Cardinal Creek 2014

Summary Report

Watershed Features

Area	38.91 square kilometres 0.92% of the Rideau Valley watershed
Land Use	54% agriculture 17% urban 17% forest 11% rural 1% wetland
Surficial Geology	75% clay 15% Paleozoic bedrock 7% diamicton 1% organic deposits 1% sand 0.5% gravel 0.5% Precambrian bedrock
Watercourse Type	*Watercourse Type:* 99% natural 1% channelized *Flow Type:* 95% permanent 5% intermittent
Invasive Species	There were ten invasive species observed in 2014: purple loosestrife, common buckthorn, Manitoba maple, curly leafed pondweed, flowering rush, garlic mustard, Japanese knotweed, wild parsnip, rusty crayfish, yellow iris
Fish Community	40 fish species have been captured in Cardinal Creek including ten game fish species

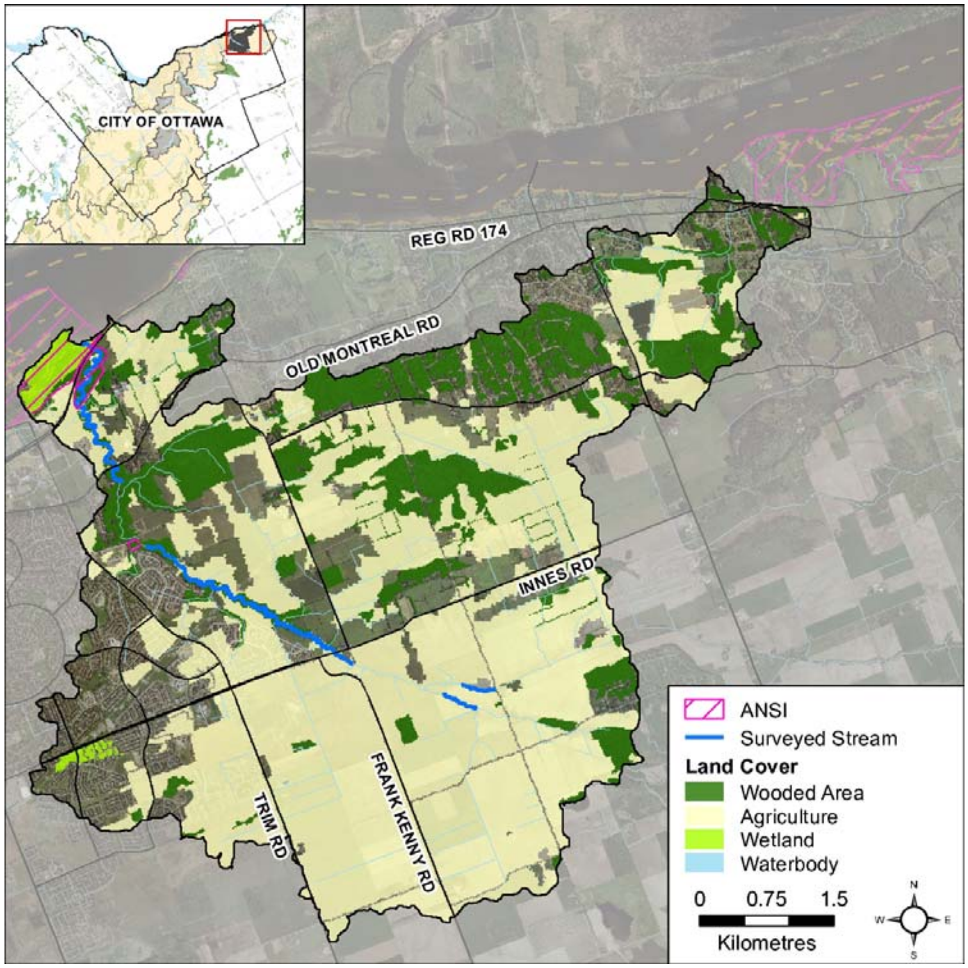


Figure 1 Land cover in the Cardinal Creek catchment

Vegetation Cover

Types	Hectares	% of Cover
Wetlands	39	6
Wooded	637	91
Hedgerow	15	2
Plantation	7	1
TOTAL		**100%**

Woodlot Cover

Size Category	Number of Woodlots	% of Woodlot Cover
10-30 ha	9	5
>30 ha	5	3

Wetland Cover

1% of the watershed is wetland

Wetlands make up 6% of the vegetation cover

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 2014 City Stream Watch collaborative.

Introduction

Cardinal Creek is approximately eight kilometres long and flows northwest under Innes Road, Old Montreal Road and Highway 174 before emptying into the Ottawa River east of Petrie Island. Cardinal Creek is dominated by head-water streams which can contribute as much as 70 percent of the flow and transport considerable amounts of sediment downstream (RVCA, 2008). Land use within the subwatershed, especially in the south portion, is predominantly agricultural with a number of municipal drains that empty into the creek. The north end of the subwatershed has been classified as a karst feature by the Ontario Geological Survey (AECOM, 2014). Upstream of Watters Road the creek flows into an online stormwater facility which is piped into the karst and flows through to the north side of Watters Road (RVCA, 2008). From here, Cardinal Creek descends into a cave and sinkhole system. Forming part of the karst feature, this area has been protected as a provincially significant Area of Natural and Scientific Interest (ANSI) (AECOM, 2014). Development pressure is recognized as the most significant threat to maintaining the environmental functions and level of biodiversity in the north portion of the subwatershed (AECOM, 2014). The area surrounding Cardinal Creek has seen considerable residential development north of Innes Road on the west side of the creek, and most recently there has been approval of the Cardinal Village development north of Old Montreal Road on the east side of the creek.

In 2014, permission was granted to survey 74 sections (7.4 km) of Cardinal Creek as part of the City Stream Watch monitoring activities. Surveying in 2014 did not include the karst feature near Watters Road, but did extend farther south than previous years reaching O'Toole Road. The following is a summary of observations made by staff and volunteers along those 74 sections.

Cardinal Creek Overbank Zone

Riparian Buffer Width Evaluation

The riparian or shoreline zone is that special area where the land meets the water. Well-vegetated shorelines are critically important in protecting water quality and creating healthy aquatic habitats, lakes and rivers. Natural shorelines intercept sediments and contaminants that could impact water quality conditions and harm fish habitat in streams. 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. A recommended target (from Environment Canada's Guideline: How Much Habitat is Enough?) is to maintain a minimum 30 meter wide vegetated buffer along at least 75 percent of the length of both sides of rivers, creeks and streams. Cardinal Creek has a very healthy buffer width along most of its length. It surpassed the target above by having a buffer of greater than 30 meters along 78 percent of the right bank and 84 percent of the left bank. Figure 2 demonstrates the buffer conditions of the left and right banks separately.

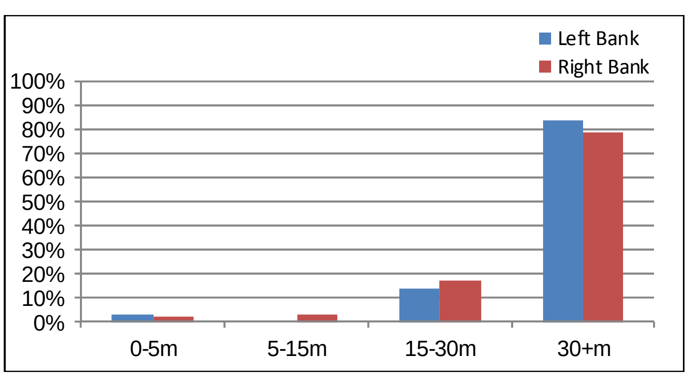


Figure 2 Vegetated buffer width along Cardinal Creek

Adjacent Land Use

The RVCA's Stream Characterization Survey Program identifies nine different land uses beside Cardinal Creek (Figure 3). Surrounding land use is considered from the beginning to end of each survey section (100m) and up to 100m 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. Natural areas made up 81 percent of the surveyed stream, characterized by forest, scrubland, meadow and wetland. Eleven percent of the land use along the surveyed sections of the stream was made up of agriculture, pasture and abandoned agriculture. The remaining eight percent of the land use surveyed was residential and infrastructure which includes road crossings.

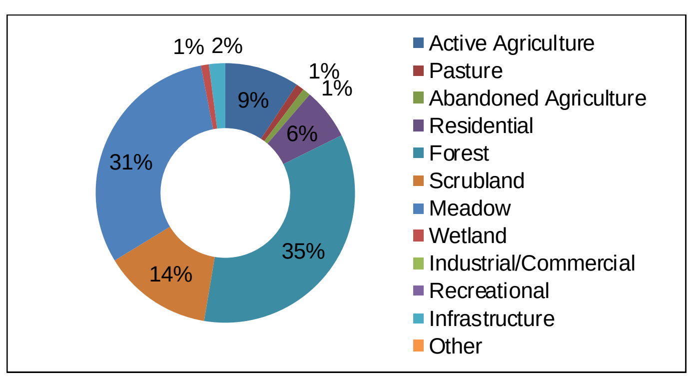


Figure 3 Land use along Cardinal Creek

Cardinal Creek Shoreline Zone

Erosion

Erosion is a normal, important stream process and may not affect actual bank stability; however, excessive erosion and deposition of sediment within a stream can have a detrimental effect on important fish and wildlife habitat. Poor bank stability can greatly contribute to the amount of sediment carried in a waterbody as well as loss of bank vegetation due to bank failure, resulting in trees falling into the stream and the potential to impact instream migration. Figure 4 shows moderate levels of bank erosion were observed along many sections of Cardinal Creek. There were a few sections where high levels of erosion were observed near O'Toole Road and between the stormwater pond and Innes Road.

