Beckett's Creek

Subwatershed Study

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Cover photo: Beckett’s Creek, upstream of Old Montréal Road (Amy MacPherson)

Preface

The City of Ottawa completed this Subwatershed Study in cooperation with the Rideau Valley Conservation Authority. The project was led by staff from the City's Natural Systems and Rural Affairs unit, in the Planning, Real Estate and Economic Development Department, with the support of staff from many other units and departments.

Several outside agencies provided information, advice and comments on the study. City staff gratefully acknowledge the contributions of the Rideau Valley Conservation Authority, South Nation Conservation, City Stream Watch, the United Counties of Prescott-Russell, the City of Clarence-Rockland, the Ottawa-Carleton District School Board and the Ontario Ministry of the Environment, Conservation and Parks.

Staff would like to thank the residents of the study area for their participation in the various public consultations and the landowners who allowed members of the study team to access their properties. Staff would also like to thank the volunteers who contributed their time and effort to the City Stream Watch program.

Questions regarding the Subwatershed Study's contents or implementation should be directed to the Natural Systems and Rural Affairs unit at the City of Ottawa.

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Executive Summary

The City of Ottawa initiated the Beckett's Creek Subwatershed Study to examine the existing conditions of the area and to identify any needed actions to improve its environmental health and condition over the long term. City staff, government agencies and the development industry should use the resulting Subwatershed Plan to inform how future development proceeds within the study area.

Information was obtained from various reports and studies undertaken by the City and the Rideau Valley Conservation Authority (RVCA). The Beckett's Creek subwatershed drains to the Ottawa River east of the Village of Cumberland. The study area also includes four small unnamed catchments adjacent to the east and west of the Beckett's Creek system that drain directly to the Ottawa River. Crop farming is the predominant land use in the study area, followed by natural areas (woodlands, wetlands and valleylands). The Village of Cumberland, the Village of Sarsfield and the French Hill rural estates subdivision are settlements that are partially located within the study area.

Issues and Opportunities

- Beckett's Creek is primarily a cool-warmwater system with many species of fish, but water quality is being impacted from adjacent land uses. The implementation of best management practices, such as vegetated buffers, tile drain control structures and appropriate manure storage, would help to reduce these impacts to the creek and its tributaries.
- The Vars-Winchester Esker is a valuable source of groundwater, and it is recognized in the Mississippi-Rideau Source Protection Plan as a Highly Vulnerable Aquifer. It is also a valuable source of mineral aggregates such as sand and gravel. The extraction of aggregate resources should be balanced with protection for the hydrologic function of the esker through studies and policy development.
- The City's Natural Heritage System identifies several woodlands and valleylands as significant features. There are also many unevaluated wetlands throughout the study area. Stewardship efforts by private landowners can play an important role in the restoration and enhancement of these natural habitat areas and wildlife corridors.
- Natural hazards, including flood plains, unstable slopes, unstable soils (e.g., sensitive marine clays) and karst geology present risks that should be addressed by site-specific studies and appropriate setbacks (where applicable) prior to any future development.
- Private servicing within the study area may be constrained by thin soils, karst geology and/or variable groundwater quantity and quality and should be evaluated at the site-specific level prior to development.
- Climate change is expected to impact subwatershed health as temperatures rise and precipitation becomes more variable with increased intensity of rainfall as well as risks of drought. Development should consider future climate conditions to protect natural heritage features and reduce risks to property owners within the subwatershed.

Recommendations

The Subwatershed Plan contains numerous recommendations to be implemented by the City of Ottawa, the RVCA, the development industry and/or private landowners. Taken together, the recommendations aim to protect and enhance the overall environmental health and ecological integrity of the study area including its aquatic and terrestrial features. The Subwatershed Plan categorizes the recommendations into these key themes:

- Identification of the Natural Heritage System
- Management of Natural Hazards
- Protection of Groundwater Features
- Restoration of Natural Habitat
- Protection of Surface Water Quality
- Stormwater Management
- Monitoring

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1 Introduction and Background

1.1 Study Purpose

The Beckett's Creek Subwatershed Study (the Study) set out to identify key natural features and apply current policies and legislation in order to guide and support future development and stewardship activities within the study area.

This report is organized as follows:

- Section 1 – Provides a description of the study area and an overview of the study's history, along with a summary of some other key studies undertaken in this area.
- Section 2 – Highlights the policies of the City of Ottawa's Official Plan and the Provincial Policy Statement, which form the basis for the study.
- Section 3 – Provides a summary of the existing environmental conditions in the study area, based on background information and field studies.
- Section 4 – Identifies environmental constraints and opportunities for improvement within the study area.
- Section 5 – Presents the Subwatershed Plan, with recommendations for preserving and enhancing natural features within the study area.

1.2 Study Area

The study area, located in the easternmost part of the City of Ottawa, is shown on Figure 1. It is comprised primarily of the Beckett's Creek subwatershed, which drains into the Ottawa River east of the Village of Cumberland. The study area also includes four adjacent unnamed creek catchments that drain directly into the Ottawa River. To enable these four catchments to be clearly identified throughout this report, they have been labeled as A, B, C or D on Figure 1. The boundaries of all catchment areas have been reviewed as part of this study using recent (2017) aerial photography and LiDAR data along with field observations.

The total subwatershed study area is approximately 6,453 hectares in size. It includes the eastern part of the Village of Cumberland and extends southwards to Colonial Road in the Village of Sarsfield, west to the O'Toole Road/Regimbald Road intersection and east to Joanisse Road (which lies outside the City's boundary in the adjacent municipality of Clarence-Rockland). The Study focuses primarily on lands that lie within the City of Ottawa boundary; however, information from the City of Clarence-Rockland has been included where available.

1.3 Study History

The City of Ottawa (City) initiated background research for the Beckett's Creek Subwatershed Study in 2014 with support from the Rideau Valley Conservation Authority (RVCA) and other regulatory agencies.

Based on background research, field investigations and consultation with relevant agencies, a draft existing conditions report was prepared in late 2018. Updates to the existing conditions report, along with draft preliminary recommendations, were prepared in early 2020. Technical working group meetings were held on November 6, 2018 and January 29, 2020, with representatives from various City departments, as well as the RVCA, South Nation

Conservation and neighbouring municipalities. The draft subwatershed study report was circulated to the working group for review in late 2021.

Several events, including flooding of the Ottawa River in spring 2019, the COVID-19 pandemic and a by-election in Cumberland ward in fall 2020, resulted in delays to the Study's progress. The release of the City's new Official Plan in 2021, and its subsequent approval (with modifications) by the Ministry of Municipal Affairs and Housing (MMAH) in late 2022, also prompted further review and alignment of all policy references within the Study.

1.3.1 Public Consultation Overview

Approximately 45 participants attended a joint Public Open House on the subwatershed study area and the RVCA's flood plain mapping project on December 4, 2018 at the R.J. Kennedy Arena and Community Hall in Cumberland. City and RVCA staff were on hand to explain the display boards for both studies, answer questions and solicit feedback. Copies of the displays and a summary of feedback received are presented in Appendix A. Following the open house, these materials were also made available on the project webpage for residents to review and provide comments.

A second public Open House was initially scheduled for March 31, 2020 to present the Study's draft preliminary recommendations, answer questions and solicit feedback. Due to risks associated with the COVID-19 pandemic, the in-person Public Open House was cancelled, and an online public consultation was subsequently held from January 25 to March 15, 2021. The online public consultation materials consisted of display boards and a survey to gather feedback on the draft recommendations (see Appendix A). Residents without access to the online materials were invited to contact the project lead by phone to receive hardcopies by mail.

Thirty-seven residents completed the online survey, and an additional nine individuals submitted comments by phone or by email. The survey results and comments were summarized in an As We Heard It report on the project webpage and are presented in Appendix A.

1.4 Village of Cumberland Water and Wastewater Servicing Study

The City of Ottawa completed a Phase 1 and Phase 2 Class Environmental Assessment (EA) for water and wastewater alternative servicing solutions for the Village of Cumberland in 2003 (Golder, 2003).

A groundwater and surface water assessment program carried out in 2001 (in preparation for the Class EA process) revealed that certain areas of the Village of Cumberland are susceptible to health-related issues in private water wells. Some issues are partially due to the natural geological setting of the area, while other issues are specific to individual water wells and are more likely related to well construction and/or water system maintenance. It was noted that poorly functioning and failing private sewage disposal systems are impacting the surface water quality in the core area of the Village and are also having a measurable effect on the bedrock groundwater which supplies some wells.

Unfortunately, the most effective long-term solutions for the above-noted issues carry a high financial cost. The EA study identified and evaluated alternative servicing solutions for the Village of Cumberland to address the long-term reliability and health-related concerns for water

quality and wastewater treatment and disposal for existing and future users. The recommendations that scored the highest, using a weighted performance review matrix, included the extension of the City's central drinking water system to the entire Village and the extension of the City's central wastewater system to the core area of the Village. Given the high capital costs associated with these solutions (in the absence of available government funding), most residents who participated in the public consultation considered the costs for central servicing to be unaffordable.

The EA study further recommended that proceeding with a community planning exercise and the next phase of the EA be put on hold until an adequate level of funding has been secured. In the meantime, the EA study recommended several interim measures for improving the water supply and surface water quality in the Village. Some measures can be implemented by Village residents (e.g., improvements to private wells and septic systems, periodic drinking water quality testing through Ottawa Public Health and/or a private laboratory), while other measures are reflected in existing City programs and practices (e.g., East Ottawa Groundwater Study, consideration of groundwater quality issues during the review of development proposals).

1.5 Regional Road 174 Widening Environmental Assessment

The City of Ottawa and the United Counties of Prescott and Russell conducted a Schedule C Municipal Class EA for improvements to Ottawa Regional Road 174 from Highway 417 extending east to the municipal boundary along with a portion of Prescott-Russell County Road 17 (AECOM, 2016). The purpose of this study was to develop a plan to address increased traffic volumes, congestion during peak periods and road safety concerns. The recommended plan includes widening the arterial road section of Regional Road 174/County Road 17 from Trim Road to Landry Road and adding service roads in Cumberland and Clarence-Rockland, along with 20 signalized intersections. These transportation projects are being carried out in response to existing issues that have been identified for many years along this corridor and to support planned growth in the eastern part of the City.

The recommended plan for widening the Regional Road 174 and other improvements bisects the northern part of the Beckett's Creek subwatershed and three of the small unnamed creek catchments (catchments A, C and D). Within this subwatershed study area, a new service road is proposed to connect East Shore Road and Morin Road to the intersection of Kinsella/Old Montréal West in the Village of Cumberland. This service road will connect about 40 properties with access to Regional Road 174 via a signalized intersection. A section of Old Montréal Road will require re-construction in the vicinity of Kinsella Drive to accommodate the widening of Regional Road 174 and the proposed eastbound right turn lane.

In the easternmost part of the subwatershed study area, McTeer Road is proposed to extend westerly to connect to the MacSkimming Outdoor Education Centre, providing school buses and other road users with a signalized intersection to access the Centre. Access to the highway on the west and east ends of McTeer Road will be closed to eliminate these uncontrolled intersections. Almost 20 properties will use the McTeer/Canaan Road intersection for access under this proposed plan.

The implementation of these transportation projects will depend on available funding and Council priorities. The City of Ottawa portion of the widening is not anticipated in the Ottawa Transportation Master Plan (2013) until after the current planning horizon of 2031.

2 Policy Framework

This Study has been developed in accordance with Provincial and City policies intended to promote sustainable land uses and activities that do not negatively impact the identified significant natural heritage features and functions of the subject area.

Several changes to planning documents and guidelines have taken place since the completion of the existing conditions report in January 2020. The Provincial Policy Statement was updated in May 2020. The City has created a new Official Plan, and series of schedules, that City Council approved on October 27, 2021. The MMAH approved the new Official Plan on November 4, 2022. The Official Plan now contains more comprehensive policies regarding urban boundary expansions, the Natural Heritage System, water resources, natural hazards, agriculture, aggregate resources, stormwater management, and climate change. In addition, City Council approved a new Climate Change Master Plan on January 29, 2020.

2.1 Provincial Policy Statement

The Provincial Policy Statement (PPS), which came into effect on May 1, 2020, is issued by the MMAH under the authority of Section 3 of the *Planning Act*, which requires that decisions affecting planning matters "shall be consistent with" policy statements issued under the Act. It establishes a framework for sustainable land use planning in the Province of Ontario (MMAH, 2020).

Section 2.1 of the PPS addresses the identification and protection of natural features and areas, and the maintenance of ecological functions and biodiversity of natural heritage systems, over the long term. The PPS does not permit development or site alteration within significant wetlands in this part of the province (Ecoregion 6E). Development and site alteration are also not permitted in fish habitat, or in habitat of endangered or threatened species, except in accordance with provincial and federal requirements. The PPS further states that development and site alteration shall not be permitted in the following, unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions:

- Significant woodlands;
- Significant valleylands;
- Significant wildlife habitat; and
- Significant areas of natural and scientific interest.

Finally, development and site alteration are not permitted to occur adjacent to any of the aforementioned natural features, unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions.

Section 2.2 of the PPS states that "*Planning authorities shall protect, improve or restore the quality and quantity of wate*r," in part by identifying water resource systems and maintaining linkages and related functions among water resource systems and natural heritage features and areas. The PPS further directs that development and site alteration shall be restricted in

or near sensitive surface and groundwater features, and that development shall generally be directed to areas outside of hazardous lands adjacent to rivers and streams (e.g., lands subject to flooding or erosion).

The PPS also addresses the need to protect agricultural lands, mineral aggregate resources, and cultural heritage landscapes and to prepare for the impacts of a changing climate.

2.2 City of Ottawa Official Plan

The City's New Official Plan contains many policies intended to ensure that land use planning and development occur in an environmentally sustainable manner consistent with the direction provided in the PPS. The Official Plan has recently undergone a comprehensive review and City Council adopted the new plan on October 27, 2021. The MMAH approved the City's Official Plan, with modifications, on November 4, 2022.

Section 4.8.1 of the Official Plan describes the City's Natural Heritage System (NHS), its Natural Heritage Features (NHFs) and how the City will protect this system. Section 4.9 has water resources policies related to the protection of surface water features, groundwater features and drinking water sources. Section 4.9.1 establishes the goals and requirements for subwatershed studies. Section 5.6.4 describes the City's two Natural Heritage Overlays, including the NHS Overlay and the NHFs Overlay (identified in Schedule C11 of the Official Plan), and provides policies for protection when development or site alteration is undertaken. Section 10.1 has natural hazard policies related to flooding, erosion, unstable soils and unstable bedrock.

Land use is one of the primary factors in determining the hydrologic response and overall health of a subwatershed. Sections 7 and 9 of the Official Plan have policies covering greenspace designations and rural designations. Schedule B9 of the Official Plan shows all designations in the rural transect, and Figure 2 of this report illustrates the designations that are present within the study area. Approximately half of the land within this study area is designated Agricultural Resource Area. Farming practices can affect the quantity and quality of water resources. Other designations in the study area include Rural Countryside, Village/ Village Core and Greenspace. Sub-designations for Greenspace including Conservation Areas (e.g., Beckett Creek Migratory Bird Sanctuary) and Significant Wetlands (e.g., Baie Lafontaine along the Ottawa River shoreline) are described in Section 7.3 and shown in Schedule C11.

The Village of Cumberland, with its associated rural estate subdivisions, is the largest settlement within the study area. Other settlement areas include the Village of Sarsfield and the French Hill rural estate subdivision. Settlement areas can have significant impacts on water quantity and quality as a result of development and associated changes in stormwater runoff. Designations within these villages are governed by the Consolidated Villages Secondary Plan, part of the City's overall Official Plan, which guides development based on each village's vision, goals and objectives.

2.2.1 Natural Heritage Features and System

The following Natural Heritage Features, as established in Section 4.8.1 of the Official Plan, have been identified within, or in proximity to, the study area and are addressed in this report:

- Significant wetlands (Baie Lafontaine along the Ottawa River shoreline);

- Habitat for endangered and threatened species [potential to be confirmed through an Environmental Impact Study (EIS)];
- Significant woodlands;
- Significant valleylands (Beckett's Creek and tributaries, Catchment A, Catchment C);
- Significant wildlife habitat (federally identified Beckett Creek Migratory Bird Sanctuary, migratory waterfowl staging areas, escarpments and other features with potential to be confirmed through an EIS);
- Areas of Natural and Scientific Interest (Vars-Winchester Esker and Baie Lafontaine Islands);
- Natural linkage features and corridors (primarily along the Beckett's Creek corridor);
- Groundwater features; and
- Surface water features, including unevaluated or non-significant wetlands and fish habitat.

