Graham Creek 2016 Summary Report

Watershed Features	
Area	24.9 square kilometres 0.59 % of the Rideau Valley watershed
Land Use	25% agriculture 44% urban 20% forest 1% rural 7% meadow 4% wetland
Surficial Geology	48% clay 6% diamicton 1% gravel 6% organic deposits 19% Paleozoic bedrock 20% sand
Watercourse Type	Thermal Conditions (2016) **Cool** to **Coldwater**
Invasive Species	Fourteen invasive species were identified in 2016, including: *common/glossy buckthorn, curly-leafed pondweed, garlic mustard, Himalayan balsam, honey suckle, English ivy, Japanese knotweed, Manitoba maple, Norway maple, periwinkle, wild parsnip, purple loosestrife* and *rusty crayfish*
Fish Community	31 fish species have been captured in the Graham Creek catchment

Wetland Cover
4% of the catchment is wetland

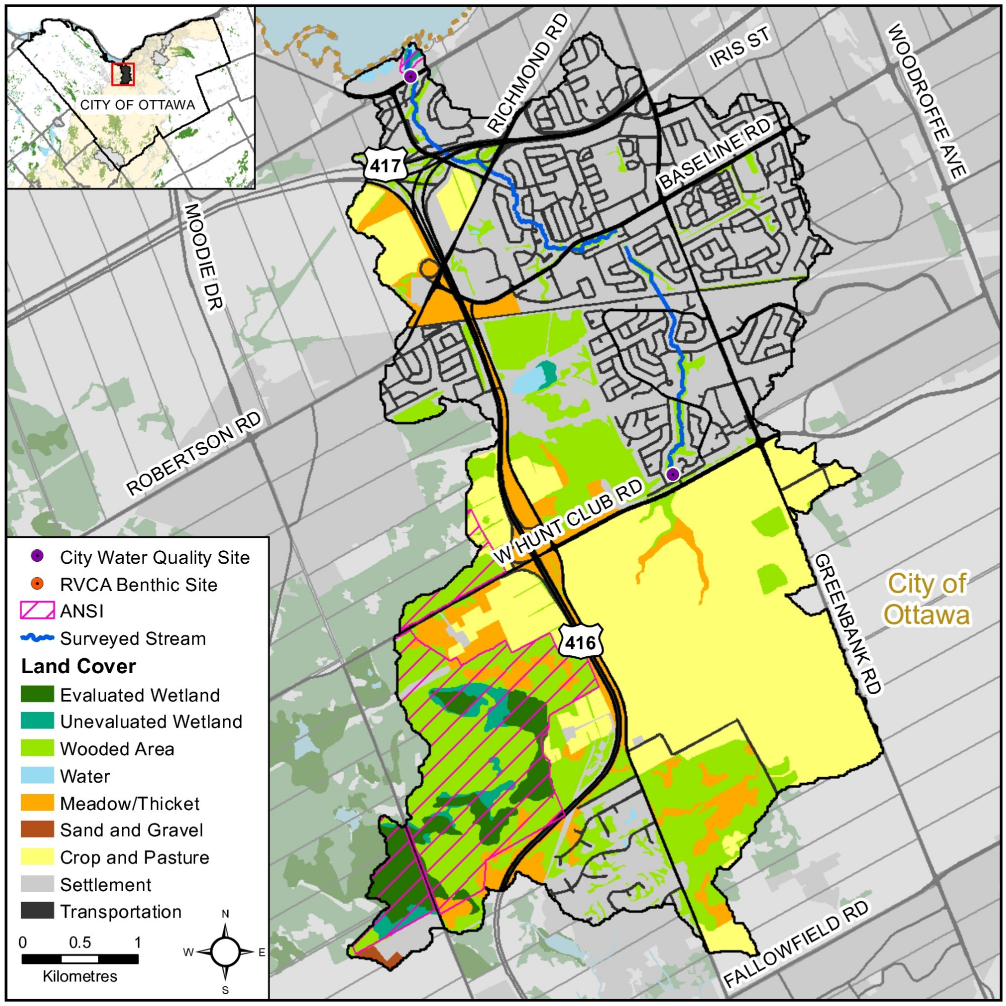

Figure 1 Land cover in the Graham Creek catchment

Mouth of Graham Creek at Andrew Haydon Park

The Rideau Valley Conservation Authority, in partnership with seven other agencies in Ottawa (City of Ottawa, Heron Park Community Association, Ottawa Flyfishers Society, Ottawa Stewardship Council, Rideau Roundtable, National Defence HQ - Fish and Game Club, and the National Capital Commission) form the 2016 City Stream Watch collaborative.

Drought Conditions - Rideau Valley Watershed

Low Water Conditions

During the summer of 2016, the Rideau Valley watershed experienced periods of *severe* drought. Precipitation levels were measured at less than 40% of the long-term average, as the water supply was unable to meet local demand. The lack of rainfall affected the success and function of farm crops, municipal and private wells, lawns and gardens, navigation and ultimately the health of our lakes, rivers and streams.

Low water conditions were readily observed throughout the watershed, as many of the streams were highly fragmented or completely dry. Aquatic species such as amphibians, fish and macroinvertebrates were affected, as suitable habitat may have been limited.

City Stream Watch

Low water levels and flows were common across many of our city streams, and is reflected in our overall evaluation. Given the atypical conditions, all assessments were subject to the effects of low water, and may not reflect the overall health of the systems. The City Stream Watch program will continue to monitor conditions over the long term to better understand the effects of climate and precipitation patterns.

Introduction

Graham Creek is located in the west Nepean region, and outflows directly into the Ottawa River at Andrew Haydon Park. The stream conveys flows from the Stony Swamp wetland, with active influences from agriculture and urban development. Graham Creek flows through multiple urban communities including, Trend-Arlington, Briar-Green Leslie Park, Qualicum and Bayshore neighbourhoods. The majority of Graham Creek has been modified to control flooding and erosion, with several piped sections and extensive channel hardening/straightening throughout. In an evaluation conducted by *Niblett Environmental Associations, Inc* (1991), it was estimated that only 500m of stream has remained unaltered.

Graham Creek is classified as a coldwater system, with coolwater reaches. Fish community sampling has identified multiple coldwater species within Graham Creek, including *mottled sculpin* and *burbot.* Based on water quality monitoring conducted by the City of Ottawa, Graham Creek experiences regular exceedances of phosphorus, *E.coli*, chlorides, iron and manganese.

Despite significant modifications to the stream, Graham Creek supports a variety of wildlife communities. Woodland composition along some parts of the stream includes sugar maple, beech, red maple, silver maple, yellow birch, white birch, basswood, white elm, slippery elm, white ash, poplar, white pine, hemlock, red oak willows and red osier dogwood (Niblett Environmental Associates Inc, 1991).

In 2016, the City Stream Watch program conducted surveys on 53 sections (5.3 km) of Graham Creek. The following is a summary of our observations and assessment.

Graham Creek Overbank Zone

Riparian Buffer Width Evaluation

The riparian zone is the interface between the water and the land surrounding a stream or river. Well-vegetated shorelines are of critical importance in protecting water quality and promoting for healthy aquatic habitats. Natural shorelines intercept sediments and contaminants that could impact water quality conditions and harm fish habitat. Furthermore, well established buffers protect the banks against erosion, improve habitat for fish by shading and cooling the water and provide protection for birds and other wildlife that feed and rear young near water. The recommended target (from Environment Canada's Guideline: How Much Habitat is Enough?) for the protection of aquatic habitat is to maintain a minimum 30 meter wide vegetated buffer along at least 75% of the stream length. Graham Creek was observed as having poor buffer conditions with only 9-11% of the shoreline meeting the suggested minimum guidelines (ie. 30m +). Shoreline conditions were primarily assessed within the 0-5m category, and indicate extensive alterations within the riparian corridor (Figure 2).

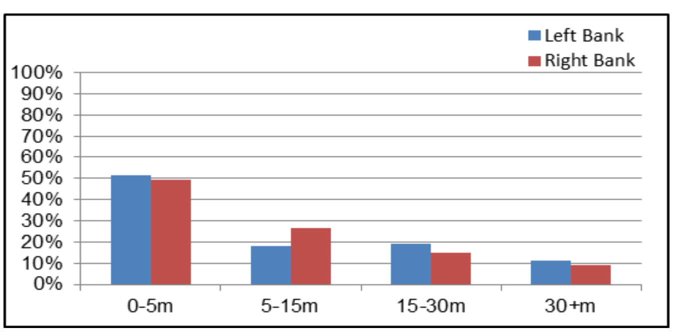

Figure 2 Vegetated buffer width along Graham Creek

Adjacent Land Use

Land use surrounding the creek is categorized into 11 classes, and assessed within 100m of each shoreline. These classes include: active and abandoned agriculture, pasture land, residential areas, forests, scrubland, meadows, wetlands, industrial /commercial zones, recreational areas, and infrastructure. Land use outside of this 100m buffer is not considered, but may still have influence within the catchment.

Residential land use was common across the surveyed stream and identified in 70% of all sites (Figure 3). Despite the overall modifications to Graham Creek, forest cover was identified in 50% of all study segments, in addition to scrubland (30%) and meadow habitat (15%). Infrastructure and recreational land use were observed in approximately 20-30% of all sites, as well as minor instances of industrial/commercial use (2%).

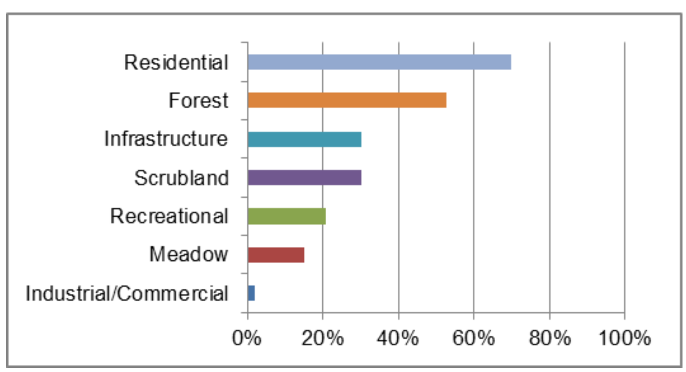

Figure 3 Land use along Graham Creek

Graham Creek Shoreline Zone

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 overall extent of each section with "unstable" shoreline conditions. These conditions are defined by the presence of significant exposed soils/roots, minimal bank vegetation, severe undercutting, slumping or scour, and potential failed erosion control measures.

Graham Creek has been extensively modified in an effort to reduce erosion and flooding. Gabion baskets, riprap and armor stone are common throughout the system, and have been utilized to mitigate against further bank destabilization. Although shoreline instability was uncommon overall, significant erosion was identified (Figure 4). Severe shoreline erosion was evident immediately downstream of the HWY 417 crossing, with instances of bank scour, fallen trees and failed erosion control measures (ie. gabion baskets). Beaver activity within the Monterey/Baseline area was also identified as a potential source of instability, as a dam within the area is retaining high water levels in proximity to residential land use. Beaver dams can provide direct benefits to stream health, however systems with limited floodplain access may experience habitat loss and instability.

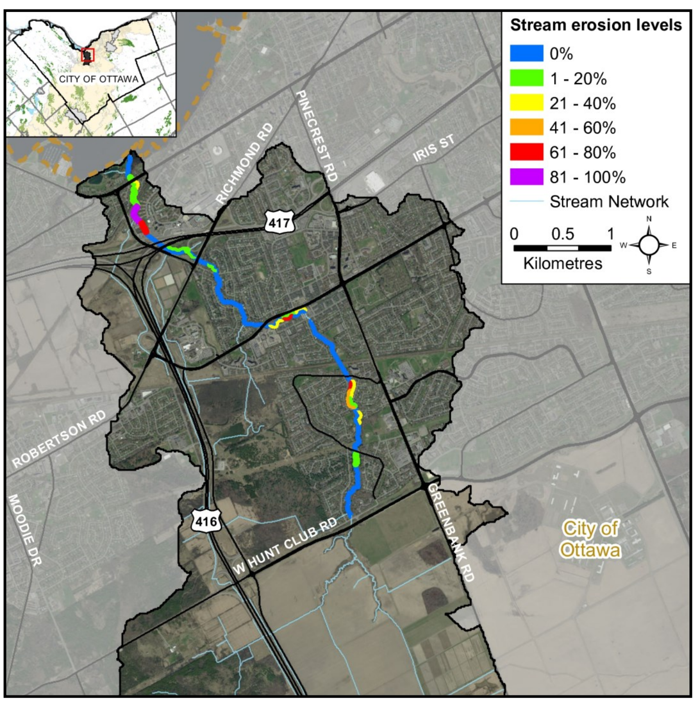

Figure 4 Erosion along Graham Creek

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 overall extent of each surveyed section with overhanging bank cover present.