Undercut Stream Banks

Undercut banks are a normal and natural part of stream function and can provide excellent refuge areas for fish. Figure 5 shows that the bank undercutting on Cardinal Creek varied considerably. Much of the creek had no bank undercutting interspersed with areas of low level undercutting. There were however, some areas that had very high levels of undercutting especially between Innes Road and Frank Kenny Road. The bank and substrate composition in this area is dominated by clay and the riparian vegetation is predominantly grasses so there is a possibility that the bank undercutting in this area may lead to some bank failure.

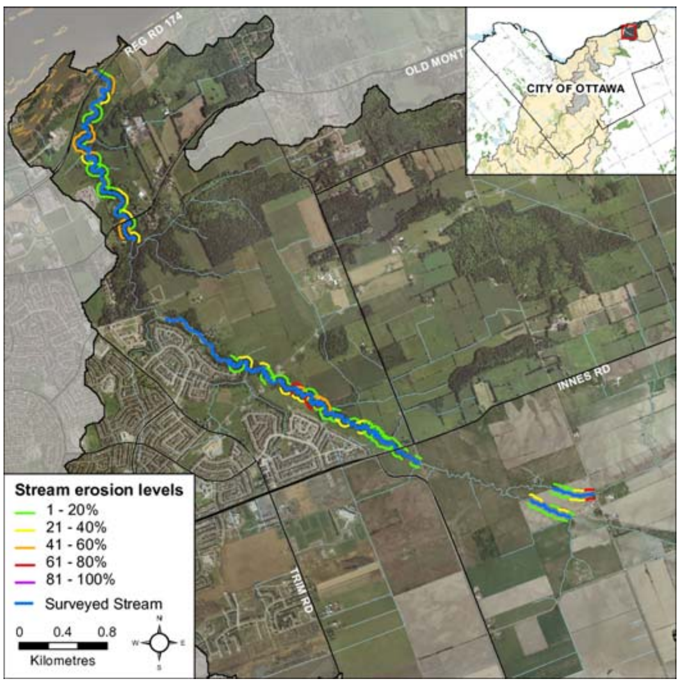


Figure 4 Erosion along Cardinal Creek

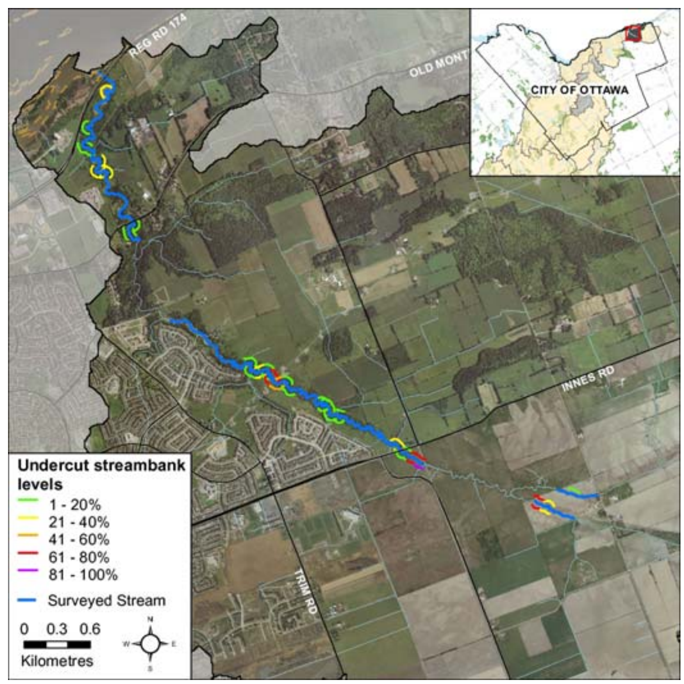


Figure 5 Undercut stream banks along Cardinal Creek

Stream bank erosion along Cardinal Creek

Bank undercutting along Cardinal 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. Figure 6 shows stream shading along Cardinal Creek. Moderate levels of shading were seen along most of the creek. Some high levels of shading were observed in heavily forested areas near Old Montreal Road and in the upper reaches near O'Toole Road where the creek is shaded completely by overhanging grasses.

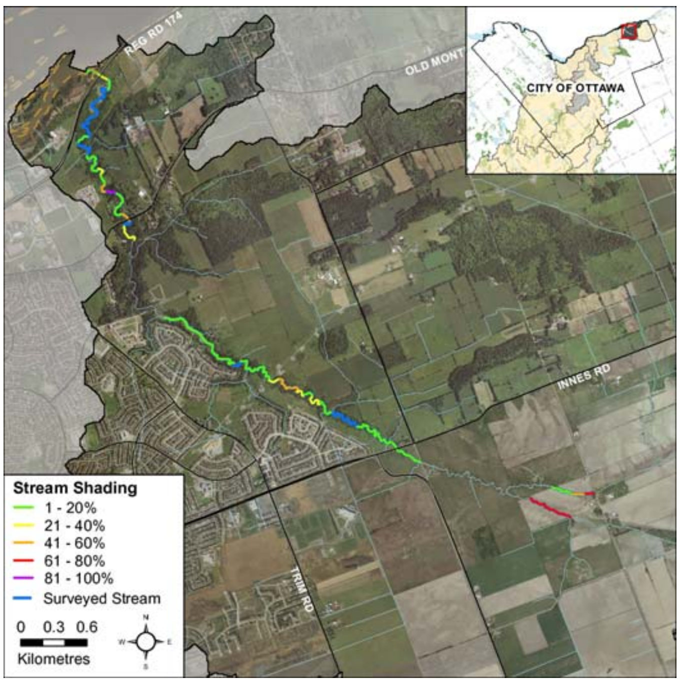


Figure 6 Stream shading along Cardinal Creek

Stream shade along Cardinal Creek

Instream Woody Debris

Figure 7 shows that overall, the surveyed sections along Cardinal Creek had low to moderate levels of instream woody debris in the form of branches and trees. Instream woody debris is important for fish and benthic habitat, by providing refuge and feeding areas.

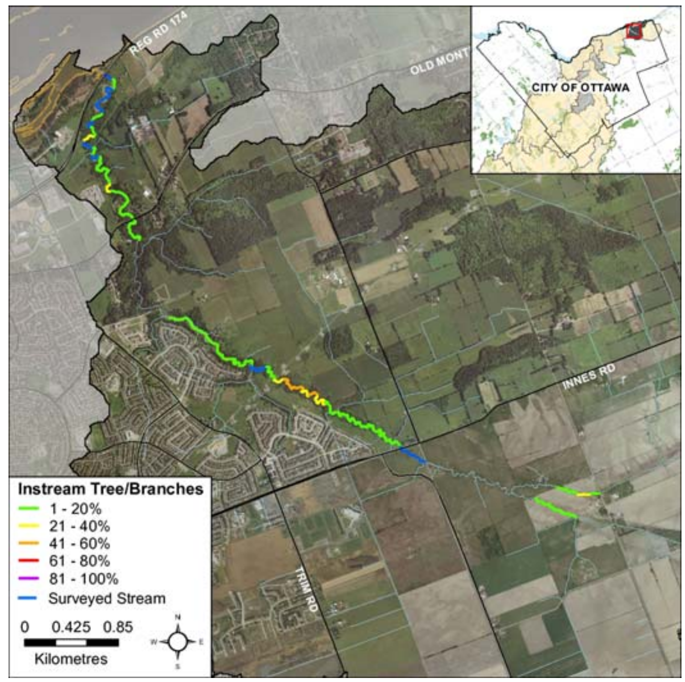


Figure 7 Instream woody debris along Mud Creek

Instream woody debris along Cardinal Creek

Overhanging Trees and Branches

Figure 8 shows that most of the sections surveyed on Cardinal Creek had low levels of overhanging branches and trees. 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.

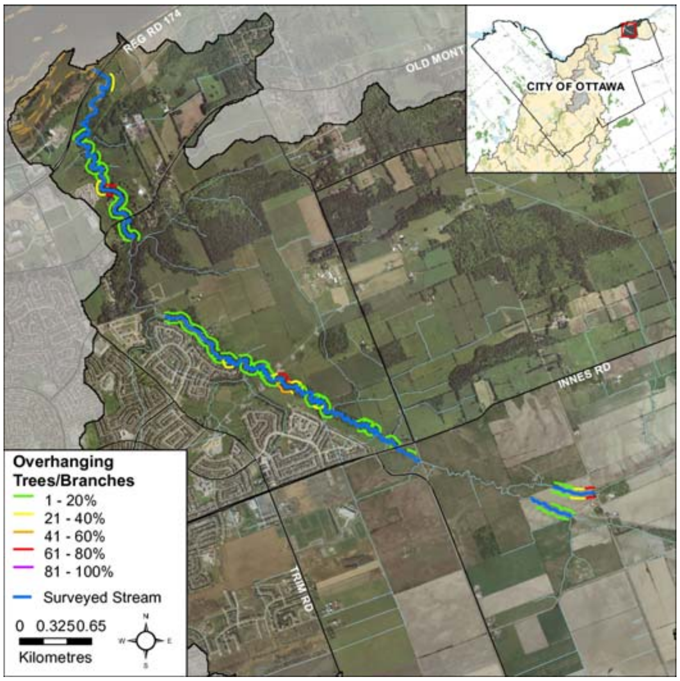
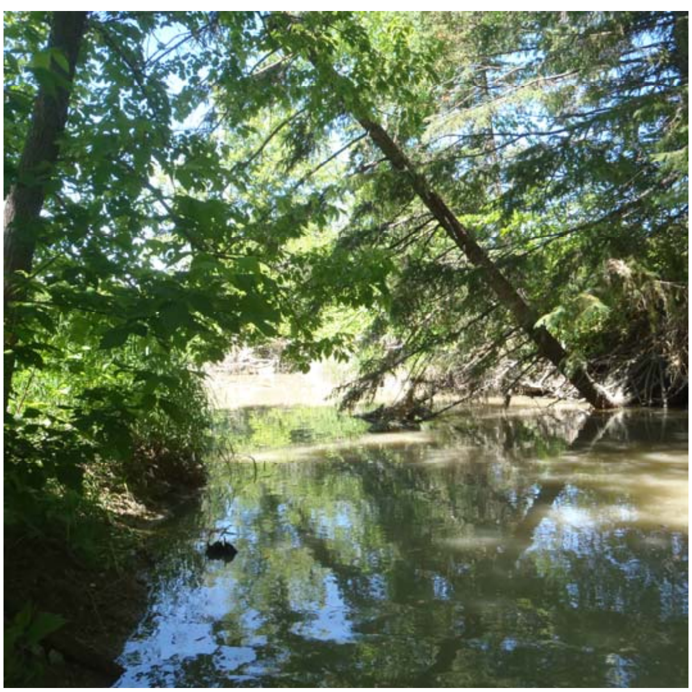


