Appendix D – City Stream Watch and RVCA Reports

- City Stream Watch Mud Creek 2014 Summary Report
- RVCA Mud Creek Catchment Report 2012

Mud Creek 2014 Summary Report

Watershed Features	
Area	57.55 square kilometres 1.36% of the Rideau Valley watershed
Land Use	64% agriculture 19% wooded area 10% urban/rural 5% transportation 2% wetland
Surficial Geology	49% clay 27% diamicton 15% sand 6% gravel 3% organic deposits
Watercourse Type	*Watercourse Type:* 98% natural 2% channelized *Flow Type:* 100% permanent
Invasive Species	There were ten invasive species observed by CSW staff in 2014: purple loosestrife, European frogbit, buckthorn, Manitoba maple, curly leafed pondweed, flowering rush, garlic mustard, Himalayan balsam, wild parsnip, rusty crayfish
Fish Community	34 fish species have been captured in Mud Creek including six game fish species: rock bass, small mouth bass, largemouth bass, yellow perch, walleye, and muskellunge

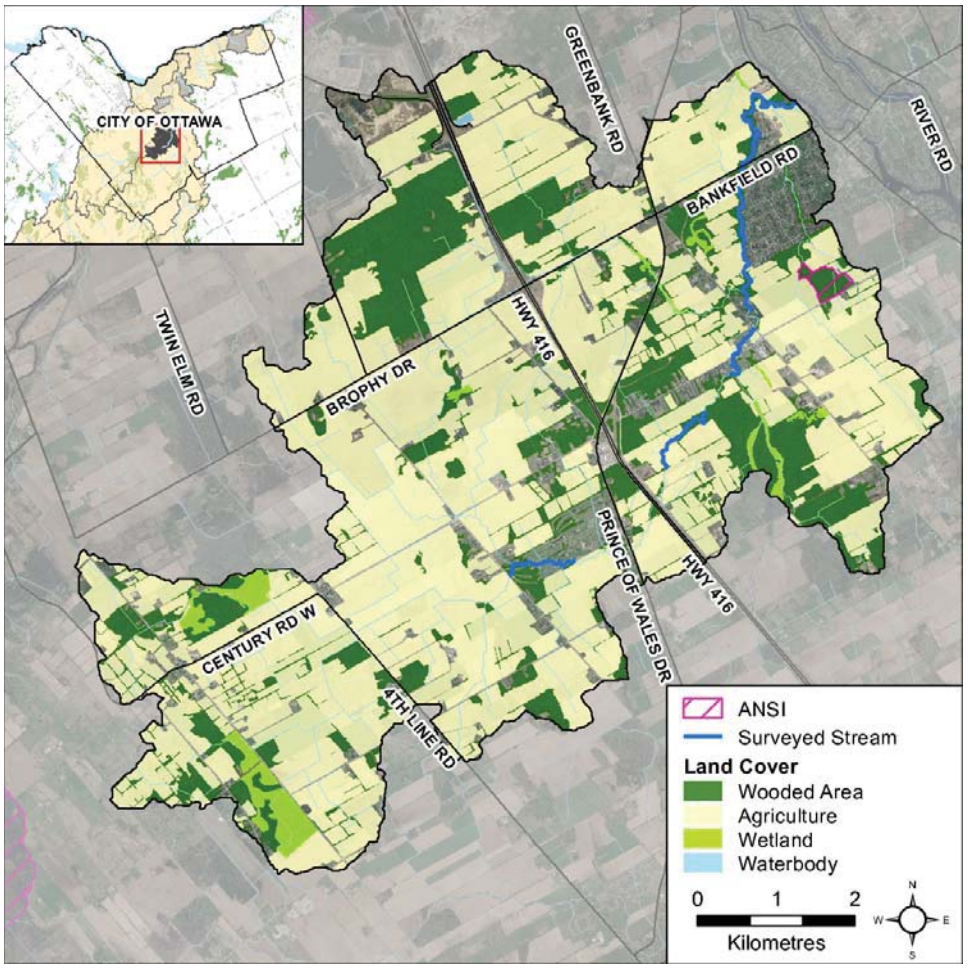

Figure 1 Land cover in the Mud Creek catchment

Vegetation Cover

Types	Hectares	% of Cover
Wetlands	116	10
Wooded	959	80
Hedgerow	83	7
Plantation	43	4
TOTAL		**100%**

Woodlot Cover

Size Category	Number of Woodlots	% of Woodlot Cover
10-30 ha	16	5
>30 ha	7	2

Wetland Cover

2% of the watershed is wetland

Wetlands make up 10% 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

Mud Creek is approximately 11 kilometres long. The land use in the area is mainly agricultural and it's headwaters consist primarily of agricultural drains. Further downstream, development pressures have occurred at Highway 416 and adjacent to the creek around the village of Manotick. The geology of the area is predominantly marine clays and till, with some gravel deposits, glaciofluvial deposits and wetlands (City of Ottawa, 2011). The Kars esker is an important geological feature that intersects Mud Creek near First Line Road. Comprised of sand and gravel deposits, eskers are very permeable and can be significant for water resources (City of Ottawa, 2011). The aquatic habitat conditions are further influenced by slow moving sediment resulting from the historic removal of forest cover and clearing of land for agriculture (City of Ottawa, 2011).

In 2014, permission was granted to survey 78 sections (7.8 km) of Mud Creek as part of the City Stream Watch monitoring activities. The following is a summary of observations made by staff and volunteers along those 78 sections.

Mud 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. Mud Creek did not quite meet this target by having a buffer of greater than 30 meters along 58 percent of the right bank and 56 percent along the left bank. Figure 2 demonstrates the buffer conditions of the left and right banks separately.

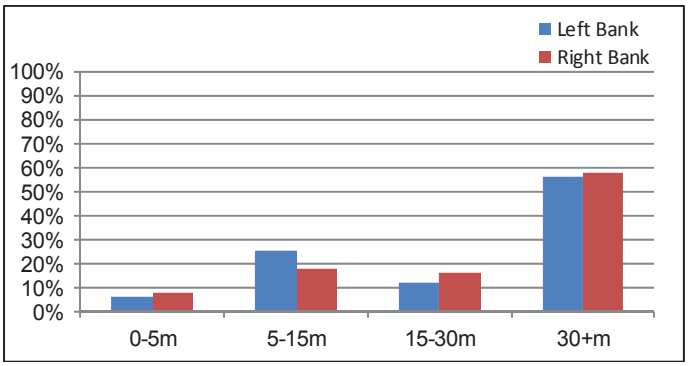

Figure 2 Vegetated buffer width along Mud Creek

Forested buffer along Mud Creek

Adjacent Land Use

The RVCA's Stream Characterization Survey Program identifies ten different land uses beside Mud 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 52 percent of the surveyed stream, characterized by forest, scrubland, meadow and wetland. Thirty-one percent of the land use along the surveyed sections of the stream was made up of residential, industrial/commercial , recreational and infrastructure. The remaining 17 percent of the land use surveyed was active agriculture and abandoned agriculture.

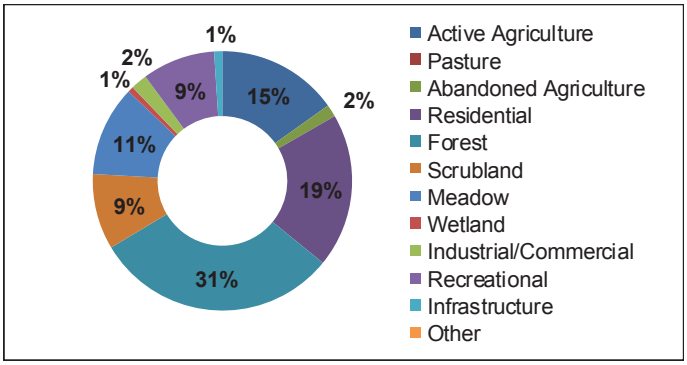

Figure 3 Land use along Mud Creek

Infrastructure along Mud Creek

Mud 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 that low to moderate levels of bank erosion were observed along many sections of Mud Creek, with a couple of sections of high erosion. Most of the bank erosion observed was concentrated in the stream sections where development has occurred adjacent to the creek. Specifically from the mouth of the creek to close to First Line Road as well as near Third Line Road.

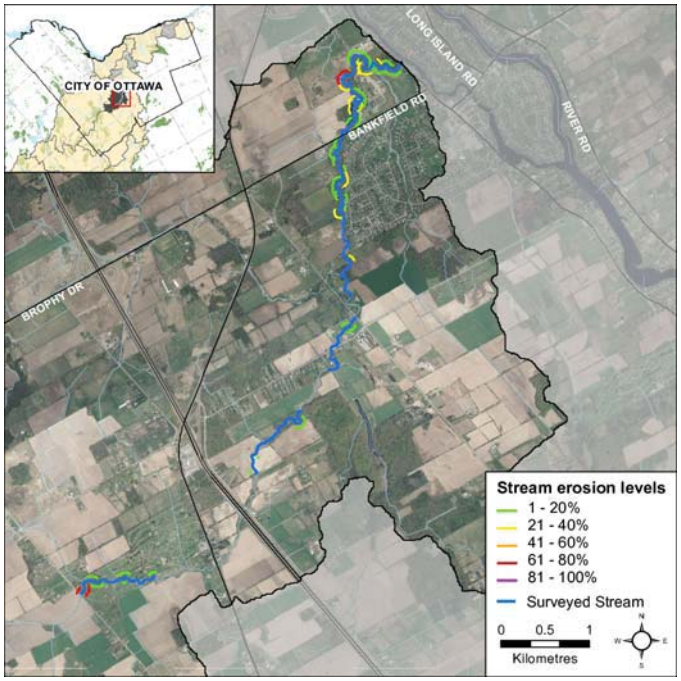

Figure 4 Erosion along Mud Creek

Stream bank erosion along Mud Creek near Third Line 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 Mud Creek had low to moderate levels of undercut banks along many sections of the creek downstream of Century Road. No bank undercutting was observed in the creek sections upstream of Century Road.

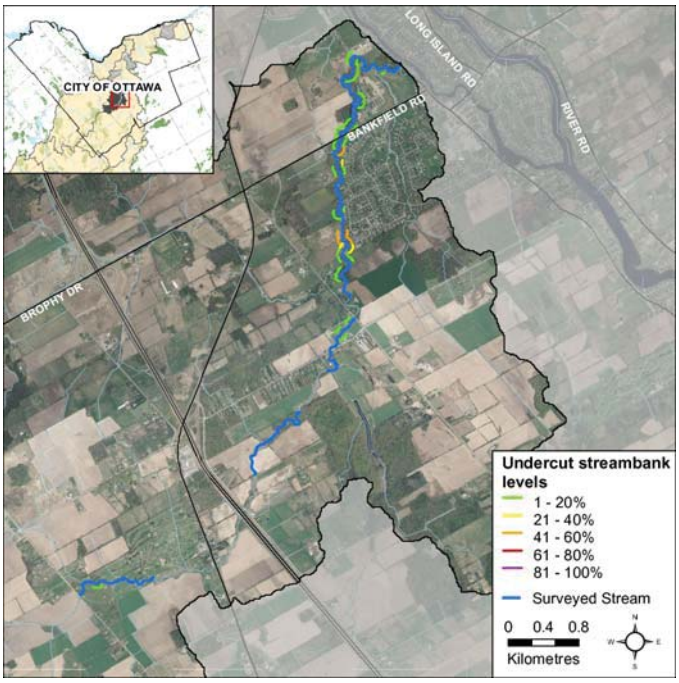

Figure 5 Undercut stream banks along Mud Creek

A section of Mud Creek with no bank undercutting

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 Mud Creek. Moderate levels of shading were seen along most of the creek. Some areas of high levels of shading were observed in forested areas where there was significant tree cover.

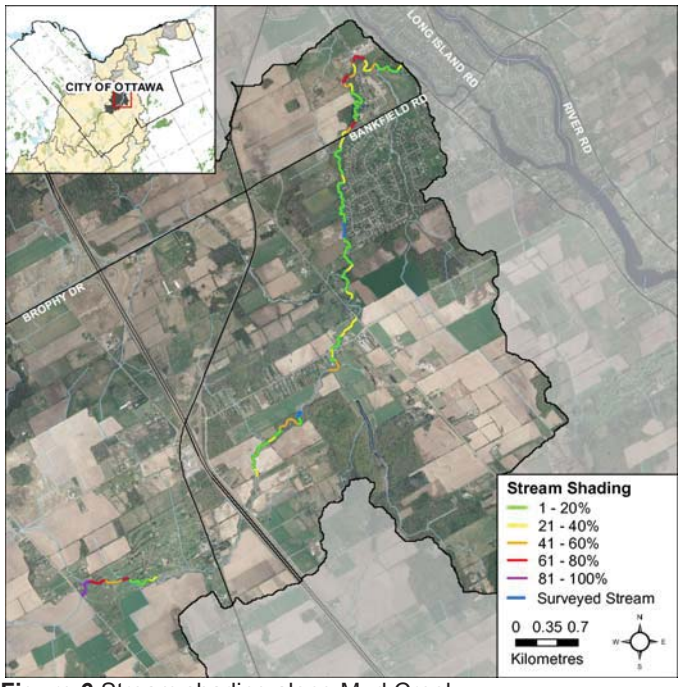

Figure 6 Stream shading along Mud Creek

Stream shade along Mud Creek

Instream Woody Debris

Figure 7 shows that overall, the surveyed sections along Mud Creek had 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.

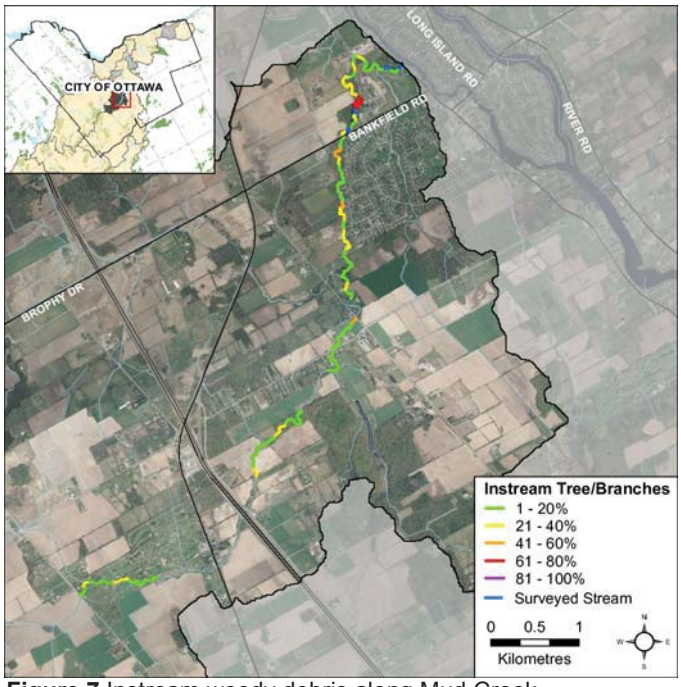

Figure 7 Instream woody debris along Mud Creek

Instream woody debris on Mud Creek

Overhanging Trees and Branches

Figure 8 shows that most of the sections surveyed on Mud Creek had low or moderate 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.

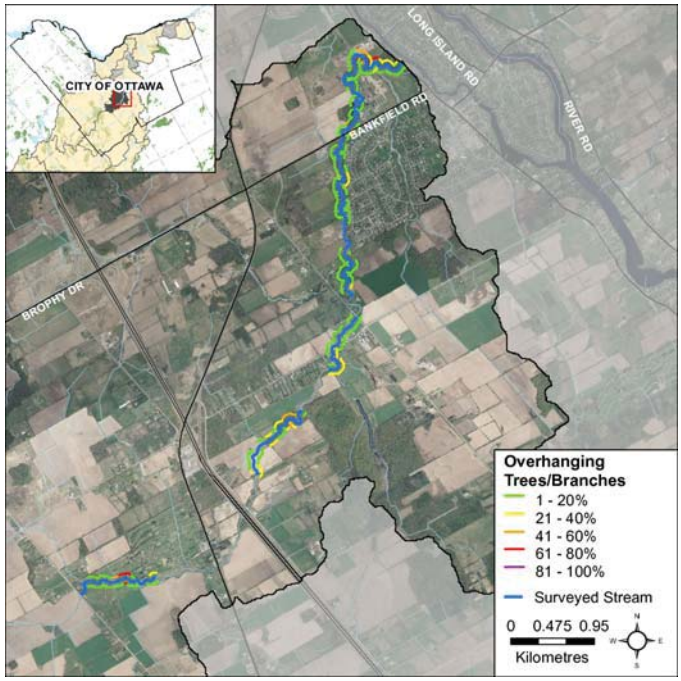

Figure 8 Overhanging trees and branches on Mud Creek

Overhanging trees and branches on Mud Creek

Anthropogenic Alterations

Figure 9 shows that 66 percent of the sections on Mud Creek remain “unaltered” or "natural". Sections considered "altered" account for 19 percent of the stream, while 14 percent of the sections sampled were considered “highly altered”. Very few of the surveyed sections of Mud 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.

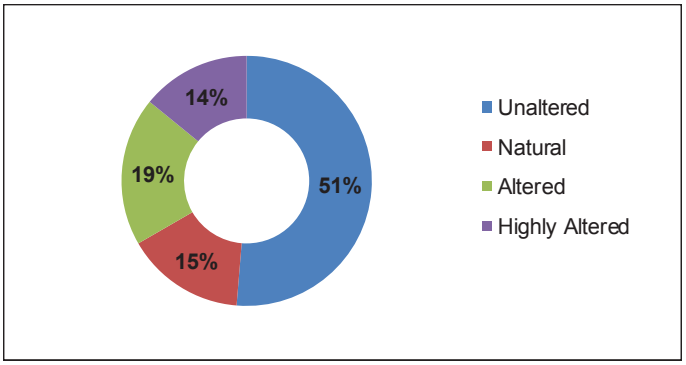

Figure 9 Anthropogenic alterations along Mud Creek

A highly altered section of Mud Creek which runs through a culvert

Mud 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 Mud Creek varied considerably with 58 percent of system considered heterogeneous and 42 percent considered homogeneous.

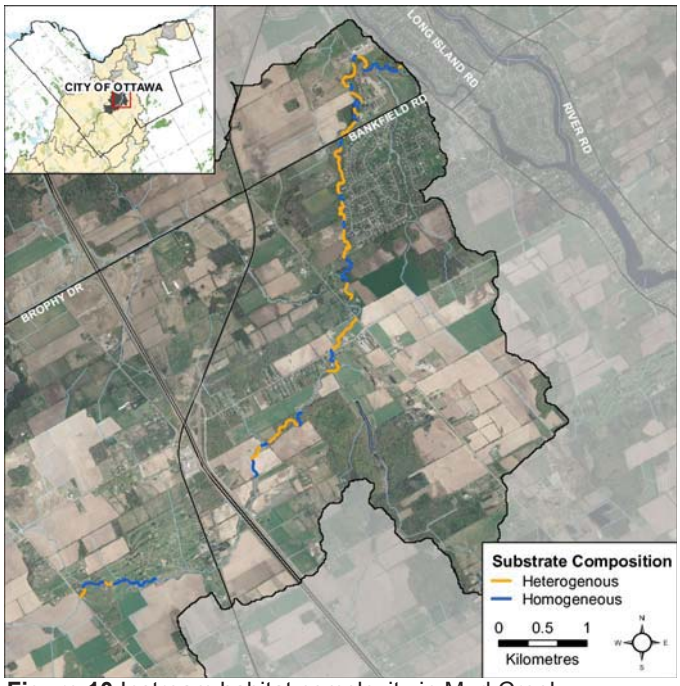

Figure 10 Instream habitat complexity in Mud Creek

Habitat complexity on Mud 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 47 percent of the instream substrate observed on Mud Creek was clay. Thirty six percent of the substrate was recorded as silt and sand and the remaining 18 percent was made up of gravel, cobble and boulder. The dominance of clay substrate with pockets of sand, silt, cobble and boulder throughout the system is also reflected in Figure 12. The presence of the Kars esker is reflected in Figure 12 by the dominance of sand substrate around First Line Road.