The Natural Heritage Overlays (Schedule C11 of the Official Plan) identify several of these features to the extent possible using available information. Features not included on the schedule are still subject to the policies of the Official Plan. Schedule C11 further identifies which features are included within the City's Natural Heritage System of core natural areas and connecting linkages and are subject to more stringent protection during the planning process.

2.3 Climate Change Master Plan

The Climate Change Master Plan (CCMP) provides a framework for how Ottawa will mitigate and adapt to climate change over the next three decades and was approved by City Council on January 29, 2020. Over the short term, the CCMP establishes the guiding principles, goals, greenhouse gas emission reduction targets, and priority actions for 2020-2025. The Beckett's Creek Subwatershed Study supports two of the priority actions including:

- Undertake a climate vulnerability assessment and develop a *Climate Resiliency Strategy;* and
- Apply a climate lens to the new Official Plan and its supporting documents.

The recommendations of this study also contribute to climate change adaptation by protecting and enhancing the natural environment and encouraging agricultural best management practices. Natural Heritage Features help to build climate resiliency through flood protection, heat regulation, stormwater management, and increased biodiversity. Support for local agriculture is important to ensure food security and to help grow the local economy.

To fulfill one of the CCMP's priority actions, the City of Ottawa, in partnership with the National Capital Commission, has released detailed climate projections for the National Capital Region. These climate projections use climate science and modelling to predict future changes in temperature, precipitation, wind, and extreme weather events up to the year 2100. It is expected that the National Capital Region will become much warmer and wetter over the coming decades with a greater chance of extreme weather events.

By the 2030s, the City can expect to see the average temperature rise by 1.8°C, with 2.5 times more very hot days (above 30 °C) and 20% less very cold days (below -10°C). The amount of precipitation received during fall, winter and spring months is expected to increase by 5% by the 2030s, with intense precipitation also increasing by 5% and snowfall amounts decreasing

by 10%. This report also predicts that winters will be shorter by four weeks, and winter freeze-thaw cycles will increase by 15%, by the 2030s. The magnitude of these changes is expected to continue increasing towards the 2050s and 2080s. Across the coming decades, the City of Ottawa can expect to see increases in freezing rain and weather conditions that are more conducive to larger storms with increased potential for wildfires and drought. The rate and extent of climate change depends on future global greenhouse gas emissions, and the degree of uncertainty increases as the climate projections look further into the future.

3 Existing Conditions Summary

City and RVCA staff conducted field investigations for this study on various dates between spring 2014 and fall 2021. A selection of photographs taken during the fieldwork is included in Appendix B. RVCA staff also worked with community volunteers to assess the condition of Beckett's Creek through the City Stream Watch program in 2006, 2007, 2011 and most recently in the summer of 2017. Summary reports from the City Stream Watch program are available in Appendix C. The MacSkimming Outdoor Education Centre has also been the subject of numerous surveys, and the summarized results of many years of observations were shared with City staff for this study.

Relevant information from all these site visits, along with existing background information, has been included in the following sections.

3.1 Land Cover

Land cover mapping for 2011 from the City of Ottawa is shown in Figure 3. Land cover data is not available for the portion of the study area that lies with the City of Clarence-Rockland, and the analyses below are limited to the lands within the City of Ottawa boundary.

Agriculture is by far the largest land use in the subwatershed study area (55%). This category includes both cropland and pasture. Based on the City's field observations, most of the agricultural lands in the study area are cultivated. There are relatively few livestock farming operations apart from several horse farms, some cattle and a hog farm. Many of the crop fields have been improved with tile drainage. Grassy or otherwise vegetated buffers were present along the creeks and most of their tributaries in agricultural areas, but these tended to be extremely narrow particularly along the smaller tributaries and municipal drains (see photos in Appendix B).

The second largest land cover category is woodlands (22%) which are concentrated along the escarpments and in the eastern part of the study area. The largest woodlands are located in the Beckett's Creek subwatershed. Settlement areas (including parts of the villages of Cumberland and Sarsfield and rural estate subdivisions) represent the third largest land use (at over 8%).

Unevaluated wetlands cover just over 6% of the study area and are found mainly in the eastern half of the Beckett's Creek subwatershed and along the Ottawa River shoreline. As shown on Figure 3, many of these wetlands coincide with woodland areas, and the numbers presented here may underestimate the percentage of unevaluated wetlands to some degree. As well, the provincially significant Baie Lafontaine wetlands cover 325 hectares along the northern boundary of the study area by the Ottawa River.

3.2 Surface Water Features

As noted previously, the study area includes the Beckett's Creek subwatershed and four smaller unnamed creek catchments that are not connected to the main branch of Beckett's Creek, all of which drain directly to the Ottawa River (Figure 4). The hydrologic regime of a

creek influences all aspects of its subwatershed health, e.g., aquatic habitat, water quality and geomorphology. The regime is partially controlled by natural factors (e.g., climate, soils) and partially by man-made factors (e.g., village development, municipal drains and tile drainage).

The Beckett's Creek system features a combination of natural, meandering creeks and modified drainage channels. Beckett's Creek itself is mostly meandering, with well-defined valley slopes along the main channel downstream of Wilhaven Drive and also in its headwater regions. The valley slopes are known to be unstable and prone to erosion. Extensive portions of tributaries to Beckett's Creek, and part of the main channel, are legally defined as municipal drains under the *Drainage Act* (see Figure 4, and Section 3.2.3 below). Headwater drainage features (HDFs) in many parts of the subwatershed have been subjected to channel modifications, with dredging and straightening being the primary alterations (RVCA, 2017).

Certain regions of the study area are susceptible to flooding, in particular those adjacent to the Ottawa River. Residents in these areas experienced significant flooding events in 2017 and 2019. Flood plain mapping of the 1:100-year event was completed for the main branch of Beckett's Creek and its four major tributaries in October 2018 (RVCA, 2018). Engineered flood risk mapping is also available for the Ottawa River (RVCA, 2014). Flood plain mapping of the 1:350-year event has recently been prepared for Beckett's Creek and the Ottawa River and is available on the City's website. The 1:100 flood lines determine the regulation limits mapping (as per Ontario Regulation 174/06) and will be used to inform municipal land use planning and development approvals processes under the *Planning Act*. The 1:100 flood plain is illustrated in Figure 4 for information purposes. The 1:350 flood lines will be used to inform flood risk management under the climate change scenario.

The four smaller unnamed watercourses contained within the study area have not been studied as extensively as Beckett's Creek and its major tributaries. Catchment A flows through the Village of Cumberland and the Hillside Estates rural subdivision. Catchment B is located immediately east of the Village of Cumberland and drains a small area along Old Montréal Road and Regional Road 174. Catchment C also flows through an area of rural subdivisions. Catchment D is heavily channelized and drains an area that is primarily agricultural with a wooded area in the headwaters.

3.2.1 Surface Water Quality

Water quality sampling was conducted by City staff in preparation for this study at several locations along Beckett's Creek and its major tributaries, as well as on Catchment A and Catchment C. In total, 16 sites were sampled across the study area with most data points being collected in 2014 and 2016. Water quality data collected to inform the subwatershed study were influenced by both dry and wet weather events. Three sites on Beckett's Creek (located at Regional Road 174, Old Montréal Road and Birchgrove Road north of Etienne Road) were part of the City's Baseline Water Quality Monitoring program and have more extensive, long-term data sets ranging from 8 to 13 years. These baseline samples were collected monthly and are predominantly dry weather flow related. The locations of the sampling sites are presented on Figure 5.

Escherichia coli (*E. coli*) is a bacterium found in the digestive tracts of humans and other animals, and it is commonly used to indicate the presence of human sewage and/or animal manure in surface water features. *E. coli* was found throughout the subwatershed, although

the results were highly variable. Bacterial counts were typically 2 to 5 times higher during or immediately following wet weather events, although significantly higher counts of between 19,000 – 54,000 colony-forming units/100 mL were observed on Catchment A, Catchment C and one tributary on separate occasions. Possible sources of *E. coli* and other pathogenic bacteria in the study area include livestock and poorly maintained septic systems.

Nutrients, including phosphorus, stimulate plant growth but can also lead to excessive growth of aquatic plants and algae in local waterbodies. Phosphorus levels along the main stem of Beckett's Creek exceeded the Provincial Water Quality Objective (PWQO) for each sample that was collected, and the results were generally 2 to 7 times higher than the PWQO. The PWQO was exceeded less frequently in smaller tributaries, Catchment A and Catchment C, however the difference between dry and wet conditions was more pronounced. Likely sources of excess nutrients include fertilizers, animal waste and poorly maintained septic systems.

Several metals parameters were consistently higher than their respective PWQOs at most sites across the subwatershed. Aluminum and iron were present in significantly high concentrations, with the median values of aluminum being 5 to 25 times higher than the PWQO. While aluminum and iron do have human-derived sources, both these metals are highly abundant in the earth's crust and can also enter waterbodies through erosion and runoff. Other metals that were consistently high across all sites include cobalt, copper and vanadium. Copper can be found in agricultural runoff, pesticides and sewage. Vanadium is often associated with iron and high levels of suspended solids, so it may be attributed to background conditions.

Levels of total suspended solids (TSS) were generally low, although exceedances of the Canadian Water Quality Guideline (CWQG) were observed at each site. The CWQG for TSS stipulates an increase of no more than 25 mg/L above background levels, and the background level was assumed to be 5 mg/L for this study. Peak TSS concentrations tended to be associated with wet weather conditions.

Overall, the City's 2016 Surface Water Quality Report rated the water quality in Beckett's Creek as "marginal" using the Canadian Council of Ministers of the Environment Water Quality Index and results from baseline monitoring sites for 2012-2014. This rating indicates that water quality in the creek is frequently threatened or impaired, often departing from natural or desirable levels. Issues with nutrient loading, bacterial contamination and metals concentrations were noted. These results are consistent with the more extensive sampling carried out in 2014 and 2016. The water quality tends to be what is expected in a rural subwatershed with a large proportion of agriculture. On a more positive note, the 2016 Surface Water Quality Report highlighted decreasing trends for copper, iron and TSS for the baseline sites on Beckett's Creek.

3.2.2 Surface Water Quantity

The Water Survey of Canada maintains two hydrometric stations along Beckett's Creek, including one station downstream of Regional Road 174 and a second station upstream of Wilhaven Drive. Water level and flow data is available online from 2007 onwards, although data for the station near Wilhaven Drive only extends back to 2018. A majority of the flow volume and the highest peak flows occur during the springtime. Very low flows occur during

the summer with only occasional rises in flow in response to larger rainfall events. The flow rises gradually through the fall period but is also low during the winter. Reasons for this pattern include:

- Soils are primarily clays and silts which have low infiltration capacity resulting in a high proportion of runoff;
- A large portion of the area is cleared, and therefore, there is little water retention by vegetation particularly in the spring when soils are frozen and saturated;
- A significant part of the area is serviced by tile drains and municipal drains. These features promote more rapid removal of water to extend the growing season, but they also contribute to reduced water retention on fields during the summer months.

An intensive stream flow sampling program was carried out by City staff across a one-day period in both 2014 and 2016 to characterize summer low flow rates within Beckett's Creek, Catchment A and Catchment C. Stream discharge conditions were measured or observed at each stream-road crossing within the study area during the late summer following a period of 48 hours without rainfall. Flow was measured at 15 sites in total, and observations of stagnant or dry conditions were made at another 16 sites across the study area. Moderate to severe drought conditions were experienced across the Rideau Valley watershed (including Beckett's Creek) from June to December 2016, and these conditions are expected to have influenced the results obtained for 2016.

Overall, the low flow assessments demonstrated that the main stem of Beckett's Creek contains measurable flow during dry summer conditions at least up to the crossing at Birchgrove Road south of Etienne Road. However, many of the tributaries in the headwater portions of the subwatershed, particularly along Emmett Road, Sarsfield Road and Dunning Road, become stagnant or completely dry. Persistent late-summer flows were also observed within Catchment A and Catchment C following the 2016 drought conditions.

An assessment of flow within HDFs was carried out by the RVCA's City Stream Watch program in 2017. The assessment focused on 61 sites classified as zero, first or second order HDFs, and observations were made in spring and summer. Catchment C, located directly west of the main Beckett's Creek subwatershed, was also included. Over half of the headwater features displayed intermittent flow conditions where water typically flows for six months of the year. Perennial flow conditions, where water flows year-round, were also observed in many areas.

Hydraulic models are used to estimate the potential for flooding, prepare flood plain mapping, and to complete stormwater management studies and water budgets. Flood risk mapping prepared by the RVCA details the use of a single-event hydrological model to estimate flood flows at key locations along Beckett's Creek (RVCA, 2018). The model is based on floods generated by summer storms, as these are expected to be larger than spring freshet for relatively small catchments such as Beckett's Creek.

3.2.3 Stormwater Management

Stormwater management is required in developed areas to maintain and improve watershed hydrologic functions, reduce the risks of flooding, prevent erosion and improve water quality in relation to uncontrolled runoff. As the study area is primarily rural with relatively few settlement areas, excess runoff that does not infiltrate into the soil or get taken up by plants is diverted

towards watercourses mainly through a network of roadside ditches and culverts. Two very small portions of the study area, along Lookout Drive and Barnett Drive in the Village of Cumberland, are serviced by piped storm sewers that outlet to a tributary in Catchment A.

Within the study area, there are two constructed stormwater management facilities designed to attenuate and filter the stormwater runoff generated from rural estate subdivisions. Cambrian Heights Stormwater Facility is a wet pond located within Catchment A on Fieldown Street in the Village of Cumberland. The Cambrian Heights facility does not have the permanent pool that is typical of wet ponds, and pollutant removal from stormwater runoff is achieved by the roadside swales found upstream of the pond. Linkland-Wilhaven Stormwater Facility is a dry pond located within Catchment C between Linkland Court and Dagg Court in the Cumberland Estates rural subdivision. The Linkland-Wilhaven facility includes design features that allow pollutants to settle out and improve water quality. Future development within the villages and surrounding subdivisions will be subject to City policies regarding stormwater management.

3.2.4 Municipal Drains

Municipal drains are watercourses that have been redesigned and engineered to remove water from fields and extend the growing season. Municipal drains are created under the authority of the Ontario *Drainage Act, 1990*, which municipalities in Ontario are required to administer on behalf of the Province. The City is responsible for maintaining municipal drains on behalf of the property owners. Each benefitting property owner pays a share of the costs to construct and maintain a municipal drain.

As shown on Figure 4, many of the watercourses within the study area, including segments of Beckett's Creek itself, are municipal drains. The study area has approximately 162 km of watercourses, including streams, municipal drains and swales, of which about 31 km (19%) are municipal drains. Municipal drains and tile drainage assist with the removal of excess water from fields in spring, permitting earlier planting. Without this, many fields would be unproductive due to waterlogging and, consequently, a reduced growing season. In some cases, as for Beckett's Creek, natural watercourses have been converted into municipal drains to allow municipalities to enter private property and maintain the watercourse. In other cases, a drain may be constructed specifically to facilitate the conveyance of water out of an area.

Becquith Creek Municipal Drain (also referred to as Beckett Creek Municipal Drain) was originally constructed in 1901 with maintenance or improvements in the years 1922 and 1955. The process for establishing a municipal drain begins with property owners submitting a petition under the *Drainage Act* to the City. If certain criteria are met, the City appoints an engineer who prepares the report, identifying the proposed solution to the problem(s) and how the costs will be shared. The engineer's report provides advice on the maintenance required, for example, removing beaver dams and for municipal drain clean-out and repair. The City then enacts a by-law to formally establish the municipal drain on the basis of the engineer's report.