Figure 8 Overhanging trees and branches



Overhanging trees and branches on Cardinal Creek

Anthropogenic Alterations

Figure 9 shows that 85 percent of the sections on Cardinal Creek remain “unaltered” or "natural". Sections considered "altered" account for 11 percent of the stream, while only four percent of the sections sampled were considered “highly altered”. Very few of the surveyed sections of Cardinal Creek were channelized so the highly altered sections of the creek refer to areas where the creek runs through a culvert or there is a road crossing with associated instream/shoreline modifications.

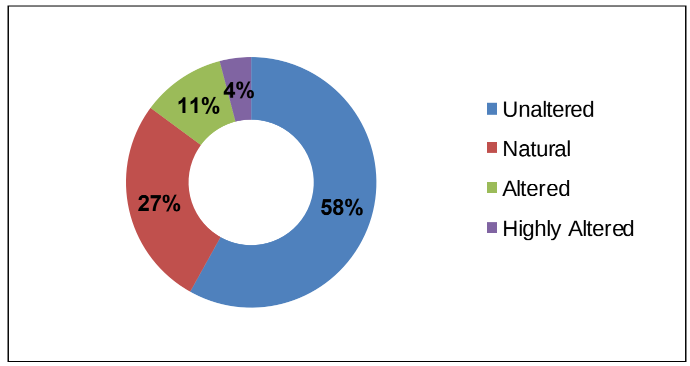


Figure 9 Anthropogenic alterations along Cardinal Creek

A highly altered section of CardinalCreek which runs through a culvert

Cardinal Creek Instream Aquatic Habitat

Habitat Complexity

Streams are naturally meandering systems and move over time; there are varying degrees of habitat complexity, depending on the creek. Examples of habitat complexity include variable habitat types such as pools and riffles as well as substrate variability and woody debris structure. A high percentage of habitat complexity (heterogeneity) typically increases the biodiversity of aquatic organisms within a system. The complexity of Cardinal Creek was very dependent on the dominant substrate type in the creek. Sixty four percent of the system was considered homogeneous. Homogeneous areas were typically dominated by clay substrate. Thirty six percent of the system was considered heterogeneous, these areas were characterized by more diverse substrate types especially near Old Montreal Road.

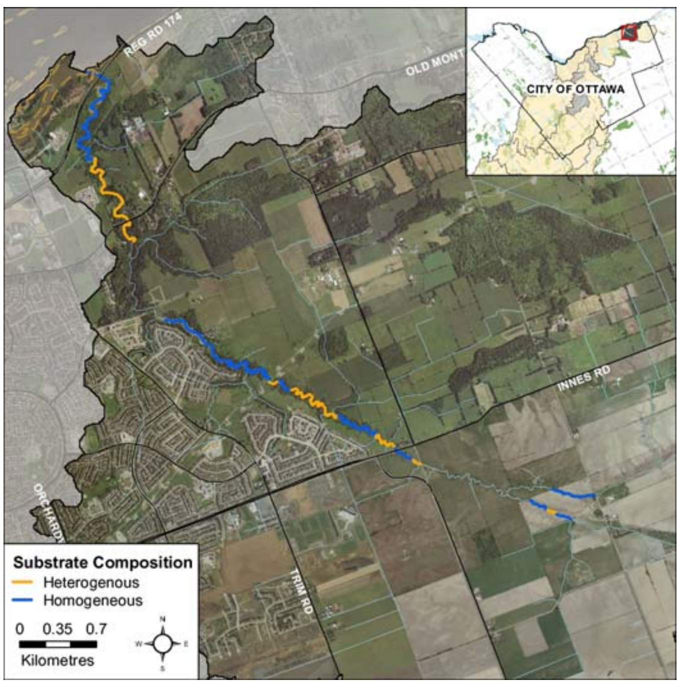


Figure 10 Instream habitat complexity in Cardinal Creek

Habitat complexity on Cardinal Creek

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. Figure 11 shows that 74 percent of the instream substrate observed on Cardinal Creek was clay. Thirteen percent of the substrate was recorded as silt and sand and the remaining 13 percent was made up of gravel, cobble, boulder and bedrock. Figure 12 shows the distribution of the dominant substrate types along the system. Clay was recorded most often as the dominant substrate near the mouth of the creek and in the reaches upstream of Watters Road. Although the sections directly downstream of Watters Road were not part of the survey in 2014 the influence of the Karst feature on Cardinal Creek is reflected in Figure 12 by the dominance of cobble and bedrock substrates around Old Montreal Road.

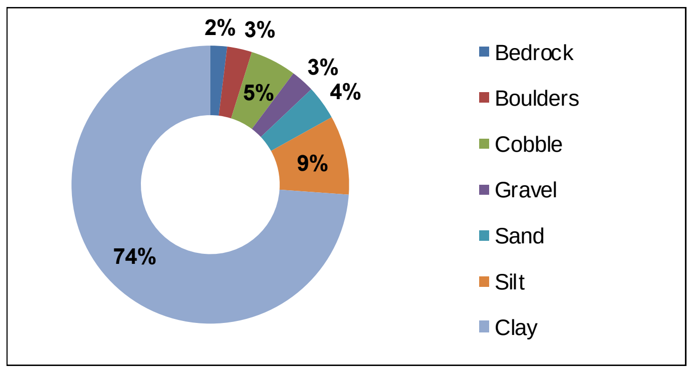


Figure 11 Instream substrate along Cardinal Creek

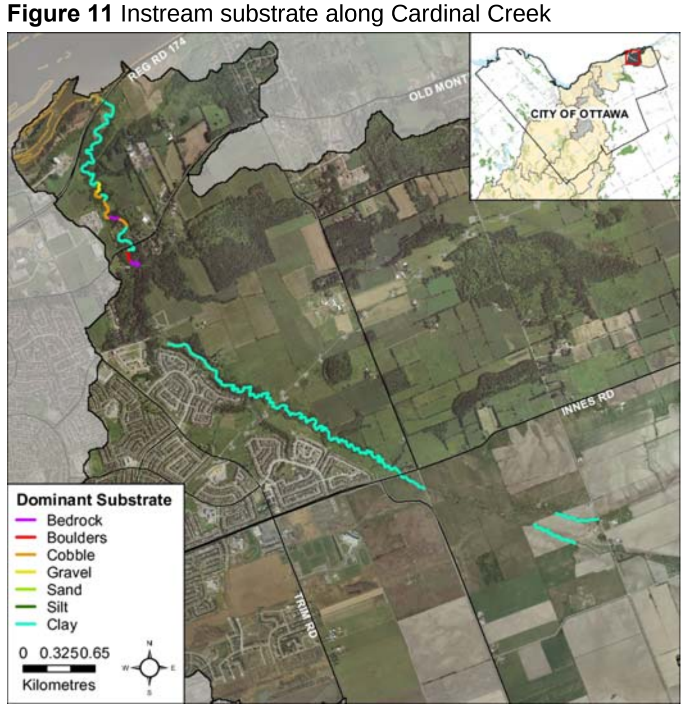


Figure 12 Dominant instream substrate in Cardinal Creek

Cobble and Boulder Habitat

Boulders create instream cover and back eddies for large fish to hide and/or rest out of the current. Cobble provides important over-wintering and/or spawning habitat for small or juvenile fish. Cobble can also provide habitat conditions for benthic invertebrates that are a key food source for many fish and wildlife species. Figure 13 shows the distribution of cobble and boulder habitat along Cardinal Creek. Areas of cobble and boulder habitat are concentrated around Old Montreal Road, Innes Road and in the upper reaches of the creek near O'Toole Road.

