maple Drive and drain to the 925 mm storm sewer outlet at the upstream extent of Mathers Stream. The residential lands and impervious surfaces drain through the storm sewer network to the 600 mm outlet from Mathers Drive.
For this study the approved hydrologic model (MIKE URBAN) from the Winona Area Flood Study (Aquafor Beech, 2015) was refined to develop the full range of design storms events (i.e., 2-yr to 100-yr). The developed design flows for the Mathers Stream sub-catchment are presented below in Table 3-2.

**Table 3-2: Return period flood flows for Mathers Stream sub-catchment**

<table>
<thead>
<tr>
<th>Design Storm Event</th>
<th>Total Subcatchment Runoff (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-YR</td>
<td>0.7</td>
</tr>
<tr>
<td>5-YR</td>
<td>1.1</td>
</tr>
<tr>
<td>10-YR</td>
<td>1.4</td>
</tr>
<tr>
<td>25-YR</td>
<td>1.8</td>
</tr>
<tr>
<td>50-YR</td>
<td>2.1</td>
</tr>
<tr>
<td>100-YR</td>
<td>2.4</td>
</tr>
</tbody>
</table>

3.4.2  **Existing HEC-RAS Model**

The Hamilton Conservation Authority (HCA) confirmed that there was no existing model or defined regulatory flood limits for Mathers Stream. Therefore, Aquafor developed a georeferenced, HEC-RAS model of Mathers Stream using GeoHECRAS™ to assess the existing hydraulic conditions.

A total of 10 cross sections were established, spaced approximately 20 m apart, the locations of which are shown in Figure 3-6. The topographic survey data was used for the cross section geometry and a ‘steady-state’ hydraulic analysis was carried out using the refined design storm flows. The model was run under mixed flow conditions and assumed critical flow conditions at the upstream and downstream extents of the model.

A summary of the average hydraulics for all the cross sections provided below in Table 3-3, and a detailed summary of the results is included in Appendix B.

**Table 3-3: Average of hydraulic results from the existing HEC-RAS model**

<table>
<thead>
<tr>
<th>Profile</th>
<th>Total Flow (m³/s)</th>
<th>Average Channel Velocity (m/s)</th>
<th>Total Channel Velocity (m/s)</th>
<th>Average Channel Shear (N/m²)</th>
<th>Total Channel Shear (N/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-YR</td>
<td>0.7</td>
<td>2.00</td>
<td>2.00</td>
<td>108.77</td>
<td>108.77</td>
</tr>
<tr>
<td>5-YR</td>
<td>1.1</td>
<td>2.26</td>
<td>2.26</td>
<td>123.69</td>
<td>123.69</td>
</tr>
<tr>
<td>10-YR</td>
<td>1.4</td>
<td>2.36</td>
<td>2.36</td>
<td>128.92</td>
<td>128.92</td>
</tr>
<tr>
<td>25-YR</td>
<td>1.8</td>
<td>2.51</td>
<td>2.51</td>
<td>138.01</td>
<td>136.62</td>
</tr>
<tr>
<td>50-YR</td>
<td>2.1</td>
<td>2.71</td>
<td>2.70</td>
<td>150.61</td>
<td>148.40</td>
</tr>
<tr>
<td>100-YR</td>
<td>2.4</td>
<td>2.81</td>
<td>2.80</td>
<td>157.43</td>
<td>154.49</td>
</tr>
</tbody>
</table>

The hydraulic results show that Mathers Stream is experiencing very high velocity and shear conditions under the existing conditions. To understand the erosional impact of the hydraulics, Aquafor reviewed published Fischenich’s data on critical erosional thresholds for river bed material (2001).

As explained in Section 3.2, the channel bed is composed primarily of till material. Fischenich’s data indicates that for rivers with till beds (e.g., alluvial silt, graded loam to cobbles or graded silts to cobbles) the permissible velocity ranges between 0.6 and 1.2 m/s and that the permissible shear ranges between 2.2 and 20.6 N/m² (2001). Fischenich’s data showed that forces exceeding these ranges resulted in sediment being mobilized along the channel bed, which could result in erosion (2001). Therefore as the average channel velocity is greater than 2 m/s
and the average channel shear is greater than 100 N/m², the hydraulic forces in Mathers Stream have significant erosional potential.