The existing conditions of municipal drains must reflect the design grade and profile specified in the by-law and engineer's reports prepared for each. Municipal drains cannot legally be altered without a report being prepared by an engineer appointed by City Council. They may, however, be officially abandoned at the written request of 75% of the landowners owning 75% of the land assessed for benefit in the watershed. Within the Beckett's Creek subwatershed, there are approximately 15 other municipal drains providing outlet for tile drainage, road

ditches, farmland and to help prevent flooding to all affected property owners within the subwatershed.

Figure 4 reflects the most up-to-date information available at the time this study was prepared. Local residents have noted that current mapping may contain minor inconsistencies in the vicinity of the Guy Talbot Municipal Drain and the Leo Guilbord Municipal Drain. It is advisable that any future drainage works planned for this area confirm the extent of the stream segments and municipal drains. The City's Drainage unit maintains this information and should be consulted prior to undertaking any works involving municipal drains.

As described above, many landowners have installed tile drainage across their fields within the study area. The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) requires licensed agricultural tile drain contractors to report on the locations that have been tile drained each year. OMAFRA is compiling a detailed geo-spatial database that can be used to access information on the locations of tile drains. Accurate mapping is important from a subwatershed perspective, as it enables a more thorough understanding of how water moves across the landscape, particularly in headwater areas.

3.2.5 Geomorphology

No geomorphological studies have been conducted on Beckett's Creek or the adjacent unnamed catchments, except in the vicinity of Regional Road 174 as part of the environmental assessment for the proposed widening of the transportation corridor. That work was not completed in detail but indicated that several of the creeks are unstable. The RVCA reviewed the topographic mapping for Beckett's Creek at five-year intervals while updating the regulatory limits and noted that it showed considerable changes over time. This indicates that Beckett's Creek is a dynamic system, although more detailed studies would be needed to assess the inherent stability or instability of the system.

3.3 Fish and Aquatic Habitat Assessment

3.3.1 Beckett's Creek

Beckett's Creek is considered a primarily cool-warmwater system, based on temperature monitoring carried out by the City of Ottawa in 2014 and 2016, and the City Stream Watch program in 2017. The main stem of the creek between French Hill Road and Birchgrove Road varies between cool-warmwater and warmwater. Maximum summer temperatures at most stations were approximately 24°C in 2014 and 2017, with a few stations reaching 26°C in 2016 (during a notably hot, dry summer). One major tributary in the southern part of the study area is warmwater, with maximum temperatures approaching 30°C in 2016.

The moderate temperatures observed in Beckett's Creek and many of its tributaries may be attributable to influxes of cool groundwater into the creek. Indicators of groundwater discharge were noted by the City Stream Watch team in the main stem of the creek near Wilhaven Drive and in several areas of the major tributaries upstream of Birchgrove Road, with the notable exception of the southern warmwater tributary. City staff also observed indicators of groundwater discharge in the headwaters of Catchment C during field work in 2018.

Surveys by various study teams over the years have shown that Beckett's Creek supports a wide variety of fish (see Table 3-1, below) as well as other aquatic organisms including frogs

and turtles (observed in several locations during the City Stream Watch field work). A total of 29 species of fish have been reported from Beckett's Creek and its tributaries, including game species such as largemouth bass, northern pike and walleye in the lower reaches of the creek. See Figure 5 for the locations of the fish sampling stations included in Table 3-1.

The habitat characterization work done by the City Stream Watch program (RVCA 2011, RVCA 2017) shows that in-stream habitat along the main channel and major tributaries of Beckett's Creek is predominantly characterized by shallow runs (rather than pools or riffles) over clay and silt substrate. Some areas of bedrock occur in the vicinity of the escarpment upstream of Old Montréal Road, including a series of waterfalls. Cobble, boulders and sand are present in other parts of the creek but do not dominate the substrate. The largely consolidated clay substrate limits the amount of instream vegetation. Shade from grasses and overhanging trees is generally low to moderate for most of the creek's length, despite the generally good amount of vegetated buffer adjacent to the creek. The RVCA has identified several opportunities for riparian plantings and erosion control and one potential fish habitat enhancement area along Beckett's Creek.

Table 3-1: Fish Species Reported from Beckett's Creek

Species	Creek mouth	Old Montréal Rd	Wilhaven Drive	French Hill Rd	Birchgrove Rd	Sarsfield Rd (north tributary)	Sarsfield / Regimbald Rd	Sarsfield Rd (south tributary)	MacSkimming tributary
Black crappie	1, 2								
Blacknose dace				3				3	
Bluegill	1, 2								
Bluntnose minnow		2	1, 2	2, 3	1, 2			1, 2, 3	
Brook stickleback		2	1, 2, 3	1, 2, 3	1, 2	1	1	1, 2, 3	4
Brown bullhead	1, 2	2, 3							
Central mudminnow				3	1, 2	1	1	1, 2, 3	4
Common carp	2								
Common shiner		2	1, 2, 3	1, 2, 3	1, 2		1	1, 2, 3	4
Creek chub		2	1, 2, 3	2, 3	1, 2	1	1	1, 2, 3	
Cyprinidae (minnows)		2, 3	2, 3	1, 2	2		1	1, 2	
Etheostoma sp. (darters)		2	1, 2, 3	2, 3	1, 2			1, 2, 3	
Fathead minnow			1	2, 3	1, 2		1	1, 2, 3	
Golden shiner	1, 2								
Largemouth bass		3							
Logperch		2, 3							
Longnose dace			2	3					
Northern pearl dace					2	1	1	2	
Northern pike	1, 2								
Northern redbelly dace				3				3	4
Pumpkinseed	1, 2	2, 3							
Rhinichthys sp. (dace)		2							
Rock bass	2	2, 3							
Shorthead redhorse		2							
Silver redhorse	1, 2								
Spottail shiner								1	
Tadpole madtom	2								
Walleye	1, 2	2							
White sucker		2	1, 2	2, 3	1, 2		1	1, 2, 3	
Yellow bullhead	2								
Yellow perch	2	2, 3							
Unknown		3						3	
Total Species:	**13**	**15**	**8**	**11**	**9**	**4**	**7**	**12**	**4**

Note: Station locations approximated to nearest road/bridge crossing for the stream reach (see Figure 5). For precise locations, refer to source documents.
1 – City Stream Watch (CSW, 2017).
2 – City Stream Watch (CSW, 2011).
3 – City Stream Watch (CSW, 2007).
4 – MacSkimming Outdoor Education Centre (2018).

3.3.2 Unnamed Catchments

Temperature monitoring was carried out during 2014 and 2016 on Catchment A and Catchment C at the crossings with Old Montréal Road. Catchment A, which flows through the Village of Cumberland, is classified as a cool-warmwater creek with maximum summer temperatures ranging from 20°C to 24°C in 2014 and just over 26°C in 2016. Catchment C, which flows through the rural estate subdivisions east of Cumberland, is classified as a cool to cool-warmwater creek with maximum summer temperatures ranging from 19°C to 21°C in 2014 and reaching 24°C in 2016.

Surveys of fish communities were not conducted in any of the four unnamed catchments, and no records of field surveys were identified as part of environmental assessment reports or environmental impact statements for projects taking place in these catchments.

3.3.3 Headwater Drainage Features

Headwater drainage features (HDFs) are small, temporary streams and swales and include headwater wetlands connected through surface flow. Their small size and the fact that they do not necessarily flow year-round, makes headwater streams and swales particularly vulnerable to impacts such as piping, channelization, flow diversion, grade lowering and realignment. HDFs are important sources of food, sediment, nutrients and flow to downstream aquatic systems, and they also provide water quality, storage and attenuation functions. These features may provide direct fish habitat, both permanent and seasonal, by the presence of refuge pools, seasonal flow or groundwater discharge (RVCA, 2017).

Headwater forests and wetlands are also essential for the maintenance of biodiversity since they provide specialized habitats for aquatic invertebrates and fish in headwater streams and contribute nutrients and energy for other aquatic invertebrates and fish downstream. They also influence the quantity and quality of surface and groundwater supplies by contributing to the base flow of streams, by providing groundwater recharge and by moderating peak flows during spring run-off and wet weather events.

As part of the RVCA's Watershed Monitoring and Reporting Framework, the City Stream Watch program added HDF assessments (part of the Ontario Stream Assessment Protocol) to the program in 2013. This protocol is a rapid assessment method that characterizes the amount of water, sediment transport and storage capacity within zero, first and second order HDFs. Indicators to evaluate the features include flow type, channel modifications, riparian vegetation, sediment deposition and channel roughness. Vegetation within the channel influences the aquatic and terrestrial ecosystem values provided by the HDF.

The Beckett's Creek headwaters were sampled in 2017 by the RVCA. The subwatershed's headwaters consist mainly of channelized features (some of which are municipal drains) and roadside ditches. Only slightly more than 25% of the features were characterized as natural channels or unevaluated wetlands. Nearly half of the HDFs did not have any vegetation, and the remaining sites contained either meadow or wetland vegetation types. Large amounts of rough materials contributing to aquatic habitat and food sources, such as vegetation, woody debris, boulders and cobble, were found at only 25% of the sites. Further information on this sampling program can be found in the Becketts Creek 2017 Catchment Report in Appendix C. Detailed information on the headwaters sampling may be obtained from the RVCA upon request.

3.4 Geological Setting

3.4.1 Physiography and Topography

The study area is situated within the St. Lawrence Lowlands, a relatively flat-lying part of Ontario. In broad physiographic terms, the majority of the Beckett's Creek subwatershed and smaller catchments lie within the Ottawa Valley Clay Plains (Chapman and Putnam, 1984). Following the last glacial period approximately 14,000 years ago, the Ottawa area was flooded by the Champlain Sea which deposited fine-textured marine clays and silts. Bedrock outcrops, deltaic, colluvial (i.e. material deposited at the base of hillslopes) and organic deposits are also found in this region.

The Prescott and Russell Sand Plains are found towards the northern and eastern sections of the study area beginning along Kinsella Drive and extending east towards the City of Clarence-Rockland (Chapman and Putnam, 1984). The sand plain forms a distinct plateau that is generally forested, with an elevation 30 to 40 m higher than the surrounding clay plain.

The topography within the study area ranges from 41 to 117 meters above sea level. The topography is generally flat, and gradually slopes towards the Ottawa River in the north, with incised channels up to 20 m along the creek and tributaries. Areas with the highest elevations are found south of the Village of Cumberland in the vicinity of Wilhaven Drive and north of Beaton Road along the divide between Catchment C and the Beckett's Creek subwatershed.

3.4.2 Bedrock Geology

The region of the St. Lawrence Lowlands is underlain by relatively flat-lying sedimentary rocks of Paleozoic age overlying the Precambrian igneous and metamorphic basement rocks.

The Ontario Geological Survey (OGS) regularly publishes maps, reports and digital data on Ontario's geology. The OGS Paleozoic Bedrock Geology mapping layer (Armstrong and Dodge, 2007) is based on 1:50 000 scale maps produced since 1974. Figure 6 illustrates the bedrock geology in the study area, as provided by the OGS.

The Paleozoic bedrock within the study area includes sandstones, limestones, dolostones and shales deposited in a marine environment. The Oxford formation subcrops (is near the surface but remains buried) along the shoreline of the Ottawa River and is comprised of sandstones and dolostones. Younger Ottawa-Group Formation limestones and shales comprise the Bobcaygeon and Gull River Formations (to the north) and the Lindsay Formation (to the south). Outcrops of the Bobcaygeon and Lindsay Formations can be found in upland areas, and the Gull River Formation commonly outcrops in lowland areas.

The Paleozoic bedrock geology in the Ottawa area is characterized by a series of faults that stretch from west to east and northwest to southeast and form part of the extensive Ottawa-Bonnechere Graben. A graben is a type of geological feature that formed when the earth's crust was stretched and pulled apart, creating a long valley such as the Ottawa Valley. Within the study area, two fault lines have been mapped, extending in an east-west direction.

The eastern portion of the Village of Cumberland and several pockets within the central and southern portions of the study area have been identified as having soils with the maximum seismic class (Hunter et al., 2010). This seismic classification relates to the amount of shaking

that may be experienced during an earthquake event and is to be accounted for in the design in order to meet the requirements of the Ontario Building Code. Areas of soft soils will experience greater shaking than areas with stiffer soils or bedrock, and soft soils are present over significant parts of the subwatershed (Hunter et al., 2010).

Given the presence of limestone bedrock within the study area, the potential for karstic hazards has also been identified, particularly within the Bobcaygeon formation. Areas with karst topography form from the dissolution of soluble rocks, including limestone, and are characterized by enhanced underground drainage systems. These areas can be characterized by both micro or macro karst features ranging from well-developed secondary porosity (where fractures are larger due to dissolution) to sinkholes, caves and sinking streams (although these larger features have not been found within the study area). Karstic features can serve as a direct conduit between surface water and groundwater resources, and karstic terrain can, depending on a number of factors, be considered hydrogeologically sensitive and vulnerable to contamination.

Areas where karst topography is present will require additional hydrogeologic investigation to determine the vulnerability of the drinking water supply prior to approvals involving or near private servicing (i.e., private drinking water wells and/or private septic systems, neither of which are maintained by the municipality). These areas may also require geotechnical investigation prior to development. Areas where the presence of karst topography has been inferred, or has the potential to occur, based on data provided by the OGS (Brunton and Dodge, 2008) is shown in Figure 7. Note that the OGS is currently updating their mapping for Eastern Ontario, including the karst map; the most up to date information will be used for planning purposes.

3.4.3 Surficial Geology

Surficial geology includes the unconsolidated sedimentary deposits that lie above bedrock. The OGS's mapping layer of the Surficial Geology of Southern Ontario was used to illustrate the surficial geology of the study area, as shown in Figure 8.

Within the study area, offshore marine deposits of clay and silt from the Champlain Sea comprise most of the surficial materials. Much of this clay has a high salt content, as it was deposited in a marine environment, and it is well known to be susceptible to retrogressive landslides and slope failures. This sensitive marine clay, formerly called Leda clay, is characterized as an unstable soil type that tends to change from a somewhat firm, stiff condition to flowing mud when it is disturbed. Although there is the potential for landslide hazards within the study area, the zones that are most susceptible have not yet been formally mapped.

Significant surficial materials related to the deposition of sand, silt and gravel by rivers (alluvial deposits) and in a nearshore marine environment (deltaic and estuarine) are also present within the study area. Other surficial materials include glacial till, composed of carbonate-derived silt and sand, and organic deposits, such as peat and marl. An area of colluvial deposits containing reworked marine sediments that accumulated at the base of a hillslope is present along the eastern boundary of the Village of Cumberland. These colluvial deposits are the result of a historical landslide that occurred at this location. A narrow band of glaciofluvial deposits, known as the Vars-Winchester esker, is present towards the southern extent of the study area and runs through the Village of Sarsfield. The esker feature is discussed in more

detail in Section 3.4.4 below.

Paleozoic bedrock outcrops are found where overburden is absent, and cover about 10 percent of the study area. There are several areas within the study area where the soils overlying the bedrock are considered thin and potentially hydrogeologically sensitive. A City-wide map was generated to identify areas where soils are expected to be less than 2 m in thickness; the map was developed by combining existing map layers of overburden thickness and bedrock topography available from OGS, the Geological Survey of Canada and the City's LiDAR data. Areas with a soil thickness of less than 2 m ('thin soils'), are shown in Figure 9. These areas may be more susceptible to contamination since there are less protective overburden layers above the bedrock aquifer.

3.4.4 Unstable Slopes

In simple terms, natural slopes (i.e., those not constructed by people through excavation or filling) are generally formed by the erosive action of flowing water, such as rivers, streams and creeks. Erosion and the formation of slopes is a natural part of the evolution of the topography. Within the study area, unstable soils related to sensitive marine clays extend across a wide swath of the region. There is an increased risk of landslide hazards in areas where sensitive marine clays are present, particularly in areas with deep valleys or embankments.

Large portions of the Beckett's Creek system are considered to have unstable slopes, also referred to as erosion hazards, as shown on Schedule C15 – Environmental Constraints of the City's Official Plan. This includes the entire main stem of Beckett's Creek itself and its major tributaries upstream of Birchgrove Road. Hazard mapping carried out by the RVCA in 2018 re-evaluated the extent of the unstable slopes along the main stem of Beckett's Creek, three major tributaries and various minor tributaries. Unstable slopes have also been identified along the smaller creeks near the steep escarpments above Old Montréal Road.

