Borthwick Creek 2019 Catchment Report

Catchment Features	
Area	11.08 square kilometres 0.26% of the Rideau Valley watershed
Land Use	8.55% agriculture 3.10% urban 27.88% forest 11.73% meadow 2.47% rural 46.27% wetlands
Surficial Geology	28.13% clay 27.21% organic deposits 44.66% sand
Watercourse Type	2019 thermal conditions **Coolwater**
Invasive Species	Eleven invasive species were identified in 2019: common and glossy buckthorn, curly-leaved pondweed, Eurasian milfoil, European frog-bit, non-native honey suckles, Manitoba maple, non-native *Phragmites*, purple loosestrife, rusty crayfish, wild parsnip
Fish Community	Fifteen species of fish have been observed from 2007-2019: blacknose dace, bluntnose minnow, brassy minnow, brook stickleback, central mudminnow, common shiner, creek chub, emerald shiner, *Etheostoma spp.*, fathead minnow, finescale dace, golden shiner, pearl dace, northern redbelly dace, white sucker

Wetland Cover
46.27% of the watershed are wetlands
13.4% are unevaluated wetlands
32.86% are evaluated wetlands

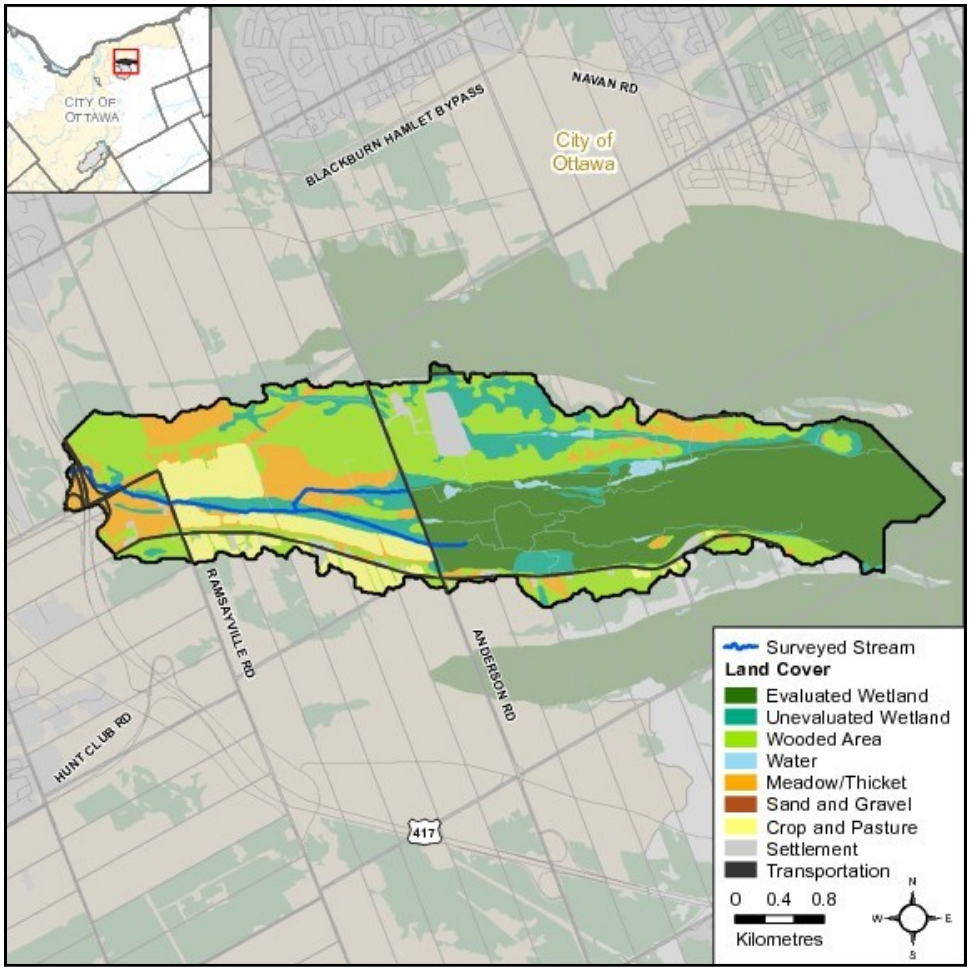


Figure 1 Land cover in the Borthwick Creek catchment

Vegetation Cover		
Type	**Hectares**	**Percent of Cover**
Wooded Areas:	**309**	**37.59%**
Hedgerow	2.37	0.29%
Plantation	3.51	0.43%
Treed	303.04	36.88%
Wetlands*	**513**	**62.41%**
Total Cover	**822**	**100%**

*Includes treed swamps

Woodlot Analysis		
Size Category	**Number of Woodlots**	**Percent of Woodlots**
1 Hectare	42	62.69%
1 to <10 Ha	18	28.87%
10 to <30 Ha	3	4.48%
>30 Ha	4	5.97%
Total Cover	**67**	**100%**

The Rideau Valley Conservation Authority in partnership with the City of Ottawa, National Capital Commission, Ottawa Flyfishers Society, Canadian Forces Ottawa Fish and Game Club, Ottawa Stewardship Council, Rideau Roundtable, South Nation Conservation and Mississippi Valley Conservation Authority form the City Stream Watch 2019 collaborative.

Introduction

Borthwick Creek is a tributary of Greens Creek, located in the east end of the City of Ottawa. The approximately four kilometer stream flows from the Mer Bleue wetland on to its confluence into Greens Creek north of Walkley Road. The catchment of Borthwick Creek measures 11 square kilometers and is comprised of mainly wetland, forest, and agricultural/rural land uses under the management of the National Capital Commission (NCC).

The majority of the headwaters of this catchment are located in the Mer Bleue, a class one Provincially Significant Wetland (PSW), also an Area of Natural and Scientific Interest (ANSI), and a wetland of international importance under the Ramsar Convention on Wetlands (NCC, 2019). The creek also flows through the Borthwick Springs, an Area of Natural and Scientific Interest (MNRF, 2019).

In 2019 the City Stream Watch program surveyed 32 sections (3.2 km) of the main stem of Borthwick Creek and 15 sections (1.5 km) of its northern branch. Six sites were sampled for fish community composition and data from one temperature logger was collected at one of these sites. Three headwater drainage feature sites were assessed in the spring and in the summer. The following is a summary of our observations and assessment.

Low Water Conditions

After a cool and wet spring with significant flooding in certain areas, especially along the Ottawa River; hot dry weather with localized rainfall characterized the summer and early fall of 2019. In August, the climate stations in the watershed measured rainfall at 80 percent under normal levels for that time of year, passing the threshold for low water status. As of August 15, minor low water status in the Rideau Valley watershed was announced by the Rideau Valley Conservation Authority under the Ontario Low Water Response Program (RVCA, 2019). Water levels in lakes and large rivers were close to average for summer conditions however smaller creeks and streams, including headwater drainage features and wetlands, became dry under these drought conditions.

Several significant rainfall events in the last two weeks of October ended the drought conditions. The average 90-day rainfall measured were well above the 80 percent of normal for the time of year. As of October 30, the Rideau Valley watershed status retuned to normal water levels (RVCA, 2019). Water levels in the smaller rivers and streams across the watershed were restored from their prior below normal dry conditions.

Borthwick Creek Overbank Zone

Riparian Buffer Width Evaluation

The riparian buffer is the adjacent land area surrounding a stream or river. Naturally vegetated buffers are important to protect the health of streams and watersheds. Natural shorelines provide buffering capacity of contaminants and nutrients that would otherwise run off freely into aquatic systems. Well established shoreline plant communities will hold soil particles in place preventing erosion and will also provide the stream with shading and cover. Environment and Climate Change Canada recommends a guideline of 30 meters of natural vegetation on both sides of the stream for at least 75 percent of the stream length (Environment Canada, 2013).

Figure 2 demonstrates buffer conditions along the left and right banks of the surveyed sections of Borthwick Creek. Buffers greater than 30 meters were present along 95 percent of the left bank and 90 percent of the right bank. A 15 to 30 meter buffer was present along five percent of the right bank. A five meter buffer or less was present along five percent of the left bank and five percent of the right bank. The buffer width evaluation on the sections surveyed of Borthwick creek are within guidelines, water quality and habitat benefit from these riparian conditions.

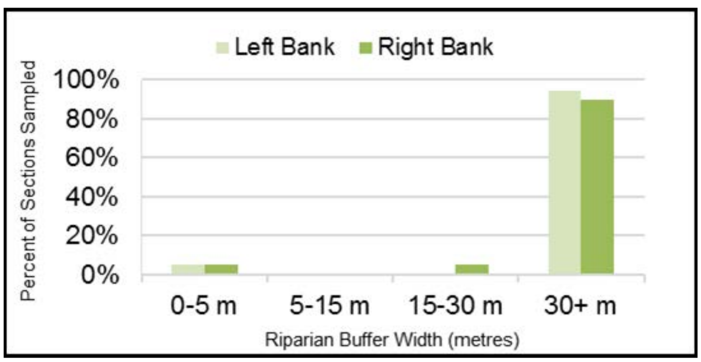


Figure 2 Vegetated buffer width along Borthwick Creek and Borthwick Creek Branch combined

Vegetated buffer greater than 30 meters in width along Borthwick Creek west of Anderson Road

Riparian Buffer Alterations

Alterations within the riparian buffer were assessed within three distinct shoreline zones (0-5 m, 5-15 m, 15-30 m), and evaluated based on the dominant vegetative community and/or land cover type. The evaluation of anthropogenic alterations to the natural riparian cover are shown in Figure 3.

Borthwick Creek surveyed riparian zones were primarily natural, with 96 percent of the right bank and 98 percent of the left bank having dominant natural riparian vegetative communities. Alterations to the riparian buffer accounted for two percent of the right bank; highly altered conditions were observed on two percent of each the right and left banks. These alterations were associated with infrastructure including roadways and agricultural land uses.

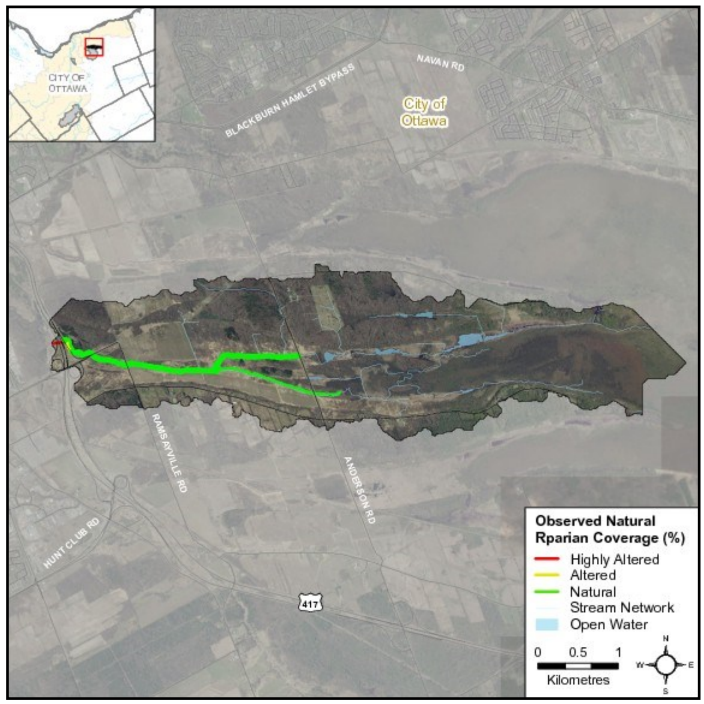


Figure 3 Riparian buffer alterations in Borthwick Creek and Borthwick Creek Branch combined

Roadway infrastructure on Walkley Road along Borthwick Creek

Adjacent Land Use

Surrounding land use is considered from the beginning to the end of the survey section (100 m) and up to 100 meters on each side of the creek. Land use outside of this area is not considered for the surveys but is nonetheless part of the subwatershed and will influence the creek. Figure 4 shows the percent of surveyed sections that contain each type of land use.

Forest and scrubland were present in 74 percent and 89 percent of the sections surveyed, being the most common land use observed. Wetlands were present in 72 percent of the surveyed areas, and meadow was present in 62 percent of sections.

Aside from the natural areas, the most common land use in the catchment was infrastructure, with 28 percent of the sections containing public facilities including roads, bridges and culverts. The other two percent of land use was attributed to abandoned agriculture.

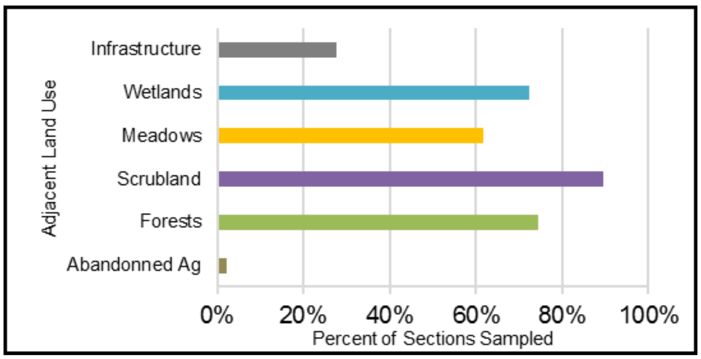


Figure 4 Adjacent land use 100 meters from each shoreline and percentage of presence along Borthwick Creek and Borthwick Creek Branch combined

Section along Borthwick Creek with scrubland, meadow and infrastructure land uses near Walkley Extension Road

Borthwick Creek Shoreline Zone

Anthropogenic Alterations

Stream alterations were classified based on specific functional criteria associated with potential human influences on the riparian buffer, shoreline state, flow conditions and channel structure.

Figure 5 shows the level of anthropogenic alterations for the 47 sections surveyed in the Borthwick Creek catchment, with 28 sections remaining without any human alteration. Of the areas surveyed, 13 sections fell in the classification of natural. Natural sections had a riparian buffer greater than 15 meters in width and natural shorelines.

Two sections were classified as altered. They contained straightened sections and riparian buffers of five to 15 meters in width. Shoreline alterations included concrete bridges.

Four of the surveyed sections were highly altered. The riparian buffers were less than five meters in width, shoreline alterations were found on most of the sections including rip rap and storm water outlets were present at road crossings. These sections were mostly found near road and highway infrastructure.