The hydraulic results shown in Table 3-3 also show that the channel velocity and shear are approximately equal to the total velocity and shear, respectively. This indicates that during flooding events the entire flow is contained to the channel, and no relief is provided from the over banks. This results in the erosional forces being focused within the channel, and increases the erosional potential.

As stated above, for all events the entire flood is contained to the valley; there is no natural or engineered flood plain relief within this area. Therefore, as the flood events are contained, it is not necessary to develop regulatory flood limits for Mathers Stream.

3.5 Species At-Risk Screening

For the purpose of this study, SAR are defined as species listed as Endangered, Threatened, or of Special Concern by the Committee on the Status of Species at Risk in Ontario (COSSARO) and the Committee On the Status of Endangered Wildlife In Canada (COSEWIC). Species of Conservation Concern are defined as species listed as Endangered, Threatened, or of Species Concern as listed by the COSSARO and COSEWIC; species with Global Ranks of G1-G3; species with Sub-National/Provincial ranks of S1-S3; and species considered rare within the City of Hamilton (Schwetz, 2014).

Aquafor consulted a number of primary and secondary information sources to assess the presence of SAR and species of conservation concern within the study area. Aquafor also solicited natural heritage information from the Guelph District MNRF, as well as the MNRF’s NHIC Make-a-Map online database. Correspondence with the MNRF is contained within Appendix C. In addition, species records were taken from the Hamilton Natural Areas Inventory (NAI) Site Summaries document (Schwetz, 2014, pp 146 – 156).

The MNRF indicated that there are records of Chimney Swift (Threatened) “in the area”, and possibly Butternut (Endangered). MNRF staff recommends undertaking a comprehensive botanical inventory of the entire area that may be subject to direct and indirect impacts from the proposed activity. The vegetation communities should be classified as per the “Ecological Land Classification (ELC) for Southern Ontario” system, to either the “Ecosite” or “Vegetation Type” level. With respect to aquatic habitats in the study area, the MNRF recommends collecting data on the physical characteristics of the waterbodies and inventory the riparian zone vegetation, so that these habitats can be classified as per the Aquatic Ecosites described in the ELC manual.

The MNRF recommended that habitat within the study area be cross-referenced with the habitat needs of SAR known to occur in Hamilton.

Data collected from the NHIC’s Make-a-Map database provided six (6) species consists of provincially rare species previously recorded within 1 km of the study area. Data obtained from the Hamilton NAI provided nine (9) species accounts of species of conservation concern within the Devil’s Punchbowl Escarpment natural area.

A detailed assessment of SAR and their potential to occur within the study area is detailed in Appendix C, with a summary of the confirmed and potential species of conservation concern within or adjacent to the study area. Species included in the screening exercise were populated from the NHIC data from the MNRF Make-a-Map query results, the list of SAR known to occur within Hamilton, species provided by the MNRF through correspondence, and species previously recorded within the Devil’s Punchbowl Escarpment natural area. In total, 67 species-at-risk and other species of conservation concern have previously been recorded within or adjacent to the study area.

Using this aggregated list of SAR and other species of conservation concern, Aquafor cross-referenced the habitat needs of each species with the habitat conditions present within the study area and adjacent lands. This information is provided in Appendix C.
3.6 Arborist Assessment

Aquafor undertook a detailed assessment of the mature trees within the study area on May 28\textsuperscript{th} and 29\textsuperscript{th}, 2015. A detailed tree survey was completed within areas where trees may be affected by potential channel and valley restoration works. Fieldwork was completed by an Aquafor ISA Certified Arborist. Each tree equal to or greater than 10 cm diameter at breast height (DBH) with the potential to be impacted was evaluated. Tree location, species, crown diameter tree health and physical condition were recorded. A summary of the trees at each site are presented below, with maps showing the locations of all the trees.

![Map of mature trees inventoried within the study area](image)

The majority of the trees identified are Sugar Maple (51%) and Red Oak (17%) with 87% of the trees surveyed being in good health, and only seven trees were identified as dead. A summary of the trees and their sizes is presented below in Table 3-4, and the full inventory of the trees is included in Appendix D.