Bank undercut was identified in 9% of all surveyed sites, with an average coverage extent of 30% in those sections (Figure 5). Given that Graham Creek is highly altered, the low presence of bank cover is likely associated with shoreline infrastructure.

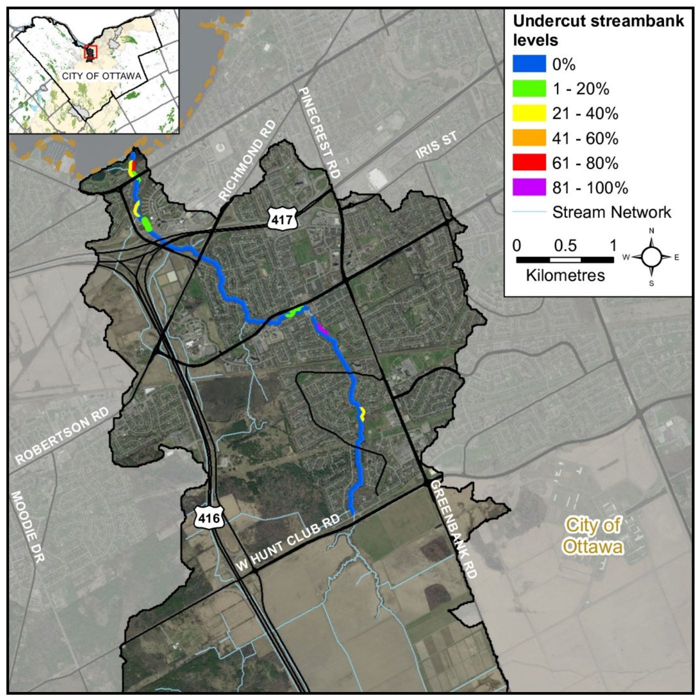

Figure 5 Undercut stream banks along Graham Creek

Erosion control measures (ie. gabion baskets) along Graham 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 1m above the water surface.

Graham Creek was characterized by relatively high shoreline cover, with shading at or below 95% within the 75th percentile (Figure 6). The most frequent cover level was assessed at 100%, and accounts for approximately 26% of the surveyed stream. Shade levels generally contrasted within the system, with regions of either low or high cover observed (Figure 7).

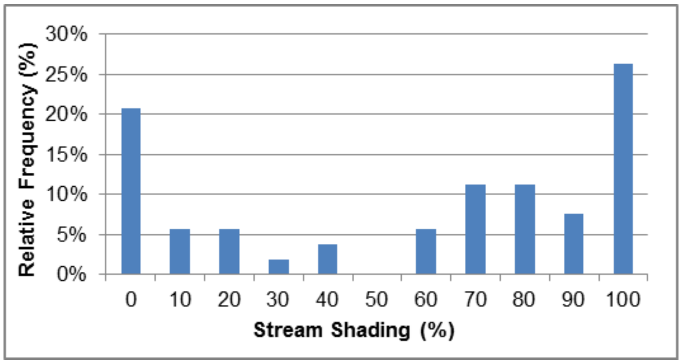

Figure 6 Stream shading along Graham Creek

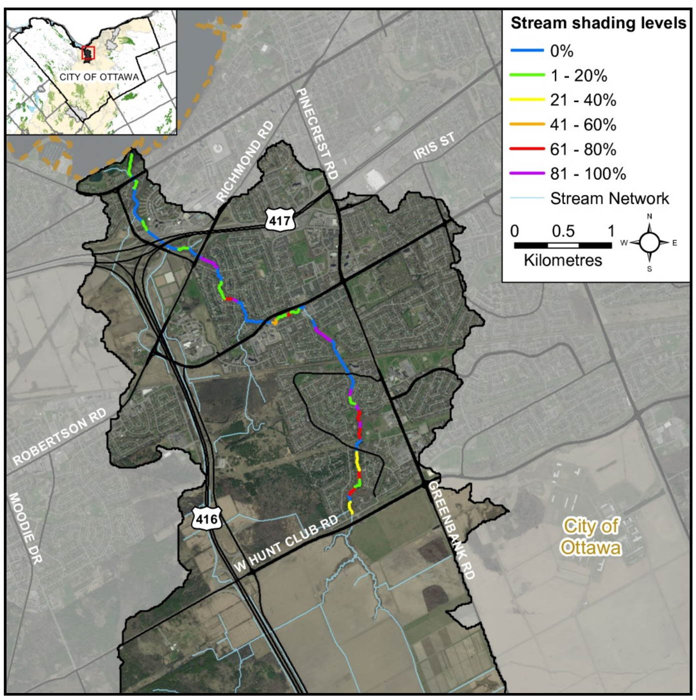

Figure 7 Stream shading along Graham Creek

Riparian Buffer Alterations

Alterations within the riparian buffer were assessed within three distinct shoreline zones (0-5m, 5-15m, 15-30m), and evaluated based on the dominant vegetative community and/or land cover type (Figure 8).

The riparian buffer zone along Graham Creek was determined to be highly modified, with approximately 68% of the shoreline classified as either altered or highly altered. Natural conditions were identified predominately within the upper reaches of Graham Creek, with an overall evaluation of 32%. Common sources of alteration include residential land use, municipal infrastructure and erosion control features.

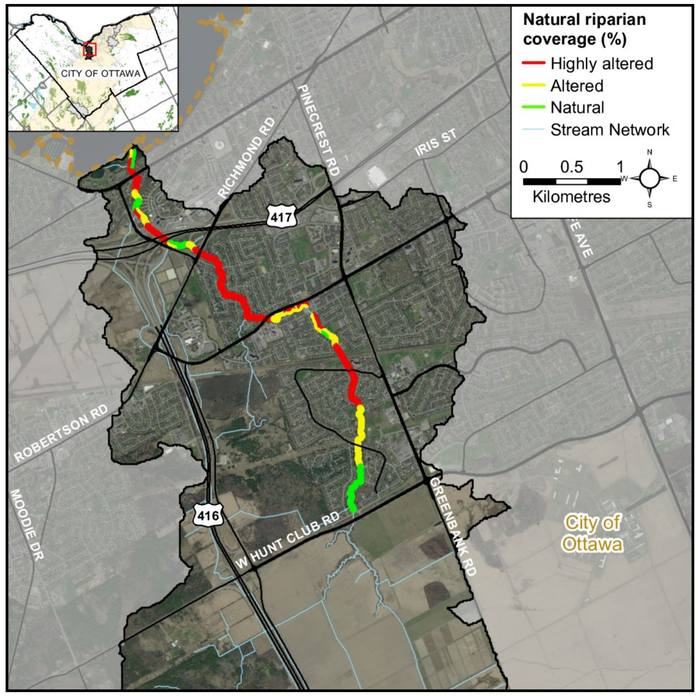

Figure 8 Riparian buffer alterations within Graham Creek

Heavily modified stream section along Graham Creek

Overhanging Trees and Branches

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

Overhanging trees and branches were identified in 76% of all surveyed sites, with an average coverage extent of 34% in those sections (Figure 9). Overhanging tree cover was common throughout the system, despite the high level of shoreline alteration observed. Low overhang in the upper reaches corresponds with larger mature trees, as direct cover was reduced in proximity to the stream.

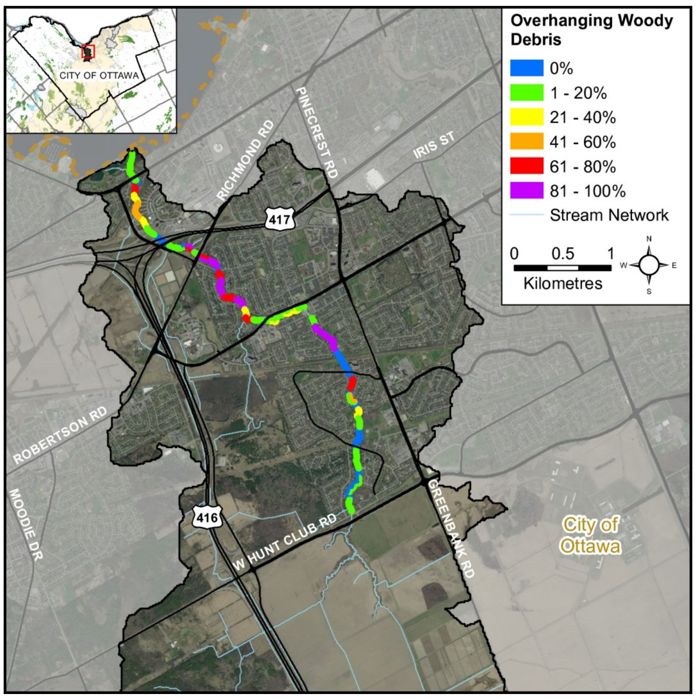

Figure 9 Overhanging trees and branches

Overhanging trees and branches on Graham Creek

Anthropogenic Alterations

Stream alterations are classified based on specific functional criteria associated with the flow conditions, the riparian buffer, and potential human influences. Graham Creek is considered to be in a natural state for 23% of the surveyed stream (Figure 10). Altered classes (ie. Altered & Highly Altered) account for approximately 78% of the stream length, with extensive alterations identified in 53% of sites. Common alterations include erosion control structures, channelization, shoreline hardening, municipal infrastructure and storm-water outlets.

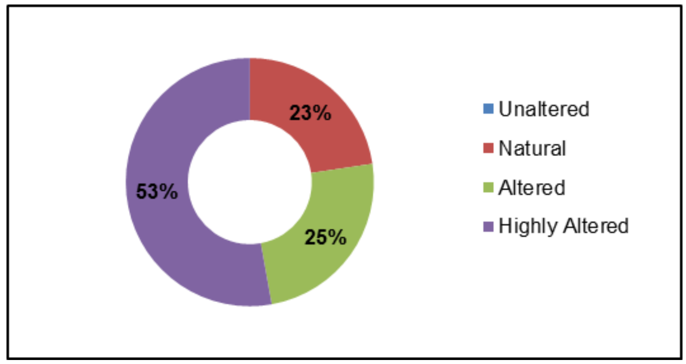

Figure 10 Anthropogenic alterations along Graham Creek

A natural stream section along Graham Creek

A highly altered stream section along Graham Creek

Graham Creek Instream Aquatic Habitat

Habitat Complexity

Habitat complexity is a measure of the overall 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, flow 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 woody material.

Habitat complexity on Graham Creek varied considerably between reaches, with a moderate level of cover habitat overall. Cobble habitat was common across the entire surveyed stream, with 91% presence across all sites. 70% of the overall area was found to have at least 2 types of habitat cover, with only 6% of surveyed sites assessed as having optimal habitat conditions. Optimal habitat cover was isolated to segments within the lower (downstream of HWY 417) and upper reaches (upstream of Canfield Rd) of the stream. Low complexity was assessed in 30% of all sites (1 habitat cover type or less) and was generally associated with road crossings and high sediment volume.