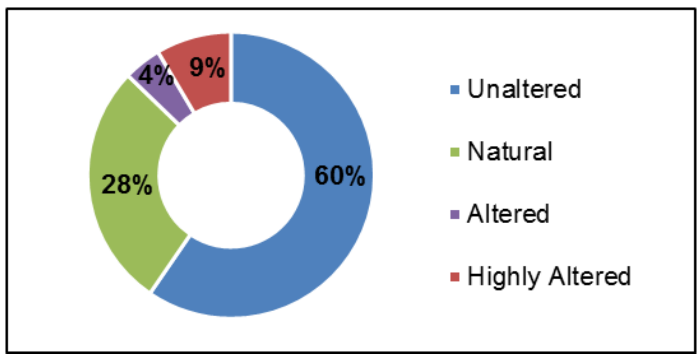


Figure 5 Anthropogenic alterations along Borthwick Creek and Borthwick Creek Branch combined

One of many unaltered sections of Borthwick Creek west of Anderson Road

Erosion

Stream erosion is the process by which water erodes and transports sediments, resulting in dynamic flows and diverse habitat conditions. Excessive erosion can result in drastic environmental changes, as habitat conditions, water quality and aquatic life are all negatively affected. Bank stability was assessed as the extent of each section with "unstable" shoreline conditions. These conditions are defined by the presence of significant exposed soils/roots, minimal bank vegetation, undercutting, slumping or scour and potential failed erosion measures (rip rap, gabion baskets, etc.). Figure 6 shows limited erosion was observed across the surveyed portions. Bank instability was observed in 28 percent of the left bank and 26 percent of the right bank of the sections surveyed.

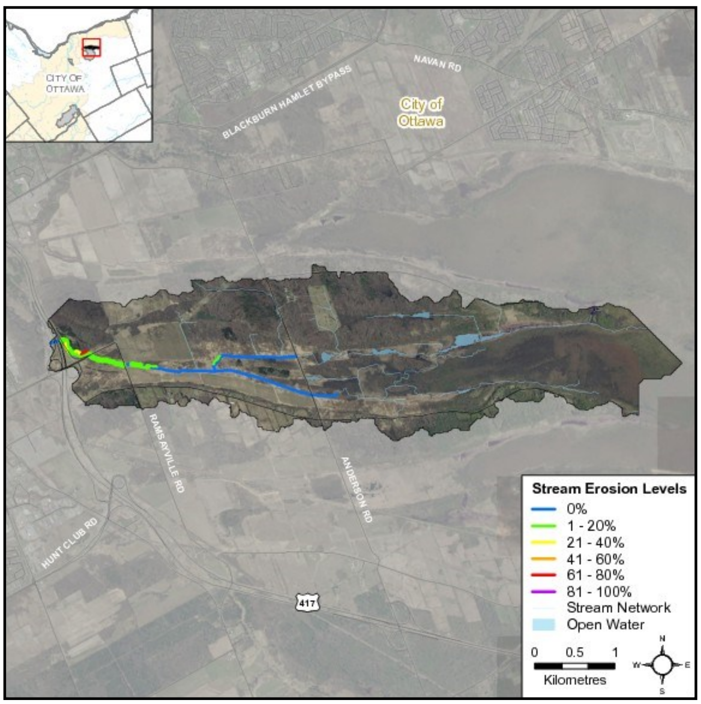


Figure 6 Erosion levels along Borthwick Creek and the Borthwick Creek Branch

Bank sloughing along Borthwick Creek between Highway 417 and Anderson Road

Borthwick Creek is a stream emerging from wetlands, and retains wetland riverine conditions throughout. This type of system has flood storage through hydric soils and a well connected floodplain area which results in lower erosion levels.

Undercut Stream Banks

Stream bank undercuts can provide excellent cover habitat for aquatic life, however excessive levels can be an indication of unstable shoreline conditions. Bank undercut was assessed as the extent of each surveyed section with overhanging bank cover present.

Figure 7 shows where undercut banks were present and to what extent each section contained them in Borthwick Creek. Along the left bank, 26 percent of sections had undercut banks; and the right bank had 28 percent of sections with undercut banks.

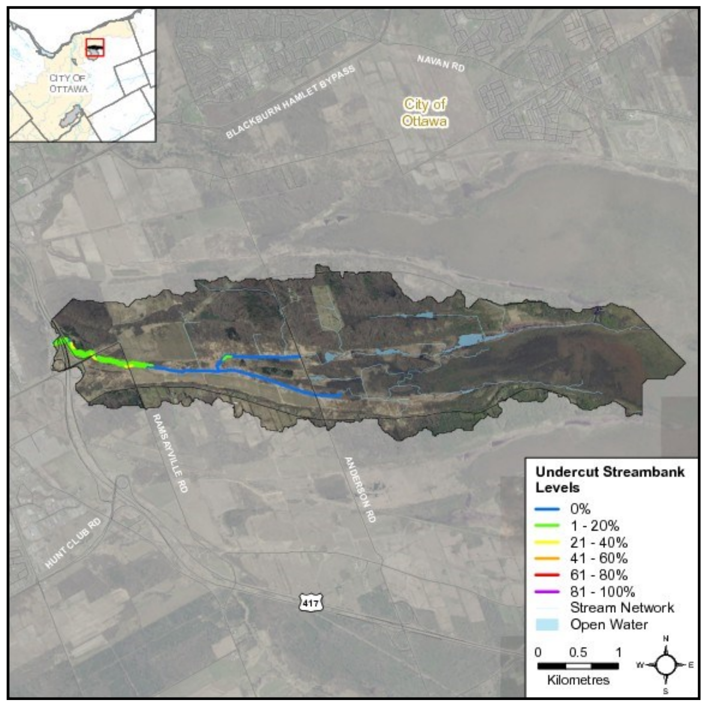


Figure 7 Undercut stream banks along Borthwick Creek and the Borthwick Creek Branch

Undercut banks north of Walkley Road along Borthwick Creek

Stream Shading

Grasses, shrubs and trees all contribute towards shading a stream. Shade is important in moderating stream temperature, contributing to food supply and helping with nutrient reduction within a stream. Stream cover is assessed as the total coverage area in each section that is shaded by overhanging trees/grasses and tree canopy, at greater than one meter above the water surface.

Figure 8 shows the percentage of sections surveyed with various levels of stream shading. The majority of sections, 36 of them, had a shade cover of one to 20 percent, which was the highest shading observed. One section had 21 to 40 percent shade cover. No cover was observed in ten of the sections. Figure 9 shows the distribution of these shading levels as a percentage of sections surveyed along Borthwick Creek.

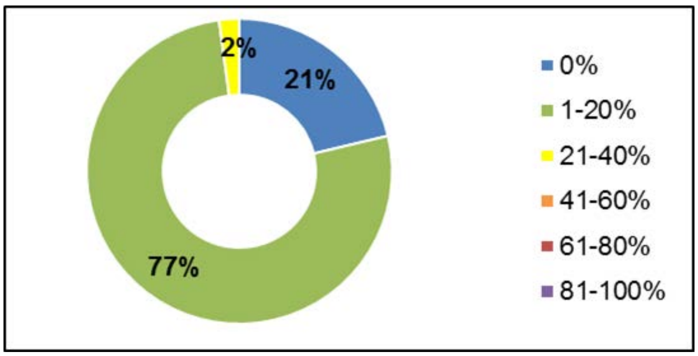


Figure 8 Stream shading along Borthwick Creek and Borthwick Creek Branch combined

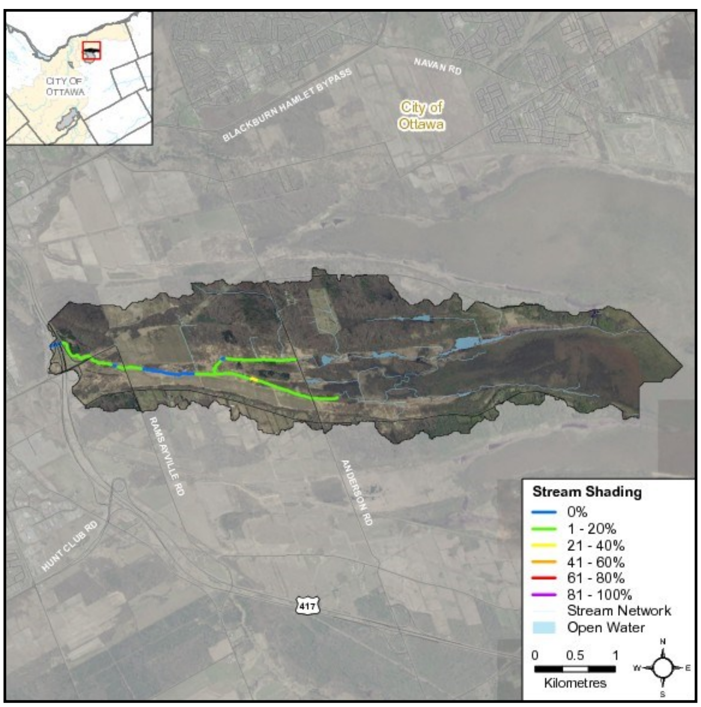


Figure 9 Stream shading along Borthwick Creek and the Borthwick Creek Branch

A mix of trees and plants comprised the majority of shading. Overhanging plants, mainly grasses, robust and broad leaved emergent plants, were seen in 79 percent of the left banks and 83 percent of the right banks.

Overhanging Trees and Branches

Trees and branches that are less than one meter from the surface of the water are defined as overhanging. Overhanging branches and trees provide a food source, nutrients and shade which helps to moderate instream water temperatures.

Figure 10 shows the presence and percentage within each section of overhanging trees and branches that were observed along Borthwick Creek. Of the surveyed portions, 19 percent of the sections had overhanging trees and branches on the left bank, and 17 percent of the sections had overhanging trees on the right bank.

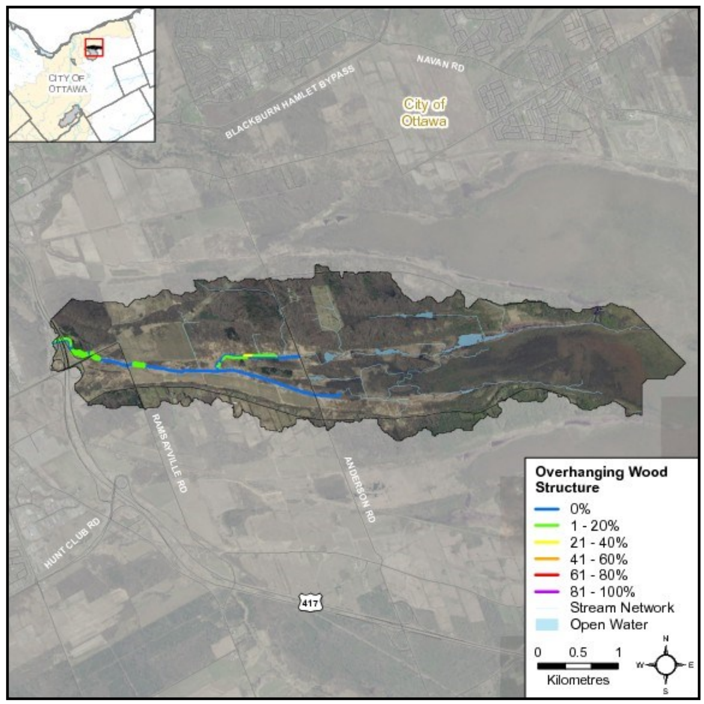


Figure 10 Overhanging trees and branches along Borthwick Creek and the Borthwick Creek Branch

Overhanging plants, such as grasses, contribute most of the shading along Borthwick Creek west of Anderson Road

Borthwick Creek Instream Aquatic Habitat

Habitat Complexity

Habitat complexity is a measure of the diversity of habitat types and features within a stream. Streams with high habitat complexity support a greater variety of species niches, and therefore contribute to greater diversity. Factors such as substrate, morphologic conditions (pools, riffles) and cover material (vegetation, wood structure, etc.) all provide crucial habitat to aquatic life. Habitat complexity is assessed based on the presence of boulder, cobble and gravel substrates, as well as the presence of instream wood structure. A higher score shows greater complexity where a variety of species can be supported. Figure 11 shows habitat complexity of the sections surveyed: 40 percent had no complexity; 30 percent had a score of one; nine percent scored two; and 15 percent scored three. Six percent of the sections surveyed scored four for habitat complexity.

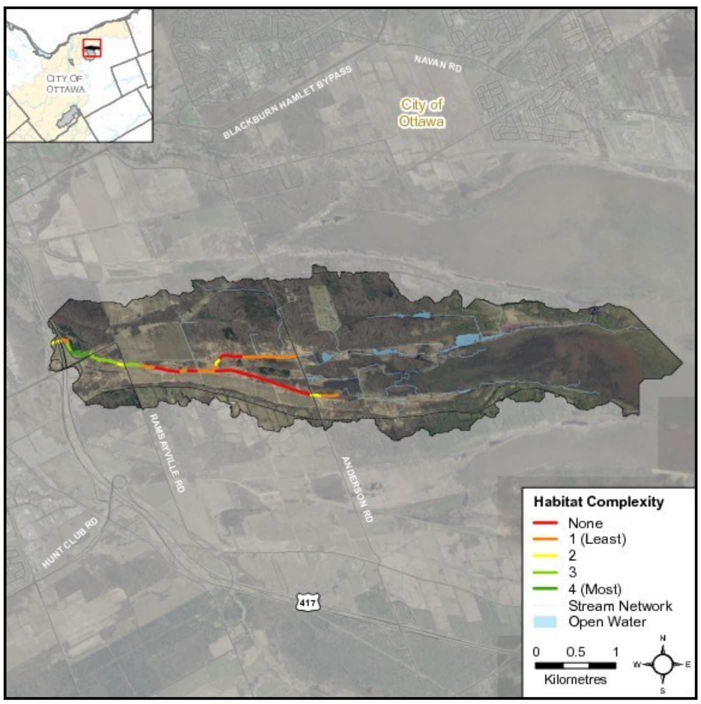
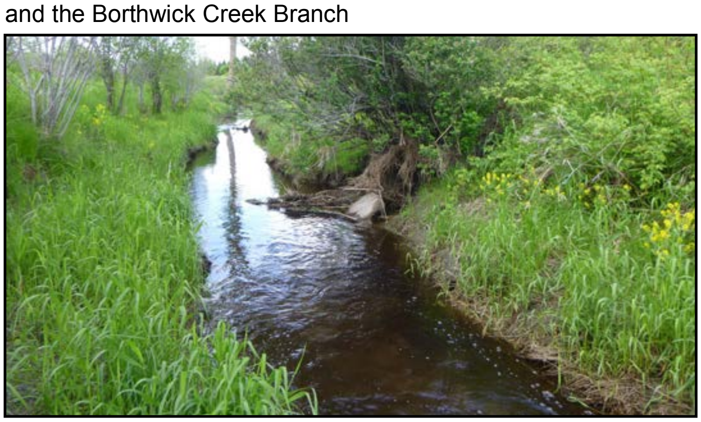


Figure 11 Instream habitat complexity along Borthwick Creek and the Borthwick Creek Branch



Section of Borthwick Creek with complex habitat features including boulders, gravel and instream wood structure

Instream Substrate

Diverse substrate is important for fish and benthic invertebrate habitat because some species have specific substrate requirements and for example will only reproduce on certain types of substrate. The absence of diverse substrate types may limit the diversity of species within a stream.