<table>
<thead>
<tr>
<th>Species Common Name</th>
<th>Species Botanical Name</th>
<th>Number of Trees</th>
<th>Average DBH (cm)</th>
<th>Average Crown Diameter (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Beech</td>
<td><em>Fagus grandifolia</em></td>
<td>9</td>
<td>25</td>
<td>8.7</td>
</tr>
<tr>
<td>Basswood</td>
<td><em>Tilia americana</em></td>
<td>5</td>
<td>35</td>
<td>10.5</td>
</tr>
<tr>
<td>Bitternut Hickory</td>
<td><em>Carya cordiformis</em></td>
<td>6</td>
<td>21</td>
<td>5.8</td>
</tr>
<tr>
<td>Black Walnut</td>
<td><em>Juglans nigra</em></td>
<td>1</td>
<td>12</td>
<td>4.0</td>
</tr>
<tr>
<td>Tree Type</td>
<td>Species</td>
<td>Diameter</td>
<td>Height</td>
<td>Erosion</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------</td>
<td>----------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>Ironwood</td>
<td>Ostrya virginiana</td>
<td>6</td>
<td>11</td>
<td>4.2</td>
</tr>
<tr>
<td>Norway Maple</td>
<td>Acer platanoides</td>
<td>1</td>
<td>10</td>
<td>4.0</td>
</tr>
<tr>
<td>Red Ash</td>
<td>Fraxinus pennsylvanica</td>
<td>1</td>
<td>18</td>
<td>5.0</td>
</tr>
<tr>
<td>Red Oak</td>
<td>Quercus rubra</td>
<td>22</td>
<td>35</td>
<td>11.0</td>
</tr>
<tr>
<td>Staghorn Sumac</td>
<td>Rhus typhina</td>
<td>1</td>
<td>12</td>
<td>3.0</td>
</tr>
<tr>
<td>Sugar Maple</td>
<td>Acer saccharum</td>
<td>65</td>
<td>20</td>
<td>7.6</td>
</tr>
<tr>
<td>White Ash</td>
<td>Fraxinus americana</td>
<td>10</td>
<td>31</td>
<td>10.7</td>
</tr>
<tr>
<td>White Oak</td>
<td>Quercus alba</td>
<td>1</td>
<td>15</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>128</strong></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### 3.7 Aquatic/Fisheries Assessment and Review

Mathers Stream does not actively support fisheries habitat, due to the extensive sewer network downstream of the stream. Mathers Stream could be represented as a natural reach of daylighted storm sewer as the main flow contributions are storm water runoff, and the upstream and downstream limits are sewer networks. Immediately upstream of Glenashton Drive, Mathers Stream drains into storm sewer catch basin. Furthermore, upstream of Mathers Stream are the headwaters of the catchment area, which drain to the catch basin at the Maple Drive. Again, these conditions do not support fisheries habitat. The stream is providing contributing habitat to downstream fisheries communities.

### 3.8 Slope Stability Assessment

As discussed in Sections 2.1 and 3.2, there is evidence of scour and slumping along the valley embankment of Mathers Stream, which could compromise the stability of the valley. The valley is composed of privately owned, residential properties, with houses along the top of the valley embankment, and several small buildings (i.e., sheds) constructed along the valley embankment.

To assess the potential impacts of the erosion and instability of the valley, the long term stable slope was defined for the valley. In doing this, we are able to understand what lands, buildings and other infrastructure might be potentially impacted by future erosion.

The Technical Guide for River and Stream Systems: Erosion Hazard Limits (MNRF, 2002), defines the inclination of the long term stable slope as 3 horizontal to 1 vertical (i.e., 3H:1V). Assuming this slope, the top of the long term stable slope was mapped for the study area, and is shown below in Figure 3-8, and for three cross sections within the study area, shown in Figure 3-9 to Figure 3-11.
Figure 3-8: Upper Limits of Long Term Stable Slope Assessment (3H:1V slope)

This analysis shows that the top of the projected stable slope extends into the limits of five houses along Mathers Drive (street numbers 14, 16, 18, 20 and 22) and is very close to three others (6, 10 and 12 Mathers Drive). Furthermore, the cross sectional analysis showed that stable slope boundary extends well beyond several secondary structures (e.g., sheds and pools) within the study area. Therefore, the private lands, buildings and secondary structures within the study area, could be at risk if the erosion within the channel and valley continues.

