McKenzie Creek Subwatershed Characterization Study
This project was undertaken with the financial support of the Government of Canada through the federal Department of the Environment.

This report should be referenced as:

EXECUTIVE SUMMARY

McKenzie Creek is a major tributary of the southern Grand River (Figure 1). Water quality studies have identified McKenzie Creek subwatershed as providing high contributions of sediments and phosphorus to the Grand River (Holeton, 2013). As the largest Canadian tributary to Lake Erie, nutrient loading from the Grand River likely has an effect on the Eastern basin of the Lake. Excessive phosphorous loading in Lake Erie has led to development of hypoxic zones, and toxic and nuisance algal blooms, threatening drinking water quality and impacting fisheries habitat and resource-based industries. In 2016 the Canadian and United States governments targeted a 40% reduction of phosphorous loading to Lake Erie’s Central and Western basins. A target for the Eastern basin is forthcoming. Phosphorus reductions to the Eastern basin will need to address point and nonpoint source loading from the Grand River watershed. Improvements in land management and water quality in McKenzie Creek could help to reduce nutrient loading to the southern Grand River and Lake Erie.

The Grand River Watershed Water Management Plan (WMP) identified a need for phosphorus and sediment management strategies for McKenzie Creek subwatershed (Grand River Conservation Authority (GRCA), 2014). The WMP also noted potential for water use conflict in the sand plain region of the subwatershed, recommending development of local and regional water management strategies (GRCA, 2014).

In anticipation of nutrient reduction targets for the Eastern basin, and to support a broad range of current and anticipated resource management needs, a characterization study was initiated for McKenzie Creek. This report draws on existing data and information to document and describe subwatershed features, functions and conditions, and identify gaps in understanding. The study assembled and analyzed available information on groundwater and surface water hydrology, water quality and water use, and aquatic and terrestrial communities and habitat.

This Executive Summary presents a brief description of the characterization findings for the McKenzie Creek subwatershed. It summarizes the key findings for each study component and outlines areas that may require future investigation to fully characterize the subwatershed.

McKenzie Creek is a largely agricultural subwatershed (70% agricultural land cover, <5% urban land cover) with scattered rural communities and very modest growth projections. Natural cover (30% of the subwatershed) is concentrated in mid-concession blocks of forest on Six Nations lands and in wetland complexes in the headwaters in Brant County. The Six Nations forest is thought to be the largest block of Carolinian woodland in Canada and is one of only two large blocks of forest remaining in the Grand River watershed. These natural areas provide habitat for many provincially significant species, including more than 20 species protected under provincial and federal species at risk legislation.
The hydrology of the subwatershed is strongly influenced by surficial geology. In the headwaters, the provincially significant Oakland Swamp is located on the permeable Norfolk Sand Plain, allowing for groundwater recharge. Groundwater discharge within and downstream of the Sand Plain contributes to low and stable baseflows supporting cool-to-cold water tributaries. However, high agricultural water demand on the Sand Plain can cause baseflows to be highly variable during the summer months. The less-permeable Clay Plain in the mid to lower parts of the subwatershed contributes to a flashier hydrology, with less infiltration and more runoff of precipitation. The lower reaches of Boston and McKenzie creeks support warmwater fish communities. On-line ponds may contribute to warming of some stretches of the watercourses. On the Clay Plain, Boston and McKenzie creeks are characterized by low gradients, meandering stream channels, and dense bank vegetation, resulting in a dampened flood response. Future conditions in McKenzie Creek subwatershed are liable to be driven by changes in water balance due to rising demands for agricultural water use, which could be exacerbated by climate change. Changes in the amount and distribution of infiltration of precipitation, particularly on the Norfolk Sand Plain, will have implications for downstream conditions (water quality and temperature, fish habitat).

Additional investigation is needed to assess the hydrologic function of natural features within the subwatershed. In particular, the role of the Norfolk Sand Plain and Oakland Swamp in groundwater recharge/discharge is poorly understood, as well as their contribution to maintaining baseflows. More distributed stream flow and temperature monitoring could better characterize the flow regime, baseflow requirements, and groundwater recharge and discharge areas.
Phosphorus and sediment concentrations remain high in McKenzie and Boston creeks; this subwatershed contributes higher loads per square kilometer to the Grand River than most other subwatersheds. Key non-point sources of sediment and phosphorus are expected to be in-stream and bank erosion, and runoff from agricultural areas; point sources include discharges from two sewage lagoons (most residents are on private septic systems). The relative contribution of these sources is unknown.

