# CHIPPEWA CREEK EROSION CONTROL STUDY AND INVENTORY

## NORTH BAY-MATTAWA CONSERVATION AUTHORITY

November 28, 2014
(Rev'd Feb. 18. 2015)

water's edge
ENVIRONMENTAL SOLUTIONS TEAM LTD

NORTH BAY-MATTAWA CONSERVATION AUTHORITY

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# 1 INTRODUCTION

The Chippewa Creek subwatershed is located within the City of North Bay, Ontario. The City of North Bay and the North Bay-Mattawa Conservation Authority (NBMCA) have completed a variety of studies to support watershed management strategies and erosion control. The recommendations of the *Chippewa Creek Watershed Management Strategy* (1996) highlighted the need to reduce flooding and excessive erosion. One of the results of this management strategy was the creation of the Chippewa Creek EcoPath, which included planting plans to improve water quality and reduce channel instability. Despite the gains made through the creation of the EcoPath and its inherent stewardship programs, Chippewa Creek and its tributaries continue undergo frequent flooding and channel degradation (geomorphological and ecological). Channel works to control erosion and stabilize banks have been employed throughout over the last few decades including: gabion baskets, rip rap, retaining walls, and some bioengineering. The integrity of many of these structures have failed or are in the process of failing, or the methods employed are dated and now enhance flooding, erosion, and sedimentation. These issues relating to erosion and flooding are of great concern, and have prompted the NBMCA to undertake the present study, for which *Water's Edge Environmental Solutions Team* has been retained to complete.

## 1.1 Objective/Overview

Chippewa Creek and its two major tributaries, Johnston Creek and Eastview Tributary, will be assessed through field investigations to provide an overall rating of channel stability, and highlight specific areas of concern. Ultimately, the assessments will identify and prioritize areas of concern and allow the NBMCA to manage specific priority sites within the watercourses under investigation.

The current inventory was carried out for the three stream systems. Fluvial characterization and erosion assessments were carried out through desktop analysis and site inspections. As a result of these assessments, a comprehensive digital database and mapping were developed.

The database includes not only the erosion sites but also defined reach areas and the condition of existing protection works, and the condition of infrastructure (bridges and outfalls). Information was collected and summarized, then recommendations were presented based on the prioritization. For example:

- immediate works/total replacement
- rehabilitation; and/or
- installation of a monitoring program.

The engineering design, construction costs and possible timing for all recommended works were also prepared as part of the study.

## 1.2 Study Area

The Chippewa Creek watershed is located entirely within the municipal boundary of North Bay with an approximate drainage area of 38km$^2$. Its headwaters originate on the North Bay Escarpment, and it flows in a southerly direction down the face of the Escarpment, discharging into Lake Nipissing. The upper portion of the watershed is rural, with open pit quarries and the Airport Lands, while the lower portion (below the escarpment) is primarily urbanized and has undergone artificial channel modification and encroachment. The total length of watercourses that were assessed was approximately 83km (**Figure 1.1**). The stretches of each stream systems that were assessed from upstream to downstream are as follows:

- Chippewa Creek (the Airport Lands to Lake Nipissing)
- Johnston Creek (Upstream of Ski Club Rd. to confluence with Chippewa Creek,

northwest of Hwy 17 and Fisher St)

- Eastview Tributary (From Ski Club Road to the confluence with Johnston Creek at Northgate Shopping Centre)

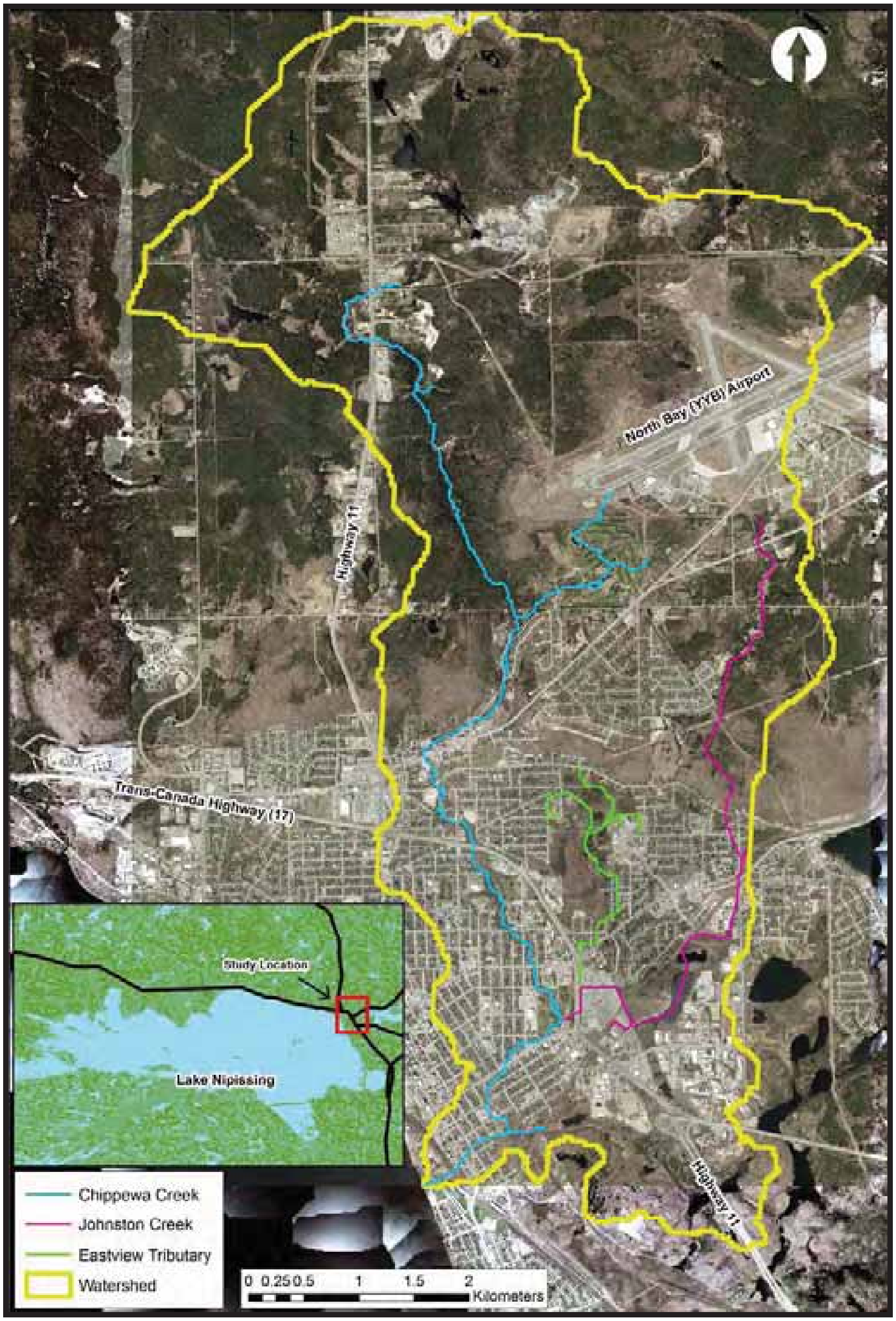



**Figure 1.1 Chippewa Watershed's Creeks**

# 2 BACKGROUND REVIEW & SITE RECONNAISSANCE

## 2.1 Desktop Study & Background Information

Water's Edge staff completed a Background Review of information provided by the NBMCA. This included a review of photographs, and existing reports. The data sources, available and relevant to this analysis, include:

- Chippewa Creek Flood and Erosion Control Study (1984)
- Chippewa Creek Watershed Background Inventory Document(1992)
- Chippewa Creek Watershed Management Study(1996)
- NBMCA Integrated Watershed Management Strategy (2013)

Relevant summary points from reports are as follows:

- Active stream bank erosion is occurring in the upper Chippewa Creek watershed within the deltaic deposits of North Bay Airport. The banks are destabilizing by runway vegetation removal, which continues to load sediment into this stream during high flows (Stantec, 2013). Siltation is a current issue, erosion is occurring in headwater areas, which can limit aquatic habitat (Stantec, 2013).
- Within the NBMCA jurisdiction, Chippewa Creek watershed has one of the steepest stream gradients. Chippewa Creek may be more prone to erosion due to higher rates of runoff (Stantec, 2013).
- Chippewa Creek's mean annual runoff depth is 516 mm (Stantec. 2013).
- Chippewa Creek watershed reacts rapidly to storm events. Flood prone areas are within the lower watershed, and they occur upstream of points of constriction (Stantec, 2013).
- Erosion control work has been carried out to stabilize major erosion sites through property acquisition, channelization, and stone armouring vulnerable stream banks (Stantec, 2013).
- The major erosion problems are: loss of bank stability with high banks, increased rates of deposition of eroded materials, and loss of streambank stability due to undercutting (Johnson, McNeice & Tomkins, 1992)

To focus the fieldwork component of the study, Water's Edge also completed a desktop assessment using GIS and mapping to determine general fluvial characteristics (slope, sinuosity, land-use, topography, and obvious alteration).

### 2.1.1 Geology and Physiography

Reviewing the site area's surficial materials is important to evaluate active channel processes. Stream channel form and sediment supply are controlled by the region's physiography and underlying surficial geology.

The City of North Bay is located in the northwestern part of the Central Gneiss Belt of Grenville Province of the Canadian Precambrian Shield (Eyles, 2002; Stantec, 2013). The Chippewa Creek watershed consists primarily of glaciolacustrine and glaciofluvial deposits, which include sand, gravelly sand, and gravel (**Figure 2.1**). Above and below the North Bay escarpment have deltaic deposits, which suggest a large river deposited into a large glacial lake (Stantec, 2013). These deposits contain a surficial groundwater aquifer that has excellent recharge and discharge properties. However, within the hardened urbanized surfaces of the lower portion of the watershed, infiltration is more restricted.

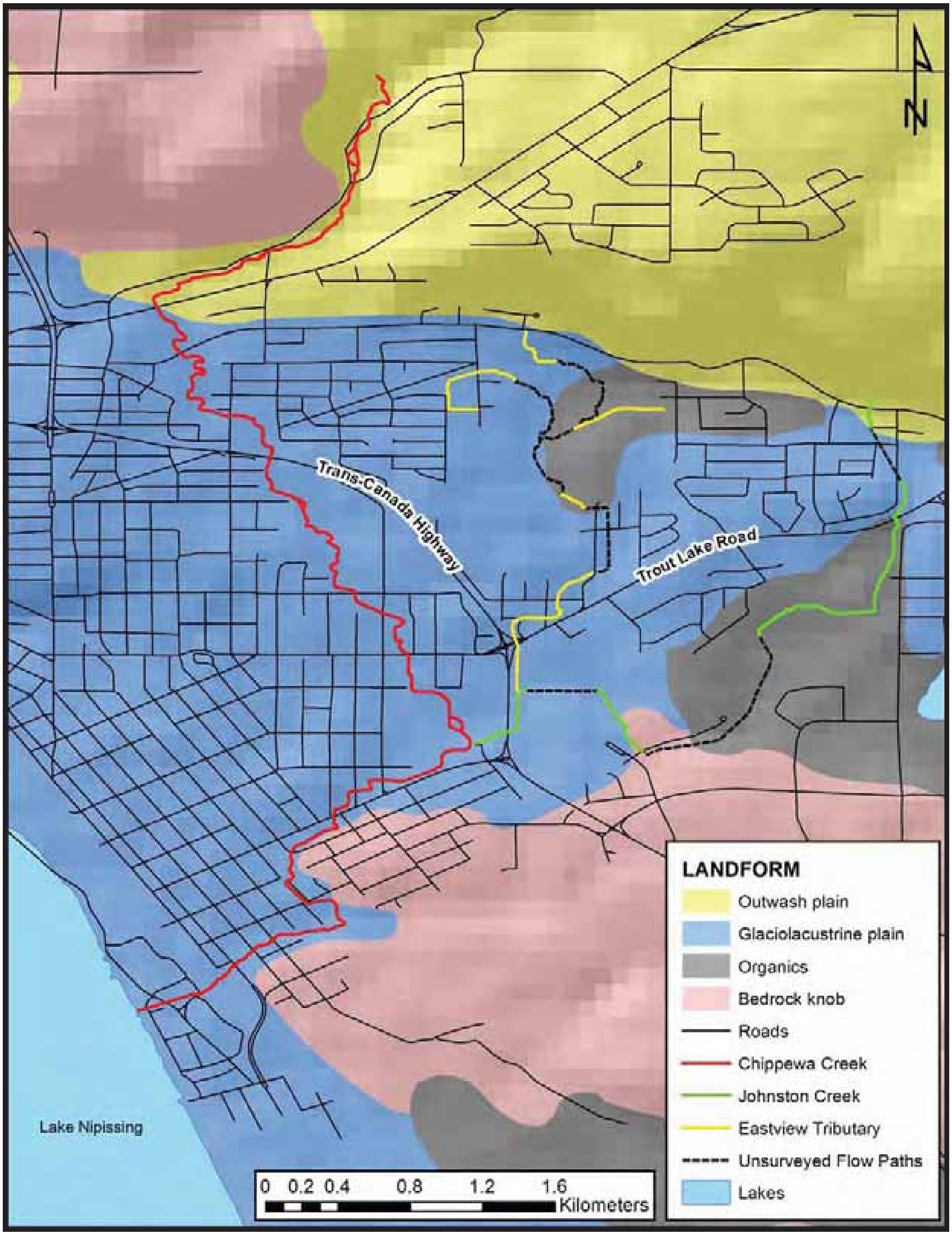



**Figure 2.1** **Geology of North Bay**

### 2.1.2 Soils

The Chippewa Creek drainage basin is comprised of 3 main types of soils (**Figure 2.2**). The downstream end of the catchment area consists of a Rockland and Monteagle combination, with a sandy loam base with an undulating topography. A very thin portion of the area consists of a Kenabeek sandy/loam soil with a very little slope. The upper portion of the watershed consists of a Muskosung gravelly sandy loam soil with an undulating topography.

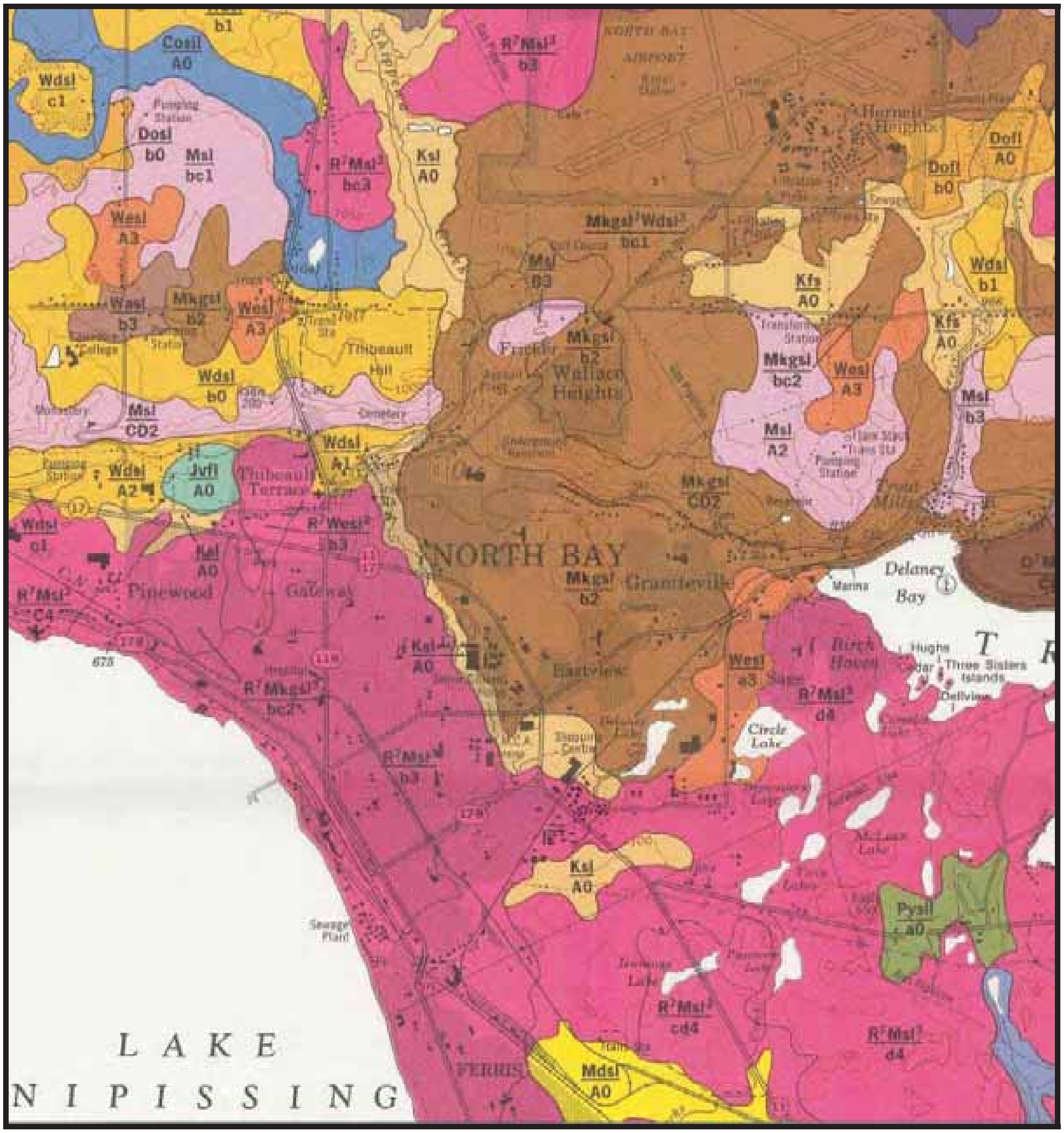



**Figure 2.2** **Soils of North Bay (Map Source: Land Resource Research Centre, 1986)**

### 2.1.3 Ecological Aspects

The upper portion of the watershed supports a cold water fishery and is primarily forested. However, several large open areas are within the upper watershed including the North Bay

Airport, the former Marsh Drive Landfill, and several aggregate operations (Stantec, 2013). A provincially significant wetland (PSW) complex is located adjacent to headwater streams known as the Upper Chippewa Creek Wetland Complex (Stantec, 2013).

#### 2.1.4 Land Usage and Cover

The Chippewa Creek subwatershed in its entirety (37.77 $km^2$) is within the City of North Bay boundaries. The watershed originates above the escarpment and flows into the urban settlement area, where 50% of the basin is located. The lower watershed is urbanized, and stormwater is effectively conveyed to the local creeks and wetlands through storm sewer outfalls. The lower watershed has flood prone areas upstream of constricting points that can cause erosion and flood damages (e.g. undersized culverts, debris jams, and tight bends). In the overall watershed, approximately 9% (3.5 $km^2$) of the area is wetland. The two main tributaries of Chippewa Creek include Johnston Creek and Eastview Tributary. **Figure 1.1** and **Figure 2.3** shows the land usage area within the Chippewa Creek subwatershed. **Table 2.1** summarizes the various areas and percentages.

The Johnston Creek watershed (6.34 $km^2$) originates within North Bay Airport and flows into the Chippewa Creek northwest of Fisher Street and Hwy 11. Wetlands cover approximately 4% (0.26 $km^2$) of the watershed.

The Eastview Tributary watershed (2.55 $km^2$) originates west of Airport Road and Hwy 11 and flows into Johnston Creek northeast of Northgate Shopping Centre. Approximately 8% (0.20 $km^2$) of Eastview watershed is covered by wetlands.

**Table 2.1 Land usage for Chippewa, Johnston, and Eastview watersheds**

| **Land Use** | **Chippewa Cr.** | | **Johnston Cr.** | | **Eastview Tr.** | |
|---|---|---|---|---|---|---|
| | Area ($km^2$) | Percentage | Area ($km^2$) | Percentage | Area ($km^2$) | Percentage |
| Clear Open Water | 0.435 | 1.11 | 0.106 | 1.67 | 0 | 0 |
| Sparse Treed | 1.918 | 4.93 | 0.193 | 3.04 | 0.271 | 10.62 |
| Treed Upland | 5.675 | 14.58 | 1.058 | 16.70 | 0.594 | 23.28 |
| Deciduous Treed | 9.245 | 23.75 | 1.039 | 16.39 | 0.22 | 8.63 |
| Mixed Treed | 2.062 | 5.30 | 0.047 | 0.75 | 0.019 | 0.75 |
| Bedrock | 0.199 | 0.51 | 0 | 0 | 0 | 0 |
| Community/Infrastructure | 19.193 | 49.31 | 3.713 | 58.56 | 1.446 | 56.72 |
| Agriculture and Undifferentiated Rural Land Use | 0.200 | 0.51 | 0.183 | 2.89 | 0 | 0 |
| TOTAL | 38.927 | 100 | 6.339 | 100 | 2.55 | 100 |

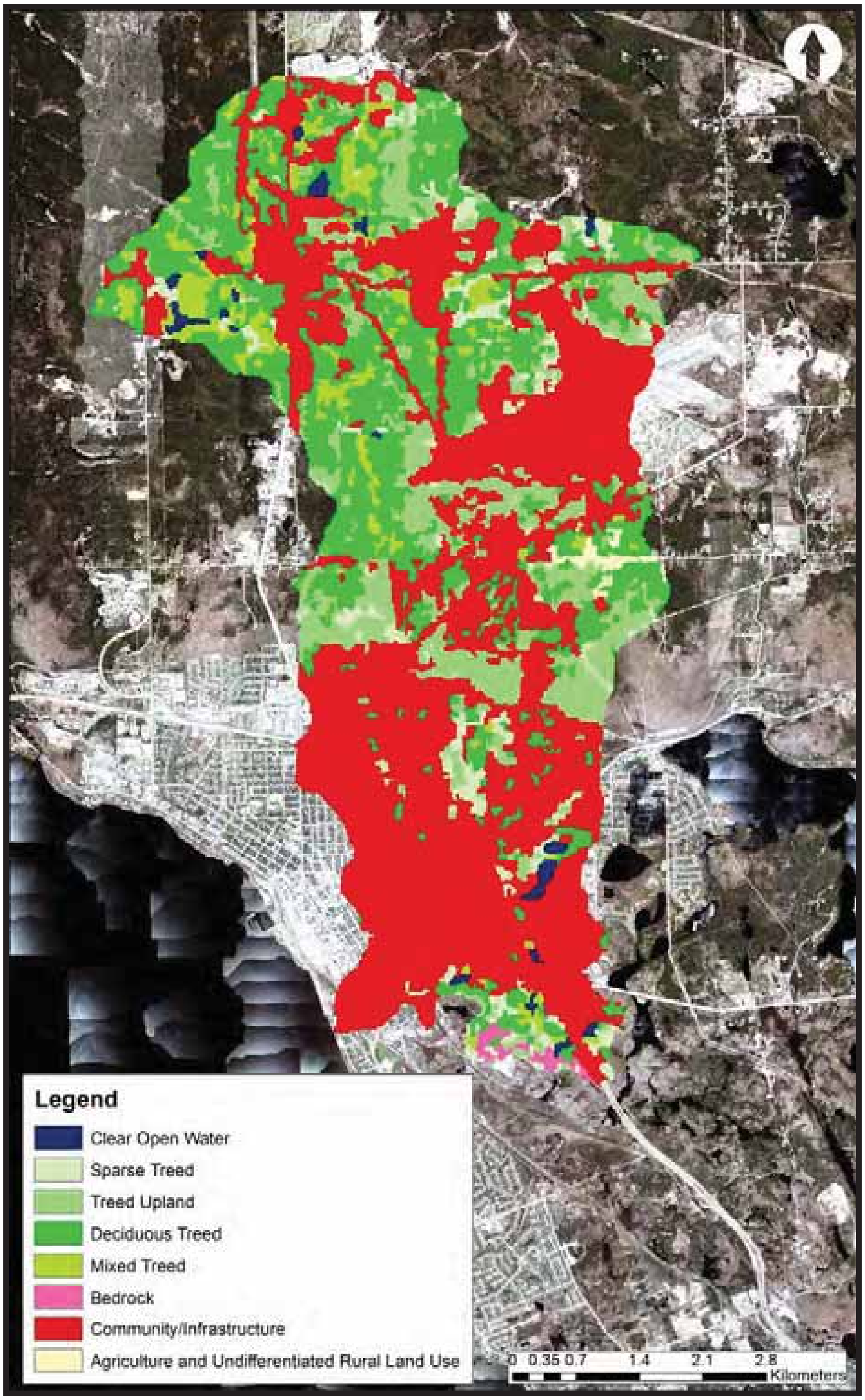



**Figure 2.3** **Land usage within Chippewa Creek Watershed.**

### 2.1.5 Stream Reaches

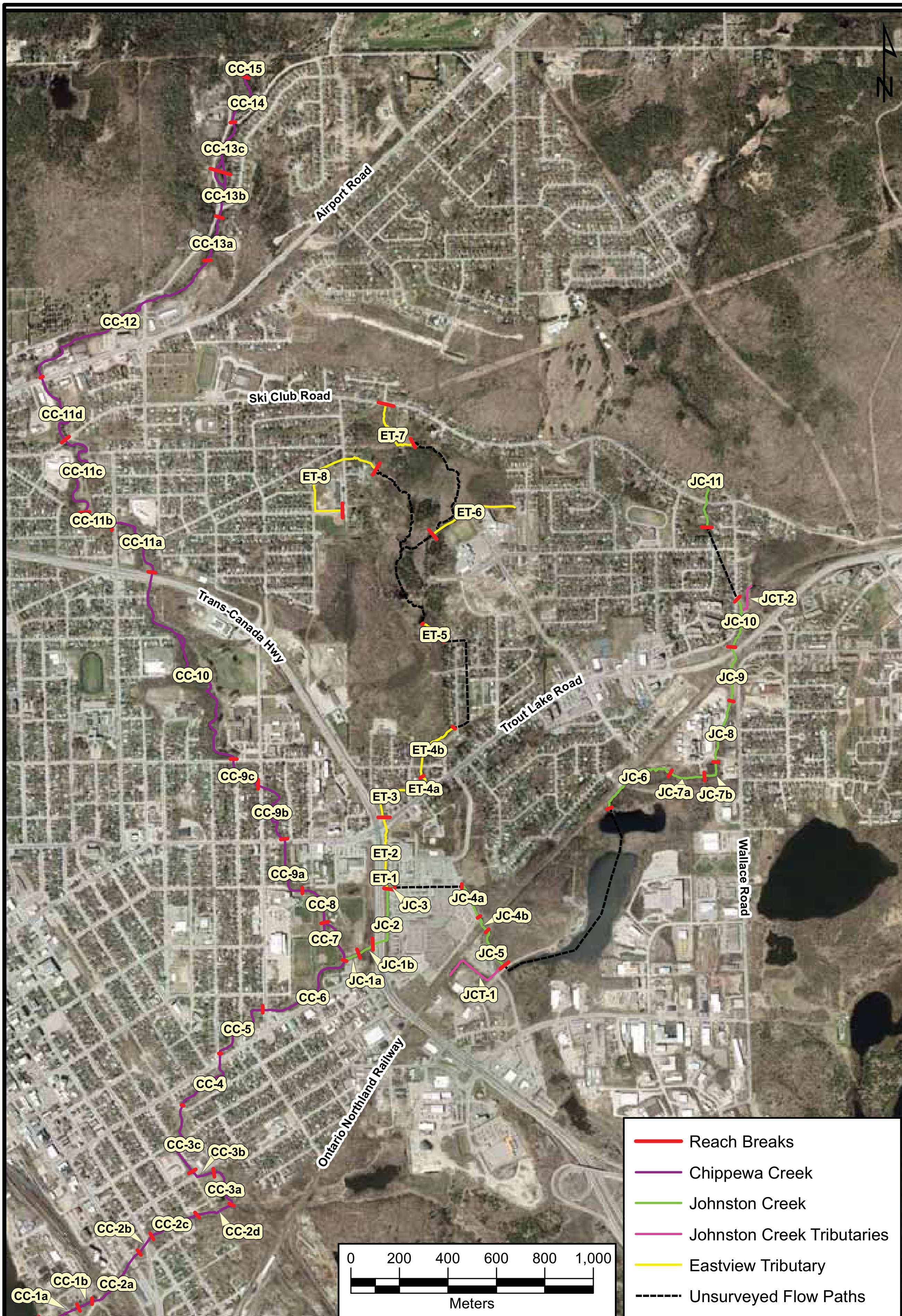
In order to better describe and quantify the processes and features of Chippewa Creek as they change along the system, the channel has been divided into sections, or *reaches* for assessment.

Reaches exhibit similar form and function within their limits, and can they can have lengths from 100m up to 2000m. Reach limits are initially determined through a desktop analysis by examining factors such as valley setting, land use, sinuosity, gradient, hydrology, and surficial geology. These may then be refined during field inspections to account for changes in substrate, vegetation, channel modification, and other features that may be less obvious from mapping or aerial photography.

Each reach was delineated using available air photos and the watercourse shapefile provided by NBMCA. Similar planform geometry, land use and the presence of hydrological inputs (tributaries) were the main factors in the reach delineation, and additionally any obvious channel modification (e.g. channelization) and road crossings. These were refined and updated during field reconnaissance where observations of similar processes and substrates for example could be made.

In this study, 33 different reaches were initially delineated, from which revisions were made during field investigations. As a result of observed changes along the channel during fieldwork, some reaches were re-numbered and/or sub-divided creating a total of 50 reaches and sub-reaches.

**Figure 2.4** details the various reaches that were identified and used during the study.

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| | | |
|---|---|---|
| Reach Delineation | Figure No.: 2.4 | Date: Oct. 29, 2014 |
| Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |

## 2.2 Field Work, Data Collection & Reporting

Field work was initiated by walking the stream systems during July 2014. A physical reconnaissance of the three creeks was carried out including geomorphic, erosion and qualitative habitat assessments.