This slope stability assessment is preliminary, and provides a broad understanding of the potential risks associated with the valley erosion. A geotechnical assessment would be required to provide further insight into the valley slope stability.
Figure 3-9: Slope stability assessment at HEC-RAS station 191 (i.e., 8 Mathers Drive)

Figure 3-10: Slope stability assessment at HEC-RAS station 116 (i.e., 14 Mathers Drive and 107 Maple Drive)
Figure 3-11: Slope stability assessment at HEC-RAS station 60 (i.e., 22 Mathers Drive and 111 Maple Drive)
3.9 Archaeological Assessment

Stage 1 and Stage 2 archaeological assessments were carried out by Archaeological Research Associates Ltd. (ARA) in August 2016. The assessments included review of background documentation and field investigations to assess if there is potential to impact significant lands.

The Stage 1 assessment indicated that while the lands within the study area have been significantly disturbed, there was potential for historically significant lands within the study area. These results prompted the field investigations, which involved visual assessments of the lands, and test pit surveys of the identified areas. The field investigations did not result in the identification of any archaeological materials and ARA does not recommend any further investigations into the study area. The full archaeological report is included in Appendix E.

![Figure 3-12: Results of the Archaeological Assessment (ARA, 2016)](image-url)
3.10 Land Ownership and Easements

The Mathers Stream is completely contained to the private lands from the surrounding residential properties from Mathers Drive and Maple Drive (Figure 3-13). There is no public access point to the valley.

The City owns an easement over some of the lands within the valley and between 14 and 16 Mathers Drive providing a very narrow access to the valley (Figure 3-13).

The easement is approximately 4.6 m wide between the private properties and 6 m wide over the storm sewer at Maple Drive. It is noted that the 4.6 m wide is unlikely to be wide enough to accommodate large construction equipment, if necessary, and therefore construction assess will likely be necessary from Maple Drive.

In order to complete construction activities temporary easements will need to be negotiated with the land owners, and depending on the preferred alternative, a permanent easement is recommended for future access and maintenance.
Figure 3-13: Property and easement limits within the study area
4 DEVELOPMENT OF THE PREFERRED SOLUTION

4.1 Description of Alternatives

Before the 1990’s, stream restoration focused on addressing site specific erosion problems without considering the larger watercourse context, and typical rehabilitation measures included the patchwork use of artificial materials such as riprap, gabions, and concrete. These measures gave little attention to short and long term environmental impacts, and typically ignored the local and broader scale implications to the geomorphological system.

Alternatives to mitigate erosional risks along the Mathers Drive Creek will focus on removing risks to municipal sewer infrastructure and protection of private lands through engineered channel design, which will focus on maintaining and enhancing the natural setting.

In consideration of the study objectives, alternatives were developed for each site. Input was sought from the City, HCA, and the public with respect to the alternatives. The following subsections provide descriptions of the alternatives, the evaluation and public consultation process, and the selection of the preferred alternative.

4.1.1 Alternative No.1 - Do Nothing

The ‘Do Nothing’ alternative would involve leaving the existing conditions to continue actively eroding the valley and down cutting the channel. Existing risks with regards to over steepened slopes, public safety, and undermining of infrastructure would occur. Figure 4-3 illustrates the existing conditions in planform and Figure 4-1 and Figure 4-2 show the existing slumping and fracturing of the valley wall.

Although no capital costs have been assigned to this alternative, ongoing monitoring of the study area would be required. Only under emergency conditions (i.e., mass slope failure / infrastructure failure) would works occur.
Figure 4-3. Null Alternative – Do Nothing to Address Erosion Issue.
4.1.2  Alternative No. 2 – Local Restoration within Existing Alignment

This alternative would involve replacing the failed grade control structures, installing additional bed treatments and maintaining the existing alignment of the creek. The failing gabion structures would be removed and armourstone ribs would be constructed in their place. Armourstone is a more natural material and has shown to have a much longer life-span than gabion baskets. Furthermore, a natural roundstone riverbed material will protect against downcutting. Vegetative restoration treatments will be installed following the construction, to restore the natural setting of the valley, and add further strength to the valley. Figure 4-6 show a plan and profile of the proposed works for Alternative 2 and Figure 4-4 and Figure 4-5 show examples of armourstone ribs and roundstone riverbed treatments.

By maintain the existing alignment of the channel, less area within the valley will be disturbed, which will help to maintain any existing strength within the valley. However, the existing alignment is not entirely contained to the City’s easement, therefore new land access agreements will have to be established between the land owners and the City to undertake these works. While temporary access agreements will be adequate to complete the construction works, it is recommended that the City investigate acquiring permanent easements for the upstream storm sewer outlet, as well as other property owners as required, as this will alleviate complications for future maintenance.