Schedule C15 and the RVCA's hazard mapping support early identification of slopes that can be assumed to require investigation but do not provide enough detail to assess site-specific constraints. Under the policies of the Official Plan, site-specific slope stability assessments will be required to support development applications on properties whether or not they are identified as being affected by unstable slopes on Schedule C15 and/or other plans. A minimum setback from the stable top of slope is also required, as detailed in Section 4.2.1.

Recurring erosion issues have been identified in association with the crossing structure at Old Montréal Road that may be related to the slope of the embankment (see photos in Appendix B). This structure was replaced in 2012 and is visually inspected at two-year intervals with localized erosion being addressed as needed. The crossing structures at Wilhaven Drive and Etienne Road are nearing the end of their life cycles and are scheduled for renewal within the next five years. In addition, many other culverts on smaller tributaries are scheduled for replacement within the next five years.

3.4.5 Vars-Winchester Esker

Eskers in the Champlain Sea basin were formed as subglacial meltwater streams deposited large amounts of sand and gravel during the last period of glacial retreat. The Vars-Winchester Esker (also referred to as the Sarsfield-Bearbrook Esker) extends from north to south along much of the eastern edge of the City of Ottawa. Most of the Vars-Winchester esker is buried, but the limits of the esker have recently been estimated through drilling and seismic studies. The feature's northern extent lies near the southern end of Beckett's Creek Road and continues through the Village of Sarsfield as shown in Figure 8. The esker extends south, beyond the Beckett's Creek subwatershed, through Vars and stretching to Winchester over a distance of approximately 50 km. The most recent study to delineate and characterize the esker began in 2007 through a collaborative partnership between South Nation Conservation, the Geological Survey of Canada, the Ontario Geological Survey and the University of Ottawa. Further details on this study are available through Open File 5624 from the Geological Survey of Canada (Cummings and Russell, 2007).

The Vars-Winchester Esker is a continuous, elongate ridge of sand and gravel that is partially buried under fine, low-permeability marine clay deposits. At its core is a highly permeable gravel ridge ranging from 2 to 20 m high and 100 to 200 m wide. Sandy fan deposits of moderate permeability flank the gravel ridge forming a gently sloping carapace that extends for 0.4 to 2 km (Cummings and Russell, 2007). Thick layers of sand (1 to 2 m) are also present near the Regimbald Road Pit located east of Regimbald Road. Although this geological feature appears as a relatively narrow band across the study area, it plays an important role in supporting the local groundwater supply and maintaining summer baseflow and water temperatures in watercourses that intersect the feature. The Vars-Winchester Esker is considered to be a prolific aquifer and is favorably shaped with a high-yielding gravel core and covered along most of its length by a thick layer of protective clay. The esker system supplies drinking water to several municipal wells along its length, including the villages of Vars, Limoges, Chesterville and Winchester.

Water is believed to enter the esker through several mechanisms. Precipitation that falls on areas where the esker is exposed (rather than buried under marine clay) most likely percolates downward into the aquifer. Streams that cross the esker may also contribute to the recharge of the aquifer. For example, a tributary of Beckett's Creek can be observed to incise through the marine clay and into the buried esker immediately north of the Regimbald Road Pit (Cummings and Russell, 2007). Groundwater flows through the esker aquifer along the highly permeable central gravel ridge and is discharged where it intersects with streams (contributing to baseflow) and into fracture-bedrock aquifers and/or subtill sediments (Cummings and Russell, 2007).

The Vars-Winchester Esker is identified by the MECP as a provincially significant Earth Science Area of Natural and Scientific Interest (ANSI). The esker has also been identified as a Significant Groundwater Recharge Area (SGRA) in the various Mississippi-Rideau Source Protection Region documents, as discussed in Section 3.5.4 below. Increased protection is required in esker areas.

3.4.6 Mineral Aggregate Resource Areas

Lands designated for mineral aggregate extraction are identified through two overlays on Schedule B9 – Rural Transect of the Official Plan: Sand and Gravel Resource Area and

Bedrock Resource Area. The function of these overlays is to "protect important mineral aggregate resources, of good quantity and quality and close to market, from incompatible development. The overlays also serve to protect existing licensed mineral aggregate operations from incompatible development and minimize negative effects on neighbourhoods. From time to time, the municipality has studied the local geological resources to ensure that the Official Plan overlays reflect the current knowledge of the landscape and land uses in the rural area. The preparation of the mapping for the Official Plan in 2013 closely followed the process and method that was completed in the 1995 Ottawa-Carleton Mineral Aggregate Resource Study.

As shown on Figure 2, two Sand and Gravel Resource Areas are part of the overlay within and adjacent to the Beckett's Creek subwatershed. The City permits pits as the primary land use within the Sand and Gravel Resource Area Overlay, subject to the provisions of the *Aggregate Resources Act* (as detailed in Section 5.6.3 of the Official Plan). Pits must be licensed by the Province under the *Aggregate Resources Act* and must be operated according to the terms and conditions of the license. All existing pit licenses require development setbacks and buffers for aggregate operations.

The Regimbald Road Pit is designated as a primary Sand and Gravel Resource and is located east of Regimbald Road in an area where the Vars-Winchester esker outcrops as a gravel ridge. Most of the gravel materials in the pit range from the size of pebbles to cobbles and are composed of carbonate mudstone. Smaller amounts of granite, sandstone and shale can also be found (Cummings and Russell, 2007). A second pit of tertiary significance is located in the westernmost extent of the study area near O'Toole Road and Regimbald Road. A Bedrock Resource Area is located near the southwest corner of the study area, although none of the lands within this overlay fall directly within the study area (Figure 2).

The OGS's Aggregate Resources Inventory of the City of Ottawa, Southern Ontario highlights areas where major aggregate resources are known to exist, and which may be desirable to set aside for resource extraction or protection purposes. The OGS inventory identifies segments of the Vars-Winchester Esker as a Selected Sand and Gravel Resource Area of primary significance (Lee, 2013). This deposit forms a central ridge of sand, gravel, cobbles and boulders, and there are five distinct ice-contact-esker segments. The OGS inventory estimates that this selected resource area covers 130.5 hectares and contains 16.2 million tonnes of aggregate materials (Lee, 2013). The inventory also identifies Selected Bedrock Resource Areas in the Beckett's Creek subwatershed that coincide with areas where bedrock is closer to the surface and thus more easily accessible for potential extraction.

Sand and gravel deposits may play an important role in maintaining quantity and temperature of water in the streams. Once sand and gravel are removed, this function is lost, and streams may become warmer with less baseflow. The result is a less healthy aquatic system, which is less resistant to impacts and less able to support fish and other wildlife. Aside from the locations identified in Figure 2, the City has not designated any other segments of the Vars-Winchester Esker, nor any other Resource Areas identified in the OGS inventory, for mineral aggregate extraction in Schedule B-9 of the Official Plan.

3.5 Hydrogeology

3.5.1 Groundwater Flow

Within the Ottawa region, shallow groundwater flow systems generally follow the same pattern as surface topography while the deeper groundwater flow systems are influenced by regional gradients. Local topography has a strong influence on shallow groundwater flow, and it generally flows from higher elevations to lower lying surface water bodies. Within the study area, shallow groundwater flows towards the creek and in a northernly direction from the higher elevations in the south towards the Ottawa River. The connectivity of aquifer materials, such as fractured bedrock, sand or gravel, has a stronger influence on deep groundwater flow. In general, the deeper groundwater within the study area flows north-east towards the Ottawa River. The flow directions for both the shallow and deep groundwater systems can be inferred from maps with annual shallow and deep groundwater elevations that are available via the Mississippi-Rideau Source Protection Region's Assessment Report for the Rideau Valley Source Protection Area (MRSPR, 2011).

Groundwater recharge is the primary method for water to enter aquifers. Groundwater recharge is the process where water moves downwards from the surface into the groundwater system from precipitation (rain or snowmelt) or from surface water bodies. In the Beckett's Creek subwatershed, recharge occurs primarily where higher permeability overburden materials exist near the surface, such as the areas of exposed bedrock, nearshore marine deposits (sands), glaciofluvial, colluvial and alluvial deposits and, to some extent, till deposits, as shown in Figure 8 - Surficial Geology. Significant Groundwater Recharge Areas are discussed further in Section 3.5.4 of this report.

3.5.2 Groundwater Quality

Groundwater quality within the study area is variable and was found to change over short distances and with depth in some areas. Well records are available from the MECP in an online database. Based on these records, most wells in the area are drilled wells drawing groundwater from limestone/shale bedrock or gravel within the esker feature. There are also some shallow dug wells found throughout the study area, with a greater density located in the Village of Cumberland. Several studies over the past 30 years, including village studies and private servicing reports, have collected groundwater samples from private wells. The City conducted a groundwater sampling and mapping study in East Ottawa (2017-2020). One of the key products from that study is a groundwater quantity and quality screening tool which is used by City staff to screen new development applications, when private services are proposed, to identify potential issues prior to the initiation of field work. The City is also developing a hydrogeological geodatabase to maintain the groundwater quality data, and the data will be available upon request in the future.

Laboratory analyses for village studies and private servicing reports have focused on major ion chemistry and bacteria, with a goal of verifying drinking water suitability. The East Ottawa Groundwater Study included an analysis of major ions, trace metals, dissolved gas, isotopes and various field parameters such as alkalinity and redox potential. When compared to Ontario Drinking Water Standards, Objectives and Guidelines, the results of groundwater quality monitoring showed that groundwater was generally acceptable with regard to health-related parameters. Monitoring identified some areas where fluoride exceeded the 1.5 mg/L

health-related warning level in the bedrock aquifer (Lindsay and Bobcaygeon formations) but does not exceed the 2.4 mg/L Maximum Acceptable Concentration. Sodium is almost consistently above the 20 mg/L health-related warning level for persons on low-sodium diets. Bacteriological exceedances (total coliform bacteria) are found to be widespread but are typically related to well construction or sampling methodology.

Water quality is considered fair to poor with regards to aesthetic-related parameters. In general, the water is hard, which is typical for a limestone bedrock aquifer. Other widespread aesthetic-related exceedances include total dissolved solids and organic nitrogen. Both sodium and chloride were found to exceed the Ontario Drinking Water Objective (200 mg/L sodium or 250 mg/L chloride) and the Maximum Concentration Considered Reasonably Treatable (MCCRT) (MECP Guideline D-5-5, 1996) at some locations throughout the study area in both deep and shallow wells, with a higher density of exceedances near the Village of Cumberland. The elevated sodium and chloride below the clay may be attributed to trapped saline water from the Champlain Sea, and exceedances in shallow overburden wells may be attributed to impacts from road salt application. New lot creation for privately serviced lots is not recommended where there is an exceedance in the MCCRT, based on MECP guidelines. Hydrogeological reports prepared to support development applications related to private servicing should include a thorough aquifer characterization and groundwater sampling program to ensure the suitability of water quality prior to approval.

Some former private landfill areas have been identified within the subwatershed study area, but there is little information about these sites as they were not operated by the City of Ottawa or the former Municipality. Any applications under the *Planning Act* should be screened using the Historic Landfill Use Information database to determine if a former landfill site is within 500 m of the application.

3.5.3 Water Use

Anthropogenic (human) water use in the subwatershed is mainly for drinking water and agricultural purposes. There are no municipally operated sources of drinking water within the study area, and all residential properties and businesses are privately serviced in the form of drinking water wells and septic systems.

Based on the MECP well records, most wells within the study area draw water from the contact zone aquifer at depths ranging from 15 to 60 m. The contact zone aquifer typically consists of the upper 0 to 15 m of bedrock and the permeable layers which are located directly above the bedrock unit. Bedrock aquifers in the area are highly variable in terms of quality and yield, and some areas are known to be of lower quality and lower yield which has implications for private servicing. Thorough groundwater studies related to water quantity and quality are recommended prior to *Planning Act* approvals for private servicing.

Some private wells in the Village of Sarsfield are installed in the Vars-Winchester esker feature. The esker aquifer is prolific, in comparison with fractured-bedrock wells, with production rates of up to 31 litres per second (Charron, 1978). This esker feature supplies drinking water to seven communities in total, including municipal systems in the villages of Vars, Limoges, Chesterville and Winchester. In total, approximately 15,250 people rely on the Vars-Winchester esker as a source of drinking water, although none of the municipal systems are located in the study area (Cummings and Russell, 2007). This important aquifer is considered a shared groundwater resource, and a better understanding of the size and extent

of the esker and occurrence and movement of groundwater within the esker is required to assist in the protection of its groundwater reserves (Cummings and Russell, 2007).

The MECP issues Permits to Take Water (PTTW) for water users taking more than 50,000 litres per day. Certain exceptions are allowed such as for livestock, poultry or domestic purposes. Regular residential and agricultural uses do not typically exceed 50,000 litres per day and are rarely recorded (Cummings and Russell, 2007). No PTTW have been issued for the Beckett's Creek subwatershed study area, based on a review of the online database.

3.5.4 Drinking Water Source Protection

Ontario's *Clean Water Act* (2006) protects water resources, including rivers, lakes and groundwater, that supply municipal drinking water systems. The Act also provides opportunities to help protect regional groundwater that is used to supply private wells. The majority of this study area falls under the Mississippi-Rideau Source Protection Region (MRSPR), although Catchment D falls under the Raisin-South Nation Source Protection Region (RSNSPR). Each SPR has its own locally developed Source Protection Plan (SPP) that addresses a range of drinking water threats and circumstances, through science-based policies, to prevent contamination and overuse in vulnerable areas. As there are no municipal drinking water systems within the study area, Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SRGAs) are the only designated vulnerable areas to be addressed under SPPs.

HVAs are subsurface geological formations used as sources of drinking water which could be easily impacted by contamination from surface sources due to a lack of sufficient protective layers (thickness or material type) above the aquifer. HVAs have been delineated in both SPRs, based on the depth of the water table and the thickness and hydraulic properties of soil or rock layers above the aquifer closest to the surface, in accordance with the MECP's Technical Rules.

Several HVAs have been identified in the study area (shown in Figure 10), including along the Ottawa River shoreline, within the wooded area approximately 600 m east of Beckett's Creek Road and along the Vars-Winchester esker feature. These assessments were carried out at a regional scale, and site-specific hydrogeological investigations are recommended for any *Planning Act* applications.

Groundwater recharge areas occur where water infiltrates or 'recharges' from the surface to an aquifer. A recharge area is considered significant when it helps maintain the water level in an aquifer that is used as a drinking water source. The MECP's Technical Rules define SGRAs as areas in which the annual recharge volume is at least 55% of the annual water budget surplus (precipitation minus actual evapotranspiration) for the area under consideration.

Several SGRAs have been identified in the central and eastern portions of the study area as shown in Figure 10. These areas are not necessarily associated with individual aquifers but are considered to be areas where groundwater recharge is important at a regional scale. This includes, but is not limited to, seepage areas, springs, headwater wetlands and groundwater-fed streams. Although this study was done at the regional scale and was not site-specific, SGRAs generally correspond to the glaciofluvial and alluvial deposits shown on the OGS's surficial geology mapping available in Figure 8.

Mapping of HVAs and SGRAs is limited to the City of Ottawa boundary adjacent to the City of Clarence-Rockland for the purposes of this study. The full extent of these vulnerable areas is available in the MRSPR and RSNSPR assessment reports.

3.5.5 Water Budget

A water budget estimates how much and where water exists in a watershed or subwatershed over a period of time, usually monthly or yearly. Water budgets account for water that is being added to a watershed (e.g., precipitation) and removed (e.g., rivers flowing out) from a watershed. They also account for changes in storage (e.g., lake level changes).

Two primary input sources into the water budget are precipitation that falls over the entire watershed and the regional groundwater that flows across the boundaries of the watershed. Outputs include surface runoff leaving the watershed, evapotranspiration (evaporation into the air, and transpiration or release of water vapour by plants), regional groundwater that flows out of the watershed boundary and changes in storage. Water budgets generally make certain assumptions as part of the equation, including that changes in storage are negligible over the long-term and that groundwater flowing in and out of the watershed is equivalent.