Throughout the site reconnaissance, information on each of the creeks was documented and was included but limited to the following: overall stream conditions, identify areas of potential erosion risk, unstable areas, undercutting, slumping, entrenchment, threat to property or structures (residence, industrial buildings etc.), fence lines, safety hazards, overhanging of vegetation, debris and fallen trees, existing protection works, utility crossings (watermains, sanitary, gas/oil, pipelines, hydro, cable etc.), debris dams, bridges, outfalls, culverts, selection of the respective reference reaches and choose potential cross-section locations requiring further study or additional assessment. Photographs at each of the sites were taken and included in the documentation information.

### 2.2.1 Site Inspection Forms

There were several site inspection forms used for the study. The following forms were developed and/or utilized in this study:

Reach Conditions
Crossing and Outlet Inventory
Critical Areas
Qualitative Habitat Evaluation Index Field Sheet (QHEI)
Slope Stability Rating Chart (Ontario Ministry of Natural Resources)
Rapid Geomorphic Assessment (RGA)

Forms that were previously developed by other agencies were typically used for the purposes of site and reach assessments rather than recreating new evaluation forms. Each of the typical forms is provided in Appendix A.

### 2.2.2 Summary of Creek Areas Under Evaluation:

The study area was divided into three watersheds as outlined previously and discussed as follows (see also **Figure 2.4**).

**Chippewa Creek**

Chippewa Creek's headwaters are located near North Bay Airport and drain into Lake Nipissing, crossing Highway 17. The surveyed areas started north of Golf Club Road and end at the outlet to Lake Nipissing (**Figure 2.4**).

**Johnston Creek**

The headwaters of Johnston Creek originate north of Tower Dr. and drain south-east under the Northgate Shopping Centre and into Chippewa Creek just west of Highway 17. Unlike Chippewa Creek, open channels were not continuous throughout Johnston Creek. The main branch was surveyed from the confluence with Chippewa Creek up to Delaney Lake, with the exception of the portion that is piped underneath Northgate Centre. Surveying continued for reaches upstream of Delaney Lake to the culvert outlet at Johnston Road (east side) from another piped section. The inlet of the this piped section is located approximately 320m upstream, between Norman Avenue and Ski Club Road, in the vicinity of Kadi Court. From this inlet, the creek survey continued to a location approximately 75m upstream of Ski Club Road.

**Eastview Tributary**

The headwaters of Eastview Tributary originate north-east North of Ski Club Road, and from residential areas around Chapais Street and Ski Club Road (northwest) and in the vicinity of

École publique L'Odyssée (northeast). It then flows through a wetland complex to a culvert inlet at the northern limit of Laurentian Avenue, eventually outletting downstream and connecting to Johnston Creek, roughly 200m south of the intersection of Highway 11 and Trout Lake Road. Similar to Johnston Creek, Eastview Tributary lacks continuous open and flowing channel. It was surveyed from the confluence with Johnston Creek up to the pipe outlet at Laurentian Avenue, north of Trout Lake Road. The piped section appears to run beneath Laurentian Avenue. A short section of defined channel was surveyed upstream of the inlet (~20), beyond which it becomes undefined through the wetland complex. This wetland complex covers a large area and lacks channel definition, but three reaches drain into this wetland from upstream (ET-6, ET-7, and ET-8). ET-6 collects flow from outfalls located behind École publique L'Odyssée, and ET-8 is a defined drainage ditch around the periphery of ET Carmichael Public School flowing eastward toward the wetland complex. Finally, ET-7 originates from an outfall at Ski-Club road and was surveyed for 100m downstream before it loses definition to in channel vegetation (wetland plants).

### 2.3 Fieldwork Summary Findings

The results of the field investigation are presented in Appendix B. A digital copy of the field results and the digital database are available separately.

Filed investigations revealed a variety of channel characteristics as relating to geomorphic processes, in-channel disturbances, channel work/bank protection, realignment, substrates, surrounding land uses, and in-stream and riparian habitats.

Streambanks ranged from completely natural with excellent floodplain access, to completely hardened and confined. Treatments included some natural bank treatments through a recent design along Chippewa Creek, to truck tire walls, or vertically stacked cobble material and armourstone. Substrates were sandy, gravelly, cobbly, and even included exposures of bedrock and glacial till. The majority of the system lacked a floodplain and was confined. Bank scour occurred throughout, and it was evident that recent work had been completed at some sites to mitigate this issue. However, due to the urban encroachment with many properties extending to the water's edge or even cross the watercourse, much work has yet to be completed, and complete failure of channel works, or continued natural bank scour is contributing to risk and channel degradation. These reach walks began at the downstream end of each system and continued upstream. During the site inspections, fish were not encountered until around Reach 9b.

### 2.4 Problem Identification

Urbanization alters the landscape of watersheds, changing the natural environment and modifying natural cycles occurring within them. Generally, as development occurs, natural surfaces are converted from vegetated soils to cityscapes with extensive impervious surfaces. Typically there is a response showing an increase in runoff and a reduction in sediment supply (Wolman, 1967; Chin, 2006). These altered sediment and hydrological regimes then have an effect on the form and function of river channels. As flows are occurring more frequently and of a greater magnitude, with less sediment supplied, energy is exerted within the channel, enlarging its cross-section and degrading the system (general response). These responses are often complicated by other factors such as channel engineering and climate change. In North Bay, along the lower (more urbanized) reaches of Chippewa Creek. This urban response has been less pronounced. Sediment is still sourced from the channel where available (not hardened), but the local geology, and supply from catch basins has loaded the creek with excess fines (clay, silt and sands).

The loading of fines coupled with higher runoff rates, has increased turbidity in the channel, and the deposition of fines along the bed and banks. This can adversely affect aquatic habitat by covering habitat which can smother eggs and vegetation, and contribute to a loss of habitat for macro-invertebrates (Cordone and Kelley, 1961). Contribution of sediment to a watercourse often also results in an increase in pollutant loadings, particularly for those pollutants that adhere to particles. The particulate (settle-able) and dissolved contaminants stress aquatic ecosystems by causing decreasing oxygen and increasing temperature (eutrophication) (Biggs, 2000). Urban development increases non-permeable surfaces, such as roofs, concrete, asphalt (roads). Rainfall events that previously contributed little or no runoff to the Creek now cause flow to occur in the channel. Consequently, the frequency of flow events, and the volume of water draining to the Chippewa Creek and its tributaries has increased significantly.

Issues with Chippewa Creek may be directly or indirectly a result of urbanization and/or human modification of the landscape include:

- erosion of private property,
- movement of watercourse in proximity to subsurface infrastructure (exposed pipes),
- planform development in areas of previous straightening,
- systemic instability along watercourse,
- undercutting and undermining of bridge abutments,
- undercutting and undermining of bank restoration materials,
- failed gabions,
- concrete walls (banks),
- over steepened banks,
- property owners mowing to edge of bank,
- loss of baseflow
- increase in temperature
- loss of floodplain access during more frequent flows.

# 3 REPORTING CURRENT CONDITIONS

## 3.1 Development of Reporting Processes

Upon completion of the desktop evaluation and the field work, detailed site conditions and results were evaluated.

The following evaluation criteria were developed for all of the creeks in the 3 watersheds. The evaluation process was broken down into 3 main areas in order to address all of the concerns of the North Bay-Mattawa Conservation Authority:

A) Risk Assessment Rating (slope instability, public safety, land use);
B) Material and Performance Condition Rating (Erosion, Structure effectiveness & performance); and
C) Environmental and Creek Characteristics Rating.

These three main categories are broken down with sub-categories further allowing for key priority areas of concern to be recognized and appropriately analyzed. This system allowed for the sensitivity of the assessment to be ranked with the ultimate result being the priority ranking of the sites and reaches. Once each of the categories had been evaluated and summarized according their specific criteria, a sensitivity weighting was placed on each of the sections resulting in a final adjusted score.

The following sections outline the process through which the reaches and critical erosion sites were taken. **Table 3.2** summarizes the risk assessment methodology.

## 3.2 A) Risk Assessment Rating

### 3.2.1 A1 - Personal Safety & Resources

"The risk of personal safety, potential impact of personal safety, with respect to the danger of structure failure either natural or man-made and the resultant loss of life or injury."

This rating evaluated the risk associated with the current land use; unimproved land or passive use, natural park areas, active recreational park areas, cemeteries, parking lots, Public Utilities [water, sewer lines], Roads, Industrial / commercial buildings, institutional buildings [Public Schools, Community Centres, Hospitals, Fire Halls, Water and Sewage treatment plants, Bridges]. This evaluation criterion looks at the type of land use and the associated property or public that would be put at risk as a result of erosion or failure of structures or natural land form. The effect on the number of people at risk is also considered and the impact of their personal safety.

### 3.2.2 A2 - Risk of Damage to Property or Structures (Distance from Structure)

"The risk of structures or personal property as a result of failure of structure or lands. Distance a) is measured from river, creek to the structure (building), distance b) is measured to property line and c) is the distance measured upstream or downstream of an existing structure or infrastructure."

Both the property line and any structures were measured that were assessed to be at risk. Also any upstream or downstream structures or infrastructures that were affecting the site were also measured. Protection works, utility crossings (watermains, sanitary, gas/oil, pipelines, hydro, cable etc.), debris jams, bridges, outfalls, culverts, fence lines etc. were documented. Depending on the site additional forms were used to document the required details for assessment (e.g. crossings/debris/dams/barriers, storm sewer outfall).

#### 3.2.3 A3 - Risk of Damage – Slope Stability Rating Chart

"The risk of loss of buildings or personal property as a result of unstable slopes."

This criterion came from the Provincial Technical Guide – River and Stream Systems in assessing unstable slopes. The field assessment sheet outlines; the soils stratigraphy at the site, slope height and inclination, seepage from slope, vegetation cover, surface drainage, distance to creek, past activity at site. Once the field sheet is filled in the resulting rating will determine the ranking for the chart. The sample summary sheet is included in Appendix A and the field data sheets are also included. Photographs of the sites were taken with GPS locations.

### 3.3 B) Materials and Performance Condition Rating

#### 3.3.1 B1 - Material Condition Rating

"The general condition of the natural soils or man-made structure materials. These materials range from excellent to good condition [e.g. natural stable river system with hard materials (granite, bedrock, limestone & strong shales), man-made structures well placed in good condition armourstone, rip rap, bioengineering structures etc.] to poor quality materials [i.e. naturally eroded or completely degraded natural materials and systems, (sand, gravels, till, clay , silt, soft shales or fill materials.], man made materials which are failing, (e.g. broken mats, gabions) and the materials are not adequate."

The materials at the site may be of excellent, good, and marginal to poor quality. They may or may not be effective and not functioning properly to carry out the level of protection they were originally designed for. The natural materials at the site can consist of excellent to stable materials (granite, bedrock, limestone & strong shale), or o.k. to poor materials consisting of sand, gravel, till, clay, silt, soft shale or fill materials. This section also allows consideration for how the structure is performing as a unit or partially for material condition and stability. That is; poor quality stone, poorly mixed materials (e.g. rip rap/armourstone with gaps/holes present in the structure, armourstones which breakdown due to freeze/thaw, wet/dry process), sections of broken gabion baskets, broken sections of concrete matting units, randomly dumped materials with no secure underlying base or proper grading of materials.

#### 3.3.2 B2 - Performance Condition Rating

"The general ability of the natural river, creek system, man-made structures and their materials to perform and function effectively. As a result of the effectiveness and performance of the natural system or man-made structure they may or may not require monitoring/maintenance/repairs/ replacement."

This category considers whether or not the natural system is stable or undergoing minor or 'active' erosion. 'Active erosion' is occurring when there is evidence of undercutting, toe erosion, oversteepening or slumping of the bank. This definition was used in the Provincial Technical Guide – River and Stream Systems to better define when a site is undergoing erosion and assist in determining the degree of erosion, which is occurring. The ability of the structure or natural system to function adequately or is completely ineffective is rated. The structure may require total replacement, partial or ongoing maintenance or monitoring.

### 3.4 C) Environmental Assessment: Environmental and Creek Characteristics Rating

The section evaluates the environmental issues and concerns at the site, which include whether or not any existing or future recommended works could lead to the destruction or alteration of fish habitat. The creek characteristics are used to assess the habitat and general health and function of the ecosystem. A new evaluation technique has been introduced for this purpose. Creek stability focuses on the geomorphic component of the river system. The function of the natural system itself determines the potential the creek system has to enhance or maintain the natural ecosystem.

### 3.4.1 C1 – Qualitative Habitat Evaluation Index

"A consideration of the environmental, ecological impacts and function of the natural river, creek system and man-made structures. Addresses aspects of; natural characteristics of system (pool/Glide and riffle/Run quality, riparian zone, in stream cover, bank erosion, substrate, channel morphology,) aquatic habitat, terrestrial habitat, uses, water quality and quantity impacts."

The evaluation of the creek characteristics was carried out in order to rate the ecological impacts in the creek system by using the State of Ohio Environmental Protection Agency (EPA) Qualitative Habitat Evaluation Index (QHEI). This evaluation system details the creek characteristics and relates them to the habitat of the system, ultimately rating the environmental and ecosystem considerations. This method was chosen for this reason as has linked the river characteristics to the environmental issues.

The following summary was taken from the "Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI), June 2006".

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat characteristics that are important to fish communities. A detailed analysis of the development and use of the QHEI is available in Rankin (1989) and Rankin (1995). The QHEI is composed of six principal metrics each of which are described below. The maximum possible QHEI site score is 100. Each of the metrics are scored individually and then summed to provide the total QHEI site score. This is completed at least once for each sampling site during each year of sampling. An exception to this convention would be when substantial changes to the macrohabitat have occurred between sampling passes. Standardized definitions for pool, run, and riffle habitats, for which a variety of existing definitions and perceptions exist, are essential for accurately using the QHEI. For consistency the following definitions are taken from Platts et al. (1983). It is recommended that this reference also be consulted prior to scoring individual sites.

**Metric 1,** Substrate includes two components, substrate type- and substrate quality. *The Substrate origin* refers to the "parent" material that the stream substrate is derived from. The *Embeddedness* is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials (sand and silt). Silt cover is the extent that substrates are covered by a silt layer (i.e., a 1 inch thick or obviously affecting aquatic habitats). Silt cover differs from the embeddedness metric in that it only considers the fine silt size particles whereas fine gravels, sands, and other fines are considered in assessing embedded conditions.

**Metric 2,** Instream Cover, scores presence of instream cover types and amount of overall instream cover. Each cover type that is present in an amount occurs in sufficient quantity to support species that may commonly be associated with the habitat type should be scored.' Cover should not be counted when it is in areas of the stream with insufficient depth (usually < 20 cm) to make it useful. For example a logjam in 5 cm of water contributes very little, if any cover, and at low flow may be dry. Other cover types with limited function in shallow water include undercut banks and overhanging vegetation, boulders, and root wads.

**Metric 3,** Channel Morphology, emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (i.e. the degree to which the stream meanders), channel development, channelization, and channel stability.

**Metric 4,** Riparian Zone and Bank Erosion, emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion.

**Metric 5**, pool, glide and riffle-run quality, emphasizes the quality of the pool, glide and/or riffle-run habitats. This includes pool depth, overall diversity of current velocities (in pools and riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality.

**Metric 6,** local or map gradient, is calculated from topographic maps by measuring the elevation drop through the sampling area. This is done by measuring the stream length between the first contour line upstream and the first contour line downstream of the sampling site, and dividing the distance by the contour interval. If the contour lines are closely "packed" a minimum distance of at least 1.6 km (one mile) should be used.

Additional information is also recorded as part of the data collection depending on the site or reach. Some additional measurements of stream channel characteristics may have been collected and they were recorded in the field sheets.

### 3.4.2 C2 – Rapid Geomorphic Assessment

Creek stability was assessed using a Rapid Geomorphic Assessment (MOE, 2003). The RGA assessment focuses entirely on the geomorphic component of a river system. The RGA method consists of four factors that summarize various components of channel adjustment, specifically: aggradation, degradation, channel widening and plan form adjustment. Each factor is assessed separately and the total score indicates the overall stability of the system. This methodology has been applied to numerous streams and rivers and the following table details the ranking criteria (see **Table 3.1**).

**Table 3.1 Interpretation of RGA Score**

| Stability Index (SI) Value | Classification | Interpretation |
|---|---|---|
| SI ≤ 0.20 | In Regime | The channel morphology is within a range of variance for rivers of similar hydrographic characteristics and evidence of instability is isolated or associated with normal river meander processes. |
| 0.21 ≤ SI ≤0.40 | Transitional/Stressed | Channel morphology is within a range of variance for rivers of similar hydrographic characteristics but the evidence of instability is frequent. |
| SI ≥ 0.40 | In Adjustment | Channel morphology is not within the range of variance and evidence of instability is wide spread. |

**Figure 3.1** details the results of the RGA analysis and indicates whether each reach is In Regime, Transitional/Stressed or In Adjustment. The majority of the reaches were transitional and in regime, according to the RGA assessment. However, one reach (CC-11d) was determined to be in adjustment.

Graphs 1, 2, and 3 compile the RGA and QHEI data for Chippewa Creek, Johnston Creek, and Eastview Tributary respectively.

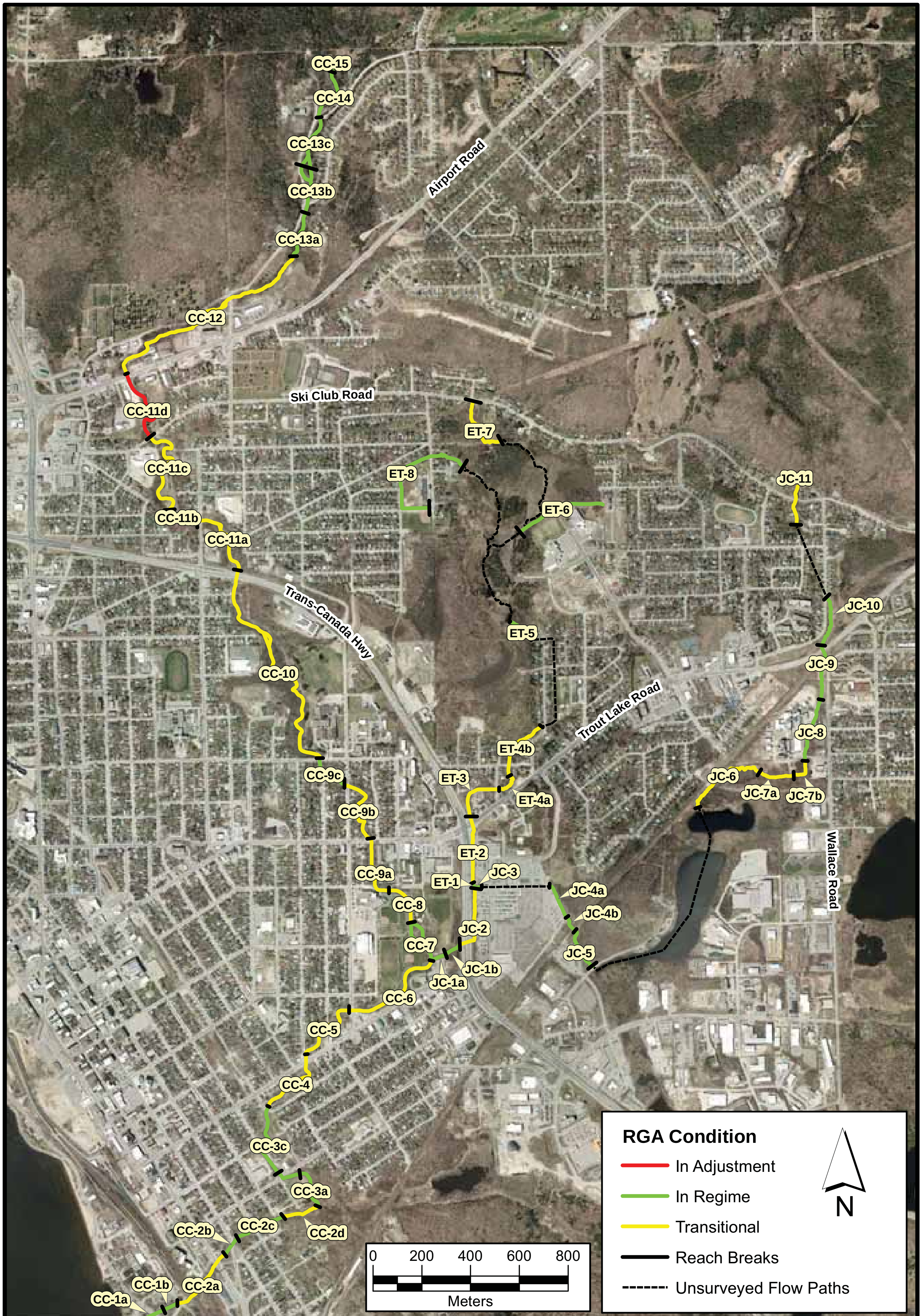
## Table 3.2 Summary of Structure Inventory and Erosion Assessment Sheet

| Category | Description | Excellent - 1 | Good - 2 | Fair - 3 | Poor - 4 | Max Potential Score |
|---|---|---|---|---|---|---|
| | | **Low** | **Moderate** | **Substantial** | **High** | |
| **A) RISK ASSESSMENT** | | | | | | |
| **A-1) Personal Safety & Resources (Number of People at Risk)** | | **Low** | **Moderate** | **Substantial** | **High** | |
| **A -1) Possible Score** | | 3 | 6 | 9 | 12 | 12 |
| **Personal Safety & Resources (Number of People at Risk)** | The risk of personal safety, potential impact of personal safety, with respect to the danger of structure failure either natural or man-made and the resultant loss of life or injury. In the case of existing erosion protection structures the loss of these structures may cause damage to bridges or infrastructure upstream or downstream of the actual site. In these isolated cases, the risk is increased because of the potential for these failures to cause additional upstream or downstream damages. | Unimproved land or passive use, natural park areas, **very occasional use [0-4 people at Risk]** | active recreational park areas, cemeteries, parking lots**, occasional use [5-25 people at Risk]** | Public Utilities (water, sewer lines), Roads, Industrial / commercial buildings **[25 + People at Risk] not permanent use** , i.e.; not 24hr/day, 7 days per week by same person, | Residential, **[ 1-4 People at Risk but Permanent use)** Institutional buildings (Public Schools, Community Centers, Hospitals, Fire Halls, Water and Sewage treatment plants, 400 series highways, Bridges) People [ 25 + People at Risk and Permanent use) , Permanently at risk because in structures potentially 24hr/day, 7 days per week | |
| **A-2) Risk of Damage to Property or structures** | The risk of structures or personal property as a result of failure of structure or lands. Distances are measured from the river or unstable slope to either a structure, private property or an upstream or downstream structure or infrastructure | | | | | |
| **A -2 a) Possible Score** | | 3 | 6 | 9 | 12 | 12 |
| **A-2 a) Risk of Damage - River to Structure** | Distance a) is measured from river, creek or unstable slope to the structure (building) and Distance | a) > 15m | a) 10-15m | a) 5-10m | a) 0-5 m | |
| **A -2 b) Possible Score** | | 3 | 6 | 9 | 12 | 12 |
| **A- 2 b) Property** | Distance is measured from river or unstable slope to property line | b) > 15 m | b) 10-15m | b) 5-10m | b) 0-5m | |
| **A -2 c) Possible Score** | | 3 | 6 | 9 | 12 | 12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **A- 2 c)** | Distance is measured from river or unstable slope to upstream or downstream structure or infrastructure | b) > 15 m | b) 10-15m | b) 5-10m | b) 0-5m | |
| **A-3) Risk of Damage - Slope Stability Rating Chart (MNR Reference)** | The risk of loss of buildings or personal property as a result of unstable slopes. Ranking takes into consideration; slope angle, type of soil stratigraphy, seepage, height, vegetation, distance to river, previous slope activity | Stable Slope | Slight Potential | Substantial Potential | High Potential | |
| **Possible Score** | | 3 | 6 | 9 | 12 | 12 |
| **Risk of Damage - Slope Stability Rating Chart** | MNR Rating Chart is used to rank each site | Rating of 24 or less | Rating of 25-30 | Rating of 30-35 | Rating of more than 35 | |
| **Section A - Total Score** | | | | | | 60 |
| **B) MATERIAL ASSESSMENT** | | | | | | |
| **B-1) Material Condition Rating** | | **Excellent Condition** | **Stable Condition** | **O.K. Condition** | **Poor Condition** | |
| **Possible Score** | | 3 | 6 | 9 | 12 | 12 |
| **B-1) Material Condition Rating (takes into consideration the condition of the structure materials)** | The general condition of the natural soils or man-made structure materials. These materials range from good condition [e.g. natural stable river system with hard materials (granite, bedrock, limestone & strong shales), man-made structures well placed in good condition armourstone, rip rap, bioengineering structures etc.] to poor quality materials [i.e. naturally eroded or completely degraded natural materials and systems, (sand, gravels, till, clay , silt, soft shales or fill materials.], man made materials which are failing, (e.g. broken mats, gabions) and the materials are not adequate. | Excellent natural substrates and soils, or quality stone and materials that are stable, new or have not shown any signs of deterioration or degradation. In natural systems the soil conditions are stable & may consist of granite, bedrock and non-eroding limestone materials. | Stable natural river, creek systems or man-made structures with good sound, quality stone and materials. In natural systems the soil conditions are generally stable and may consist of limestone (which can erode) and some strong shale materials. | Materials in structure are missing or weak, poor quality stone due to either degradation, deterioration. Structures that have poorly mixed materials (e.g. rip rap/armourstone with gaps/holes present in the structure, armourstones which breakdown due to freeze/thaw, wet/dry process). In natural systems the soil conditions are much less stable & may consist of soft shales, very hard tills, or hard clay materials. | Rubble and/or materials are of poor quality, broken and disconnected so that they are generally not effective and not functioning as a unit for material stability (e.g. sections of broken gabion baskets, broken sections of concrete matting units, randomly dumped materials with no secure underlying base or proper grading of materials). In natural systems the soil conditions are unstable & may consist of sand, gravels, till, clay, silt or fill materials. | |
| **B-2) Performance Condition Rating** | | **Excellent Performance** | **Good Performance** | **Fair Performance** | **Poor Performance** | |
| **Possible Score** | | 3 | 6 | 9 | 12 | 12 |