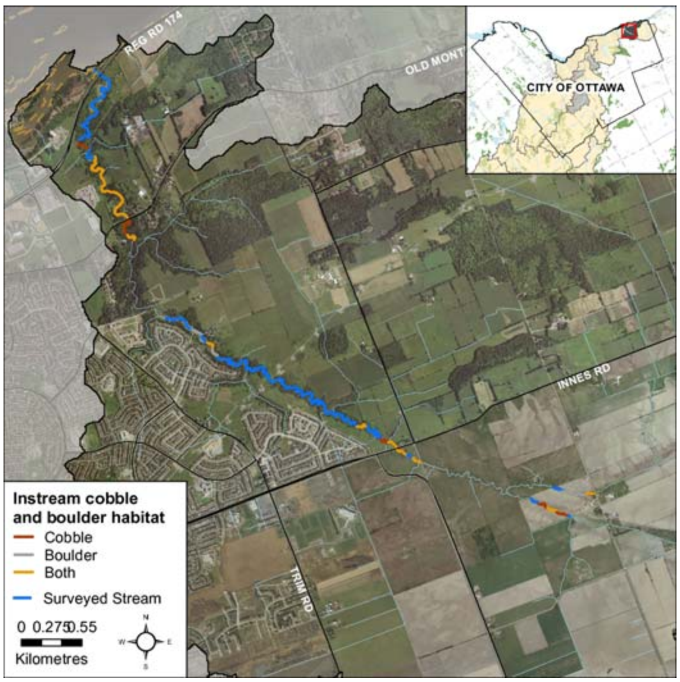


Figure 13 Cobble and boulder habitat in Cardinal Creek

Cobble and boulder habitat observed along Cardinal Creek downstream of Old Montreal Road

Instream Morphology

Pools and riffles are important habitat features for fish. Riffles are areas of agitated water and they contribute higher dissolved oxygen to the stream and act as spawning substrate for some species of fish, such as sauger and walleye. Pools provide shelter for fish and can be refuge areas in the summer if water levels drop and water temperature in the creek increases. Pools also provide important over-wintering areas for fish. Runs are usually 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 Cardinal Creek has some variability in instream morphology; 80 percent consists of runs, 15 percent consists of pools and five percent consists of riffles. Figure 15 shows where areas of riffle habitat was observed in Cardinal Creek. The riffle habitat was most concentrated upstream and downstream of Old Montreal Road.

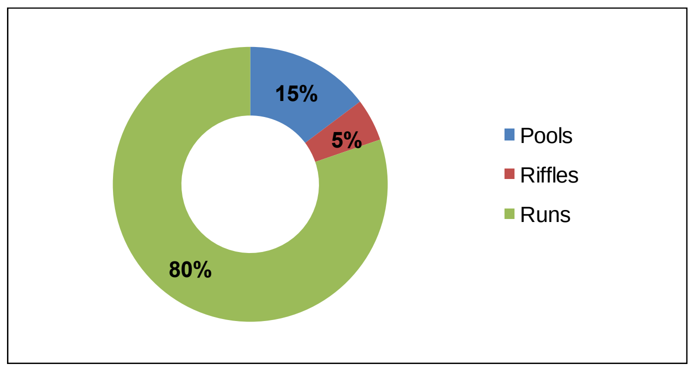


Figure 14 Instream morphology along Cardinal Creek

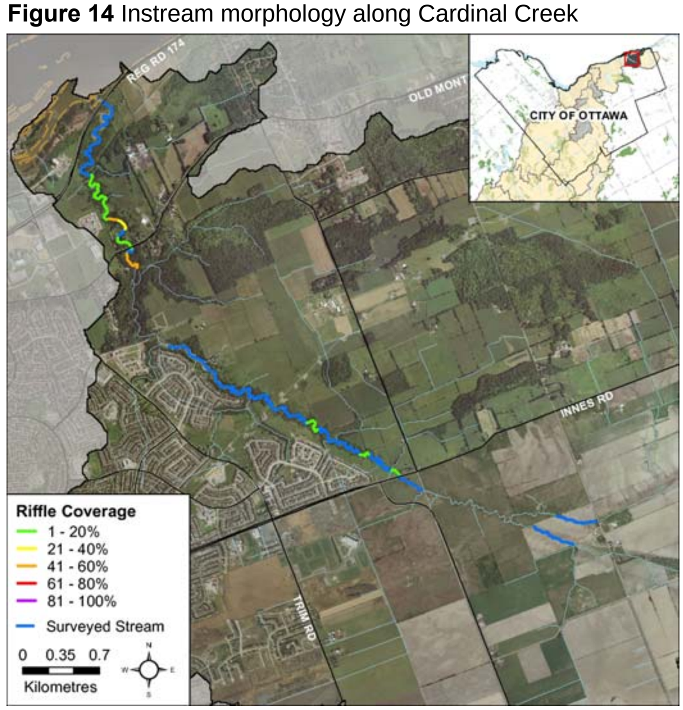


Figure 15 riffle coverage in Cardinal Creek

Vegetation Type

Instream vegetation provides a variety of functions and is a critical component of the aquatic ecosystem. For example emergent plants along the shoreline can provide shoreline protection from wave action and important rearing habitat for species of waterfowl. Submerged plants provide habitat for fish to find shelter from predator fish while they feed. Floating plants such as water lilies shade the water and can keep temperatures cool while reducing algae growth. Figure 16 depicts the high diversity of plant community structure in Cardinal Creek. The vegetation type observed in highest percentage, at 24 percent, is algae. Narrow-leaved emergent plants and submerged plants were also recorded often, at 22 percent and 19 percent respectively. The distribution of overall dominant types of instream vegetation is reflected in Figure 17.

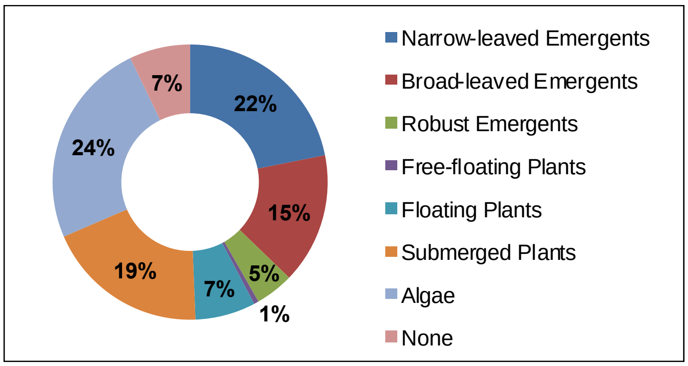


Figure 16 Vegetation types along Cardinal Creek

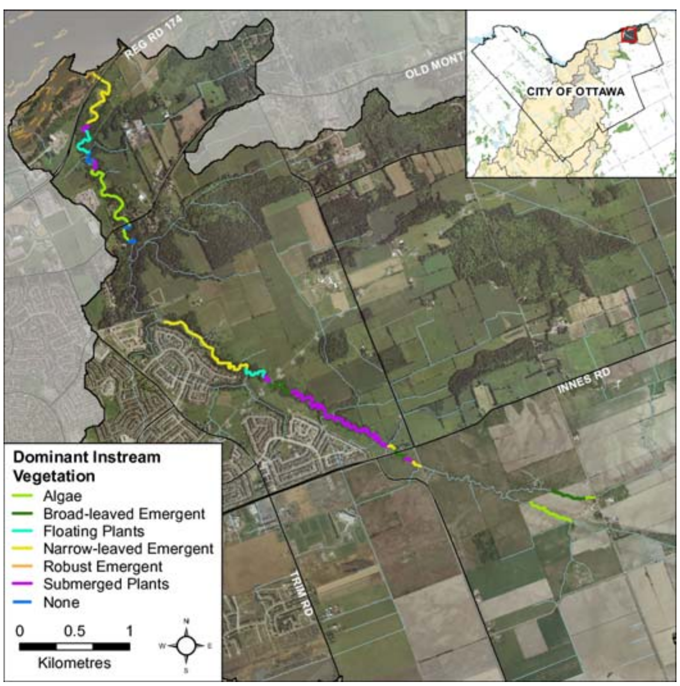


Figure 17 Dominant instream vegetation types in Cardinal Creek

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. Figure 18 demonstrates that overall Cardinal Creek had low to normal levels of instream vegetation. Low levels accounted for 43 percent, normal levels accounted for 33 percent, common levels accounted for 12 percent and the remaining 11 percent were rare levels and no vegetation. The low levels of vegetation are the result of clay substrates and high flows in the system as most types of vegetation, other than algae, have trouble establishing root structure in these conditions.

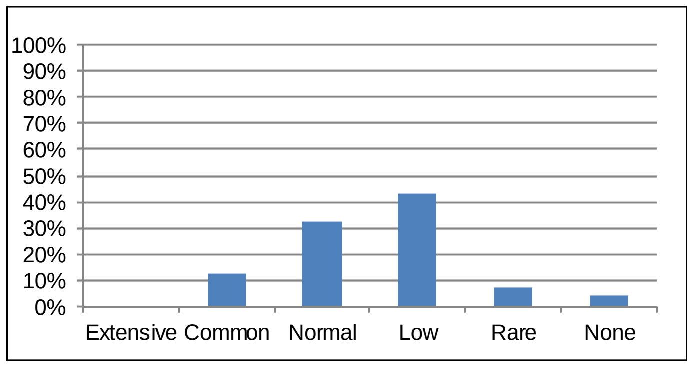


Figure 18 Instream vegetation abundance in Cardinal Creek

Narrow-leaved emergent vegetation observed on Cardinal Creek

Cardinal 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 85 percent of the sections surveyed along Cardinal Creek (Figure 19). Figure 20 shows the variety of invasive species observed along Cardinal Creek. The invasive species that were observed most often were purple loosestrife (*Lythrum salicaria)* which was observed in 57 percent of the sections with invasive species, Manitoba maple (*Acer negundo*) which was observed in 34 percent of the sections with invasive species, and curly leaf pondweed (*Potamogeton crispus*) which was observed in 31 percent of the sections with invasive species.