With regards to the erosional concerns within the study area, this alternative is able to address the existing issues scour within the creek, and will provide protection to the channel from future channel bed erosion. This will also protect the municipal storm sewer infrastructure. By protecting the channel from future erosion, the valley embankments will be protected from any further deterioration.

Aquafor estimates that the duration of the construction will range between two to three months. This estimate is based on Aquafor’s observations for the time require to complete similar projects, however the time required to complete the project is highly subject to the experience level of the contractor and the weather conditions. During construction, road closures are not expected, however traffic may be reduced to a single lane at access locations throughout the day.

Figure 4-4: Example of armourstone rib structures  
Figure 4-5: Example of roundstone bed treatment
Figure 4-6: Alternative No. 2 – Local Restoration within Existing Alignment
4.1.3 Alternative No. 3 – Major Realignment & Restoration of Channel

Alternative 3 would involve realigning Mathers Stream to be contained to the City easement, with an armourstone reinforced channel. The armourstone treatments would be designed to prevent the channel from migrating and add increase the strength of the valley walls. Aquafor has designed and constructed this type of treatment for many different confined river settings, including steep valleys (Figure 4-7) and areas with impinging private lands (Figure 4-8).

The construction of this alternative will be more invasive than Alternative 2, as it will require more disturbance to the valley and creek. Realigning the creek to the limits of the City’s easement will require more excavation and grading and removal of trees than Alternative 2. However, if the creek is contained to the limits of the City easement, undertraining maintenance of the creek or sewer infrastructure will be less intrusive for the surrounding residents.

The cost of constructing this alternative would be much greater than Alternative 2, as this design will require considerable amounts of armourstone.

Aquafor estimates that the duration of the construction will range between four to six months, which is much longer than the time expected for the construction for Alternative 2. This estimate is based on Aquafor’s observations for the time require to complete similar projects, however the time required to complete the project is highly subject to the experience level of the contractor and the weather conditions. During construction, road closures are not expected, however traffic may be reduced to a single lane at access locations throughout the day.

Figure 4-7: Example armourstone channel in steep valley setting

Figure 4-8: Example of armourstone channel with roundstone bed treatment
Figure 4-9: Alternative No. 3 – Major Realignment & Restoration of Channel
4.2 Evaluation of Alternatives

Each alternative was compared using selective criteria in order to apply a ranking and select the most appropriate remediation alternative. The criteria that were used in this evaluation include:

1. Physical and Natural
   a. Erosion
   b. Water Quality
   c. Aquatic Habitat
   d. Terrestrial Habitat
   e. Terrestrial Vegetation
2. Social and Cultural
   a. Public Safety
   b. Landowner Impacts
   c. Benefit to Community
   d. Aesthetic Value
3. Technical and Engineering
   a. Impact on Existing Infrastructure
   b. Lifespan of proposed works
4. Economic
   a. Capital Costs
   b. Operations and Maintenance Costs

The evaluation was completed with input from Aquafor technical staff, as well as the City of Hamilton. The results of the evaluation are presented within Table 4-2, in which points were assigned to each alternative based on the above criteria, applying a score to each alternative. For each criteria item (i.e., row), a score was applied ranging from 0 to 4 (Table 4-1), where:

- 0 = Unfavourable, no improvement or negative impact
- 2 = Acceptable
- 4 = Favourable, most improvement or most positive impact

<table>
<thead>
<tr>
<th>Unfavourable / No Improvement / Negative Impact</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favourable Most Improvement / Most Positive Impact</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 are presented in Table 4-2.

This ranking has been presented to the public, landowners, and relevant stakeholders, and updated based on comments as well as technical investigations.
Table 4-2. Evaluation of Alternatives.