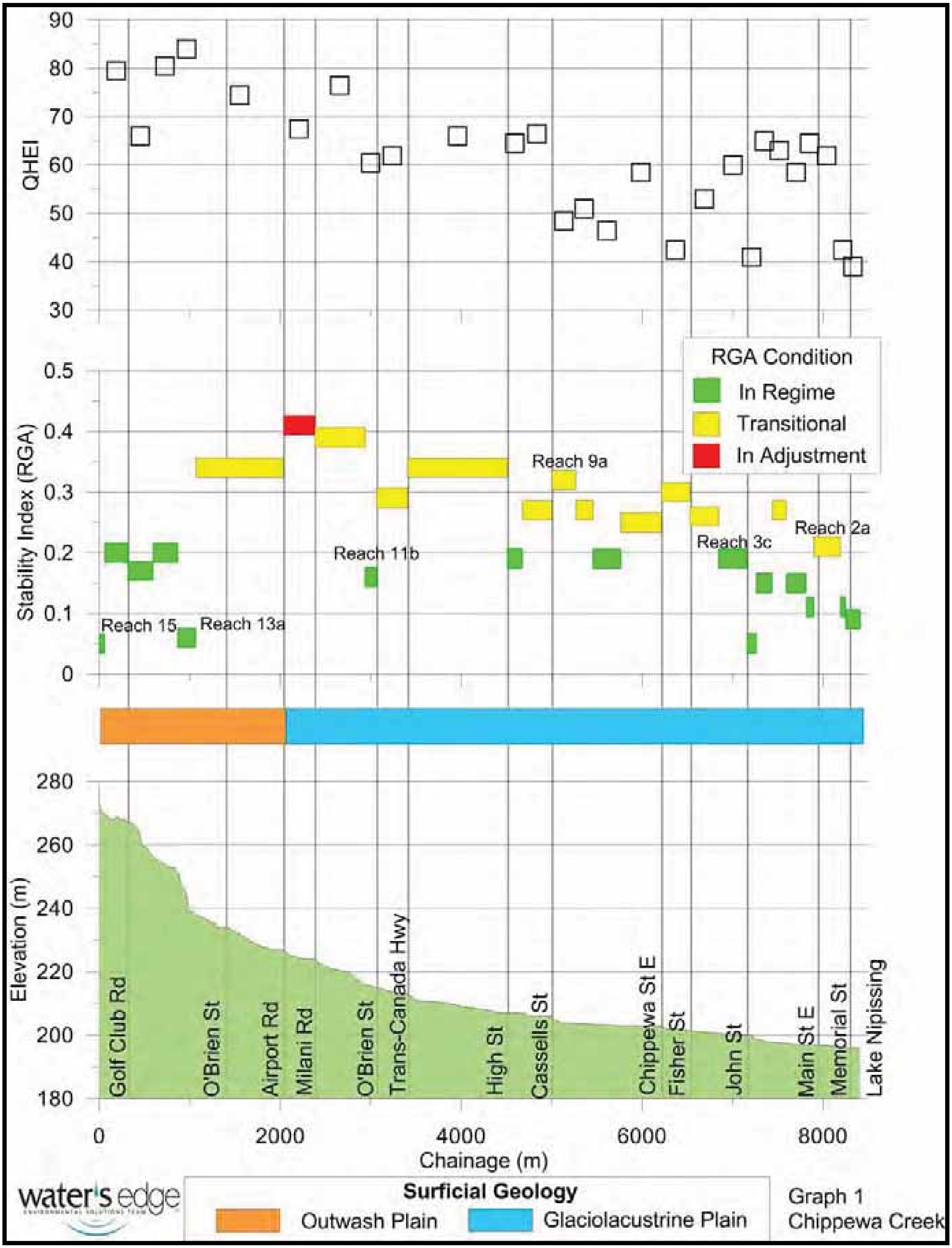
| | | | | | | |
|---|---|---|---|---|---|---|
| **B-2) Performance Condition Rating (Structure Effectiveness & Performance and the Erosion Processes occurring)** | The general ability of natural river, creek system, man-made structures and their materials to perform and function effectively. As a result of the effectiveness and performance of the natural system or man-made structure they may or may not require monitoring/maintenance/repairs/ replacement. | Natural river, creek system and man-made structure and materials are functioning and performing very well and are effective from a protection perspective through natural processes and stabilization designs. | The natural river, creek system, man-made structures and materials are functioning adequately. Monitoring, and/or repairs/maintenance may be required. | The natural river, creek system is undergoing erosion but not undergoing 'active' erosion (area may suffer erosion at some point in the future as a result of shifting of the channel). The structure is functioning minimally. The man-made structures are showing signs of poor performance or minimally functional. Both natural system and structures will require regular, ongoing monitoring, major or minor repairs/maintenance required. Structures with poorly placed stones or connections will also need repairs/maintenance. | Natural systems are undergoing 'active' erosion ('active erosion' is occurring when there is evidence of undercutting, toe erosion, oversteepening, slumping of bank). The river, creek is unstable and eroding. The structures are not effective or functional. Remedial or replacement of either entire section or sections of existing structure are required. The natural river, creek system will need to be stabilized through natural channel design or stabilization techniques. | |
| **Section B - Total Score** | | | | | | 24 |
| **C)ENVIRONMENTAL ASSESSMENT** | | | | | | |
| **Qualitative Habitat Evaluation Index (QHEI) Score** | | **>75** | **50-75** | **25-50** | **<25** | |
| **Possible Score** | | 2 | 4 | 6 | 8 | |
| **Environmental Factors - Use Qualitative Habitat Evaluation Index from Ohio (QHEI)** | A consideration of the environmental, ecological impacts and function of the natural river, creek system and man-made structures. Addresses aspects of; natural characteristics of system (pool/Glide and riffle/Run quality, riparian zone, in stream cover, bank erosion, substrate, channel morphology) aquatic habitat, terrestrial habitat, uses, water quality and quantity impacts. | Environmentally and ecologically beneficial impacts and allows natural function of system. Supports natural system characteristics, aquatic, terrestrial habitat and uses, water quality and quality aspects. Bioengineering or 'soft' structures which support aquatic, terrestrial habitat and uses, water quality aspects. | Is generally not causing any detrimental impacts but is not enhancing the natural function, characteristics, environment of the river, creek system; (e.g. armourstone, rip rap structures with some vegetation, bioengineering and access to water's edge) | Disruption of natural function of river, creek system. Natural occurring or man-made interruption and minor barriers to aquatic and terrestrial movement and habitat; (e.g. sloped revetments and armourstone, rip rap or gabion walls with no vegetation) | Destruction of natural function of system. Naturally occurring or man-made structures which are complete barriers. No access or opportunity for movement, for aquatic and terrestrial habitat (e.g. smooth concrete walls, high vertical armourstone, gabion, rip rap walls, old sites with inappropriate fill materials) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Rapid Geomorphic Assessment (RGA)** | Uses visual indicators to determine if the stream is stable or undergoing physical change through aggradation, degradation, channel widening, and planimetric form adjustment. | Stable: <0.20 | Transitional: 0.20 – 0.30 | Transitional: 0.31 – 0.40 | In-Adjustment: >0.40 | |
| **Section C - Score** | | | | | | 16 |
| | | | | | **Total Score A+B+C =** | 100 |

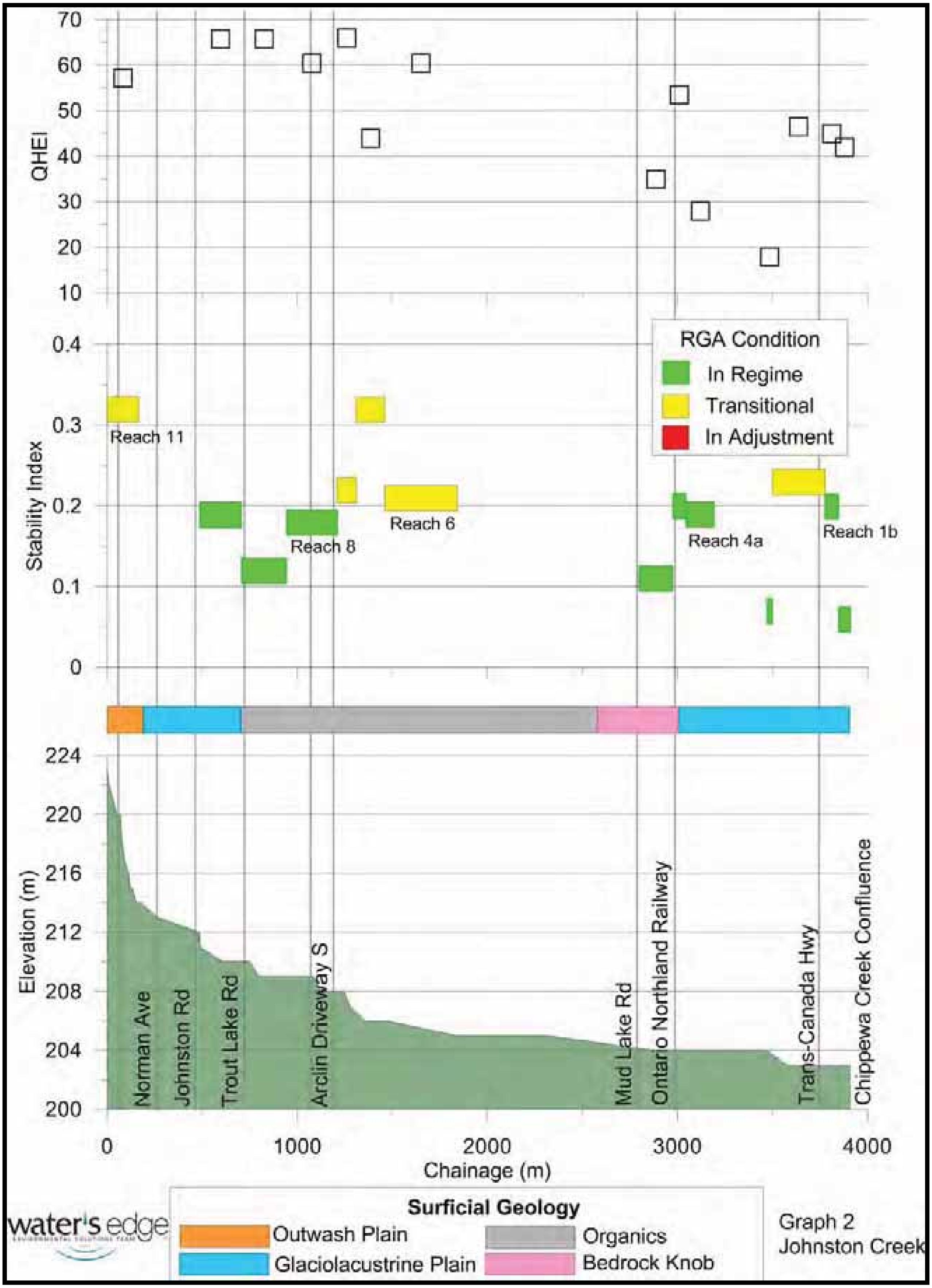


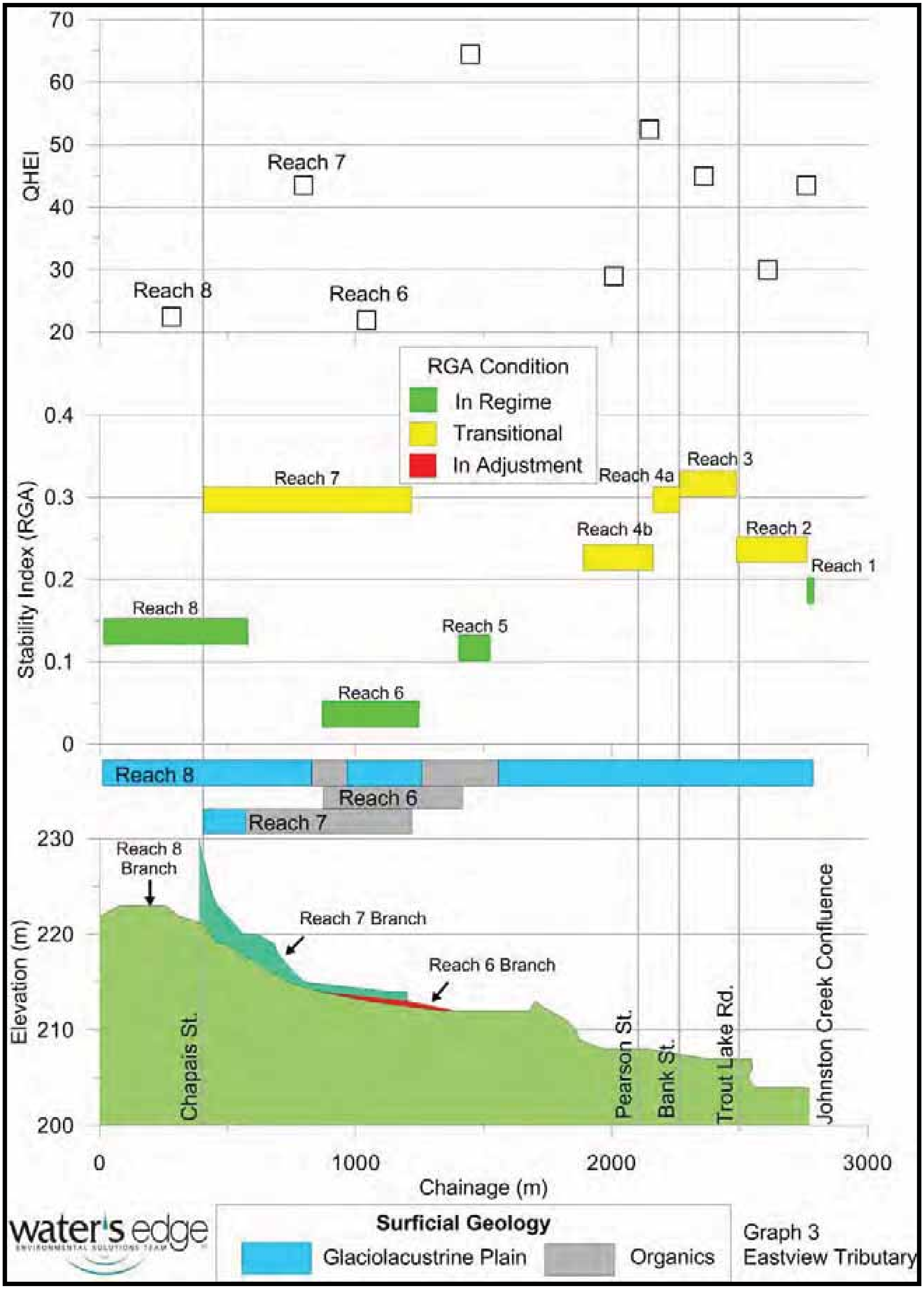

water's edge ENVIRONMENTAL SOLUTIONS TEAM

| | | |
|---|---|---|
| Rapid Geomorphic Assessment by Reach | Figure No.: 3.1 | Date: Oct. 29, 2014 |
| Chippewa Creek Watershed Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |




Graph 1
Chippewa Creek


QHEI
Stability Index
RGA Condition
In Regime
Transitional
In Adjustment
Reach 11
Reach 8
Reach 6
Reach 4a
Reach 1b
Elevation (m)
Norman Ave
Johnston Rd
Trout Lake Rd
Arclin Driveway S
Mud Lake Rd
Ontario Northland Railway
Trans-Canada Hwy
Chippewa Creek Confluence
Chainage (m)
Surficial Geology
Outwash Plain
Organics
Glaciolacustrine Plain
Bedrock Knob
water's edge
Graph 2
Johnston Creek


QHEI
Reach 7
Reach 8
Reach 6
RGA Condition
In Regime
Transitional
In Adjustment
Stability Index (RGA)
Reach 7
Reach 4a
Reach 3
Reach 4b
Reach 2
Reach 1
Reach 8
Reach 5
Reach 6
Reach 8
Reach 6
Reach 7
Elevation (m)
Reach 8 Branch
Reach 7 Branch
Reach 6 Branch
Chapais St.
Pearson St.
Bank St.
Trout Lake Rd.
Johnston Creek Confluence
Chainage (m)
water's edge
Surficial Geology
Glaciolacustrine Plain
Organics
Graph 3
Eastview Tributary

### 3.5 Inventory and Priority Listing Sites

Throughout the Risk Assessment Rating (slope instability, public safety and landuse), Material and Performance Condition Rating (Erosion, Structure effectiveness & performance) and Environmental and Creek Characteristics Rating process, all of the key areas were addressed for a full evaluation of the geomorphic and erosion assessments for all of the sites and reaches within the study area. The total rating for the sites and reaches allowed for a comprehensive evaluation of the watersheds. The resulting ranking has provided for the top priority sites and/or reaches to be identified. A full listing of all of the sites and their ranking results has been provided in **Table 3.3** and **3.4**.

**Figure 3.2** shows the high, medium and lower priority sites within the Chippewa Creek watershed. Nine of the 10 high priority sites are located within Chippewa Creek, the remaining high priority critical area is located in Johnston Creek. The medium priority sites are distributed throughout the study area. However, the low priority sites tend to be in the upper portion of the watershed.

**Figures 3.3 to 3.11** show the location of each of the priority sites in greater detail.

A complete list of all Priority Sites by watershed is provided in **Table 3.3** while a complete list of Priority Sites by priority ranking is provided in **Table 3.4**.

It is noted that the rankings should not be construed as definitive but rather as a series of works that should be completed in an acceptable timeframe with the general recommendation that the higher ranking sites be remediated or replaced before those of lower ranking.

**Table 3.3 Complete List of Priority Sites by Watershed**

| LOCATION ID | REACH | NAME - LOCATION | SCORE | PRIORITY # |
|---|---|---|---|---|
| | | | | |
| | | **Chippewa Creek** | | |
| CA1 | CC-1a | Chippewa Cr. - Gabions u/s and d/s of Memorial Dr. | 68 | 23 |
| CA2 | CC-1b | Chippewa Cr. - ~50m u/s of Memorial Dr. ("old dock") | 66.5 | 30 |
| CA3 | CC-1b | Chippewa Cr. - Boulder rip rap d/s Stanley St. | 69.5 | 16 |
| CA4 | CC-2a | Chippewa Cr. - Between Stanley St. and Railway Bridge (RB) | 62 | 43 |
| CA5 | CC-2a | Chippewa Cr. - d/s of Oak St. pedestrian bridge (currently closed) | 72.5 | 11 |
| CA6 | CC-2a | Chippewa Cr. - Oat St. pedestrian bridge | 89 | 1 |
| CA7 | CC-2a | Chippewa Cr. - d/s of Main St. | 57.5 | 59 |
| CA8 | CC-2a and CC-2b | Chippewa Cr. - Main St. to ~20m u/s McIntyre St. E | 58 | 56 |
| CA9 | CC-2c | Chippewa Cr. - 20m u/s McIntyre St. E to u/s First Ave. ped. bridge | 73.5 | 8 |
| CA10 | CC-2d | Chippewa Cr. - ~110m u/s First Ave. ped. Bridge | 42.5 | 78 |
| CA11 | CC-3a | Chippewa Cr. - ~190m d/s John St. | 57 | 60 |
| CA12 | CC-3a | Chippewa Cr. - ~90m d/s John St. (rail embankment) | 42 | 79 |
| CA13 | CC-3b | Chippewa Cr. - u/s and d/s of John St. (armoured rip rap) | 59 | 52 |
| CA14 | CC-4 | Chippewa Cr. - Hammond St. to Fisher St. | 74 | 7 |
| CA15 | CC-4 | Chippewa Cr. - u/s of Fisher St. (retaining wall) | 68 | 24 |

| | | | | |
|---|---|---|---|---|
| CA16 | CC-5 | Chippewa Cr. - ~55m u/s Princess St. E to ~40m u/s Duke St. E | 79 | 4 |
| CA17 | CC-6 | Chippewa Cr. - u/s Chippewa St. E (gabions) | 80 | 3 |
| CA18 | CC-6 and CC-7 | Chippewa Cr. - u/s and d/s of Johnston Cr. Confluence | 59.5 | 51 |
| CA19 | CC-7 | Chippewa Cr. - Old crossing east of sports arena | 50 | 74 |
| CA20 | CC-7 | Chippewa Cr. - u/s of old crossing | 56 | 63 |
| CA21 | CC-7 | Chippewa Cr. - ~50m d/s of removed Fraser St. crossing (piled slabs) | 57.5 | 57 |
| CA22 | CC-7 | Chippewa Cr. - Removed pedestrian bridge (Fraser St.) | 48.5 | 77 |
| CA23 | CC-8 | Chippewa Cr. - Armour stones ~25m u/s of removed ped. Bridge | 56.5 | 61 |
| CA24 | CC-8 | Chippewa Cr. - At Fraser St. (YMCA - rip rap) | 62.5 | 41 |
| CA25 | CC-8 | Chippewa Cr. - ~110m d/s of Cassells St. | 62.5 | 42 |
| CA26 | CC-8 | Chippewa Cr. - ~95m d/s of Cassells St. | 53.5 | 67 |
| CA27 | CC-9a | Chippewa Cr. - d/s Cassells St. (gravel bar forming) | 78 | 5 |
| CA28 | CC-9b | Chippewa Cr. - Cassells St. bridge and u/s of Cassells St. | 81.5 | 2 |
| CA29 | CC-9b | Chippewa Cr. - ~35m u/s of Cassells St. (steep banks) | 65 | 34 |
| CA30 | CC-9b | Chippewa Cr. - ~75m u/s of Cassells St. | 69.5 | 17 |
| CA31 | CC-9b | Chippewa Cr. - ~120m u/s of Cassells St. (apartment parking lot) | 75.5 | 6 |
| CA32 | CC-9b | Chippewa Cr. - ~115m d/s of Chippewa St. W | 66.5 | 31 |
| CA33 | CC-9b | Chippewa Cr. - ~55m d/s of Chippewa St. W (vertical rubble) | 71 | 13 |
| CA34 | CC-9b | Chippewa Cr. - ~45m d/s of Chippewa St. W (undercut bank) | 71 | 14 |
| CA35 | CC-9b | Chippewa Cr. - ~15m d/s of Chippewa St. W | 65 | 35 |
| CA36 | CC-9b | Chippewa Cr. - Gabions d/s of Chippewa St. W | 72.5 | 10 |
| CA37 | CC-9c | Chippewa Cr. - Gabions ~50m u/s of Chippewa St. W | 58.5 | 53 |
| CA38 | CC-10 | Chippewa Cr. - ~20m u/s of High St. | 49 | 76 |
| CA39 | CC-10 | Chippewa Cr. - u/s High St. to Dudley Ave. ped. Bridge | 50.5 | 73 |
| CA40 | CC-10 | Chippewa Cr. - ~400m u/s of High St. | 52 | 71 |
| CA41 | CC-10 | Chippewa Cr. - ~30 d/s Dudley Ave. ped bridge to Hwy 17 | 68.5 | 21 |
| CA42 | CC-11a | Chippewa Cr. - d/s and u/s of Hwy 17 (gabions) to d/s O'Brien St. | 63.5 | 39 |
| CA43 | CC-11a | Chippewa Cr. - ~130m d/s of O'Brien St. (gabions) | 57.5 | 58 |
| *CA44** | *CC-11a partially in CC-11b* | *Chippewa Cr. - u/s and d/s of O'Brien St.(culvert corroding)* | *80* | *4* |
| CA45 | CC-11b and CC-11c | Chippewa Cr. - u/s of O'Brien St. to u/s of Airport Rd. | 53.5 | 68 |
| CA46 | CC-11c | Chippewa Cr. - ~150m u/s of O'Brien St. | 38 | 80 |
| CA47 | CC-11d | Chippewa Cr. - ~280m u/s of O'Brien St. (filter fabric on till) | 49.5 | 75 |
| CA48 | CC-11d | Chippewa Cr. - u/s of Milani Rd. (gabions and rip rap) | 51 | 72 |
| CA49 | CC-11d | Chippewa Cr. - ~95m d/s of Airport Rd. (large boulder treatment) | 67.5 | 25 |
| CA50 | CC-11d | Chippewa Cr. - ~40m d/s of Airport Rd. (Tires/ slabs) | 69 | 19 |
| CA51 | CC-12 | Chippewa Cr. - ~40m (RB) and ~85m (LB) u/s of Airport Rd. | 64 | 37 |

| | | | | |
|---|---|---|---|---|
| CA52 | CC-12 | Chippewa Cr. - ~40m u/s of Airport Rd. and ~45m d/s of O'Brien St. | 61 | 47 |
| CA53 | CC-12 | Chippewa Cr. - ~160m u/s of Airport Rd. (BMW dealership) | 64 | 38 |
| CA54 | CC-12 | Chippewa Cr. - ~95m d/s of O'Brien St. (rip rap point bar from road) | 67 | 28 |
| CA55 | CC-12 | Chippewa Cr. - u/s of O'Brien St. at Golf Club Rd. | 53.5 | 69 |
| CA56 | CC-12 | Chippewa Cr. - ~200m u/s of O'Brien St. (new sanitary crossing) | 56.5 | 62 |
| CA57 | CC-12 | Chippewa Cr. - ~290m u/s of O'Brien St. | 55 | 65 |
| CA58 | CC-13a | Chippewa Cr. - ~40m d/s of Bain Dr. (piled concrete slabs) | 67 | 29 |
| CA59 | CC-13b | Chippewa Cr. - Gabions u/s of Bain Dr. | 60 | 50 |
| CA60 | CC-13b | Chippewa Cr. - ~60m u/s of Bain Dr. | 61.5 | 45 |
| CA61 | CC-13c | Chippewa Cr. - ~150m u/s of Bain Dr. | 58.5 | 54 |
| CA62 | CC-13c | Chippewa Cr. - ~135m d/s of Golf Club Rd. | 55.5 | 64 |
| CA63 | CC-13c | Chippewa Cr. - ~85m d/s of Golf Club Rd. | 58.5 | 55 |
| CA64 | CC-14 | Chippewa Cr. - ~35m u/s of Golf Club Rd. | 61.5 | 46 |
| CA65 | CC-14 | Chippewa Cr. - ~85m u/s of Golf Club Rd. | 67.5 | 26 |
| | | | | |
| | | **Johnston Creek** | | |
| CA66 | JC-1a | Johnston Cr. - u/s Chippewa Cr. Confluence | 62 | 44 |
| CA67 | JC-1a | Johnston Cr. - u/s and d/s ped. bridge u/s of confluence | 69.5 | 18 |
| CA68 | JC-4a | Johnston Cr. - Rip rap at outlet from under the Super Centre (east) | 68.5 | 22 |
| CA69 | JC-4a | Johnston Cr. - Along east parking lot (Super Centre) | 61 | 48 |
| CA70 | JC-4b | Johnston Cr. - Railway to Mud Lake Rd. | 60.5 | 49 |
| CA71 | JC-7a and JC-7b | Johnston Cr. - ~210m d/s Arclin S driveway to N driveway | 73 | 9 |
| CA72 | JC-8 | Johnston Cr. - u/s of Arclin N driveway (~190m) | 67.5 | 27 |
| CA73 | JC-11 | Johnston Cr. - Gabion and rip rap ~55m d/s of Ski Club Rd. | 71.5 | 12 |
| CA74 | JC-11 | Johnston Cr. - Vertical rubble walls u/s Ski Club Rd. | 70 | 15 |
| | | | | |
| | | **East View Tributary** | | |
| CA75 | ET-2 | East View Trib. - Gabions at NE corner of grocer's parking lot | 52.5 | 70 |
| CA76 | ET-2 | East View Trib. - Rip rap d/s of Trout Lake Rd. | 66 | 32 |
| CA77 | ET-3 | East View Trib. - u/s Trout Lake Rd. (at Hwy 17/11) | 69 | 20 |
| CA78 | ET-4b | East View Trib. - d/s Pearson St. | 64.5 | 36 |
| CA79 | ET-4b | East View Trib. - ~70m d/s of Laurentian Ave. | 63 | 40 |
| CA80 | ET-4b | East View Trib. - d/s Laurentian Ave. | 54 | 66 |
| CA81 | ET-7 | East View Trib. - Gravel d/s Ski Club Rd. (at Riddle St.) | 65.5 | 33 |

* Site CA44 is excluded from further analysis as it is currently being repaired by the City of North Bay

**Table 3.4 Complete List of Priority Sites by Priority #**

| Location ID | Reach | Name - Location | Score | Priority # |
|---|---|---|---|---|
| CA6 | CC-2a | Chippewa Cr. - Oak St. pedestrian bridge | 89 | 1 |
| CA28 | CC-9b | Chippewa Cr. - Cassells St. bridge and u/s of Cassells St. | 81.5 | 2 |

| | | | | |
|---|---|---|---|---|
| CA17 | CC-6 | Chippewa Cr. - u/s Chippewa St. E (gabions) | 80 | 3 |
| *CA44** | *CC-11a partially in CC-11b* | *Chippewa Cr. - u/s and d/s of O'Brien St.(culvert corroding)* | *80* | *4* |
| CA16 | CC-5 | Chippewa Cr. - ~55m u/s Princess St. E to ~40m u/s Duke St. E | 79 | 4 |
| CA27 | CC-9a | Chippewa Cr. - d/s Cassells St. (gravel bar forming) | 78 | 5 |
| CA31 | CC-9b | Chippewa Cr. - ~120m u/s of Cassells St. (apartment parking lot) | 75.5 | 6 |
| CA14 | CC-4 | Chippewa Cr. - Hammond St. to Fisher St. | 74 | 7 |
| CA9 | CC-2c | Chippewa Cr. - 20m u/s McIntyre St. E to u/s First Ave. ped. bridge | 73.5 | 8 |
| CA71 | JC-7a and JC-7b | Johnston Cr. - ~210m d/s Arclin S driveway to N driveway | 73 | 9 |
| CA36 | CC-9b | Chippewa Cr. - Gabions d/s of Chippewa St. W | 72.5 | 10 |
| CA5 | CC-2a | Chippewa Cr. - d/s of Oak St. pedestrian bridge (currently closed) | 72.5 | 11 |
| CA73 | JC-11 | Johnston Cr. - Gabion and rip rap ~55m d/s of Ski Club Rd. | 71.5 | 12 |
| CA33 | CC-9b | Chippewa Cr. - ~55m d/s of Chippewa St. W (vertical rubble) | 71 | 13 |
| CA34 | CC-9b | Chippewa Cr. - ~45m d/s of Chippewa St. W (undercut bank) | 71 | 14 |
| CA74 | JC-11 | Johnston Cr. - Vertical rubble walls u/s Ski Club Rd. | 70 | 15 |
| CA3 | CC-1b | Chippewa Cr. - Boulder rip rap d/s Stanley St. | 69.5 | 16 |
| CA30 | CC-9b | Chippewa Cr. - ~75m u/s of Cassells St. | 69.5 | 17 |
| CA67 | JC-1a | Johnston Cr. - u/s and d/s ped. bridge u/s of confluence | 69.5 | 18 |
| CA50 | CC-11d | Chippewa Cr. - ~40m d/s of Airport Rd. (Tires/ slabs) | 69 | 19 |
| CA77 | ET-3 | East View Trib. - u/s Trout Lake Rd. (at Hwy 17/11) | 69 | 20 |
| CA41 | CC-10 | Chippewa Cr. - ~30 d/s Dudley Ave. ped. bridge to Hwy 17 | 68.5 | 21 |
| CA68 | JC-4a | Johnston Cr. - Rip rap at outlet from under the Super Centre (east) | 68.5 | 22 |
| CA1 | CC-1a | Chippewa Cr. - Gabions u/s and d/s of Memorial Dr. | 68 | 23 |
| CA15 | CC-4 | Chippewa Cr. - u/s of Fisher St. (retaining wall) | 68 | 24 |
| CA49 | CC-11d | Chippewa Cr. - ~95m d/s of Airport Rd. (large boulder treatment) | 67.5 | 25 |
| CA65 | CC-14 | Chippewa Cr. - ~85m u/s of Golf Club Rd. | 67.5 | 26 |
| CA72 | JC-8 | Johnston Cr. - u/s of Arclin N driveway (~190m) | 67.5 | 27 |
| CA54 | CC-12 | Chippewa Cr. - ~95m d/s of O'Brien St. (rip rap point bar from road) | 67 | 28 |
| CA58 | CC-13a | Chippewa Cr. - ~40m d/s of Bain Dr. (piled concrete slabs) | 67 | 29 |
| CA2 | CC-1b | Chippewa Cr. - ~50m u/s of Memorial Dr. ("old dock") | 66.5 | 30 |
| CA32 | CC-9b | Chippewa Cr. - ~115m d/s of Chippewa St. W | 66.5 | 31 |
| CA76 | ET-2 | East View Trib. - Rip rap d/s of Trout Lake Rd. | 66 | 32 |
| CA81 | ET-7 | East View Trib. - Gravel d/s Ski Club Rd. (at Riddle St.) | 65.5 | 33 |
| CA29 | CC-9b | Chippewa Cr. - ~35m u/s of Cassells St. (steep banks) | 65 | 34 |
| CA35 | CC-9b | Chippewa Cr. - ~15m d/s of Chippewa St. W | 65 | 35 |
| CA78 | ET-4b | East View Trib. - d/s Pearson St. | 64.5 | 36 |