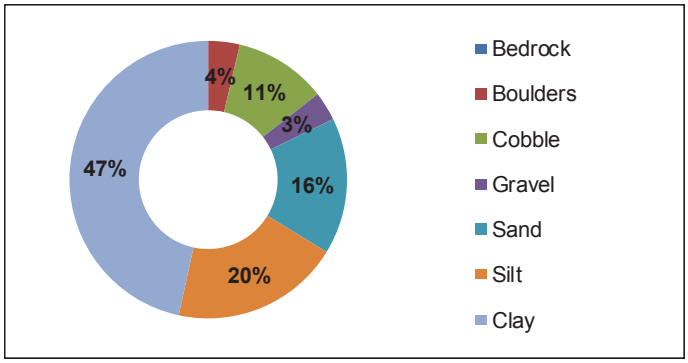

Figure 11 Instream substrate along Mud Creek

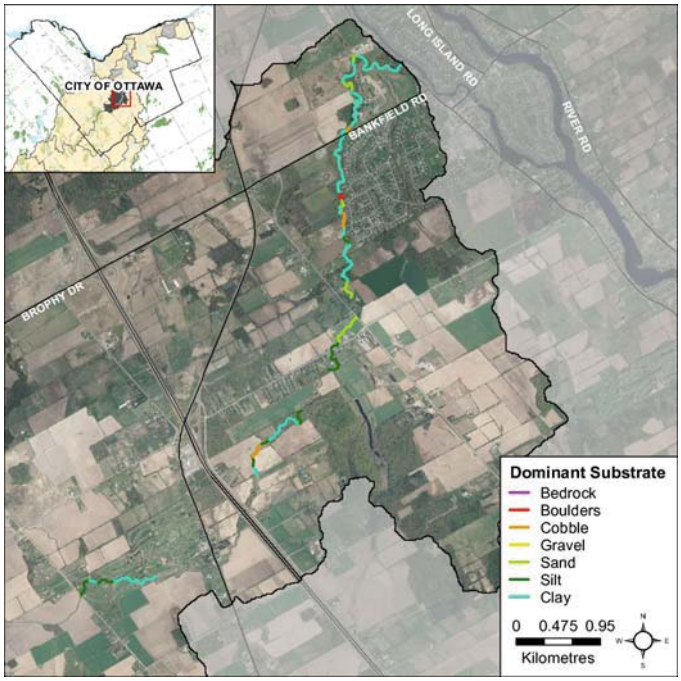

Figure 12 Dominant instream substrate along Mud Creek

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 that although it wasn't often the dominant substrate feature, cobble and boulder substrate was present in most of the surveyed sections of Mud Creek.

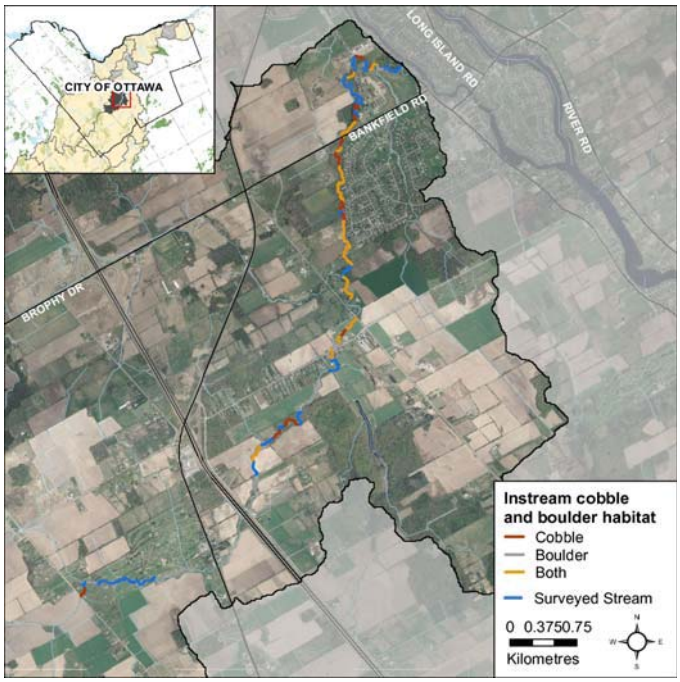

Figure 13 Cobble and boulder habitat in Mud Creek

Cobble and boulder habitat observed along Mud Creek

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 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 Mud Creek has minimal variability in instream morphology; 85 percent consists of runs, 12 percent consists of pools and four percent consists of riffles. Figure 15 shows where areas of riffle habitat was observed in Mud Creek.

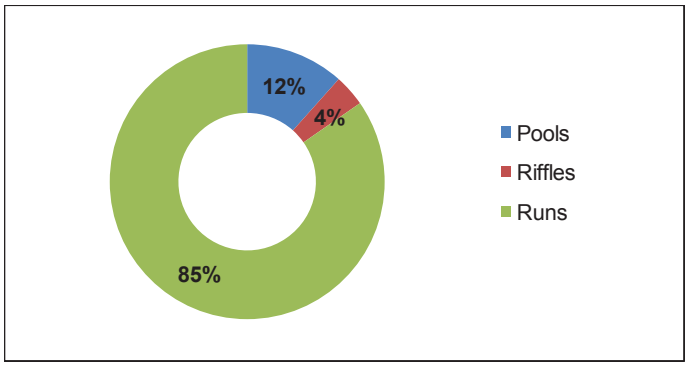

Figure 14 Instream morphology along Mud Creek

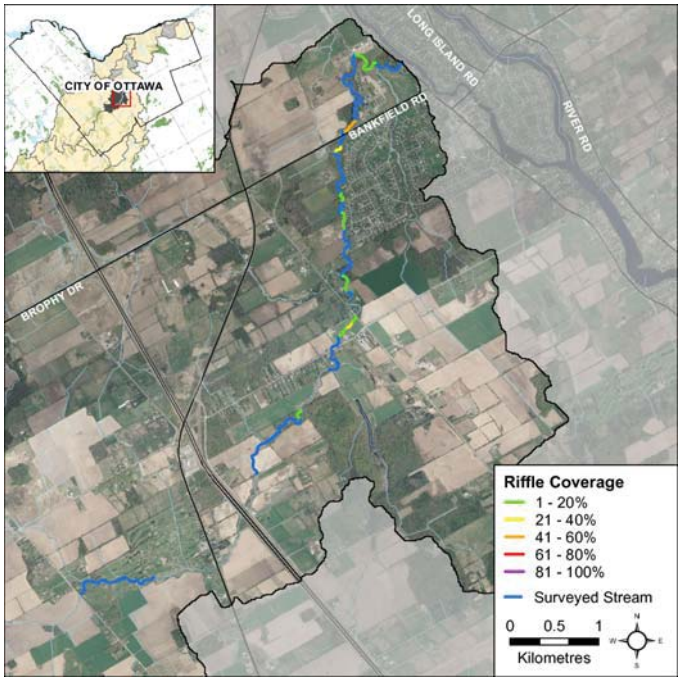

Figure 15 riffle coverage in Mud Creek

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. Mud Creek has high diversity of instream vegetation. Figure 16 depicts the highly varied plant community structure for Mud Creek. The overall dominant vegetation type, recorded at 33 percent, is narrowed-leaved emergent plants. The dominance of narrow-leaved emergent plants is also reflected in Figure 17; where narrow-leaved emergent plants, algae and submerged plants were observed as the dominant plant types along some sections of the creek.

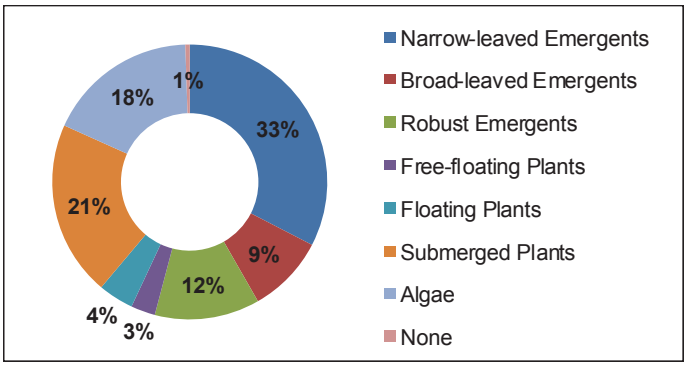

Figure 16 Vegetation types along Mud Creek

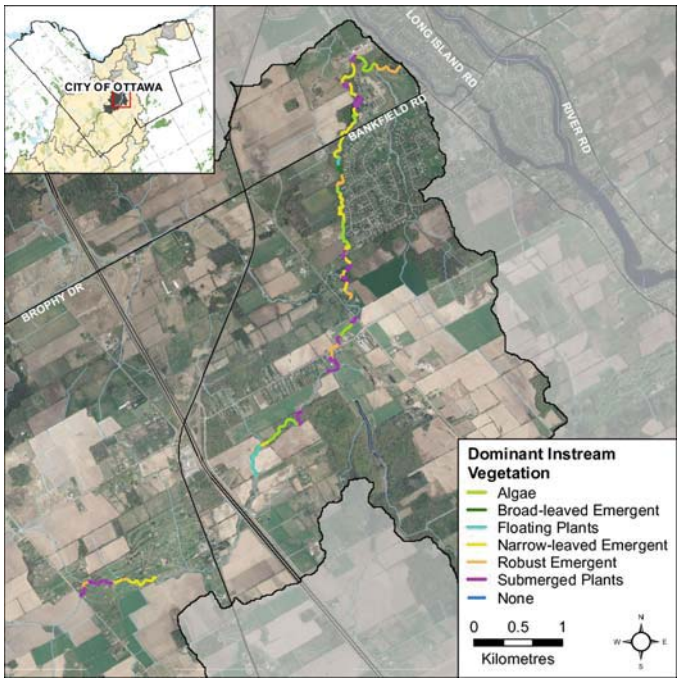

Figure 17 Dominant instream vegetation types in Mud Creek

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 Mud Creek had normal levels of instream vegetation. The levels of instream vegetation in Mud Creek were fairly well distributed between normal levels accounting for 32 percent, common levels accounting for 30 percent and low levels accounting for 29 percent.

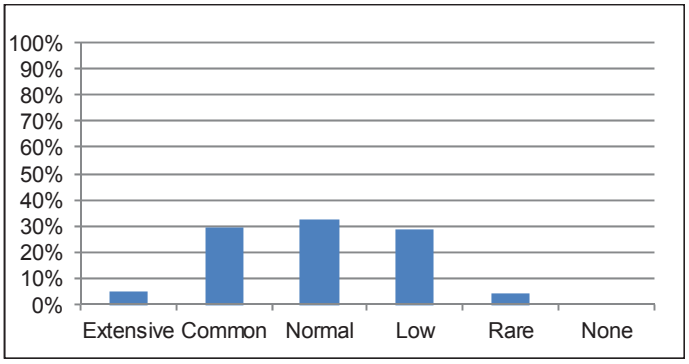

Figure 18 Instream vegetation abundance along Mud Creek

Instream vegetation observed on Mud Creek

Mud 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 seventy four percent of the sections surveyed along Mud Creek (Figure 19). Figure 20 shows the variety of invasive species observed along Mud Creek. The invasive species that were observed most often were purple loosestrife (*Lythrum salicaria)* which was observed in 50 percent of the sections with invasive species, Manitoba maple (*Acer negundo*) which was observed in 36 percent of the sections with invasive species, and flowering rush (*Botomus umbellatus*) which was observed in 35 percent of the sections with invasive species.

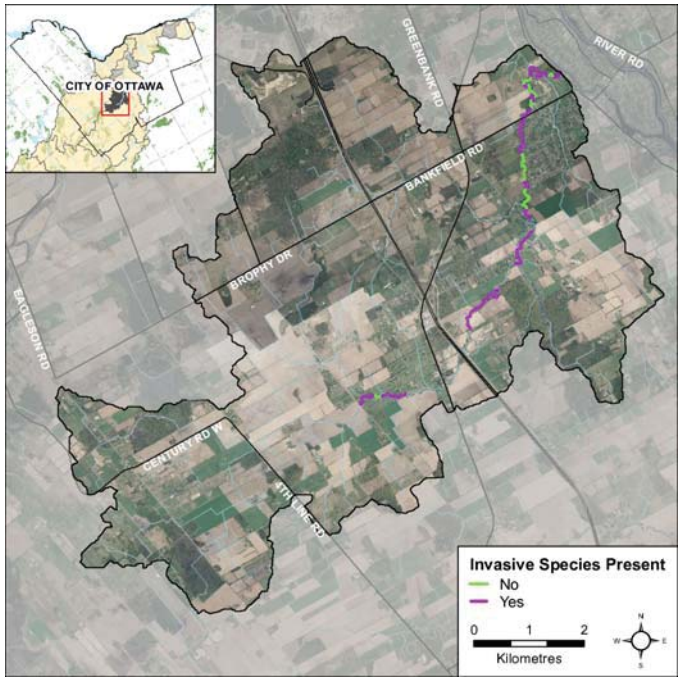

Figure 19 Presence of invasive species along Mud Creek

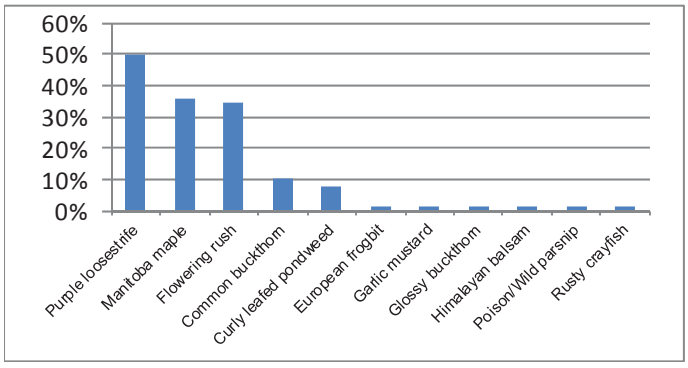

Figure 20 Invasive species observed along Mud Creek

Pollution

Figure 21 demonstrates the incidence of pollution/ garbage in Mud Creek. Fifty-seven percent of the sections surveyed on Mud Creek did not have any observable garbage. Twenty-eight percent had garbage on the stream bottom, twenty-one percent had floating garbage, and one percent had an unclassified type of garbage. Most of the sections where garbage was observed were near road crossings or where development has occurred close to the creek.

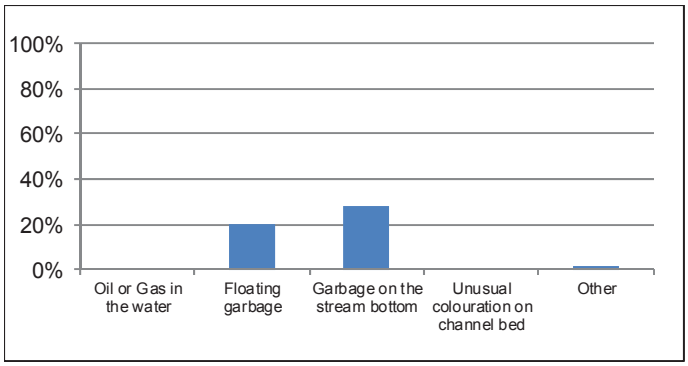

Figure 21 Pollution observed along Mud Creek

Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and overall stream health. Table 1 is a summary of all wildlife observed during stream surveys.

Wildlife	Observed
Birds	mallard, great blue heron, red-winged black bird, song sparrow, blue jay, red tail hawk, downy woodpecker, grey catbird, chickadee, red-eyed vireo, cardinal, pileated woodpecker, goldfinch, flicker, grackle, cedar waxwing, warbling vireo, crow, robin, kingfisher, mourning dove, turkey vulture, starling, roan chipping sparrow, barn swallow,
Mammals	deer, raccoon, chipmunk, red squirrel, muskrat
Reptiles Amphibians	green frog, tadpoles, wood frog, snapping turtle, american toad, bullfrog, leopard frog
Aquatic Insects	snail, mussel, clam, crayfish, giant water bug
Other	jewelwing, cabbage white, dragonfly, familiar bluet, deer fly, cicada, pollinators caddisfly, scalebug, slug, cricket, spider

Table 1 Wildlife observed along Mud Creek

Mud 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.

A volunteer 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 all the surveyed stretches of the creek achieved the standard for warmwater biota. The stretch of creek from Century Rd to Second Line Rd had lower average dissolved oxygen compared to other stretches but it still meets the standard of 6 mg/L.

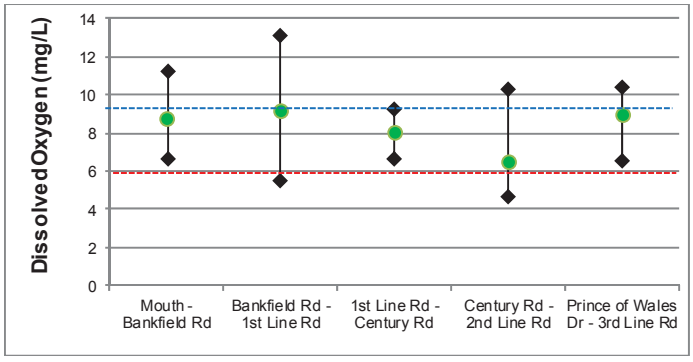

Figure 22 Dissolved oxygen ranges in Mud Creek

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 Mud Creek was 746 µs/cm. Figure 23 shows that the average conductivity in each of the stretches of creek analyzed does not vary significantly from the overall average. The highest conductivity reading on Mud Creek was 957 µs/cm which was recorded in the stretch of creek between Prince of Wales Drive and Third Line Road. The lowest recorded conductivity was 513 µs/cm which was recorded in the stretch of creek downstream of Bankfield Road.

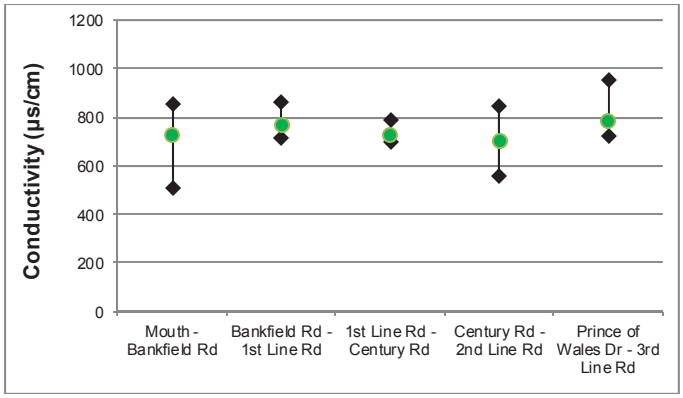

Figure 23 Conductivity ranges in Mud Creek

pH

Based on the PWQO for pH, a range of 6.5 to 8.5 should be maintained for the protection of aquatic life. pH values for Mud Creek ranged between 7.3 and 8.7, thereby meeting the provincial standard.

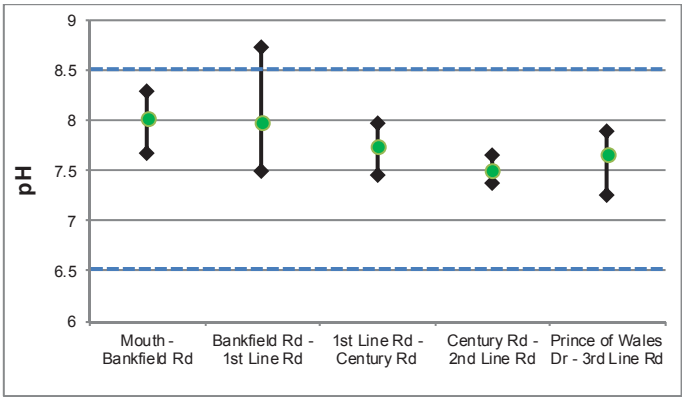

Figure 24 pH ranges in Mud Creek

Mud 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 Mud 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 Mud Creek Analysis of the data collected indicates that the thermal classification of Mud Creek ranges between coolwater and cool-warm water (Figure 27).

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. Indicators include: spring/seeps, watercress, iron staining, significant temperature change, and rainbow mineral film. Figure 26 shows areas where one or more groundwater indicators were observed during stream surveys.