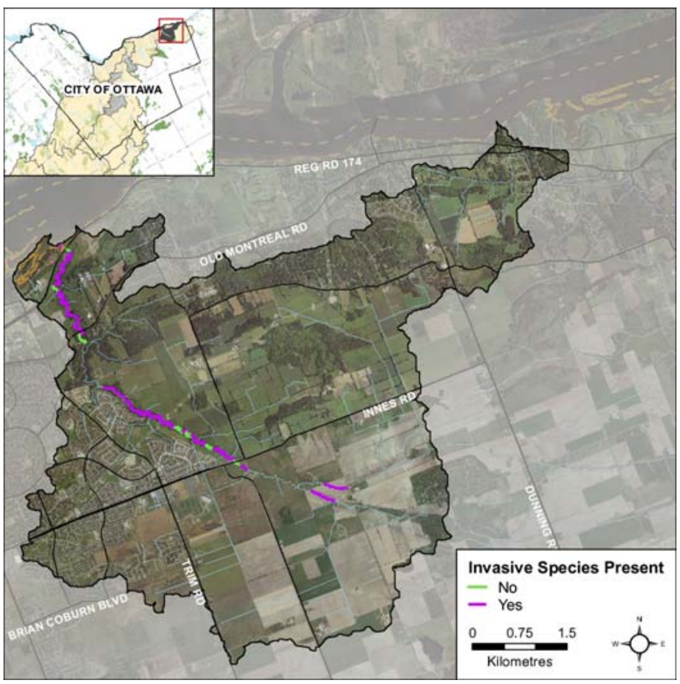


Figure 19 Presence of invasive species along Cardinal Creek

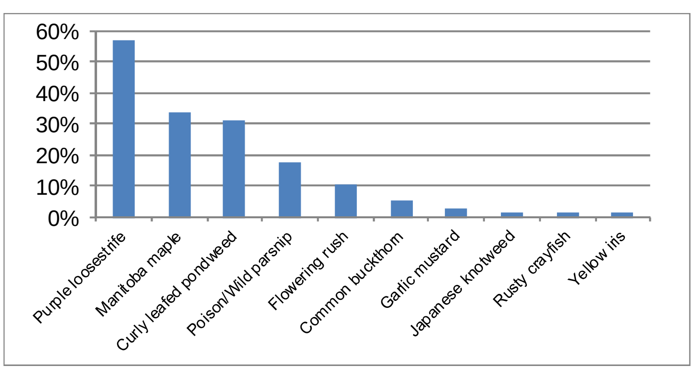


Figure 20 Invasive species observed along Cardinal Creek

Pollution

Figure 21 demonstrates the incidence of pollution/ garbage in Cardinal Creek. Fifty-one percent of the sections surveyed on Cardinal Creek did not have any observable garbage. Thirty percent had floating garbage, twenty-three percent had garbage on the stream bottom, and five percent had an unclassified type of pollution. Most of the sections where garbage was observed were near road crossings or along the stormwater ponds upstream of Watters Road.

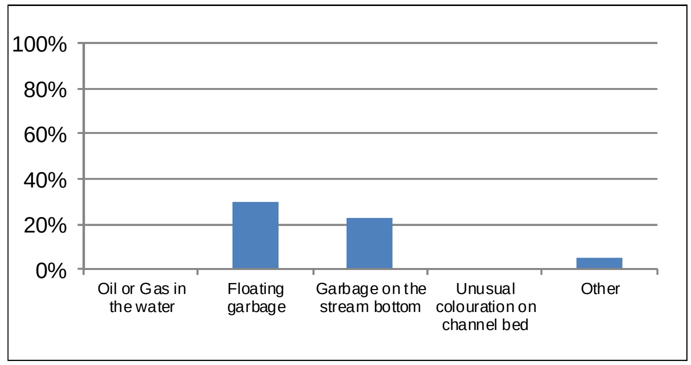


Figure 21 Pollution observed along Cardinal Creek

Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and overall stream health.

Wildlife	Observed
Birds	american woodcock, black-capped chickadee, bluejay, cardinal, catbird, crow, downy woodpecker, eastern phoebe, goldfinch, grackle, great blue heron, gull, hawk, housewren, kingfisher, mallard, mourning dove, pigeon, red-eyed vireo, red-winged blackbird, robin, sandpiper, sparrow spp, swallow, thrush, yellow-bellied sapsucker
Mammals	black squirrel, chipmunk, deer, muskrat, raccoon, red squirrel
Reptiles Amphibians	bullfrog, garter snake, green frog, leopard frog, painted turtle, snapping turtle, tadpoles
Aquatic Insects	aquatic beetle, aquatic spider, mayflies, beetle spp, water boatmen, crayfish, snail, mussels, water scorpion, water striders, whirlygig beetle
Other	admiral butterfly, bumblebee, cabbage white, cicada, deerfly, dragonfly, eastern tiger swallowtail, ebony jewelwing, honeybee, horseflie, monarch, mosquito, slug, snail, spider, wasp

Table 1 Wildlife observed along Cardinal Creek

Cardinal Creek Water Chemistry

Water Chemistry Measurement

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

Volunteers measuring water chemistry using a YSI

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen dissolved in water. The Canadian Environmental Quality Guidelines of 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 22) and 9.5 mg/L for coldwater biota (blue line in Figure 22) (CCME, 1999). Figure 22 shows that most of the stretches of Cardinal Creek meet that standard for warmwater biota. The stretch of creek downstream of Old Montreal Road has higher than average dissolved oxygen meeting the critera for coldwater biota. Conversely, the upper reaches of the creek had lower average dissolved oxygen compared to other stretches and doesn't meet standard of 6 mg/L for warmwater biota.

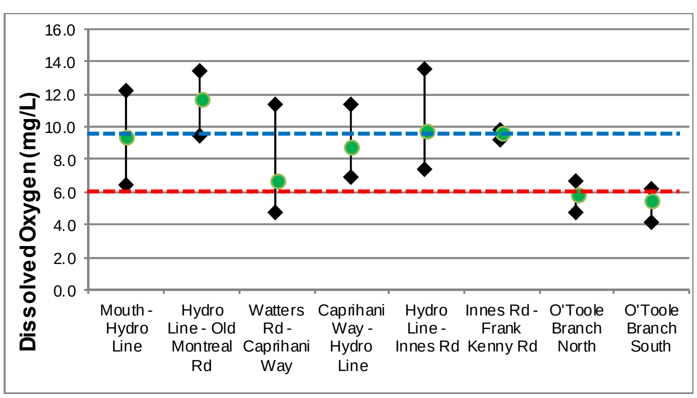


Figure 22 Dissolved oxygen ranges in Cardinal Creek

Conductivity

Conductivity in streams is primarily influenced by the geology of the surrounding environment, but can vary drastically as a function of surface water runoff. Currently there are no CCME guideline standards for stream conductivity, however readings which are outside the normal range observed within the system are often an indication of unmitigated discharge and/or stormwater input. The average conductivity observed within Cardinal Creek was 706 µs/cm. Figure 23 shows that the conductivity readings varied along the course of the creek. The lowest conductivity reading on Cardinal Creek was 523 µs/cm which was recorded in the stretch of the creek between Innes Road and Frank Kenny Road. There is a significant spike in conductivity in the south branch of the creek downstream of O'Toole Road where the average recorded conductivity was 973 µs/cm. The south branch of the creek is used primarily as drainage for agricultural lands and doesn't convey as much flow as the main branch to the north.

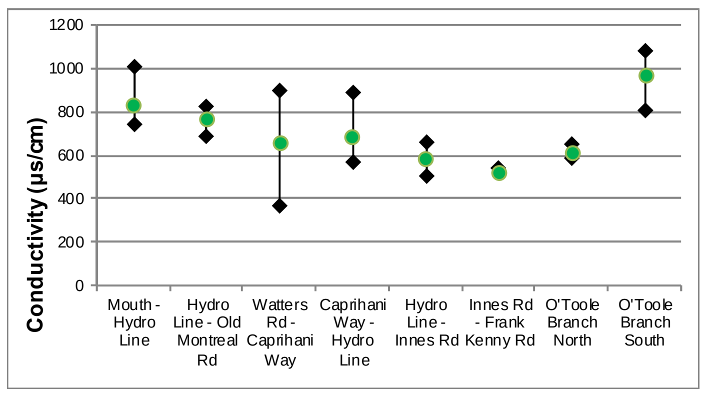


Figure 23 Conductivity ranges in Cardinal Creek

pH

Based on the PWQO for pH, a range of 6.5 to 8.5 should be maintained for the protection of aquatic life. Average pH values for Cardinal Creek ranged between 7.6 and 8.2, thereby meeting the provincial standard.

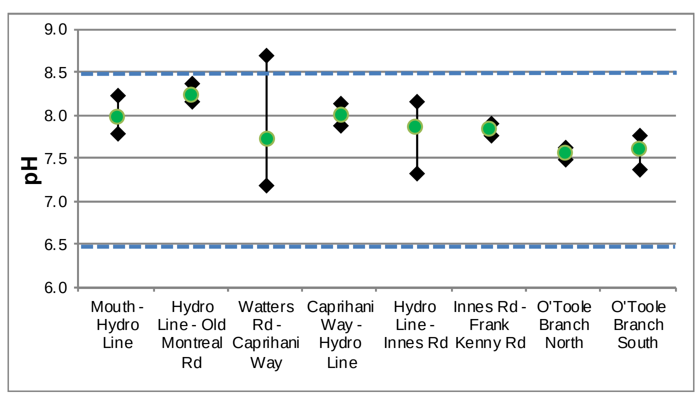


Figure 24 pH ranges in Cardinal Creek

Cardinal 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 temperature loggers were deployed in late April to monitor water temperature in Cardinal Creek. 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 27). Figure 25 shows the locations where temperature loggers were installed on Cardinal Creek Unfortunately logger 1 which was installed upstream of Highway 174 was not retrieved.

Analysis of the data collected indicates that the thermal classification of Cardinal Creek ranges between cool and warm water (Figure 27). The warm water reach was recorded at Frank Kenny Road.