| | | | | |
|---|---|---|---|---|
| CA51 | CC-12 | Chippewa Cr. - ~40m (RB) and ~85m (LB) u/s of Airport Rd. | 64 | 37 |
| CA53 | CC-12 | Chippewa Cr. - ~160m u/s of Airport Rd. (BMW dealership) | 64 | 38 |
| CA42 | CC-11a | Chippewa Cr. - d/s and u/s of Hwy 17 (gabions) to d/s O'Brien St. | 63.5 | 39 |
| CA79 | ET-4b | East View Trib. - ~70m d/s of Laurentian Ave. | 63 | 40 |
| CA24 | CC-8 | Chippewa Cr. - At Fraser St. (YMCA - rip rap) | 62.5 | 41 |
| CA25 | CC-8 | Chippewa Cr. - ~110m d/s of Cassells St. | 62.5 | 42 |
| CA4 | CC-2a | Chippewa Cr. - Between Stanley St. and Railway Bridge (RB) | 62 | 43 |
| CA66 | JC-1a | Johnston Cr. - u/s Chippewa Cr. Confluence | 62 | 44 |
| CA60 | CC-13b | Chippewa Cr. - ~60m u/s of Bain Dr. | 61.5 | 45 |
| CA64 | CC-14 | Chippewa Cr. - ~35m u/s of Golf Club Rd. | 61.5 | 46 |
| CA52 | CC-12 | Chippewa Cr. - ~40m u/s of Airport Rd. and ~45m d/s of O'Brien St. | 61 | 47 |
| CA69 | JC-4a | Johnston Cr. - Along east parking lot (Super Centre) | 61 | 48 |
| CA70 | JC-4b | Johnston Cr. - Railway to Mud Lake Rd. | 60.5 | 49 |
| CA59 | CC-13b | Chippewa Cr. - Gabions u/s of Bain Dr. | 60 | 50 |
| CA18 | CC-6 and CC-7 | Chippewa Cr. - u/s and d/s of Johnston Cr. Confluence | 59.5 | 51 |
| CA13 | CC-3b | Chippewa Cr. - u/s and d/s of John St. (armoured rip rap) | 59 | 52 |
| CA37 | CC-9c | Chippewa Cr. - Gabions ~50m u/s of Chippewa St. W | 58.5 | 53 |
| CA61 | CC-13c | Chippewa Cr. - ~150m u/s of Bain Dr. | 58.5 | 54 |
| CA63 | CC-13c | Chippewa Cr. - ~85m d/s of Golf Club Rd. | 58.5 | 55 |
| CA8 | CC-2a and CC-2b | Chippewa Cr. - Main St. to ~20m u/s McIntyre St. E | 58 | 56 |
| CA21 | CC-7 | Chippewa Cr. - ~50m d/s of removed Fraser St. crossing (piled slabs) | 57.5 | 57 |
| CA43 | CC-11a | Chippewa Cr. - ~130m d/s of O’Brien St. (gabions) | 57.5 | 58 |
| CA7 | CC-2a | Chippewa Cr. - d/s of Main St. | 57.5 | 59 |
| CA11 | CC-3a | Chippewa Cr. - ~190m d/s John St. | 57 | 60 |
| CA23 | CC-8 | Chippewa Cr. - Armour stones ~25m u/s of removed ped. Bridge | 56.5 | 61 |
| CA56 | CC-12 | Chippewa Cr. - ~200m u/s of O'Brien St. (new sanitary crossing) | 56.5 | 62 |
| CA20 | CC-7 | Chippewa Cr. - u/s of old crossing | 56 | 63 |
| CA62 | CC-13c | Chippewa Cr. - ~135m d/s of Golf Club Rd. | 55.5 | 64 |
| CA57 | CC-12 | Chippewa Cr. - ~290m u/s of O'Brien St. | 55 | 65 |
| CA80 | ET-4b | East View Trib. - d/s Laurentian Ave. | 54 | 66 |
| CA26 | CC-8 | Chippewa Cr. - ~95m d/s of Cassells St. | 53.5 | 67 |
| CA45 | CC-11b and CC-11c | Chippewa Cr. - u/s of O'Brien St. to u/s of Airport Rd. | 53.5 | 68 |
| CA55 | CC-12 | Chippewa Cr. - u/s of O'Brien St. at Golf Club Rd. | 53.5 | 69 |
| CA75 | ET-2 | East View Trib. - Gabions at NE corner of grocer's parking lot | 52.5 | 70 |
| CA40 | CC-10 | Chippewa Cr. - ~400m u/s of High St. | 52 | 71 |

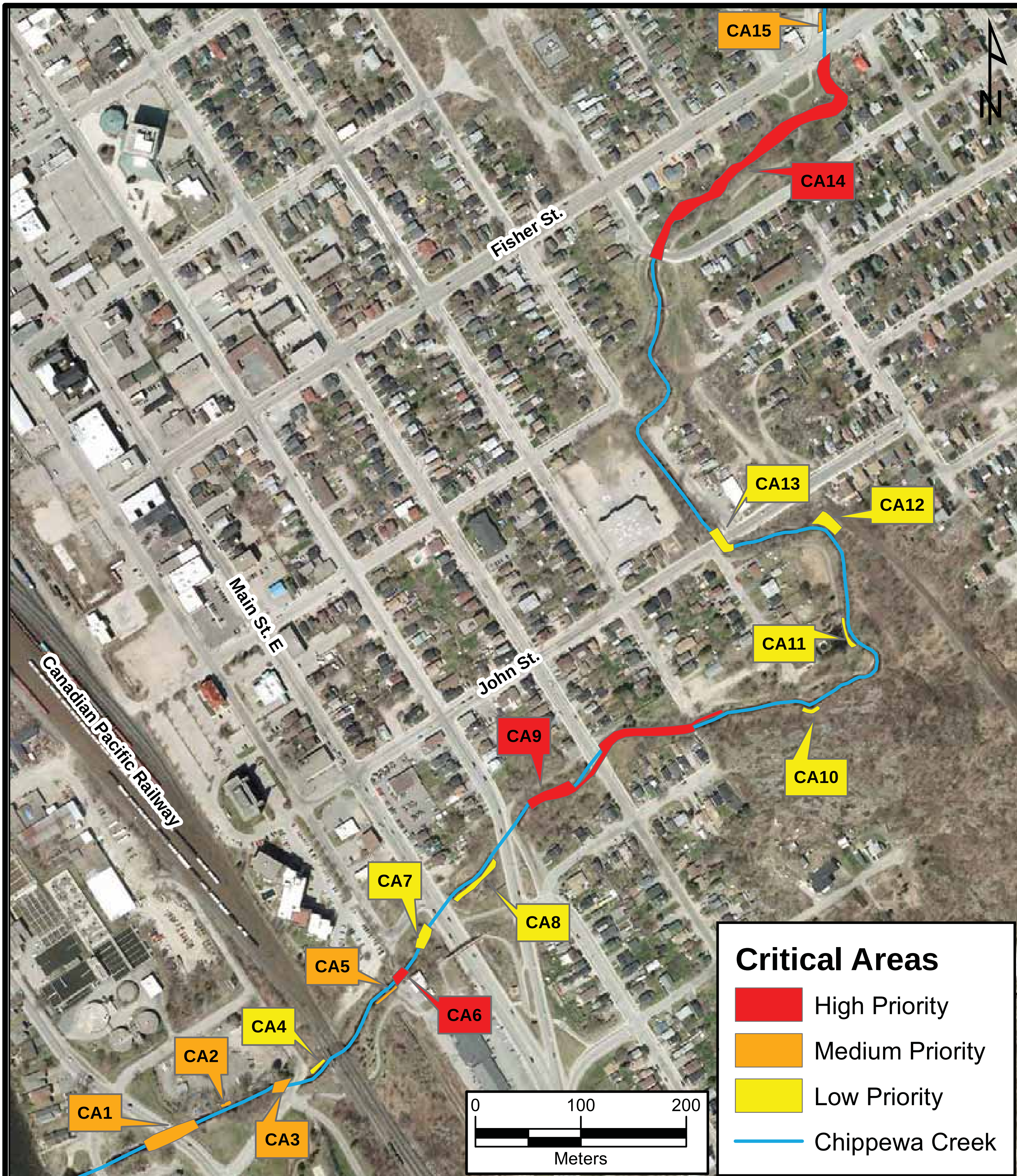
| | | | | |
|---|---|---|---|---|
| CA48 | CC-11d | Chippewa Cr. - u/s of Milani Rd. (gabions and rip rap) | 51 | 72 |
| CA39 | CC-10 | Chippewa Cr. - u/s High St. to Dudley Ave. ped. Bridge | 50.5 | 73 |
| CA19 | CC-7 | Chippewa Cr. - Old crossing east of sports arena | 50 | 74 |
| CA47 | CC-11d | Chippewa Cr. - ~280m u/s of O'Brien St. (filter fabric) | 49.5 | 75 |
| CA38 | CC-10 | Chippewa Cr. - ~20m u/s of High St. | 49 | 76 |
| CA22 | CC-7 | Chippewa Cr. - Removed pedestrian bridge (Fraser St.) | 48.5 | 77 |
| CA10 | CC-2d | Chippewa Cr. - ~110m u/s First Ave. ped. Bridge | 42.5 | 78 |
| CA12 | CC-3a | Chippewa Cr. - ~90m d/s John St. (rail embankment) | 42 | 79 |
| CA46 | CC-11c | Chippewa Cr. - ~150m u/s of O'Brien St. | 38 | 80 |

* Site CA44 is excluded from further analysis as it is currently being repaired by the City of North Bay

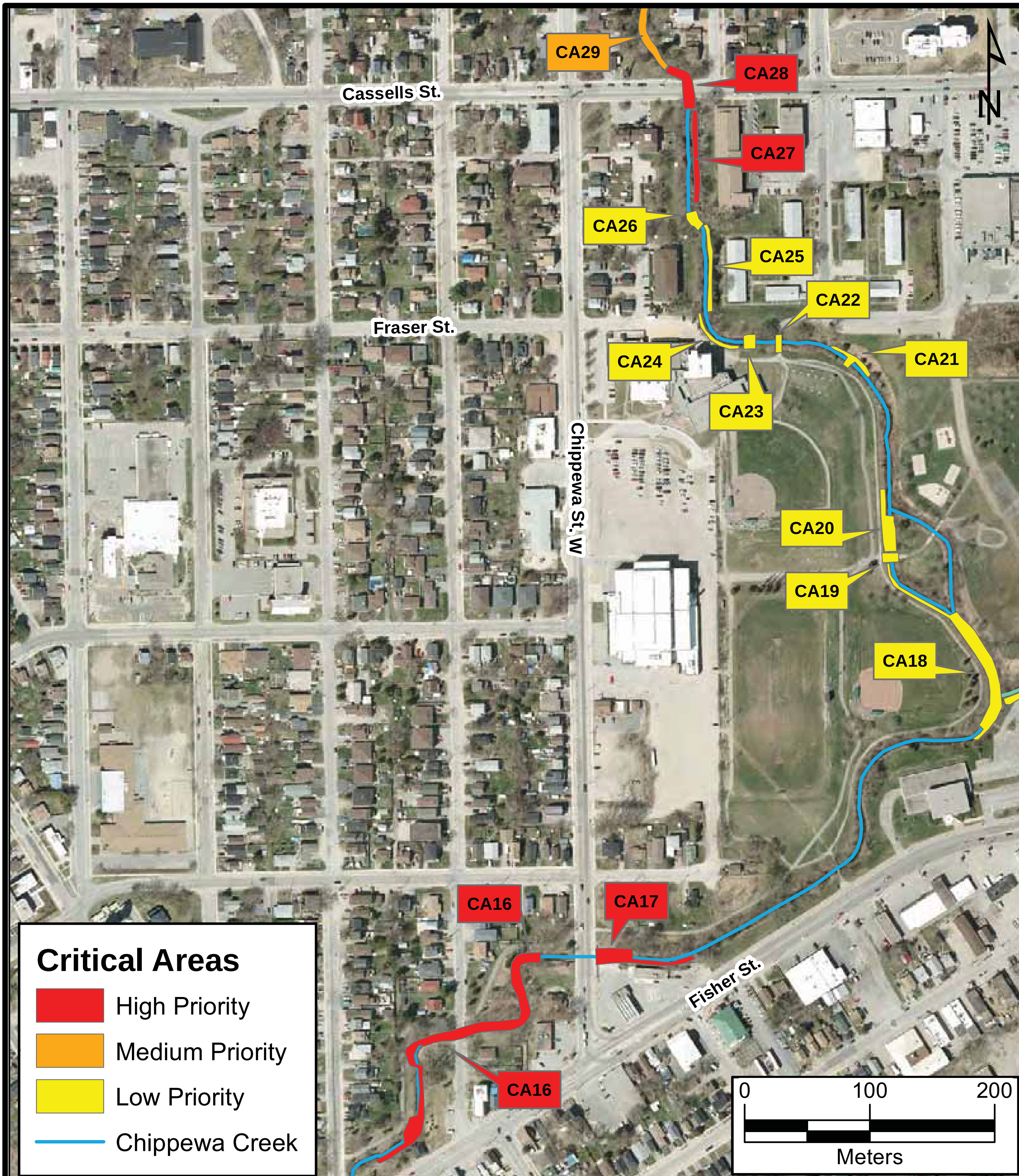
# Figures 3.2 – 3.11
# Critical Area Maps


water's edge ENVIRONMENTAL SOLUTIONS TEAM

| | | | |
|---|---|---|---|
| Critical Area Priority Map | Figure No.: 3.2 | Date: Oct. 29, 2014 |
| Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |



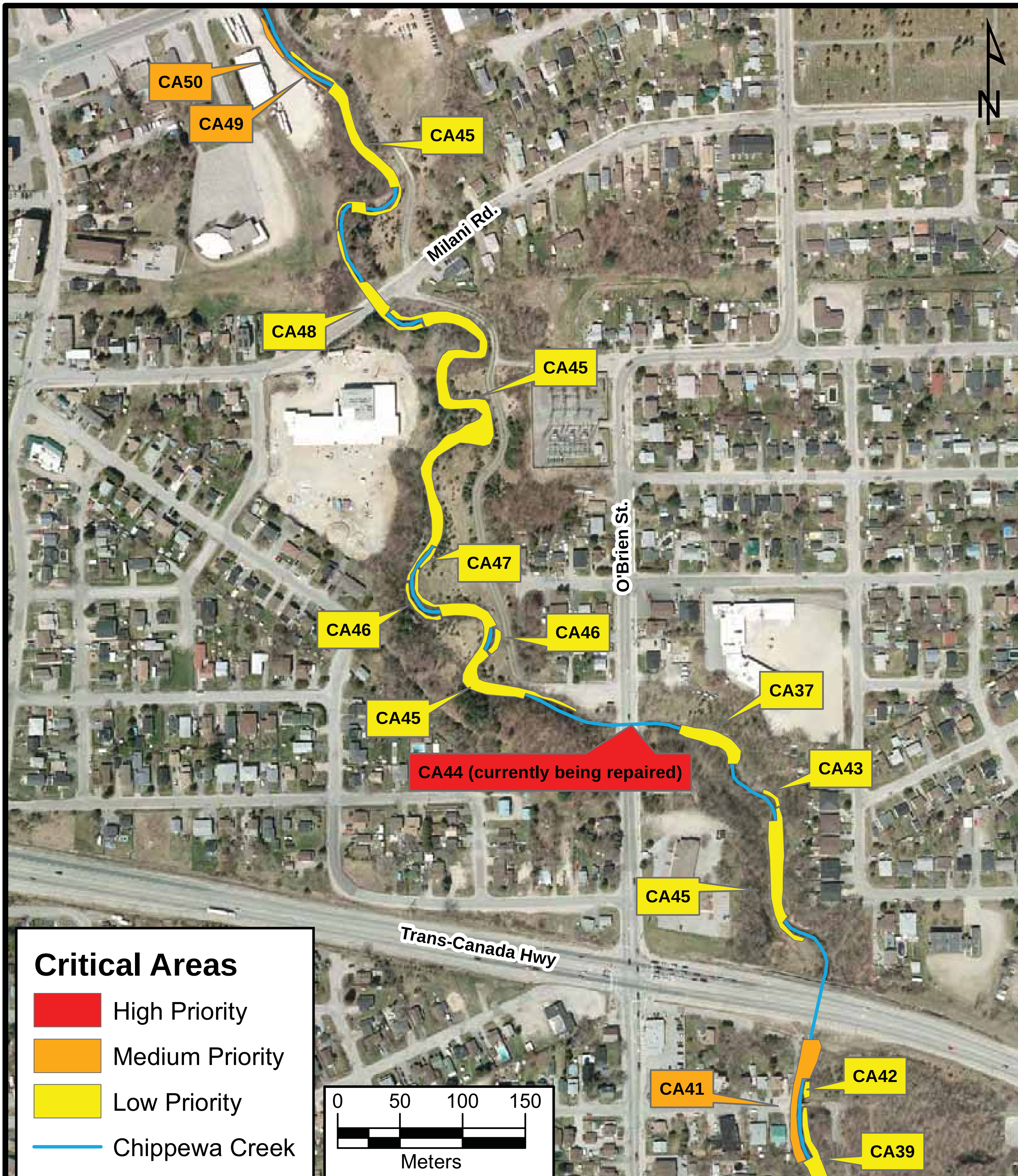

| water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD | Critical Area Priority Map<br>Sites CA1 to CA15 | Figure No.:<br>3.3 | Date:<br>Oct. 29, 2014 |
|---|---|---|---|
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By:<br>EG/JM | Drawn By:<br>AC |



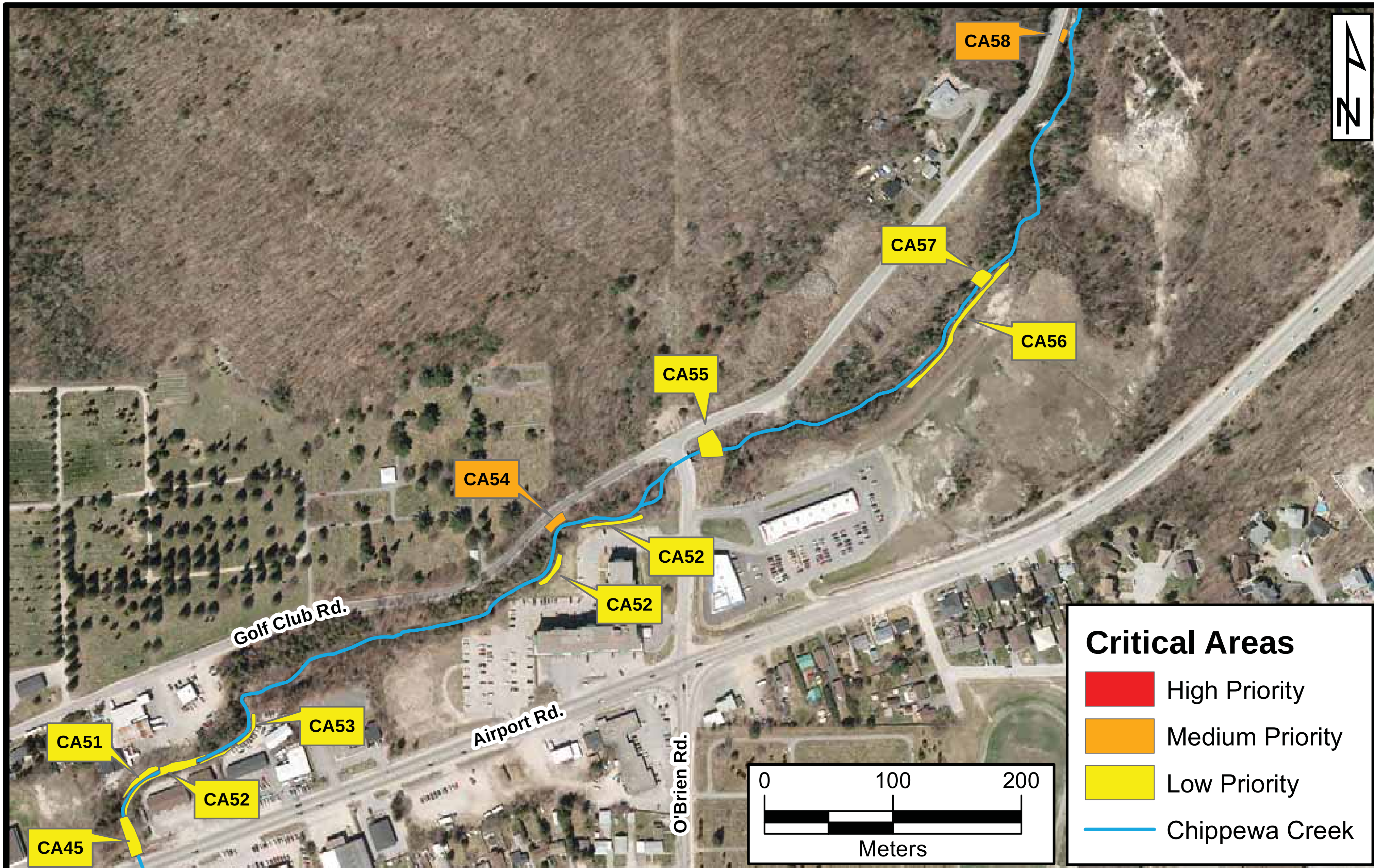

| | | | |
|---|---|---|---|
| | Critical Area Priority Map<br>Sites CA16 to CA29 | Figure No.:<br>3.4 | Date:<br>Oct. 29, 2014 |
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By:<br>EG/JM | Drawn By:<br>AC |


water's edge
ENVIRONMENTAL SOLUTIONS TEAM

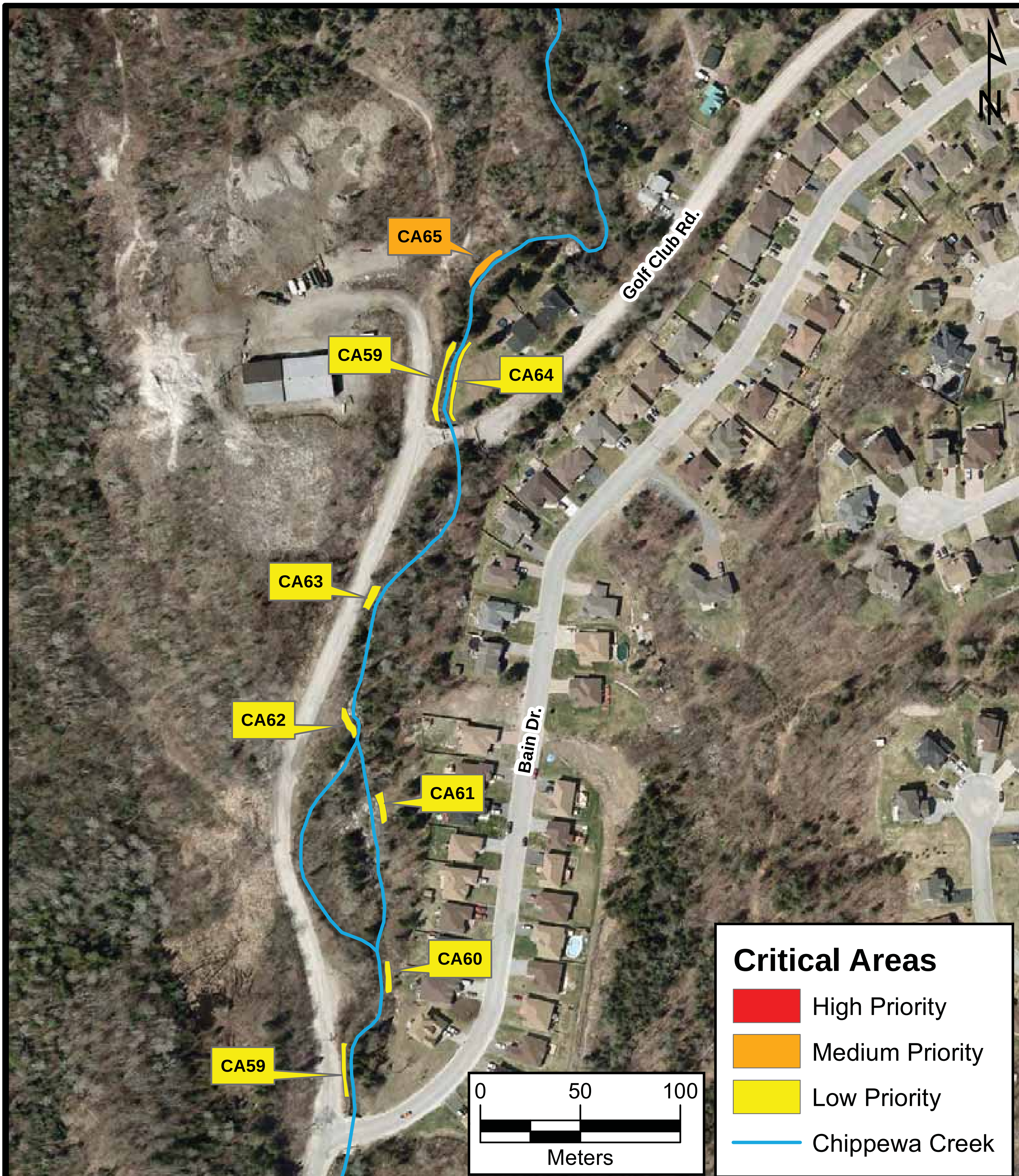
| Critical Area Priority Map<br>Sites CA29 to CA40 | Figure No.: 3.5 | Date: Oct. 29, 2014 |
|---|---|---|
| Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |




| | | | |
|---|---|---|---|
| water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD | Critical Area Priority Map<br>Sites CA41 to CA50 | Figure No.: 3.6 | Date: Oct. 29, 2014 |
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |



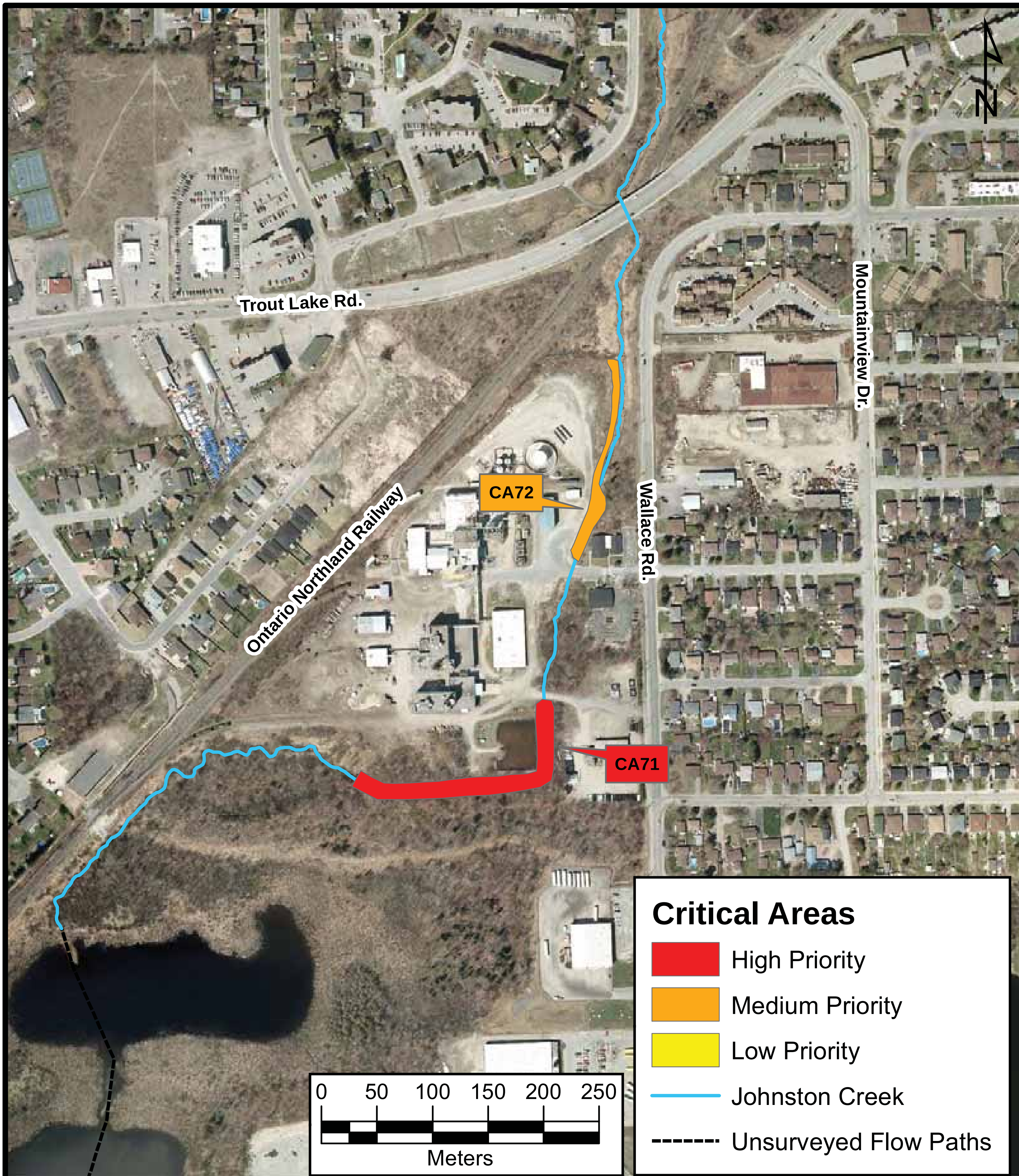

| | | | |
|---|---|---|---|
| water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD. | Critical Area Priority Map<br>Sites CA52 to CA58 | Figure No.: 3.7 | Date: Oct. 29, 2014 |
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |




| | | | |
|---|---|---|---|
| water's edge ENVIRONMENTAL SOLUTIONS TEAM | Critical Area Priority Map<br>Sites CA59 to CA65 | Figure No.: 3.8 | Date: Oct. 29, 2014 |
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |


water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD

| Critical Area Priority Map<br>Sites CA66 to CA70 and CA75 to CA80 | Figure No.: 3.9 | Date: Oct. 29, 2014 |
|---|---|---|
| Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |




water's edge ENVIRONMENTAL SOLUTIONS TEAM

| | | | |
|---|---|---|---|
| Critical Area Priority Map<br>Sites CA66 to CA70 and CA75 to CA80 | Figure No.: 3.10 | Date: Oct. 29, 2014 |
| Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |


| | | | |
|---|---|---|---|
| water's edge ENVIRONMENTAL SOLUTIONS TEAM LTD. | Critical Area Priority Map<br>Sites CA73, CA74, and CA81 | Figure No.: 3.11 | Date: Oct. 29, 2014 |
| | Chippewa Creek Watershed<br>Creek Inventory and Erosion Assessment | Checked By: EG/JM | Drawn By: AC |

### 3.6 Options for Priority Restoration

Through completion of the field inventory, mapping, and ranking of the critical areas, and based on acceptable approaches for stream restoration, there are general opportunities for erosion restoration and stream enhancement (see **Table 3.5**). These restoration activities could occur for the high priority sites, as well as the other critical areas that can use maintenance activities within the Chippewa Creek watershed. Incorporating vegetation in and around previously placed hardened bank protection can also be undertaken by stewardship activities to promote stability of the banks and to enhance terrestrial and aquatic habitat.