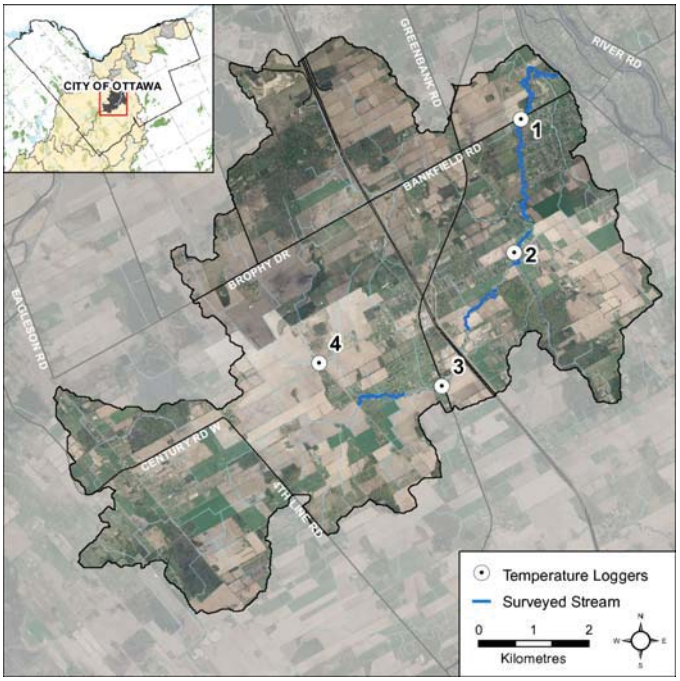

Figure 25 Temperature loggers along Mud Creek

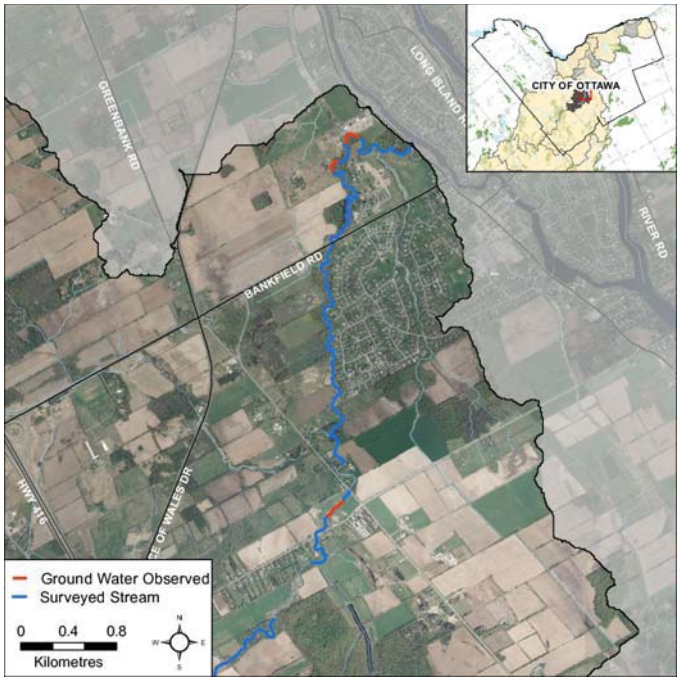

Figure 26 Groundwater indicators observed on Mud Creek

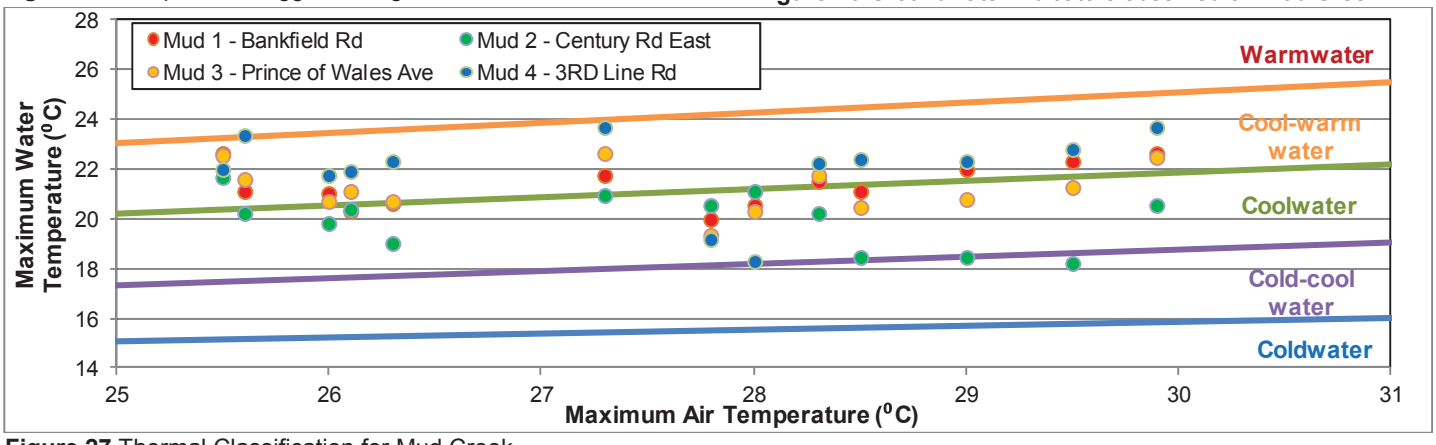

Figure 27 Thermal Classification for Mud Creek

Mud Creek Fish Community

Fish Community

Fish community sampling results for all the fish sampling sessions completed by RVCA from 2003 to 2014 along Mud Creek are shown in Figure 28. The provincial fish codes shown on the following map are listed (in Table 2) beside the common name of those fish species identified in Mud Creek. The thermal classification of Mud Creek ranges between coolwater and cool-warm water. Thirty-four fish species have been observed.

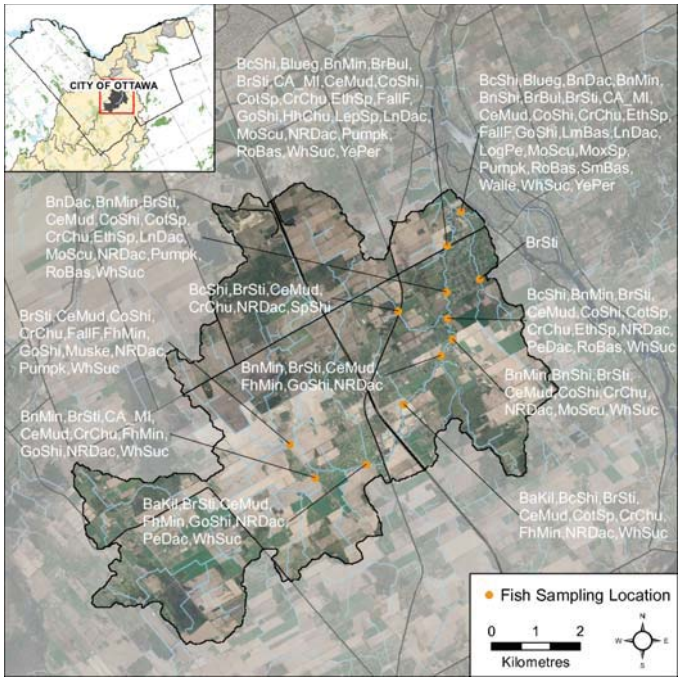

Figure 28 Mud Creek fish community

Species observed in Mud Creek (with fish code)			
banded killifish.....	BaKil	hornyhead chub.....	HdChu
blackchin shiner.....	BcShi	lepomis sp.....	LepSp
bluegill.....	Blueg	largemouth bass.....	LmBas
blacknose dace.....	BnDac	longnose dace.....	LnDac
bluntnose minnow.....	BnMin	logperch.....	LogPe
blacknose shiner.....	BnShi	mottled sculpin.....	MoScu
brown bullhead.....	BrBul	*Moxostoma sp*.....	MoxSp
brook stickleback.....	BrSti	muskellunge.....	Muske
carps and minnows...	CA_MI	northern redbelly dace	NRDac
central mudminnow...	CeMud	pearl dace.....	PeDac
common shiner.....	CoShi	pumpkinseed.....	Pumpk
Cottus sp.....	CotSp	rock bass.....	RoBas
creek chub.....	CrChu	smallmouth bass.....	SmBas
Etheostoma sp.....	EthSp	spottail shiner.....	SpShi
fallfish.....	Fallf	walleye.....	Walle
fathead minnow.....	FhMin	white sucker.....	WhSuc
golden shiner.....	GoShi	yellow perch.....	YePer

Table 2 Fish species observed in Mud Creek

Staff pulling a seine net on Mud Creek near First Line Road

Horny head chub and brown bullhead caught on Mud Creek

Walleye caught near the mouth of Mud 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 Mud Creek, one permanent debris dam was observed downstream of First Line Road and one seasonal weir was observed between First Line Road and Century Road East.

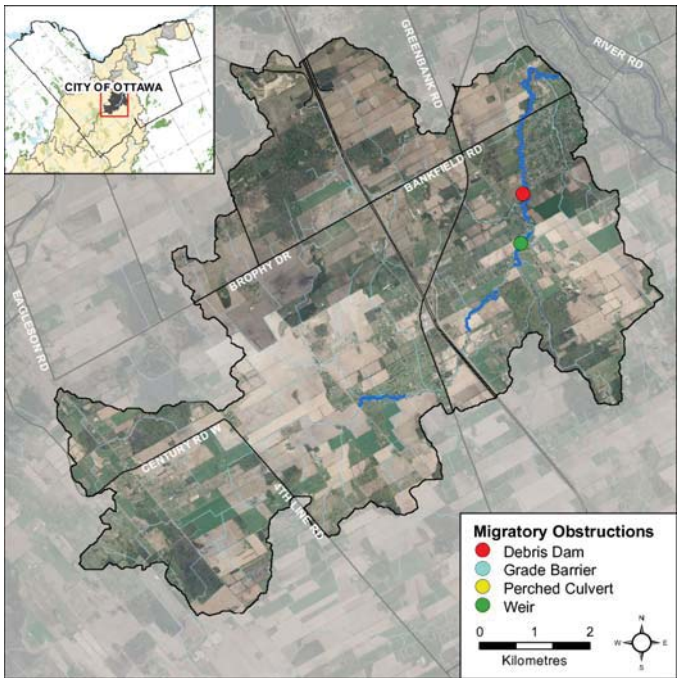

Figure 29 Mud Creek migratory obstructions

Beaver Dams

Beaver dams can also act as obstructions to fish migration. Figure 30 shows that one abandoned beaver dam was observed on Mud Creek downstream of Third Line Road. The head, or difference between the water level up and down stream, of the abandoned beaver dam was 11cm.

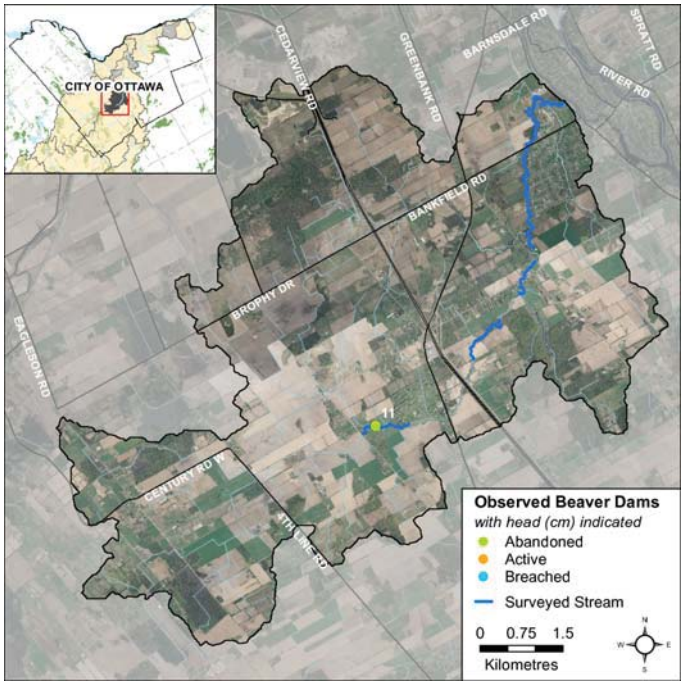

Figure 30 Beaver dams observed on Mud Creek

A seasonal weir observed along Mud Creek

An abandoned beaver dam observed on Mud Creek

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 36 sites in the Mud Creek catchment in 2014 (Figure 31).

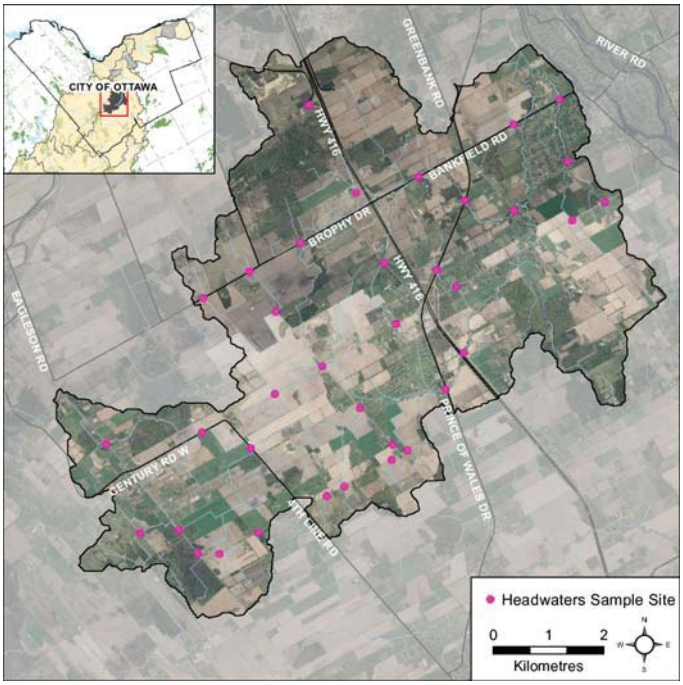

Figure 31 HDF sampling sites on Mud Creek

Headwaters site at Century Road East during spring sampling in April

The same site at Century Road East in August

Below: measuring bankfull width at a headwaters site on Fourth Line

Stream Comparison Between 2008 and 2014

The following tables provide a comparison of observations on Mud Creek between the 2008 and 2014 survey years. Mud 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. In addition, 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 3 shows that between 2008 and 2014 anthropogenic alterations along Mud Creek have increased. This change can be attributed to residential development which has taken place between Bankfield Road and First Line Road as well as 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	63	51
"Natural" conditions with minor human alterations	28	15
"Altered" with considerable human impact but significant natural portions	8	19
"Highly altered" by humans with few natural portions	0	14

Table 3 Comparison of anthropogenic alterations along Mud Creek between 2008 and 2014

A pedestrian bridge near Revell Drive that was not present in 2008

Bank Stability Changes

According to observations bank stability has improved overall since 2008. In 2008, 72 percent of the left bank and 74 percent of the right bank were considered stable. In 2014, 94 percent of the left bank and 93 percent of the right bank were stable. Mud Creek is a very stable system overall with most of the erosion occurring in areas between Rideau Valley Drive and First Line Road.

Bank Stability	2008 (%) Left Bank	2008 (%) Right Bank	2014 (%) Left Bank	2014 (%) Right Bank
Stable	72	74	94	93
Unstable	28	26	6	7

Table 4 Comparison of bank stability along Mud Creek between 2008 and 2014

Changes in Instream Vegetation

Figure 32 shows that there has been a decrease in instream vegetation in Mud Creek since 2008. The amount of extensive levels of vegetation totaled 17 percent in 2008, and that number has decreased to 5 percent in 2014. In addition, the number of areas classified as having common levels of vegetation has decreased from 54 percent in 2008 to 30 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.

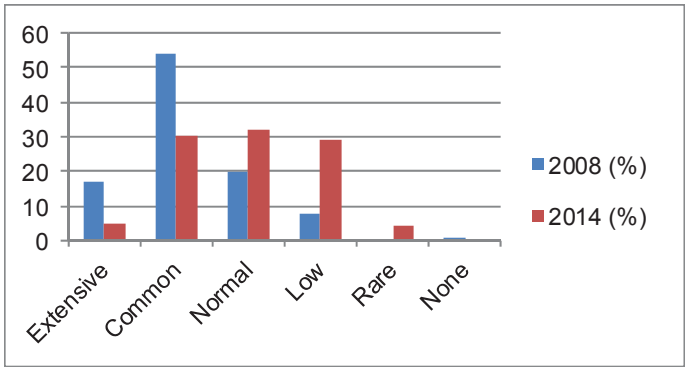

Figure 32 Comparison of instream vegetation levels between 2008 and 2014

Changes in Pollution and Garbage

Overall the amount of pollution and garbage in Mud Creek has decreased since 2008. Table 5 shows that the number of sections surveyed that were free from garbage has increased from 47 to 56 percent since 2008.

Pollution/Garbage	2008 (%)	2014 (%)
None	47	56
Floating garbage	35	21
Garbage on stream bottom	13	28
Oil or gas trails	5	0
Discoloration of channel bed	2	0

Table 5 Comparison of pollution/garbage levels between 2008 and 2014

Mud Creek upstream of Revell Drive

Mud Creek upstream of Century Road

Fish Community

Fish sampling was conducted on Mud Creek by the City Stream Watch program in 2003, 2008 and 2014. In total, 26 species of fish have been captured through City Stream Watch fish sampling efforts.
In 2003, eight species were caught in one fish sampling session using a seine net. In 2008 fish sampling effort was significantly increased resulting in seventeen species were caught by seining at seven sites and electrofishing at two sites. In 2014, 24 species were caught using a variety of methods (electrofishing, seining, fyke nets) at seven sites.
Two species caught in 2008 were not found in 2014, which are blackchin shiner, and largemouth bass. This does not mean the species have disappeared from Mud Creek but could be influenced by location, weather conditions or time of sampling.

Species	Code	2003	2008	2014
blackchin shiner.....	BcShi		X	
bluegill.....	Blueg			X
blacknose dace.....	BnDac		X	X
bluntnose minnow.....	BnMin	X	X	X
blacknose shiner.....	BnShi	X	X	X
brown bullhead.....	BrBul			X
brook stickleback.....	BrSti		X	X
carps and minnows....	CA_MI		X	X
central mudminnow.....	CeMud		X	X
common shiner.....	CoShi	X		X
creek chub.....	CrChu	X	X	X
Etheostoma sp.....	EthSp	X	X	X
fallfish.....	Fallf			X
fathead minnow.....	FhMin			X
golden shiner.....	GoShi		X	X
hornyhead chub.....	HdChu			X
largemouth bass.....	LmBas		X	
longnose dace.....	LnDac		X	X
mottled sculpin.....	MoScu	X	X	X
Moxostoma sp.....	MoxSp			X
northern redbelly dace	NRDac			X
pumpkinseed.....	Pumpk		X	X
rock bass.....	RoBas	X	X	X
walleye.....	Walle			X
white sucker.....	WhSuc	X	X	X
yellow perch.....	YePer		X	X
Total		**8**	**17**	**24**

Table 6 Comparison of fish species caught in 2003, 2008 and 2014

Monitoring and Restoration

Monitoring and Restoration Projects on Mud Creek

Table 7 below highlights the monitoring and restoration work that has been done on Mud Creek to date by the Rideau Valley Conservation Authority.

Accomplishment	Year	Description
City Stream Watch Monitoring	2003	37 stream surveys were completed on Mud Creek
	2008	95 stream surveys were completed on Mud Creek
	2014	78 stream surveys were completed on Mud Creek
City Stream Watch Fish Sampling	2003	One site was sampled on Mud Creek
	2008	Seven sites were sampled on Mud Creek
	2014	Eight sites were sampled on Mud 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	36 headwater drainage feature sites were sampled in the Mud Creek catchment
City Stream Watch Invasive Species Removal	2014	City Stream Watch volunteers removed Himalayan Balsam from Mud Creek
Shoreline Naturalization Program Planting	2010 -2014	Shoreline Naturalization Program staff and volunteers have completed 13 projects planting over 3000 shrubs and trees along Mud Creek

Table 7 Monitoring and Restoration on Mud Creek

Mud Creek Himalayan Balsam Removal

A patch of Himalayan Balsam was observed during stream surveys this year on Mud Creek. City Stream Watch staff returned to the site with one volunteer for three hours to remove the plants. Ten paper yard waste bags were filled with Himalayan Balsam plants and 50m of shoreline was successfully cleared of the invasive species before it spread any further along the stream banks.