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 are noted when observed. Figure 26 shows areas where one or more groundwater indicators were observed during stream surveys on Cardinal Creek. All of the groundwater indicators observed were upstream of the temperature logger at Caprihani way which displayed cool water readings.

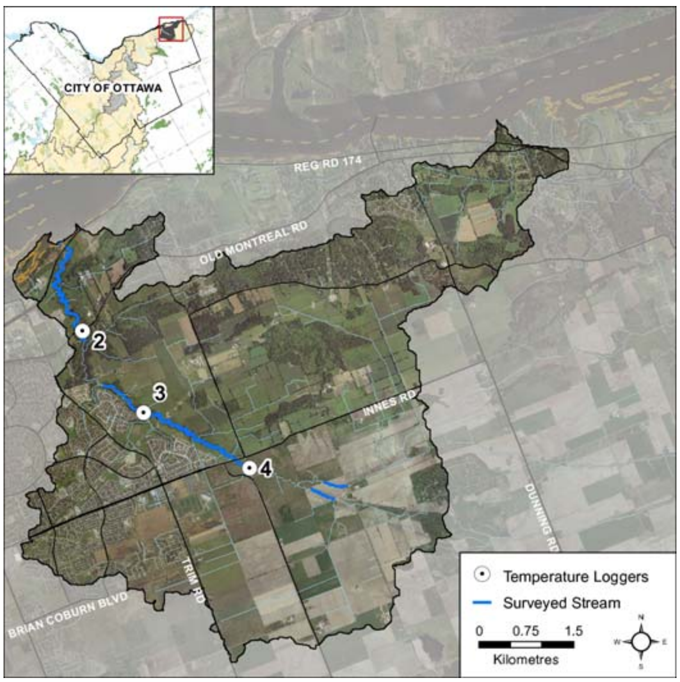


Figure 25 Temperature loggers along Cardinal Creek

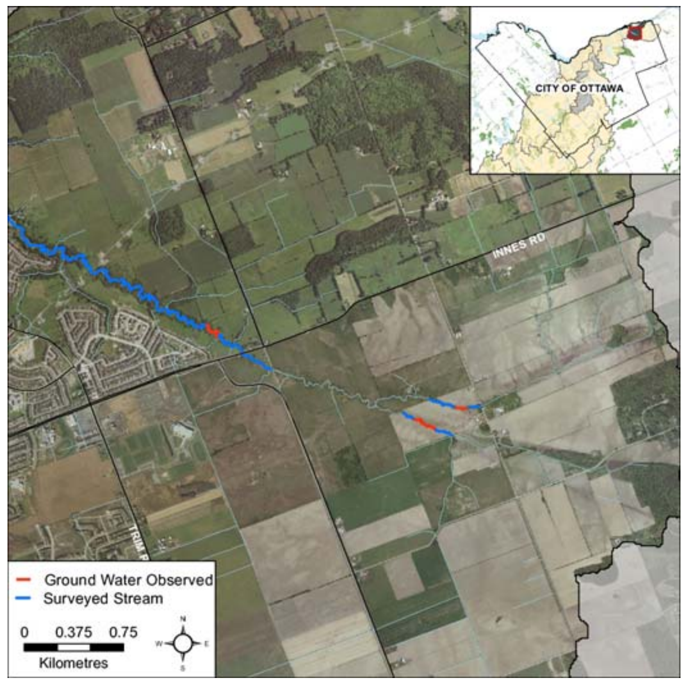


Figure 26 Groundwater indicators observed

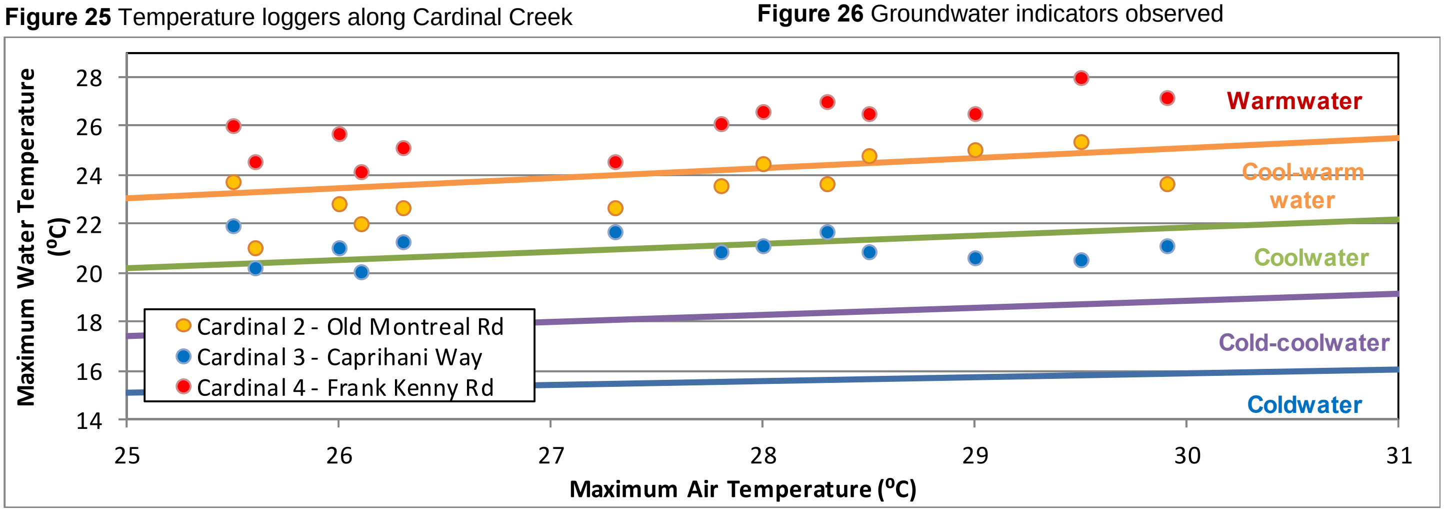


Figure 27 Thermal Classification for Cardinal Creek

Cardinal Creek Fish Community

Fish Community

Fish sampling sites located along Cardinal Creek are shown in Figure 28. The provincial fish codes shown in Figure 28 are listed (in Table 2) beside the common name of those fish species identified in Cardinal Creek. The thermal classification of Cardinal Creek ranges between coolwarm and warmwater, forty fish species have been observed. During City Stream Watch fish community sampling in 2014, a brook trout was captured at the mouth of the creek near the Ottawa River. The brook trout was likely not a resident species of Cardinal Creek and probably came from a stocked population on another tributary of the Ottawa River as the habitat and thermal classification of Cardinal Creek does not support this species.

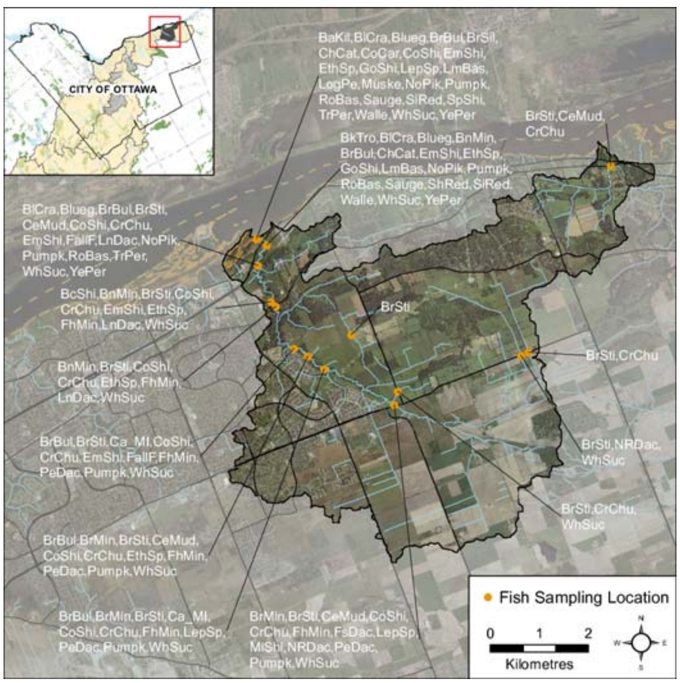


Figure 28 Cardinal Creek fish community

Species observed in Cardinal Creek (with fish code)			
black crappie………	BlCra	largemouth bass……..	LmBas
blackchin shiner…..	BcShi	*Lepomis spp…………*	LepSp
bluegill…………….	Blueg	logperch………………	LogPe
bluntnose minnow…	BnMin	longnose dace……….	LnDac
brassy minnow……	BrMin	muskellunge…………	Muske
brook stickleback…	BrSti	northern pike…………	NoPik
brook trout………..	BkTro	northern redbelly dace	NRDac
brown bullhead…….	BrBul	pearl dace…………….	PeDac
central mudminnow.	CeMud	pumpkinseed………..	Pumpk
Centrarchid spp……	SUNFI	rock bass…………….	RoBas
channel catfish……	ChCat	sauger…………………	Sauge
common shiner……	CoShi	shorthead redhorse….	ShRed
creek chub………..	CrChu	silver redhorse……….	SiRed
Cyprinid spp	Ca_MI	spottail shiner……….	SpShi
emerald shiner…….	EmShi	tessellated darter…….	TeDar
Etheostoma spp…..	EthSp	trout-perch……………	TrPer
fallfish……………..	Fallf	walleye……………….	Walle
fathead minnow……	FhMin	white sucker…………	WhSuc
golden shiner………	GoShi	yellow bullhead………	YeBul
johnny darter………	JoDar	yellow perch…………	YePer

Table 2 Fish species observed in Cardinal Creek

Brook trout captured at the mouth of Cardinal Creek

Muskellunge captured at the mouth of Cardinal 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. Figure 29 shows that on the surveyed sections of Cardinal Creek, two grade barriers were observed. One was upstream of Old Montreal Road and the other was downstream of Old Montreal Road. The grade barriers were the result of the karst feature in the north end of the creek.