**Table 3.5 General Restoration Opportunities**

| Issue | Opportunity |
|---|---|
| Rip-Rap | Few sections of rock lining have incorporated little vegetation. Placement of live stakes, plugs, or potted plants within rip-rap could contribute to stabilization of bank materials while enhancing the riparian area. |
| Gabion baskets | Many gabions are failing by undergoing toe erosion, slumping, and a loss of rock content. Considerations should be given for replacing gabions with softer but equally effective solutions that will enhance the riparian habitat. |
| Armourstone | Where armourstone is currently used as erosional control, it may be necessary to ensure that the cross-sectional capacity is sufficient for current and future flow regimes. |
| Landscaping | Some critical areas flows directly adjacent to private property. Education and vegetative plantings will increase the riparian habitat and bank stability. |
| Riparian Vegetation | Enhancement of vegetation along the banks throughout the watercourses will contribute to aquatic, terrestrial, and other environmental benefits. |
| Concrete/Stone Walls | Many vertical concrete or stone walls are undergoing toe erosion, slumping, and loss of rock content. Considerations should be given for replacing vertical walls with softer but equally effective solutions that will enhance the riparian habitat. |
| Straightened Channels | If property is available, realignment of the channel to a properly functioning dimension, pattern and profile is possible (using Natural Channel Design principles). |

Details of various mitigation and channel restoration opportunities is provided in **Figure 3.12.**

### 3.7 Objectives

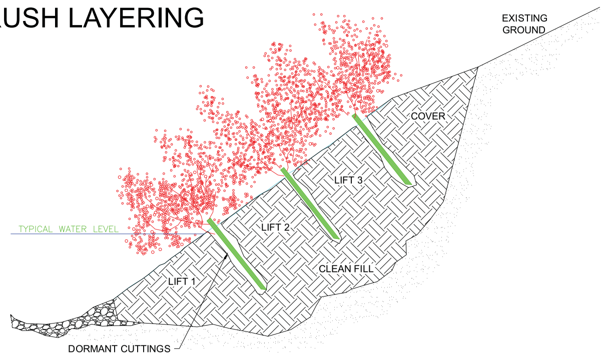
Prior to selecting a preferred alternative for the priority critical areas, it is important to clearly define restoration goals and objectives. Each of the alternatives identified in Section 3.7 can then be evaluated against the restoration objectives to carefully select the most appropriate recommended option.

The primary goal of the erosion restoration works is to eliminate or reduce risk to public and property safety. In addition, restoration should include the enhancement, if possible, to aquatic habitat. These solutions must meet the expectations of property owners and the people managing the resource on their behalf.

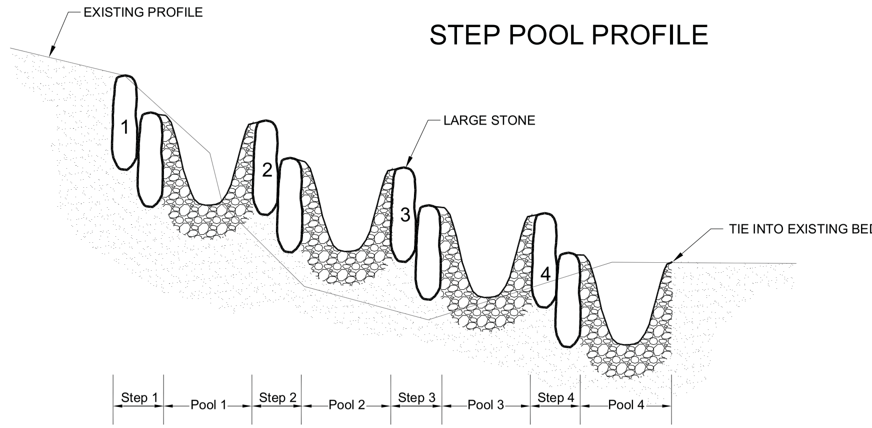
Restoration objectives that have been identified for watercourses situated within the Chippewa Creek watershed are as follows:

- minimize risk to infrastructure
- provide erosion protection that is compatible with the natural tendencies of the creek
- enable adaptive management
- maintain or reduce the need for erosion control
- provide environmental enhancement wherever possible

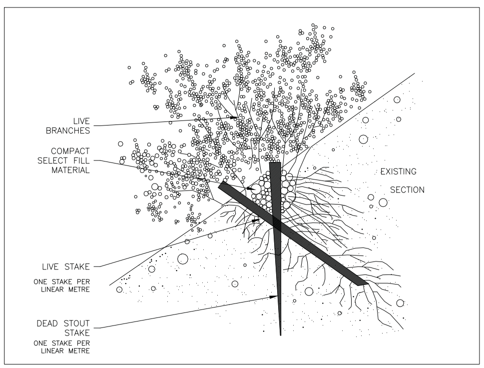
## BRUSH LAYERING



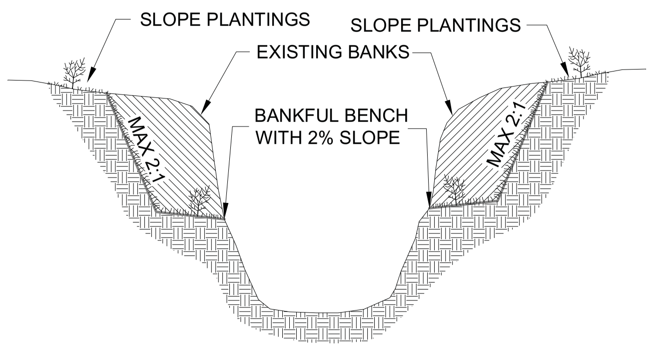

## STEP POOL PROFILE



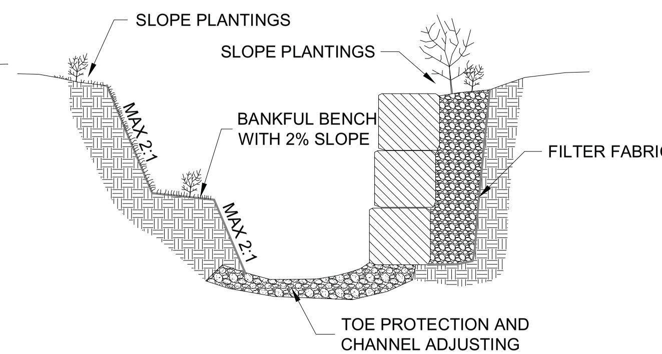

## LIVE STAKES



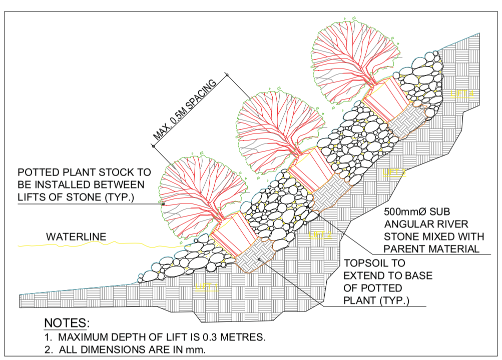

## BANK RE-GRADING



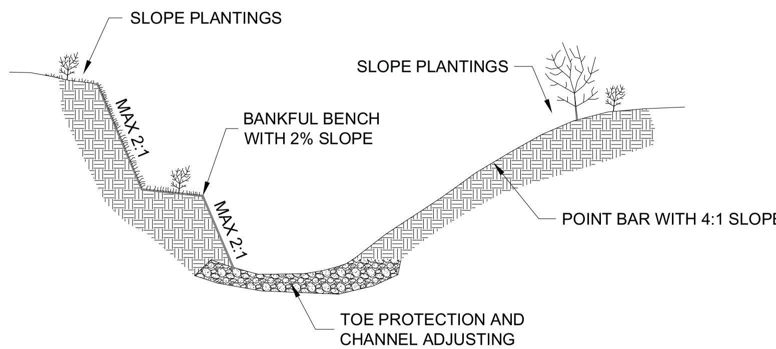

## ARMOURSTONE WALL / BANK GRADING




## VEGETATED RIVERSTONE




## MEANDER BEND CROSS-SECTION



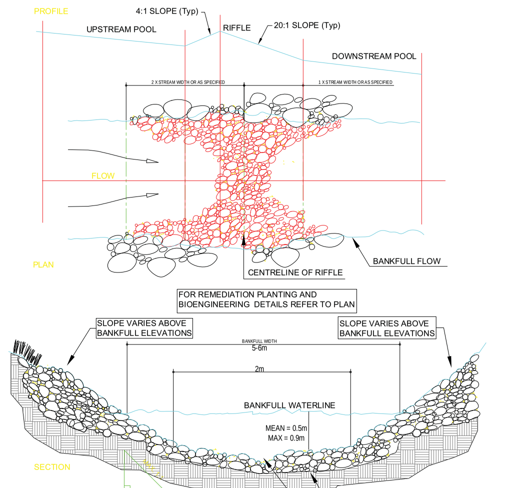

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek
Erosion Control Study and Inventory

RESTORATION OPTIONS

| PROJECT FILE NO. | FIGURE NO. |
|---|---|
| 14040 | 3.12a |

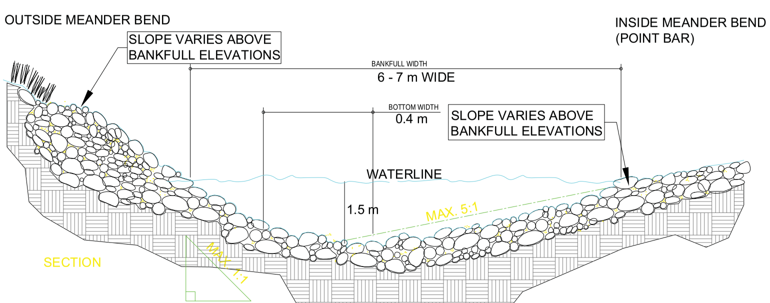
## RIFFLE DETAIL




NOTES:
1. REFER TO PLAN FOR GRAVEL & STONE DEPTHS.
2. REFER TO PLAN FOR POOL SPACING AND PLACEMENT.
3. ALL DIMENSIONS ARE AS NOTED
4. BOTTOM ELEVATION OF POOL SHOULD BE LOWER THAN BASE FLOW (REFER TO PLAN AND NOTES). A LOW FLOW CHANNEL IS REQUIRED THROUGH THE CENTRE OF THE POOL STRUCTURE AS REQUIRED OR DIRECTED BY ENGINEER.
5. REFER TO GRADING PLAN FOR SLOPE AND GRADE INFORMATION ABOVE THE BANKFULL WIDTH.

**$D_{50}$ refers to the average sediment diameter of riverstone material. Material to consist of a range of sediment sizes, with the majority being of $D_{50}$.

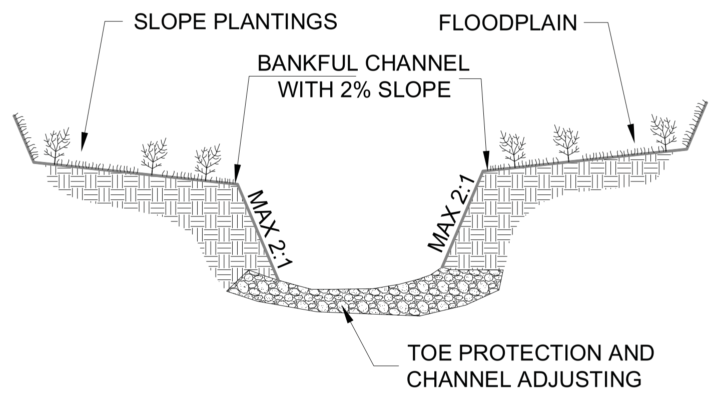
## POOL DETAIL



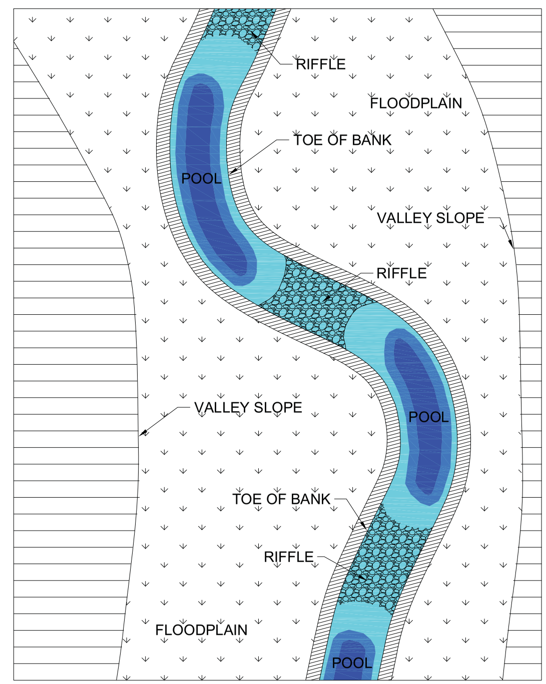

NOTES:
1. REFER TO PLAN FOR GRAVEL & STONE DEPTHS.
2. REFER TO PLAN FOR POOL SPACING AND PLACEMENT.
3. ALL DIMENSIONS ARE AS NOTED
4. BOTTOM ELEVATION OF POOL TO BE LOWER THAN BASE FLOW (REFER TO PLAN AND NOTES). A LOW FLOW CHANNEL IS REQUIRED THROUGH THE CENTRE OF THE POOL STRUCTURE AS REQUIRED OR DIRECTED BY ENGINEER.
5. REFER TO GRADING PLAN FOR SLOPE AND GRADE INFORMATION ABOVE THE BANKFULL WIDTH.
6. EXCAVATE POOLS TO NATIVE MATERIAL

**$D_{50}$ refers to the average sediment diameter of riverstone material. Material to consist of a range of sediment sizes, with the majority being of $D_{50}$.

## NATURAL CHANNEL CORRIDOR CROSS-SECTION




## NATURAL CHANNEL PLANVIEW




water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek
Erosion Control Study and Inventory

RESTORATION OPTIONS

| PROJECT FILE NO. | FIGURE NO. |
|---|---|
| 14040 | 3.12b |

- maintain connection of channel for seepage in banks and valley walls
- be visually ‘natural’ in appearance
- minimize environmental impacts during and post construction
- decrease property loss
- minimize capital and maintenance costs

#### 3.7.1 Natural Channel Design

As a part of the objectives proposed above, each should take a more ‘natural’ approach in the design. *Natural Channel Design* principles use existing knowledge of the stability of the channel, the stresses imposed upon it, and resident aquatic and terrestrial species to develop a plan that can range from dynamically stable to static in position while having a more natural form. NCD attempts to create a channel that replicates natural watercourses in the local area, often using a reference reach for direction. Channel form (plan, profile, and cross-section), bed and bank treatments, and material sizes are combined in the design of a natural channel section. **Figure 3.13** shows the general planform, relative dimensions, and features of a natural channel in the case of a single-thread, meandering system within a floodplain.

From **Figure 3.13** the bankfull width is shown to encompass the design of the main river channel. The term ‘bankfull’ refers to the point at which flows are contained entirely within the active channel cross-section before spilling onto the floodplain. This geometry is reflective of the dominant forces acting upon the channel as it attempts to develop a dynamic equilibrium and stability, and is often referred to as being synonymous with the ‘effective’ or ‘dominant’ discharges, having a return period on the range of 1-2 years (Wolman and Leopold, 1957; Emmet and Wolman, 2001). However, there is likely variability on the recurrence of this event, especially as flow regimes are altered. Therefore, field indicators of bankfull, or recurrence intervals using gauged (or modeled) data can be used to estimate the bankfull discharge for a reach, which may then be applied as the design flow.

Selection of a design discharge is necessary in the development of the cross-section and bank and bed treatments. The channel cross-section needs to be designed to convey the design discharge at the designed slope, and materials need to be sized appropriately so that they are not flushed out during frequent flows, and also that they do not remain entirely stable, unless design constraints require this. The design discharge is often selected to be the existing bankfull discharge as estimated from field indicators of the bankfull level. However, in many cases a specific flow as modeled or gauged is chosen as the design discharge (e.g. 2-year, 5-year). Usually the reason for this is to minimize flooding to surrounding areas, and threats to infrastructure such as road crossings. Therefore, the design discharge for each site throughout the Chippewa Creek watershed should be selected upon review of the objectives, opportunities, and constraints.

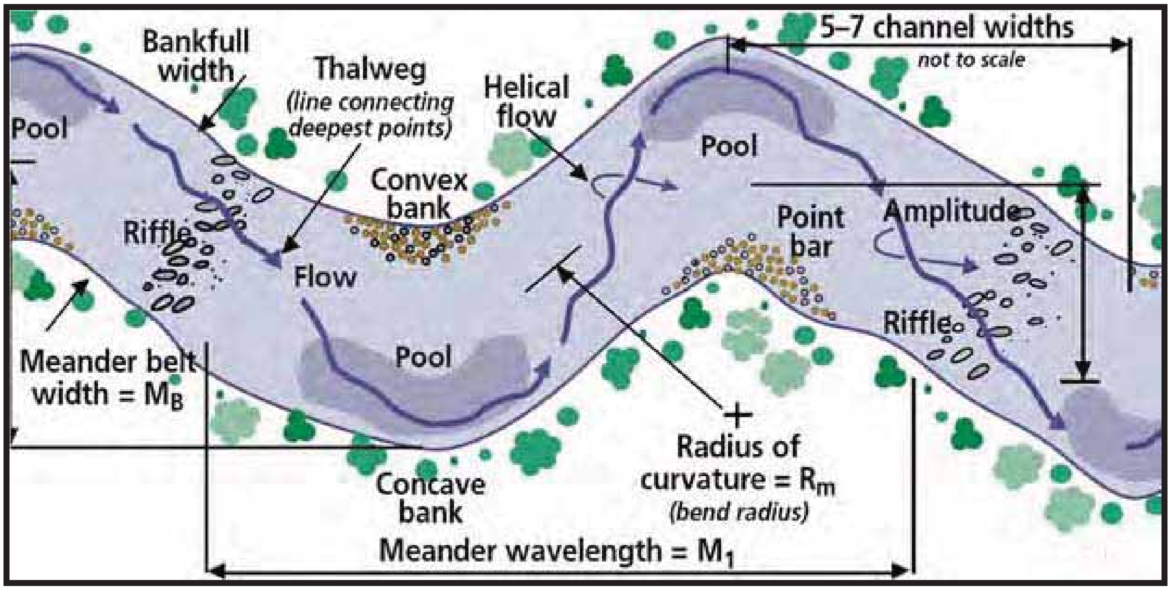



**Figure 3.13**: Typical natural channel planform, features, and relative dimensions.

### 3.8 Priority Restoration Recommendations

Further to **Tables 3.2 and 3.3**, High Priority Sites were selected as being those sites whose assessment score is 73 or above. It is noted, however, that creeks are dynamic systems and that since the field investigations, changes may have occurred to creek systems that change the ranking and prioritization. **Table 3.6** lists the High Priority Sites. .

**Table 3.6 High Priority Sites**

| Location ID | Reach | Name | Score | Priority # |
|---|---|---|---|---|
| CA06 | CC-2a | Chippewa Cr. - Oak St. closed pedestrian bridge | 89 | 1 |
| CA28 | CC-9b | Chippewa Cr. - Cassells St. bridge and u/s of Cassells St. | 81.5 | 2 |
| CA17 | CC-6 | Chippewa Cr. - u/s Chippewa St. E (gabions) | 80 | 3 |
| *CA44** | *CC-11a partially in CC-11b* | *Chippewa Cr. - u/s and d/s of O'Brien St.(culvert corroding)* | *80* | *N/A* |
| CA16 | CC-5 | Chippewa Cr. - ~55m u/s Princess St. E to ~40m u/s Duke St. E | 79 | 4 |
| CA27 | CC-9a | Chippewa Cr. - d/s Cassells St. (gravel bar forming) | 78 | 5 |
| CA31 | CC-9b | Chippewa Cr. - ~120m u/s of Cassells St. (apartment parking lot) | 75.5 | 6 |
| CA14 | CC-4 | Chippewa Cr. - Hammond St. to Fisher St. | 74 | 7 |
| CA09 | CC-2c | Chippewa Cr. - 20m u/s McIntyre St. E to u/s First Ave. ped. bridge | 73.5 | 8 |
| CA71 | JC-7a and JC-7b | Johnston Cr. - ~210m d/s Arclin S driveway to N driveway | 73 | 9 |
| CA36 | CC-9b | Chippewa Cr.- Gabions d/s of Chippewa St. W | 72.5 | 10 |

* Site CA44 is excluded from further analysis as it is currently being repaired by the City of North Bay

Field reconnaissance along Chippewa Creek's watercourses resulted in observations of the success and failure of varying treatment types that have been used to prevent erosion. The stream walk and observations acted as a guide to determine the recommended approaches for the high priority sites (see **Table 3.6**). When a combination of more than one approach is possible to reduce environmental impact or enhance habitat, then this should be considered.

Figures of each priority sites were prepared. Each figure noted the problem associated with the site and detailed the restoration or recommended works (see **Sheets 1 to 10**). As noted previously, **Figure 3.2** shows the overall location of each of the Priority Sites.

It is recommended that a Class Environmental Assessment be undertaken for major sections of Chippewa Creek. A Class EA would examine the possibilities of each major section and provide a final recommendation for any proposed works. Since the Class EA would be valid for a five year period, a variety of projects could be contained within the Class EA approval.


## 1. SITE LOCATION/DESCRIPTION

Approximately 60m downstream of Main Street East, near Oak Street East.

This is a concrete bridge crossing that links Oak Street to the Kinsmen Way Trail through a property along the top of the left bank. Presumably this is an older bridge that has been repurposed as a pedestrian link.

CA-05 is located immediately downstream along the left bank.

## 2. PROBLEM DESCRIPTION

The bridge span is undersized with respect to the channel width. Bridge abutments and vertical retaining walls (stacked rock slabs) confine the channel, promoting degradation. As a result, bridge footings have become exposed.

CA-05 has been included in this figure because it shares similar problems along the left bank where the former railway bridge footing has become undermined and appears to be deteoriating. The vertical footing confines this side of the channel. Works can be undertaken at the same time.

## 3. DESIGN CONSIDERATIONS

A building adjacent to the creek on the left bank is within a few metres of the top of the retaining wall.

The function of each bridge crossing should be assessed for necessity. For example, connectivity to the trail network, construction access.

Main Street East can be used as an alternative crossing.

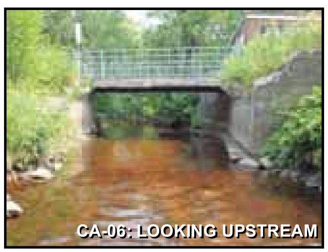
## 4. RECOMMENDATIONS

Undertake a structural examination of the concrete structure prior to any works in order to utilize the existing retaning wall along the left bank, reducing costs.

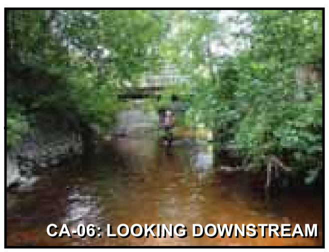
Remove old rail bridge at CA-05 and possibly at CA-06 if it is not deemed necessary to retain the crossing at this location.

Re-grade the right bank to reduce in channel stresses and provide some floodplain access, plant with riparian plantings. Blend into banks upstream and downstream.

With minimal setbacks to property along the left bank, a vertical armourstone wall with shrubs along the top should be constructed.

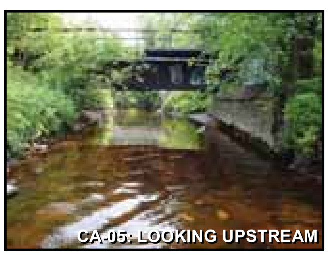


CA-06: LOOKING UPSTREAM

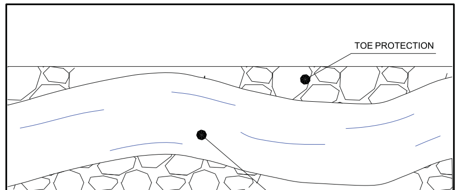


CA-06: LOOKING DOWNSTREAM

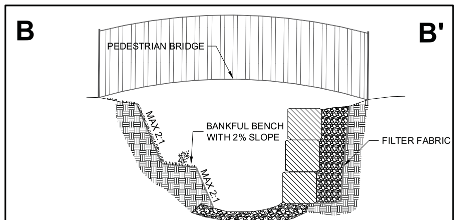
CA-06: RETAINING WALL UPSTREAM



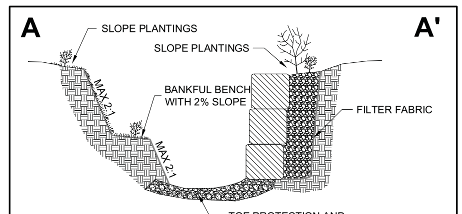
CA-05: LOOKING UPSTREAM




STRAIGHT CHANNEL PLANFORM
N.T.S.




ARMOURSTONE/GRADING/BRIDGE
N.T.S.




ARMOURSTONE/GRADING
N.T.S.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#1 - CA6 (Reach CC-2a)

| PROJECT FILE NO. | SHEET NO. |
| --- | --- |
| 14040 | 1 |


## 1. SITE LOCATION/DESCRIPTION

The area includes Cassells Street bridge and immediately upstream and downstream of the bridge.

Site access would be Cassells Street.

## 2. PROBLEM DESCRIPTION

Properties at risk on both sides, fences along top of bank.
Channel banks armour and confine flows, as a result, toe and bed erosoin is causing bank failure and has exposed a pipe at the upstream end of the road crossing.
The opening of the bridge is not perpendicular to flow, as seen by the sharp bend immediately upstream. This orientation will put more stress on the left bank upstream and within the structure.

## 3. DESIGN CONSIDERATIONS

Piled rubble banks are high and steep.
Channel is confined by properties on either side, but there is the possibility to purchase some along the right bank.
The exposed pipe needs to be covered with stable substrates.
The confinement of this section will require a design in the channel proflie.

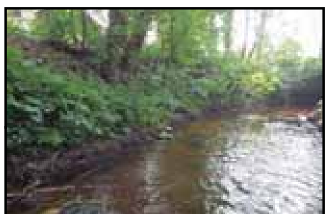
## 4. RECOMMENDATIONS

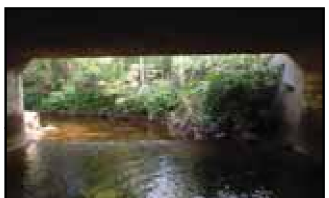
Widening and a preferred skew to the bridge would be ideal in this case.

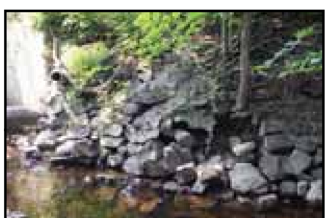
If the above cannot be undertaken, the channel profile should be re-designed with a large pool upstream to help dissipate erosive forces, and a riffle over-top of the exposed pipe to create a better depth of cover.

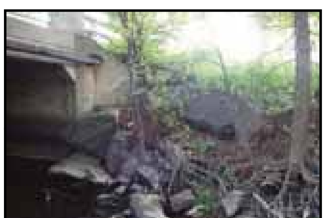
If it is possible to regrade, or bench some banks, particularly upstream this would help reduce flood erosion effects.

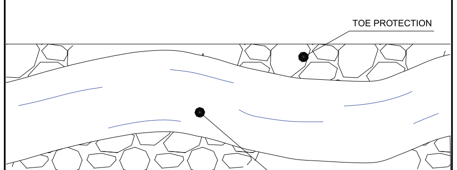
Replace rubble with large vegetated rip rap where a 1:1 angle can be achieved. Anything steeper will require an armourstone-block treatment.