As part of Source Protection characterization assessments, conceptual water budgets and Tier 1 water budgets were produced and are summarized in the Assessment Reports for each Source Protection Region (MRSPR, 2011; RSNSPR, 2016). A Tier 1 Water Budget and Stress Assessment Study was completed for each SPR by Intera Engineering. The assessment of stress levels for the Tier 1 study is based on the process prescribed under the MECP's Technical Rules. Climate change was not accounted for in the conceptual and Tier 1 studies as the Technical Rules require the use of historical data to estimate the water supply. However, a climate change technical report was prepared summarizing the current state of knowledge, climate data and potential impacts with respect to climate change (MRSPR, 2011).

The conceptual water budgets were completed at a watershed-scale. The Tier 1 stress assessment studies refined the scale of the conceptual studies by dividing the SPRs into representative subwatersheds, based on the location of surface water flow gauges, and developed water budgets using monthly and annual data. Stress levels for the surface water and groundwater systems were calculated for each of the subwatersheds. The study area (apart from Catchment D) was evaluated within the Rideau Valley Source Protection Authority's "Ottawa RVCA (East)" subwatershed (MRSPR, 2011). Catchment D was evaluated within "SWS #59 – Drains to Ottawa River" in the South Nation Source Protection Area (RSNSPR, 2016). The assigned water quantity stress level for both surface water and groundwater systems within the Ottawa RVCA (East) and SWS #59 subwatersheds were found to be low.

No further studies were required for the Ottawa RVCA (East) subwatershed since it does not supply municipal drinking water systems and was not found to be moderately or highly stressed. Although municipal drinking water systems are supplied within SWS #59, the source is the Ottawa River and the overall water quantity stress levels for this area are low, therefore no further studies were required. Overall, policies to address water quantity were not required within the MRSPR Source Protection Plan since the water quantity stress level was low for all the subwatersheds with municipal drinking water systems. Water conservation is still being promoted through various education programs as the region can be vulnerable to seasonal shortages (MRSPR, 2014).

3.6 Natural Heritage Features and System

The City's Natural Heritage System (NHS) consists of core natural areas and natural linkage areas, with Natural Heritage Features (NHFs) occurring both inside and outside of this system. Figure 11 outlines the NHS and shows many of the NHFs identified to date within the study area. Several core natural areas, and one natural linkage area, have been identified in the eastern portion of the study area. The NHS and the features within it are subject to a higher degree of protection than NHFs located outside the NHS, as per the policies in Section 5.6.4 of the Official Plan.

Under the policies of Sections 4.8.1 and 5.6.4 of Ottawa's Official Plan, these NHFs could trigger the requirement for an Environmental Impact Study (EIS) for development applications proposed within the study area. It is important to note that some features, such as habitat for endangered or threatened species, are not identified on this map even though such features may occur in or around the study area. Also, future on-site investigations may reveal the presence of additional NHFs in this area, such as significant wildlife habitat, which would also need to be addressed in an EIS.

Other features, including hedgerows and smaller clumps of trees scattered throughout the fields of the study area, have not been mapped as components of the NHS but do contribute to the City's tree canopy and wildlife habitat and protect soil by reducing wind and water erosion. Such features are considered particularly valuable in settlement areas such as the villages of Cumberland and Sarsfield. They would need to be addressed in any future development planning in those areas as part of the Tree Conservation Report (TCR) and Landscape Plan required during the application process.

3.6.1 Significant Wetlands

A provincially significant wetland (PSW), previously evaluated and mapped by the Province, occurs immediately north of the study area and east of the Village of Cumberland along the shoreline and within an island complex of the Ottawa River. This PSW has also been identified as a core natural area within the City's NHS. The Baie Lafontaine PSW also extends further east of the study area into the City of Clarence-Rockland. This PSW is a riverine wetland, 325 hectares in area, composed of an extensive submerged and emergent aquatic vegetation complex in a shallow, quiet bay of the Ottawa River. This wetland provides shelter and feeding areas for migratory and breeding waterfowl.

While Baie Lafontaine is the only known PSW in the vicinity of the study area at this time, the Beckett's Creek subwatershed contains many unevaluated wetlands including a large area known as the French Hill Swamp. Located in the areas north of French Hill Road and east of Birchgrove Road, the main communities found in this site include poplar and white cedar upland forest, red maple swamp forest and alder thicket swamp on acidic sand plain. The French Hill Swamp is considered important for the maintenance of biodiversity, productivity and hydrological functions, and has been included in the City's Natural Heritage System as a core area. Wetlands located in or adjacent to woodlands typically support critical hydrological and ecological functions, and in many cases are found to provide significant wildlife habitat. This includes wetlands which are not in themselves provincially significant, or which have not been evaluated for their significance under the Province's wetland evaluation system. For this

study, unevaluated wetlands are shown as part of the land cover mapping on Figure 3, rather than on Figure 11.

3.6.2 Significant Woodlands

Updates to the significant woodlands mapping used in the previous Official Plan have been incorporated into Schedule C11 of the new Official Plan. Many of the larger woodlands in the study area have consistently been identified as significant natural features through a series of different analyses: the former Region's Natural Environment System Strategy in 1997; the City's significant woodlands mapping in 2009 and 2011; the draft significant woodlands mapping prepared by the Province in 2011; and the newest mapping by the City based on 2018 forest cover data. Most of these significant woodlands represent core natural areas and natural linkage areas under the City's NHS, but some also occur outside the system. While the policies of the Official Plan stipulate that there shall be no negative impacts on significant woodlands found either inside or outside the NHS, more flexibility is permitted outside the NHS where a "no net negative impact" approach may be an acceptable alternative.

MacSkimming Woods is one of the larger significant woodlands in the study area (at 126.1 hectares), and it is currently used as an outdoor education centre by the Ottawa-Carleton District School Board. The MacSkimming property is also designated as Greenspace on Schedule B9 of the Official Plan, with a sub-designation of Conservation Area on Schedule C11, and it is also designated federally as the Beckett Creek Migratory Bird Sanctuary. The Sanctuary supports various bird populations that are representative of the Ottawa Valley, although the site has not been documented as significant for migratory waterfowl. Other large significant woodlands exist west of Emmett Road and in the vicinity of French Hill and Birchgrove roads.

3.6.3 Significant Valleylands

Significant valleylands are defined under the EIS Guidelines as having slopes greater than 15%, a length of more than 50 m, with water present for some period of the year, excluding man-made features such as pits and quarries. More than 48 km of valleylands have been identified along the watercourse features within the study area, bordering over 25% of the total watercourses. The entire section of the Beckett's Creek corridor between Regional Road 174 and Wilhaven Drive, covering a distance of approximately 1.8 km, has been identified as a significant valleyland, as shown on Figure 11. It is a meandering valley with a significant amount of tree cover along its length, and the slopes are known to be unstable. Slope failures have occurred in recent years, demonstrating the importance of setback limits established during the planning process. Refer to Section 4.2.1 below for more details on the minimum setback provisions of the Official Plan and Zoning By-Law. Property owners along the creek should avoid encroaching on these setbacks to reduce the risks of property damage or loss. Other areas with significant valleylands include the major tributaries west of Birchgrove Road, Catchment A and Catchment C.

Some minor discontinuities have been identified along several sections of the significant valleylands mapping layer in Schedule C11. The extent of the significant valleylands in the areas east of Birchgrove Road, east of Dunning Road and within Catchment A should be reviewed as part of any future development applications in these areas. A slope stability study may also be required adjacent to valleylands.

The Becketts's Creek valley and the associated woodlands function as a linkage between natural features within the study area, creating a nearly continuous corridor between the Vars-Winchester Esker and the Ottawa River. Several core natural areas and a natural linkage area have been identified along the Beckett's Creek corridor and are shown in Figure 11. Any development proposed in or within 120 m of the NHS (including both core natural areas and linkages) must demonstrate, through an EIS, that there will be no negative impacts. Stewardship to maintain and enhance the ecological value of this corridor (e.g., through naturalization or shoreline restoration) is encouraged. In general, the wider a natural linkage corridor is, the better.

3.6.4 Areas of Natural and Scientific Interest

As discussed previously, the study area contains the northern portion of the Vars-Winchester Esker (also known as the Sarsfield-Bearbrook Esker), a provincially significant Earth Science Area of Natural and Scientific Interest (ANSI). This ANSI feature is delineated in Figure 11. Any proposed development applications in the vicinity of the ANSI would be subject to an EIS.

The Baie Lafontaine Islands, located immediately north of the study area within the Ottawa River and east of the Village of Cumberland, have been identified as a candidate regionally significant Life Science ANSI, but this status has not been formally confirmed. This site provides good representation of a large complex of alluvial islands and aquatic communities and is associated with the provincially significant wetland in the same area.

3.7 Species at Risk

Numerous species at risk, protected by the federal *Species at Risk Act* and/or the provincial *Endangered Species Act*, 2007, have been reported or are expected to occur in the vicinity of the study area (see Appendix D). An EIS may be required to address potential concerns with habitat for endangered or threatened species, or with habitat for species of special concern (which is considered significant wildlife habitat), if any is identified or suspected to be present within 120 m of a proposed development.

Butternut and a few other species that have been reported to occur more frequently within the study area are discussed in detail below. Due to the frequency with which the regulated lists of species at risk are updated (typically, at least once per year) and the evolving state of knowledge with respect to species occurrence, the information in this study should not be exclusively relied upon for the purposes of development review. The most up-to-date species at risk lists and occurrence data should always be used.

3.7.1 Trees

Butternut, or white walnut, is a commonly encountered tree species in Ottawa. However, it is endangered in Ontario and in Canada due to widespread mortality caused by the butternut canker, a fungal disease. Butternut has been found near the Cumberland Heritage Village Museum in Catchment C, and it is expected to be present elsewhere in the study area's upland woods and hedgerows.

Butternut should be explicitly addressed in the preparation of an EIS and/or Tree Conservation Report in support of development applications, to confirm its presence or absence on or adjacent to the proposed development site. Similarly, the area of the proposed widening of

Regional Road 174 should be examined prior to, or during, the detailed design stage to determine whether butternut is present on or adjacent to the project site. If butternut is identified, the health of the tree(s) will need to be ascertained by a qualified professional. Trees that have been seriously impacted by the canker may be assessed as non-retainable and can then be removed without penalty. Authorization may need to be obtained from the MECP to remove or harm any butternut trees that have been assessed as retainable, depending on how many such trees are affected. Property owners do not need authorization to prune or remove butternut trees that they planted for ornamental purposes, or other purposes not related to compensation under the *Endangered Species Act* (ESA).

Near the eastern boundary of the study area, adjacent to the MacSkimming Outdoor Education Centre, the Rideau Valley Conservation Foundation maintains a property dedicated to providing compensation for species at risk affected by development. The compensation property covers 36 hectares and includes a grove of approximately 1,600 butternut trees that are being raised from stock that may be tolerant of the butternut canker. These trees are protected under the ESA as compensation plantings.

Another tree species of note is the black ash, which was recently listed as endangered under the ESA on January 26, 2022. Black ash is found scattered throughout the study area, and its preferred habitat is wetlands, flood plains and moist woodlands. The Emerald Ash Borer, an invasive insect species, is the primary threat to black ash as it causes infested trees to die. The Emerald Ash Borer is expected to cause more than a 70% reduction in black ash trees over the next 100 years across Ontario. The MECP is currently developing a recovery strategy and a government response statement for black ash to protect and recover this tree species. Activities that impact black ash and its habitat will not require an ESA authorization or exemption for a period of two years from the date of the species being listed.

3.7.2 Birds

Two species at risk birds that have the potential to be found in association with existing buildings within the study area are the barn swallow and the chimney swift. The barn swallow was previously listed as a threatened species, but it has been downlisted to a species of special concern provincially (as of January 2023) and federally. The chimney swift is a threatened species. Both species are aerial insectivores, meaning that they feed almost exclusively on flying insects that they pursue and catch in skilful displays of airborne acrobatics. Barn swallows build their bowl-shaped mud nests in or on barns, homes and other structures such as bridges, usually in open areas near water. They may re-use nests from previous years or build new ones. Chimney swifts typically roost and nest in open unlined chimneys, returning to the same nest site each year. They are threatened in part by the loss of suitable nesting habitat as fewer homes with traditional-style brick chimneys are built and existing chimneys are retrofitted with metal linings and wire mesh to keep wildlife out. Any buildings or structures that are proposed to be altered or demolished within the study area should first be examined to determine whether barn swallow nests are present. If a building includes an open chimney, it should be examined to determine whether any chimney swift nests are present (note that these are often located in the lower portion of the chimney and may not be readily visible from above).

The bank swallow, a provincially and federally threatened species, has also been reported from the study area. Bank swallows are aerial insectivores like the barn swallow and the chimney swift. They are colonial nesters, creating clusters of burrows in exposed soil banks

and bluffs along watercourses, or in the walls of sand pits. Bank swallow nesting sites have been confirmed in several parts of the study area.

The bobolink and the eastern meadowlark, both threatened species, have been found in open grasslands and hayfields within the study area. The short-eared owl is another grassland species found in open fields and marshes, which has been reported from the area. It was previously listed as a species of special concern, but it has been uplisted to threatened status provincially (as of January 2023) and federally. These species nest on the ground in areas with tall grass. They are vulnerable to mowing or haying during nesting season, as well as loss of habitat to cultivation or development. While agricultural activities are exempted from the *Endangered Species Act*, development activities that could impact the birds or their habitat must comply with the relevant regulations. The Rideau Valley Conservation Foundation's property also contains two fields, for a total of 10 hectares, that are being maintained as meadows to provide habitat for bobolink and eastern meadowlark.

All of the above species of birds and their nests, with the exception of the owl, are also protected under the federal *Migratory Birds Convention Act*. Short-eared owls and their nests are protected from harm under the provincial *Fish and Wildlife Conservation Act*. The short-eared owl will receive additional protection as a threatened species under the provincial *Endangered Species Act*, which may include protection of both its breeding and overwintering habitat (previously considered significant wildlife habitat under provincial criteria).

3.7.3 Turtles

The snapping turtle is a species of special concern in Ontario. It is not currently protected under the *Endangered Species Act* but is afforded some protection under the Ontario *Fish and Wildlife Conservation Act*. As a species of special concern, critical portions of its habitat, such as egg-laying sites or wintering areas, are considered significant wildlife habitat. The Ottawa River, Beckett's Creek and the various tributaries provide habitat for snapping turtles. The threatened Blanding's turtle, which has been occasionally reported in the study area, may also use these watercourses and any adjacent woodlands and wetlands.

3.7.4 Fishes

Two endangered fish species, American eel and lake sturgeon, are known to occur in the Ottawa River which borders the northern extent of the study area. The American eel is primarily nocturnal, hiding in soft substrate of submerged vegetation during the day, and has the potential to be found in the lower reach of Beckett's Creek near the confluence with the Ottawa River. The lake sturgeon prefers deeper, cool water with soft substrate and spawns in shallower, fast-flowing areas over rocks or gravel. Both species are vulnerable to habitat fragmentation caused primarily by hydro-electric dams, and turbines have contributed to high rates of mortality among American eel populations during migration.

Several fish species of special concern also have known distributions within the Ottawa River, including channel darter, northern brook lamprey, northern sunfish, river redhorse and silver lamprey.

4 Environmental Constraints and Opportunities

The following section addresses both the constraints to development and the opportunities for improvement that have been identified through the review of existing conditions within the study area. This subwatershed study will be referred to during the review of any development applications in the study area.

The risks associated with climate change add an additional layer of complexity when addressing the environmental constraints associated with a proposed development. Climate change has implications for the overall environmental health of the subwatershed and the risks posed to people and property. While climate impacts were not explicitly included in the development of the Beckett's Creek Subwatershed Study, the City is developing a Climate Resiliency Strategy through the Climate Change Master Plan that identifies how Ottawa is vulnerable to changing climate conditions and recommends ways to mitigate the top risks.