Substrate complexity along Borthwick Creek was observed to be fairly homogenous in 89 percent of sections surveyed, and heterogenous in the remaining eleven percent. Figure 12 shows the substrate types observed. It is a system dominated by clay, with 100 percent of sections containing this type of substrate. Most sections surveyed also contained silt. Other substrate types included sand, gravel, cobble and boulders.

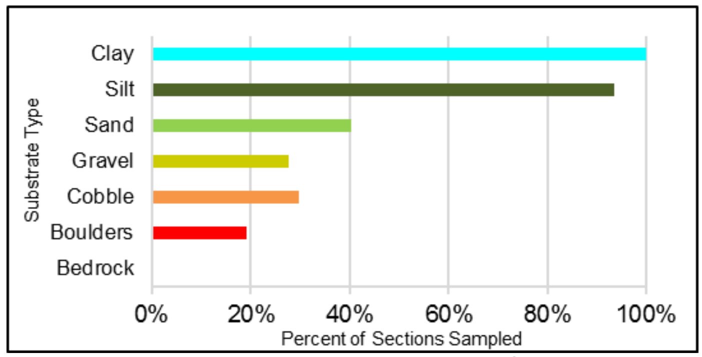


Figure 12 Instream substrate along Borthwick Creek and Borthwick Creek Branch combined

Figure 13 shows the dominant substrate types along the creek. From the assessed areas, clay was the dominant substrate type in 53 percent of sections surveyed, silt in 45 percent and sand was dominant in two percent.

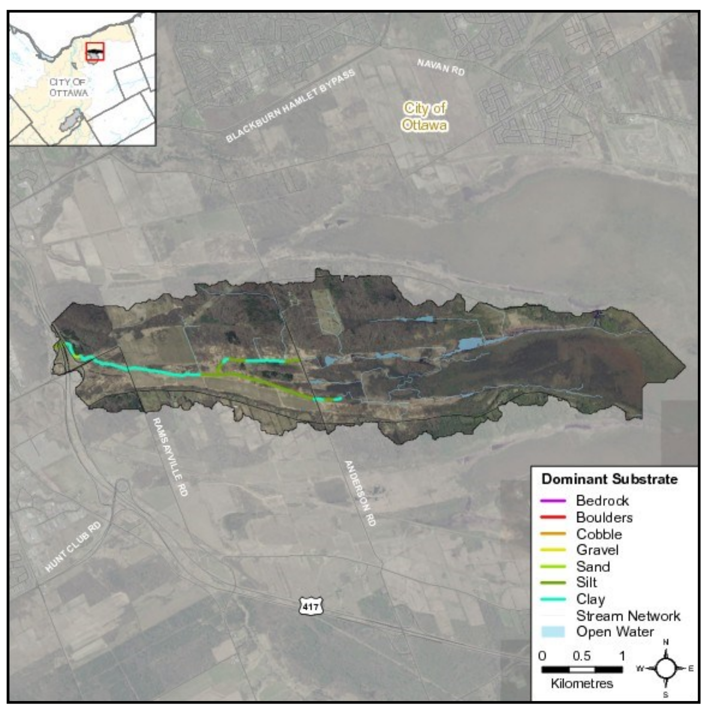


Figure 13 Dominant instream substrates along Borthwick Creek and the Borthwick Creek Branch

Instream Morphology

Pools and riffles are important habitat features for aquatic life. Riffles are fast flowing areas characterized by agitation and overturn of the water surface. Riffles thereby play a crucial role in contributing to dissolved oxygen conditions and directly support spawning for some fish species. They are also areas that support increased benthic invertebrate populations which are an important food source for many aquatic species. Pools are characterized by minimal flows, with relatively deep water and winter and summer refuge habitat for aquatic species. Runs are moderately shallow, with unagitated surfaces of water and areas where the thalweg (deepest part of the channel) is in the center of the channel.

Figure 14 shows that the surveyed portions of Borthwick Creek has moderate diversity of morphological conditions, suitable for a variety of aquatic species and life stages; 66 percent of sections contained pools, 23 percent of sections contained riffles and 100 percent contained runs. Figure 15 shows the locations of sections surveyed which contained riffle habitat and the extent of presence within each section.

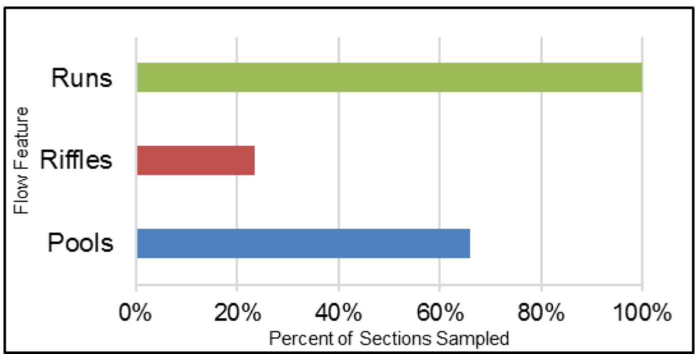


Figure 14 Instream morphology along Borthwick Creek and Borthwick Creek Branch combined

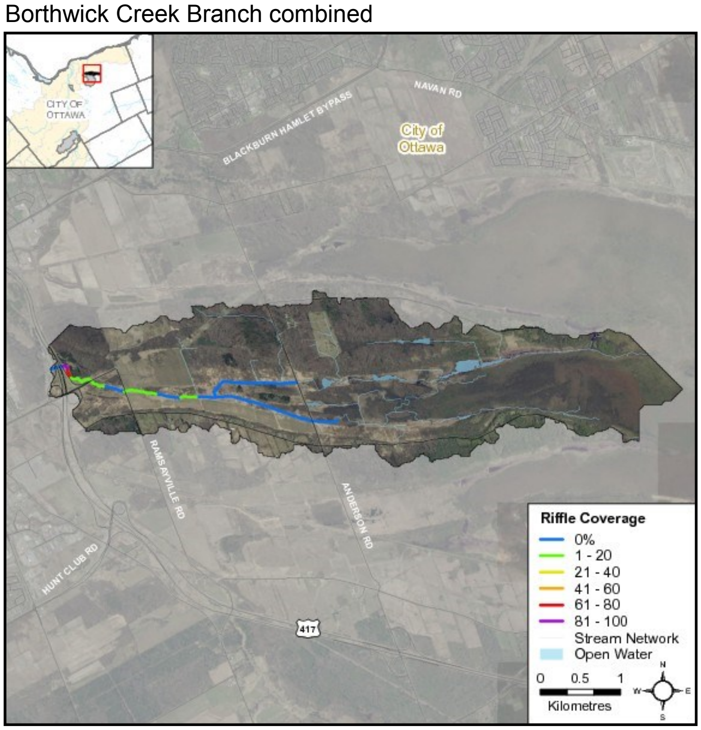


Figure 15 Riffle habitat locations along Borthwick Creek and the Borthwick Creek Branch

Instream Wood Structure

Figure 16 shows that a large portion of Borthwick Creek had moderate levels of instream wood structure in the form of branches and trees. Instream wood structure is important for fish and wildlife habitat, by providing refuge and feeding areas. Excessive amounts can result in temporary seasonal migration barriers.

Instream wood structures found along Borthwick Creek and its Branch are important for fish and wildlife habitat

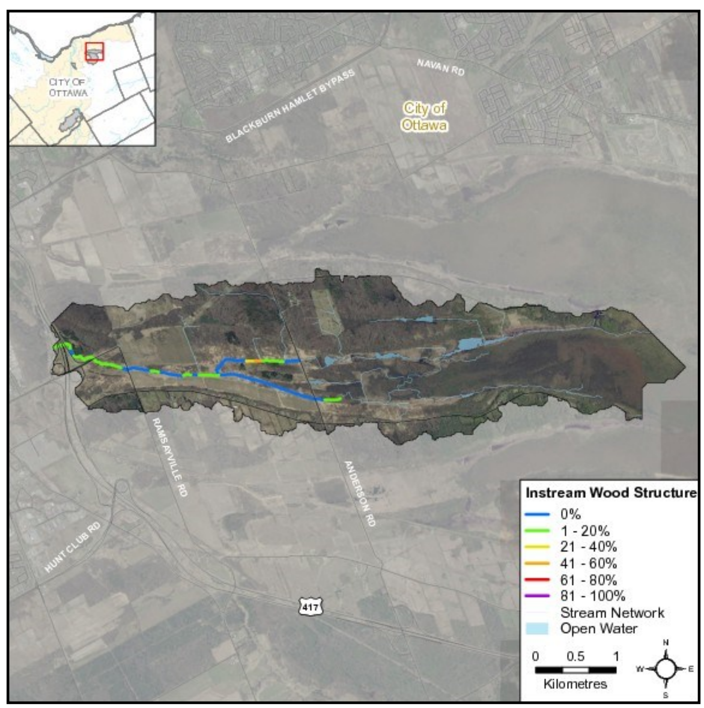


Figure 16 Instream wood structures along Borthwick Creek and the Borthwick Creek Branch

Instream Aquatic Vegetation Type

Instream vegetation is a key component of aquatic ecosystems. It promotes stream health by:

- Providing riparian and instream habitat.
- Maintaining water quality by erosion control, nutrient cycling, and pollutant absorption.
- Stabilizing flows and reducing shoreline erosion.
- Contributing dissolved oxygen via photosynthesis.
- Moderating temperatures through shading.

Figure 17 shows the aquatic vegetation community structure along Borthwick Creek. Vegetation types included: submerged vegetation present in 91 percent of sections; narrow-leaved emergent vegetation in 80 percent; free-floating in 40 percent; floating plants in 26 percent; robust emergent and algae in 23 percent; broad -leaved emergent in nine percent of sections.

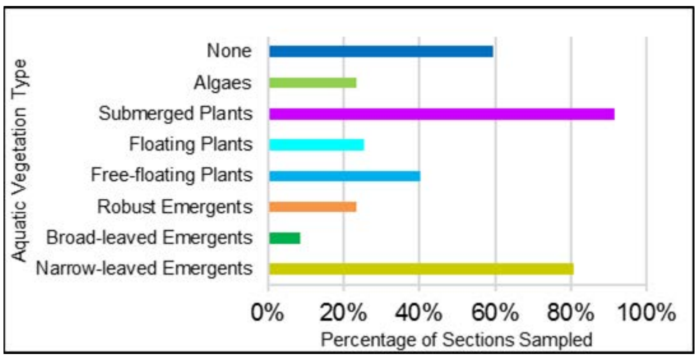


Figure 17 Aquatic vegetation presence along Borthwick Creek and Borthwick Creek Branch combined

Figure 18 shows Borthwick Creek had diverse instream aquatic vegetation and submerged vegetation was the most dominant type. Narrow-leaved emergent plants dominated 19 percent of sections; robust emergent and floating plants were dominant in two percent.

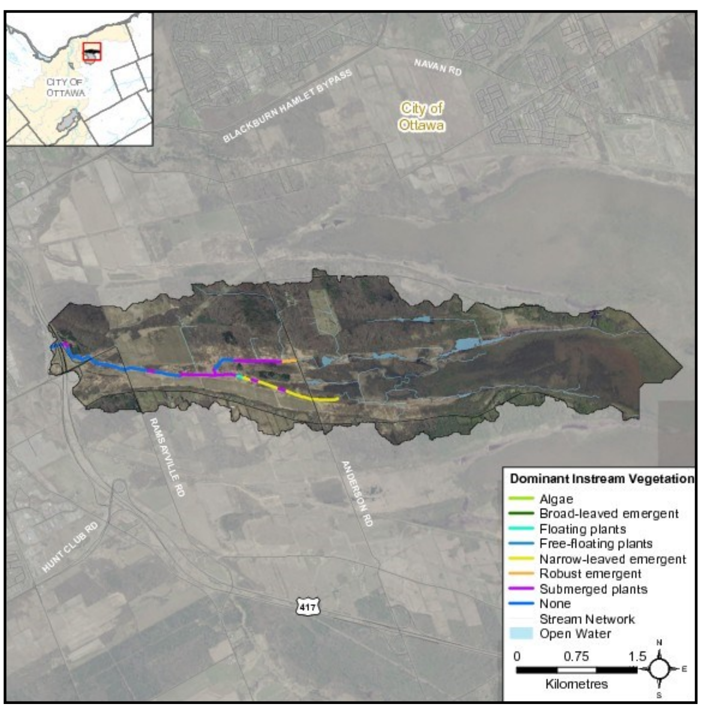


Figure 18 Dominant instream vegetation in Borthwick Creek and the Borthwick Creek Branch

Instream Vegetation Abundance

The abundance of instream vegetation is also crucial for aquatic ecosystem health. Lack of vegetation, rare or low abundances can impair the ability of plants to contribute adequately to dissolved oxygen, provide habitat, and remove nutrients and contaminants. Extensive amounts of vegetation can also have negative impacts by lowering dissolved oxygen levels. It can act as a physical barrier for humans and wildlife, and it can lead to a reduction in plant diversity. Invasive species in particular tend to have this extensive mode of growth.