Beaver Dams

Beaver dams can also act as obstructions to fish migration. Figure 30 shows that three abandoned beaver dams were observed on Cardinal Creek downstream of Third Line Road. The head, or difference between the water level up and down stream, of the beaver dams ranged from 0 cm to 23 cm.

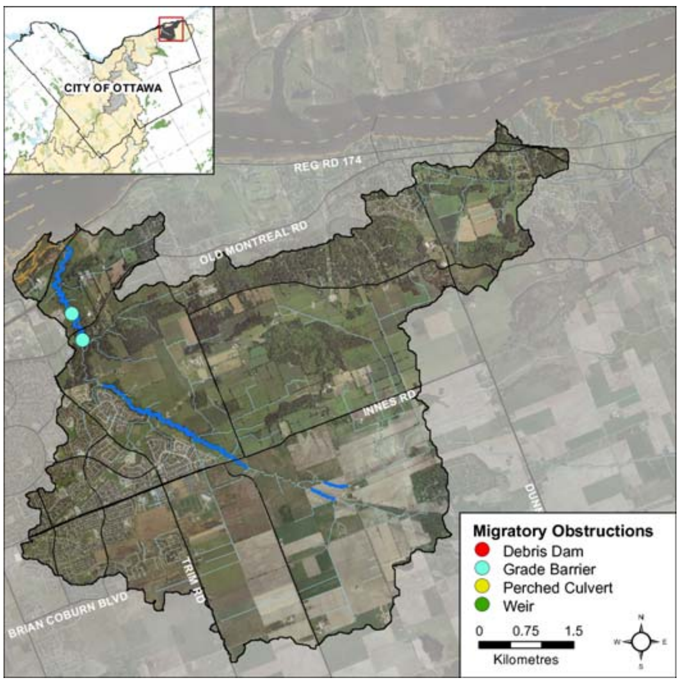


Figure 29 Cardinal Creek migratory obstructions

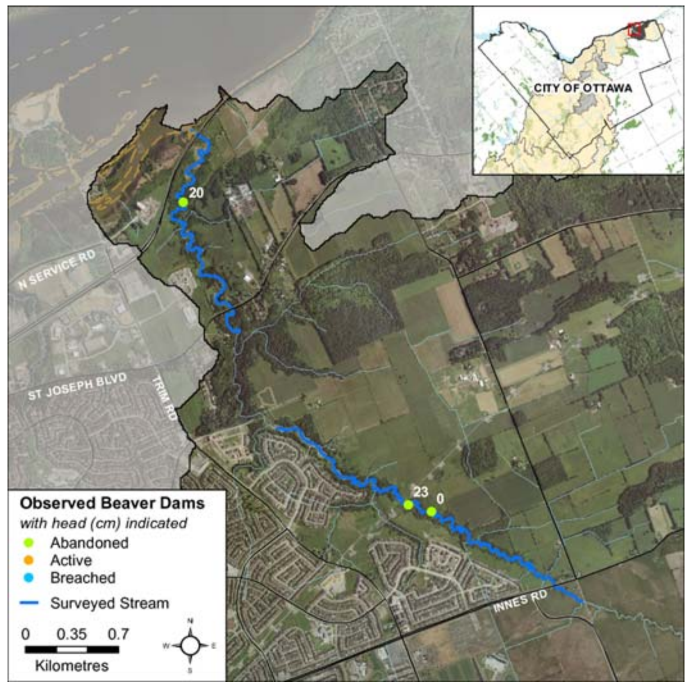
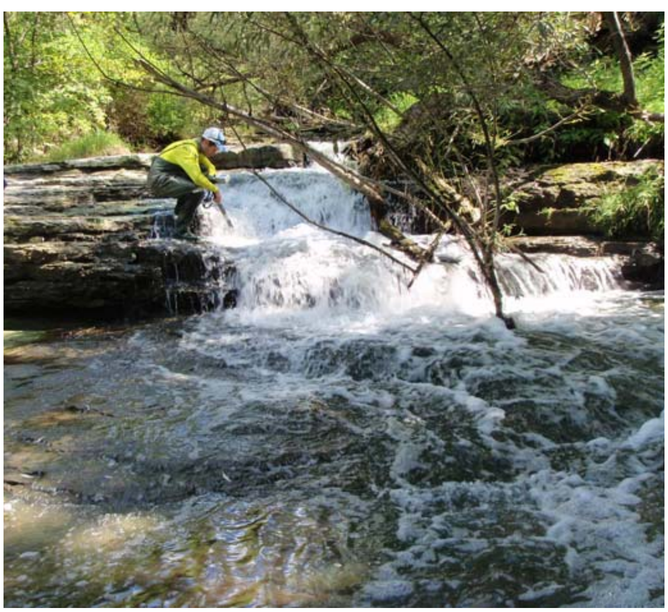


Figure 30 Beaver dams observed on Cardinal Creek



A grade barrier observed along Cardinal Creek

A volunteer measuring the head of a beaver dam

Headwater Drainage Feature Sampling

The Headwater Drainage Feature sampling protocol is a rapid assessment method characterizing the amount of water, sediment transport, and storage capacity within headwater drainage features (HDF). An HDF is a depression in the land that conveys surface flow. These features may provide direct, both permanent and seasonal, habitat for fish by the presence of refuge pools, seasonal flow, or groundwater discharge. They may also provide indirect habitat through the contribution of exported food (detritus/invertebrates) (Wipfli and Gregovich 2002).
As a result of their importance and a lack of existing information for headwater drainage features, the City Stream Watch program incorporated monitoring of these systems at 17 sites in the Cardinal Creek catchment in 2014 (Figure 31).

A headwaters site at French Hill Road during spring sampling in April

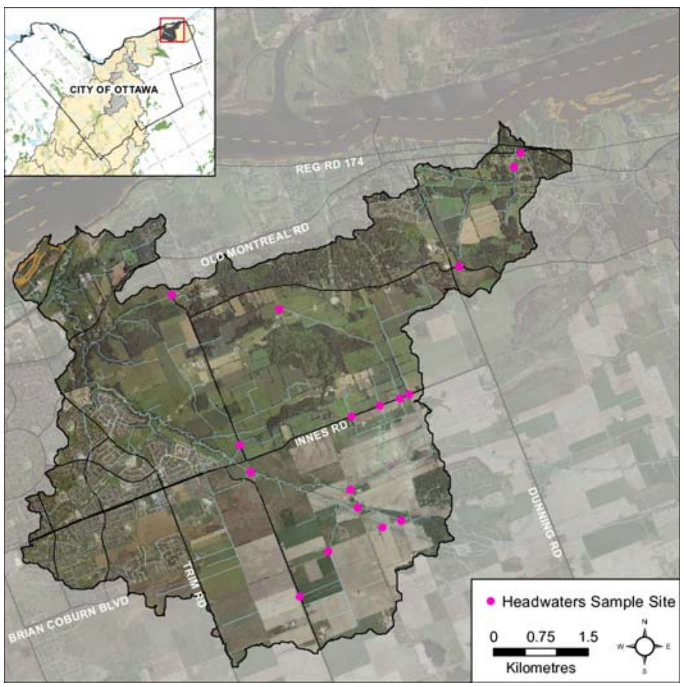


Figure 31 HDF sampling sites on Cardinal Creek

The same site at French Hill Road in August

Below: taking water chemistry measurement at an HDF site

Stream Comparison Between 2008 and 2014

The following tables provide a comparison of observations on Cardinal Creek between the 2008 and 2014 survey years. Cardinal Creek was also surveyed in 2003, but the surveying protocol has changed significantly since that time so data from 2003 cannot be compared to data from 2008 and 2014. The sections surveyed in 2014 were different from the sections surveyed in 2008 so the comparison is only done for those sections that were surveyed in both years. A comparison of the results of fish community sampling is done for all three survey years.

Anthropogenic Changes

Table 4 shows that between 2008 and 2014 anthropogenic alterations along Cardinal Creek have increased. In 2008, 81 percent of the sections had no anthropogenic alterations, in 2014 that number has decreased to 66 percent. This change many be caused by changes in the stream survey protocol and the classification of channelization. In 2010 anthropogenic alterations were further defined in the protocol, which has caused some land uses to shift categories.

Anthropogenic Alterations	2008 (%)	2014 (%)
No anthropogenic alterations	81	66
"Natural" conditions with minor human alterations	15	22
"Altered" with considerable human impact but significant natural portions	4	8
"Highly altered" by humans with few natural portions	0	5

Table 4 Comparison of anthropogenic alterations along Cardinal Creek between 2008 and 2014

An anthropogenic alteration to Cardinal Creek that was observed in 2008 and 2014

Bank Stability Changes

According to observations bank stability on Cardinal Creek has improved slightly overall since 2008. In 2008, 75 percent of the left bank and 81 percent of the right bank were considered stable. In 2014, 85 percent of the left bank and 88 percent of the right bank were stable. Although Cardinal Creek appears to be stable overall, erosion is observed along most of the creek with some areas experiencing high levels of erosion.

Bank Stability	2008 (%) Left Bank	2008 (%) Right Bank	2014 (%) Left Bank	2014 (%) Right Bank
Stable	75	81	85	88
Unstable	25	19	15	12

Table 5 Comparison of bank stability along Cardinal Creek between 2008 and 2014

Changes in Instream Vegetation

Figure 32 shows that there has been a decrease in instream vegetation in Cardinal Creek since 2008. The amount of common levels of vegetation totaled 50 percent in 2008, and that number has decreased to 10 percent in 2014. The amount of normal levels of vegetation totaled nine percent in 2008 and increased to 37 percent in 2014. Finally, the number of areas classified as having low levels of vegetation has increased from 19 percent in 2008 to 40 percent in 2014. The decrease in instream vegetation may be in part attributed to increased sedimentation in the system but vegetation growth is also dependent on climatic variables as well as the stage of the growing season when observations took place.