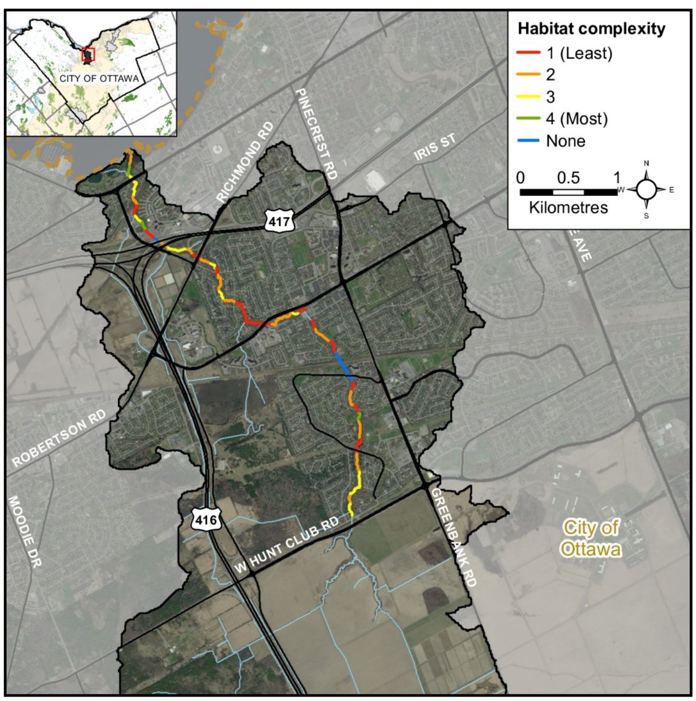

Figure 11 Instream habitat complexity in Graham Creek

Instream Substrate

Diverse substrate is important for fish and benthic invertebrates as many species rely on specific substrate types to complete their life cycles. The absence of diverse substrate types may limit the overall diversity of species within a stream.

Cobble was identified in 91% of all surveyed sites, with direct contribution from the destabilization of riprap/ gabion structures on the shoreline (Figure 12 & 13). Sands and silt were common across the system with 74% silt and 47% sand presence overall. Boulder and gravel substrates were less common, and were limited to approximately 30% of the surveyed extent. Clay and bedrock presence was uncommon, with only 6% bedrock and 13% clay substrate identified overall.

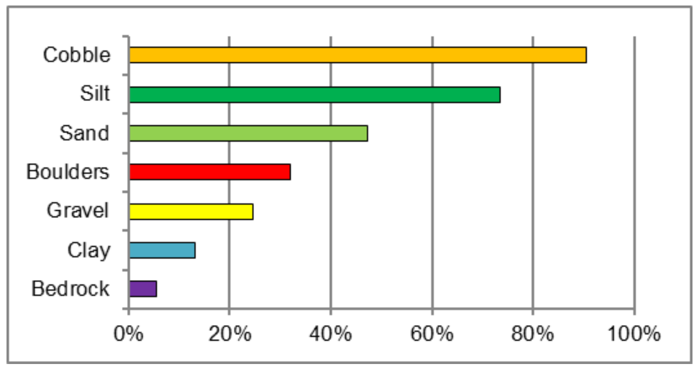

Figure 12 Instream substrate presence along Graham Creek

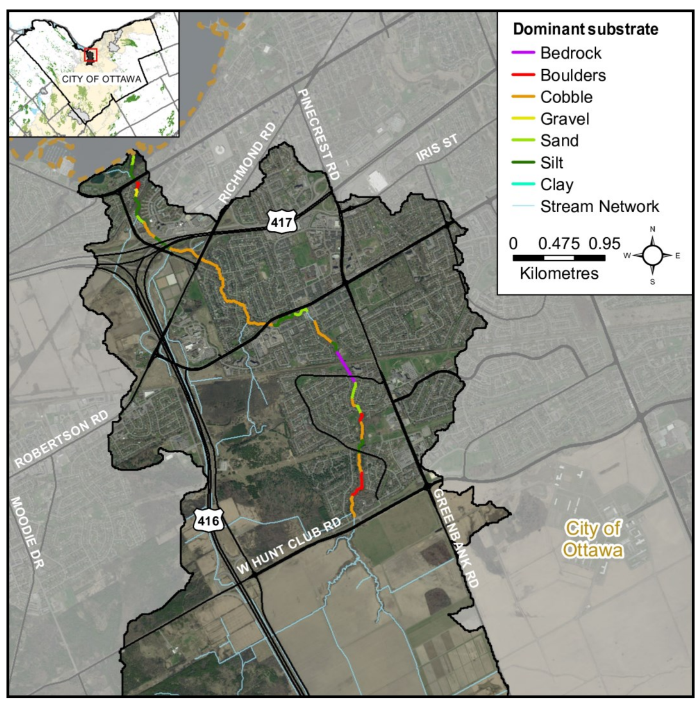

Figure 13 Dominant instream substrate in Graham Creek

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. Pools are characterized by minimal flows, with relatively deep water and provide thermal, habitat and flow refuge for aquatic species. Runs are moderately shallow, with unagitated surface flow and areas where the thalweg (deepest part of the channel) is in the center of the channel.

Despite the presence of extensive channel constraints (ie. shoreline hardening/erosion control), Graham Creek was found to have a high diversity of flow/habitat types. Riffle habitat was identified in 74% of the surveyed stream, with corresponding pool habitat in 68% of all sites (Figure 14 & 15). Run conditions were most common and observed in 89% of the surveyed stream.

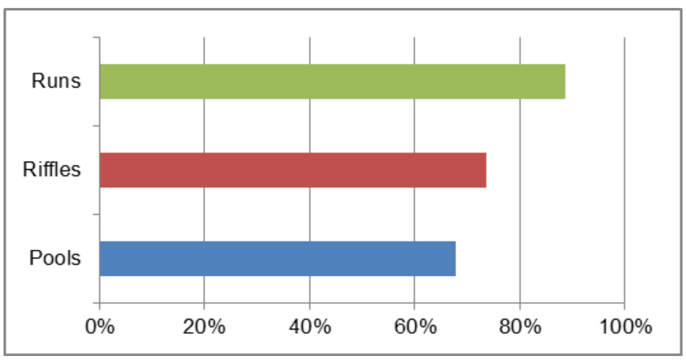

Figure 14 Instream morphology along Graham Creek

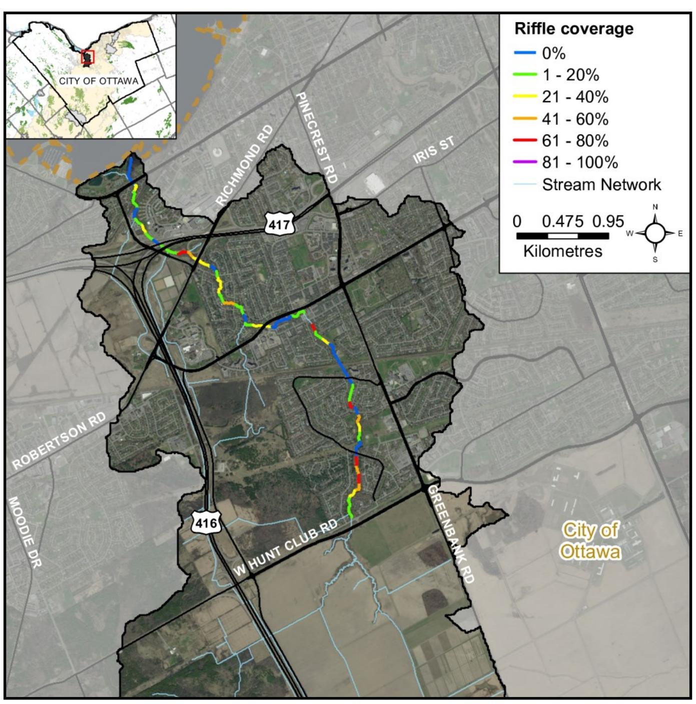

Figure 15 Riffle coverage in Graham Creek

Vegetation Type

Instream vegetative communities are a crucial component of aquatic ecosystems, providing both direct and indirect support to aquatic life. Aquatic plants promote for stream health by:

- Providing direct riparian/instream habitat
- Stabilizing flows/reducing shoreline erosion
- Contributing to dissolved oxygen through photosynthesis
- Maintaining temperature conditions through shading

Aquatic plant diversity was identified as low and/or impaired, with few healthy communities present across the system (Figure 17). Algaes were categorized as the most common instream vegetation observed, with 68% presence within the surveyed stream (Figure 16). Submergent plant types were identified in 47% of all surveyed sites, however many of these observations may have included the presence of the invasive *curly-leaf pondweed*. These species have the potential to reduce overall diversity, despite the fact that they may provide some ecosystem function. Narrow-leaved emergents such as grasses and sedges were minimal and observed in only 11% of sites. Robust emergents were rare across Graham Creek, and were limited to 2% of the surveyed extent.

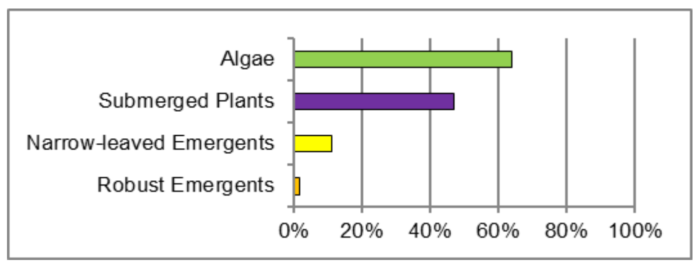

Figure 16 Aquatic vegetation presence along Graham Creek

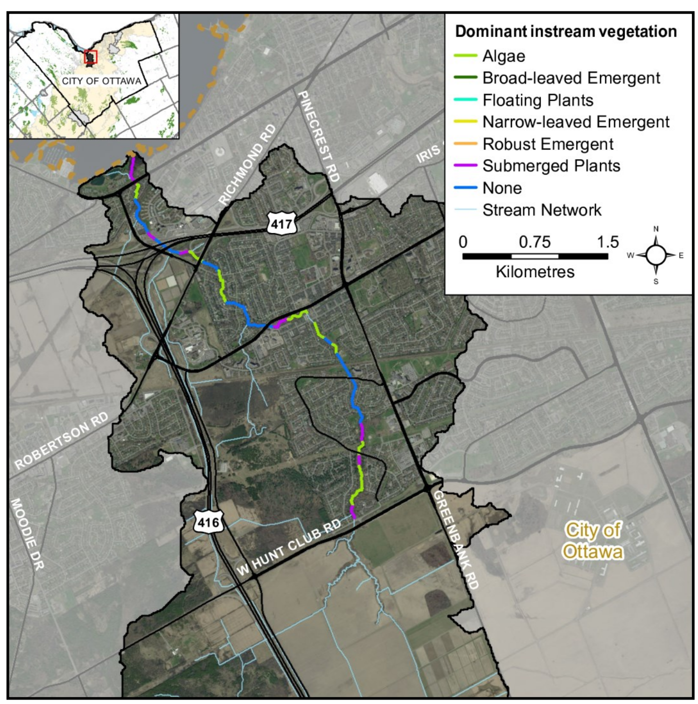

Figure 17 Dominant instream vegetation in Graham Creek

Instream Vegetation Abundance

Instream vegetation is an important factor for a healthy stream ecosystem. Vegetation helps to remove contaminants from the water, contributes oxygen to the stream, and provides habitat for fish and wildlife. Too much vegetation can also be detrimental.

Instream vegetation abundance was found to be impaired, with “normal to common” levels identified within only 5-8% of the instream surface area (Figure 18). Low to absent (ie. low, rare, none) levels accounted for the majority of observations at greater than 80%. The poor conditions observed on Graham Creek are likely influenced by sedimentation, channel modifications and unstable flows throughout the system.

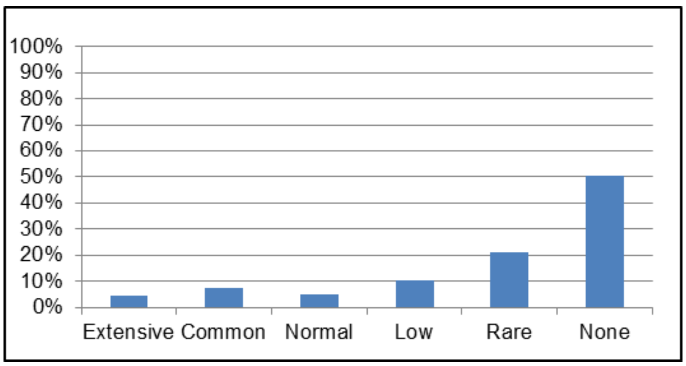

Figure 18 Instream vegetation abundance in Graham Creek

Instream aquatic plants on Graham Creek

Invasive *Japanese knotweed* along Baseline/Monterey Dr

Graham Creek Stream Health

Invasive Species

Invasive species can have major implications on streams and species diversity. Invasive species are one of the largest threats to ecosystems throughout Ontario and can outcompete native species, having negative effects on local wildlife, fish and plant populations. Invasive species were observed along 75% of the surveyed stream, with a total of 14 species identified.