Abundance of vegetation is classified by the amount of vegetation present along each section. Levels of vegetation are categorized based on the extent of coverage of a section from none and sparse to an entire section choked with vegetation. As seen in Figure 19, 62 percent of sections along Borthwick Creek had low levels of vegetation in part, 34 percent had normal, and 15 percent had both extensive and common vegetation. Rare abundance was observed in 17 percent of sections surveyed and no vegetation was found along 62 percent.

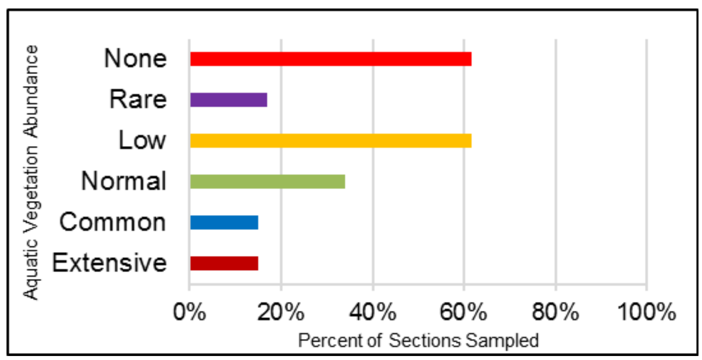


Figure 19 Instream vegetation abundance along Borthwick Creek and Borthwick Creek Branch combined

Slender-leaved pond weed is a type of submerged vegetation observed along Borthwick Creek

Borthwick Creek Stream Health

Invasive Species

Invasive species are harmful to the environment, the economy and our society. They have high reproduction, quick establishment of dense colonies, tolerate a variety of environmental conditions and lack natural predators. They can have major implications on stream health and reduce species diversity (OMNR 2012). They can be difficult to eradicate, however it is important to continue to research, monitor and manage them.

Invasive species were observed in all sections surveyed along Borthwick Creek, Figure 20 shows the diversity of species observed per section surveyed.

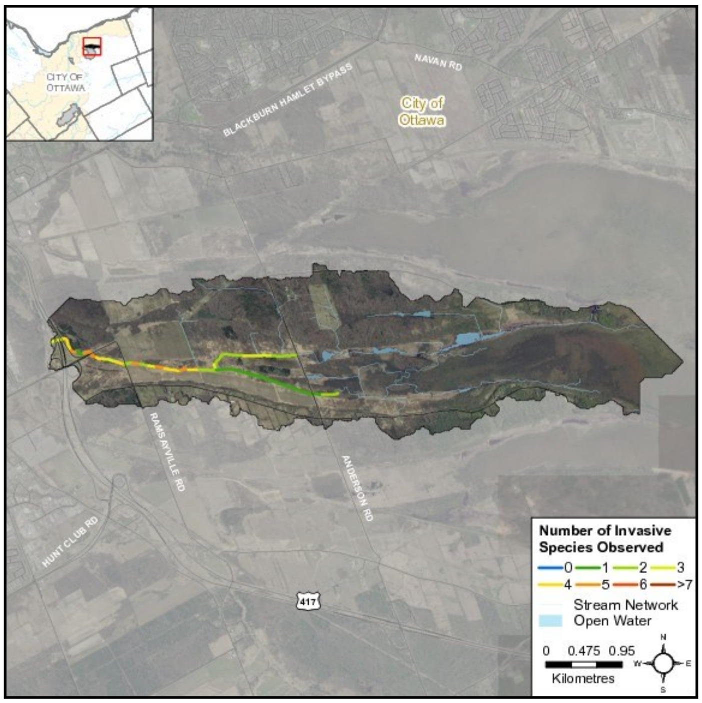


Figure 20 Invasive species diversity along Borthwick Creek and the Borthwick Creek Branch

The following are a list of species observed in 2019 in the surveyed portions of Borthwick Creek:

- common buckthorn (*Rhamnus cathartica*)
- curly-leaved pondweed (*Potamogeton crispus*)
- Eurasian water-milfoil (*Myriophyllum spicatum*)
- European frog-bit (*Hydrocharis morsus-ranae*)
- glossy buckthorn (*Rhamnus frangula*)
- non-native honeysuckles (*Lonicera spp.)*
- Manitoba maple (*Acer negundo*)
- non-native *Phragmites* (*Phragmites australis*)
- poison/wild parsnip (*Pastinaca sativa*)
- purple loosestrife (*Lythrum salicaria*)
- rusty crayfish (*Orconectes rusticus*)

Invasive curly-leaved pondweed observed along surveyed portions of Borthwick Creek

To report and find information about invasive species visit

http://www.invadingspecies.com

Managed by the Ontario Federation of Anglers and Hunters

Pollution

Figure 21 shows where pollution was observed along Borthwick Creek. The levels of garbage found in the main portion of the stream were low, with 79 percent of sections surveyed containing no garbage. Garbage on the stream bottom was found in 19 percent of sections surveyed. Other types of pollution, included tires buried along the banks of the stream in two percent of sections surveyed.

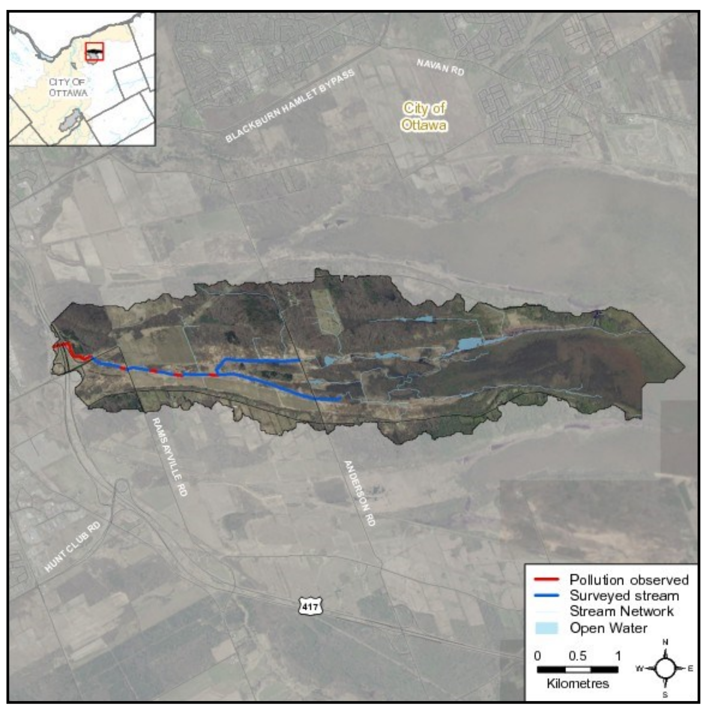


Figure 21 Pollution observed along Borthwick Creek and the Borthwick Creek Branch

Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and stream health (Table 1). Wildlife observations are noted during monitoring and survey activities; they do not represent an extensive evaluation of species presence in the Borthwick Creek catchment.

White-striped black moth (above) and a giant water bug (below) are some of the invertebrates observed along Borthwick Creek

Juvenile giant floater mussel (above) and a newly transformed juvenile green frog (below) found along Borthwick Creek

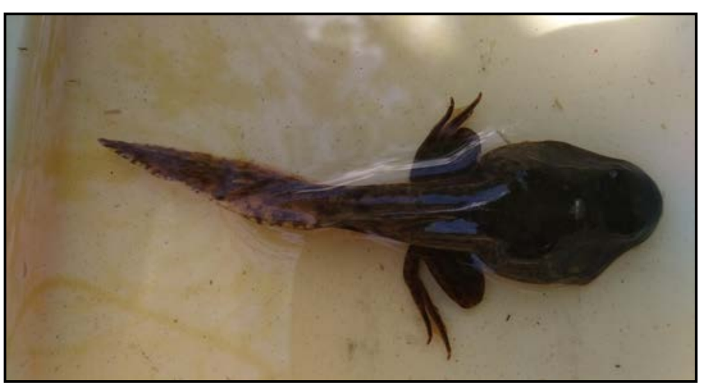
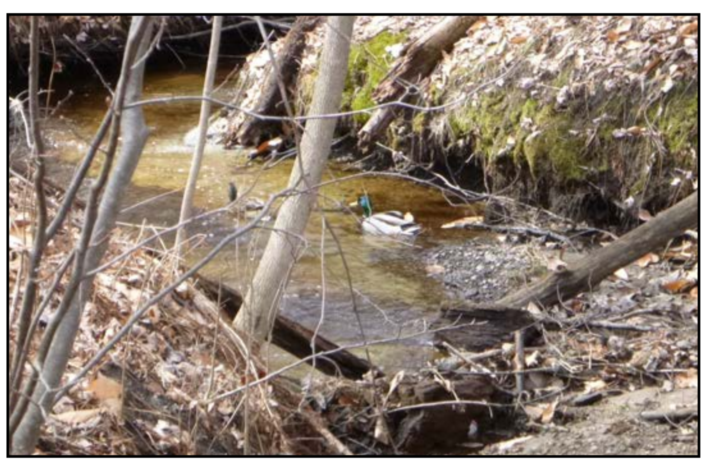


Table 1 Wildlife observations along Borthwick Creek and the Borthwick Creek Branch in 2019

Birds	American bittern, American goldfinch, American robin, black-capped chickadee, Canada goose, common grackle, eastern kingbird, great blue heron, grey catbird, house finch, killdeer, least sandpiper, mallard, pileated woodpecker, song sparrow, red-winged blackbird, tree swallow, turkey vulture, yellow warbler
Reptiles & Amphibians	American bullfrog, American toad, gray treefrog, green frog, northern leopard frog, snapping turtle
Mammals	American beaver, coyote tracks, deer tracks, moose tracks, muskrat tracks, raccoon tracks
Aquatic Insects & Benthic Invertebrates	crayfish, dragonfly larvae, damselfly larvae, isopods, giant floater, giant water bug, leeches, mussels, snails, whirligig beetle, water striders
Other	beetles, black flies, bumblebees, butterflies, damselflies, deer flies, dragonflies, mosquitoes, moths, spiders, snails

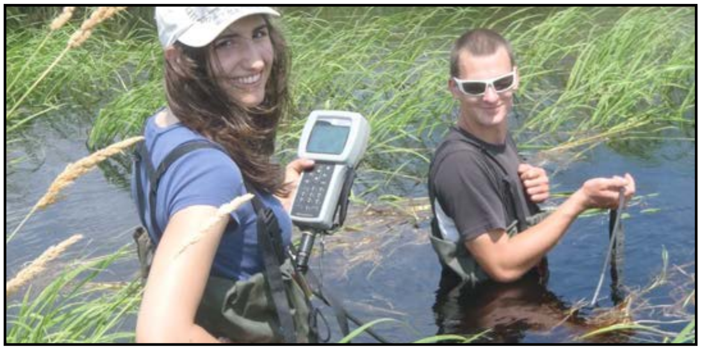
Tree swallows on a dead standing tree in Borthwick Creek (above) and a pair of mallards (below) observed in the headwaters of the Borthwick Creek catchment



Borthwick Creek Water Chemistry

Water Chemistry Assessment

Water chemistry collection is done at the start and end of each 100 meter section with a multiparameter YSI probe. The parameters monitored are: air and water temperature, pH, conductivity, dissolved oxygen concentration and saturation.



Volunteers collecting water chemistry measurements with a multiparameter YSI probe

Dissolved Oxygen

Dissolved oxygen is essential for a healthy aquatic ecosystem, fish and other aquatic organisms need oxygen to survive. The level of oxygen required is dependent on the particular species and life stage. The lowest acceptable concentration for the early and other life stages according to the Canadian water quality guidelines for the protection of aquatic life are: 6.0 milligrams per liter in warm-water biota and 9.5 milligrams per liter for cold-water biota (CCME 1999).

Figure 22 shows the concentration levels found in the surveyed portions of Borthwick Creek. The two dashed lines depicted represent the Canadian water quality guidelines. Most of the surveyed portions were found to have oxygen levels below the Canadian water quality guidelines (sec. 18-32; B1-B15). Lower levels of dissolved oxygen are typically found in wetland habitats as a result of high biological oxygen demand. Dissolved oxygen levels that are sufficient to support warm-water aquatic life were found in the areas approaching the confluence with Greens Creek (sec. 1-17). Average concentration levels across the system were 5.0 mg/L.

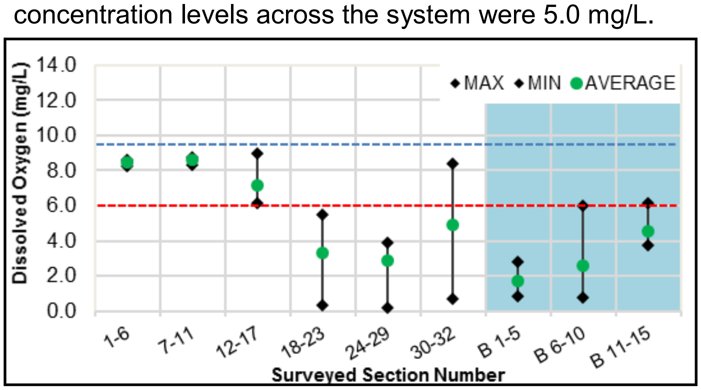


Figure 22 Dissolved oxygen ranges along surveyed sections of Borthwick Creek: sections 1-32 represent the main stem, sections B1-15 in blue represent the branch

Conductivity

Conductivity is a measure of water's capacity to conduct electrical flow. This capacity is dictated by the presence of conductive ions that originate from inorganic materials and dissolved salts. Water conductivity in natural environments is typically dictated by the geology of the area, however anthropogenic inputs also have a profound effect. Currently there is no existing guideline for stream conductivity levels, however conductivity measurements outside of normal range across a system are good indicators of anthropogenic inputs including unmitigated discharges and storm water input.

Figure 23 shows specific conductivity levels in Borthwick Creek, the average level is depicted by the dashed line (371 µS/cm). Conductivity levels are lower in areas approaching headwater reaches. Higher levels were observed in the sections closer to road infrastructure and the confluence with Greens Creek (sec.1-17).