Preliminary risks to subwatersheds identified to date, in relation to climate change, include:

- Increasing temperatures and drier summers can warm stream temperatures, alter flows and harm aquatic ecosystems;
- Shifting seasons can influence habitat and affect biodiversity;
- Variable precipitation, including less summer rain and increased likelihood of drought, can reduce agricultural yields;
- Drought conditions can harm shallow aquifers, including private wells;
- Increasing rainfall intensity can increase surface runoff affecting water quality in watercourses and highly vulnerable aquifers;
- Increasing precipitation can increase the risks of erosion or slope destabilization, especially in areas with sensitive marine clay;
- Increasing frequency or severity of riverine flooding along the Ottawa River, or in Beckett's Creek or other tributaries, may damage properties or cause erosion; and
- Increasing freeze-thaw cycles in the winter, and additional freezing rain, may increase road salt use and result in reduced riverine and shallow well water quality.

Climate Projections for the National Capital Region (City of Ottawa and National Capital Commission, 2020) is a document that describes how the climate is expected to change over the coming decades. The anticipated climate projections from this report should be incorporated into required studies (e.g., Water Budget Assessments, Environmental Impact Studies) to inform future development application proposals within the study area. Once it is available, the Climate Resiliency Strategy should also be consulted to inform how the potential risks can be managed.

4.1 Natural Heritage System

Most of the Natural Heritage System (NHS) and Natural Heritage Features (NHFs) identified within the study area occur on private lands and are dependant on continued stewardship by individual landowners. The City currently has little ability to protect these features outside of the development review process.

Under the policies of Ottawa's Official Plan, development or site alteration will not be permitted in or adjacent to the NHS or NHFs unless an Environmental Impact Study (EIS) demonstrates that there will be no negative impacts. The Official Plan provides additional protection for core natural areas within the NHS by requiring that development or site alteration maintain or enhance, and not compromise the potential for long-term enhancement and restoration of, the integrity, biodiversity and ecosystem services of the area. Within natural linkage areas of the NHS, the Official Plan requires that development or site alteration maintain or enhance, and not compromise the potential for long-term enhancement and restoration of, ecological and recreational connectivity of the area. The policies of the Official Plan also require the City to take a no net loss approach for unevaluated or non-provincially significant wetlands and for forest cover outside the urban area and villages.

The mapping for the City's NHS and certain NHFs (e.g., significant woodlands) was recently updated in 2021 as part of the new Official Plan. However, not all components of the NHS are shown on Figure 11 or on Schedule C11 of the Official Plan. Any NHFs that are found to meet the City's criteria, as established in Section 4.8.1 of the Official Plan and the EIS Guidelines, are subject to the policies of the Official Plan whether or not they are included on the City's mapping.

Many of the wetlands found within the study area have not been evaluated under the provincial system. Under the policies of the Official Plan in Section 7.3, unevaluated wetlands may require a wetland evaluation (using the Ontario Wetland Evaluation System) when recommended in a planning study such as this subwatershed study. Development and site alteration in or near wetlands that are determined to be non-provincially significant will require management and minimum setback requirements to be established, as described in Section 4.9.3 of the Official Plan.

Beckett's Creek, its tributaries and neighbouring catchments provide natural linkages between the various features that comprise the City's NHS. In many cases, these natural linkages are comprised of very narrow bands of vegetation, and this reduces their ecological function as viable corridors. The creation or enhancement of riparian buffers would increase the connectivity of the NHS and should be encouraged. Vegetated buffers are also useful to protect water quality and aquatic habitat (see discussion on watercourse setbacks and buffers, below). Existing programs such as Green Acres, the Ottawa Rural Clean Water Program and the Rideau Valley Conservation Authority (RVCA) Shoreline Naturalization Program could be used to promote and support such enhancements by willing landowners.

4.2 Surface Water Features

In addition to Beckett's Creek and its tributaries, the study area includes four smaller, unnamed surface water features whose catchments drain directly to the Ottawa River. The possibility of officially naming these features presents an opportunity to foster greater awareness and appreciation of the natural environment within the study area. The Ontario Geographic Names Board receives and reviews requests for naming geographic features on the landscape. The City of Ottawa encourages any interested local community organizations to consider submitting naming requests to the Province to formally recognize the smaller watercourses flowing through several rural estate communities in the study area.

4.2.1 Setbacks and Buffers from Surface Water Features

Protecting stream corridors and surface water features serves a dual purpose of preserving and enhancing aquatic habitat, as well as reducing risks from natural hazards associated with watercourses. This is generally accomplished through the use of regulatory setbacks or development limits, in combination with buffer strips of vegetation. Ensuring that development is set back an appropriate distance from watercourses helps preserve a natural riparian buffer zone and provides a margin of safety from natural hazards such as flooding and unstable slopes.

Development setbacks have already been imposed along Beckett's Creek and the other watercourses in the study area as per the policies in Section 4.9.3 of the Official Plan. These minimum setbacks must be respected during the development of properties adjacent to watercourses. The Official Plan specifies that the minimum setback from surface water features will be the greater of the following:

a. Development limits as established by the Conservation Authority's hazard limit, which includes the regulatory flood line, geotechnical hazard limit and meander belt;
b. Development limits as established by the geotechnical hazard limit in keeping with Council-approved Slope Stability Guidelines for Development Applications;
c. 30 metres from the top of bank, or the maximum point to which water can rise within the channel before spilling across the adjacent land; and
d. 15 metres from the existing stable top of slope, where there is a defined valley slope or ravine.

Section 4.9.3 of the Official Plan also specifies that lands within the minimum setback from surface water features should remain in a naturally vegetated condition to help preserve ecological function. The minimum setbacks are implemented through the Zoning By-law, and any change in the setback requires a Zoning By-law amendment or variance that is consistent with the policies of the Official Plan. The policies of the Official Plan provide for some exceptions to the minimum setback, such as the creation of infrastructure or pathways and cases where historical development has influenced the setback area.

Beckett's Creek is primarily a cool-warmwater system with many species of fish, but it is being impacted by runoff from adjacent land uses and ongoing erosion issues. Runoff can be expected to increase along with the increased precipitation and intense rain events noted in the climate projections report. Many of these impacts could be reduced by maintaining or improving the vegetated buffers along the creek and its tributaries. Well-established buffers protect creek banks against erosion, improve habitat for fish by shading and cooling the water, and prevent runoff from adjacent land uses. They also help to reduce the maintenance requirements on municipal drains, by reducing the amount of sediment that reaches the drain. The use of vegetated riparian buffers is therefore strongly recommended, both for new development and for existing land uses, to reduce the impacts of these adjacent land uses on the watercourses and associated aquatic habitat.

Many landowners in the study area have developed their properties in accordance with the regulatory setbacks and are maintaining well-vegetated buffers along the watercourses. Others may benefit from targeted outreach campaigns regarding the importance of setbacks and buffers.

Setback provisions do not apply to agricultural land uses (unless a building permit or other development approval is required). The farming community is encouraged to implement best management practices for the protection of watercourses and to take advantage of funding opportunities available at the federal, provincial and municipal levels. For example, funding is available to rural landowners for projects that improve surface water and groundwater quality through the Ottawa Rural Clean Water Program (ORCWP). Vegetated buffers (including trees and shrubs) can be used to protect erosion-prone streambanks and/or reduce impacts from cropping practices. The ORCWP's guideline specifies a minimum width of 3 m from the top of any bank, and wider widths are encouraged. Other best management practices that offer protection for watercourses include fencing to control livestock access, tile drain control structures to retain water in the soil (where appropriate), and fragile land retirement.

Projects undertaken in and around watercourses must also comply with the fish and fish habitat protection provisions of the *Fisheries Act* to avoid causing the death of fish and to avoid harmful alteration, disruption or destruction of fish habitat. Fisheries and Oceans Canada has developed standards and codes of practice for common activities such as beaver dam removal, culvert maintenance and temporary stream crossings. Projects that aren't covered by existing standards and codes of practice may need to be reviewed and authorized under the *Fisheries Act*.

4.2.2 Headwater Drainage Features

The headwater drainage features (HDFs) found within the study area are vulnerable to modification or loss from development and agricultural practices (e.g., tile drainage). These changes can result in cumulative impacts to the subwatershed's ecological and hydrological functions and downstream geomorphic processes. Changes to the connected headwater wetlands could result in significant changes to the watercourses that depend on them.

HDFs are included under the definition of surface water features in the City's Official Plan and are subject to the minimum setback requirements described in Section 4.9.3. When development or site alteration is proposed within or adjacent to an HDF, and an exception to the minimum setback is requested, an assessment of the feature and its hydrological and ecological functions is required. The assessment must also provide recommendations regarding the level of protection for the feature and an appropriate minimum setback (which may be none, if the feature can be removed).

The City's EIS Guidelines and the RVCA recommend using the Evaluation, Classification and Management of Headwater Drainage Features Guideline as a standardized approach to inform decision making with respect to HDFs. The HDF Guideline provides a framework for baseline information, evaluation, classification and management recommendations to assist with the protection of aquatic functions from a watershed management perspective. It can be used as a tool when evaluating master servicing studies, applications under the *Planning Act* and applications for alterations to waterways under Section 28 of the *Conservation Authorities Act*. The guideline provides a consistent approach to assessing the value of HDFs. It is important to note that the HDF Guideline does not apply to municipal drain maintenance.

4.2.3 Municipal Drains

The study area is primarily a rural agricultural landscape and is expected to remain so for the foreseeable future. Therefore, the extensive network of municipal drains in the area will also

continue to be maintained. Improvements to the drains will focus on the retention and development of buffer strips and the promotion of environmentally friendly farming practices. Programs such as the ORCWP and the Ontario Soil and Crop Improvement Association's Environmental Farm Plan continue to encourage agricultural best management practices.

Section 4.9.3 of Ottawa's Official Plan recognizes that, in addition to minimum setbacks from surface water features, development next to municipal drains and other works under the *Drainage Act* must maintain clear access to the legal working space adjacent to the drain. The working space is defined in the engineer's report for each drain, which is adopted through a by-law approved by City Council under the *Drainage Act* for the construction and future maintenance of drainage works. Usually, this working space is a minimum 15 metres from the top of bank on one side of the municipal drain, but this may vary depending on the recommendations contained within the engineer's report.

It is expected that the installation of tile drainage will continue across the study area's agricultural lands to reduce standing water on fields and increase crop productivity. In Ontario, the installation of agricultural tile drainage systems is regulated by the *Agricultural Tile Drainage Installations Act*. Anyone other than the landowner doing tile drainage installation work on a farm must be licensed by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). Additional information and publications are available on OMAFRA's website.

The farming community should be encouraged to consider the merits of agricultural best management practices such as controlled tile drain structures to manage water levels on fields, especially given the variable precipitation and risk of droughts expected in the coming decades.

4.3 Natural Hazards and Regulations

When determining setback limits as part of the development application process, other technical studies may also be required to address the constraints posed by natural hazards. These include flood plains, unstable slopes, unstable soils and unstable bedrock. These natural hazards are addressed within the policies of the Official Plan in Sections 4.9.3, 10.1.1, 10.1.3 and 10.1.4.

4.3.1 Flood Plains and Unstable Slopes

Flood plain mapping for the 1:100-year event has been completed for the main branch of Beckett's Creek, from Sarsfield Road to its confluence with the Ottawa River, and three major tributaries (RVCA, 2018). Engineered flood risk mapping is also available for the Ottawa River (RVCA, 2014). In the lower reaches of Beckett's Creek (downstream of Wilhaven Drive) and the three tributaries, flooding under 1:100-year conditions is expected to remain contained within the well-defined valleys. However, in the upper reaches (upstream of Wilhaven Drive), flood plain mapping for the 1:100-year event shows water levels rising beyond the valley slopes and accessing the adjacent lands (RVCA, 2018). The mapping also shows that several road segments (e.g., French Hill Road, Birchgrove Road, Etienne Road) can expect to experience water depths greater than 0.3 m as often as the 1:20-year flood event. The 1:100 flood lines delineated in the report determine the regulation limits mapping (as per Ontario Regulation 174/06) and will be used to inform municipal land use planning and development approvals processes under the *Planning Act*.

The City's Official Plan also contains new policies for areas vulnerable to flooding under climate change (Section 10.1.3). These policies recognize the risk of extreme flooding events due to increasingly variable climate conditions, as described in the City of Ottawa and National Capital Commission's joint climate projections report. For the purposes of these policies, the climate change scenario flood event is the 1:350-year flood plain. When development requiring site plan control or a plan of subdivision is proposed for lands within a climate change flood vulnerable area, flood risk will be evaluated, and mitigation measures will be applied as part of the planning and design of the site. Flood plain mapping for the 1:350-year event has been developed for Beckett's Creek and the Ottawa River and is available on the City of Ottawa's website.

Large portions of the Beckett's Creek system are considered to have unstable slopes, also referred to as erosion hazards, as shown on Schedule C15 – Environmental Constraints of the City's Official Plan. This includes the entire main stem of Beckett's Creek itself and its major tributaries upstream of Birchgrove Road. Unstable slopes have also been identified along the smaller creeks near the steep escarpments above Old Montréal Road. Under a climate change scenario with increasing precipitation and more intense rainfall events, the risk of erosion can be expected to increase. Recurring erosion issues have also been identified in association with the road crossing structure at Old Montréal Road.

Schedule C15 and the RVCA's 2018 hazard mapping show the general areas where slope stability is a concern, but this mapping is not exhaustive and does not contain detailed information for all sites characterized by unstable slopes. Development proponents may be required to undertake site-specific slope stability assessments as part of the development review and approvals process, to delineate the extent of these natural hazards.

A permit under Ontario Regulation 174/06, *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*, may be required from the RVCA for works such as site grading, the placement of fill, the alteration of existing watercourse channels, and certain construction projects. The Conservation Authority must be consulted for any project where development may be subject to flooding, erosion hazards, interference with wetlands and/or alterations to shorelines and watercourses due to the potential for adverse environmental effects.

4.3.2 Unstable Bedrock and Soils

As described in sub-sections 3.4.2 and 3.4.3 of this report, unstable bedrock associated with karst topography and unstable soils such as sensitive marine clays (formerly known as Leda clays) and are potential hazards in the study area. The policies of the Official Plan (Section 10.1.4) require that development generally be directed to areas outside of unstable bedrock or soils. Exceptions to this policy are possible, however, site-specific geotechnical studies may be required to ensure that the area is safe for development to proceed. The Conservation Authority must be consulted for any development on unstable bedrock or unstable soils.

A band approximately 2.5 to 3 km wide across the northern portion of the study area contains inferred and potential areas of karst topography (Figure 7). While karstic areas in this region are not generally considered to be geotechnical hazards, it is prudent to retain a qualified

professional to undertake a site-specific assessment before proceeding with development in areas of inferred karst topography.

Sensitive marine clays cover a large portion of the study area, and under certain conditions, these areas can be more susceptible to landslide hazards. These hazardous zones have not yet been formally mapped, and geotechnical studies by sensitive marine clay experts are strongly recommended to evaluate and determine the extent any hazards as part of a *Planning Act* application. The Province's "Technical Guide for Hazardous Sites" should be followed for sites containing sensitive marine clays. The scope of any geotechnical studies should include a review of available LiDAR information.

4.4 Groundwater Protection

Certain characteristics of the bedrock geology in the Beckett's Creek subwatershed area result in zones that may be hydrogeologically sensitive. Due to the potential for fractures, sinkholes, caves and sinking streams, karstic features can act as a direct pathway between surface water and groundwater resources. Areas with inferred or potential karst topography (Figure 7) are more vulnerable to contamination and require site-specific hydrogeologic studies to support development applications and/or approvals for private servicing. These studies should include an assessment of karstic features and potential vulnerability of the supply aquifer and a description of mitigative measures necessary to protect the aquifer.

The groundwater beneath areas with thin soils (less than 2 m soil thickness, as shown in Figure 9) may become contaminated more easily because of a lack of protective soil layers. These areas require additional site-specific hydrogeologic investigation to determine the vulnerability and security of the drinking water supply prior to approvals involving private servicing. Mitigative measures related to well construction and private sewage system construction may be required to support the long-term safety of the aquifer.

The Vars-Winchester Esker plays a significant role in supporting the local groundwater supply. The esker system is a prolific aquifer, as it supplies drinking water to several municipal wells outside the study area and to many private wells. The esker system also improves the water quality and aquatic habitat conditions in Beckett's Creek by maintaining summer baseflow and cooler water temperatures in the tributaries that intersect the feature. The policies in the Official Plan offer increased protection for the form and function of the esker feature.