Invasive species abundance (ie. the number of observed invasives per section) was assessed to determine the potential range/vector of many of these species. Approximately 59% of Graham Creek had 3 or fewer invasive species identified within each section. (Figure 19). Higher density (4 - 6 species) and/or isolated invasive communities were identified in the lower and middle reaches of the system. Invasive abundance was determined to be high immediately downstream of HWY 417 over approximately 400m of stream. Invasive *buckthorn, curly-leafed pondweed, garlic mustard* and *Himalayan balsam* were associated with this reach. *Himalayan balsam* was found to be isolated to the Monterey/Baseline area, with no further observations upstream of this location. All removal efforts in 2016 were focused on this location, and the subsequent downstream observations.

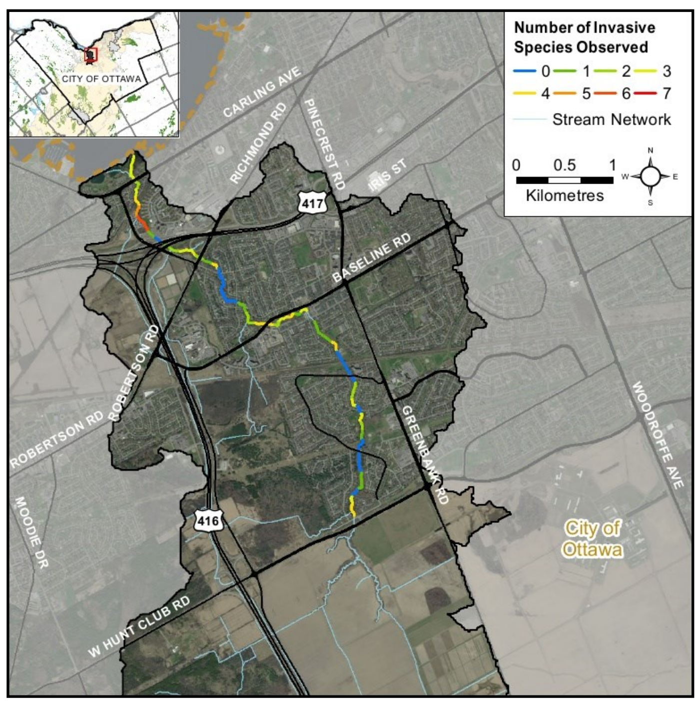

Figure 19 Invasive species abundance in Graham Creek

Pollution

Pollution was identified in 79% of all surveyed sections in Graham Creek (Figure 20). Common waste identified included scrap metals and domestic products. Garbage was identified along the stream bottom in 70% of sites, with floating garbage identified in 21% of all surveyed locations. Unusual colouration was observed in 8% of all sites, as well as minor instances of industrial/commercial waste dumping (ie. Other-4%)

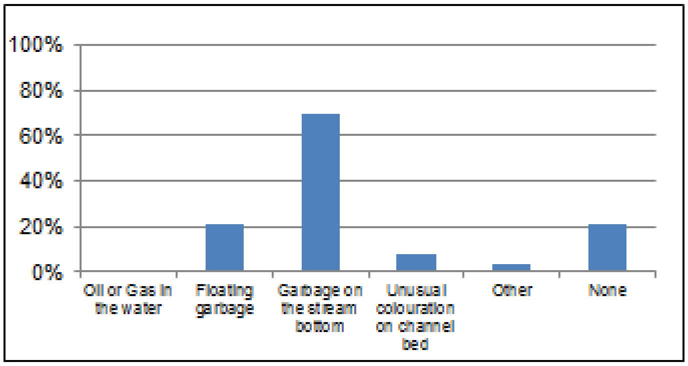

Figure 20 Pollution observed within Graham Creek

Volunteers collecting garbage and removing invasive plants along Graham Creek

Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and overall stream health (Table 1). Wildlife observations are noted during standard monitoring and survey activities, and do not represent an extensive evaluation of species presence/absence. No species of note or special consideration were observed.

Table 1 Wildlife observed along Graham Creek in 2016

Birds	American crow, American robin, black-crowned night heron, bluejay, Canada goose, downy woodpecker, grackle, mallard, northern cardinal, red-winged black bird, ring-billed gull, song sparrow, sparrow sp.
Reptiles & Amphibians	green frog, leopard frog, northern two lined salamander, wood frog
Mammals	chipmunk, mink, muskrat, raccoon, squirrel
Aquatic Insects	caddisflies, crayfish, elmidae, isopoda, mayflies, trichoptera, water striders
Other	ebony jewelwing, mosquitoes, spider sp.

Northern two lined salamander captured in Graham Creek

Wood frog along the shoreline of Graham Creek

Graham Creek Water Chemistry

Water Chemistry Assessment

During the stream characterization survey, a YSI probe is used to collect water chemistry information. Dissolved oxygen (DO), specific conductivity (SPC) and pH are measured at the start and end of each section.

Noting water chemistry collected in Graham Creek

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen dissolved in water. Guidelines supported under the Canadian Council of Ministers of the Environment (CCME) suggest that for the protection of aquatic life the lowest acceptable dissolved oxygen concentration should be 6 mg/L for warmwater biota (red line in Figure 21) and 9.5 mg/L for coldwater biota (blue line in Figure 21) (CCME, 1999).

Warm and coldwater conditions were largely maintained throughout the system, however most regions showed signs of oxygen depletion. Sections between Banner and McClellan Rd were particularly affected, as oxygen levels were depleted 20% below the theoretical concentration. These conditions are indicative of potential impairment despite the suitable concentrations above the cold and warmwater thresholds (Figure 21).

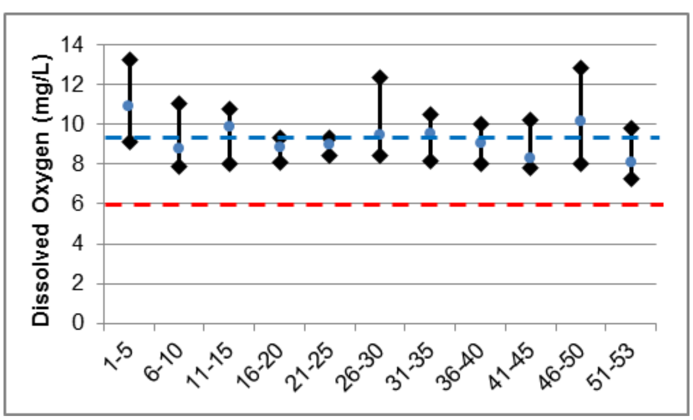

Figure 21 Dissolved oxygen ranges in Graham Creek

Conductivity

Conductivity in streams is primarily influenced by the geology of the surrounding environment, but can vary drastically as a result of surface water runoff. Currently there are no CCME guidelines for stream conductivity, however readings which are outside the normal range observed within the system are often an indication of unmitigated discharge and/or storm-water input. The average specific conductivity observed within Graham Creek was 1279 μs/cm (green line in Figure 22).

Peak conductivity levels were identified between the mouth of Graham Creek to downstream of the Richmond Rd crossing (2108 μs/cm). These elevated levels can likely be attributed to storm-water influence from nearby land-use. Elevated levels were also observed within the upstream reaches, and likely corresponds to drainage from agricultural lands.

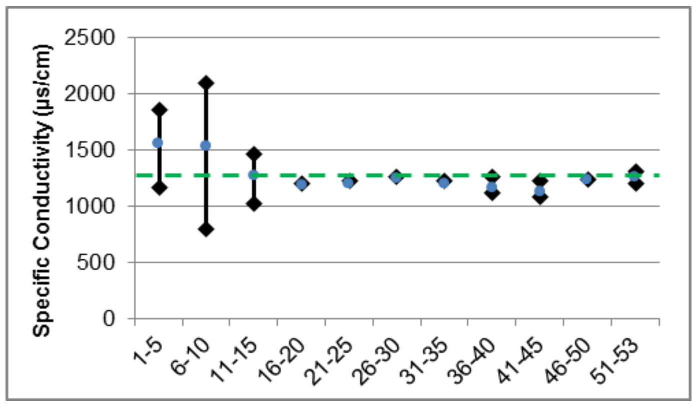

Figure 22 Conductivity ranges in Graham Creek

pH

Based on the Provincial water quality objectives for pH, a range of 6.5 to 8.5 should be maintained for the protection of aquatic life.

Average pH throughout Graham Creek was approximately 7.9, with some minor exceedances above the Provincial standard (Figure 23). Variation in pH was occasionally found to parallel high conductivity readings, however several isolated instances were observed. This association may indicate potential impairment and/or environmental instability.

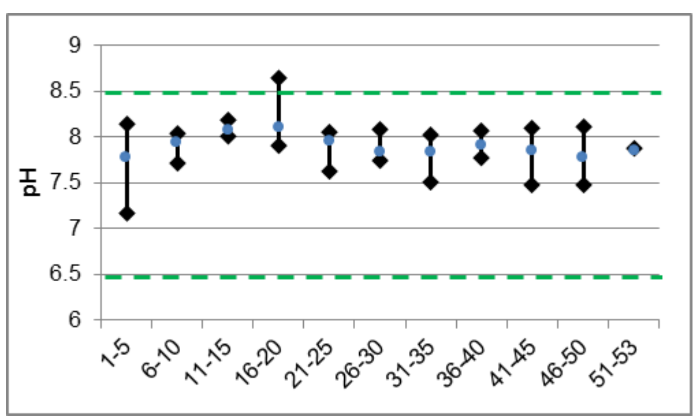

Figure 23 pH ranges in Graham Creek

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% 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% to a maximum of 500%, 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 warmwater 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 warmwater biota.

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

- Oxygen concentration is sufficient to support coldwater 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 coldwater biota.

Impaired dissolved oxygen conditions were found in Graham Creek downstream of Baseline Road

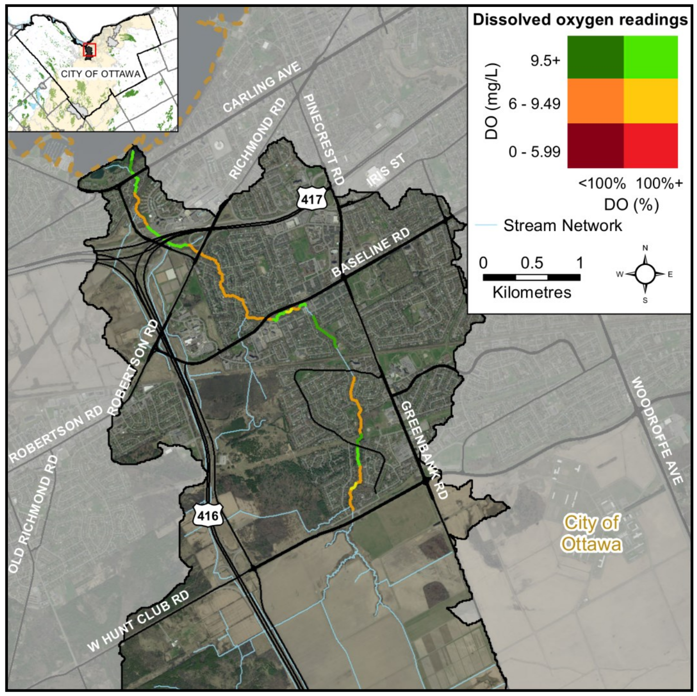

Figure 24 A bivariate assessment of dissolved oxygen concentration (mg/L) and saturation (%) on Graham Creek

Dissolved oxygen conditions on Graham Creek are generally sufficient for both warm and coldwater species, however several regions exist with potential impairment (Figure 24). Impaired conditions were identified between Richmond and Baseline Rd, as well as upstream of Banner Rd. Although the oxygen concentration was generally sufficient for warm and coldwater biota, the corresponding saturation levels were indicative of oxygen depletion. Optimal conditions were observed in some instances, however a high degree of fragmentation exists between these reaches.

Optimal dissolved oxygen levels were measured in portions of Graham creek upstream of Baseline Road

Specific Conductivity Assessment

Specific conductivity (SPC) is a standardized measure of electrical conductance, collected at or corrected to a water temperature of 25ºC. SPC is directly related to the concentration of ions in water, and is commonly influenced by 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 storm water, agricultural inputs and commercial/industrial effluents.