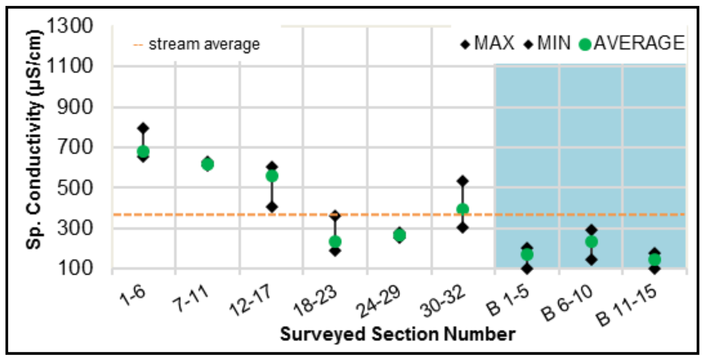


Figure 23 Specific Conductivity ranges along surveyed sections of Borthwick Creek: sections 1-32 represent the main stem, sections B1-15 in blue represent the branch

pH

pH is a measure of alkalinity or acidity. This parameter is also influenced by the geology of the system but can also be influenced by anthropogenic input. For pH, the provincial water quality objective (PWQO) is the range of 6.5 to 8.5 to protect aquatic life (MOEE 1994).

Figure 24 shows Borthwick Creek had mostly pH levels that meet the PWQO, depicted by the dashed lines. Average levels across the system were pH 6.78.

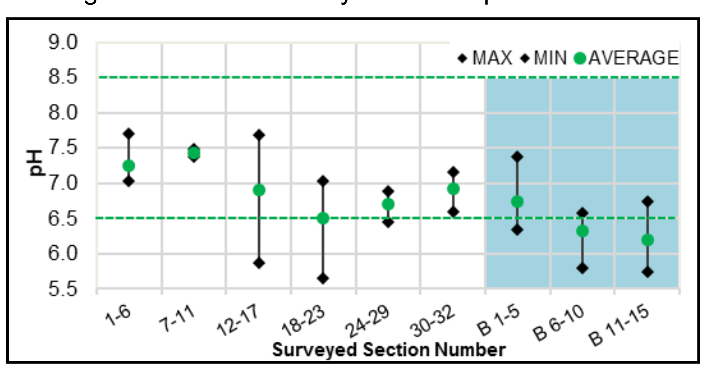


Figure 24 pH ranges along surveyed sections of Borthwick Creek: sections 1-32 represent the main stem, sections B1-15 in blue represent the branch

Oxygen Saturation (%)

Oxygen saturation is measured as the ratio of dissolved oxygen relative to the maximum amount of oxygen that will dissolve based on the temperature and atmospheric pressure. Well oxygenated water will stabilize at or above 100 percent saturation, however the presence of decaying matter/pollutants can drastically reduce these levels. Oxygen input through photosynthesis has the potential to increase saturation above 100 percent to a maximum of 500 percent, depending on the productivity level of the environment. In order to represent the relationship between concentration and saturation, the measured values have been summarized into 6 classes:

1) <100% Saturation / <6.0 mg/L Concentration

Oxygen concentration and saturation are not sufficient to support aquatic life and may represent impairment.

2) >100% Saturation / <6.0 mg/L Concentration

Oxygen concentration is not sufficient to support aquatic life, however saturation levels indicate that the water has stabilized at its estimated maximum. This is indicative of higher water temperatures and stagnant flows.

3) <100% Saturation / 6.0—9.5 mg/L Concentration

Oxygen concentration is sufficient to support warm-water biota, however depletion factors are likely present and are limiting maximum saturation.

4) >100% Saturation / 6.0—9.5 mg/L Concentration

Oxygen concentration and saturation levels are optimal for warm-water biota.

5) <100% Saturation / >9.5 mg/L Concentration

Oxygen concentration is sufficient to support cold-water biota, however depletion factors are likely present and are limiting maximum saturation.

6) >100% Saturation / >9.5 mg/L Concentration

Oxygen concentration and saturation levels are optimal for warm and cold-water biota.

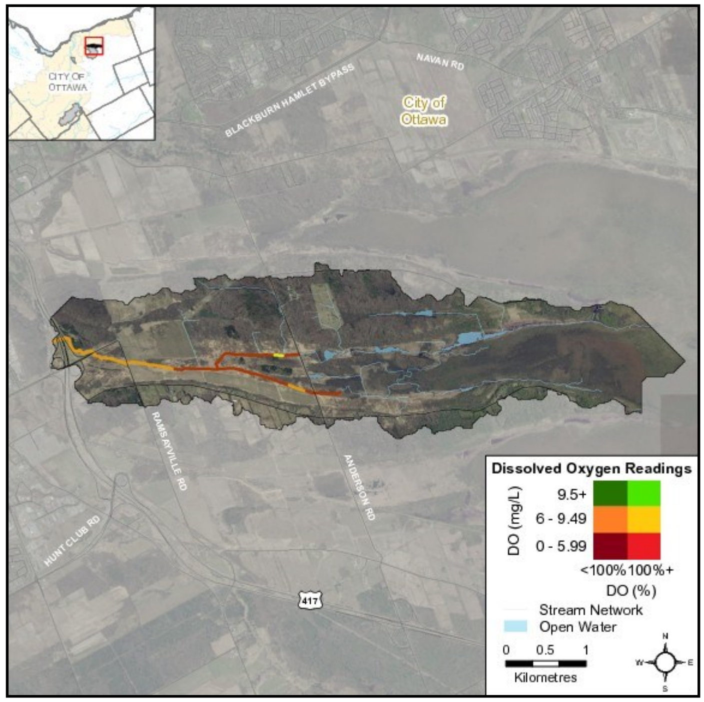


Figure 25 Bivariate assessment of dissolved oxygen concentration (mg/L) and saturation (%) along Borthwick Creek and the Borthwick Creek Branch

Figure 25 shows the oxygen conditions across the areas that were surveyed in 2019. Dissolved oxygen conditions in Borthwick Creek were sufficient to sustain warm-water biota in areas from the confluence with Greens Creek to just upstream of Ramsayville Road. Sections shown in dark red Figure 25, had significant levels of impairment both in concentration and percent saturation. These areas had wetland features that have naturally lower oxygen levels. There were some pockets that contained slightly higher concentrations and saturation conditions near Anderson Road. In this area various fish species were observed, even though the average conditions are low in oxygen, there were refuge areas throughout the system. An increase in shading conditions, through riparian planting of trees and shrubs can potentially help cool conditions and possibly increase levels of dissolved oxygen.

Section on Borthwick Creek west of Anderson Road with **impaired** oxygen conditions (Dissolved oxygen levels of 2.24 mg/L and 23.5 % saturation)

Section on Borthwick Creek near Anderson Road with **optimal** oxygen conditions for warm-water biota (Dissolved oxygen levels of 8.39 mg/L and 101.4 % saturation)

Specific Conductivity Assessment

Specific conductivity (SPC) is a standardized measure of electrical conductance, collected at or corrected to a water temperature of 25°C. SPC is directly related to the concentration of ions in water, and is influenced by the area geology and anthropogenic input as it contributes to the presence of dissolved salts, alkalis, chlorides, sulfides and carbonate compounds. The higher the concentration of these compounds, the higher the conductivity. Common sources of elevated conductivity include stormwater, agricultural inputs as well as commercial and industrial effluents.

In order to summarize the conditions observed, levels were evaluated as either normal, moderately elevated or highly elevated. These categories are defined by the amount of variation (standard deviation) at each section compared to the system's average.

Average levels of specific conductivity measured in the surveyed portions of Borthwick Creek (370.8 µS/cm) were below guidelines (500 µS/cm) used for the Canadian Environmental Performance Index (Environment Canada 2011).

Figure 26 shows relative specific conductivity levels in Borthwick Creek. Normal levels were maintained for most of the surveyed portions. Moderately elevated conditions were observed approaching Ramsayville Road and Walkley Extension Road. This area has agricultural land use influences and road runoff. Approaching the confluence with Greens Creek the highway passes over the creek which could elevate conductivity levels. All of these factors combined contributed to elevated conductivity levels.

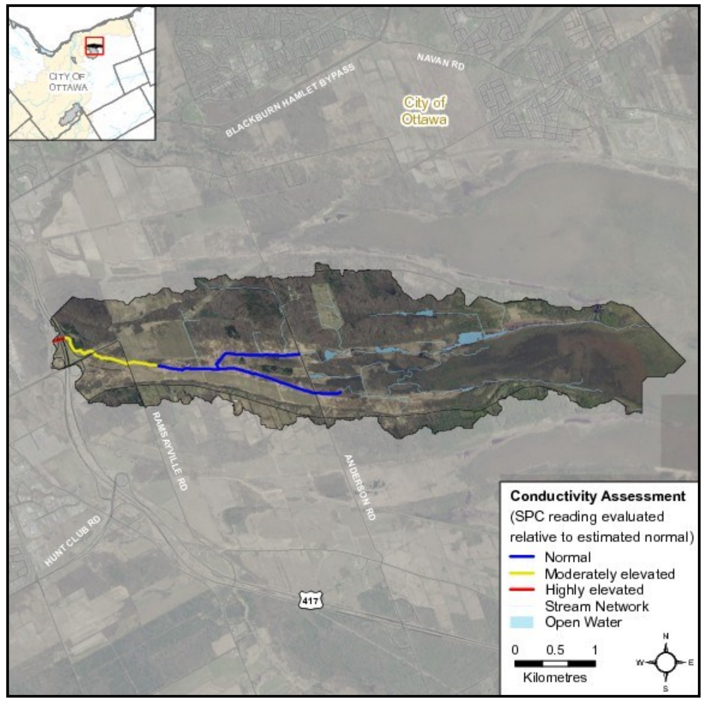


Figure 26 Relative specific conductivity levels along Borthwick Creek and the Borthwick Creek Branch

Section of Borthwick Creek near highway 417 with highly elevated levels of specific conductivity

Section of the Borthwick Creek Branch near the confluence with the main stem has lower than average specific conductivity levels

Borthwick Creek Thermal Classification

Thermal Classification

Instream water temperatures are influenced by various factors including, season, time of day, precipitation, storm water run off, springs, tributaries, drains, discharge pipes, stream shading from riparian vegetation and artificial shade created by infrastructure. To monitor water temperatures in Borthwick Creek, three temperature loggers were placed in April and retrieved in early November.

Figure 27 shows where thermal sampling sites were located. Due to instrument malfunction and a lost logger, only data from logger at Anderson Road (#3) was retrieved. Analysis of data from one logger (using the Stoneman and Jones, 1996, method adapted by Chu et al., 2009), indicated Borthwick Creek was classified as **coolwater** at Anderson Road (Figure 28). Fish species observed in that area have thermal preferences from cool to warm as indicated by Cocker at al. (2001).

Groundwater

Groundwater discharge areas can influence stream temperature, contribute nutrients, and provide important stream habitat for fish and other biota. During stream surveys and HDF assessments, indicators of groundwater discharge were noted when observed (Figure 29). Indicators included: springs/ seeps, watercress, iron staining, significant temperature changes and rainbow mineral film.

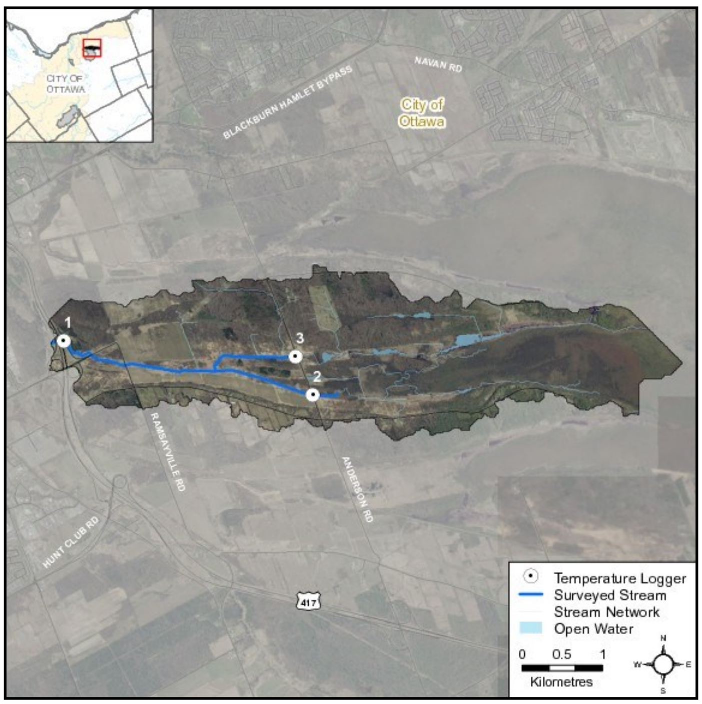


Figure 27 Temperature logger locations on Borthwick Creek and the Borthwick Creek Branch