LEFT BANK UPSTREAM OF CULVERT

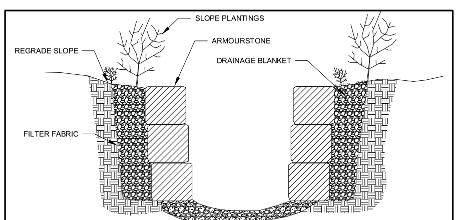

VIEW UPSTREAM
PIPE EXPOSE AT INLET


RIGHT BANK UPSTREAM CULVERT

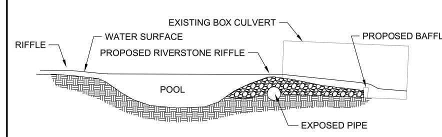

LEFT BANK DOWNSTREAM CULVERT



STRAIGHT CHANNEL PLANFORM
N.T.S.



ARMOURSTONE PROTECTION
N.T.S.



LONG PROFILE - PIPE PROTECTION
N.T.S.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#2 - CA28 (Reach CC-9b)

| PROJECT FILE NO. | SHEET NO. |
|---|---|
| 14040 | 2 |


## 1. SITE LOCATION/DESCRIPTION

The site is immediately upstream of Chippewa Street East and around the first bend on the left bank. Located behind the Shell Gas Station at Chippewa St and Fisher St.

Kinsmen Trail runs along the right bank, with a setback of approximately 15m.

Access can be made along the KinsmenTrail.

## 2. PROBLEM DESCRIPTION

Rright bank gabion baskets are failing at toe and buckling outward towards the creek. This site has material accumulation resulting in a vegetated bar on the left bank.

In addition, there are various bank treatments that support local private property along the left banks and structures which are in varying degree of failure.

Channel is confined in close proximity to the bridge.

## 3. DESIGN CONSIDERATIONS

Failing gabion baskets and close proximity to gas station.

Maintain channel planform geometry up and downstream of crossing.

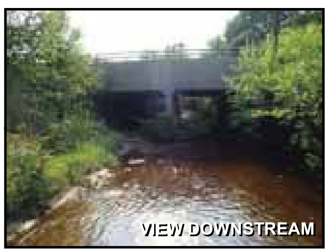
15m buffer to trail can provide some space for floodplain expansion/connectivity.

Trees will need to be surveyed in the case of hoarding or removals.

## 4. RECOMMENDATIONS

Remove gabion baskets and other slope retaining features behind Shell Station and install a block armourstone wall with plantings. The slope of the armourstone wall may be less steep where setbacks permit.

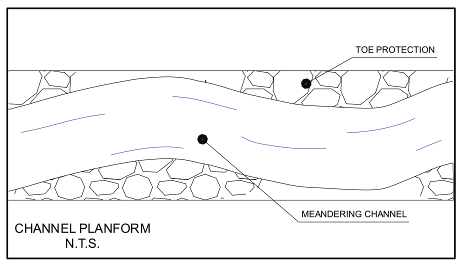
Remove gabions along right bank and regrade slope. Apply a bioengineering treatment such as vegetated rip rap up to the bankfull slope and perhaps the entire slope within closer proximity to the crossing (5m upstream). If possible create floodplain bench, otherwise try to create a 3:1 slope up to the trail.


VIEW DOWNSTREAM

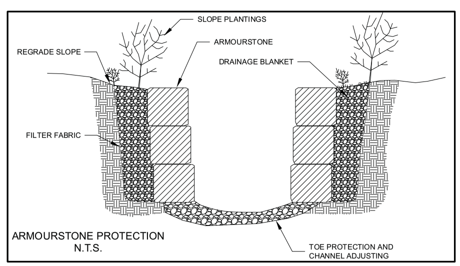

RIGHT BANK GABION WALL


LEFT BANK RETAINING WALL

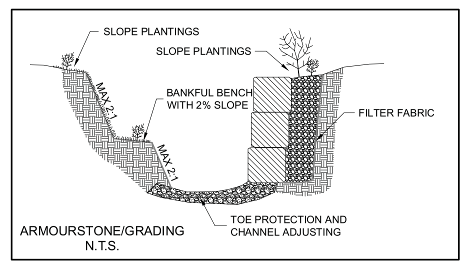

LEFT BANK SCOUR UPSTREAM OF RETAINING WALL



CHANNEL PLANFORM
N.T.S.



ARMOURSTONE PROTECTION
N.T.S.



ARMOURSTONE/GRADING
N.T.S.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#3 - CA17 (Reach CC-6)

| PROJECT FILE NO. | SHEET NO. |
|---|---|
| 14040 | 3 |


## 1. SITE LOCATION/DESCRIPTION

This section of Chippewa Creek is located upstream of Princess Street E to downstream of Chippewa Street E.

This site consists of eroding banks, piled rock walls and failing gabion baskets. A large debris Jam is also located at the first bend upstream of Duke St.

Access can be made using the Kinsmen trail along the right bank.

## 2. PROBLEM DESCRIPTION

Unconsolidated substrates are easily scoured around in-channel structures including debris.

Vertically piled rock walls and gabion baskets are degraded and/or failing.

The channel is confined with high banks and close contact with the Kinsmen Trail and private residences. These properties are at risk to bank failure. The Kinsmen trail setback ranges from 5 to 30m.

## 3. DESIGN CONSIDERATIONS

Protection of private property and the Kinsmen trail.

Removal of in channel debris.

Trees will need to be surveyed for hoarding or removal.

Enhance aquatic and riparian habitat.

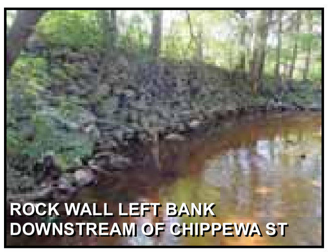
## 4. RECOMMENDATIONS

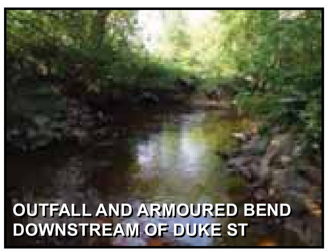
Regrade banks and utilize bioengineering such as vegetated rip rap. If setbacks limit bank grading, vertical armourstone should be utilized.

Blend treatments into treatments/banks upstream and downstream.

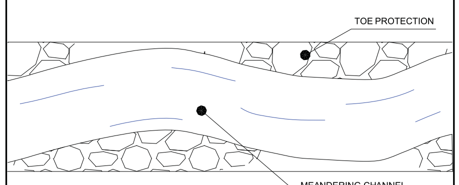
On inner bank at bends, remove bank treatmetns and construct a point bar with plantings and bioengineering. These zones present areas that floodplain can be created/enhanced.

Realign channel away from eroding bank at first bend upstream of Duke St

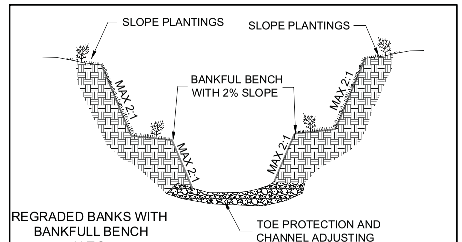


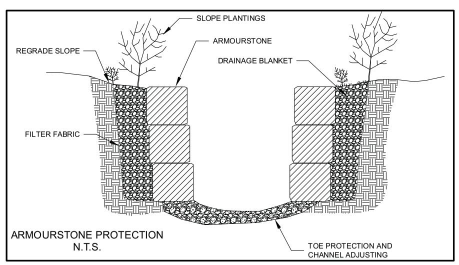


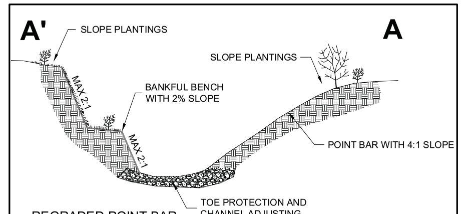

STRAIGHT CHANNEL PLANFORM
N.T.S.




REGRADED BANKS WITH BANKFULL BENCH
N.T.S.




ARMOURSTONE PROTECTION
N.T.S.




REGRADED POINT BAR BANKFULL BENCH OPPOSITE
N.T.S.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#4 - CA16 (Reach CC-5)

| PROJECT FILE NO. | SHEET NO. |
| --- | --- |
| 14040 | 4 |


## 1. SITE LOCATION/DESCRIPTION

The site is immediately downstream of Cassells Street. Private property is located at the very top of and eroding left bank with a residential unit located approximately >15m from top of slope.

Access could be made along the channel from Cassells or through private property.

## 2. PROBLEM DESCRIPTION

Channel bed and bank armouring along a steep section immediately downstream of Cassells St essentially increases the erosive potential downstream. Channel confinement and lack of floodplain ensures that erosive forces are contained within the channel, resulting in scour.

The slope at this site is currently eroding due to toe scour.

A fence is located along the top of the bank that has footings exposed.

## 3. DESIGN CONSIDERATIONS

Create better transition from Cassells Street and downstream.

Protect private property.

Land acquisition may be required.

Survey trees in the case of hoarding and removals.

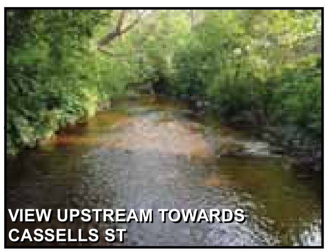
## 4. RECOMMENDATIONS

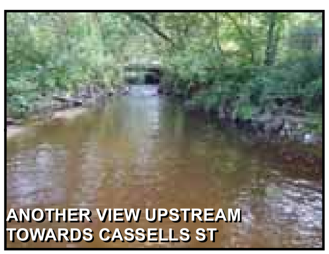
Create pool-riffle sequence to transition from Cassels Street and downstream.

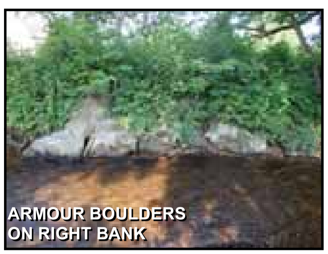
Acquire land along right bank in order to develop a floodplain bench and regrade the banks.

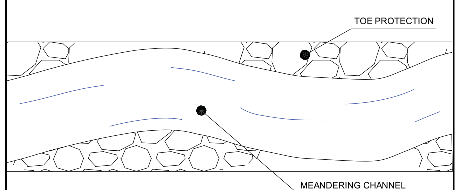
WIth setback being limited along right bank, Create a vertical brush mattress wall or vegetated rip rap buttress to ensure that failure does not continue. Brush Layering may also be a possible treatment, but this can be determined during detailed design.


FENCE ALONG TOP OF LEFT BANK


VIEW UPSTREAM TOWARDS CASSELLS ST


ANOTHER VIEW UPSTREAM TOWARDS CASSELLS ST

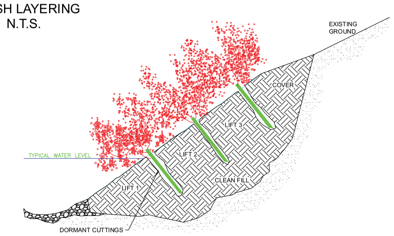

ARMOUR BOULDERS ON RIGHT BANK



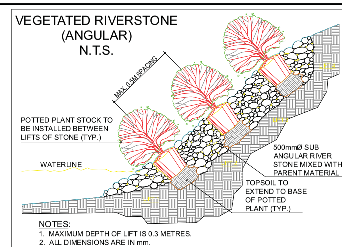
STRAIGHT CHANNEL PLANFORM
N.T.S.

POOL-RIFFLE SEQUENCE
IN PROFILE
N.T.S.

BRUSH LAYERING
N.T.S.




VEGETATED RIVERSTONE
(ANGULAR)
N.T.S.




**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

| | |
|---|---|
| Chippewa Creek<br>Erosion Control Study and Inventory | |
| Priority Sites<br>#5 - CA27 (Reach CC-9a) | |
| PROJECT FILE NO. 14040 | SHEET NO. 5 |


### 1. SITE LOCATION/DESCRIPTION

The site is along the right bank of Chippewa Creek located behind an apartment building at 365 Aubrey St.

Access could be made through the building parking lot.

### 2. PROBLEM DESCRIPTION

A cemented stone retaining wall which serves to protect the parking lot for the building is currently undermined by the creek, and creek alignment is forcing stresses upon the upstream end of the structure.

### 3. DESIGN CONSIDERATIONS

Maintain the parking lot function for residents.

Enhance vegetative cover along the parking lot boundary with the creek.

Work on the opposite bank may require a tree survey for hoarding and removals.

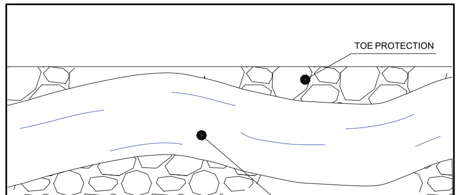
### 4. RECOMMENDATIONS

Remove cemented stone structure and replace with armourstone wall with plantings.

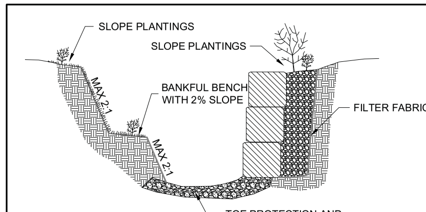
Realign channel upstream to better align with structure, or extend treatment upstream.

Regrade opposite bank or develop floodplain bench and apply vegetated rip rap.



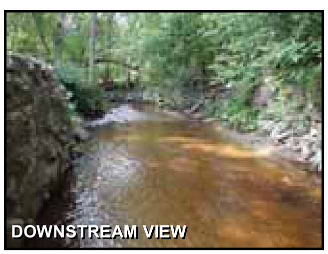


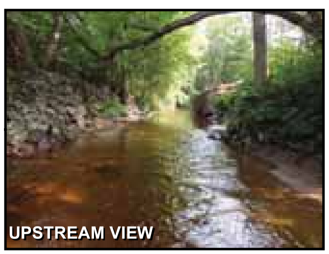

STRAIGHT CHANNEL PLANFORM
N.T.S.



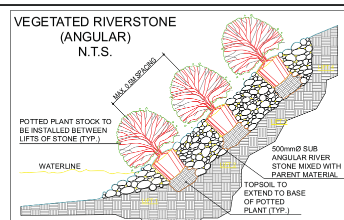

ARMOURSTONE/GRADING
N.T.S.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**




VEGETATED RIVERSTONE
(ANGULAR)
N.T.S.




NOTES:
1. MAXIMUM DEPTH OF LIFT IS 0.3 METRES.
2. ALL DIMENSIONS ARE IN mm.

water's edge ENVIRONMENTAL SOLUTIONS TEAM

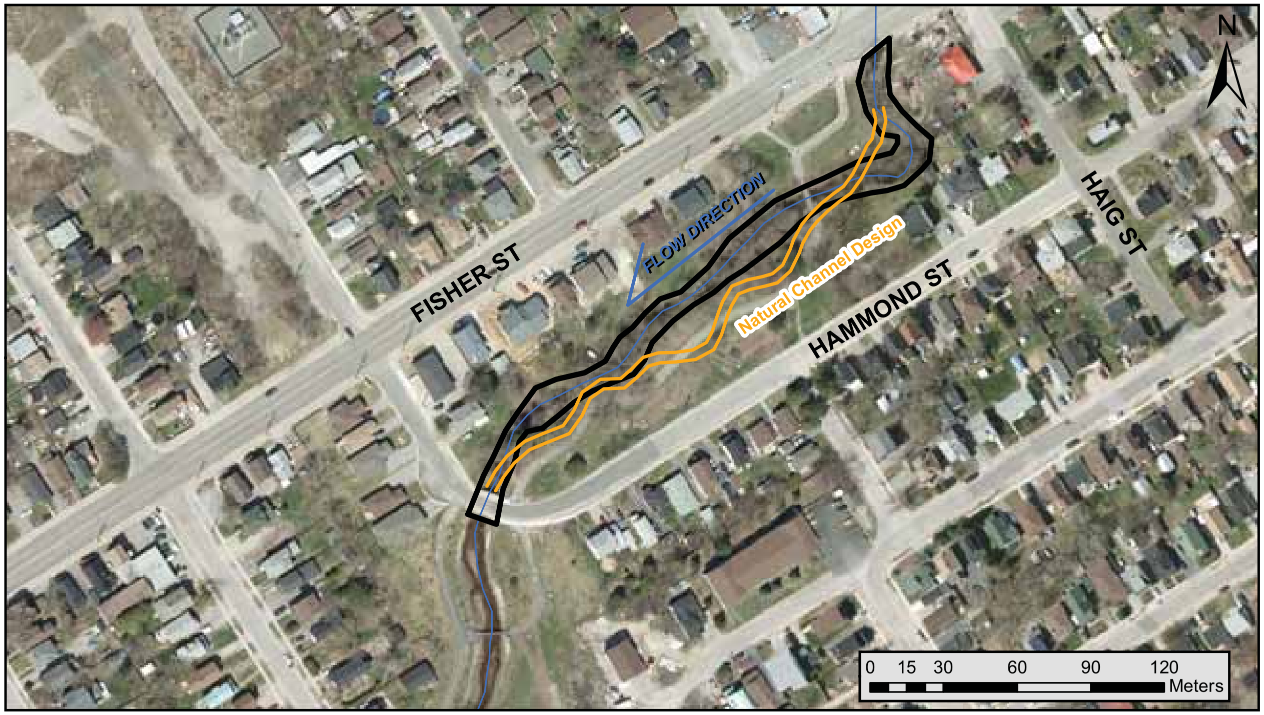
Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#6 - CA31 (Reach CC-9b)

| PROJECT FILE NO. | SHEET NO. |
| --- | --- |
| 14040 | 6 |




## 1. SITE LOCATION/DESCRIPTION

The site is on Chippewa Creek between Hammond Street and Fisher Street, and runs through Fisher Street Park. This site consists of eroding banks, failing retaining wall, fence falling into creek, and vertical boulder wall.

Along the left bank, there is the Kinsmen trail and what appears to be empty park space between the trail and Hammond St.

## 2. PROBLEM DESCRIPTION

Bank erosion is threatening private property (less than 5 metres away in multiple locations), where the fence is falling in the creek. A retaining wall downstream of Fisher Street is failing.

The channel is confined with high banks, up to 3m, and comprised of piled cobbles and boulders.

## 3. DESIGN CONSIDERATIONS

Ensure a smooth transition to culverts and bridges.

Protect private property.

Enhance aquatic and riparian habitat.

Survey trees for hoarding and removals.

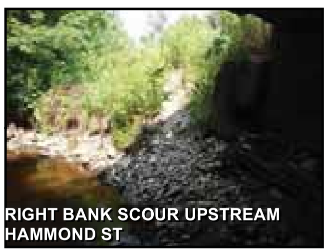
## 4. RECOMMENDATIONS

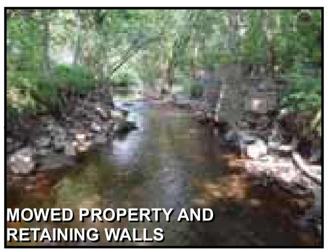
The Kinsman trail appears to follow a park corridor consisting of open space. This provides the opportunity to realign the channel away from private properties and develop a more sinuous and natural planform with a floodplain.

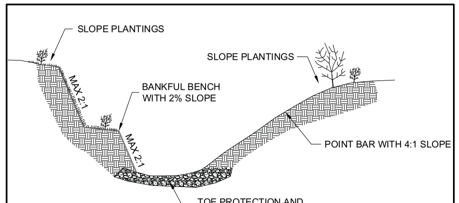
Upstream of the pedestrian bridge, relocate the channel bend towards the west, and downstream of the pedestrian bridge, relocate the path and the channel away from private property.

If that is not possible, a pool riffle sequence should be developed with bioengineering techniques. Regrade the inner bank of meander bends and create a floodplain area.

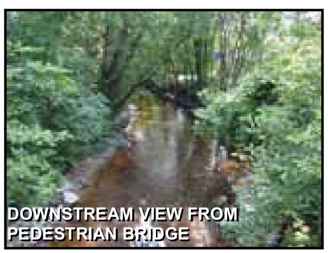
Replace Hammond Street bridge with wider structure.


RIGHT BANK SCOUR UPSTREAM HAMMOND ST

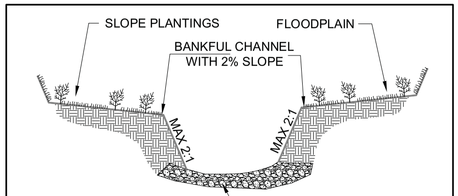

MOWED PROPERTY AND RETAINING WALLS



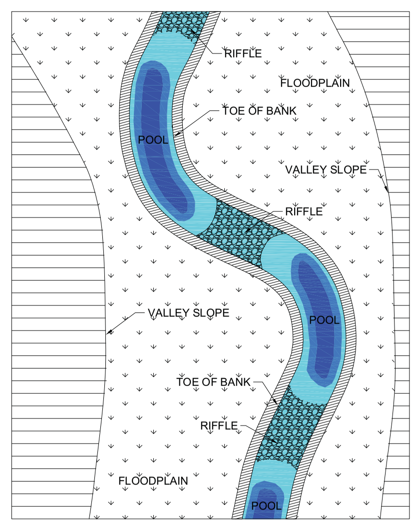
REGRADED POINT BAR BANKFULL BENCH OPPOSITE
N.T.S.


DOWNSTREAM VIEW FROM PEDESTRIAN BRIDGE


FAILING RETAINING WALL DOWNSTREAM OF FISHER ST



NATURAL CHANNEL CORRIDOR CROSS-SECTION
N.T.S.




**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#7 - CA14 (Reach CC-4)

| PROJECT FILE NO. | SHEET NO. |
| --- | --- |
| 14040 | 7 |


## 1. SITE LOCATION/DESCRIPTION

The site is located on Chippewa Creek upstream of McIntyre Street E to just upstream of the pedestrian bridge at the end of First Ave E.

Residential properties follow both banks throughout. The Kinsmen Trail follows the RIght bank, and is within 3m of the creek.

Some open space and woodlots are visible from air photos.

## 2. PROBLEM DESCRIPTION

Throughout cobble/boulder treatments have been applied to each bank in some cases extending to the top of bank. Some vertically piled material is failing, particularly upstream of Worthington Street.

The creek bed is rather steep through the Worthington St culvert and immediately downstream.

## 3. DESIGN CONSIDERATIONS

Lateral confinement due to close proximity of Kinsmen trail and a few property lines and structures.

Fish passage could be enhanced through the construction of a pool-riffle sequence.

Wooded areas can be utilized for floodplain or channel realignment, but will require a tree survey.

Upstream of First Avenue, some rock outcrops along the Left bank may limit work that can be achieved

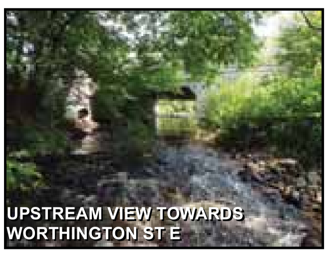
## 4. RECOMMENDATIONS

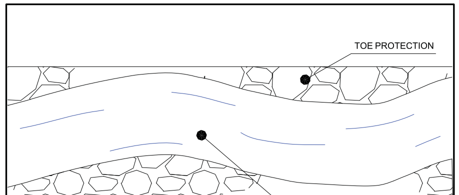
Banks should be regraded where possible and a floodplain developed. Bioengineering techniques such as vegetated rip rap can be used for the bankfull channel. Plantings in the floodplain.

Vertical armourstone will likely need to be applied along portions of the trail and on the upstream and downstream sides of Worthington Street.

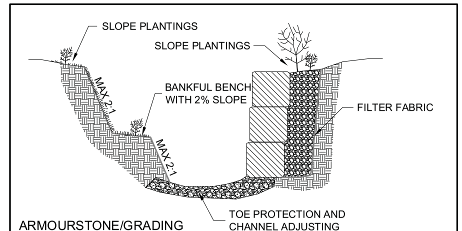
The pedestrian bridge at the end of First Ave should be upgraded,
with 2:1 banks underneath instead of the exposed footings and piled concrete sidewalk slabs.

Vernal pools (depressions) in floodplain areas can add some storage and habitat.

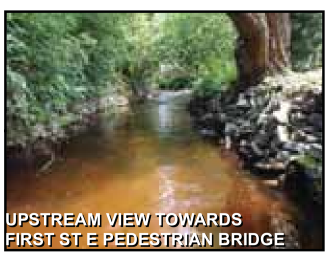



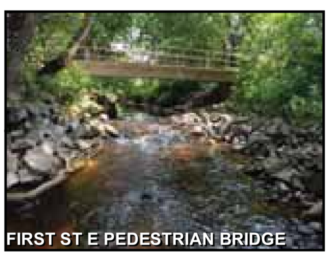
STRAIGHT CHANNEL PLANFORM
N.T.S.

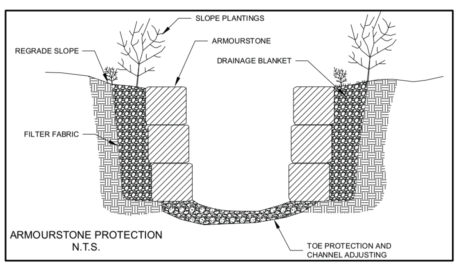


ARMOURSTONE/GRADING
N.T.S.

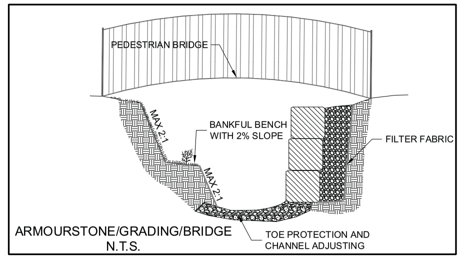
**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**



ARMOURSTONE PROTECTION
N.T.S.



ARMOURSTONE/GRADING/BRIDGE
N.T.S.

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

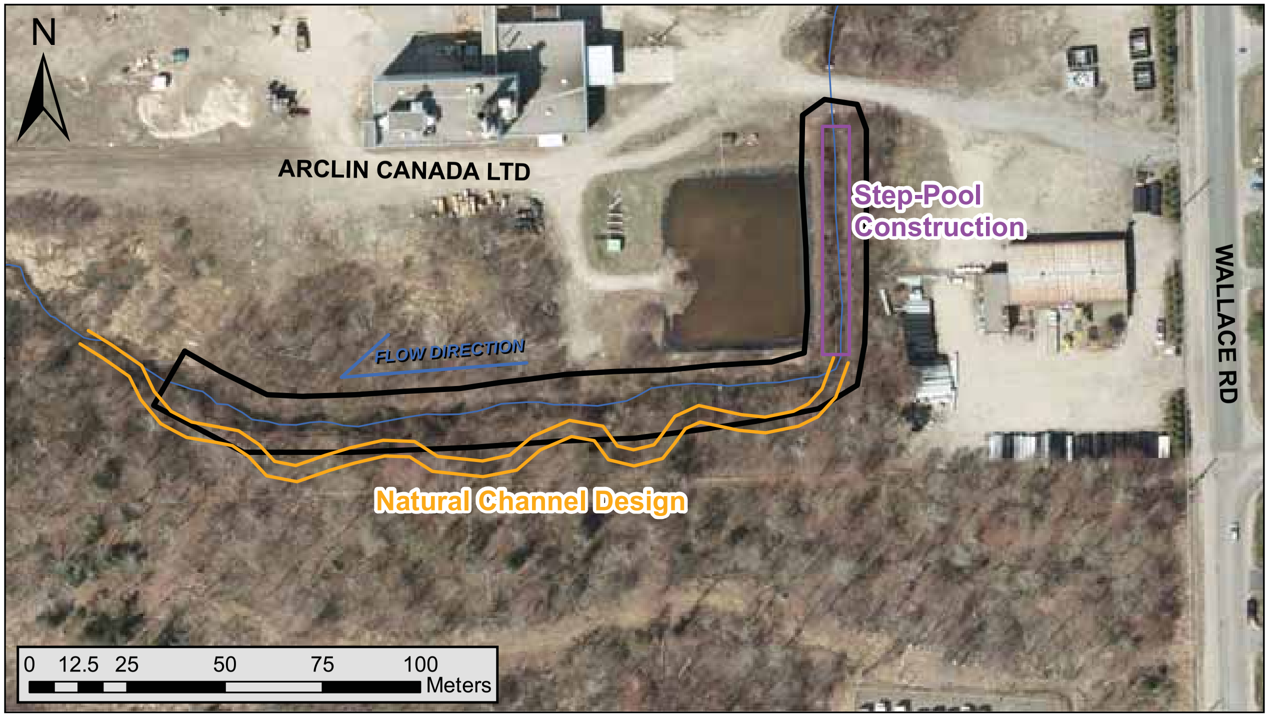
Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#8 - CA09 (Reach CC-2c)

| PROJECT FILE NO. | SHEET NO. |
|---|---|
| 14040 | 8 |




## 1. SITE LOCATION/DESCRIPTION

The site is located along Johnstons Creek within the industrial plant (Arclin) property.

This section is relatively straight, steep and confined. Sand and silt banks are eroding, and wood debris occurs throughout. Exposures of glacial till occur at some locations.

## 2. PROBLEM DESCRIPTION

Historical watercourse lines indicate that this portion has been relocated and channelized around a water quality pond along the southern boundary of the property.

As a result of this channelization, the channel has become increasingly entrenched with failing sand banks and woody debris throughout.

## 3. DESIGN CONSIDERATIONS

The Arclin facility is currently being decommissioned. Remediation of the site and land acquisition can restore the channel to its previous location.

Reduction in the channel slope.