Volunteer and staff removing Himalayan Balsam along Mud Creek

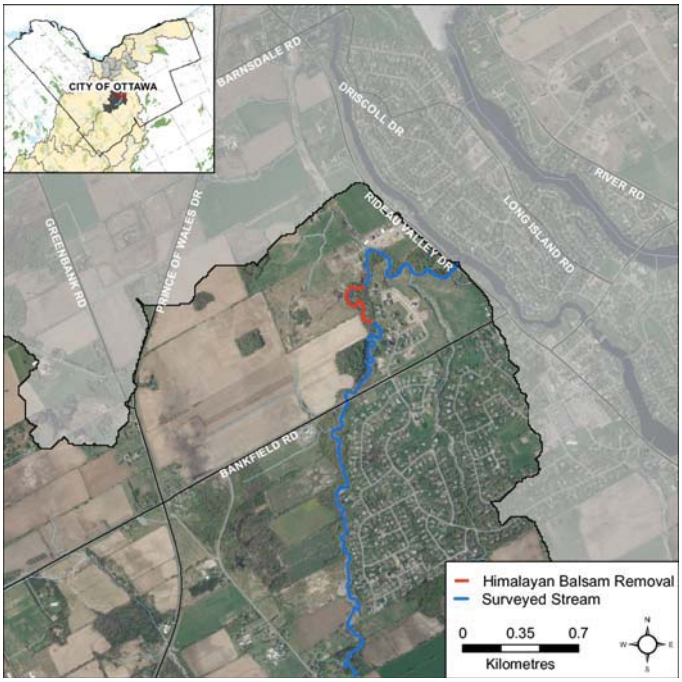

Figure 33 Himalayan Balsam Removal on Mud Creek

Potential Riparian Restoration Opportunities

Figure 34 depicts the locations where City Stream Watch staff and volunteers made note of 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 in targeted developed areas along the creek.

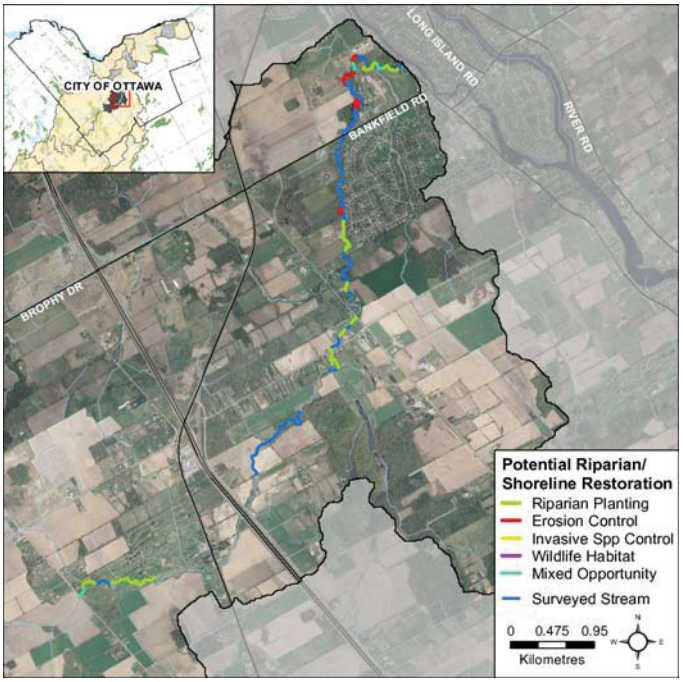

Figure 34 Potential riparian/shoreline restoration opportunities

An area along Mud Creek with riparian planting opportunity on the left bank

Potential Instream Restoration Opportunities

Figure 35 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.
There were two opportunities for fish habitat enhancement; one upstream of First Line Road and one downstream of First Line Road. There was also a small garbage cleanup opportunity downstream of First Line Road.

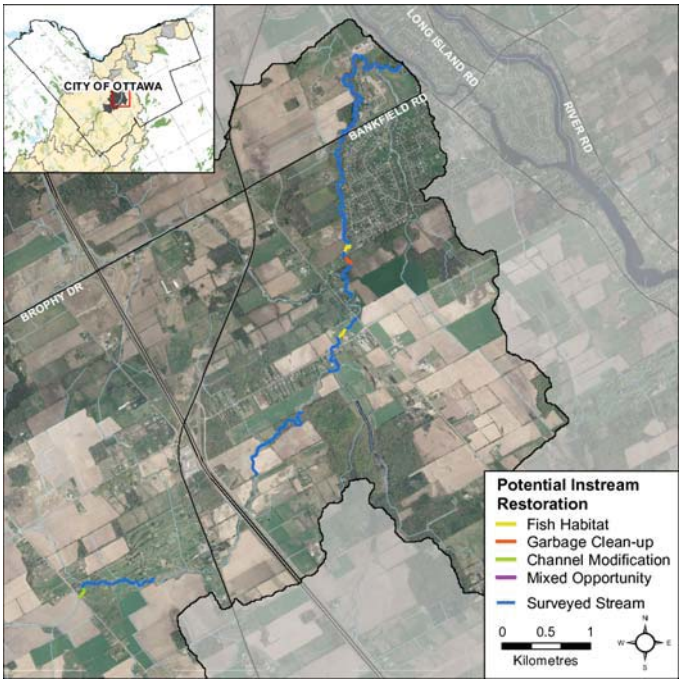

Figure 35 Potential instream restoration opportunities

An area along Mud Creek where fish habitat would be enhanced by removing a seasonal migratory obstruction



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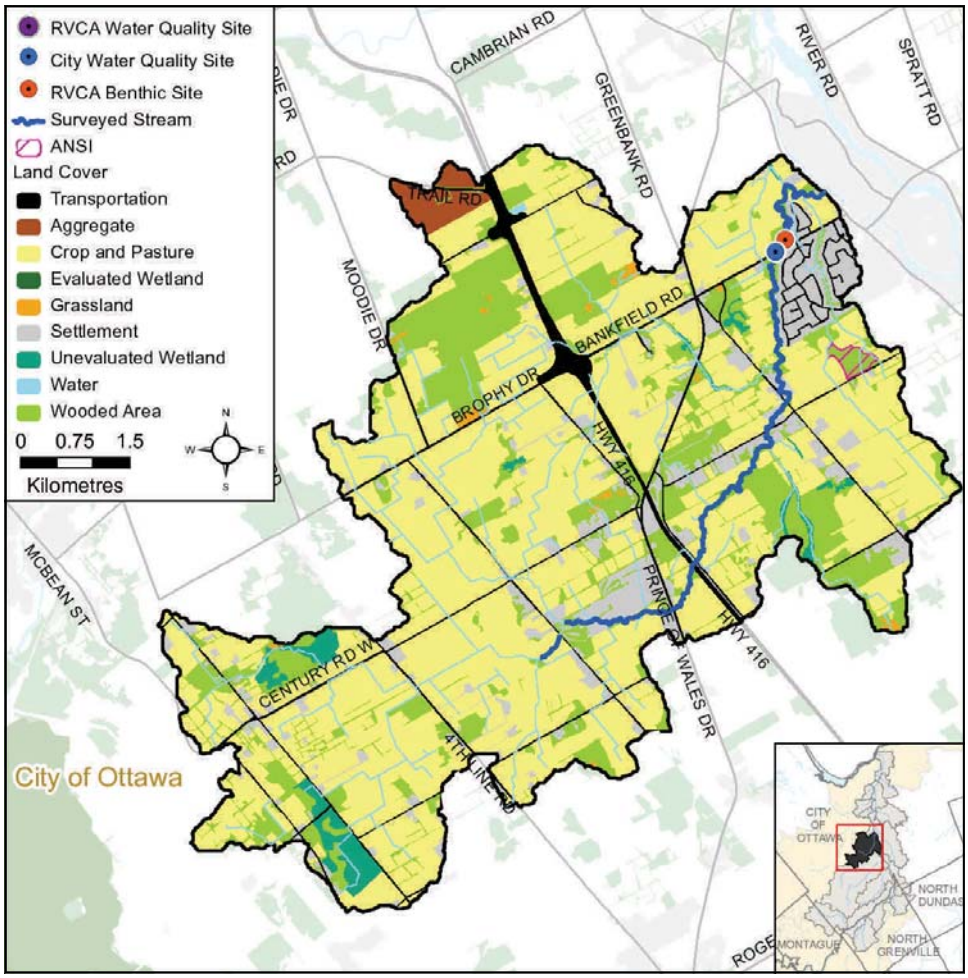
For more information on the overall 2014 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2014 Summary Report.



MUD CREEK CATCHMENT

LOWER RIDEAU RIVER SUBWATERSHED REPORT 2012

RIDEAU VALLEY CONSERVATION AUTHORITY



The RVCA produces individual reports for 16 catchments in the Lower Rideau subwatershed. Using data collected and analysed by the RVCA through its watershed monitoring and land cover classification programs, surface water quality conditions are reported for Mud Creek along with a summary of environmental conditions for the surrounding countryside every six years.

This information is used to help better understand the effects of human activity on our water resources, allows us to better track environmental change over time and helps focus watershed management actions where they are needed the most.

The following pages of this report are a compilation of that work. For other Lower Rideau catchments and the Lower Rideau Subwatershed Report, please visit the RVCA website at www.rvca.ca.

Inside

Catchment Facts

- A mostly rural, agricultural watershed with some suburban development occurring in its most downstream reaches near the Village of Manotick
- The creek and its numerous tributaries are comprised of a combination of channelized and natural meandering features along with a well-defined ravine downstream of Bankfield Road
- Flood plain mapping of the main branch of Mud Creek from First Line Road to the Rideau River has been completed within studies related to urbanization within and adjacent to the Village of Manotick, but has generally not been undertaken upstream of First Line Road. Flooding under 1:100 year conditions will be contained within the watercourse's well-defined valley, in the reach where maping is available
- Erosion and related valley wall instability has been the primary constraint for new development and factored into the establishment of separation distances between new development and the creek/valley system
- RVCA enforces only the "alterations to waterways provisions" of O. Reg. 174/06, as regulation limits mapping of Mud Creek has not been prepared
- Drains 52 sq. km of land or 6.8% of the Lower Rideau Subwatershed and 1.2% of the Rideau Valley Watershed
- Dominant land cover is crop and pastureland (64%), woodland (19%), settlement (10%), transportation (4%) wetland (2%) and aggregate site (1%)
- Riparian buffer (30 m. wide along both sides of Mud Creek and its tributaries) is comprised of crop and pastureland (61%), woodland (21%), transportation (7%), wetland (5%), settlement (5%) and grassland (1%)
- Contains a cold/cool water recreational and baitfish fishery with 20 fish species
- Contains 34 municipal drains
- Water quality rating is poor along Mud Creek and has declined over a 12 year reporting period (2000-2005 vs. 2006-2011)
- Woodland cover has decreased by 1.5 percent (81 ha.) from 2002 to 2008
- Seventy-four stewardship (landowner tree planting/clean water/shoreline naturalization) projects have been completed
- Major studies completed include: Manotick Master Drainage Plan. 1996 (Robinson Consultants for Rideau Township); Jock River Reach 2 and Mud Creek Subwatershed Study: Existing Conditions Report. Vol. 1. Draft. 2005 (Marshall Macklin Monaghan for the City of Ottawa); Village of Manotick Environmental Management Plan: Special Design Area Component. 2005 (Marshall Macklin Monaghan and WESA)
- Between 2003 and 2008, fish sampling has been conducted on Mud Creek and its tributaries by the City Ottawa, City Stream Watch, volunteers and consultants for development related initiatives
- Since 2003, the RVCA has conducted benthic macroinvertebrate sampling downstream of Bankfield Road; in 2003 and 2009, volunteers undertook macro stream surveys along Mud Creek; also in 2008, RVCA staff undertook temperature profiling to gain a better understanding of temperature and habitat variations in the creek

1) Surface Water Quality

Assessment of streams in the Lower Rideau is based on 24 parameters including nutrients (total phosphorus, total Kjeldahl nitrogen, nitrates), E. coli, metals (like aluminum and copper) and additional chemical/physical parameters (such as alkalinity, chlorides pH and total suspended solids). Each parameter is evaluated against established guidelines to determine water quality conditions. Those parameters that frequently exceed guidelines are presented below.

The assessment of water quality throughout the Lower Rideau Subwatershed also looks at water quality targets that are presented in the 2005 Lower Rideau Watershed Strategy (LRWS), to see if they are being met. The LRWS identifies improving water quality as a priority concern; specifically reducing the levels of nutrients, bacteria and contaminants in the Lower Rideau.

1) a. Mud Creek

Surface water quality conditions in Mud Creek are monitored through the City of Ottawa's Baseline Water Quality Program. (downstream side of Bankfield Road bridge, see Fig. 1 for the location)

The water quality rating for Mud Creek ranges from “Fair” in the 2000-2005 period to "Poor" in the 2006-2011 period as determined by the CCME Water Quality Index (CCME WQI); analysis of the data has been broken into two periods 2000-2005 and 2006-2011, to examine if conditions have changed in this timeframe. Table 1 outlines the WQI scores and their corresponding ratings

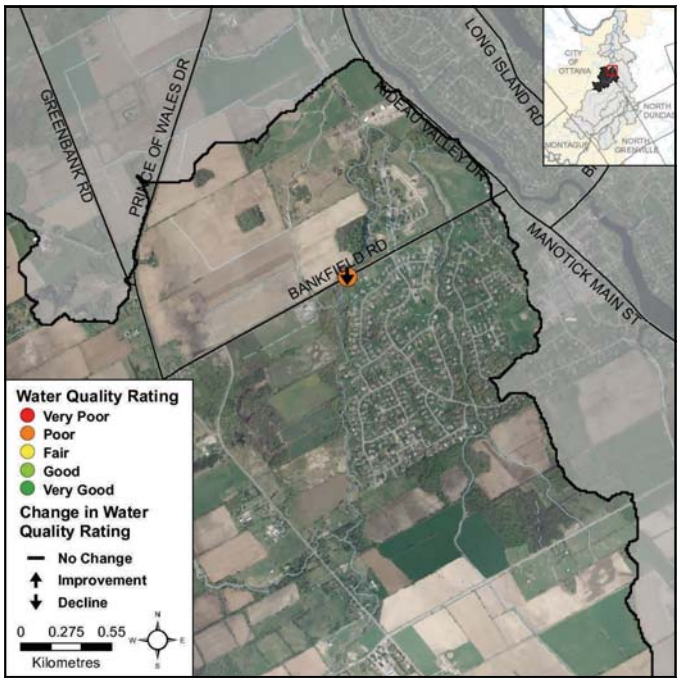


Figure 1. Sample site for Mud Creek

For more information on the CCME WQI please see the Lower Rideau Subwatershed Report.

Table 1. WQI Ratings and corresponding index scores (RVCA terminology, original WQI category names in brackets).

Rating	Index Score
Very good (Excellent)	95-100
Good	80-94
Fair	65-79
Poor (Marginal)	45-64
Very poor (Poor)	0-44

Mud Creek Nutrients

Total phosphorus (TP) is used as a primary indicator of excessive nutrient loading and may contribute to abundant aquatic vegetation growth and depleted dissolved oxygen levels. The Provincial Water Quality Objectives (PWQO) of 0.030mg/l is used as the TP Guideline. Concentrations greater than 0.030 mg/l indicate an excessive amount of TP. Mud Creek TP results are shown in Figures 2a and 2b. In addition to the TP guideline,the Lower Rideau Watershed Strategy also set a target for TP concentration of 0.030 mg/l at the 85th percentile for tributaries of the Rideau River, such as Mud Creek. Percentile plots for this data are shown in Figures 3a and 3b. Any point to the left of the 85th percentile line (vertical) and above the guideline (horizontal line) have failed to reach the LRWS target.

Total Kjeldahl nitrogen (TKN) is used as a secondary indicator of nutrient loading; RVCA uses a guideline of 0.500 mg/l (TKN Guideline) to assess TKN concentrations. Mud Creek TKN results are shown in Figures 4a and 4b.

Tables 2 and 3 summarize average nutrient concentrations at monitored sites on Mud Creek and shows the proportion of samples that meet guidelines. Highlighted values indicate averages that exceeded guideline

Table 2. Summary of total phosphorous results for Mud Creek

Total Phosphorus 2000-2005			
Site	Average (mg/l)	% Below Guideline	No. Samples
CK41-01	0.052	43	53
Total Phosphorus 2006-2011			
Site	Average (mg/l)	% Below Guideline	No. Samples
CK41-01	0.047	29	52

Table 3. Summary of total Kjeldahl nitrogen results for Mud Creek from 2000-2005 and 2006-2011

Total Kjeldahl Nitrogen 2000-2005			
Site	Average (mg/l)	% Below	No. Samples
CK41-01	0.670	26	53
Total Phosphorus 2006-2011			
Site	Average (mg/l)	% Below	No. Samples
CK41-01	0.683	15	52

Mud Creek Nutrients: Site CK41-01

Total phosphorus (TP) concentrations at site CK41-01 on Mud Creek were frequently elevated and often exceeded the guideline of 0.030 mg/l. The proportion of samples below the guideline decreased over the time periods of interest from forty-three percent (Fig. 2a, 2000-2005) to only twenty nine percent (Fig. 2b. 2006-2011). Though the frequency of exceedances increased there has a slight decline in average TP concentrations 0.052 mg/l (2000-2005) to 0.047 mg/l (2006-2011). Percentile plots of TP data at site CK41-01 in Figures 3a, 2000-2005 and 3b, 2006-2011. These figures show that the target is not achieved at this site though TP concentration at the 85th percentile have declined from 0.067 mg/l to 0.052 mg/l.