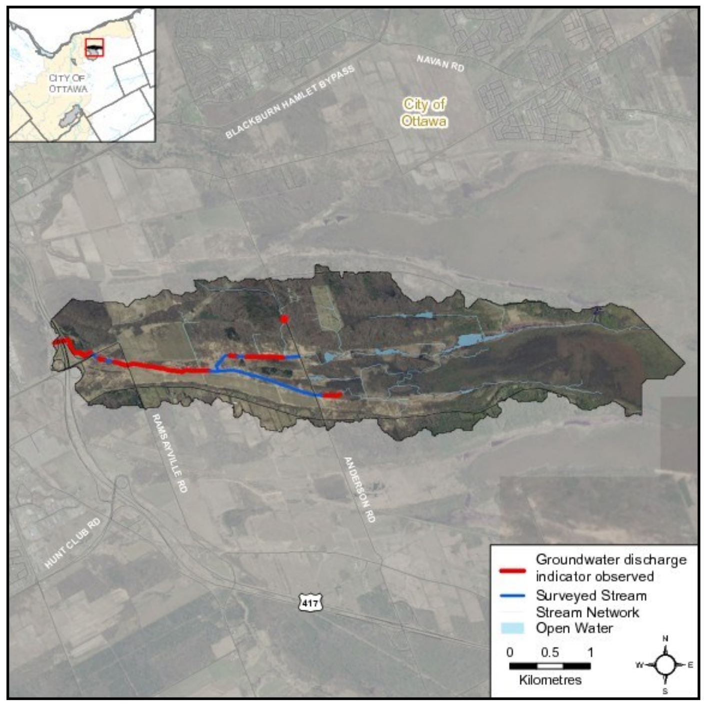


Figure 29 Groundwater indicators observed in the Borthwick Creek catchment

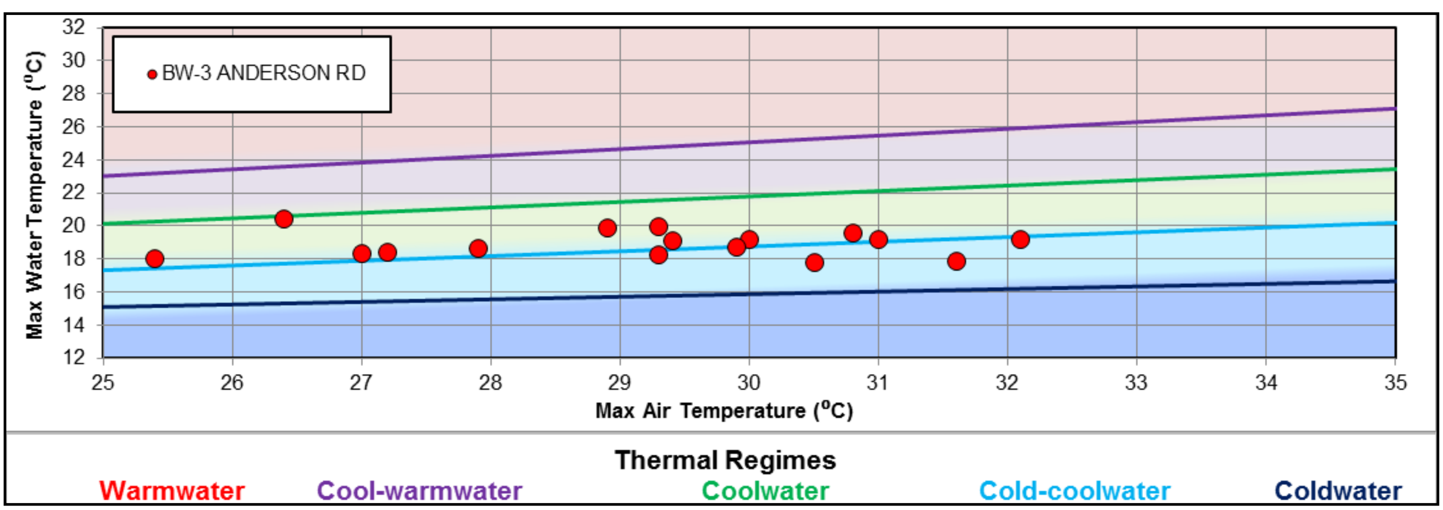


Figure 28 Thermal Classification for Borthwick Creek with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009): **coolwater** category for one site sampled on Borthwick Creek

Borthwick Creek Fish Community

Fish Community Summary

Six fish sampling sites were evaluated between May and July 2019. Four site locations were sampled with the use of a backpack electrofishing unit, and two sites were sampled with a bag seine net.

Thirteen species were captured in 2019, they are listed in Table 2 along with their thermal classification preferences (Coker et al., 2001) and MNR species codes. Borthwick Creek had a mixed fish community ranging from cold-cool to warm water species.

Table 2 Fish species observed in Borthwick Creek in 2019

Species	Thermal Class	MNR Species Code
blacknose dace *Rhinichthys atratulus*	**Cool**	BnDac
bluntnose minnow *Pimephales notatus*	**Warm**	BnMin
brassy minnow *Hybognathus hankinsoni*	**Cool**	BrMin
brook stickleback *Culaea inconstans*	**Cool**	BrSti
central mudminnow *Umbra limi*	**Cool**	CeMud
common shiner *Luxilus cornutus*	**Cool**	CoShi
creek chub *Semotilus atromaculatus*	**Cool**	CrChu
fathead minnow Pimephales promelas	**Warm**	FhMin
golden shiner *Notemigonus crysoleucas*	**Cool**	GoShi
johnny/tessalated darter *Etheostoma spp.*	**Cool**	EthSp
northern pearl dace *Margariscus nachtriebi*	**Cold-Cool**	PeDac
northern redbelly dace *Chrosomus eos*	**Cool-warm**	NRDac
white sucker *Catostomus commersonii*	**Cool**	WhSuc
Total Species		**13**

Central mudminnows were prominent in all sampling locations of Borthwick Creek

The sampling locations where these species were observed, as well as RVCA historical sites, are depicted in Figure 30. The codes used in the figure are the MNR species codes provided in Table 2. For comparisons across sampling years and a complete list of RVCA historical fish records from Borthwick Creek refer to page 22 of this report.

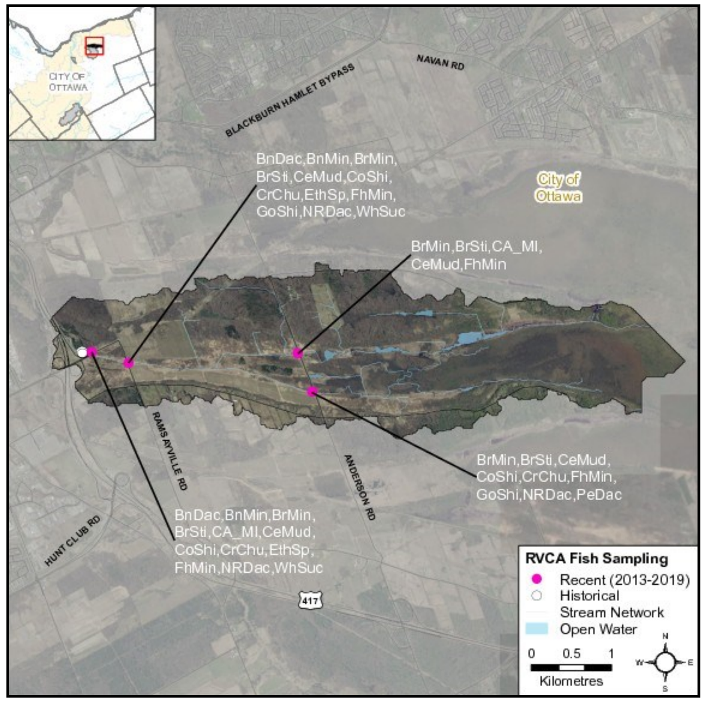


Figure 30 Borthwick Creek and the Borthwick Creek Branch fish sampling locations and fish species observations from 2013-2019

Fish community sampling by electrofishing (above) and a creek chub (below) observed in Borthwick Creek

Migratory Obstructions

It is important to know locations of migratory obstructions because these can prevent fish from accessing important spawning and rearing habitat. Migratory obstructions can be natural or manmade, and they can be permanent or seasonal.

There were no migratory obstructions observed along the surveyed portions of Borthwick Creek. The location of a migratory obstruction observed during headwater drainage feature assessments in 2019 is shown in Figure 31. This headwater feature had a perched culvert acting as a migration barrier.

Perched culverts create fish migratory obstructions and loss of aquatic habitat and seasonal grounds for many fish species

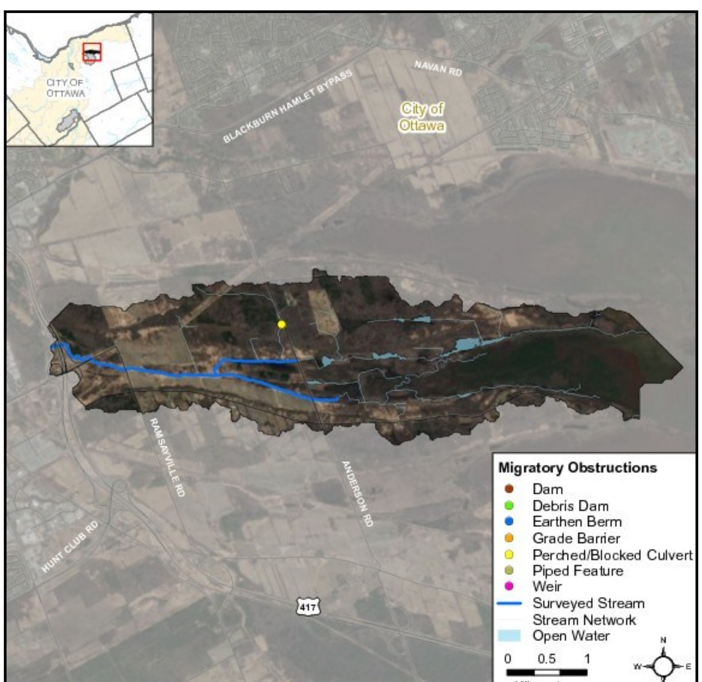


Figure 31 Locations of migratory obstructions along Borthwick Creek catchment

Beaver Dams

Beaver dams create natural changes in the environment. Some of the benefits include providing habitat for wildlife, flood control, and silt retention. Additional benefits come from bacterial decomposition of wood material used in the dams which removes excess nutrient and toxins. Beaver dams may be seasonal potential barriers to fish migration.

In 2019 a total of 18 beaver dams were identified on the surveyed portions of Borthwick Creek and are shown in Figure 32. Seven dams were observed in the Borthwick Branch, and 11 were observed on the main stem of Borthwick Creek. Additionally, five beaver lodges were noted as well. Due to the proximity to Mer Bleue it is not uncommon to see increased beaver activity near wetlands.

An active beaver dam and a lodge along Borthwick Creek downstream of Anderson Road

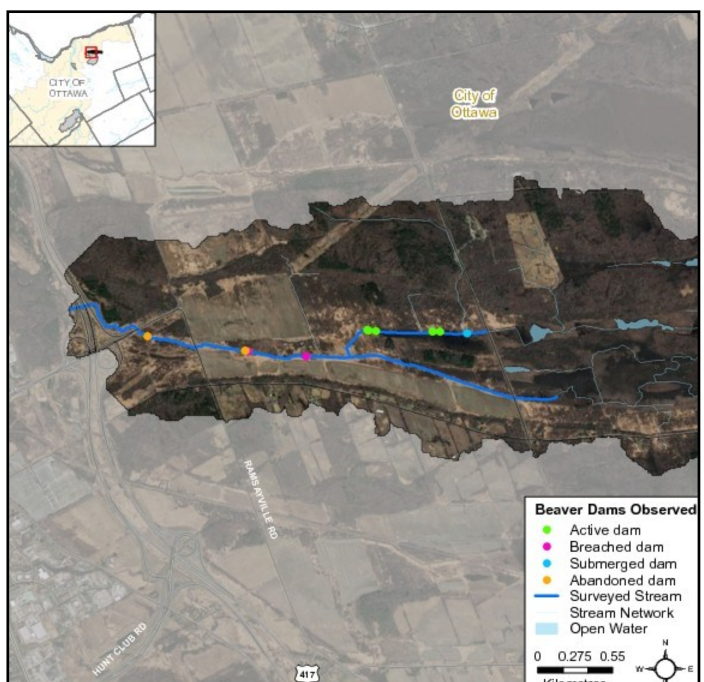


Figure 32 Locations of beaver dams along Borthwick Creek catchment

Headwater Drainage Feature Assessment

Headwater drainage features (HDF) represent the origin from which water enters a watershed. These are small depressions, stream and wetland features that capture flows from groundwater discharge, rain and snow melt water and transport it to larger streams and rivers. In their natural state, they provide (OSAP, 2019):

- flood mitigation as water storage capacity
- water purification and groundwater discharge
- seasonal and permanent habitat refuge for fish, including spawning and nursery areas
- wildlife migration corridors/breeding areas
- storage and conveyance of sediment, nutrients and food sources for fish and wildlife

Headwaters Sampling

RVCA is working with other Conservation Authorities and the Ministry of Natural Resources and Forestry to implement the protocol with the goal of providing standard datasets to support science development and monitoring of headwater drainage features.

Features were evaluated as per the Ontario Stream Assessment Protocol (OSAP, 2019). This protocol measures zero, first and second order headwater drainage features. It is a rapid assessment method characterizing the amount of water, sediment transport, and storage capacity within headwater drainage features. In 2019 a total of three HDF sites were assessed in the Borthwick Creek Catchment (Figure 33).

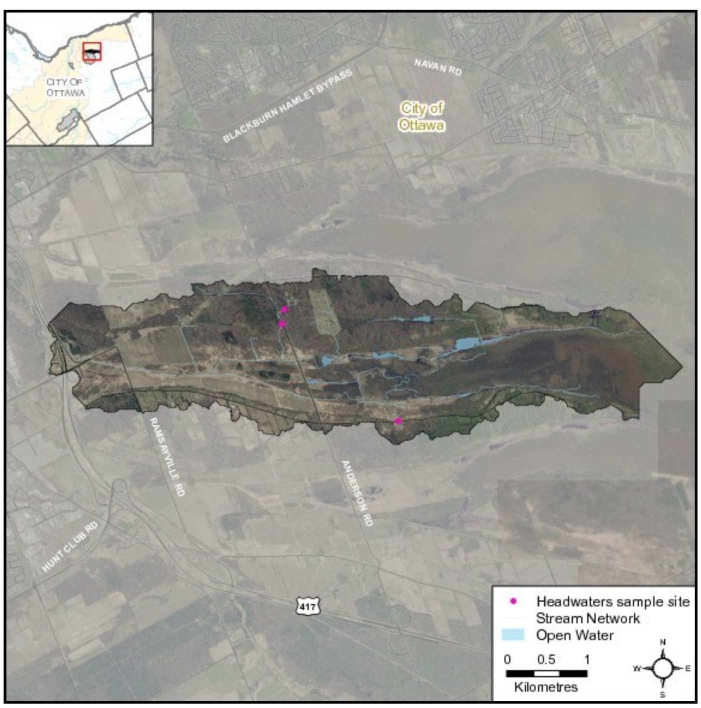


Figure 33 Location of headwater drainage feature sampling sites in the Borthwick Creek catchment

Feature Type

The headwater sampling protocol assesses the feature type in order to understand the function of each feature. The evaluation includes the following classifications: defined natural channel, channelized or constrained, multi-thread, no defined feature, tiled, wetland, swale, roadside ditch and pond outlet. By assessing the values associated with the headwater drainage features in the catchment area we can understand the ecosystem services that they provide to the watershed in the form of hydrology, sediment transport, and aquatic and terrestrial functions.

Figure 34 shows the feature type of the primary feature at the sampling locations. All features sampled were natural features. Defined natural channel features were observed in two sites, the other site was a wetland feature type.