In order to summarize the conditions observed, SPC levels were evaluated as either normal, moderately elevated or highly elevated. These categories correspond directly to the degree of variation (ie. standard deviation) at each site relative to the average across the system.

Normal (ie.average) conditions were maintained throughout most of the surveyed stream, with moderately to highly elevated levels identified in three distinct locations (Figure 25). Highly elevated conditions were observed in the upper reaches, as well as downstream of HWY 417. These regions likely corresponds with storm-water and agricultural inputs.

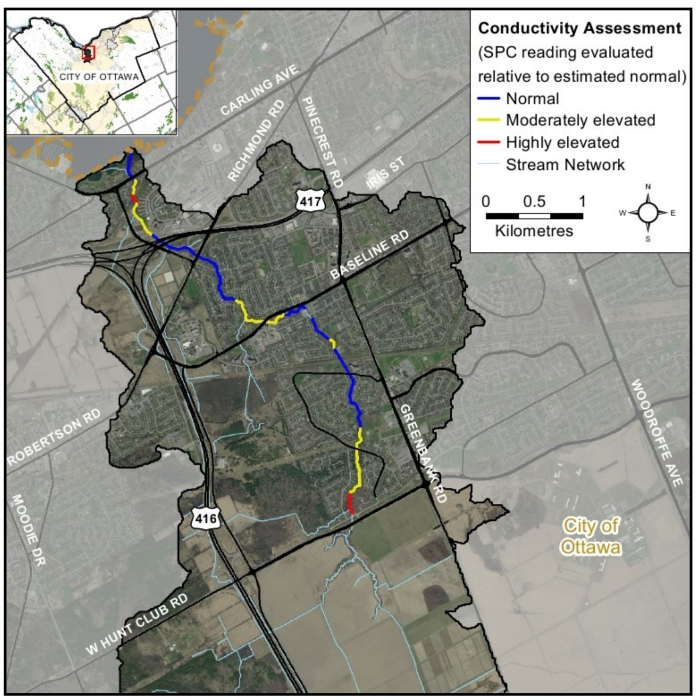

Figure 25 Relative specific conductivity levels on Graham Creek

Areas of Concern

Based on an overall evaluation of the sampled water chemistry attributes, several areas of Graham Creek show potential impairment. These regions generally correspond with outflow and/or proximity to developed areas. The following sites are associated with poor oxygen conditions, elevated conductivity and variable pH levels (Figure 26).

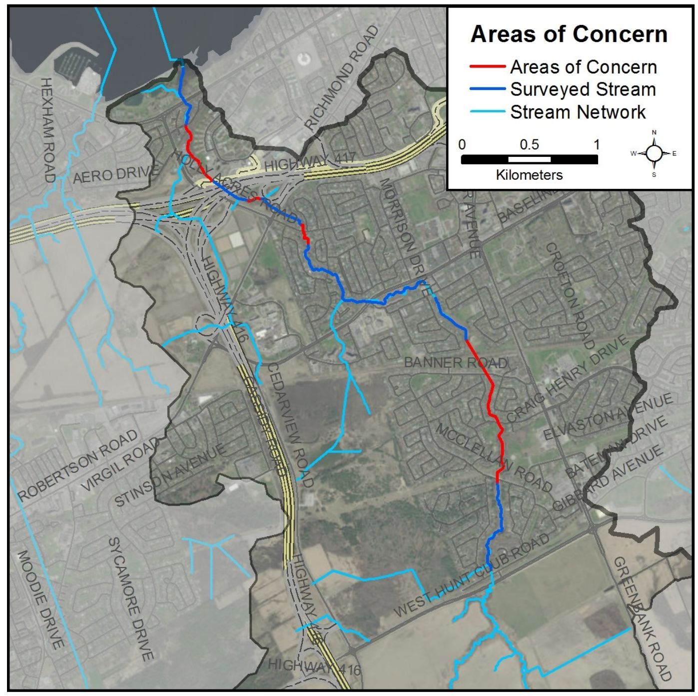

Figure 26 Graham Creek areas of concern based on water chemistry evaluation

Storm water outlet with elevated conductivity and reduced dissolved oxygen conditions

Graham Creek Thermal Classification

Thermal Classification

Many factors can influence fluctuations in stream temperature, including springs, tributaries, precipitation runoff, discharge pipes and stream shading from riparian vegetation. Four loggers were deployed in late April to monitor water temperature in Graham Creek (Figure 27). Water temperature is used along with the maximum air temperature (using a revised Stoneman and Jones method) to classify sampling reaches into one of five categories that correspond to the thermal preferences of local fish communities (Figure 29). Graham Creek is primarily a coldwater system, with coolwater to cold-coolwater reaches. Temperatures at the HWY 417 site stabilized within the coldwater range, while the Monterey and Siskin sites maintained slightly higher temperatures . Only 3 of the 4 deployed loggers were evaluated, as logger ID-1 was compromised due to an out-of-water condition.

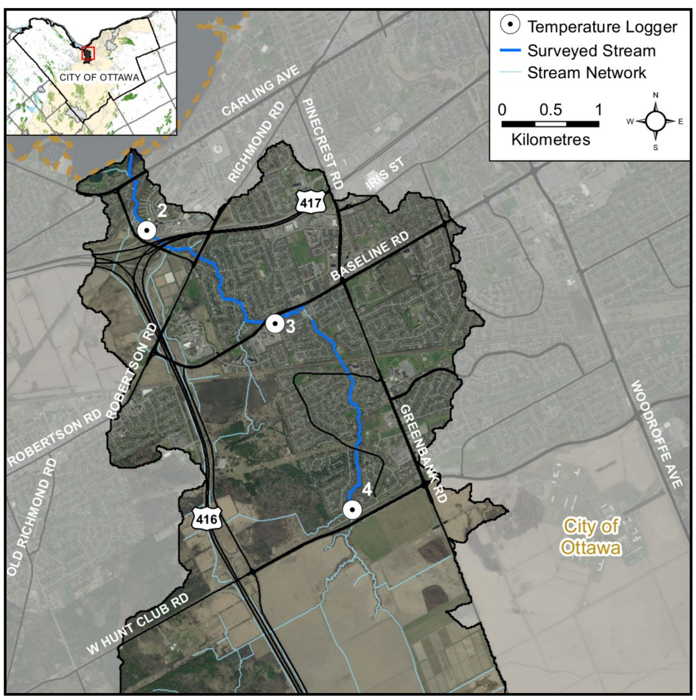

Figure 27 Temperature loggers along Graham Creek

Groundwater

Groundwater discharge areas can influence stream temperature, contribute nutrients, and provide important stream habitat for fish and other biota. During stream surveys, indicators of groundwater discharge were assessed and identified (Figure 28).

Indicators of potential groundwater input were identified throughout Graham Creek and include instances of observed iron staining, watercress, mineral films and significant temperature variation.

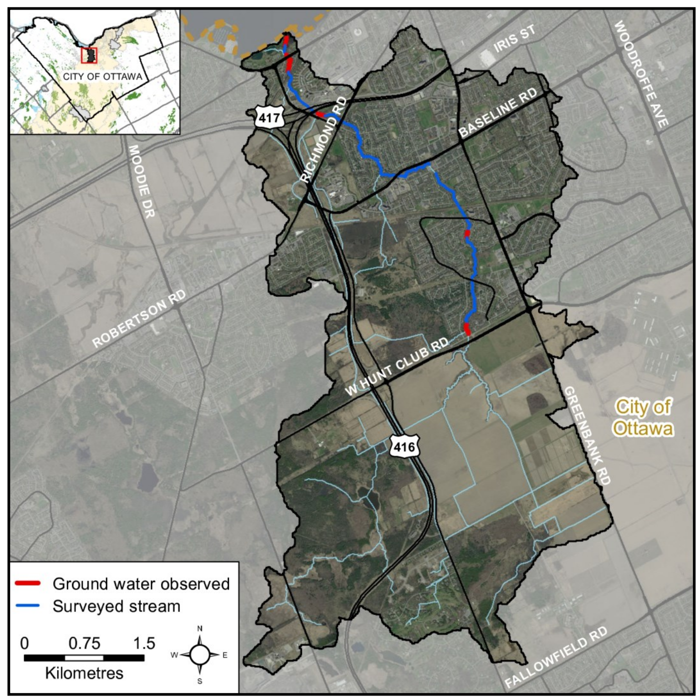

Figure 28 Groundwater indicators observed in Graham Creek

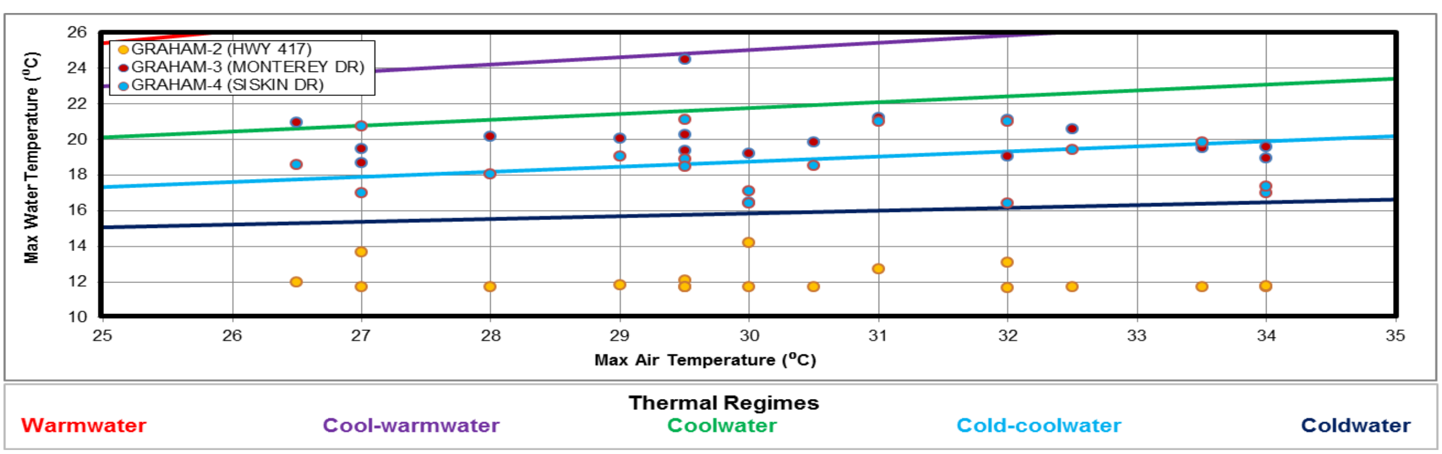

Figure 29 Thermal Classification for Graham Creek

Graham Creek Fish Community

Fish Community

Historic fish sampling records indicate the presence of 31 distinct species within Graham Creek (Table 2). RVCA fish sampling efforts have identified 29 of the listed species, but unable to verify the presence of *American eel* and *finescale dace*. Species of note or special consideration include: *American eel* (SAR).

Fish sampling records include data from 50 separate sampling events and 9 sites (Figure 30).