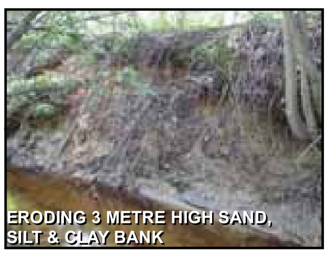
Woodlots exist on both sides of the creek.

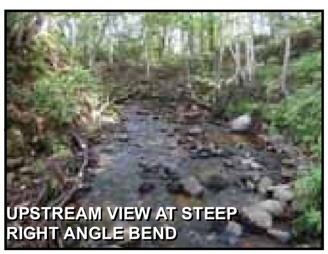
## 4. RECOMMENDATIONS

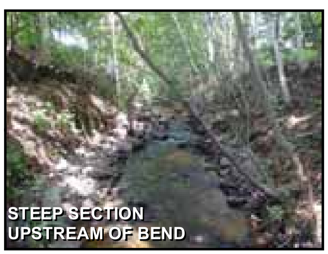
In order to address this site sooner than later, it is assumed that realignment through portions of the industrial site cannot be achieved.

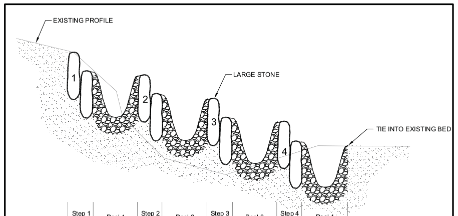
Upstream and around the 90 degree bend, a step pool sequence can help reduce the slope. Downstream of this bend, the channel should be relocated away and a new corridor with floodplain created, including a sinuous channel and appropriate plantings. If a corridor is developed, robust bank treatments will not be required and the channel should be allowed to adjust over time.


DEBRIS JAM & SEDIMENT ACCUMULATION

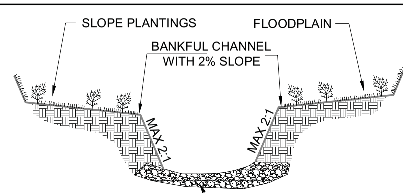

ERODING 3 METRE HIGH SAND, SILT & CLAY BANK


UPSTREAM VIEW AT STEEP RIGHT ANGLE BEND

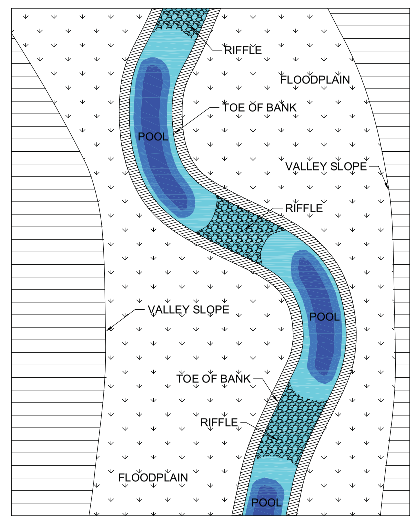

STEEP SECTION UPSTREAM OF BEND



STEP-POOL PROFLIE
N.T.S.



NATURAL CHANNEL CORRIDOR CROSS-SECTION
N.T.S.




**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#9 - CA71 (Reaches JC-7a and JC-7b)

| PROJECT FILE NO. | SHEET NO. |
|---|---|
| 14040 | 9 |


## 1. SITE LOCATION/DESCRIPTION

The site is immediately downstream of Chippewa St. W, south of the intersection with High St. The site can be accessed off of Chippewa St. W bridge.

Both banks are comprised of gabion baskets immediately downstream of the arch culvert.

Each bank is well vegetated above the gabion baskets. A vegetated toe has developed in front of the left bank.

## 2. PROBLEM DESCRIPTION

The gabion baskets are slumping and failing. The bed is armoured between each bank. .

Private property is at risk along the top of each bank.

## 3. DESIGN CONSIDERATIONS

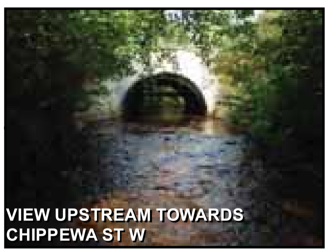
Protect private property.

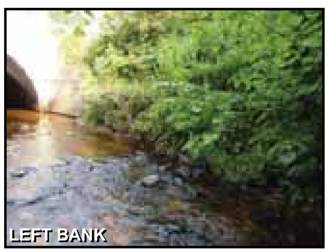
## 4. RECOMMENDATIONS

Install armourstone walls up to the existing top of bank.

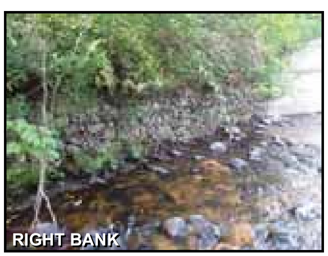
If possible, use vegetated rip rap where setbacks permit the creation of a 2:1 slope.

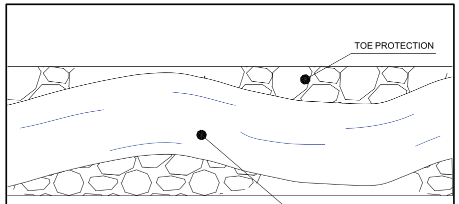
Remove Japanese Knotweed from banks.


VIEW UPSTREAM TOWARDS CHIPPEWA ST W

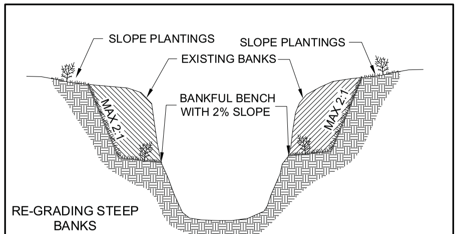

LEFT BANK


DOWNSTREAM VIEW FROM CULVERT

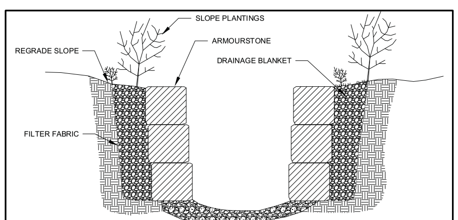

RIGHT BANK



STRAIGHT CHANNEL PLANFORM
N.T.S.

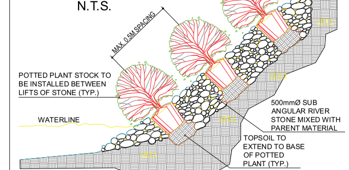


RE-GRADING STEEP BANKS
N.T.S.



ARMOURSTONE PROTECTION
N.T.S.

VEGETATED RIVERSTONE (ANGULAR)
N.T.S.




NOTES:
1. MAXIMUM DEPTH OF LIFT IS 0.3 METRES.
2. ALL DIMENSIONS ARE IN mm.

**NOTE: THE TERMS 'LEFT BANK' AND 'RIGHT BANK' REFER TO A DOWNSTREAM VIEW OF THE CHANNEL**

water's edge
ENVIRONMENTAL SOLUTIONS TEAM

Chippewa Creek

Erosion Control Study and Inventory

Priority Sites

#10 - CA36 (Reach CC-9b)

| PROJECT FILE NO. | SHEET NO. |
|---|---|
| 14040 | 10 |

### 3.9 Costs for Protection Works

Preliminary cost estimates were prepared for the top ten concern areas and have been included in **Table 3.7** below. Details of the cost breakdown are provided in Appendix C.

**Table 3.7 High Priority Sites Construction Estimate Summary**

| Location ID | Reach | Name | Cost Estimate $ | Priority # |
|---|---|---|---|---|
| CA6 | CC-2a | Chippewa Cr. - Oak St. pedestrian bridge (currently closed) | $142,078 | 1 |
| CA28 | CC-9b | Chippewa Cr. - Cassells St. bridge and u/s of Cassells St. | $139,219 | 2 |
| CA17 | CC-6 | Chippewa Cr. - u/s Chippewa St. E (gabions) | $253,688 | 3 |
| CA16 | CC-5 | Chippewa Cr. - ~55m u/s Princess St. E to ~40m u/s Duke St. E | $498,281 | 4 |
| CA27 | CC-9a | Chippewa Cr. - d/s Cassells St. (gravel bar forming) | $186,625 | 5 |
| CA31 | CC-9b | Chippewa Cr. - ~120m u/s of Cassells St. (apartment parking lot) | $128,078 | 6 |
| CA14 | CC-4 | Chippewa Cr. - Hammond St. to Fisher St. | $713,906 | 7 |
| CA9 | CC-2c | Chippewa Cr. - 20m u/s McIntyre St. E to u/s First Ave. ped. bridge | $417,844 | 8 |
| CA71 | JC-7a and JC-7b | Johnston Cr. - ~210m d/s Arclin S driveway to S driveway | $595,625 | 9 |
| CA36 | CC-9b | Chippewa Cr.- Gabions d/s of Chippewa St. W | $42,950 | 10 |
| | | **TOTAL COST OF PRIORITY ITEMS** | **$3,118,294** | |

In spite of the priority assigned to each site based on the prioritization methodology developed in this study, economic and causative factors must also be realized. As such, it may be necessary to reprioritize required works based on these factors. If this is the case, priority should be assigned to works that must be completed in order to avoid further structural degradation. It may be more appropriate to carry out works on one of the lower priority sites sooner rather than latter as the loss of a section of the structure could ultimately increase the corresponding costs by orders of magnitude if not attended to immediately.

Re-ordering of the prioritization order may also be rationalized by the fact that priority items have primarily been ranked based on environmental and personal risk factors rather than strict structural factors.

The costs for the works were based on preliminary and general concepts only. The engineering (civil, geotechnical, fluvial), environmental (fisheries and terrestrial) and contingency costs were included but no alternative designs were considered. A combination of hard engineering techniques along with bioengineering were considered as the general concept. If the site conditions allowed Natural Channel Design concepts to be considered then they were applied and noted in the summary. It was also assumed that Fluvial Geomorphology would be included in the design team and it is noted that provision for Landscape Architecture was not included. This is an aspect which may be considered depending on the site and design criteria. It would be desirable to include landscape architecture in order to undertake a more comprehensive and holistic approach. The environmental aspects are key and the fisheries and terrestrial assessment have been included in the environmental aspects in order to ensure the protection of the ecosystem.

**3.10 Order and Timing of Implementation of Priority Sites:**

The priority list of sites was reviewed for timing of the works and the projected budget (**Table 3.8**). Based on current trends, approximately $250,000 is budgeted for creek projects each year, including both design and construction.

It is noted that the Class EA should be completed in Year 0, i.e. 2015 and it was assumed that the ten high priority sites would be done following that approval. However, based on this budget and the cost of the priority works, it will take approximately 13 years to complete the works and it would be recommended that the budget for the works should be increased and that the timeline for the completion of the top 10 be shortened to approximately 5 years.

It is noted that these costs are approximate and final designs would be required on each project in order to determine the actual costs. Staging of the project design and actual construction of the works will need to be determined.

**Table 3.8 Order of Implementation and Associated Costs**

| Year | Priority Number/Site | Range of Cost of Remedial Works | Current Capital Budget Forecast |
|---|---|---|---|
| 2015 | Class EA | | Prev. Yr: $000,000<br>Budget: $250,000<br>Total: $250,000<br>Remaining: $000,000 |
| 2016 | Priority 1 | $142,078<br><br>Total: 142,078 | Prev. Yr: $000,000<br>Budget: $250,000<br>Total: $142,078<br>Remaining: $107,922 |
| 2017 | Priority 3 | $253,688<br><br>Total: $253,688 | Prev. Yr: $107,922<br>Budget: $250,000<br>Total: $253,688<br>Remaining: $104,234 |
| 2018 | Priority 5 | $186,625<br><br>Total: $186,625 | Prev. Yr: $104,234<br>Budget: $250,000<br>Total: $186,625<br>Remaining: $167,609 |
| 2019 | None | $000,000 | Prev. Yr: $167,609<br>Budget: $250,000<br>Total: $000,000<br>Remaining: $417,609 |
| 2020 | Priority 4 | $498,281<br><br>Total: $498,281 | Prev. Yr: $417,609<br>Budget: $250,000<br>Total: $498,281<br>Remaining: $169,328 |
| 2021 | Priority 2<br>Priority 6 | $139,219<br>$128,078<br><br>Total: $267,297 | Prev. Yr: $169,328<br>Budget: $250,000<br>Total: $267,297<br>Remaining: $152,031 |
| 2022 | Priority 10 | $42,950<br><br>Total: $42,950 | Prev. Yr: $152,031<br>Budget: $250,000<br>Total: $42,950<br>Remaining: $359,081 |
| 2023 | Priority 8 | $417,844<br><br>Total: $417,844 | Prev. Yr: $359,081<br>Budget: $250,000<br>Total: $417,844<br>Remaining: $191,237 |
| 2024 | None | $000,000 | Prev. Yr: $191,237<br>Budget: $250,000<br>Total: $000,000<br>Remaining: $441,237 |

| | | | |
|---|---|---|---|
| 2025 | Priority 9 | $595,625<br><br>Total: $595,625 | Prev. Yr: $441,237<br>Budget: $250,000<br>Total: $595,625<br>Remaining: $95,612 |
| 2026 | None | $000,000 | Prev. Yr: $95,612<br>Budget: $250,000<br>Total: $000,000<br>Remaining: $345,612 |
| 2027 | None | $000,000 | Prev. Yr: $345,612<br>Budget: $250,000<br>Total: $000,000<br>Remaining: $595,612 |
| 2028 | Priority 7 | $713,906<br><br>Total: $713,906 | Prev. Yr: : $595,612<br>Budget: $250,000<br>Total: $713,906<br>Remaining: $131,706 |

It should be noted that through monitoring of the priority locations, the relative priority of each site may shift and therefore the order of implementation should be considered dynamic.

### 3.11 Maintenance Work Requirements

In addition to the sites noted on the priority listing in Section 3.5, various sites require maintenance to ensure that the entire site is not degraded or lost. For example a misplaced/dislodged section of armourstone, rip rap or gabions along the creek can cause a major portion or the entire section of the structure to become unstable, increasing its rate of structural decline.

These sites typically did not rank as the priority sites but have been noted as this work is relatively cost effective. Therefore a maintenance list has also been provided with suggested timing but no costs were provided for the proposed works. **Table 3.9** details the sites and the necessary actions. Further reference should be made to Appendix A and B (i.e. field forms and completed field forms respectively).

Three exposed pipes were discovered along two reaches (CC-9a and CC-10) (**Figure 3.13**). Appropriate costs are allotted to each exposed pipe. Critical Area 28, a high priority site, has an exposed pipe within its area. The other exposed pipes are located in Critical Area 41 and 42, and Critical Area 24 (**Figures 3.4 and 3.6**).

In addition, Priority Items noted in the Summary List (**Table 3.2**) that are not *High Priority* should be inspected and stabilized where possible so that major work can be delayed. This is particularly applicable to those that have scored relatively high, i.e. ≥75. Relevant locations of the Moderate Priority Sites have been noted in yellow on **Figure 3.2**.

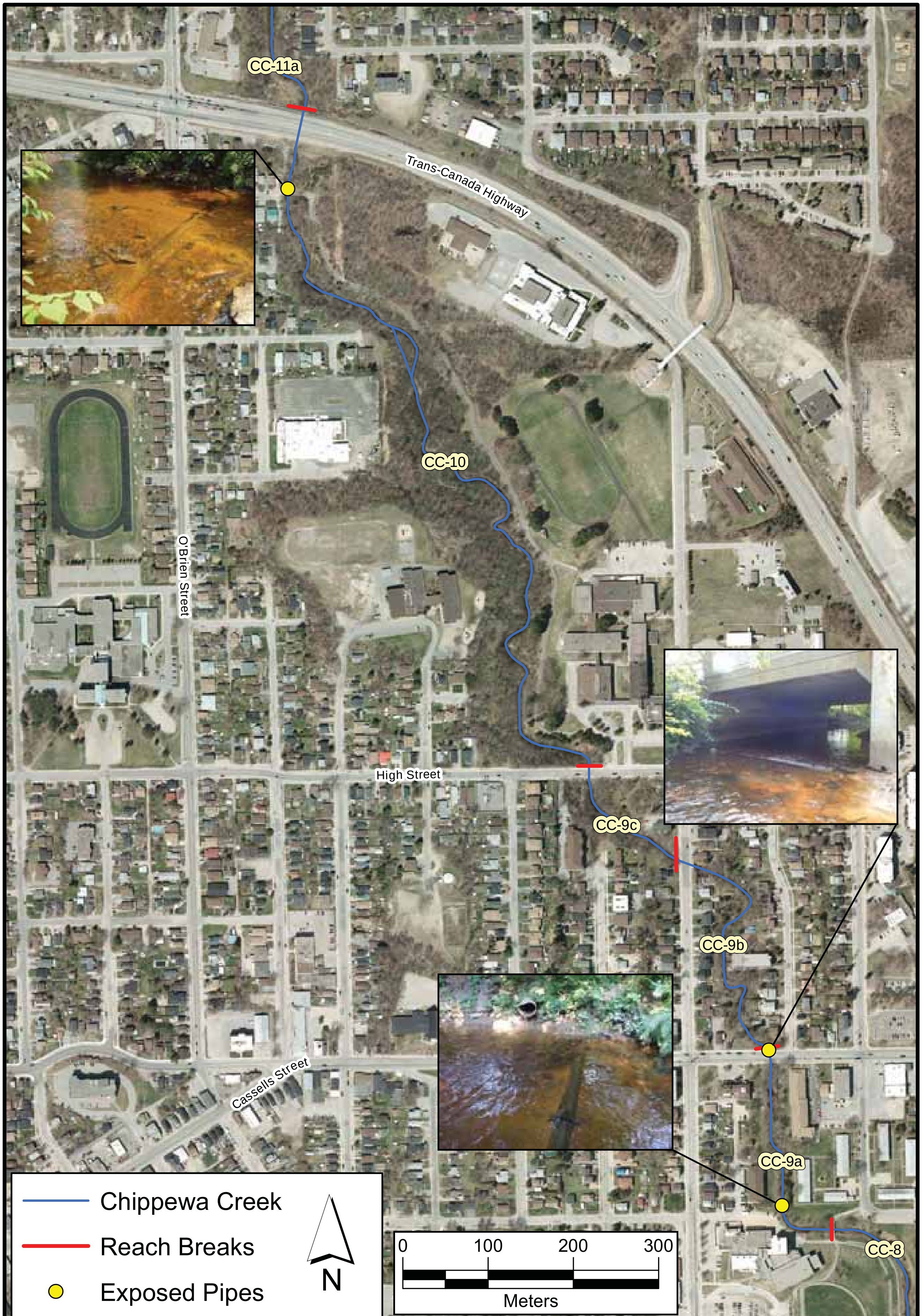
**Table 3.9 Sites Requiring Maintenance Work or Rehabilitation**

| Reach | Type | Openings | Size | Restoration | Comments | Cost |
|---|---|---|---|---|---|---|
| JC-9 | | | 1000 mm +/- | OS | Trout Lake Rd / RR culverts | $5,000.00 |
| CC-1b | OUT | 1 | 300mm | OS | tie into gabions/rip rap | $5,000.00 |
| CC-5 | OUT | 1 | 300mm | OS | Iron rust | $5,000.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CC-5 | OUT | 1 | 300mm | OS | | $5,000.00 |
| CC-5 | OUT | 1 | 300mm | OS | U/S of Duke | $5,000.00 |
| CC-5 | OUT | 1 | 200mm | OS | U/S of Duke | $5,000.00 |
| CC-5 | OUT | 1 | 300mm | OS | U/S of Duke | $5,000.00 |
| CC-5 | OUT | 1 | 400mm | OS | U/S of Duke | $5,000.00 |
| CC-5 | OUT | PS-1 | 1150mm | OS | D/S of Chippewa at bend | $5,000.00 |
| CC-5 | OUT | 1 | 450mm | OS | D/S of Chippewa at bend | $5,000.00 |
| CC-6 | OUT | 1 | 875mm | GR | 20 m u/s of Ped Bridge with conc headwall | $10,000.00 |
| CC-9a | OUT | 1 | 750mm | OS | west side - corroded invert | $5,000.00 |
| CC-9a | OUT | 1 | 350mm | OS | east side - corroded invert | $5,000.00 |
| CC-9a | OUT | 1 | 150mm | OS | | $5,000.00 |
| CC-9b | OUT | 1 | 450mm | OS | 30m u/s of Cassells | $5,000.00 |
| CC-10 | OUT | 1 | 900mm | OS | Also made of asphalt | $5,000.00 |
| CC-10 | OUT | 1 | 525mm | OS | concrete headwall | $5,000.00 |
| CC-10 | OUT | 1 | 900mm | GR / OS | | $15,000.00 |
| CC-11a | OUT | 1 | 1.2 x 0.9 m | OS | u/s of Hwy 11 on east side | $5,000.00 |
| CC-11b | OUT | 1 | 450mm | OS | culvert is under pathway | $5,000.00 |
| CC-11c | OUT | 1 | 450mm | OS | at Milani west side | $5,000.00 |
| CC-11c | OUT | 1 | 300mm | OS | u/s face of Milani | $5,000.00 |
| CC-11d | OUT | 1 | 200mm | O | u/s of Milani - flap gate not working | $2,500.00 |
| CC-11d | OUT | 1 | 400mm | OS | 100 m d/s of O'Brien on NS - road outlet | $5,000.00 |
| CC-11d | OUT | 1 | 400mm | OS | d/s from Bain | $5,000.00 |
| JC-1a | OUT | 1 | 200mm | OS | | $5,000.00 |
| JC-2 | OUT | FS-1 | 450mm (est) | OS | from Mall Parking Lot - conc headwall | $5,000.00 |
| JC-4 | OUT | PS-1 | 500mm | OS | remove grocery cart also | $5,000.00 |
| JC-4 | OUT | 1 | 1200mm | CR | RR Xing - poor condition, plunge pool | $10,000.00 |
| JC-5 | OUT | 1 | 250mm | OS | u/s of Railroad | $5,000.00 |
| JC-5 | OUT | 1 (assumed) | 400 mm (est) | BR | Culvert flooded by Beaver Dam - JCT-1 | $2,500.00 |
| JC-7b | OUT | 1 | 200mm | OS | Outlet from Arclin PLUS 2 Big O pipes also | $5,000.00 |
| JC-8 | OUT | 1 | 200mm | OS | | $5,000.00 |
| JC-8 | OUT | 1 | 300mm | CR/OS | culvert squashed | |
| JC-10 | OUT | 1 | 300mm | OS | | $5,000.00 |
| JC-10 | OUT | 1 | 500mm | OS | replacement required | $5,000.00 |
| JC-11 | OUT | 1 | 2.4 x 1.2m | NC/CR | Gabions w RR toe protection - in backyards | $10,000.00 |
| CC-2c | OUT | 1 | 1050mm | OS | Smell, running water | $5,000.00 |
| CC-2c | OUT | 1 | 400mm | OS | Minor OS required | $5,000.00 |
| CC-9a | PIPE | 1/2 TO 1/3 exposed | 250mm | CHR | EXPOSED - bell and spigot present | $25,000.00 |
| CC-9a | PIPE | 1/2 TO 1/3 exposed | 400mm | CHR | EXPOSED | $25,000.00 |
| CC-10 | PIPE | 1/3 exposed | 400mm | CHR | EXPOSED - B&S present - 5 m u/s of ped | $25,000.00 |
| CC-1a | R | PS-1 | 48m | CR | Queen St - Concrete needs fixing | $5,000.00 |
| CC-1a | R | PS-1 | | CHR | Memorial Dr - failing gabions | $25,000.00 |
| CC-3b | R | 1 | 7m | CHR | John St - all wingwalls are suspect | $25,000.00 |
| CC-3c | R | 1 | 7m | CHR | Hammond St - U/S abutment - need CHR | $25,000.00 |
| CC-4 | R | PS-1 | 6.5m | CHR | Fisher St - CA17 conc wingwall | $25,000.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | tipping, etc. | |
| CC-5 | R | PS-1 | 4.5m | CHR | Duke St - u/s abutments need work | $25,000.00 |
| CC-9a | R | 1 | 7m | CHR | Cassells Rd - CA28 | $25,000.00 |
| CC-11c | R | 1 | 4m | OS | Milani Rd - d/s and u/s ends, fabric exposed | $5,000.00 |
| CC-11d | R | 1 | 6 x 1.9 m | BR/CR | sill and box - need substrate / u/s gullies | $25,000.00 |
| CC-11d | R | 1 | 7m | CHR | O'Brien St - u/s riprap and exposed fabric | $25,000.00 |
| CC-11d | R | | 5-6 m | OS | Bain Dr - gabions on all 4 corners | $5,000.00 |
| JC-2 | R | 1 | 2.4 x 1.2m | CR | Highway 11 - partially failing gabions | $25,000.00 |
| JC-8 | R | 1 | 2000mm | OS/CR | Arclin Driveway | $10,000.00 |
| JC-8 | R | PS-2 | 900 / 1650mm | OS/CR | Arclin Driveway | $10,000.00 |
| JC-11 | R | 1 | 1050mm | OS | JC11 - Driveway off Kadi Crt | $5,000.00 |
| JC-11 | R | 1 | 750mm | OS | Driveway off Kadi Crt | $5,000.00 |
| JC-11 | R | 1 | 1050mm | OS | Ski Club Rd - u/s and d/s OS required!! | $5,000.00 |
| ET-2 | R | 1 | 1600mm x 1000mm | CR | Trout Lake Road Culverts | $10,000.00 |
| ET-2 | R | 1 | 300mm | OS | Trout Lake Road Culverts | $5,000.00 |
| ET-2 | R | 1 | 1200mm | CR / OS | Under trail from Brennan St | $10,000.00 |
| ET-3 | R | 1 | 2m | OS | Bank St - slight drop to create barrier | $5,000.00 |
| ET-4b | R | 1 | 2000mm | CR | Pearson St.- some invert eroded | $10,000.00 |
| ET-4b | R | 1 | 2100mm x 1200mm | GR/BR | Laurentian Ave - clean up grate | $2,500.00 |
| ET-7 | R | 1 | 900mm | OS | Ski Club Rd - 200 mm barrier | $5,000.00 |
| ET-8 | R | PS-1 | 825mm | OS | Chapais St - asphalt banks in poor shape | $5,000.00 |
| JC-9 | R/RR | PS-2 | 1600mm | OS | Trout Lake Rd / RR culverts | $5,000.00 |
| CC-2a | RR | 1 | ≥10m | OS | D/S abutment is poor shape | $5,000.00 |
| CC-2a | RR | PS-1 | | OS | concrete poor / rip rap poor (old rail way) | $5,000.00 |
| CC-2a | S | PS-1 | | OS | Ped bridge- concrete poor on all 4 corners | $5,000.00 |
| CC-2c | S | 1 | | CHR | Ped Bridge - bank treatment required | $10,000.00 |
| JC-1a | S | 1 | >6m | CHR | Ped Bridge - see also CA71 | $10,000.00 |

NOTE: “Type” refers to what is being assessed such as outlets (OUT), exposed pipes (PIPE), road (R), railway (RR), and structure (S). The “Openings” refer to the number and the orientation of the outlets. The categories for the opening orientation are partially submerged (PS), and fully submerged (FS). The “Restoration” column recommends restoration options for the maintenance sites. The restoration options are as follows: outfall stabilization (OS), grate repair (GR), barrier removal (BR), culvert repair (CR), channel restoration (CHR), no change (NC), and other (O). Further reference should be made to Appendix A and B (i.e. field forms and completed field forms respectively).




water's edge ENVIRONMENTAL SOLUTIONS TEAM

| | | | |
|---|---|---|---|
| Exposed Pipes in Chippewa Watershed | | Figure No.: 3.14 | Date: Nov. 10, 2014 |
| Chippewa Creek Watershed Creek Inventory and Erosion Assessment | | Checked By: EG/JM | Drawn By: AC |

### 3.12 Monitoring

An annual review of the priority sites is recommended. In addition, an Annual Monitoring program should be established to minimize risk to the City of North Bay. The monitoring of restoration works is recommended to enable adaptive management which recognizes that managed ecosystems are complex and occasionally unpredictable. Implementing adaptive management can be considered as a cycle consisting of a number of steps which are repeated:

1. develop/implement a solution;
2. monitor for effectiveness;
3. develop/adapt new solutions; and,
4. implement the new solution and monitor again.

### 3.13 Compilation of Inventory and Database

All fieldwork was processed in an EXCEL database in order to manage the inventory assessment data. All database information and GIS data have been provided to the NBMCA in digital format.

### 3.14 Sediment Budget and Sand Accumulations in Downstream Reaches

As per the Stantec (2013) study, active stream bank erosion is occurring in the Upper Chippewa Creek watershed within the deltaic deposits of around North Bay Airport. The banks are destabilizing by vegetation removal, which continues to supply sediment into this stream during high flows. It has been further suggested that local aggregate pits on the escarpment may be compounding this problem.

Water's Edge staff examined Chippewa Creek from its mouth on Lake Nipissing to the headwater reaches above the escarpment. Staff observed the following:

1. The lower reaches have extensive deposits of sand. This is typically downstream of the park and in reaches with low gradient, and those that undergo backwatering from the Lake.
2. Upper reaches, particularly those on the escarpment and immediately below the escarpment, have minimal sediment accumulations. This may be in part due to the local slopes and the ability of the channel to convey sediment to the lower reaches.
3. Staff also observed minimal bank erosion in the upper reaches, with the exception of some fill eroding along CC-13.
4. While sand deposits were naturally present, staff did not observe any excessive sediment deposition or transport in upper reaches, particularly those upstream of the Hwy 11 culverts.
5. Staff observed a significant amount of local bank erosion downstream of the escarpment. While not all bank erosion would result in removal and transport of sand, there were also draws and swales leading directly to the creek that were developed in sandy soil conditions.
6. Staff observed deposits of road sands in various locations that would eventually be transported to the creek system.
7. Staff also observed areas earlier in the year where there was large deposits of road sand. During our July site inspections, much of these deposits have since been removed (assumed by rain and runoff).
8. Road fill on steep embankments was eroding due to rill and gully erosion in the vicinity of creek crossings. This was visible along Highway 11 on the escarpment.
9. Staff observed sediment-laden road runoff being discharged to the creek at Marsh Drive (north side of the road) while the creek flow itself was entirely clear of sediment (see **Photograph 1**).