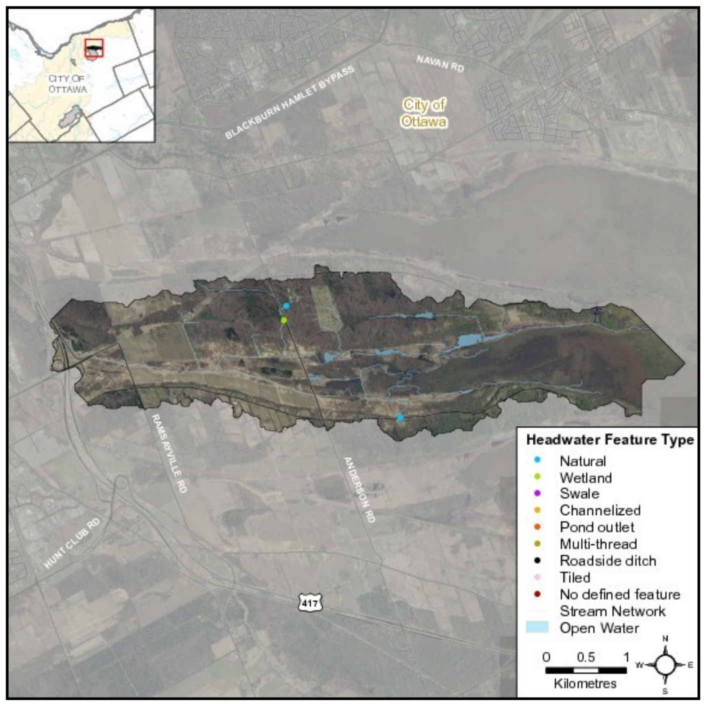


Figure 34 Map of Borthwick Creek catchment headwater drainage feature types

Defined natural channel headwater drainage feature type along an NCC walking path near Anderson Road

Headwater Feature Flow

Flow conditions in headwater features can be variable throughout the year in response to yearly seasonal weather conditions. This protocol targets features that are perennial or intermittent. Intermittent flow conditions are those where water typically flows at least six months of the year. Perennial systems flow year round. Sites were observed in the spring and summer; flow conditions were compared. Drought conditions were experienced in 2019 which influenced flow conditions in the summer.

Flow conditions in the Borthwick Creek catchment area are shown in Figure 35.

Intermittent headwater drainage feature with spring and summer conditions along an NCC walking path near Anderson Road

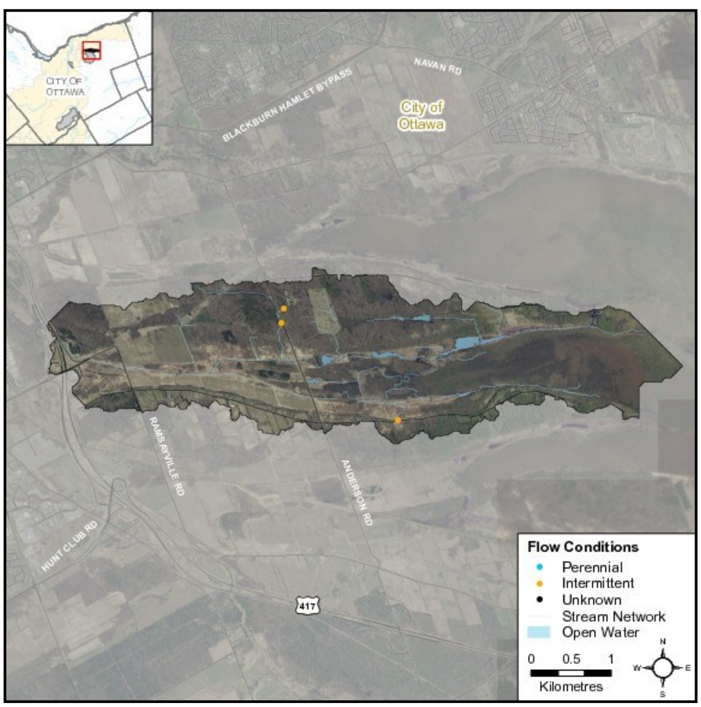


Figure 35 Headwater drainage feature flow conditions in the Borthwick Creek catchment

Feature Channel Modifications

Channel modifications can influence HDF conditions and function. Modifications that were of focus included dredging (and historical channel straightening), hardening (e.g. rip-rap, armourstone, gabion baskets) or on-line ponds.

Figure 36 shows channel modifications observed in Borthwick Creek headwater drainage features. Modifications in this catchment for its headwater drainage features are channel hardening with rip rap or gabion baskets.

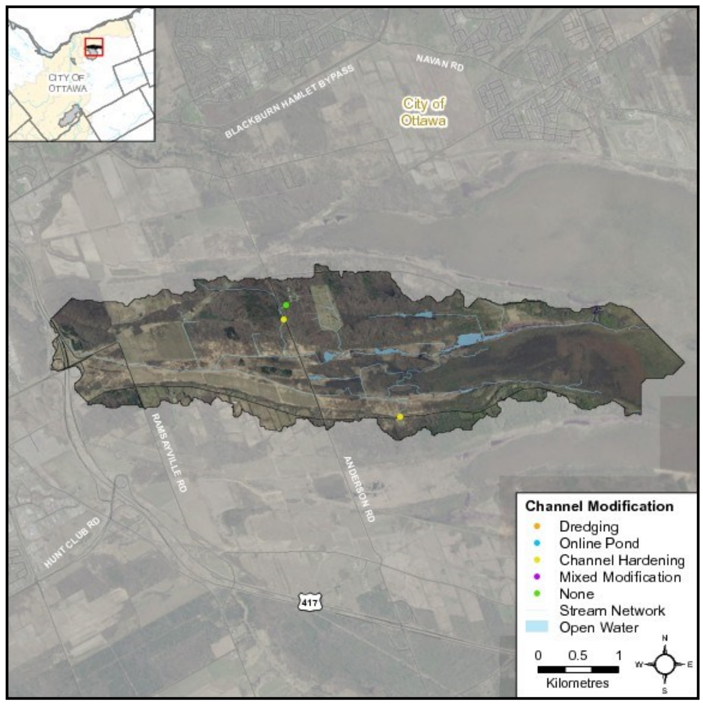


Figure 36 Headwater drainage feature channel modifications in the Borthwick Creek catchment

An example of the use of gabion baskets on a headwater drainage feature on Anderson Road

Headwater Feature Vegetation

Headwater feature vegetation evaluates the type of vegetation that is found within the drainage feature. The type of vegetation within the channel influences the aquatic and terrestrial ecosystem values that the feature provides. For some types of headwater features the vegetation within the feature plays an important role in flow, sediment movement and provides wildlife habitat. The following classifications are evaluated: none, lawn, wetland, meadow, scrubland and forest.

Figure 37 depicts the dominant vegetation observed at the sampled sites in the Borthwick Creek catchment. One feature was dominated by meadow vegetation. Two features had no vegetation in the spring time, where flows and sediment transport are unmitigated by the lack of vegetation.

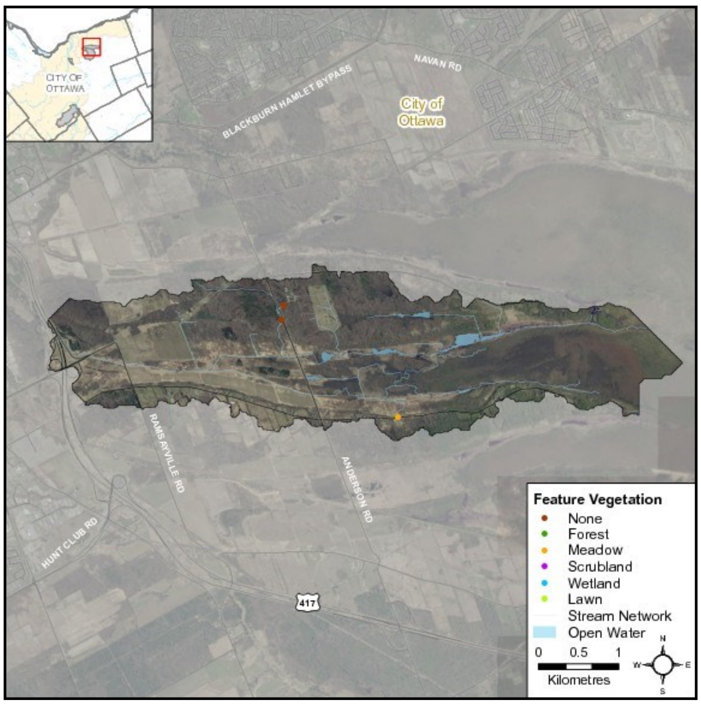


Figure 37 Headwater drainage in feature vegetation in the Borthwick Creek catchment

Meadow feature vegetation in a headwater drainage feature on Anderson Road

Headwater Feature Riparian Vegetation

Headwater riparian vegetation evaluates the type of vegetation that is found along the adjacent lands of a headwater drainage feature. The type of vegetation within the riparian corridor influences the aquatic and terrestrial ecosystem values that the feature provides to the watershed.

Figure 38 shows the type of riparian vegetation observed at the sampled headwater sites in the Borthwick Creek catchment. They are grouped as natural, and other riparian zones which have anthropogenic influences from agricultural areas, residential areas as well as road infrastructure.

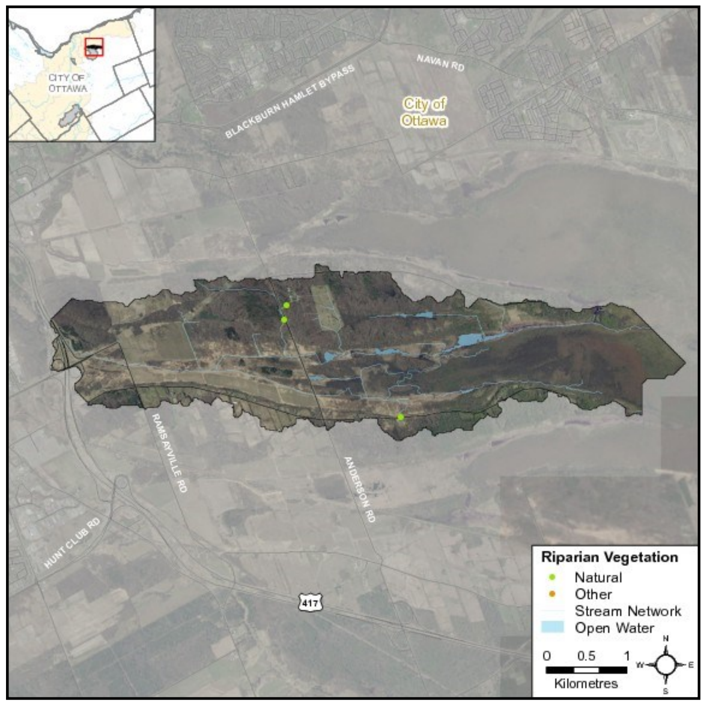


Figure 38 Riparian vegetation types along headwater drainage features in the Borthwick Creek catchment

Headwater drainage feature with natural scrubland and forest riparian vegetation along an NCC walking path

Headwater Feature Sediment Deposition

Assessing the amount of recent sediment deposition in a channel provides an index of the degree to which the feature could be transporting sediment downstream (OSAP, 2019). Sediment transport is a natural process, however, excessive sedimentation can be indicative of higher erosion than a natural system can accommodate. High sediment deposition can indicate the need for further assessment and potential implementation of best management practices.

From the features assessed, sediment deposition ranged from moderate to substantial. Two features had evidence of moderate deposition levels. One feature had substantial amounts of deposition. Figure 39 shows the levels of sediment deposition observed in the catchment headwaters.

Headwater Feature Upstream Roughness

Feature roughness is a relative measure of the amount of material within the feature that diffuses flows (OSAP, 2019). Materials on the channel bottom that provide roughness include vegetation, wood material as well as boulders and cobble substrates. Roughness can reduce erosion downstream of the feature, as well as providing important habitat to a variety of aquatic organisms, and producing food sources.

This parameter is categorized depending on the amount of roughness coverage in a channel: minimal (less than 10 %), moderate (10-40 %), high (40-60 %), and extreme (more than 60 %). In the Borthwick Creek catchment, all three sampled sited had moderate feature roughness as shown in figure 40.