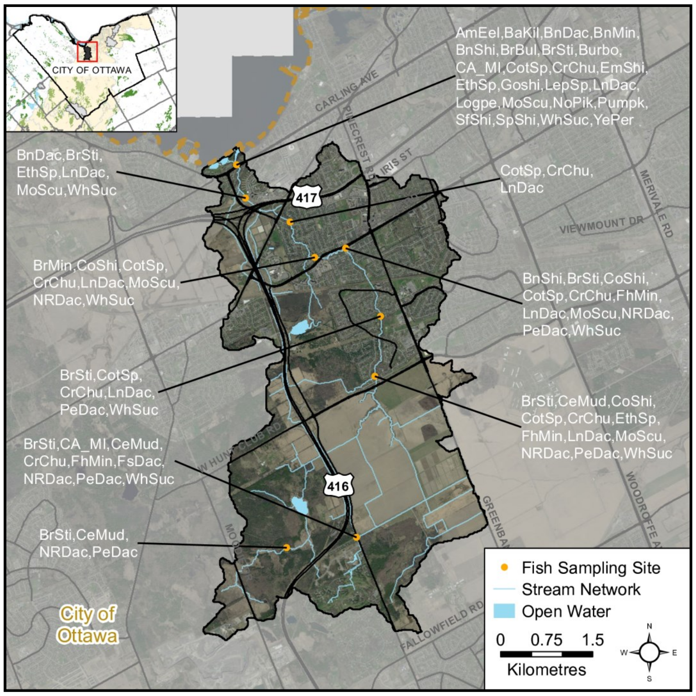

Figure 30 Graham Creek fish community

Students assisting with fish processing and identification

Table 2 Fish species observed in Graham Creek

Species	Code	Species	Code
American eel	AmEel	Finescale dace	FsDac
Banded killifish	BaKil	Golden shiner	GoShi
Blacknose dace	BnDac	Iowa darter	IoDar
Blacknose shiner	BnShi	Lepomis sp.	LepSp
Bluntnose minnow	BnMin	Logperch	Logpe
Brassy minnow	BrMin	Longnose dace	LnDac
Brook stickleback	BrSti	Longnose gar	LnGar
Brown bullhead	BrBul	Mottled sculpin	MoScu
Burbot	Burbo	Northern pearl dace	PeDac
Cyprinid sp.	CA_MI	Northern pike	NoPik
Central mudminnow	CeMud	Northern redbelly dace	NRDac
Common shiner	CoShi	Pumpkinseed	Pumpk
Cottus sp.	CotSp	Rock bass	RoBas
Creek chub	CrChu	Spotfin shiner	SpShi
Emerald shiner	EmShi	Spottail shiner	SfShi
Etheostoma sp.	EthSp	White sucker	WhSuc
Fathead minnow	FhMin	Yellow perch	YePer

Northern pearl dace captured in Graham Creek

Golden shiners captured in Graham Creek

Migratory Obstructions

Migratory obstructions represent limitations to fish dispersal within a system and may restrict access to important spawning and rearing habitat. Barriers can be natural or man-made features, with either seasonal or permanent influence.

Migratory obstructions were limited within the catchment, with two locations identified as potential barriers (Figure 31). A large debris dam was identified in the Baseline/Monterey area, and is associated with beaver activity. A grade barrier was also observed, and corresponds to a headwater feature along Riverbrook Rd.

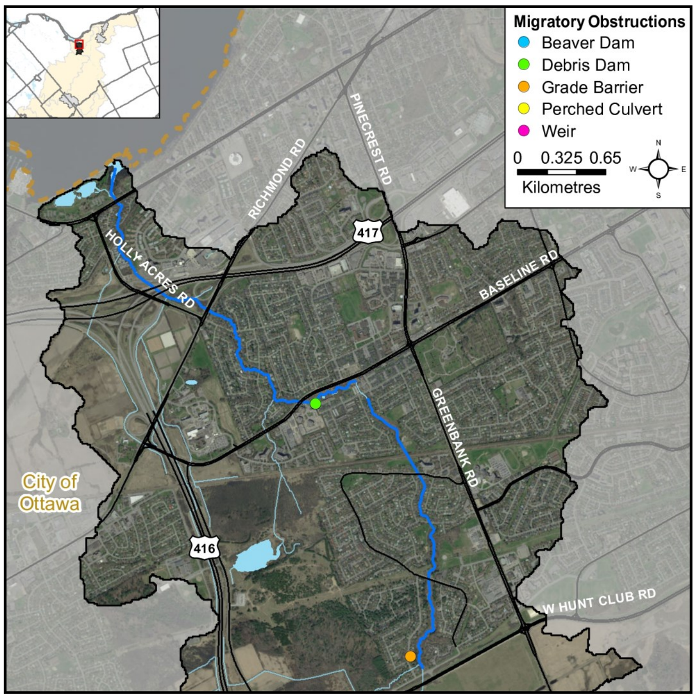

Figure 31 Graham Creek migratory obstructions

A perched culvert observed along a tributary of Graham Creek

Beaver Dams

Beaver dams are considered potential barriers to fish migration. Multiple active, abandoned and breached beaver dams were identified between Baseline Rd and Siskin Dr (Figure 32). Active dams were observed adjacent to the Baseline/Monterey area, and have resulted in considerable backwater throughout the reach.

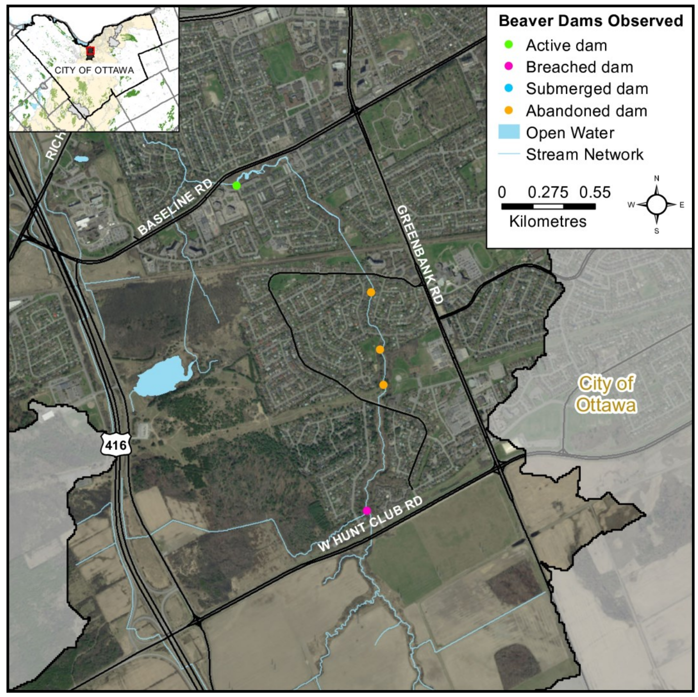

Figure 32 Beaver dams observed on Graham Creek

Active beaver dam observed on Graham Creek

Headwater Drainage Feature Assessment

Headwaters Sampling

Headwater drainage features (HDF) represent the origin from which water enters a watershed. These features convey surface flows directly from groundwater discharge, rain and melt water to the greater catchment area. HDF's have not traditionally been a component of most monitoring efforts, as their form and function on the landscape are not well established. These features may provide direct and seasonal fish habitat, as well as thermal refuge as a result of groundwater influence (OSAP Protocol, 2013). Furthermore, HDF's may be important sources, conveyors and storers of sediment, nutrients and flow, and may have an important role for terrestrial and wetland species. The RVCA is currently working with other Conservation Authorities and the Ministry of Natural Resources and Forestry to implement a sampling protocol with the goal of providing standard datasets to support scientific development and monitoring of these features. This protocol provides a direct means of characterizing the sediment and flow capacity, connectivity, form and unique features associated with each HDF (OSAP Protocol, 2013). Features are evaluated through a rapid assessment protocol and sampled at road crossings.

In 2016 the CSW program assessed 10 sites in the Graham Creek catchment area (Figure 33).

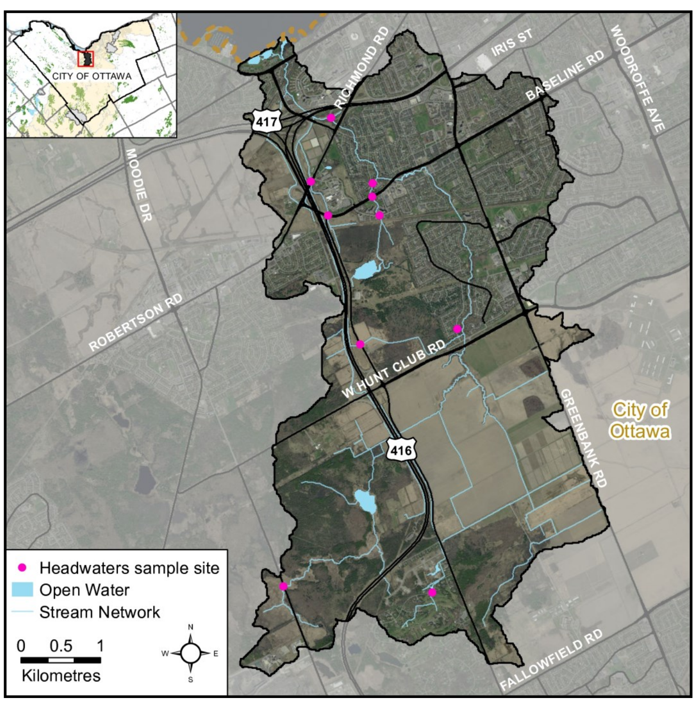

Figure 33 Graham Creek HDF sampling sites

Feature Type

The headwater sampling protocol assesses the feature type in order to understand the function of each feature. The evaluation includes the following feature classifications: defined natural channel, channelized or constrained, multi-thread, no defined feature, tiled, wetland, swale, roadside ditch and pond outlet. By assessing the form of the HDF, we can better understand the function it provides within the catchment as it relates to the hydrology, sediment transport capacity and habitat conditions.

The Graham Creek catchment is comprised of a variety of feature types, including natural channels, channelized and multi-thread streams, wetland features and undefined flow conditions (Figure 34).

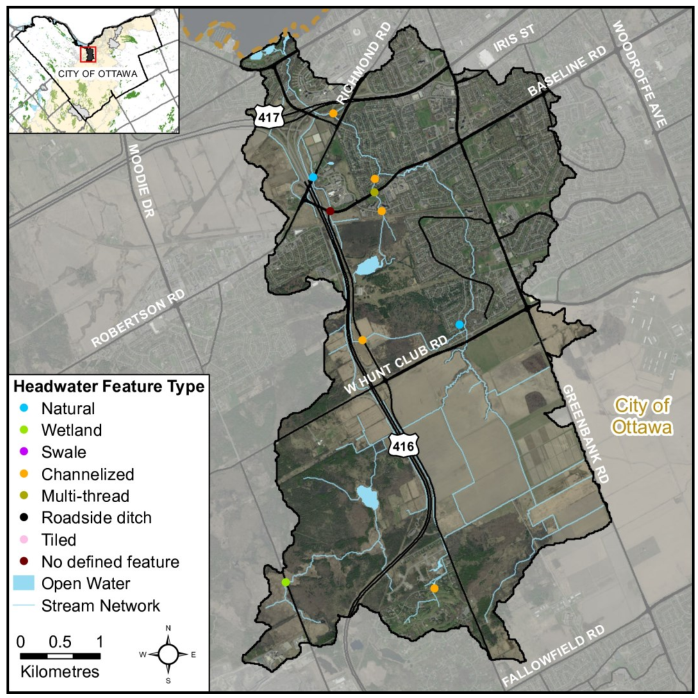

Figure 34 Graham Creek HDF feature types

Channelized flow feature along Valley Stream Dr

Headwater Feature Flow

Flow conditions within an HDF can be highly variable as a result of seasonal factors, moisture conditions, rainfall events and snow-melt. Flow conditions are assessed in the spring and in the summer to determine if features are perennial and flow year round, if they are intermittent and dry up during the summer months or if they are ephemeral systems with irregular flow patterns that generally respond to specific rainstorm events or snowmelt. Flow conditions in headwater systems can change from year to year depending on local precipitation patterns.

Flow conditions in the Graham Creek catchment varied between perennial, intermittent and unknown (Figure 35). Unknown flow features were generally associated with variable flow conditions as a result of municipal infrastructure (ie. storm water, etc).