Additional water quality monitoring and assessment is needed to better understand the relative contribution of rural point and nonpoint sources of sediment and phosphorus to McKenzie Creek, to inform selection of management strategies to reduce loading to the creek and the Southern Grand River. A lack of current monitoring of biological indicators like benthic macroinvertebrates and fish communities makes it difficult to report on the overall health of the aquatic ecosystem with regards to water quality. Biological indices can help to identify key stressors and threshold limits for nutrients and chemicals within the subwatershed.

**Landform, Geology and Groundwater**

- McKenzie Creek subwatershed is comprised of two distinct **physiographic regions**. The Norfolk Sand Plain covers the western end of the subwatershed and is characterized by coarse sands and silts. The Haldimand Clay Plain dominates the majority of the subwatershed, is glacio-lacustrine in nature, and consists of laminated to varved silt, clay and some minor sand deposits.
- The **Salina Formation** is the main bedrock formation underlying the subwatershed, with bands of Bass Islands-Bertie and Bois Blanc formations overlying along the southwestern edge of the subwatershed. The Bois Blanc formation is exposed at the surface in several areas near Hagersville. The Salina Formation is the primary bedrock aquifer and provides the main source of groundwater across the subwatershed.
- Overburden thickness ranges from 10-20 m over much of the subwatershed, to over 70 m in the Norfolk Sand Plain. The Norfolk Sand Plain forms an **unconfined overburden aquifer** which is a locally significant source of water. This shallow aquifer is particularly vulnerable to surface contamination.
- **Groundwater flows** primarily from the headwaters in the west toward the confluence with the Grand River in the east.
- **Groundwater recharge** is estimated at 127 mm/yr for the subwatershed, lower than the watershed average (180 mm/yr). The highest groundwater recharge rates occur in the Norfolk Sand Plain. Groundwater recharge in the headwaters of McKenzie Creek is thought to discharge into the Grand River near Brantford.
- The provincially significant Oakland Swamp functions as a **groundwater storage and discharge** area.
Surface Water Quantity

- The two main watercourses, McKenzie Creek in the north and Boston Creek in the south, flow from west to east, before merging and flowing into the Grand River. There are several named and un-named tributaries including Moses Creek, Spring Creek, Sour Spring Creek, and Montour Creek.
- The hydrology of the system is strongly influenced by surficial geology. In the headwaters the Norfolk Sand Plain allows for greater infiltration of precipitation and less runoff, while the hydrology of the Clay Plain area is flashier, with less infiltration and more runoff. Overall, McKenzie Creek is a runoff dominated system with a low and stable baseflow component throughout the summer months and high median flows during snow melt and spring freshet. Intensive agriculture in the Sand Plain region can cause the baseflow component to be highly variable during the summer months.
- Baseflows are supported by groundwater discharge from the Sand Plain region and the Oakland Swamp wetland complex.
- The mean annual flow at the stream gauge is 1.9 m$^3$/s or 350 mm/yr. The creek has very little influence on flows in the Grand River.
- Runoff from the subwatershed is approximately 337 mm/y, which is higher than the Grand River watershed average of 266 mm/y.
- Impervious cover is low, with less than 5% of the subwatershed with urban land cover.
- Agricultural land with tile drainage covers 13% of the subwatershed, largely in the Clay Plain region.
- There are 7 known impoundments in the subwatershed, largely in the Sand Plain region.
- The highly meandering stream channel, dense bank vegetation, on-line ponds, and the overall low gradient through much of the subwatershed combine to produce a dampened flood response to spring melts and rain events.