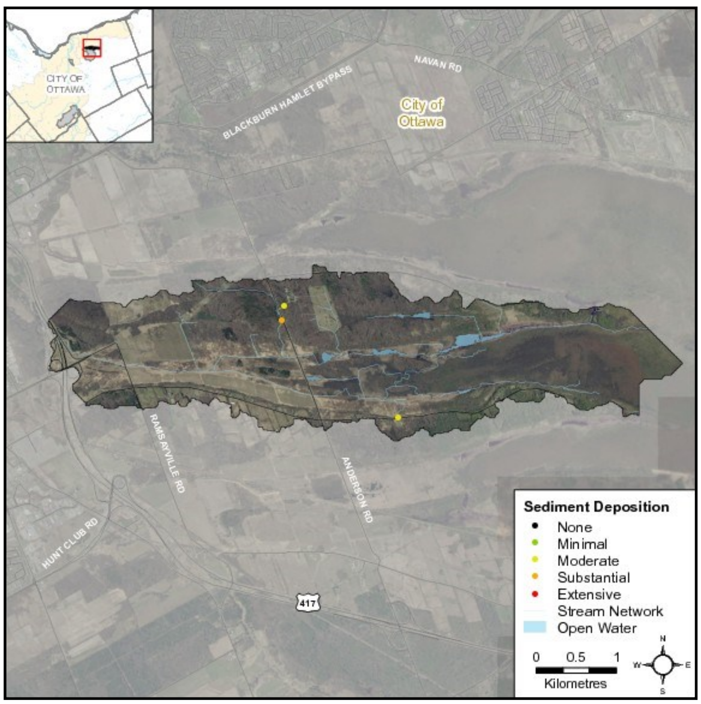


Figure 39 Headwater drainage feature sediment deposition in the Borthwick Creek catchment

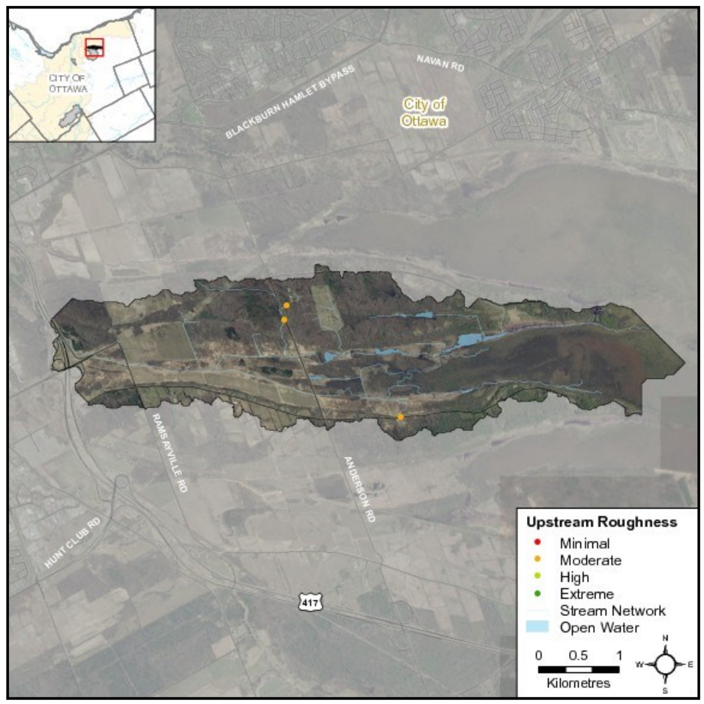


Figure 40 Headwater drainage feature roughness in the Borthwick Creek catchment

Substantial sediment deposition observed in a headwater drainage feature on Anderson Road

Moderate roughness due to low presence of vegetation and coarse substrate that diffuse flow

Stream Comparison Between 2007, 2013 and 2019

The following tables provide a comparison of observations on Borthwick Creek between the 2007, 2013 and 2019 survey years (RVCA 2007, RVCA 2013). Monitoring protocols since 2007 have been modified and enhanced, only certain data from that year can be compared to later years. In order to accurately represent current and historical information, the data was only compared for those sections which were surveyed in both 2013 and 2019. This results in changes to our summary information, averages presented in this section differ from ones in previous pages of this report. This information is a comparative evaluation and doesn't represent the entirety of our assessment.

Water Chemistry

Water chemistry parameters are collected throughout all the sections surveyed in the stream. This criteria reflects the conditions and changes in the environment. Variation in these conditions can be attributed to environmental and ecological changes. Some can be in part due to natural variability within the system from various weather, seasonal, and annual conditions. Table 3 shows a comparison of these water chemistry parameters between 2013 and 2019.

Average pH increased by 0.14 units from 2013 to 2019 and specific conductivity decreased from 2013 by 109 µS/cm. These slight changes may reflect seasonal variability. Average dissolved oxygen levels were found to be higher by 2.8 milligrams per liter from 2013 to 2019. These changes can also be attributed to seasonal conditions and cooler temperatures which are conducive to the stream's ability to hold more oxygen.

Table 3 Water chemistry comparison (2013/2019)

Water Chemistry (2013/2019)				
Year	**Parameter**	**Unit**	**Average**	**STND Error**
2013	pH	-	6.65	± 0.45
2019	pH	-	6.79	± 0.38
2013	Sp. Conductivity	us/cm	482.2	± 69.2
2019	Sp. Conductivity	us/cm	373.2	± 30.5
2013	Dissolved Oxygen	mg/L	2.2	± 0.02
2019	Dissolved Oxygen	mg/L	5.0	± 0.44
2013	Water Temperature	ºC	20.4	± 0.4
2019	Water Temperature	ºC	16.5	± 0.4
2013	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.67	± 0.20
2019	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.67	± 0.07

[1] ***Standardized Stream Temperature:*** Temperature data is collected via logger and standardized based on the following conditions:

- Daily maximum air temperatures must exceed 24.5 ºC
- No precipitation for 3 days preceding measurement
- Measurements to be taken between 4:00PM—6:00PM
- Water temperature points collected from July 1st —September 10th
- Logger must be deployed in flowing waters

Average summer water temperatures range from cooler water in 2019 (16.5°C) to warmer values in 2013 (20.4° C), with 3.9 degrees centigrade of variation. In 2019 cooler temperatures than the previous reporting year are probably due to the different sampling time windows. Observations from 2013 were made from July, whereas observations in 2019 were made in June. Aside from these general temperature observations, loggers provide a detailed recording of stream thermal conditions. Standardized stream temperature assessments account for climatic factors including air temperatures and precipitation. With the data collected from temperature loggers at Anderson Road, the 2019 data from the main stem and 2013 data from the branch, standardized stream temperature factors were calculated and summarized in Table 3. This factor has remained the same, 0.67 for every degree of air temperature from 2013 to 2019. In both cycle years, Borthwick Creek at both sites on Anderson Road was classified as cool water (methods from Chu et al., 2009).

Invasive Species

The percentage of sections surveyed where invasive species were observed had a significant increase of 44 percent (Table 4). All invasive species previously reported had an increase in the number of sections they were observed in. There are also several species that were not previously reported, including curly-leaved pondweed, Eurasian milfoil, non-native honey suckles, non-native *Phragmites*, wild parsnip and rusty crayfish.

Table 4 Invasive species presence (% of sections) observed in 2013 and 2019 (NPR are Not Previously Reported species)

Invasive Species	2013	2019	+/-
common & glossy buckthorn	21%	32%	▲
curly-leaved pondweed	NPR	28%	▲
Eurasian milfoil	NPR	4%	▲
honey suckle (non-native)	NPR	6%	▲
Manitoba maple	2%	9%	▲
Phragmites	NPR	19%	▲
poison/wild parsnip	NPR	2%	▲
purple loosestrife	51%	70%	▲
rusty crayfish	NPR	2%	▲
Total percent of sections invaded	**56%**	**100%**	▲

Pollution

Garbage accumulation on Borthwick Creek was found to decrease from 2007 to 2013 and back to 2007 levels by 2019. Frequent precipitation events in 2019 may have flushed garbage downstream. In 2019 the polluted sections contained garbage, such as plastics, packaging, cardboard, pylons, beverage containers and tires. Table 5 shows pollution levels in all three monitoring years.

Table 5 Pollution levels (presence in % of sections surveyed) comparison between 2007-3019

Pollution/Garbage	2007	2013	2019	+/-
floating garbage	6%	2%	0%	▼
garbage on stream bottom	16%	4%	20%	▲
unusual colouration	0%	0%	0%	▼
other	22%	0%	2%	▲
Total polluted sections	**22%**	**13%**	**22%**	▲

Instream Aquatic Vegetation

Table 6 shows decreases in instream aquatic vegetation from 2013-2019. Narrow-leaved emergent plants (e.g. sedges, submerged plants (e.g. pondweed) and robust emergent plants (e.g. cattails) were present in comparable abundance in both survey years. Free-floating plants (e.g. frog-bit), floating plants (e.g. water lilies) and algae had lower observations in the number of sections surveyed. Drastic declines seen in broad leaved emergent plants (e.g. arrowhead), associated with different seasonal plant emergence, observations in 2013 were made later in the summer compared to 2019.

Table 6 Instream aquatic vegetation (presence in % of sections) comparison between 2007-2019

Instream Vegetation	2013	2019	+/-
narrow-leaved emergent plants	77%	80%	▼
broad-leaved emergent plants	40%	7%	▼
robust emergent plants	36%	20%	▼
free-floating plants	57%	38%	▼
floating plants	51%	22%	▼
submerged plants	89%	91%	▲
algae	43%	20%	▼

Fish Community

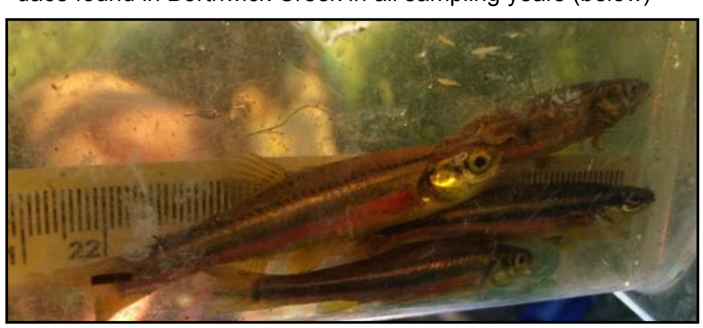
Fish sampling was carried out by the City Stream Watch program in 2007, 2013 and 2019 to evaluate fish community composition in Borthwick Creek (see Table 7). In total 15 species have been observed in Borthwick Creek. In 2007, nine fish species were captured at one site; in 2013, 13 species were observed in four sites; and 13 species were observed in six sites in 2019. Sample locations in 2019 were replicates of 2013, with a couple of new additions.

The majority of species observed in 2019 had been captured in previous years, with the blacknose dace and the pearl dace as new observations.

Table 7 Comparison of fish species caught between 2007-2019

Species	2007	2013	2019
blacknose dace *Rhinichthys atratulus*			X
bluntnose minnow *Pimephales notatus*		X	X
brassy minnow *Hybognathus hankinsoni*		X	X
brook stickleback *Culaea inconstans*	X	X	X
central mudminnow *Umbra limi*	X	X	X
common shiner *Luxilus cornutus*	X	X	X
creek chub *Semotilus atromaculatus*	X	X	X
emerald shiner *Notropis atherinoides*	X	X	
fathead minnow Pimephales promelas		X	X
finescale dace *Chrosomus neogaeus*		X	
golden shiner *Notemigonus crysoleucas*	X	X	X
johnny/tessalated darter *Etheostoma spp.*	X	X	X
northern pearl dace *Margariscus nachtriebi*			X
northern redbelly dace *Chrosomus eos*	X	X	X
white sucker *Catostomus commersonii*	X	X	X
Total Species 15	**9**	**13**	**13**

RVCA staff pulling a seine net (above) and northern redbelly dace found in Borthwick Creek in all sampling years (below)



Monitoring and Restoration

Monitoring on Borthwick Creek

Table 8 highlights recent and past monitoring that has been done on Borthwick Creek by the Rideau Valley Conservation Authority's City Stream Watch program. Monitoring activities and efforts have changed over the years.

Table 8 City Stream Watch monitoring on Borthwick Creek

Accomplishment	Year	Description
City Stream Watch Stream Monitoring	2007	3.2 km of stream was surveyed
	2013	4.7 km of stream was surveyed
	2019	4.7 km of stream was surveyed
City Stream Watch Fish Sampling	2007	one fish community site was sampled
	2013	four fish community sites were sampled
	2019	six fish community sites were sampled
City Stream Watch Thermal Classification	2007	two temperature probes were deployed from June to September
	2013	two temperature probes were deployed from June to September
	2019	one temperature probe was deployed from April to October
Headwater Drainage Feature Assessment	2013	six headwater drainage feature sites were sampled in the catchment (included main stem of Borthwick Creek)
	2019	three headwater drainage feature sites were sampled in the catchment

Volunteer co-op student placing a temperature probe along Borthwick Creek (above); NCC staff and RVCA staff assessing a headwater drainage feature in the Borthwick catchment

Potential Riparian Restoration Opportunities

Riparian restoration opportunities include potential enhancement through riparian planting. Opportunities were identified along Borthwick Creek surveyed areas (Figure 41).

Riparian Planting

Various riparian areas of Borthwick Creek can benefit from planting to increase plant diversity. Many sections had riparian buffers of low plant diversity. Additional planting would increase shading, enhance wildlife habitat, prevent soil erosion and mitigate negative impacts from runoff and anthropogenic input.

Area of Borthwick Creek north of Walkley Extension Road that would benefit from riparian planting

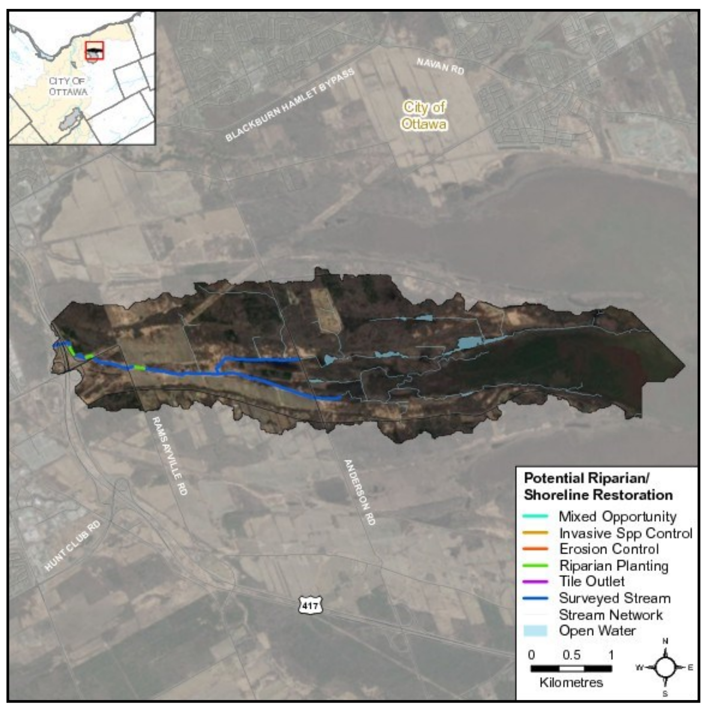
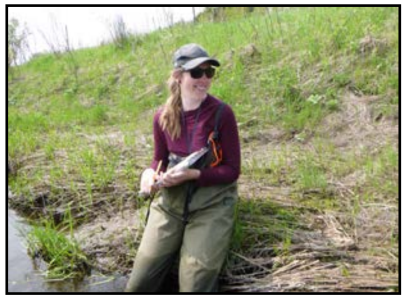


Figure 41 Potential riparian/shoreline restoration opportunities along Borthwick Creek and its headwater reaches



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For more information on the 2019 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2019 Summary Report:

https://www.rvca.ca/rvca-publications/city-stream-watch-reports

RVCA City Stream Watch would like to thank all the **volunteers** who assisted in the collection of information; as well as the many **landowners** who gave us property access to portions of the stream; and to our **City Stream Watch Collaborative members**: City of Ottawa, National Capital Commission, Ottawa Flyfishers Society, Canadian Forces Ottawa Fish and Game Club, Ottawa Stewardship Council, Rideau Roundtable, South Nation Conservation, Mississippi Valley Conservation Authority and Rideau Valley Conservation Authority