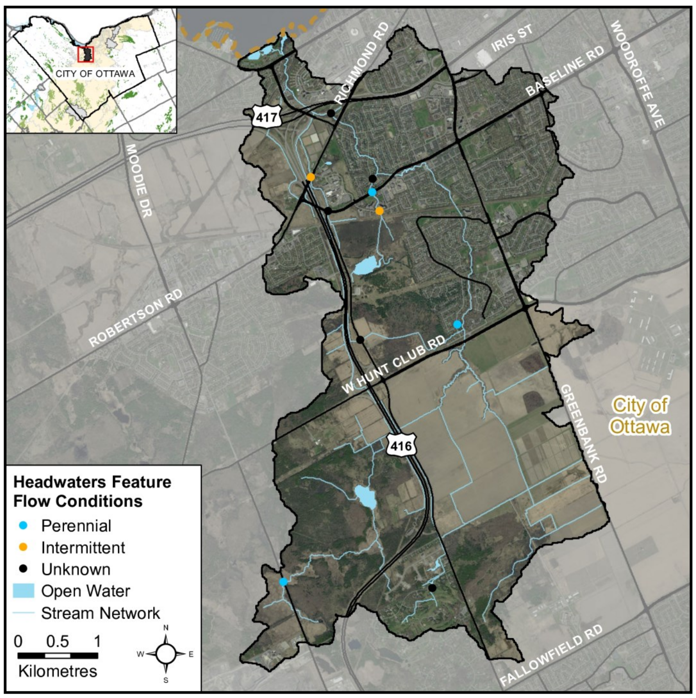

Figure 35 Graham Creek HDF flow conditions

Intermittent flow feature along Cowitchan Way

Feature Channel Modifications

Channel modifications were assessed at each headwater drainage feature sampling location. Modifications include channelization, dredging, hardening and realignments.

The majority of drainage features in the Graham Creek catchment showed some level of modification, and included instances of dredging/straightening, channel hardening and entrenchment (ie. armor stone, gabions, etc), and pond modifications (Figure 36). Three sites were identified as having limited/no modification within the primary feature.

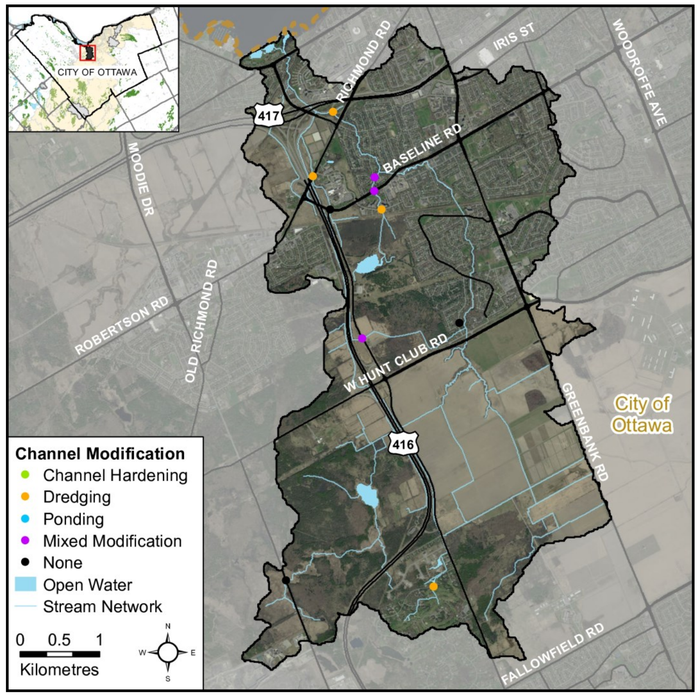

Figure 36 Graham Creek HDF channel modifications

Highly modified headwater feature along Cowitchan Way

Headwater Feature Vegetation

Feature vegetation is evaluated as the dominant vegetation type found directly within the stream channel. Vegetation within the feature plays a significant role in flow and sediment movement, as well as providing critical aquatic and terrestrial habitat. Vegetation types include: no vegetation, lawn, wetland, meadow, scrubland and forest.

Flow feature vegetation within the Graham Creek catchment was limited to either wetland, meadow or as having no defined vegetation (Figure 37). Features with no vegetation and wetlands were the most common, and each represent 40% of the surveyed sites.

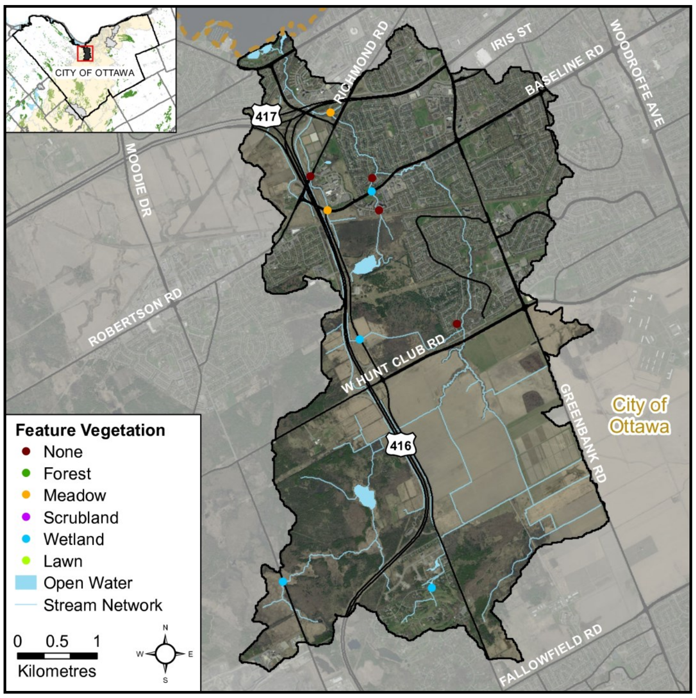

Figure 37 Graham Creek HDF feature vegetation

Wetland feature vegetation observed along Robertson Road

Headwater Feature Riparian Vegetation

Riparian vegetation is evaluated as the dominant vegetation type observed within 3 standardized shoreline zones. The vegetative community is assessed at 0-1.5m, 1.5-10m and 10-30m from the stream bank.

Riparian conditions within the Graham Creek catchment were predominantly altered, with 70% of sites evaluated as having modifications within the riparian area (Figure 38). Common riparian modifications included storm-water infrastructure and erosion control features.

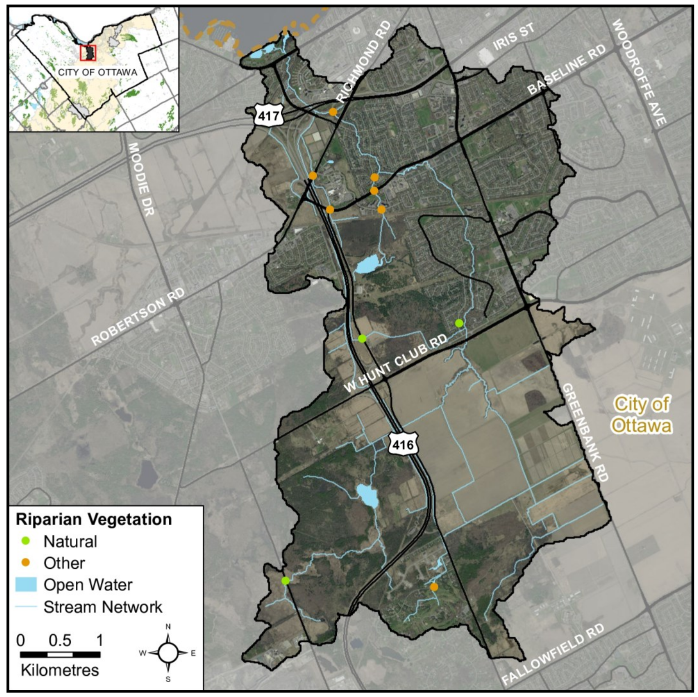

Figure 38 Graham Creek HDF riparian vegetation

A natural forested riparian buffer upstream of Highway 417

Headwater Feature Sediment Deposition

Assessing the amount of recent sediment deposited in a channel provides an index of the degree to which the feature could be transporting sediment to downstream reaches (OSAP, 2013). Evidence of excessive sediment deposition might indicate the requirement for further assessment and potential implementation of best management practices.

Sediment deposition within the Graham Creek catchment was assessed as minimal to moderate in 90% of monitoring sites (Figure 39). Substantial levels of deposition were identified at a single site, and was associated with shoreline destabilization and channel dredging upstream.

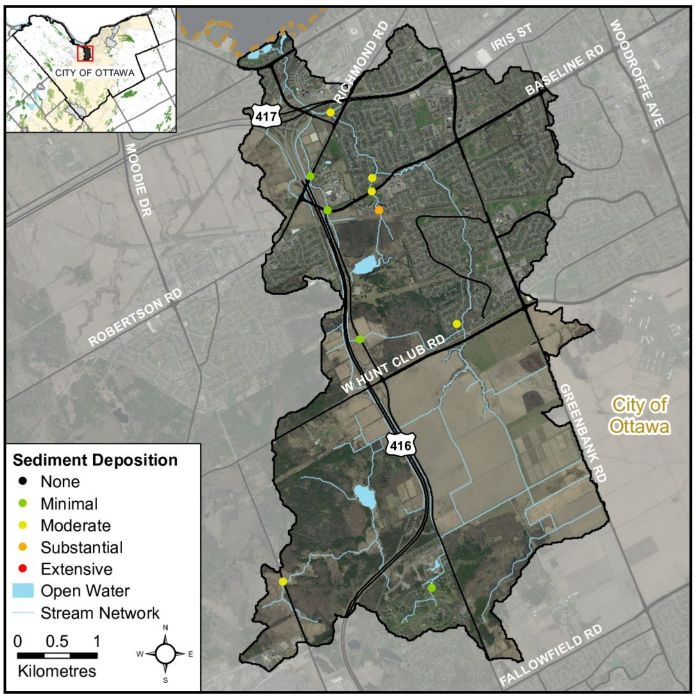

Figure 39 Graham Creek HDF sediment deposition

Substantial sediment deposition, entrenchment and bank destabilization along Valley Stream Dr

Headwater Feature Upstream Roughness

Feature roughness is a measure of the amount of material within the bankfull channel capable of slowing water velocity and stabilizing flows (OSAP, 2013). Materials on the channel bottom that provide roughness include vegetation, woody debris and boulders/cobble substrates. Roughness can promote for reduced erosion downstream of the feature, as well as providing important habitat to aquatic organisms.

Feature roughness varied considerably between sites, with minimal to extreme levels common throughout the catchment (Figure 40). Minimal levels were identified in three distinct locations, and were generally associated with significant feature modifications.

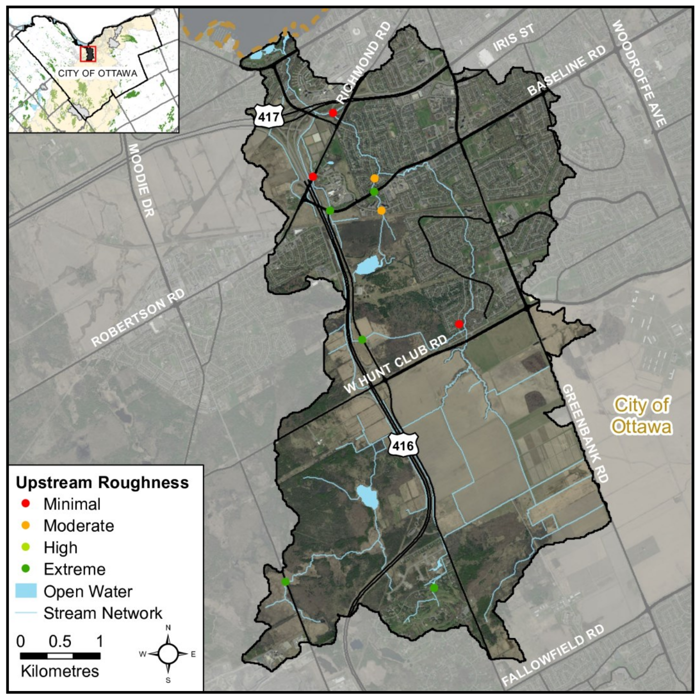

Figure 40 Graham Creek HDF feature roughness

Headwater feature with extreme roughness conditions along Cedarview Rd

Stream Comparison Between 2010 and 2016

The following tables provide a comparison of observations on Graham Creek between the 2010 and 2016 survey years. Graham Creek was also surveyed in 2005, but the surveying protocol has changed significantly since that time so data from 2005 cannot be compared to data from 2010 and 2016. In order to accurately represent current and historical information, the site data was only compared for those locations which were surveyed in both reporting periods. In some instances, this resulted in changes to our overall summary information. This information is therefore only a comparative evaluation and does not represent the entirety of our assessment.

Water Chemistry

Water chemistry parameters are tracked throughout the entire surveyed stream and reflect the general conditions, stability and quality of the environment. Shifts in these conditions can be indicative of general ecological changes within the environment, but also enable us to better understand the natural level of variability within the system (Table 3).