<table>
<thead>
<tr>
<th>EVALUATION CRITERIA</th>
<th>Alternative 1 Do Nothing</th>
<th>Alternative 2 Local Restoration</th>
<th>Alternative 3 Major Realignment &amp; Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td><strong>Physical and Natural Criteria</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>7</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Rate of erosion, slope failures, and loss of table / private properties</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Water Quality</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Impact on Water quality to receiving stream and Lake Ontario</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Aquatic Habitat</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Impact on contributing aquatic habitat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrestrial Habitat</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Impact on connectivity, diversity and quantity/quality of habitat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrestrial Vegetation</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Impact on existing mature vegetation and wooded ravine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social and Cultural Criteria</strong></td>
<td>1</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Public Safety</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Impact on public safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landowner Impacts</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Impact on private property</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefit to Community</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Access to trails, enjoyment of surrounding lands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesthetic Value</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Impact on existing and proposed aesthetic value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical and Engineering Criteria</strong></td>
<td>0</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Impact on Existing Infrastructure</td>
<td>0</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Protection or potential exposure of infrastructure (storm sewer, road / bridge network)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifespan of Works</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Expected lifespan / years of works before intervention needs to be repeated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Economic Criteria</strong></td>
<td>5</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Capital Costs</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>One time cost to City</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### EVALUATION CRITERIA

<table>
<thead>
<tr>
<th></th>
<th>Alternative 1 Do Nothing</th>
<th>Alternative 2 Local Restoration</th>
<th>Alternative 3 Major Realignment &amp; Restoration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations &amp; Maintenance Costs</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL SCORE</strong></td>
<td>13</td>
<td>41</td>
<td>26</td>
</tr>
</tbody>
</table>

#### 4.3 Notice of Commencement, Stakeholder Consultation and Public Information Centre

The Notice of Commencement for the study was issued June 16th and was published in the Stoney Creek News on June 16th and 23rd and the Hamilton Spectator on June 17th and 24th. Additionally, a letter was distributed to all homes adjacent to the study area informing them of the study. Notices were also mailed to relevant utilities, agencies, Aboriginal Communities, and other stakeholders identified through recent relevant studies completed for the City of Hamilton. A copy of the notice, reply form and distribution list are included in Appendix A.

In response to the Notice of Commencement, a number of correspondences were received, including comments from the Ministry of the Environment & Climate Change (MOECC), Hamilton Conservation Authority (HCA), HydroOne, the Niagara Escarpment Commission and the Canadian Environmental Assessment Agency, Aboriginal Communities, and other key stakeholders. A summary of consultation is provided in Appendix A.

The Public Information Centre (PIC) was held on **June 30th, 2016** at the Stoney Creek Municipal Centre, 777 Highway No.8, Stoney Creek. This PIC was advertised in conjunction with the Notice of Commencement in the Stone Creek News on June 16th and 23rd, 2016 and the Hamilton Spectator on June 17th and 24th, 2016.

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

- The objectives of the study and of the public information package;
- The study area;
- The EA process;
- The existing conditions within the Mathers Drive Creek valley;
- The problems and opportunities;
- The permitting requirements to undertake works;
- The alternatives for the study areas;
- The evaluation criteria and preliminary scoring; and
- The next steps in the process.

The PIC was attended by approximately 12 people, eight of which signed in. Most of the attendees were local residents to the study area and owned properties that backed onto Mathers Stream. A comment sheet was provided to the attendee to solicit input on the project, and obtain input on the information presented. The questions asked on the comment form included:

1) Do you have any environmental interests with respect to the study area?
2) Do you have any comments related to the evaluation process used to select the preferred alternative?
3) Are there any other alternatives (other than those shown) that should be considered?
4) Do you have any comments, concerns, questions or suggestions regarding the preferred alternative?
5) Do you have any comments, concerns, questions or suggestions related to the potential impacts and/or proposed mitigation measures to address the impacts for this project?

City staff, as well as staff from Aquafor Beech Limited provided responses and clarification to questions raised by the public. No formal response forms were received, however attendees did express concerns about construction access and the timing and duration of construction.

Both the public information package (slides), sign in sheet, and blank comment sheet are provided in Appendix F.
5 SELECTION AND DESCRIPTION OF PREFERRED ALTERNATIVE

5.1 Selection of Preferred Alternative

Based on the evaluation of criteria, consultation with the City and public, the preferred alternative is Local Restoration (Alternative No. 2), focusing on replacing the deteriorated infrastructure and maintaining the channel to its existing alignment.

This alternative provides the necessary erosion protection for the stream and valley, with the least invasive approach. This option also has a shorter construction duration, addressing some of the concerns of the public.

In order to undertake the works outside of the City easement, new land agreements or easements will need to be negotiated between the City and the land owners.