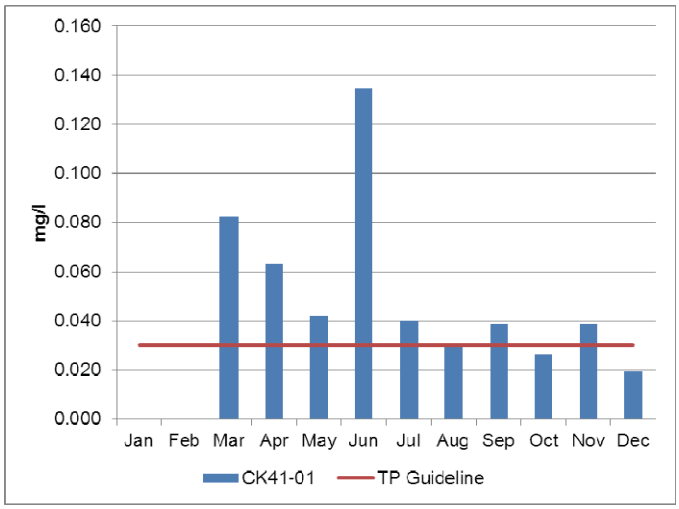


Figure 2a. Total phosphorous concentrations in Mud Creek from 2000-2005

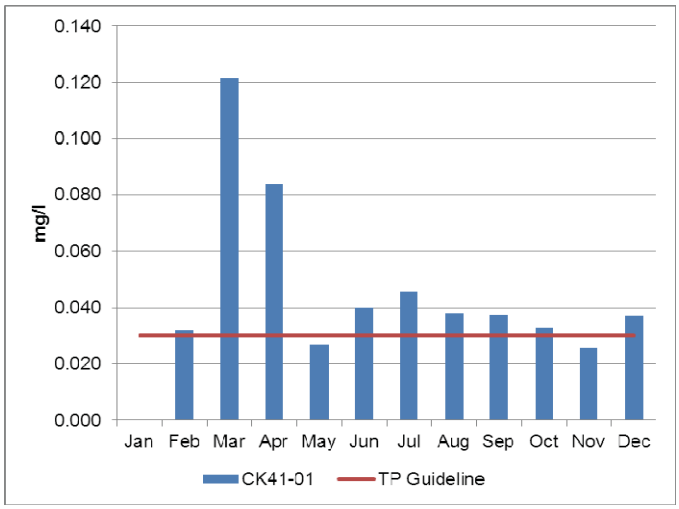


Figure 2b. Total phosphorous concentrations in Mud Creek from 2006-2011

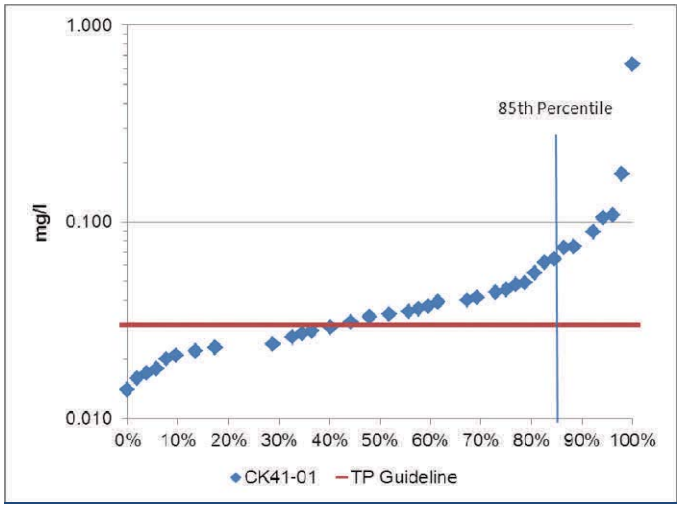


Figure 3a. Percentile plots of total phosphorus in Mud Creek from 2000-2005

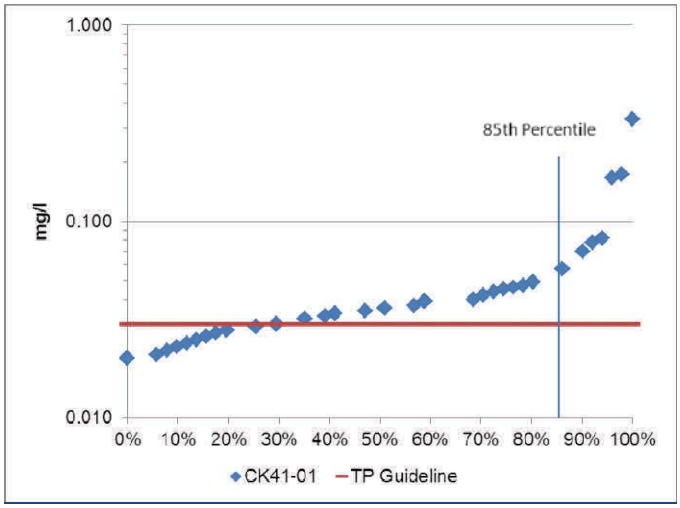


Figure 3b. Percentile plots of total phosphorous in Mud Creek from 2006-2011

TKN is used as a secondary indicator of nutrient enrichment and results remained fairly consistent at the site. Exceedances above the guideline of 0.500 mg/l were common; the proportion of samples below the guideline decreased from twenty-six percent (Fig. 4a, 2000-2005) to fifteen percent (Fig. 4b, 2006-2011). The mean concentration however dropped slightly from 0.670 mg/l to 0.638 mg/l and continued to exceed the guideline.

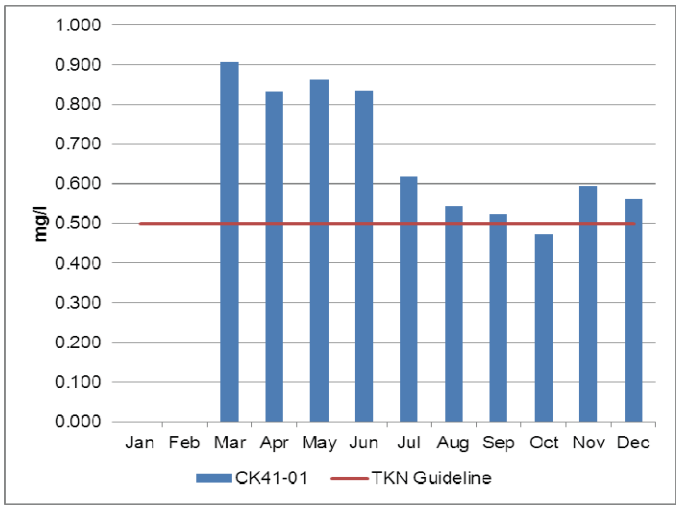


Figure 4a. Total Kjeldahl nitrogen concentrations in Mud Creek from 2000-2005

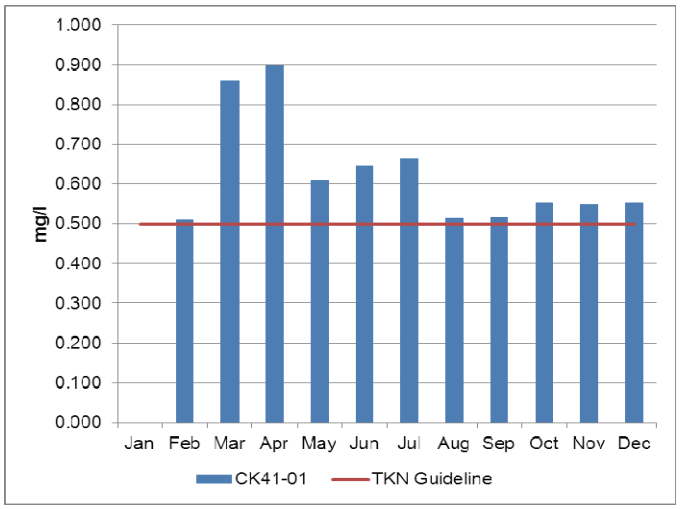


Figure 4b. Total Kjeldahl nitrogen concentrations in Mud Creek from 2006-2011

Mud Creek Nutrients Summary

Overall the data suggests that nutrient loading does occur at this site and effort should be made to reduce any possible sources of nutrient inputs.

Mud Creek E. coli

E. coli is used as an indicator of bacterial pollution from human or animal waste; in elevated concentrations it can pose a risk to human health. The PWQO of 100 colony forming units/100 millilitres is used. E. coli counts greater than this guideline indicate that bacterial contamination may be a problem within a waterbody. The Lower Rideau Watershed Strategy also set a target for E. coli counts of 200 CFU/100 ml at the 80th percentile for tributaries of the Rideau River, such as Mud Creek.

Table 4 summarizes the geometric mean at the monitored site on Mud Creek and shows the proportion of samples that meet the E. coli guideline of 100 CFU/100ml. Highlighted values indicate averages that have exceeded the guideline.

Figure 5 shows the results of the geometric mean with respect to the guideline for the two periods 2000-2005 (Fig. 5a) and 2006-2011 (Fig 5b). Figures 6a and 6b show percentile plots of the data for the two time periods of interest 2000-2005 (Fig. 6a) and 2006-2011 (Fig. 6b). Any point to the left of the 80th percentile line (vertical) and above the guideline (horizontal line) have failed to reach the LRWS target

Table 4. Summary of E. coli results for Mud Creek.

E. coli 2000-2005			
Site	Geometric mean	% Below Guideline	No. Samples
CK41-01	89	52	52
E. coli 200-2006			
Site	Geometric mean	% Below Guideline	No. Samples
CK41-01	142	35	52

Mud Creek E. coli: Site CK41-01

E. coli counts above the guideline of 100 colony forming units per 100 mL (CFU/100mL) were common at site CK41-01. In comparing the two time periods the proportion of samples below the guideline decreased from fifty-two percent (Fig. 5a) to thirty-five percent (Fig. 5b), indicating higher counts occur more frequently. The count at the geometric mean increased from 89 CFU/100 ml to 142 CFU/100 ml. Percentile plots of E. coli data at site CK41-01 are shown for both periods. Figures 6a, 2000-2005 and 6b, 2006-2011 show that the LRWS target has exceeded in both time periods, the E. coli count at the 80th percentile increased from 250 CFU/100 ml to 428 CFU/100 ml.

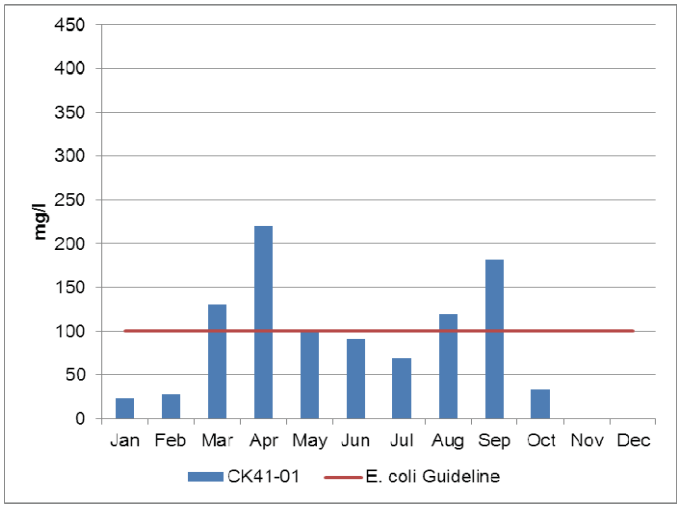


Figure 5a. E. coli counts in Mud Creek from 2000-2005

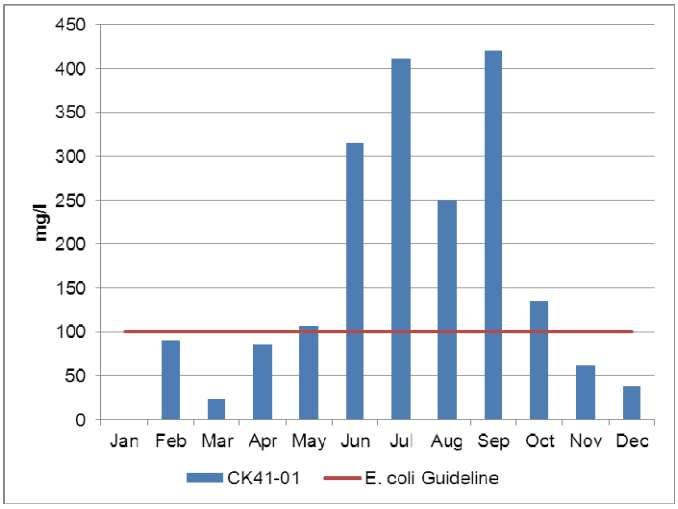


Figure 5b. E. coli counts in Mud Creek from 2006-2011

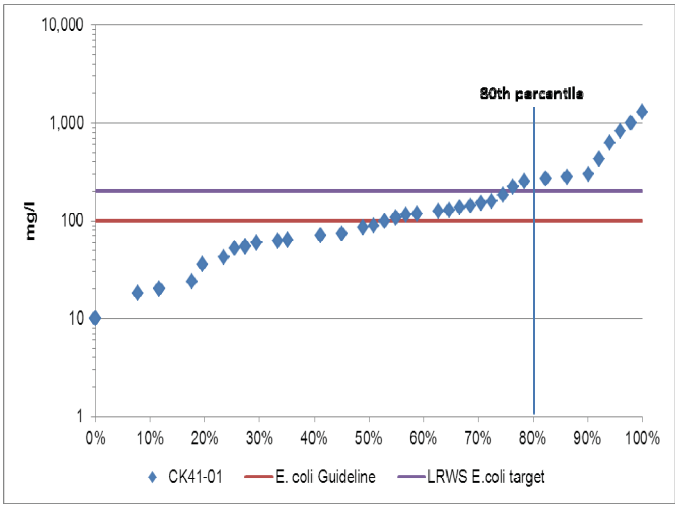


Figure 6a. Percentile plots of E. coli in Mud Creek from 2000-2005

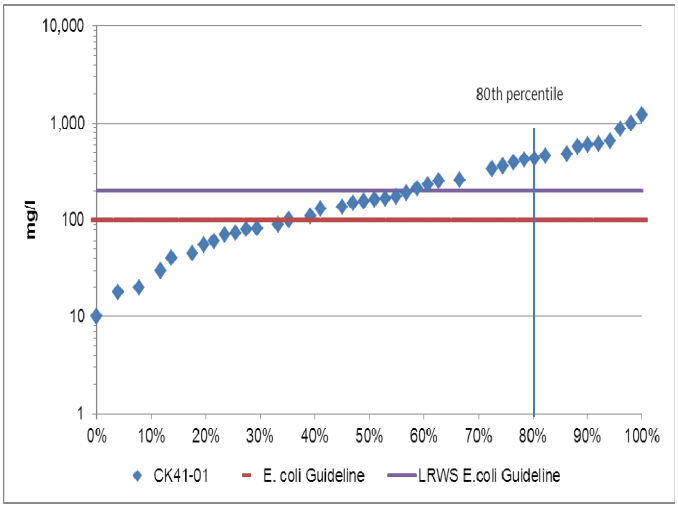


Figure 6b. Percentile plots of E. coli in Mud Creek from 2006-2011

Mud Creek E. coli Summary

These statistics indicated that bacterial counts have increased at this site and efforts should be made to reduce any possible sources of contamination to the creek to protect overall water quality and aquatic life.

Mud Creek Metals

Of the metals routinely monitored in Stevens Creek, aluminum (Al), copper (Cu) and iron (Fe) all reported concentrations above their respective PWQO. In elevated concentrations these metals can have toxic effects on sensitive aquatic species.

Table 5 summarizes average metal concentrations at monitored sites in Mud Creek and shows the proportion of samples that meet guidelines.

Figures 7, 8 and 9, show the results for each site with respect to guidelines for the two periods 2000-2005 (Figures 7a, 8a and 9a) and 2006-2011 (Figures 7b, 8b and 9b). The guidelines for each metal as stated by the PWQO are Al 0.075 mg/l, Cu 0.005 mg/l and Fe 0.300 mg/l. The Lower Rideau Watershed Strategy set a target for Cu concentration of 0.005 mg/l (Cu guideline) at the 80th percentile for tributaries of the Rideau River, such as Mud Creek. Figure 10 shows percentile plots of the data for the two time periods of interest (Fig. 10a, 2000-

Table 5. Summary of metal results for Mud Creek

Aluminum (Al)			
2000-2005			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.221	27	20
2006-2011			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.372	23	18
Iron (Fe)			
2000-2005			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.317	75	20
2006-2011			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.479	77	18
Copper (Cu)			
2000-2005			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.003	83	20
2006-2011			
Site	Average (mg/l)	% below	No. Samples
CK41-01	0.006	62	18

2005) (Fig. 10b, 2006-2011). Any point to the left of the 80th percentile line (vertical) and above the guideline (horizontal line) have failed to reach the LRWS target

Mud Creek Metals: Site CK41-01

The majority of metals monitored at site CK41-01 were below guidelines however results for aluminum (Al), iron (Fe) and copper (Cu) were all occasionally elevated.

The Al guideline of 0.075 mg/l was generally exceeded in both time periods (7a, 2000-2005 and 7b, 2006-2011), only twenty-seven percent of samples were below the guideline in the 2000-2005 period and this remained fairly consistent at twenty-three percent in the 2006-2011 period. There was an increase in average Al concentration from 0.221mg/l (2000-2005) to 0.372 mg/l (2006-2011).

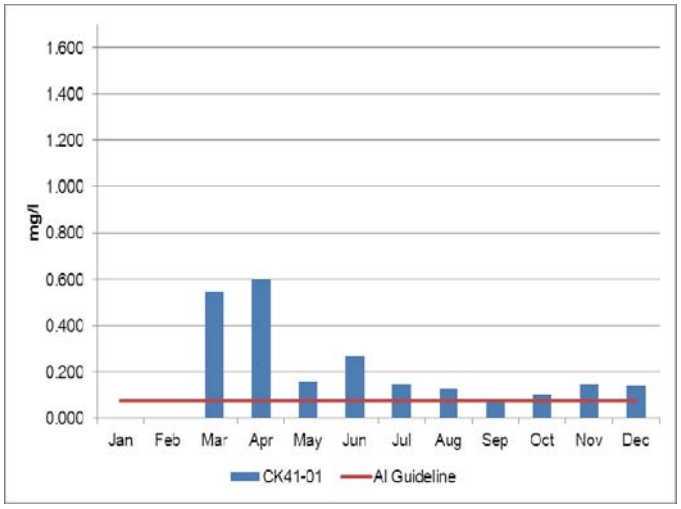


Figure 7a. Aluminum concentrations in Mud Creek from 2000-2005

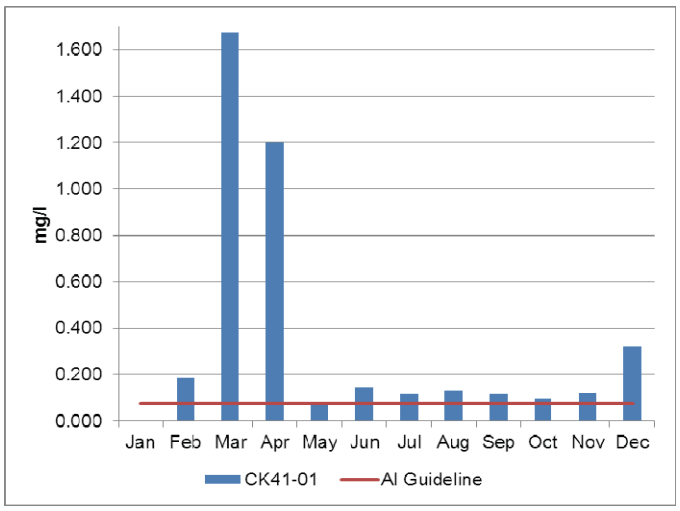


Figure 7b. Aluminum concentrations in Mud Creek from 2006-2011

Figures 8a, 2000-2006 and 8b, 2006-2011 show that the Fe results occasionally exceed the guideline of 0.300 mg/l and there was an overall increase in concentrations over the periods of interest. Seventy-five percent of samples were below the guideline in 2000-2005 and increased to seventy-seven percent in the 2006-2011 period. The average concentration increased from 0.317 mg/l to 0.479 mg/l, exceeding the guideline.