Between 2010-2016, pH levels on Graham Creek were comparable, with an overall trend towards more acidic conditions. Conversely, stream conductivity was found to have improved, with an average reduction of 106 µs/cm. Dissolved oxygen conditions were found to be in decline, with an average decrease of 1.92 mg/L. Changes in the pH and dissolved oxygen indicate a potential shift towards reduced ecological function, however given the limited scale of the data set (2 sampling years), it is difficult to determine if this trend falls within a natural level of variability or is a result of impairment. Stream conductivity was found to have improved slightly, however this may simply be a result of varying climate factors (ie. precipitation).

Stream temperatures were monitored via stationary temperature logger (*see thermal classification—Page 13)* and concurrently during stream sampling. General temperature observations identified a significant decrease in stream temperatures, with an average decline of 3.32 ºC. In order to account for differences in climate factors such as daily air temperature and precipitation, a standardized stream temperature assessment[1] was also utilized. Between 2010-2016, the stream temperature factor was found to have decreased, with an average drop of 0.13 ºC for every 1ºC of air temperature.

Table 3 Water chemistry comparison (2010/2016)

Water Chemistry (2010—2016)				
YEAR	**PARAMETER**	**UNIT**	**AVERAGE**	**STND ERROR**
2010	pH	-	8.06	0.31
2016	pH	-	7.89	0.26
2010	Sp. Conductivity	us/cm	1397	126
2016	Sp. Conductivity	us/cm	1291	37
2010	Dissolved Oxygen	mg/L	11.21	0.81
2016	Dissolved Oxygen	mg/L	9.29	0.23
2010	Water Temperature	ºC	19.31	0.92
2016	Water Temperature	ºC	15.99	0.39
2010	Standardized Stream Temperature [1]	ºC Water / 1ºC Air	0.69	0.03
2016	Standardized Stream Temperature [1]	ºC Water / 1ºC Air	0.56	0.08

[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
- All temperatures points to be collected in July/August
- Logger must be deployed in flowing waters

Invasive Species

Invasive species presence was compared between 2010-2016 to determine if the overall distribution of these species had changed (Table 4). In general, invasive species presence was observed to have decreased within Graham Creek, however several species appear to increased their range considerably. Species such as *common buckthorn, curly-leafed pondweed, Himalayan balsam,* and *Norway maple* were identified in more than double the amount of sites observed in the previous study year (2010). Conversely, *garlic mustard*, *wild parsnip* and *purple loosestrife* were found to be in decline and may be associated with on-going management efforts.

Table 4 Invasive species presence (2010/2016)

Invasive Species	2010 (%)	2016 (%)	+/-
Total	98%	75%	▼
Common buckthorn	8%	34%	▲
Curly-leafed pondweed	8%	17%	▲
Garlic Mustard	38%	21%	▼
Glossy buckthorn	6%	8%	-
Himalayan balsam	6%	28%	▲
Japanese knotweed	2%	2%	-
Manitoba maple	40%	40%	-
Norway maple	2%	13%	▲
Poison/Wild parsnip	6%	2%	▼
Purple loosestrife	75%	11%	▼

Pollution

Garbage accumulation on Graham Creek was found to be in decline from 2010 –2016 (Table 5). In 2010, garbage was identified in 87% of all surveyed sections. By comparison, 79% of sites in 2016 were found to have some form of garbage/pollution. Efforts were also undertaken in 2016 to further reduce potential waste within Graham Creek. Clean up efforts accounted for 13% of the identified waste areas, further reducing the overall levels observed.

Table 5 Pollution levels (2010/2016)

Pollution/Garbage	2010 (%)	2016 (%)	+/-
Total	87%	79%	▼
Floating garbage	36%	21%	▼
Garbage on stream bottom	81%	70%	▼
Oil or gas trails	2%	0%	-
Discoloration of channel bed	2%	8%	▲

Instream Aquatic Vegetation

Aquatic vegetation presence was compared between 2010-2016 to determine if the overall distribution of these plant communities had changed (Table 6). The presence of all plant communities was found to have decreased in 2016 and may be associated with drought conditions, sedimentation, seasonal factors and/or flow modification (ie. obstructions, storm water, etc).

Table 6 Instream aquatic vegetation (2010/2016)

Instream Vegetation	2010 (%)	2016 (%)	+/-
Narrow-leaved emergents	23%	11%	▼
Broad-leaved emergents	26%	0%	▼
Robust emergents	9%	2%	▼
Free-floating plants	17%	0%	▼
Floating plants	4%	0%	▼
Submerged plants	72%	47%	▼

Fish Community

Fish sampling was conducted on Graham Creek by the City Stream Watch program in 2005, 2010 and 2016 (Table 7). In total, 30 species of fish have been captured through City Stream Watch fish sampling efforts. In 2005, 11 species were captured with most species recaptured in the following sample sessions. In 2010, 25 fish species were identified, as sampling efforts were increased significantly. 2016 sampling resulted in the capture of 4 additional species, with a total of 21 species identified.

Table 7 Fish species comparison from 2005 / 2010 / 2016

Species	Code	2005	2010	2016
Banded killifish	BaKil		X	X
Blacknose dace	BnDac		X	
Blacknose shiner	BnShi		X	X
Bluntnose minnow	BnMin	X	X	X
Brassy minnow	BrMin			X
Brook stickleback	BrSti	X	X	X
Brown bullhead	BrBul		X	
Burbot	Burbo		X	X
Cyprinid sp.	CA_MI			X
Central mudminnow	CeMud		X	X
Common shiner	CoShi		X	X
Cottus sp.	CotSp	X		
Creek chub	CrChu		X	X
Emerald shiner	EmShi		X	
Etheostoma sp.	EthSp	X	X	X
Fathead minnow	FhMin	X	X	X
Golden shiner	GoShi			X
Iowa darter	IoDar		X	
Lepomis sp.	LepSp			X
Logperch	Logpe	X	X	X
Longnose dace	LnDac	X	X	X
Longnose gar	LnGar		X	
Mottled sculpin	MoScu		X	X
Northern pearl dace	PeDac		X	X
Northern pike	NoPik			X
Northern redbelly dace	NRDac	X	X	X
Pumpkinseed	Pumpk		X	
Rock bass	RoBas		X	
Spotfin shiner	SpShi	X	X	
Spottail shiner	SfShi			X
White sucker	WhSuc	X	X	X
Yellow perch	YePer	X	X	X

Longnose gar young of year (YOY) caught at the mouth of Graham Creek

Monitoring and Restoration

Monitoring and Restoration Projects on Graham Creek

Table 8 highlights recent monitoring and restoration work that has been done on Graham Creek by the Rideau Valley Conservation Authority. Potential restoration opportunities are listed on the following page.

Table 8 Monitoring and Restoration on Graham Creek

Accomplishment	Year	Description
City Stream Watch Stream Monitoring	2005	67 stream surveys completed on Graham Creek
	2010	64 stream surveys completed on Graham Creek
	2016	53 stream surveys completed on Graham Creek
City Stream Watch Fish Sampling	2005	3 fish community sites were sampling in Graham Creek
	2010	6 fish community sites were sampling in Graham Creek
	2016	8 fish community sites were sampling in Graham Creek
City Stream Watch Thermal Classification	2005	2 temperature probes were deployed in Graham Creek
	2010	4 temperature probes were deployed in Graham Creek
	2016	4 temperature probes were deployed in Graham Creek
City Stream Watch Headwater Drainage Feature Assessment	2016	10 headwater drainage feature sites were sampled in the Graham Creek catchment
City Stream Watch Stream Cleanups	2016	City stream watch volunteers assisted in cleaning over 850m of shoreline during 1 cleanup session
City Stream Watch Invasive Species Removal	2016	City stream watch volunteers assisted in the removal of Himalayan balsam over 2 removal sessions


Volunteers attending a training session on Graham Creek


Volunteers planting trees along Graham Creek

Potential Riparian Restoration Opportunities

Riparian restoration opportunities were assessed in field and include potential enhancement through riparian planting, erosion control, invasive species management and/or wildlife habitat creation (Figure 41).

Erosion Control
Unstable flow conditions and failed gabions were noted upstream of Banner Rd and may be due to regular debris accumulation within the culverts.

Invasive Species Control
Invasive species were common within the catchment, with several small isolated communities identified. *Himalayan balsam* was isolated to the Monterey/ Baseline region and is presumed to be the point of entry. Several additional communities of *Himalayan balsam* were identified downstream, and may be effectively removed due to their isolated state.

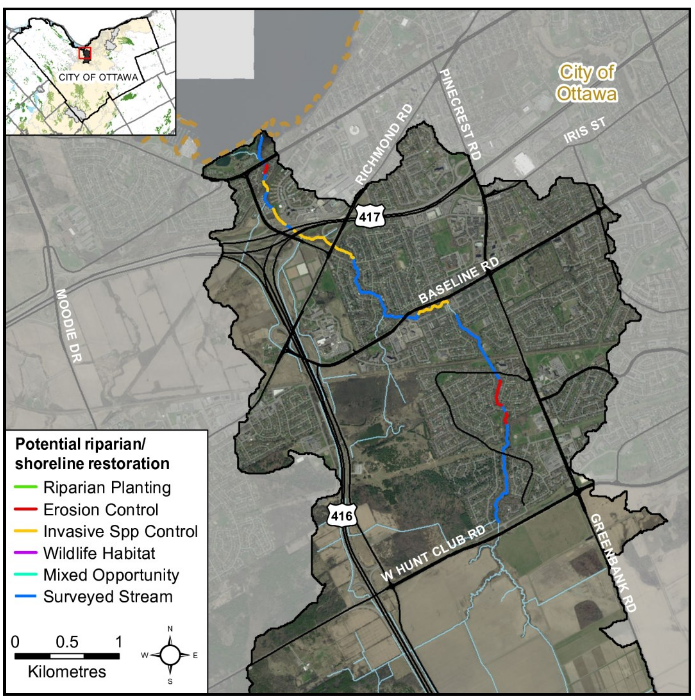

Figure 41 Potential riparian/shoreline restoration opportunities

Himalayan balsam removal from Graham Creek

Potential Instream Restoration Opportunities

Instream restoration opportunities were assessed in field and include potential enhancement through channel modification, stream cleanups and fish habitat creation (Figure 42).

Stream Cleanup
Efforts were employed to remove a considerable amount of garbage in 2016, however several locations still exist which could benefit from a cleanup. Garbage accumulation was identified in proximity to Carling Ave, Baseline Rd and McClellan Rd.

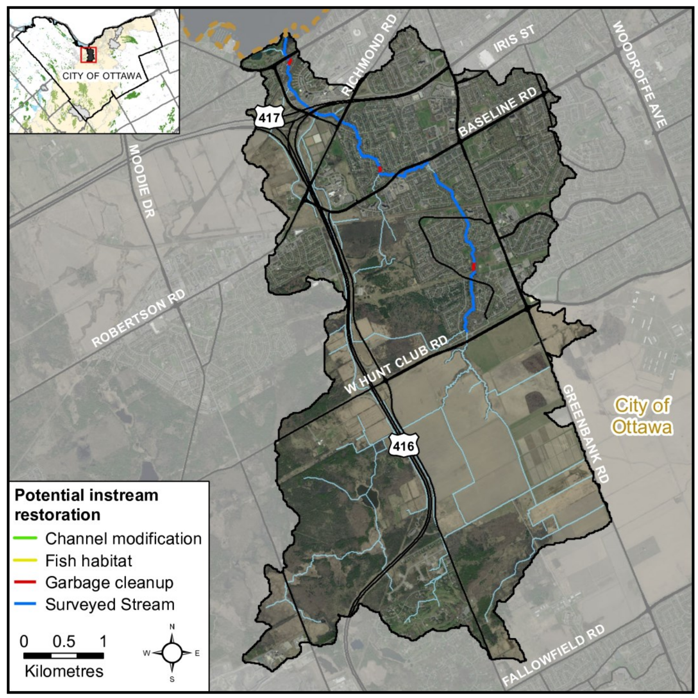

Figure 42 Potential instream restoration opportunities

Bank wall failure along a tributary to Graham Creek



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For more information on the overall 2016 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2016 Summary Report.