5.2 Description of Preferred Alternative

For the preferred alternative the gabion grade control structures will be removed and replaced with armourstone structures, and the existing storm sewer outlet will be tied into the armourstone treatments. Additionally natural round stone will be used to line the channel, maintain the existing alignment, but providing erosion protection.

Following the construction full vegetative restoration will be undertaken, with native grasses, shrubs and trees. The plantings will compensate for loses resulting from construction activities, and will provide additional bank stability and reinforcement.

5.3 Conceptual Design of Preferred Alternative

Conceptual design drawings for the preferred alternative have been included within Appendix G. Locations of the grade control structure and the width of the proposed channel are highlighted in the general plan. The proposed access from Maple Drive is also shown. Technical details will be refined through the detailed design process.

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

5.4 Construction Timing

The City plans to proceed with the construction of the preferred alternative following the completion of the detailed design.

Due to the steepness of the valley slopes and the existing erosion, it is recommended that these works be undertaking in the fall or winter months, when the ground is frozen and more solid, and will generally provide more stable conditions for the heavy machinery.

Please note that should construction works be undertaken during the summer season, it is recommended that vegetation removal occur prior to the generalized nesting period (i.e. between April 1st and August 31st), to ensure that the proposed works do not contravene the federal Migratory Birds Convention Act (1994), which protects the nests of most breeding bird species in Ontario. Should this not be possible, it is recommended that vegetation removals occur prior to the generalized nesting period. Should work occur within the generalized nesting period, it is recommended that a Qualified Avian Ecologist conduct a nest search prior to construction and, if applicable, establish temporary Nest Protection Zones for any found nests which will remain in place until all fledged birds have left the vicinity or as advised by a qualified wildlife biologist.
5.5 Preliminary Cost Estimate

Rough costing for the preferred alternative has been summarized below in Table 5-1. Cost estimates are based on unit prices of similar projects recently completed. These costs do not include additional fees such as engineering services, contractor mobilization or traffic control (if necessary). The total approximate cost to implement the preferred solution is approximately $680,000. As indicated, this is a rough, preliminary cost estimate, and will be refined as part of the detailed design.

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Costs</td>
<td>$640,000</td>
</tr>
<tr>
<td>Engineering &amp; Contingency Costs (25%)</td>
<td>$160,000</td>
</tr>
<tr>
<td>Property Costs</td>
<td>$100,000</td>
</tr>
<tr>
<td><strong>Total Estimated Cost</strong></td>
<td><strong>$900,000</strong></td>
</tr>
</tbody>
</table>

NOTE: costs rounded to the nearest $10K
6 IMPLEMENTATION PLAN

This chapter will summarize the implementation considerations associated with the various elements of the Preferred Alternative as described in Chapter 5.

The next steps for implementation of the preferred alternative include:

- Issue Notice of Completion
- Detailed design and associated investigations
- Easement negotiations
- Permits and Approvals
- Contract document preparation and tender; and
- Construction
- Post Construction Monitoring

Below the steps required for the above tasks have been outlined.

6.1 Notice of Completion

The Notice of Completion, will be published in the Stoney Creek News and Hamilton Spectator for two consecutive weeks in June, 2017. The notice was also distributed to local residents who own properties adjacent to the study area, stakeholders, and agencies as noted on the distribution list.

6.2 Detailed Design and Investigations

The detail design package should include the preparation of 40%, 90% and final design drawings for review by the City and relevant stakeholders. The detail design package should include, but not be limited to, 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 proposed utility bridge, existing utilities and existing bridge);
- Erosion and sediment control plan (as per the Erosion and Sediment Guidelines for Urban Construction, GGHACA);
- Landscape restoration plan (including tree removal, preservation and planting plan);
- Storm outfall restoration plan; and
- Associated design brief

The following implementation measures must be considered at the detailed design and implementation stages:

**Hydraulic Assessment**

A hydraulic assessment of the proposed conditions will be conducted and the results will be included in the design brief. The assessment will be used to confirm that no negative flooding impacts will result from the proposed works, a condition of the HCA permit, and to size the granular material for the channel bed.

**SAR Site Investigations**

Species that are Endangered and Threatened are protected under the Ontario Endangered Species Act (2007), and species that are Special Concern and Provincially rare (S1-S3) are protected under the City of Hamilton’s OP. It is recommended that the following studies are completed during subsequent planning stages to identify the location of potential SAR and other species of conservation concern within the study area and adjacent natural area so that potential impacts can be mitigated, and to avoid contravening the Endangered Species Act (2007), and policies within the City of Hamilton’s OP.
Botanical Inventory
A summer botanical inventory is recommended to identify potential herbaceous and tree species of conservation concern within the study area. Any individuals should be flagged and their location documented. Applicable policies will direct the scope of the proposed work once potential species of conservation concern are identified.