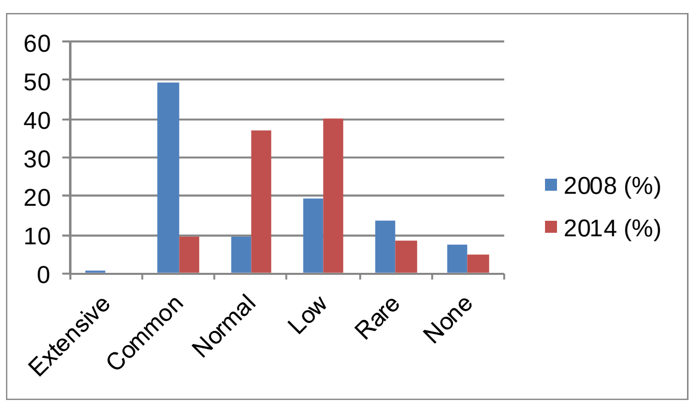


Figure 32 Comparison of instream vegetation levels between 2008 and 2014

Changes in Pollution and Garbage

Overall the amount of pollution and garbage in Cardinal Creek has decreased since 2008. Table 6 shows that the number of sections surveyed that were free from garbage has increased from 38 to 52 percent since 2008.

Pollution/Garbage	2008 (%)	2014 (%)
None	38	52
Floating garbage	35	31
Garbage on stream bottom	23	20
Oil or gas trails	0	0
Discoloration of channel bed	0	0

Table 6 Comparison of pollution/garbage levels between 2008 and 2014

A debris pile found along Cardinal Creek

Fish Community

Fish sampling was conducted on Cardinal Creek by the City Stream Watch program in 2003, 2008 and 2014. In total, 40 species of fish have been captured through City Stream Watch fish sampling efforts.
In 2003, seven species were captured in one fish sampling session using a seine net. In 2008 fish sampling effort was significantly increased resulting in 20 species captured by seining at six sites. In 2014, 28 species were caught using a variety of methods (electrofishing, seining, fyke nets) at seven sites. Twelve species caught in 2008 were not found in 2014. This does not mean the species have disappeared from Cardinal Creek but could be influenced by location, weather conditions, time of sampling and sampling method.

Species	Code	2003	2008	2014
black crappie	BlCra			X
blackchin shiner	BcShi		X	
bluegill	Blueg			X
bluntnose minnow	BnMin		X	X
brassy minnow	BrMin			X
brook stickleback	BrSti	X	X	X
brook trout	BkTro			X
brown bullhead	BrBul	X		X
central mudminnow	CeMud			X
Centrarchid spp	SUNFI		X	
channel catfish	ChCat			X
common shiner	CoShi	X	X	X
creek chub	CrChu	X	X	X
Cyprinid spp	Ca_MI		X	X
emerald shiner	EmShi		X	
Etheostoma spp	EthSp			X
fallfish	Fallf			X
fathead minnow	FhMin		X	X
golden shiner	GoShi		X	
johnny darter	JoDar		X	
largemouth bass	LmBas			X
Lepomis spp	LepSp			X
logperch	LogPe		X	
longnose dace	LnDac	X		X
muskellunge	Muske			X
northern pike	NoPik		X	
northern redbelly dace	NRDac		X	X
pearl dace	PeDac			X
pumpkinseed	Pumpk			X
rock bass	RoBas			X
sauger	Sauge			X
shorthead redhorse	ShRed			X
silver redhorse	SiRed			X
spottail shiner	SpShi	X	X	
tessellated darter	TeDar		X	
trout-perch	TrPer		X	
walleye	Walle			X
white sucker	WhSuc	X	X	X
yellow bullhead	YeBul		X	
yellow perch	YePer		X	
Total		**7**	**20**	**28**

Table 7 Comparison of fish species caught in 2003, 2008 and 2014

Monitoring and Restoration

Monitoring and Restoration Projects on Cardinal Creek

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

Accomplishment	Year	Description
City Stream Watch Monitoring	2003	51 stream surveys were completed on Cardinal Creek
	2008	74 stream surveys were completed on Cardinal Creek
	2014	74 stream surveys were completed on Cardinal Creek
City Stream Watch Fish Sampling	2003	Two fish sampling sessions were conducted on Cardinal Creek
	2008	Six fish sampling sessions were conducted on Cardinal Creek
	2014	Twenty-one fish sampling sessions were conducted on Cardinal Creek
City Stream Watch Termal Classification	2008	Three temperature loggers were deployed
	2014	Four temperature loggers were deployed
City Stream Watch Headwater Drainage Feature Sampling	2014	17 headwater drainage feature sites were sampled in the Cardinal Creek catchment
Cardinal Creek Riparian Planting	2008	In partnership with the Cardinal Creek Community Association, 295 trees and shrubs were planted near the Springridge subdivision

Table 8 Monitoring and Restoration on Cardinal Creek

Volunteers performing stream surveys on Cardinal Creek

A volunteer measuring water depth on Cardinal Creek

Potential Riparian Restoration Opportunities

Figure 33 depicts the locations where City Stream Watch staff and volunteers observed areas where the riparian zone could be restored or enhanced using one or more of the following techniques: riparian planting, erosion control, invasive species control and wildlife habitat creation.
The majority of the opportunities listed were riparian planting and erosion control or a combination of both. The areas highlighted were near Old Montreal Road, Innes Road and in the headwaters towards O'Toole Road.

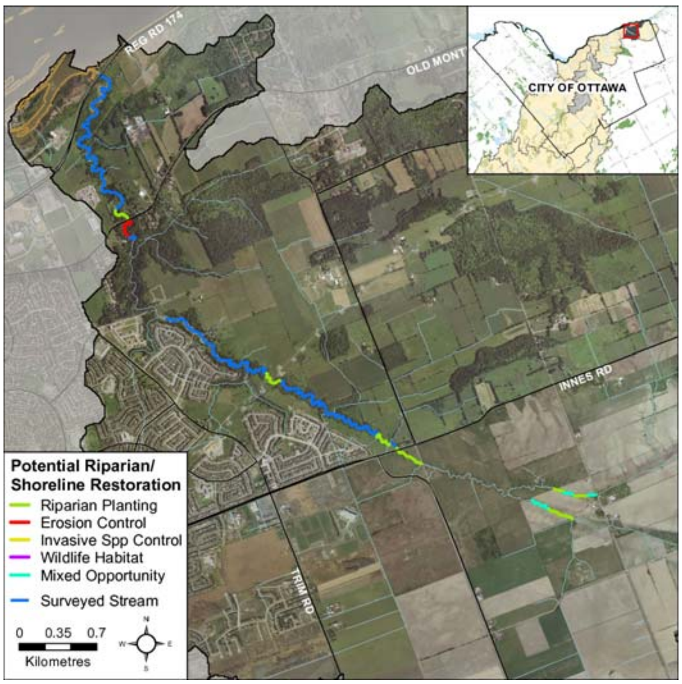


Figure 33 Potential riparian/shoreline restoration opportunities

Riparian planting opportunity along Cardinal Creek downstream of Innes Road

Potential Instream Restoration Opportunities

Figure 34 depicts the locations where City Stream Watch staff and volunteers made note of areas where there were one or more of the following instream restoration opportunities: fish habitat enhancement, garbage cleanup and channel modification.
All of the opportunities listed for Cardinal Creek were stream garbage cleanups in the stretch of the creek between Watters Road and Innes Road. Most of the garbage noted in this section appeared to be washed downstream through the stormwater system and eventually collected in the retention pond at Watters Road.

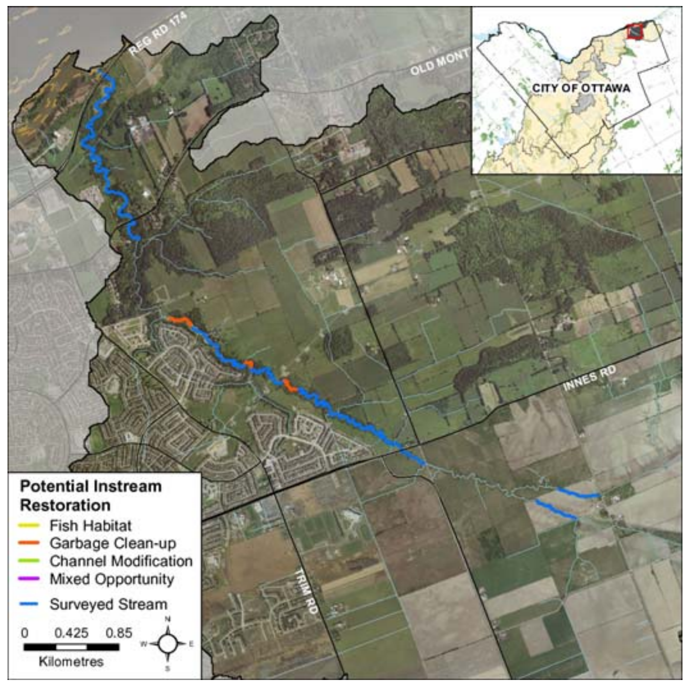


Figure 34 Potential instream restoration opportunities

Retention pond upstream of Watters Road where garbage accumulates after rain events



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For more information on the overall 2014 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2014 Summary Report.