**Photograph 1 Sediment movement into Chippewa Creek upstream of Marsh Drive**

Based on field observations, staff believe that road sand applications during winter periods is a large contributor to the sediment accumulation in lower reaches. NBMCA should gain access to road sand application rates within the City of North Bay in order to verify this assumption.

Based on field observations, sediment accumulation in lower reaches are due to two primary factors:

1. Winter road sand applications; and,
2. Local bank erosion and drainage swale contributions.

Given the quantity of sand deposition in the lower reaches, the possibility of sand removal and re-use in an environmentally responsible manner should be explored. Erosion and sediment control (ESC) measures should be implemented for further development of the Airport Lands. Furthermore, ESC applications to drainage ditches and swales to capture road sand should be implemented (e.g. check dams and filter socks).

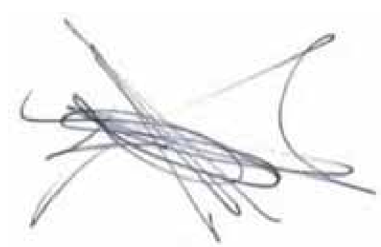
# 4 RECOMMENDATIONS

Based on the field investigations, desktop and database assessments and the summary listing of priority sites, we recommend to the North Bay-Mattawa Conservation Authority that:

1. The Priority Listings (High Priority, Moderate Priority and Priority) as presented in Tables 3.3 and 3.4 be accepted;

2. That concepts in Sheets 1 to 10 be used as a guideline for future design of Priority Items;
3. That Class Environmental Assessments be carried out for larger sections of Chippewa Creek and its Tributaries in order to encompass several of the priority areas and allow for a five year plan for their implementation;
4. That any work program examine adjacent areas to determine if additional work is warranted so that it can be completed at the same time, minimizing disturbance;
5. Road sand application rates should be acquired by NBMCA staff for their assessment into possible sediment loadings into Chippewa Creek;
6. The maintenance listing be reviewed annually;
7. A three to five year time frame be implemented for the maintenance of current deficiencies noted in the maintenance listing;
8. An annual review of the priority sites be carried out and an Annual Geomorphic Monitoring program be established for all of the sites and watersheds to ensure that the site conditions are stable and to minimize risk to the City;
9. A sediment monitoring program should be developed including measures of bedload and suspended load, particularly during flood events;
10. The Field Inspection forms developed as part of this study be used for the Annual Monitoring Program;
11. Encourage residents and other property owners to establish a riparian buffer to reduce erosion and enhance stream habitat;
12. Erosion and Sediment Control measures should be used not only in construction areas close to watercourses, but also within drainage ditches and storm sewers to control road sand transport, possibly requiring maintenance;
13. Size stone treatments appropriately and utilize a range of particle sizes; and that;
14. The City of North Bay and NBMCA avoid the use of filter fabric underneath creek bank rock treatments throughout the study area as there is evidence that filter fabric provides a failure plane rather than ensuring the success of channel work.

All of which is respectfully submitted,
**WATER'S EDGE ENVIRONMENTAL SOLUTIONS TEAM LTD.**



Ed Gazendam, M.Eng., P.Eng.
Principal, Sr. Geomorphologist
Project Manager

John S. McDonald
Fluvial Geomorphologist

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# APPENDIX A:

# Field Forms

# Reach Conditions

| | |
|---|---|
| **Date:** | |
| **Time:** | |
| **Surveyor:** | |
| **Weather (During):** | |
| **Weather (Shortly Before):** | |
| **GPS #:** | |
| **Catchment:** | |
| **Tributary:** | |
| **Reach:** | |
| **Reach Length:** | |

**Channel Type:**

**General Description of Reach:**

**Channel Type Key:**

| | | | |
|---|---|---|---|
| Natural Channel (NC) | Concrete (C ) | Gabion (G) | Bio-engineering (BE) |
| Armourstone (AS) | CableCrete (CC) | Rip Rap (RR) | Other (O) - Please Specify |

**Reach Level Assessments:**

**Rapid Geomorphic Assessment (RGA)**

| Process | Value |
|---|---|
| 1. Aggradation | 0.00 |
| 2. Widening | 0.00 |
| 3. Degradation | 0.00 |
| 4. Planform Adjustment | 0.00 |
| Stability Index: | 0.00 |
| Stability Condition | |

**Qualitative Habitat Evaluation Index (QHEI)**

| | |
|---|---|
| 1. Substrate | 0 |
| 2. Instream Cover | 0 |
| 3. Channel Morphology | 0 |
| 4. Bank Erosion and Riparian Zone | 0 |
| 5. Pool/Glide and Riffle/Run Quality | 0 |
| 6. Gradient | 0 |
| Total: | 0 |

**Comments (General Issues/Conditions):**

**Key / Typical Photograph or Sketch:**

# Crossing and Outlet Inventory

**Reach:**

NORTH BAY-MATTAWA CONSERVATION AUTHORITY

water's edge ENVIRONMENTAL SOLUTIONS TEAM

| Reach | Type | Material | Shape | Openings | Channel Width | Substrate | Barrier | Size (mm) | Restoration | Comments: |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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**KEY:**

**Type:** Road (R ), Structure (S), Beaver Dams (B), Rail (RR), Other (O), Debris (D), Geologic (G), Outlet (OUT), Utility (U)

**Material:** Concrete (C ), PVC (P), Metal (M), Other (O)

**Shape:** Circular (C ), Elliptical (E), Box (B), Other (O), Arch (A), Rectangle Open Bottom (R), Skewed (S)

**Openings:** Partially Submerged (PS), Fully Submerged (FS), Not Submerged (NS), Blocked (BL) - %, Add number of openings

**Channel Width:** Greater Than Opening (>), Less Than Opening (<), Equal to Opening (=)

**Substrate Through Crossing:** Yes: Clay (Cl), Sand (S), Gravel (G), Cobble ( C Boulder (B), N/A Outfalls

**Barrier:** Drop (D), Shallow Flows (F), Other (O)

**Restoration Options:** Channel Restoration (CR), Culvert Repair (CR), Grate Repair (GR), Outfall Stabilization (OS), Barrier Removal (BR), SWM Restoration (SR), No Change (NC), Other (O)

# Critical Areas

| | |
|---|---|
| Reach: | |
| GPS #: | |
| Length: | |
| Height: | |
| Structure Length: | |
| Access Point for Site: | |

**Description:**

**Overall Prioritization:**

| | 3 | 6 | 9 | 12 | | Score | Max |
|---|---|---|---|---|---|---|---|
| **A) Risk Assessment:** | | | | | | | |
| **A-1 Personal Safety** | Low | Moderate | Substantial | High | | 0 | /12 |
| **A-2a Structural** | >15 | 10 to 15 | 5 to 10 | <5 | | 0 | /12 |
| **A-2b Property** | >15 | 10 to 15 | 5 to 10 | <5 | | 0 | /12 |
| **A-2c Infrastructure** | >100 | <75 | <50 | <25 | | 0 | /12 |
| **A-3 Risk Damage - Slope** | <25 | 25 to 30 | 30 to 35 | >35 | | 0 | /12 |
| | | | | | Subtotal: | 0 | /60 |

| | 3 | 6 | 9 | 12 | | Score | Max |
|---|---|---|---|---|---|---|---|
| **B) Material Assessment:** | | | | | | | |
| **B-1 Material Condition** | Excellent | Stable | OK | Poor | | 0 | /12 |
| **B-2 Performance Condition** | Excellent | Good | Fair | Poor | | 0 | /12 |
| | | | | | Subtotal: | 0 | /24 |

| | 2 | 4 | 6 | 8 | Score | Max |
|---|---|---|---|---|---|---|
| **C) Environmental Assessment:** | | | | | | |
| **C-1 QHEI** | >75 | 53 to 74 | 31 to 52 | <30 | 0 | /8 |
| **C-2 RGA** | <0.20 | 0.20 to 0.30 | 0.31 to 0.40 | >0.40 | 0 | /8 |
| | | | | | 0 | /16 |

**TOTAL:** 0 /100

**Photograph(s) / Sketch(es):**

**Notes:**

**Issues:**

**Possible Solutions:**

Ontario

# Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

***QHEI Score:*** ______

***Stream & Location:*** ______________________ ***RM:*** _ _ _._ ***Date:*** _ _/ _ _/ _ _

***Scorers Full Name & Affiliation:*** ______________________

***River Code:*** _ _ _- _ _ _- _ _ _ ***STORET #:*** _ _ _ _ _ _ ***Lat./ Long.:*** (NAD 83 - decimal °) _ _ . _ _ _ _ /8_ . _ _ _ _ ***Office verified location*** ☐

## 1] *SUBSTRATE*

Check *ONLY* **Two** substrate *TYPE BOXES*; estimate % or note every type present

| BEST TYPES | POOL | RIFFLE | OTHER TYPES | POOL | RIFFLE |
|---|---|---|---|---|---|
| ☐☐ BLDR /SLABS [10] | ___ | ___ | ☐☐ HARDPAN [4] | ___ | ___ |
| ☐☐ BOULDER [9] | ___ | ___ | ☐☐ DETRITUS [3] | ___ | ___ |
| ☐☐ COBBLE [8] | ___ | ___ | ☐☐ MUCK [2] | ___ | ___ |
| ☐☐ GRAVEL [7] | ___ | ___ | ☐☐ SILT [2] | ___ | ___ |
| ☐☐ SAND [6] | ___ | ___ | ☐☐ ARTIFICIAL [0] | ___ | ___ |
| ☐☐ BEDROCK [5] | ___ | ___ | | | |

(Score natural substrates; ignore sludge from point-sources)

**NUMBER OF BEST TYPES:** ☐ 4 or more [2] ☐ 3 or less [0]

***Comments***

Check ONE (*Or 2 & average*)

| ORIGIN | QUALITY |
|---|---|
| ☐ LIMESTONE [1] | SILT: ☐ HEAVY [-2] |
| ☐ TILLS [1] | ☐ MODERATE [-1] |
| ☐ WETLANDS [0] | ☐ NORMAL [0] |
| ☐ HARDPAN [0] | ☐ FREE [1] |
| ☐ SANDSTONE [0] | EMBEDDEDNESS: ☐ EXTENSIVE [-2] |
| ☐ RIP/RAP [0] | ☐ MODERATE [-1] |
| ☐ LACUSTURINE [0] | ☐ NORMAL [0] |
| ☐ SHALE [-1] | ☐ NONE [1] |
| ☐ COAL FINES [-2] | |

***Substrate*** ______ *Maximum 20*

## 2] *INSTREAM COVER*

Indicate presence 0 to 3: **0**-Absent; **1**-Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

___ UNDERCUT BANKS [1]
___ OVERHANGING VEGETATION [1]
___ SHALLOWS (IN SLOW WATER) [1]
___ ROOTMATS [1]
___ POOLS > 70cm [2]
___ ROOTWADS [1]
___ BOULDERS [1]
___ OXBOWS, BACKWATERS [1]
___ AQUATIC MACROPHYTES [1]
___ LOGS OR WOODY DEBRIS [1]

**AMOUNT**

Check ONE (*Or 2 & average*)

☐ EXTENSIVE >75% [11]
☐ MODERATE 25-75% [7]
☐ SPARSE 5-<25% [3]
☐ NEARLY ABSENT <5% [1]

***Comments***

***Cover*** ______ *Maximum 20*

## 3] *CHANNEL MORPHOLOGY*

Check ONE in each category (*Or 2 & average*)

| SINUOSITY | DEVELOPMENT | CHANNELIZATION | STABILITY |
|---|---|---|---|
| ☐ HIGH [4] | ☐ EXCELLENT [7] | ☐ NONE [6] | ☐ HIGH [3] |
| ☐ MODERATE [3] | ☐ GOOD [5] | ☐ RECOVERED [4] | ☐ MODERATE [2] |
| ☐ LOW [2] | ☐ FAIR [3] | ☐ RECOVERING [3] | ☐ LOW [1] |
| ☐ NONE [1] | ☐ POOR [1] | ☐ RECENT OR NO RECOVERY [1] | |

***Comments***

***Channel*** ______ *Maximum 20*

## 4] *BANK EROSION AND RIPARIAN ZONE*

Check **ONE** in each category for ***EACH BANK*** (*Or 2 per bank & average*)

River right looking downstream

| EROSION (L R) | RIPARIAN WIDTH (L R) | FLOOD PLAIN QUALITY (L R) | (L R) |
|---|---|---|---|
| ☐☐ NONE / LITTLE [3] | ☐☐ WIDE > 50m [4] | ☐☐ FOREST, SWAMP [3] | ☐☐ CONSERVATION TILLAGE [1] |
| ☐☐ MODERATE [2] | ☐☐ MODERATE 10-50m [3] | ☐☐ SHRUB OR OLD FIELD [2] | ☐☐ URBAN OR INDUSTRIAL [0] |
| ☐☐ HEAVY / SEVERE [1] | ☐☐ NARROW 5-10m [2] | ☐☐ RESIDENTIAL, PARK, NEW FIELD [1] | ☐☐ MINING / CONSTRUCTION [0] |
| | ☐☐ VERY NARROW < 5m [1] | ☐☐ FENCED PASTURE [1] | |
| | ☐☐ NONE [0] | ☐☐ OPEN PASTURE, ROWCROP [0] | |

*Indicate predominant land use(s) past 100m riparian.*

***Comments***

***Riparian*** ______ *Maximum 10*

## 5] *POOL / GLIDE AND RIFFLE / RUN QUALITY*

**MAXIMUM DEPTH**

Check **ONE** (*ONLY!*)

☐ > 1m [6]
☐ 0.7-<1m [4]
☐ 0.4-<0.7m [2]
☐ 0.2-<0.4m [1]
☐ < 0.2m [0]

**CHANNEL WIDTH**

Check ONE (*Or 2 & average*)

☐ POOL WIDTH > RIFFLE WIDTH [2]
☐ POOL WIDTH = RIFFLE WIDTH [1]
☐ POOL WIDTH < RIFFLE WIDTH [0]

**CURRENT VELOCITY**

Check ALL that apply

☐ TORRENTIAL [-1] ☐ SLOW [1]
☐ VERY FAST [1] ☐ INTERSTITIAL [-1]
☐ FAST [1] ☐ INTERMITTENT [-2]
☐ MODERATE [1] ☐ EDDIES [1]

*Indicate for reach - pools and riffles.*

**Recreation Potential**
***Primary Contact***
***Secondary Contact***
(circle one and comment on back)

***Comments***

***Pool / Current*** ______ *Maximum 12*

**Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:** Check ONE (*Or 2 & average*). ☐ **NO RIFFLE [metric=0]**

| RIFFLE DEPTH | RUN DEPTH | RIFFLE / RUN SUBSTRATE | RIFFLE / RUN EMBEDDEDNESS |
|---|---|---|---|
| ☐ BEST AREAS > 10cm [2] | ☐ MAXIMUM > 50cm [2] | ☐ STABLE (e.g., Cobble, Boulder) [2] | ☐ NONE [2] |
| ☐ BEST AREAS 5-10cm [1] | ☐ MAXIMUM < 50cm [1] | ☐ MOD. STABLE (e.g., Large Gravel) [1] | ☐ LOW [1] |
| ☐ BEST AREAS < 5cm [metric=0] | | ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0] | ☐ MODERATE [0] |
| | | | ☐ EXTENSIVE [-1] |

***Comments***

***Riffle / Run*** ______ *Maximum 8*

## 6] *GRADIENT* ( ft/mi)

**DRAINAGE AREA** ( mi²)

☐ VERY LOW - LOW [2-4]
☐ MODERATE [6-10]
☐ HIGH - VERY HIGH [10-6]

**%POOL:** ______ **%GLIDE:** ______
**%RUN:** ______ **%RIFFLE:** ______

***Gradient*** ______ *Maximum 10*

# Slope Stability Rating Chart

## For Critical Areas

Individual Problem Sites

Site Number:
Reach Number:
GPS #:

Slope Stability Individual Ranking Criteria Score

| KEY: | | | Score | | |
|---|---|---|---|---|---|
| **1. Slope Angle:** | | [Horizontal:Vertical] | | | |
| | a) 18 or less | [3:1 or flatter] | 0 | | |
| | b) 18-26 | [2:1 to more than 3:1] | 6 | | |
| | c) > 26 | [steeper than 2:1] | 16 | | |
| **2. Soil Stratigraphy:** | | | | | |
| | a) Shale, Limestone, Granite (Bedrock) | | 0 | d) Clay, Silt | 12 |
| | b) Sand, Gravel | | 6 | e) Fill | 16 |
| | c) Glacial Till | | 9 | f) Leda Clay | 24 |
| **3. Seepage From Slope Face:** | | | | | |
| | a) None or Near bottom only | | 0 | | |
| | b) Near mid-slope only | | 6 | | |
| | c) Near crest only or, From several levels | | 12 | | |
| **4. Slope Height:** | | | | | |
| | a) 2 m or less | | 0 | | |
| | b) 2.1 to 5 m | | 2 | | |
| | c) 5.1m to 10 m | | 4 | | |
| | d) > 10 m | | 8 | | |
| **5. Vegetation cover on Slope Face:** | | | | | |
| | a) Well vegetated; heavy shrubs or forested with mature trees | | 0 | | |
| | b) Light vegetation;mostly grass,weeds,occasional trees,shrubs | | 4 | | |
| | c) No vegetation, bare | | 8 | | |
| **6. Table Land Drainage** | | | | | |
| | a) Table Land flat, no apparent drainage over slope | | 0 | | |
| | b) Minor drainage over slope, no active erosion | | 2 | | |
| | c) Drainage over slope, active erosion, gullies | | 4 | | |
| **7. Proximity of Watercourse to Slope Toe** | | | | | |
| | a) 15 m or more from slope toe | | 0 | | |
| | b) Less than 15 m from slope toe | | 6 | | |
| **8. Previous Landslide Activity** | | | | | |
| | a) No | | 0 | | |
| | b) Yes | | 6 | | |

| Criterion | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Slope Angle | | | | | | | | | | |
| 2. Soil Stratigraphy | | | | | | | | | | |
| 3. Seepage From Slope Face | | | | | | | | | | |
| 4. Slope Height | | | | | | | | | | |
| 5. Vegetation cover on Slope Face | | | | | | | | | | |
| 6. Table Land Drainage | | | | | | | | | | |
| 7. Proximity of Watercourse to Slope Toe | | | | | | | | | | |
| 8. Previous Landslide Activity | | | | | | | | | | |
| Summary | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Total Slope Instability Summary Rating Value = Total of # 1 to 8**

# Rapid Geomorphic Assessment

**Date:**
**Evaluator:**
**Stream:**
**Conditions:**

| Process | Geomorphic Indicator No | Description | Reach Number: 1 | 2 | 3 | … |
|---|---|---|---|---|---|---|
| **Evidence of Aggradation (AI)** | 1 | Lobate bar | | | | |
| | 2 | Coarse material in riffles embedded | | | | |
| | 3 | Siltation in pools | | | | |
| | 4 | Medial bars | | | | |
| | 5 | Accretion on point bars | | | | |
| | 6 | Poor longitudinal sorting of bed materials | | | | |
| | 7 | Deposition in the overbank zone | | | | |
| | | **Sum of Indices** | | | | |
| | | **Factor Value** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Evidence of Degradation (DI)** | 1 | Exposed bridge footing(s) | | | | |
| | 2 | Exposed sanitary/storm sewer/pipeline/etc. | | | | |
| | 3 | Elevated storm sewer outfall(s) | | | | |
| | 4 | Undermined gabion baskets/concrete aprons/etc. | | | | |
| | 5 | Scour pools d/s of culverts/storm sewer outlets | | | | |
| | 6 | Cut face on bar forms | | | | |
| | 7 | Head cutting due to knick point migration | | | | |
| | 8 | Terrace cut through older bar material | | | | |
| | 9 | Suspended armour layer visible in bank | | | | |
| | 10 | Channel worn into undisturbed overburden/bedrock | | | | |
| | | **Sum of Indices** | | | | |
| | | **Factor Value** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Evidence of Widening (WI)** | 1 | Fallen/leaning trees/fence posts/etc. | | | | |
| | 2 | Occurrence of large organic debris | | | | |
| | 3 | Exposed tree roots | | | | |
| | 4 | Basal scour on inside meander bends | | | | |
| | 5 | Basal scour on both sides of channel through riffle | | | | |
| | 6 | Gabion baskets/concrete walls/etc. out flanked | | | | |
| | 7 | Length of basal scour >50% through subject reach | | | | |
| | 8 | Exposed length of previously buried pipe/cable/etc. | | | | |
| | 9 | Fracture lines along top of bank | | | | |
| | 10 | Exposed building foundation | | | | |
| | | **Sum of Indices** | | | | |
| | | **Factor Value** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Evidence of Planimetric Form Adjustment (PI)** | 1 | Formation of cut (s) | | | | |
| | 2 | Single thread channel to multiple channel | | | | |
| | 3 | Evolution of pool-riffle form to low bed relief form | | | | |
| | 4 | Cutoff channel(s) | | | | |
| | 5 | Formation of island(s) | | | | |
| | 6 | Thalweg alignment out of phase meander form | | | | |
| | 7 | Bar forms poorly formed/reworked/removed | | | | |
| | | **Sum of Indices** | | | | |
| | | **Factor Value** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Stability Index (SI) = ( AI + DI+ WI+ PI) /m** | | | 0.00 | 0.00 | 0.00 | 0.00 |

**General Comments:**


# APPENDIX B:

# Completed Field Forms (Digital Version Only)


# APPENDIX C:

# Priority Areas Cost Estimates

1

| | | | |
|---|---|---|---|
| Location ID: | CA6 | | |
| Name: | Chippewa Creek- Priority 1 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 25 metres | | |
| Site and Access Preparation | 1 | 7500.00 | 7,500.00 |
| Removals inc veg removal (sm) | 104 | 100.00 | 10,400.00 |
| Shape channel banks and floodplain area (m) | 52 | 100.00 | 5,200.00 |
| Supply and place Armourstone (tonnes): | 397.5 | 175.00 | 69,562.50 |
| Bridge Removal and Replacement | 1 | 5000.00 | 5,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 8750.00 | 8,750.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 7250.00 | 7,250.00 |
| Engineering and Contingencies (25%) | | | 28,415.63 |
| **Total:** | | | **$142,078.13** |

2

| | | | |
|---|---|---|---|
| Location ID: | CA28 | | |
| Name: | Chippewa Creek- Priority 2 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 25 metres | | |
| Site Preparation: | 1 | 7500.00 | 7,500.00 |
| Removals inc veg removal (sm) | 75 | 100.00 | 7,500.00 |
| Supply and place Armourstone (tonnes): | 265 | 175.00 | 46,375.00 |
| Pool-Riffle Construction (m) | 34 | 1000.00 | 34,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 8750.00 | 8,750.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 7250.00 | 7,250.00 |
| Engineering and Contingencies (25%) | | | 27,843.75 |
| **Total:** | | | **$139,218.75** |

3

| | | | |
|---|---|---|---|
| Location ID: | CA17 | | |
| Name: | Chippewa Creek- Priority 3 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 80 metres | | |
| Site Preparation | 1 | 13000.00 | 13,000.00 |
| Removals inc veg removal (sm) | 160 | 100.00 | 16,000.00 |
| Supply and place Armourstone (tonnes): | 424 | 175.00 | 74,200.00 |
| Shape channel banks and floodplain area (sm) | 250 | 100.00 | 25,000.00 |
| Supply and place Vegetated Riverstone (cm) | 250 | 125.00 | 31,250.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 22500.00 | 22,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 21000.00 | 21,000.00 |
| Engineering and Contingencies (25%) | | | 50,737.50 |
| **Total:** | | | **$253,687.50** |

**4**

| | | | |
|---|---|---|---|
| Location ID: | CA16 | | |
| Name: | Chippewa Creek- Priority 4 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 220 metres | | |
| Site Preparation: | 1 | 27000.00 | 27,000.00 |
| Removals inc veg removal (sm) | 1100 | 100.00 | 110,000.00 |
| Supply and place Armourstone (tonnes): | 477 | 175.00 | 83,475.00 |
| Shape channel banks and floodplain area (sm) | 390 | 50.00 | 19,500.00 |
| Supply and place Vegetated Riverstone (cm) | 390 | 125.00 | 48,750.00 |
| Pool-Riffle Construction (m) | 35 | 1000.00 | 35,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 57500.00 | 57,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 56000.00 | 56,000.00 |
| Engineering and Contingencies (25%) | | | 61,056.25 |
| **Total:** | | | **$498,281.25** |

**5**

| | | | |
|---|---|---|---|
| Location ID: | CA27 | | |
| Name: | Chippewa Creek- Priority 5 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 80 metres (overall length of reach) | | |
| Site Preparation: | 1 | 13000.00 | 13,000.00 |
| Removals inc veg removal (sm) | 200 | 100.00 | 20,000.00 |
| Shape channel banks and floodplain area (sm) | 200 | 100.00 | 20,000.00 |
| Supply and place Vegetated Riverstone (cm) | 200 | 125.00 | 25,000.00 |
| Supply and place Brush Mattressing (sm) | 160 | 200.00 | 32,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 22500.00 | 22,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 21000.00 | 21,000.00 |
| Engineering and Contingencies (25%) | | | 33,125.00 |
| **Total:** | | | **$186,625.00** |

**6**

| | | | |
|---|---|---|---|
| Location ID: | CA31 | | |
| Name: | Chippewa Creek- Priority 6 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 40 metres | | |
| Site Preparation: | 1 | 9000.00 | 9,000.00 |
| Removals inc veg removal (sm) | 100 | 100.00 | 10,000.00 |
| Supply and place Armourstone (tonnes): | 185.5 | 175.00 | 32,462.50 |
| Shape channel banks and floodplain area (sm) | 100 | 100.00 | 10,000.00 |
| Supply and place Vegetated Riverstone (cm) | 100 | 125.00 | 12,500.00 |
| Realign Channel Upstream | 10 | 500.00 | 5,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 12500.00 | 12,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 11000.00 | 11,000.00 |
| Engineering and Contingencies (25%) | | | 25,615.63 |
| **Total:** | | | **$128,078.13** |

7

| | | | |
|---|---|---|---|
| Location ID: | CA14 | | |
| Name: | Chippewa Creek- Priority 7 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 300 metres | | |
| Site Preparation | 1 | 35000.00 | 35,000.00 |
| Removals inc veg removal (sm) | 300 | 100.00 | 30,000.00 |
| Supply and place Armourstone (tonnes): | 265 | 175.00 | 46,375.00 |
| Natural Channel Design | 300 | 1000.00 | 300,000.00 |
| Supply and place Vegetated Riverstone (cm) | 50 | 125.00 | 6,250.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 77500.00 | 77,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 76000.00 | 76,000.00 |
| Engineering and Contingencies (25%) | | | 142,781.25 |
| **Total:** | | | **$713,906.25** |

8

| | | | |
|---|---|---|---|
| Location ID: | CA9 | | |
| Name: | Chippewa Creek- Priority 8 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 210 metres | | |
| Site Preparation: | 1 | 26000.00 | 26,000.00 |
| Removals inc veg removal (sm) | 210 | 100.00 | 21,000.00 |
| Supply and place Armourstone (tonnes): | 318 | 175.00 | 55,650.00 |
| Shape channel banks and floodplain area (sm) | 525 | 100.00 | 52,500.00 |
| Supply and place Vegetated Riverstone (cm) | 525 | 125.00 | 65,625.00 |
| Bridge Removal and Replacement | 1 | 5000.00 | 5,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 55000.00 | 55,000.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 53500.00 | 53,500.00 |
| Engineering and Contingencies (25%) | | | 83,568.75 |
| **Total:** | | | **$417,843.75** |

9

| | | | |
|---|---|---|---|
| Location ID: | CA71 | | |
| Name: | Johnston Creek- Priority 9 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 390 metres | | |
| Site Preparation: | 1 | 44000.00 | 44,000.00 |
| Removals inc veg removal (sm) | 390 | 100.00 | 39,000.00 |
| Natural Channel Design | 390 | 1000.00 | 390,000.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 2500.00 | 2,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 1000.00 | 1,000.00 |
| Engineering and Contingencies (25%) | | | 119,125.00 |
| **Total:** | | | **$595,625.00** |

10

| Location ID: | CA36 | | |
| --- | --- | --- | --- |
| Name: | Chippewa Creek- Priority 10 | | |
| Description of Work | Units | Unit Cost | Associated Costs |
| Length of Work Area: | 12 metres | | |
| Site Preparation: | 1 | 6200.00 | 6,200.00 |
| Removals inc veg removal (sm) | 24 | 100.00 | 2,400.00 |
| Supply and place Armourstone (tonnes): | 127.2 | 175.00 | 22,260.00 |
| Site Rehabilitation (inc fabric, seeding and Plants) | 1 | 2500.00 | 2,500.00 |
| Erosion and Sediment Control inc Dam & Pump | 1 | 1000.00 | 1,000.00 |
| Engineering and Contingencies (25%) | | | 8,590.00 |
| **Total:** | | | **$42,950.00** |