Bat Maternity Roost Surveys
Surveys for candidate maternity roost sites should be conducted throughout the study area to identify candidate bat roosting sites within the natural area. As the proposed work may require tree removal, trees that are candidate roosting sites should be located. Applicable policies will direct the scope of the proposed work once potential candidate bat maternity roost sites are identified.

Construction Staging, Erosion and Sediment Control Measures – Appropriate plans are to be included within the detailed design package, based on consultations with the City and HCA. These plans will include information such as access route and staging areas, with comprehensive erosion and sediment control requirements to be implemented throughout construction. This will include both flow management plans to enable working in dry conditions, as well as detailed fencing and delineation of the extents of disturbance. In this regard, all areas of disturbance will be fully restored and stabilized to prevent loss and contribution of sediments downstream.

Utility Locations
All utility organizations should be contacted for as-constructed drawings and field marking of all 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. At storm outfalls, the structure stability and flow hydraulics of the outfall channel must be considered in the detailed design.

6.3 Property Limitations
Mathers Stream is located on privately owned property. The extent of the works to achieve the preferred alternative would involve work outside of the existing easement; however, this is subject to finalization of the detailed design. Nevertheless, in order for the City to undertake works outside of the dedicated easement, the City will require co-operation from the private land owners. Without the co-operation of the land owners, the implementation of the preferred alternative is not achievable.

6.4 Permits
Prior to construction it will be necessary to obtain a Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses permit from Hamilton Conservation Authority (HCA) (pursuant to Ontario Regulation 161/06).

Fisheries permits or construction timing constraints are not applicable to this project, as Mathers Stream does not actively support fisheries habitat.

6.5 Post Construction Monitoring Plans
For stream restoration projects, HCA will require a commitment to post-construction monitoring for a period of 3 to 5 years following construction as a part of the permitting agreement. Detailed as-built surveys and drawings should also be completed immediately post construction by the contractor and/or stream restoration consultant. The specific details refined for the proposed restoration are described below, and are consistent with other monitoring programs the City is presently undertaking.

Immediate Post Construction:
An as-built assessment of the entire Local Study Area should be completed which will address the goals and objectives for the project. The data collected during the as-built survey will be suitable for subsequent analysis.
The information will also be suitable for the vegetation, fisheries, geomorphic, and land ownership components of the project.

A report will then be provided summarizing the above noted tasks, comparing the post construction conditions to those proposed within the detailed design. Any deficiencies observed will be outlined and accompanied by photographic illustrations and recommendations for improvement.

End of Year, Post-Construction – 3 Year Monitoring Program:
The implementation of monitoring program of the remedial works should be completed for three (3) years (years 1, 2 and 3) immediately following construction. At the end of each year, a report will be compiled and appended to the first report. The report will document the conditions and success of the restoration, review the status of aforementioned deficiencies, and make recommendations for additional works as required. The yearly monitoring program will include the following:

- The success of the plantings will be assessed by a certified botanist. If the health of the plantings are in poor condition, there will be recommendations to reduce or eliminate the risk of failure. Recommendations will be required to be implemented. If monitoring shows the need to implement additional works or plantings, the monitoring period may be extended as required.
- Success of groundcover (Terraseeding or erosion control blankets) will be assessed. If areas are observed where bare, loose soil may be exposed additional seeding, planting, or erosion control blanket applications will be recommended and implemented. If monitoring shows the need to implement additional works or plantings, the monitoring period may be extended as required.
- The stability of the riffle features and banks will be assessed through photographic comparisons of chosen vantage points.
- The monitoring of the stream channel morphology will be completed by a qualified fluvial geomorphologist for channel stability and long-term viability. The report will include field assessment of channel form including: bank stability and treatments (planform), riffle/step placement and hydraulics (profile), flow concentration and width adjustments (cross-section), photographic inventory and map to document observations. Recommendations for any required mitigative measures during the monitoring period.

The focus of field monitoring should be on the locations of channel works. A final monitoring report, data analysis and recommendation summary will be submitted after the completion of year three monitoring.