Where the Vars-Winchester Esker lies beneath the clay plain (see Figure 8), the groundwater contained within it is likely under very high pressure. There is the potential for uncontrolled groundwater discharge to occur during excavation or drilling of the esker, and groundwater control should be considered in these instances. Deep excavations or drilling near the esker may also require significant mitigation to accommodate the high pressure and volume of water. While the central core of the esker feature has recently been delineated, less information is available on the extent that the esker fans out below the surface. More information is required from site-specific studies to assess where the esker is vulnerable from development and what activities might affect its form and function. Additional hydrogeological testing will be required for future development to determine the exact limit of the hydrogeological constraint area.

Vulnerable areas identified under provincial drinking water Source Protection Plans include Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge Areas (SGRAs). HVAs are shallow and can be easily impacted by contamination from the surface and/or land

use due to a lack of protective layers above the aquifer. HVAs may also be subjected to increased risk of contamination from more intense rainfall associated with climate change. SGRAs benefit from higher recharge which helps replenish local shallow aquifers to maintain water levels for drinking water sources. Both features directly contribute to the quality and quantity of groundwater, which is used extensively throughout the study area as a source of drinking water and for watering livestock. Areas where HVAs and/or SGRAS are present should be appropriately protected during future development through site-specific hydrogeological testing to determine the impact of development on the vulnerability and hydrologic function of the aquifer.

4.5 Surface Water Quality

Surface water quality is influenced by both the bio-physical characteristics of the subwatershed such as surficial soils, vegetative cover and wetlands, and by human-made disturbances such as development, agriculture and aggregate extraction. The increasing precipitation and intensity of rainfall events that are expected under a climate change scenario could also serve to exacerbate existing issues with surface runoff. There are opportunities to improve water quality by reducing contaminant-laden stormwater runoff. The release of pollutants, such as *E. coli* and phosphorus, can also be mitigated using a range of best management practices.

Beckett's Creek and its tributaries provide a range of coolwater to warmwater fish habitat that supports up to 29 species of fish. The factors that contribute to the existing aquatic habitat include groundwater recharge and discharge, riparian habitat, wetland habitat and forest cover. These features and their functions should be protected to ensure that the thermal regime and productivity of this aquatic system are maintained. Furthermore, these features and their functions should be enhanced, where possible, as it would result in a direct influence on Beckett's Creek and the receiving Ottawa River. The expected temperature increases under the climate projections may also impact in-stream water temperatures and aquatic habitat.

4.5.1 Agricultural Best Management Practices

Most contaminant inputs from agricultural lands are a form of nonpoint-source pollution, and the effectiveness of best management practices (BMPs) for improving water quality can be difficult to measure. Several studies have combined monitoring and modelling techniques to show significant reductions in nutrient loads to watersheds following the adoption of BMPs such as riparian buffers, filter strips, exclusion fencing and manure storage (Easton et al., 2008; Rao et al., 2009). Other studies have measured rates and magnitudes of pollutants from agricultural runoff, the impacts of these pollutants on surface water quality and the ability of various BMPs to mitigate these impacts (Udawatta et al., 2002; Jaynes et al., 2004; Bishop et al., 2005; Gassman et al., 2010). Nonpoint-source runoff also has the potential to contaminate groundwater sources.

Of all the nonpoint-source pollution derived from agricultural land use, sediment is seen as having the most widespread and cumulative impact on aquatic environments (Waters, 1995). The erosion of agricultural lands leads to downstream sedimentation, unstable channels, loss of aquatic habitat, impacts to aquatic organisms and plays a role in contaminant transport. It is also an indicator of agricultural sustainability, and the prevention of soil loss from farmland should be a long-term goal.

The OMAFRA has published a series of Best Management Practice manuals that describes various practical, affordable approaches to conserving a farm's soil and water resources without sacrificing productivity. These publications offer a summary of environmental concerns in the context of farming operations and demonstrate options for addressing issues in specific circumstances. BMPs on farms are also encouraged through the Ottawa Rural Clean Water Program (ORCWP) and the Province's Environmental Farm Plan Program.

The ORCWP provides grants of up to $15,000 to farmers and other rural landowners to undertake a variety of projects on their property that protect water quality. The ORCWP has supported over 1,300 projects since it began in 2000. Projects delivered in the Beckett's Creek subwatershed since 2016 include two fragile land retirement incentives and a forest management plan. Two projects related to manure storage and treatment and washwater treatment are currently underway. The ORCWP is delivered in partnership with the Rideau Valley, Mississippi Valley and South Nation Conservation Authorities.

Environmental Farm Plans (EFPs) are assessments voluntarily prepared by participating farmers to increase their environmental awareness in up to 23 different aspects of farm life. Through local EFP workshops, farmers highlight their farm's environmental strengths, identify areas of environmental concern and set realistic action plans with timelines to improve environmental conditions. The EFP program is delivered locally by the Ontario Soil and Crop Improvement Association and technical expertise is provided by OMAFRA. An EFP is typically required to be eligible for provincial or local grants, including the ORCWP.

4.5.2 Residential Best Management Practices

Residents living within the villages of Cumberland and Sarsfield, as well as in rural estate subdivisions, also have a role to play in the protection of surface water quality. Common sources of pollutants from rural residential properties include poorly maintained and/or aging septic systems, improper use and/or disposal of toxic substances and inadequate waste management.

Properly built and maintained septic systems are critical for preventing bacterial contamination and nutrient loading of Beckett's Creek and its tributaries. Homeowners are responsible for their own septic system's maintenance. To ensure that septic systems function properly and don't become overloaded, it is important to conserve water and to pump out the tank regularly. It is recommended that the septic tank be inspected for cracks and leaks every 3 to 5 years by a licensed contractor. The Ottawa Septic System Office (OSSO) regulates the construction, replacement and decommissioning of septic systems within the City. Details for permit applications, septic records and further information are available by contacting the OSSO.

Chemicals that are found in pesticides, fertilizers and road salt can enter Beckett's Creek and its tributaries through stormwater runoff and can also infiltrate into groundwater. Avoiding the use of pesticides on lawns and gardens and applying fertilizers sparingly and according to the product's directions can help reduce the amount of toxic substances that are entering the environment. Spreading road salt on driveways and walkways during winter months should also be kept to a minimum to prevent excess chloride from entering drinking water sources.

Proper disposal of hazardous products such as pharmaceuticals, batteries, paint and motor oil also prevents unsafe runoff into creeks and rivers. The City of Ottawa offers periodic

Household Hazardous Waste Depots, and many retailers also accept returns of household hazardous waste.

4.6 Stormwater Management

Most of the villages of Cumberland and Sarsfield were developed before there was a requirement for municipalities to manage stormwater. For this reason, there are no facilities to treat stormwater in those older parts of the villages. The engineered drainage within the villages differs from the natural drainage of the surrounding landscape. Buildings, roads and parking lots prevent rainfall from infiltrating into the soil. This produces increased runoff, which is captured and conveyed mainly through ditches and outlets to nearby tributaries and ultimately the Ottawa River.

Two stormwater management facilities (a dry pond and a wet pond) are located in newer rural estate subdivisions. These facilities are designed to store runoff and release it back into the environment at a controlled rate, which helps to prevent downstream flooding and erosion. As described in subsection 3.2.3 of this report, improvements to water quality, including pollutant removal, are achieved by different means for these two facilities.

New development within the villages and in rural subdivisions, whether greenfield or infill, will be subject to stormwater management requirements established through provincial legislation and the policies in the City's Official Plan, including an enhanced water quality target of 80% Total Suspended Solids removal. New stormwater management solutions should also consider the impacts on the overall hydrologic cycle with a focus on maintaining, or improving, the components of the water budget. Water budget targets should be identified and implemented as outlined in the City's Water Budget Assessment Terms of Reference (currently in draft, expected to be completed in 2023). The extreme vulnerability of groundwater in areas with karst topography should also be considered.

4.6.1 Stormwater Management Retrofit Opportunities

Stormwater management "retrofits" refer to a variety of measures that can be applied to existing communities, where needed, to improve water quality, reduce erosion and flooding, protect infrastructure and improve aquatic habitat. Retrofit measures that could be beneficial within the Beckett's Creek subwatershed include lot level and conveyance measures.

Lot level measures are located on individual properties to reduce the amount of rainfall runoff and prevent pollutants from being washed off the property. They are the first line of protection in maintaining or restoring the health of a watershed and can be implemented by individual homeowners. Though each property may be relatively small, the use of lot level measures across many properties produces a cumulative benefit. Typical lot level measures include:

- Rain barrels or cisterns;
- Rain gardens and other absorbent landscaping measures;
- Downspout disconnection/redirection to permeable surfaces; and
- Using permeable materials for the construction of driveways and parking lots.

Conveyance measures collect and accumulate runoff from individual lots and transport it to the drainage system's outlet, usually the closest creek or river. Conveyance measures include drainage ditches, swales, storm sewers and the road allowance. Conveyance retrofits include:

- Perforated storm sewers that allow some water to leave the pipe and enter the surrounding soil; and
- Curb extensions that treat and absorb runoff using soils and plantings (bioretention).

Individual homeowners are encouraged to consider the use of lot level measures on their properties, if they are not already in place. The City's Rain Ready Ottawa program offers a variety of online educational materials that can assist residents with managing rainwater on their properties. Implementation of appropriate stormwater retrofit measures should be considered during the planning stages for municipal infrastructure renewal projects, such as culvert replacements and road widening, other projects on City-owned property and any infill development.

5 Subwatershed Plan

The environmental health and ecological integrity of the study area, and its aquatic and terrestrial features, can be protected and enhanced through the following initiatives by the City, the RVCA, other agency partners and private residents. Table 5-1, located at the end of this section, provides a detailed list of recommendations and triggers for their implementation. The recommendations have been broadly categorized into seven key themes that relate to the environmental constraints and opportunities described in Section 4. Note that many of these recommendations will result in environmental benefits that cut across multiple themes. This Subwatershed Plan should be used by City staff, government agencies and the development industry to inform how future development proceeds within the study area, and it may also be used to help guide stewardship actions.

5.1 Identification of the Natural Heritage System

The protection of the Natural Heritage System and Natural Heritage Features within the study area, with respect to development and site alteration, is governed by the policies of the Official Plan. The preparation of an Environmental Impact Study (EIS) that demonstrates no negative impacts, in keeping with the Official Plan policies and the EIS Guidelines, is a requirement for any proposed development or site alteration in or adjacent to Natural Heritage Features.

This study has highlighted the presence of many unevaluated wetlands throughout the study area. These wetlands often occur in association with significant woodlands and have the potential to be recognized as significant wildlife habitat. A wetland evaluation may be required for any development proposed within 120 m of a wetland that lies within the Natural Heritage System (core areas or linkage areas) as shown on Figure 11 of this study and Schedule C11 of the Official Plan. The status of the wetland, based on the Ontario Wetland Evaluation System, will guide the appropriate protective measures. This may range from strict protection in the case of provincially significant wetlands, should any be identified, to more flexible approaches involving mitigation and compensation for impacts to wetlands that are not significant.

This study has also identified that the extent of the significant valleylands in a few areas needs to be confirmed. This verification can be done in support of future development applications in the affected areas.

The NHS within the study area contains several core natural areas and a natural linkage area that provide important habitat and movement corridors for many species of wildlife. In addition to the protection offered by policies under the Official Plan, these areas can be enhanced through reforestation and habitat restoration efforts by the City of Ottawa, the RVCA and private landowners. Programs that offer assistance to private landowners include the Ottawa Rural Clean Water Program, Green Acres (the City's rural reforestation program) and the RVCA's Shoreline Naturalization Program.

5.2 Management of Natural Hazards

The requirements for new development in the vicinity of natural hazards, including flood plains, unstable slopes, unstable soils and unstable bedrock, are addressed in the policies of the Official Plan. Flood plain and hazard mapping have been developed by the RVCA to establish regulation limits along the Ottawa River and Beckett's Creek. Any development or site alteration that is proposed within a regulated area will require a permit from the RVCA (as per Ontario Regulation 174/06 – *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*).

General areas of unstable slopes are shown on Schedule C15 of the Official Plan, and mapping is available at a regional scale for hazards related to karst topography. Site-specific geotechnical studies to delineate and evaluate the extent of the hazard(s) may be required to support applications under the *Planning Act.*

Development setbacks from surface water features shall be determined following the policies in Section 4.9.3 of the Official Plan. These setbacks are intended to protect both the aquatic habitat in the creeks and the abutting landowners from property damage due to unstable slopes. These setbacks must be respected during the development review process. The City should also ensure that setbacks are appropriately respected on municipal property. Targeted outreach by the City and/or the RVCA may help private landowners to better understand and respect the setbacks that affect their property. Sheds and other valuable amenities should not be placed within setback areas to avoid property damage or loss.

5.3 Protection of Groundwater Features

Development and site alteration should proceed with caution within and adjacent to the Significant Groundwater Resources Areas, Highly Vulnerable Aquifers and other hydrogeologically sensitive areas (i.e., areas with potential or inferred karst topography, thin soils) identified through this study. When development is proposed in areas of groundwater sensitivity, detailed, site-specific hydrogeological studies should be carried out to determine the exact limit of the constraint area, the vulnerability of the groundwater feature and any mitigative measures needed to support development and protect the feature.

While the central core of the Vars-Winchester Esker has recently been delineated, the extent to which this geological feature fans out below the surface has not been fully mapped. Additional hydrogeological testing will be required for future development in the vicinity of the esker to determine the exact limit of the hydrogeological constraint area.

Additional measures to protect the groundwater resources are recommended within the study area such as:

- Reduce the impact of winter salt application; consider updates to salt management plans and education/outreach;
- Ensure abandoned wells are properly decommissioned; and
- Require the preparation of a detailed Water Budget Assessment for circumstances outlined in the City's Water Budget Assessment Terms of Reference (currently in draft, expected to be completed in 2023).

Groundwater quantity and quality is variable in parts of the study area and may not meet Provincial Guideline requirements to support private servicing (for private drinking water wells and/or private septic systems). This information will be provided during development pre-application consultation with the City's Development Review planners, and detailed site-specific hydrogeological studies may be required to support development applications for a risk review of private servicing.

5.4 Restoration of Natural Habitat

Several locations along Beckett's Creek have been identified as potential sites for habitat restoration and enhancement projects through the RVCA's City Stream Watch Program. Detailed mapping highlighting where these opportunities exist are available in the RVCA's *Becketts Creek 2017 Catchment Report* (see Figures 41 and 42 in Appendix D). These projects include riparian plantings, erosion control works, fish habitat enhancement and/or invasive species control. These projects could be implemented through existing initiatives such as the RVCA's Shoreline Naturalization Program and/or the Ottawa Rural Clean Water Program or as compensation for development-related impacts to aquatic habitat in the study area.

Other sources of funding and support are available for rural landowners interested in restoring and conserving natural habitat on their property. Examples include Green Acres (the City's rural reforestation program), Ducks Unlimited (for wetland/grassland habitats) or through provincial initiatives such as the Managed Forest Tax Incentive Program (for managed forests at least 4 ha in size). Landowners interested in long-term conservation of ecologically sensitive lands could consider donating their property, or a conservation easement upon it, to eligible agencies such as the Rideau Valley Conservation Foundation or the City in return for income tax benefits under the federal Ecological Gifts Program.

Landowners are encouraged to maintain a buffer strip along municipal drains with a hay or forage crop that can be harvested, however, compensation under the *Drainage Act* is not available for this practice. Improvements to any municipal drains should also consider the retention and naturalization of buffer strips, where appropriate, by working with landowners and in consultation with the City's Municipal Drains unit. It is critical to ensure that any proposed riparian plantings, or other creek restoration projects, will not conflict with the continued function and maintenance of a municipal drain. Planting plans may need to be adapted to ensure that the required access to the drain is maintained (e.g., by using species that can be cut back periodically to allow access such as willows or dogwoods). The implementation of plantings along a municipal drain may increase the costs of future maintenance, and these costs may be charged back to the landowner.

While many of the opportunities for habitat restoration and enhancement are located on private property, there are several City-owned properties along watercourses in Catchment A which could provide additional project sites. A list of potential projects, along with recommendations for implementation, is provided in Table 5-1 below. These opportunities to restore natural habitat will also contribute to increasing resilience to climate change by mitigating the risk of flooding and improving in-stream temperature regulation.