Surface Water Quality

- Between 1981 and 2001, total phosphorus and total nitrate concentrations in McKenzie and Boston Creeks showed no increasing or decreasing trends, while chloride concentrations rose. In McKenzie Creek total ammonia and total suspended sediment concentrations remained steady, while in Boston Creek they declined.
- McKenzie Creek subwatershed contributes more phosphorus and sediment per square kilometer to the Grand River than many other subwatersheds. Between 2007 and 2014, phosphorus concentrations exceeded the Provincial Water Quality Objective of 0.030 mg/L 98.5% of the time, and total suspended solids exceeded the 25 mg/L benchmark 50% of the time.
- Key non-point sources of sediment and phosphorus are expected to be in-stream and bank erosion, and runoff from rural and agricultural areas; point sources include discharges from two sewage lagoons.
- The Rural Water Quality Program has resulted in implementation of 27 best management practice (BMP) projects in McKenzie Creek subwatershed since 2002 (largely tree planting). Implementation of BMPs to reduce agricultural nutrient applications and soil erosion could help to reduce nutrient and sediment concentrations in McKenzie Creek.
- While appearing to increase over time, chloride concentrations only occasionally exceed the 120 mg/L guideline for long-term exposure. Future development may increase these levels.

Water Use
- Agriculture is the dominant category for permitted water takings in the McKenzie Creek subwatershed. Agricultural water takings are clustered on the Sand Plains and draw from groundwater or combined surface and groundwater sources.
- Demand for irrigation water use in the McKenzie Creek subwatershed is the second highest of any sub-basin in the Grand River watershed, and demand is expected to rise in the future.
- Actual water takings often are much lower than permitted maximum takings. In 2012, agricultural water uses accounted for 92% of permitted water use, but only 32% of reported actual water use (less reported water use than for dewatering).
- There are no water takings for municipal water supply within the subwatershed; all municipal and First nations water supply systems draw from surface water sources outside the subwatershed. Rural residents are on private well systems.
- McKenzie Creek subwatershed has a moderate potential for water stress and water use conflict, particularly in the summer months in the Sand Plains region, when demand for irrigation is high.

Terrestrial Natural Heritage
- McKenzie Creek subwatershed has about 30% natural cover, concentrated on Six Nations land and within the Oakland Swamp.
- Subwatershed forest cover is 26% and highest on Six Nations Territory where forest cover is about 50%. The Six Nations mid-concession forest tracts have been described as the largest block of Carolinian woodland in Canada, and collectively they are one of only two areas in the Grand River watershed to exceed Environment Canada’s woodland cover target of 30%.
- Interior forest accounts for 26% of all woodlands within this subwatershed, or 7% of the subwatershed area.
- Subwatershed wetland cover is 4%, lower than both the watershed average (9.5%) and Environment Canada’s target (6%). About 70% of the wetland area has been evaluated by OMNRF. Sixty percent of the wetland area has been designated provincially-significant. Most evaluated wetlands are located in Brant County. The extensive wetlands on Six Nations land have not been evaluated.
- The Oakland Swamp PSW (803 ha) is the largest wetland in the subwatershed and represents the headwater for McKenzie Creek. Because of its size, this wetland is significant for area-sensitive wildlife which require large amounts of habitat for breeding, foraging, and resting.
- Two provincially significant earth science ANSIs and one regionally significant life science ANSI have been identified and mapped by the province.
- A total of 59 **provincially significant species** (S1-S3) have been recorded in the McKenzie Creek subwatershed. Of these, 22 species have been assessed as threatened and endangered provincially, and 19 species have been assessed as threatened or endangered federally.

**Aquatic Natural Heritage**
- Fifty-six **fish species** have been recorded within McKenzie Creek subwatershed and adjacent sections of the Grand River. A majority (61%) of the species prefer cool or cold water habitat. **Salmonids** (Brook Trout) are only found in the headwaters of McKenzie Creek.
- **Cold and coolwater reaches** receive groundwater discharge from the Norfolk sand plain region and are located within and downstream of the sand plain. Lower reaches of McKenzie and Boston creeks, located on the clay plain, are classified as **warm water**. Several online ponds or reservoirs are found along McKenzie Creek and the main tributaries of Boston Creek, and may be contributing to thermal warming in some reaches.
- Two **provincially rare fish species** have historically been found in these waters, Silver Shiner and Greater Redhorse. Silver Shiner is considered to be threatened in Ontario. The species and its habitat are protected under the Federal Endangered Species Act. Greater Redhorse has no official Federal status.
- Seven **mussel species** recorded within the McKenzie Creek system and/or the nearby sections of the Grand River are considered to be at risk at the provincial and/or federal level.