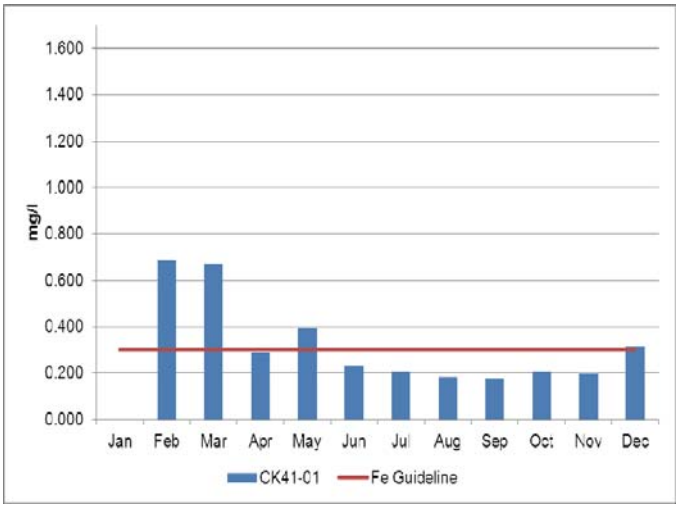


Figure 8a. Iron concentrations in Mud Creek from 2000-2005

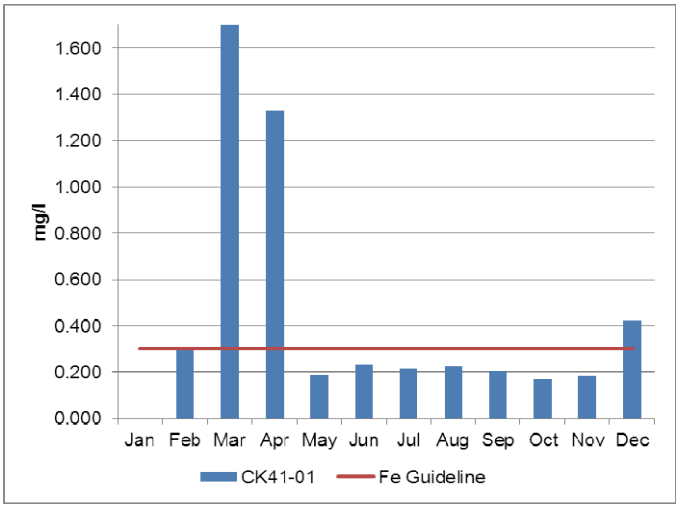


Figure 8b. Iron concentrations in Mud Creek from 2006-2011

Results for Cu concentrations were also occasionally above the guideline of 0.005 mg/l. The proportion of samples below the guideline decreased slightly from eighty-three percent (Fig. 9a, 2000-2005) to sixty-two (Fig. 9b, 2006-2011); the average concentration increased from 0.003 mg/l to 0.006 mg/l to just exceed the guideline. Percentile plots of Cu data are shown for the two time periods 2000-2005 (Fig. 10a) and 2006-2011 (Fig. 10b). The target of a Cu concentration of 0.005 mg/l at the 80th percentile has not been achieved at this site, the concentration at the 80th percentile

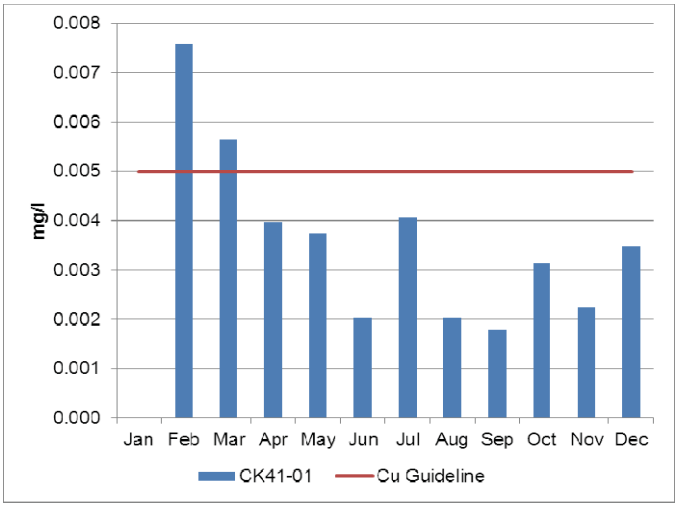


Figure 9a. Copper concentrations in Mud Creek from 2000-2005

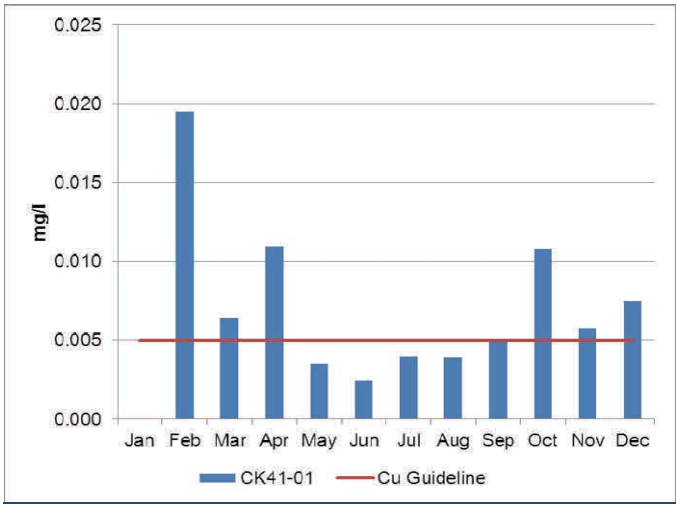


Figure 9b. Copper concentrations in Mud Creek from 2006-2011

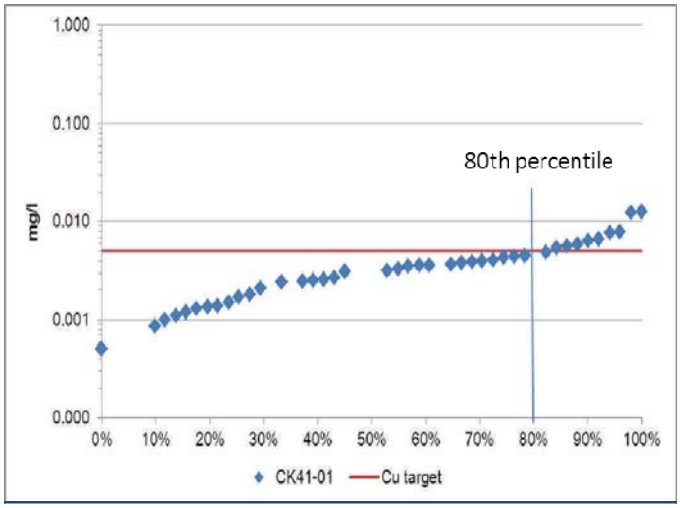


Figure 10a. Percentile plots of Copper in Mud Creek from 2000-2005

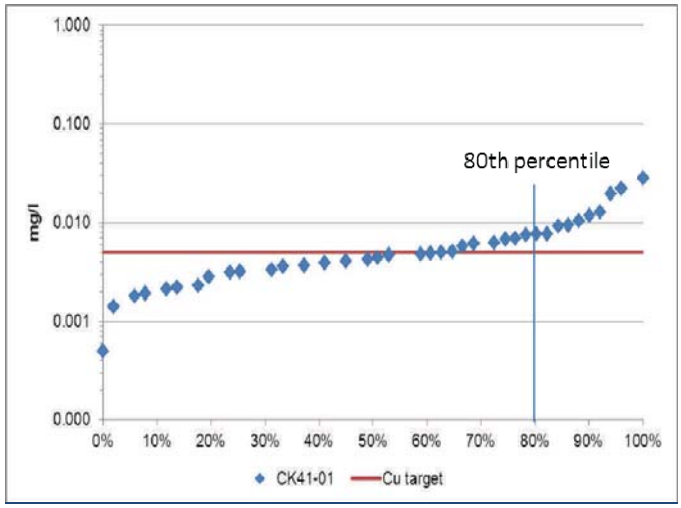


Figure 10b. Percentile plots of copper in Mud Creek from 2006-2011

increased from 0.005 mg/l (2000-2005, Fig. 10a) to 0.008 mg/l (2006-2011, Fig. 10b).

Mud Creek Metals Summary

Overall the data shows that metal pollution is a problem in the creek and efforts should be made to reduce concentrations wherever possible.

Mud Creek Benthic Invertebrates

Freshwater benthic invertebrates are animals without backbones that live on the stream bottom and include crustaceans such as crayfish, molluscs and immature forms of aquatic insects. Benthos represent an extremely diverse group of aquatic animals and exhibit wide ranges of responses to stressors such as organic pollutants, sediments and toxicants, which allows scientists to use them as bioindicators.

Benthic sampling site replicate one on Mud Creek at Bankfield in the City of Ottawa, this image was captured in the spring of 2008.

As part of the Ontario Benthic Biomonitoring Network (OBBN), the RVCA has been collecting benthic invertebrates at one location on Mud Creek at Bankfield Road since 2003. Monitoring data is analyzed and the results are presented using the Family Biotic Index, Family Richness and percent Ephemeroptera, Plecoptera and Trichoptera.

The Hilsenhoff Family Biotic Index (FBI) is an indicator of organic and nutrient pollution and provides an estimate of water quality conditions for each site using established pollution tolerance values for benthic invertebrates.

FBI results for Mud Creek show that it has "Poor" water quality conditions for the period from 2006 to 2011 (Fig.11) and scores an overall "Poor" surface water quality rating using a grading scheme developed by Conservation Authorities in Ontario for benthic invertebrates.

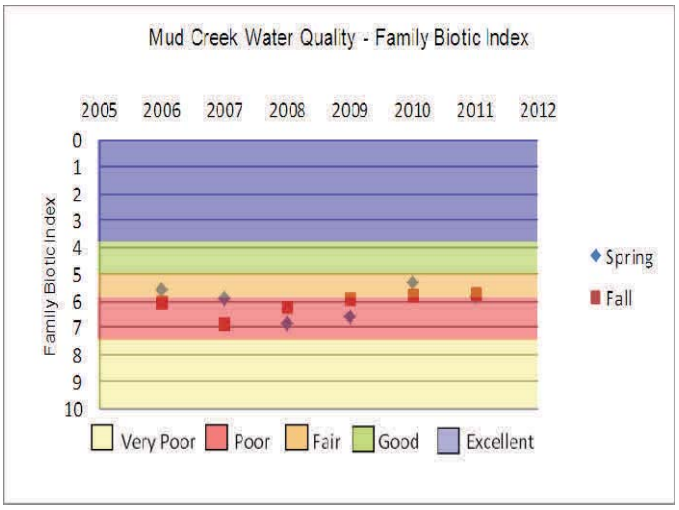


Figure 11. Surface water quality conditions in Mud Creek based on the Family Biotic Index

Family Richness measures the health of the community through its diversity and increases with increasing habitat diversity suitability and healthy water quality conditions. Family Richness is equivalent to the total number of benthic invertebrate families found within a sample.

Using Family Richness as the indicator, Mud Creek is reported to have "Fair" water quality (Fig.12).

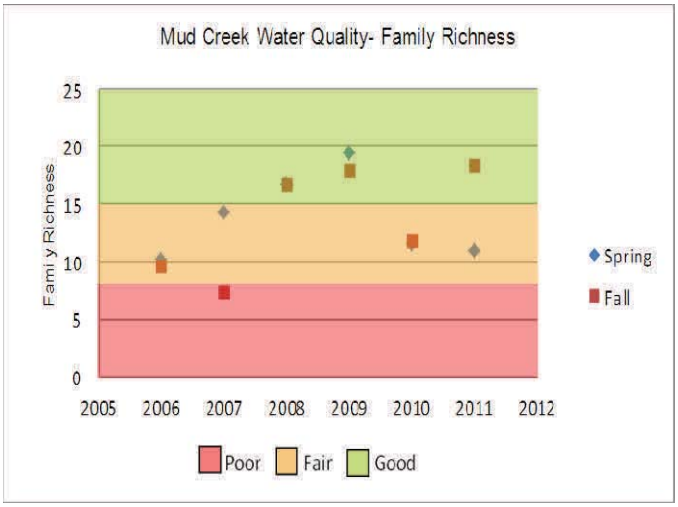


Figure 12. Surface water quality conditions in Mud Creek based on Family Richness

Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) are species considered to be very sensitive to poor water quality conditions. High abundance of these organisms is generally an indication of good water quality conditions at a sample location.

With the EPT indicator, Mud Creek is reported to have water quality ranging from "Poor" to "Fair" (Fig.13) from 2006 to 2011.

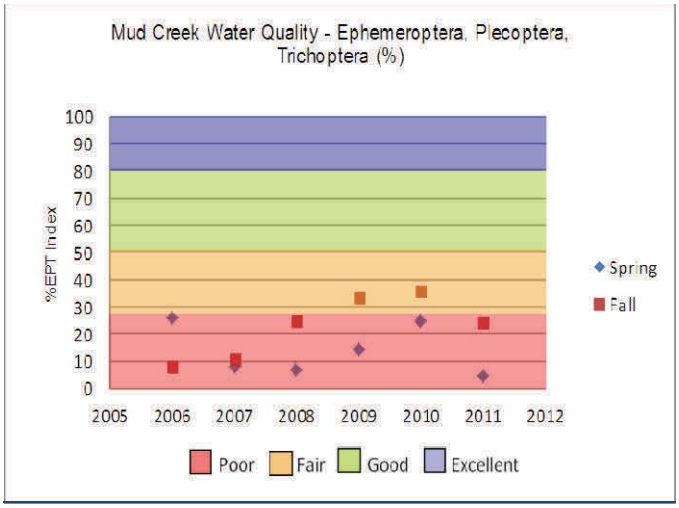


Figure 13. Surface water quality conditions in Mud Creek using the EPT Index

Overall Mud Creek has a water quality rating of "Poor" from 2006 to 2011.

2) a. Overbank Zone

Riparian Buffer along Mud Creek and Tributaries

Figure 14 shows the extent of the naturally vegetated riparian zone in the catchment, 30 metres on either side of all waterbodies and watercourses. Results from the RVCA's Land Cover Classification Program show that 27 percent of streams, creeks and lakes are buffered with woodland, wetland and grassland; the remaining 73 percent of the riparian buffer is occupied by settlement, crop and pastureland, transportation and grassland.

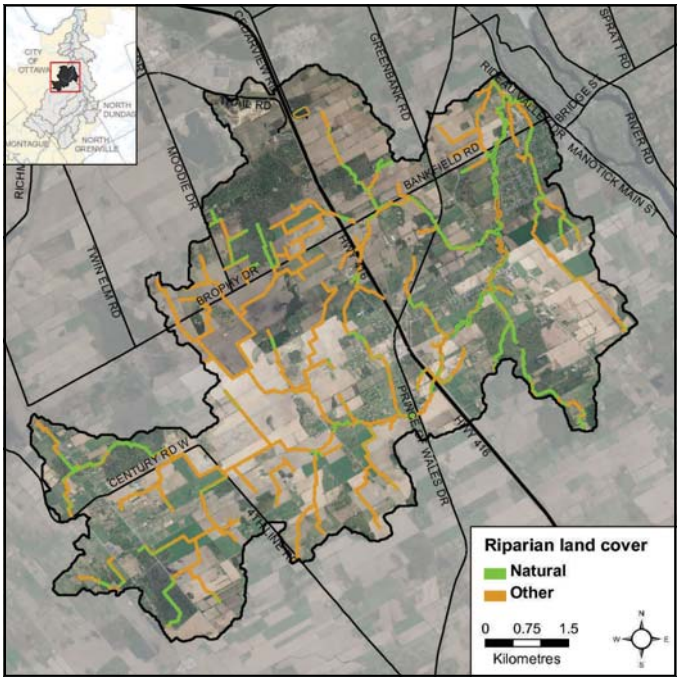


Figure 14. Catchment land cover in the riparian zone

Data from the RVCA's Macrostream Survey Program (Stream Characterization) is used in this section of the report and is generated from an assessment of 94 (100 metre long) sections along Mud Creek in 2008.

Riparian Buffer along Mud Creek

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 metre wide vegetated buffer along at least 75 percent of the length of both sides of rivers, creeks and streams. Figure 15 demonstrates the buffer conditions of the left and right banks separately. Mud Creek had a buffer of greater than 30 metres along 45 percent of the left bank and 54 percent of the right bank.

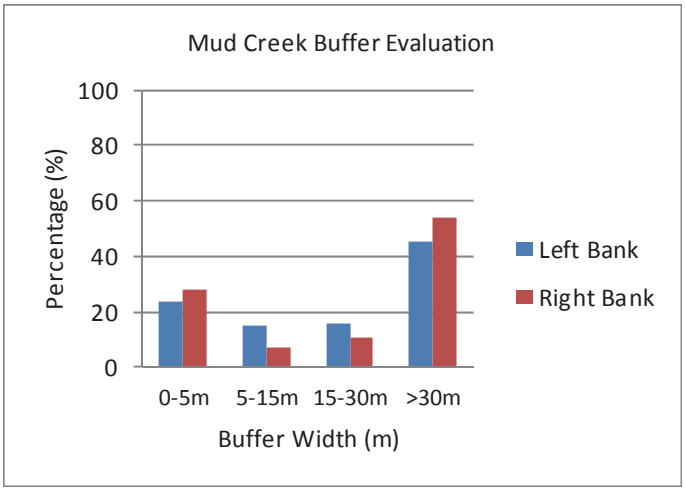


Figure 15. Vegetated buffer width along Mud Creek

Land Use beside Mud Creek

The RVCA's Macrostream Survey Program identified 11 different land uses beside Mud Creek (Figure 16). Surrounding land use is considered from the beginning to end of the 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 52 percent of the stream, characterized by wetland, forest, scrubland and meadow. The remaining land use consisted of residential, pasture, active agriculture, abandoned agriculture, commercial/ industrial, infrastructure, and recreational.

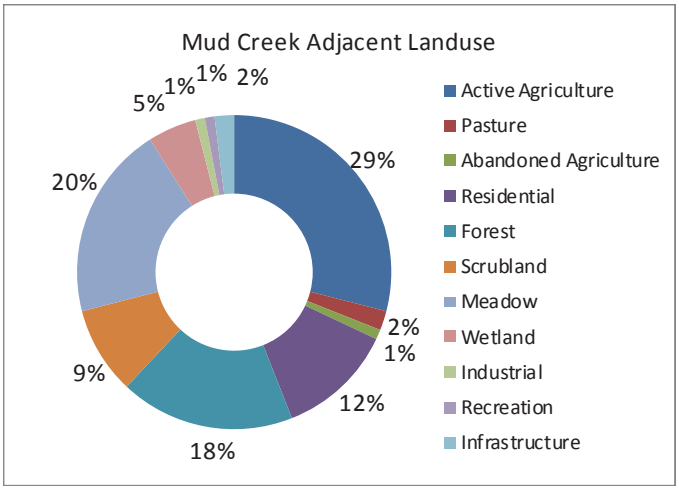


Figure 16. Land use alongside Mud Creek

2) b. 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. Bank stability indicates how much soil has eroded from the bank into the stream. 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 17 shows the bank stability of the left and right bank along Mud Creek.

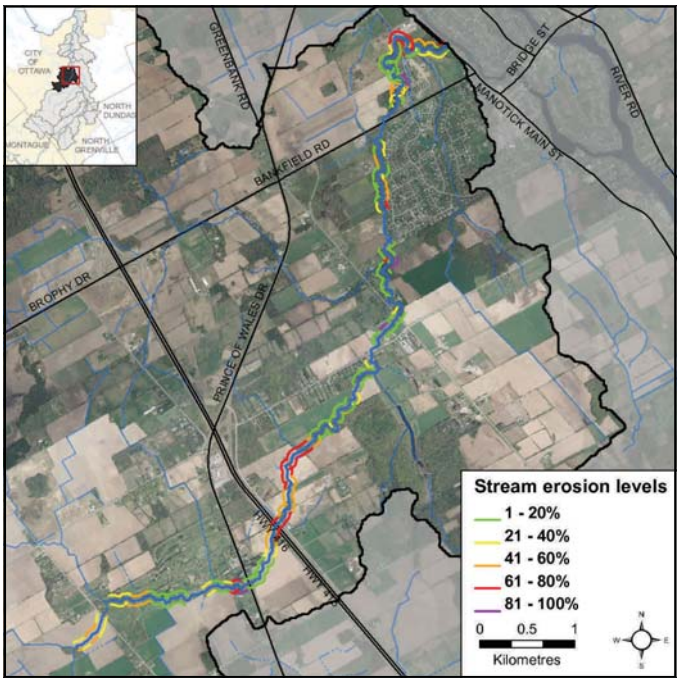


Figure 17. Erosion along Mud Creek

Streambank Undercutting

Undercut banks are a normal and natural part of stream function and can provide excellent refuge areas for fish. Figure 18 shows that Mud Creek had several locations with identified undercut banks.

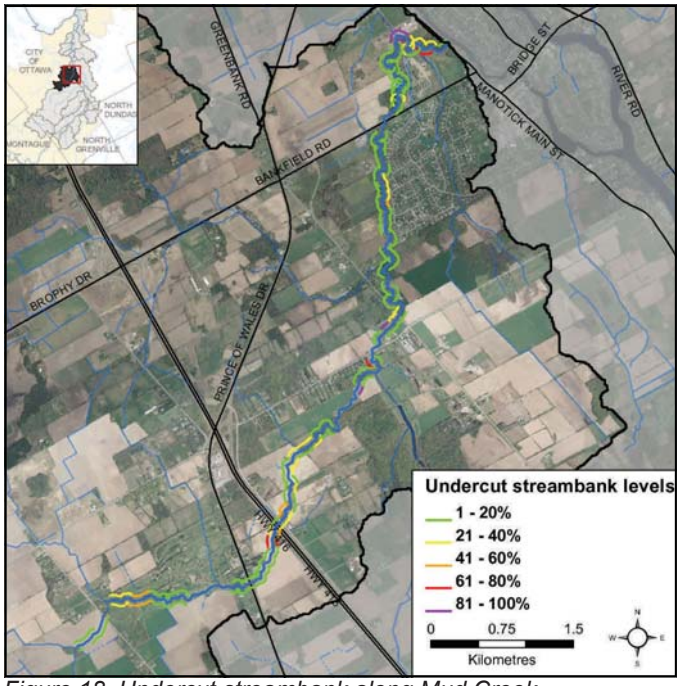


Figure 18. Undercut streambank along Mud Creek

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 19 shows the stream shading locations along Mud Creek.

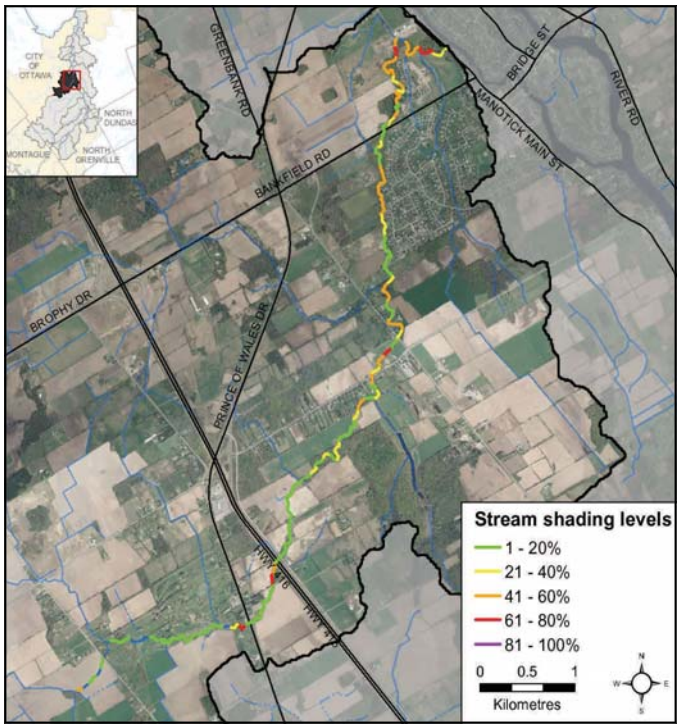


Figure 19. Stream shading along Mud Creek

Human Alterations

Figure 20 shows that 57 percent of Mud Creek remains “unaltered.” Sections considered “natural” with some human changes account for 26 percent of sections, with the remaining 17 percent of sections sampled being considered “altered” (e.g., with road crossings and little or no buffer). No areas were recorded as being "highly altered" along Mud Creek.

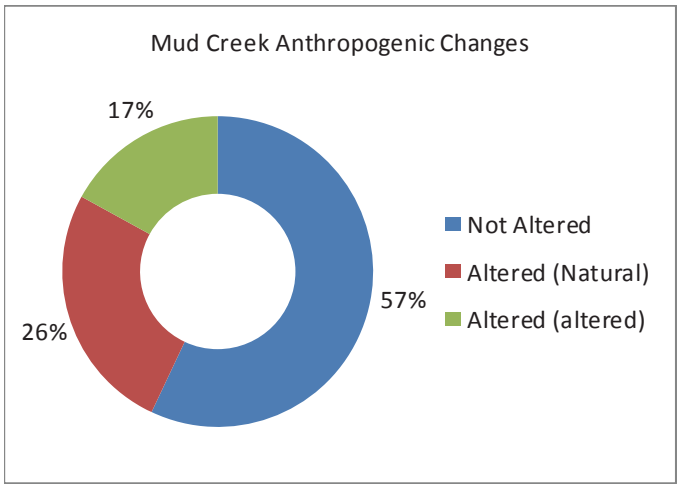


Figure 20. Alterations to Mud Creek

Overhanging Trees and Branches

Figure 21 shows that the majority of Mud Creek has varying levels of overhanging trees and branches. Overhanging trees and branches provide a food source, nutrients and shade which helps to moderate instream water temperatures.

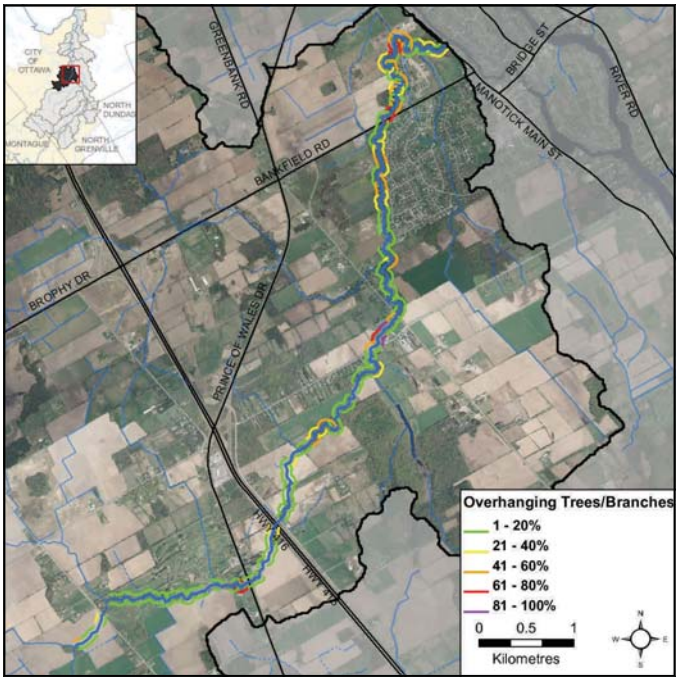


Figure 21. Overhanging trees and branches

Instream Woody Debris

Figure 22 shows that the majority of Mud Creek has varying levels of instream woody debris in the form of trees and branches. Instream woody debris is important for fish and benthic habitat, by providing refuge and

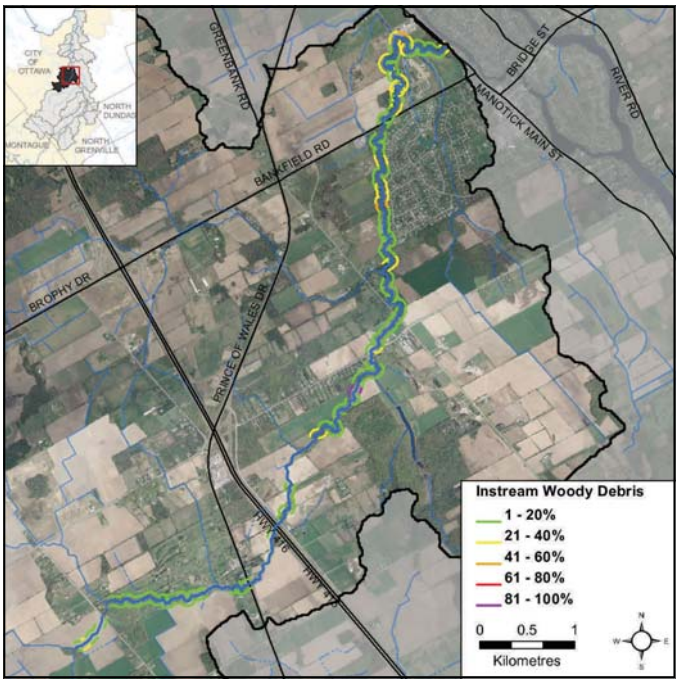


Figure 22. Instream woody debris

2) c. 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. A high percentage of habitat complexity (heterogeneity) typically increases the biodiversity of aquatic organisms within a system. Seventy-six percent of Mud Creek was considered heterogeneous, as shown in Figure 23.

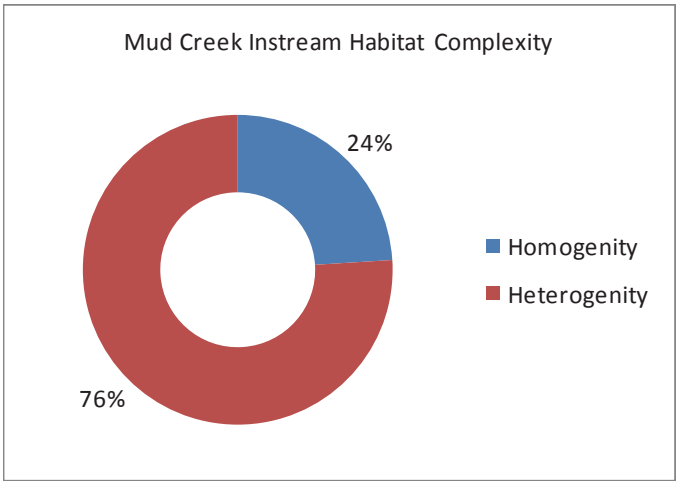


Figure 23. Instream habitat complexity in Mud Creek.

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 24 shows the diversity of substrate for Mud Creek.

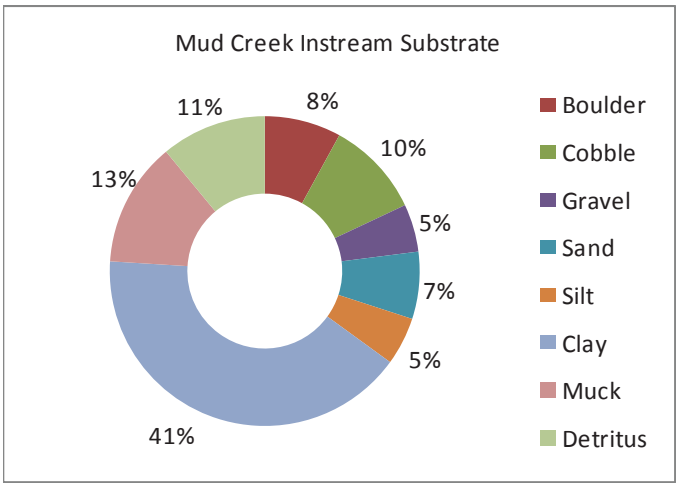


Figure 24. Instream substrate in Mud Creek

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 25 shows where cobble and boulder substrate was found in Mud Creek.

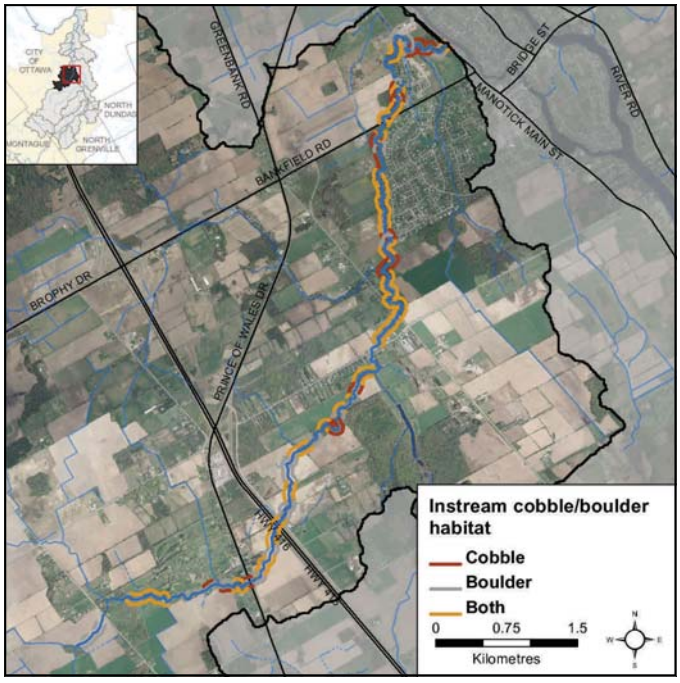


Figure 25. Instream cobble and boulder habitat along Mud Creek

Instream Morphology

Pools and riffles are important features for fish habitat. 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 walleye. Pools provide shelter for fish and can be refuge pools 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 26 shows that Mud Creek was fairly uniform; 90 percent consisted of runs, eight percent pools and two percent riffles.

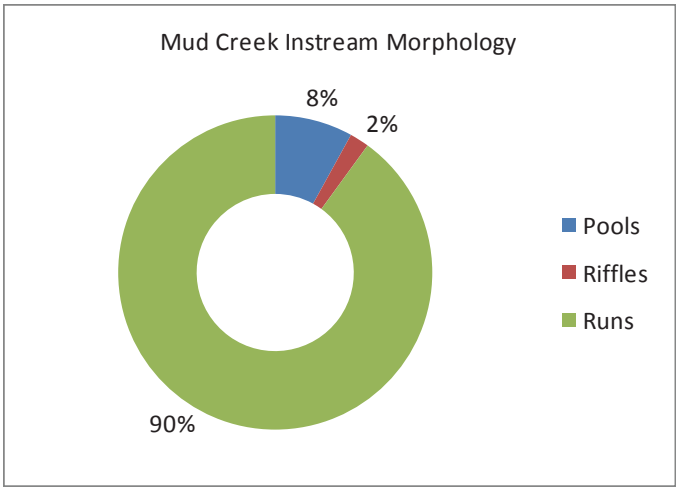


Figure 26. Instream morphology in Mud Creek

Types of Instream Vegetation

Mud Creek had fairly diverse types of instream vegetation (Figure 27). The dominant vegetation type recorded at twenty-nine percent consisted of algae. Submerged vegetation was recorded at 22 percent. Robust emergents were recorded at 16 percent. Narrow emergents were recorded at 15 percent. Free floating vegetation made up 13 percent of the vegetation types recorded in the stream. Broad emergent vegetation made up the remaining five percent of the vegetation community.

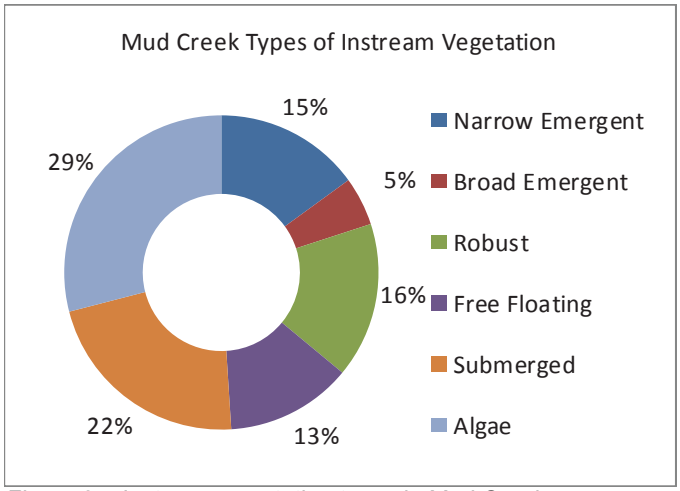


Figure 27. Instream vegetation types in Mud Creek.

Amount of Instream Vegetation

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 28 demonstrates that Mud Creek had healthy instream vegetation levels for most of its length.

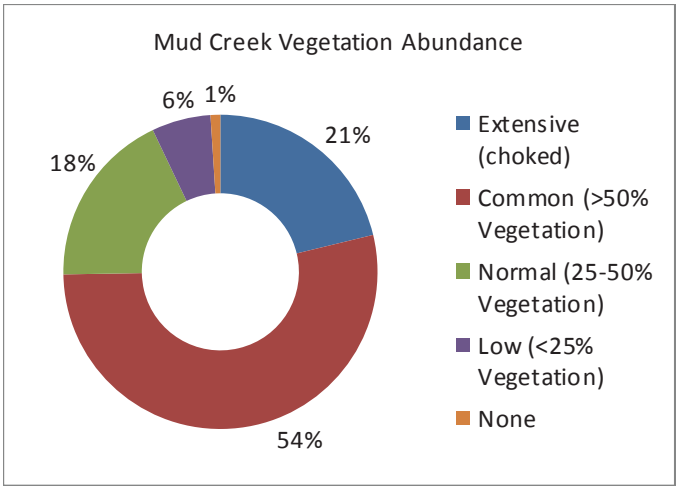


Figure 28. Vegetation abundance in Mud Creek

Riparian Restoration

Figure 29 depicts the locations where various riparian restoration activities can be implemented as a result of observations made during the stream survey assessments.

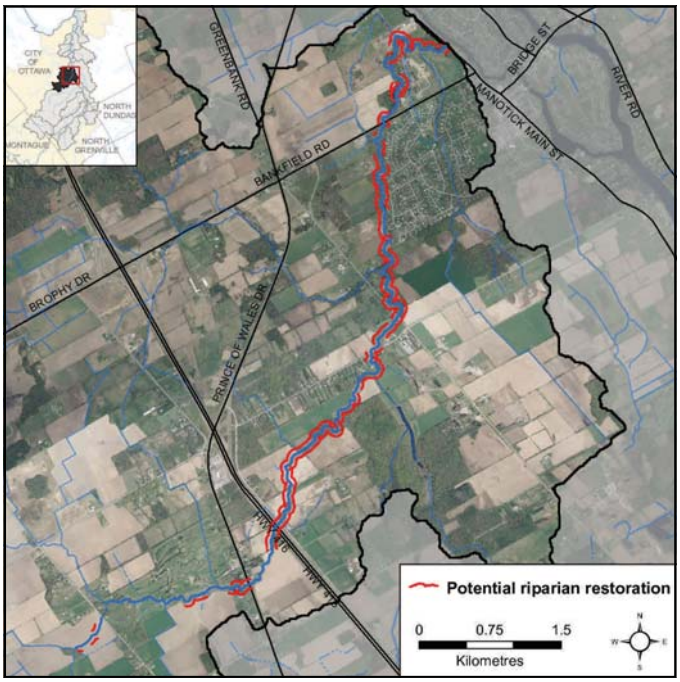


Figure 29. Riparian restoration opportunities

Instream Restoration

Figure 30 depicts the locations where various instream restoration activities can be implemented as a result of observations made during the stream survey assessments.

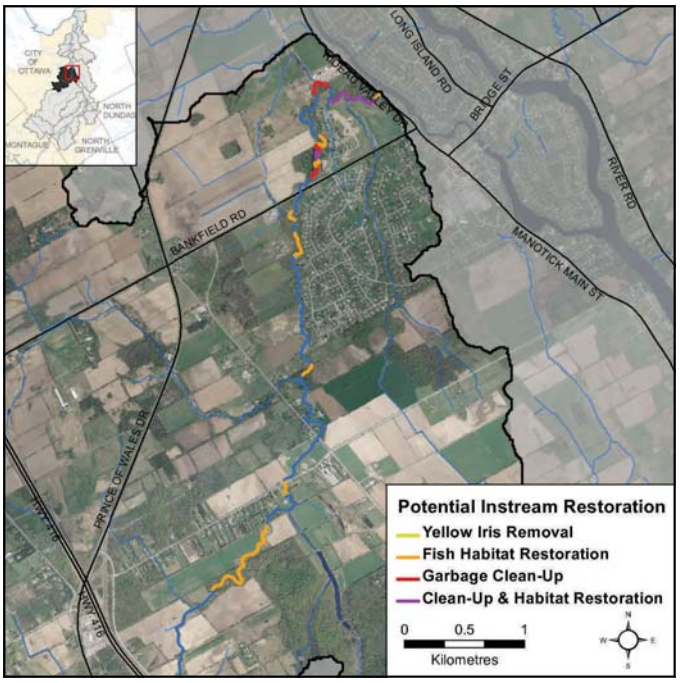


Figure 30. Instream restoration opportunities

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. Fifty percent of the sections surveyed along Mud Creek had invasive species (Figure 31). The species observed in Mud Creek were purple loosestrife, European frogbit, oxeye daisy, rusty crayfish, flowering rush.

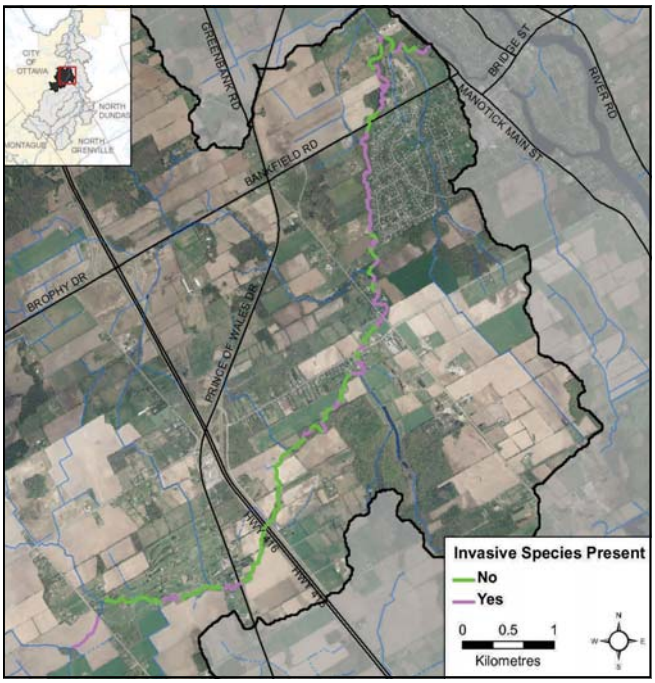


Figure 31. Invasive species along Mud Creek

Thermal Classification

Temperature is an important parameter in streams as it influences many aspects of physical, chemical and biological health. Three temperature dataloggers were deployed in Mud Creek from April to late September 2008 (Figure 32) to give a representative sample of how water temperature fluctuates. Many factors can influence fluctuations in stream temperature, including springs, tributaries, precipitation runoff, discharge pipes and stream shading from riparian vegetation. Water temperature is used along with the maximum air temperature (using the Stoneman and Jones method) to classify a watercourse as either warmwater, coolwater or cold water. Analysis of the data collected indicates that Mud Creek is a coolwater system.

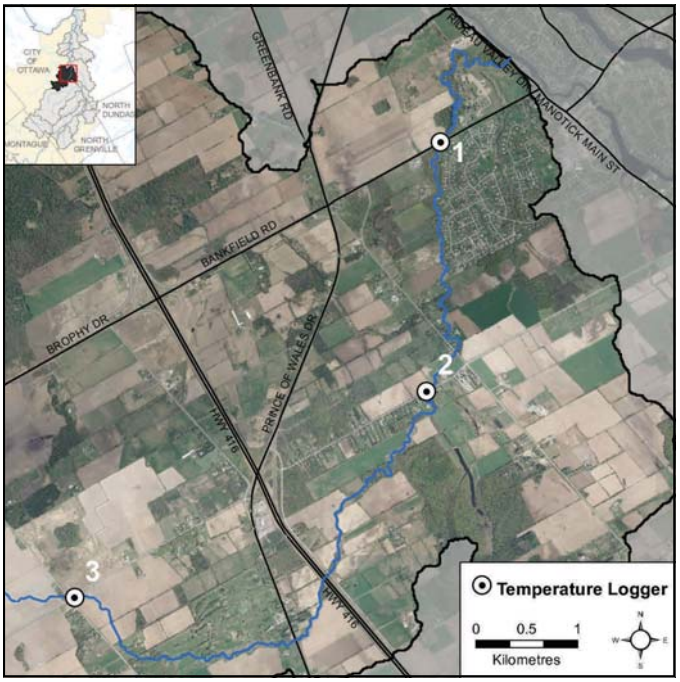


Figure 32. Temperature dataloggers along Mud Creek

Fish Sampling

Fish sampling sites located along Mud Creek are shown in Figure 33. The provincial fish codes shown on the map below are listed (in Table 6) beside the common name of those fish species identified in Mud Creek (Data source: RVCA and City of Ottawa).

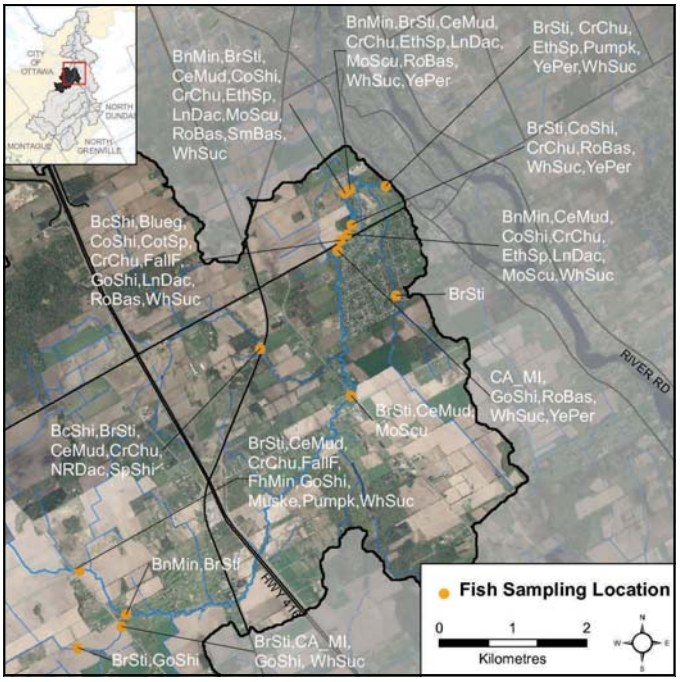


Figure 33. Fish species observed along Mud Creek

Table 6. Fish species observed in Mud Creek

BcShi **blackchin shiner**	Blueg **bluegill**	BnMin **bluntnose minnow**	BrSti **brook stickleback**	CeMin **central mudminnow**
CoShi **common shiner**	CrChu **creek chub**	EthSp **etheostoma spp.**	Fallf **fallfish**	FhMin **fathead minnow**
GoShi **golden shiner**	LnDac **longnose dace**	MoScu **mottled sculpin**	Muske **muskellunge**	NRDac **northern redbelly dace**
Pumpk **pumpkinseed**	RoBass **rock bass**	SpShi **spottail shiner**	WhSuc **white sucker**	YePer **yelllow perch**
CA_MI **carps and minnows**	SmBas **smallmouth bass**	Cotsp **cottus species**		

Migratory Obstructions

It is important to know the locations of migratory obstructions because they can prevent fish from accessing important spawning and rearing habitat (Figure 34). Migratory obstructions can be natural or manmade, and they can be permanent or seasonal. There were four beaver dams and one grade barrier within the Mud Creek catchment at the time the survey.

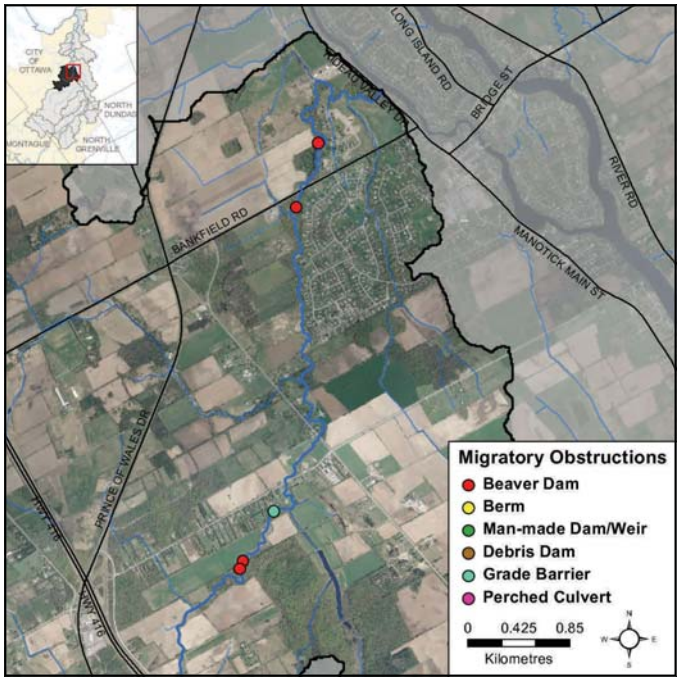


Figure 34. Migratory obstructions in Mud Creek

Water Chemistry

During the macrostream survey, a YSI probe is used to collect water chemistry, as follows:

- Dissolved Oxygen is a measure of the amount of oxygen dissolved in water. The lowest acceptable concentration of dissolved oxygen is 6.0 mg/L for early stages of warmwater fish and 9.5 mg/L for cold water fish (CCME, 1999). A saturation value (concentration of oxygen in water) of 90 percent or above is considered healthy
- Conductivity is the ability of a substance to transfer electricity. This measure is influenced by the presence of dissolved salts and other ions in the stream
- pH is a measure of relative acidity or alkalinity, ranging from 1 (most acidic) to 14 (most alkaline/ basic), with 7 occupying a neutral point.

2008 data for these three parameters is summarized in Table 7.

Table 7. 2008 Water chemistry collected along Mud Creek

Month	Range	DO (mg/L)	DO (%)	Conductivity (µs/cm)	pH
May-08	low	-	-	-	-
	high	-	-	-	-
Jun-08	low	3.9	44	601	7.74
	high	14.84	130	743	8.39
Jul-08	low	-	-	-	-
	high	-	-	-	-
Aug-08	low	8.9	90	666	7.4
	high	12.13	122	733	8.23

Electrofishing is a method of fish sampling for small streams

3) ***Land Cover***

Crop and pastureland is the dominant land cover type in the catchment as shown in Table 8 and displayed in the land cover map on the front cover of the report.

Table 8. Catchment land cover type

Cover Type	Area (ha)	Area (% of Cover)
Crop & Pasture	3650	63
Woodland	1085	19
Settlement	553	10
Transportation	255	5
Wetland	116	2
Aggregate Site	64	1

Woodland Cover

The Mud Creek catchment contains 1085 hectares of woodland (Fig.35) that occupies 19 percent of the drainage area. This figure is less than the 30 percent of woodland area required to sustain forest birds, according to Environment Canada's Guideline: "How much habitat is enough?" When forest cover declines below 30 percent, forest birds tend to disappear as breeders across the landscape.

Eighty-five (44%) of the 194 woodland patches in the catchment are very small, being less than one hectare in size. Another 97 (50%) of the wooded patches ranging from one to less than 20 hectares in size tend to be dominated by edge-tolerant bird species. The remaining 12 (6%) of woodland patches range between 21 and 213 hectares. Ten of these patches contain woodland between 20 and 100 hectares and may support a few area-sensitive species and some edge intolerant species, but will be dominated by edge tolerant species.

Conversely, two (1%) of the 194 woodland patches in the drainage area exceeds the 100 plus hectare size needed to support most forest dependent, area sensitive birds and is large enough to support approximately 60 percent of edge-intolerant species. One of these patches tops 200 hectares, which according to the Environment Canada Guideline will support 80 percent of edge-intolerant forest bird species (including most area sensitive species) that prefer interior forest habitat conditions.

Forest Interior

The same 194 woodlands contain 33 forest interior patches (Fig.35) that occupy 3 percent (192 ha.) of the catchment land area. This is below the ten percent figure referred to in the Environment Canada Guideline that is considered to be the minimum threshold for supporting edge intolerant bird species and other forest dwelling species in the landscape.

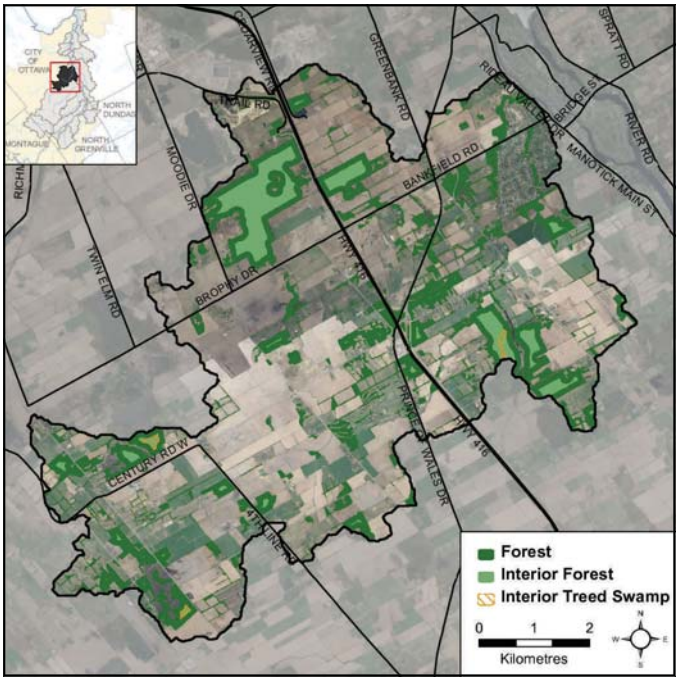


Figure 35. Catchment woodland cover and forest interior

Most patches (29) have less than 10 hectares of interior forest, 22 of which have small areas of interior forest habitat less than one hectare in size. Conversely, four patches have greater than 10 hectares of interior forest, the largest of which contains more than 100 hectares of interior forest (at 106 ha.).

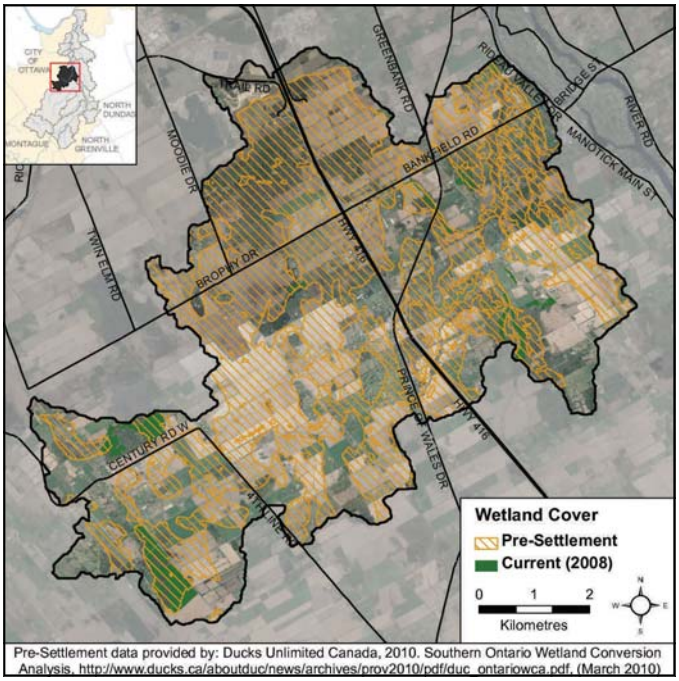


Figure 36. Pre-settlement and present day wetland cover

4) Stewardship and Protection

The RVCA and its partners are working to protect and enhance environmental conditions in the Lower Rideau Subwatershed.

Rural Clean Water Projects

Figure 37 shows the location of all Rural Clean Water Projects in the Mud Creek drainage area. From 2006 to 2011, landowners completed 30 projects including 9 septic system repair/replacements,12 well upgrades, 2 well decommissions, 1 well replacement, 3 fencing, 2 buffers/windbreaks and 1 precision farming. In total, RVCA contributed $33,671 in grant dollars to projects valued at $211,711.

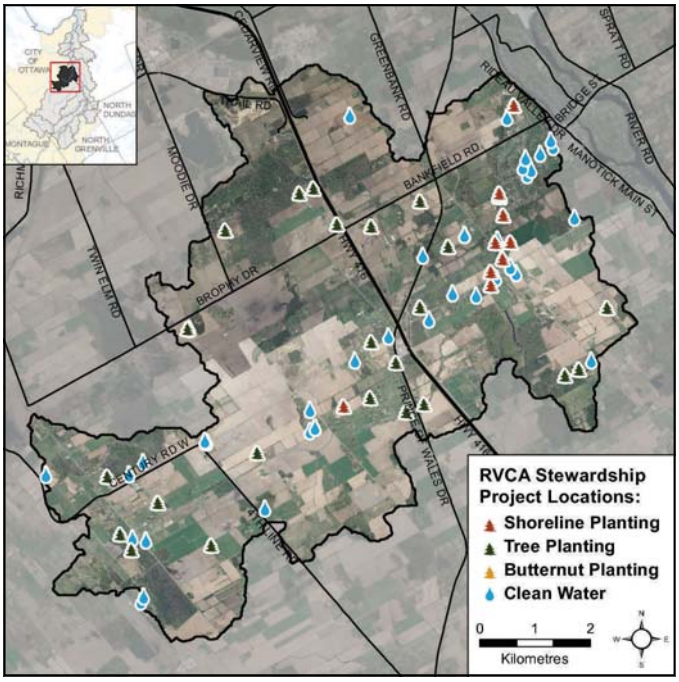


Figure 37. RVCA stewardship program project locations

Prior to 2006, the RVCA completed 20 projects in the area consisting of 2 septic repairs/replacements, 8 well upgrades, 2 well decommissions, 2 well replacements, 3 cropping practices, 2 surface wastewater disposal 1 chemical/fuel storage and handling, 1 manure storage treatment and 1 precision farming. In total RVCA contributed $27,800 in grant dollars to projects valued at project $96,954.

Tree Planting Projects

The location of all tree planting and shoreline projects is also shown in Figure 37. From 2006 to 2011, 17,200 trees, valued at $36,401, were planted on 5 sites through the RVCA Tree Planting Program..

Before that, from 1984 to 2006, landowners helped plant 77,200 trees, valued at $82,607, on 18 project sites, using the RVCA Tree Planting Program, on 39 hectares of private land; fundraising dollars account for $63,257 of that amount.

Shoreline Naturalization Projects

Throughout 2011, 11 shoreline naturalization projects were completed in partnership with private landowners and community volunteers on mud creek. These projects saw just over 2000 tree and shrub seedlings planted along 1.1 km of shoreline, with a combined project value of $14,730. Project funding was provided in part through Environment Canada's EcoAction Community Grants Program during the Rideau Valley Conservation Foundation's *Making Shorelines Natural* Project.

Valley, Stream, Wetland and Hazard Land Regulation

Less than one percent of the catchment drainage area is within the regulation limit of Ontario Regulation 174/06 (Fig.38), giving protection to wetland areas and river or stream valleys that are affected by flooding and erosion hazards. Plotting of the regulation limit on the 105.3 km (or 100 percent) of streams requires identification of flood and erosion hazards and valley systems.

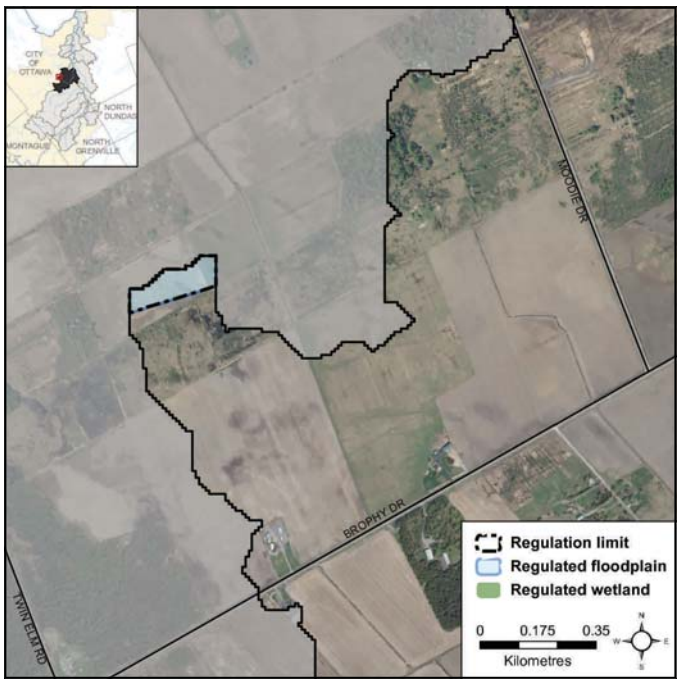


Figure 38. RVCA regulation limits

Within the regulation limit, "development" and "site alteration" require RVCA permission, as do any proposed works to alter a watercourse, which are subject to the "alteration to waterways" provision of Ontario Regulation 174/06.

5) Issues

- Loss and channelization of headwater tributaries due to rural drainage practices
- Removal of natural riparian vegetation
- Altered hydrology causing in-stream erosion and impacts to aquatic habitats
- Reduced biodiversity
- Loss of wetland and forest habitats
- Increasing presence of invasive species
- Barriers to fish movement
- Nutrient, E.coli and metal exceedances observed in water samples taken

6) Opportunities for Action

- Educate landowners about appropriate best management practices for lawn maintenance and yard waste disposal practices
- Work with landowners and other interest groups to implement agricultural best management practices and pursue improvements to the riparian corridor along Mud Creek and tributaries (by increasing buffers through reforestation/ riparian plantings, invasive species removal and creek clean-up)
- In accordance with the direction provided in the Village of Manotick Environmental Management Plan, runoff quality control is required for new development and redevelopment, including the use of infiltrative BMP's where soil conditions are suitable
- Require geotechnical investigation for new development or redevelopment on adjacent table lands to ensure adequate slope stability
- Remove barriers to fish movement and improve in-stream structure
- Improve access to the Mud Creek corridor for public use and recreation
- Target riparian and instream restoration at sites identified in this report (as shown in Figures 29, 30 and 34) and explore other restoration and enhancement opportunities along the Mud Creek riparian corridor