5.5 Protection of Surface Water Quality

The retention of existing natural watercourse form and function (where it currently remains intact) will assist in maintaining the existing natural aquatic communities including cool-warmwater fish communities and nursery habitat. Similarly, retaining the meander belt in a natural condition will allow for the natural evolution of the watercourses while preventing erosion hazards to structures and maintaining buffer strips and riparian habitats.

The City and the RVCA should continue to work together to promote good environmental stewardship in the study area through ongoing initiatives such as the Ottawa Rural Clean Water Program (ORCWP), the RVCA Shoreline Naturalization Program and Green Acres. Community-based stewardship can also be promoted through the City Stream Watch program and the bi-annual Cleaning the Capital program. The City should also consider opportunities to demonstrate good stewardship on its properties in the study area.

Eligible projects under the ORCWP that could be particularly beneficial for improving surface water quality in the Beckett's Creek study area include:

- Installation of tile drain control structures (where appropriate) and tile outlet erosion protection;
- Development of nutrient management plans and the acquisition of precision farming equipment;
- Fencing to keep livestock out of watercourses;
- Manure storage and treatment facilities;
- Erosion control and streambank stabilization;
- Fragile land retirement;
- Planting trees and shrubs to create or enhance watercourse buffers and windbreaks;
- Septic system repair or replacement; and
- Chemical or fuel storage.

Interested landowners can request a site visit through the ORCWP to discuss possible projects on their property. Grants of up to $15,000 are available covering 50 to 90 percent of eligible costs. Applicants must contact the Landowner Resource Centre (located at the RVCA headquarters near Manotick) prior to starting their projects to be eligible for funding.

5.6 Stormwater Management

The City should consider opportunities to improve stormwater management in existing developed areas within the villages of Cumberland and Sarsfield as part of future renewal projects involving roads and other public facilities. The City should also continue to promote the Rain Ready Ottawa program to encourage homeowners to adopt practices that reduce stormwater runoff from their properties.

New development within the villages and in rural subdivisions, whether greenfield or infill, will be subject to stormwater management requirements established through provincial legislation and the policies in the City's Official Plan, including an enhanced water quality target of 80% Total Suspended Solids removal. New stormwater management solutions should also consider the impacts on the overall hydrologic cycle with a focus on maintaining, or improving,

the components of the water budget. The extreme vulnerability of groundwater in areas with karst topography should also be considered.

5.7 Monitoring

Ongoing monitoring of the environmental conditions within the study area should continue, as this provides critical information for evaluating incremental changes within the subwatershed. This includes the long-term baseline water quality monitoring that RVCA staff are currently carrying out at two locations, as well as the City Stream Watch volunteer program. These complementary programs provide valuable information necessary to guide management actions, support development review and address environmental issues. Geospatial mapping of land cover (including forest cover) within the Beckett's Creek subwatershed should be updated on a regular basis to enable a long-term assessment of any changes.

Table 5-1 – Beckett's Creek Subwatershed Study Recommendations and Responsibilities

Recommendation	Responsibility	Triggers for Implementation
Identification of the Natural Heritage System		
Evaluate unevaluated wetlands within the Natural Heritage System (core areas and linkage areas) to determine whether they meet provincial criteria for significance.	City of Ottawa, Development Industry, Private Landowners	Any proposed development (except for a severance) that is located within 120 m of a wetland that lies within the Natural Heritage System (core areas or linkage areas) as identified on Schedule C11 of the Official Plan. Section 7.3 of the Official Plan provides policies to identify and protect significant wetlands. All evaluations shall be carried out using the methods from the Ontario Wetland Evaluation System.
Verify the extent of significant valleylands east of Birchgrove Road, east of Dunning Road and within Catchment A.	City of Ottawa, Development Industry	Future *Planning Act* applications adjacent to valleylands. The policies under Section 4.8.1 of the Official Plan apply to all Natural Heritage Features whether or not they appear on Schedules to the Official Plan.
Management of Natural Hazards		
Respect watercourse setbacks within the Village of Cumberland, the rural estate subdivisions and the subwatershed area in general.	City of Ottawa, RVCA, Development Industry, Private Landowners	Any alteration proposed to any watercourse within the study area may require a permit from the RVCA under Ontario Regulation 174/06. Section 4.9.3 of the Official Plan outlines the protection of surface water features. Section 69 of the Comprehensive Zoning By-law (2008-250) is the general provision for Setbacks from Watercourses.
Respect geotechnical setbacks within the villages of Cumberland and Sarsfield, the rural estate subdivisions and the subwatershed area in general.	City of Ottawa, RVCA, Development Industry, Private Landowners	Any proposed development or site alteration in an area that is identified on Schedule C15 of the Official Plan, or where site-specific information from the applicant, Conservation Authority or City staff indicates that unstable slopes may be present, may be required to complete a Slope Stability Assessment. Schedule C15 is not exhaustive and may not show all unstable slopes along the Beckett's Creek valley. Policies under sections 4.9.3 and 10.1 of the Official Plan address geotechnical hazards.
Evaluate the hazards associated areas of inferred karst topography.	City of Ottawa, Development Industry, Private Landowners	Future *Planning Act* applications within areas of inferred karst topography. Implemented under the policies in Section 11.8 of the Official Plan to provide direction for pre-consultations and required prescribed information. A detailed geotechnical study undertaken by a qualified professional shall be required before proceeding with development.
Evaluate the potential for retrogressive landslide hazards associated with sensitive marine clay soils and determine the extent of any hazards.	City of Ottawa, Development Industry	Future *Planning Act* applications within areas of sensitive marine clay soils, or where site-specific information from the applicant, Conservation Authority or City staff indicates a risk of landslide hazards. Implemented under the policies in Section 11.8 of the Official Plan to provide direction for pre-consultations and required prescribed information. A detailed geotechnical study undertaken by sensitive marine clay experts, including retrogressive landslide investigations and a review of the latest available LiDAR information, shall be required before proceeding with development.
Address the recurring erosion issues (gully erosion along the steep embankment) at the Old Montréal Road crossing of Beckett's Creek and re-evaluate the type of crossing structure.	City of Ottawa	Investigate the cause of the localized erosion and consider mitigative measures to improve energy dissipation and reduce erosion. Consider a more suitable crossing structure (span bridge instead of culverts) when this infrastructure is due for renewal.

Recommendation	Responsibility	Triggers for Implementation
Address the potential for water depths to exceed 0.3 m during the 1:20-year and 1:50-year flood events, thereby leading to unsafe access, along French Hill Road, Birchgrove Road, and Etienne Road.	City of Ottawa	Consider mitigative measures to reduce flood risk to the road segments identified in the RVCA's hazard mapping and provide safe access. Infrastructure renewal projects, such as road reconstruction and culvert replacements.
Protection of Groundwater Features		
Mitigate the potential for uncontrolled groundwater discharge to occur as a result of construction activities within or adjacent to the Vars-Winchester Esker, where it lies beneath the clay plain, by considering groundwater control.	Development Industry, Private Landowners	Construction activities, or other projects, occurring within or adjacent to the Vars-Winchester Esker that involve excavating and/or drilling.
Protect the form and function of the Vars-Winchester Esker by avoiding the creation of new sand and gravel pits within or adjacent to this feature.		Future requests to include additional pits in the vicinity of the Vars-Winchester Esker within the Sand and Gravel Resource Areas overlay of Schedule B-9 of the Official Plan. Additional hydrogeological studies undertaken by a qualified professional, to evaluate the role of the esker in maintaining base flow and stream temperatures and characterize the groundwater in the vicinity, shall be required before proceeding with the creation of any new pits.
Consider the potential vulnerability and hydrogeologic function of the Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers when reviewing development proposals.	City of Ottawa, Development Industry, Private Landowners	Future *Planning Act* applications for areas shown within Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers on Figure 10. Implemented under the policies in Section 11.8 of the Official Plan to provide direction for pre-application consultations and required prescribed information. Additional site-specific hydrogeological testing will be required to determine the effect of development on the vulnerability and hydrologic function of the aquifer.
Prepare detailed, site-specific hydrogeologic studies to support development applications in areas identified as having potential or inferred karst topography and/or thin soils during site investigations or based on regional mapping (if available/applicable).	City of Ottawa, Development Industry, Private Landowners	Future *Planning Act* applications for areas shown with karst geology on Figure 7 and/or thin soils on Figure 9. Implemented under the policies in Section 11.8 of the Official Plan to provide direction for pre-consultations and required prescribed information. A Hydrogeological and Terrain Analysis report, following applicable City Guidelines, may be required. An assessment of the vulnerability of the supply aquifer and the need for any mitigative measures shall be included.
Provide information at development pre-consultation that the groundwater quantity and quality is variable in parts of the study area and may not meet Provincial Guideline requirements to support private servicing. Prepare detailed, site-specific hydrogeologic studies to support development applications related to private servicing.	City of Ottawa, Development Industry, Private Landowners	Future *Planning Act* applications where private servicing will be used. Implemented under the policies in Section 11.8 of the Official Plan for the Development Application Review process. A Hydrogeological and Terrain Analysis report, following applicable City Guidelines, may be required.
Prepare a detailed Water Budget Assessment to identify the impacts of land use changes on the hydrologic cycle and the post-development targets needed to mitigate those impacts.	City of Ottawa, Development Industry	Future *Planning Act* applications, and for circumstances relating to Site Plan Control applications, as described in the City's Water Budget Assessment Terms of Reference (currently in draft, completion expected in 2023). Implemented under the policies in Section 11.8 of the Official Plan to provide direction for pre-consultations and required prescribed information.
Screen for the presence of former private landfill sites to determine if a landfill site is, or was, within 500 m of the proposed development.	City of Ottawa, Development Industry	Future *Planning Act* applications. Refer to the Historic Landfill Use Inventory database when reviewing development applications.

Recommendation	Responsibility	Triggers for Implementation
Promote proper decommissioning of abandoned wells, either privately or as a condition of development approval, to prevent contamination of the aquifer.	Private Landowners, City of Ottawa, RVCA	Grants for well decommissioning are available through the Ottawa Rural Clean Water Program (ORCWP); maximum grant is 90% up to $3,000 per well. Any property within the City of Ottawa is eligible, and applications are accepted year-round.
Promote proper construction and maintenance of private septic systems to protect groundwater and surface water quality.	Private Landowners, Ottawa Septic System Office	Grants for the repair/replacement of faulty septic systems are available through the ORCWP; maximum grant is 50% up to $2,000. Projects must be located within 50 m of a waterbody or a Wellhead Protection Area.
Consider the impacts of road salt application for the areas identified as a Significant Groundwater Recharge Area, a Highly Vulnerable Aquifer and/or with potential or inferred karst topography.	City of Ottawa, Private Landowners	Adopt a multifaceted approach to reducing the impact of winter salt application in these areas. Consider updates to salt management plans and education/outreach to contractors and homeowners.
Restoration of Natural Habitat		
Create or enhance vegetated riparian buffers, for new development and existing land uses, to prevent erosion, protect water quality, improve fish/aquatic habitat and increase the connectivity of the Natural Heritage System.	Private Landowners, City of Ottawa, RVCA	Grants are available through the ORCWP (e.g., watercourse buffers, erosion control, land retirement incentive) and assistance is available through the RVCA's Shoreline Naturalization Program. RVCA's Becketts Creek 2017 Catchment Report (Figures 41 and 42, shown in Appendix D) identifies various areas throughout the subwatershed that could benefit from restoration.
Undertake reforestation, tree planting and habitat restoration to enhance linkages along privately-owned portions of Beckett's Creek and elsewhere in the subwatershed.	Private Landowners, City of Ottawa, RVCA	Assistance and subsidies are available through the Green Acres program; requires a minimum 0.4 ha of suitable land and minimum order of 1,000 trees.
Undertake tree planting and shoreline naturalization on City-owned lands within the study area such as: • Cumberland Heritage Village Museum (2940 Old Montréal Road) • City property at 2830 and 2925 Old Montréal Road • Hillside Estates Park (2660 Pierrette Drive) • Wilfred Murray Park (1115 Dunning Road)	City of Ottawa – Forestry Services Department	Any City property in Ottawa meeting criteria for tree planting/naturalization projects. Potential projects require coordination with Forestry Services Department, and approval is dependent on available resources.
Develop and promote a vegetated buffer demonstration site along a municipal drain (or other suitable watercourse within the subwatershed) to educate landowners on techniques to stabilize stream banks and reduce erosion from fields while protecting local water quality and improving habitat.	City of Ottawa, RVCA, Private Landowners	Undertake as a partnership between the RVCA, City of Ottawa and a willing/supportive landowner on a case-by-case basis. The feasibility of a demonstration site could also be explored on City-owned lands (e.g., 2940 Old Montréal Road).
Protection of Surface Water Quality		
Manage surface water contamination (related to *E. coli* and phosphorus) from point and non-point source runoff.	Private Landowners, City of Ottawa, RVCA	Complete Environmental Farm Plans (EFPs) to increase environmental awareness and qualify for grants. Grants are available through the ORCWP (e.g., manure storage and treatment, nutrient management plan, precision farming, clean water diversion).
Farming operations adjacent to watercourses and/or ditches should include appropriate buffer strips (with a minimum width of 3 m) and/or barriers to help minimize disturbances and provide water quality management benefits.	Private Landowners, City of Ottawa, RVCA	Grants are available through the ORCWP (e.g., fencing and alternate watering to keep livestock away from watercourses, buffer strips, land retirement, cover crops).
Educate landowners on Agricultural Best Management Practices (BMPs) and funding available for projects.	City of Ottawa, RVCA	BMPs on farms are primarily encouraged through two programs: the ORCWP and the Province's Environmental Farm Plan Program, implemented by the Ontario Soil and Crop Improvement Association.

Recommendation	Responsibility	Triggers for Implementation
Promote tile drain control structures as a BMP for retaining water and nutrients on fields during the growing season, thereby improving water quality and crop yields and increasing resilience to changing climate conditions.	City of Ottawa, RVCA	Grants for tile drain control structures are available through the ORCWP; maximum grant is 75% up to $5,000. Any agricultural property within the City of Ottawa is eligible.
Identify and promote the preservation of low order and/or headwater streams.	City of Ottawa, Development Industry	Future *Planning Act* applications within or adjacent to a headwater drainage feature(s). Environmental Impact Study guidelines require a Headwater Drainage Feature Analysis, using the TRCA/CVC Headwater Drainage Feature Analysis Guideline.
Stormwater Management		
Address stormwater runoff within the villages and other rural residential developments to improve the water quality and attenuate peak flows.	City of Ottawa, Development Industry	Section 4.7 of the Official Plan provides policies for stormwater infrastructure. Also implemented through provincial legislation.
Consider opportunities to improve stormwater management within existing developed areas in the villages of Cumberland and Sarsfield and along existing infrastructure corridors.	City of Ottawa	Promote and implement stormwater management retrofit measures to improve the quality of runoff from areas that developed without stormwater treatment and/or through municipal infrastructure renewal projects (e.g., culvert replacements, road widening). Implement practices recommended through the Environmental Assessment Study for the proposed widening of Ottawa Regional Road 174 when this project proceeds.
Consider opportunities to implement stormwater management and drainage solutions that do not negatively impact natural features identified for protection.	City of Ottawa, Development Industry	Degraded streams should be rehabilitated in combination with the implementation of stormwater management to maximize benefits to servicing solutions and improve habitats.
Identify and consider opportunities for low impact development measures on City parcels.	City of Ottawa	Promote and implement low impact development solutions in concert with planned infrastructure renewal projects (e.g., roadway renewals, community centre projects).
Lot level measures can prevent pollutants from being picked up by runoff and minimize the amount of off-site drainage.	City of Ottawa, Private Landowners	Encourage private property owners to implement lot level measures for managing runoff (e.g., direct downspouts to lawn surfaces, install rain barrels, plant trees, establish rain gardens). Leverage the Rain Ready Ottawa program as an online educational tool to inform homeowners about common rainwater management projects.
Monitoring		
Continue surface water quality and aquatic habitat monitoring.	City Stream Watch Program – Conservation Authorities and Partners	The City Stream Watch program will continue to monitor and evaluate Beckett's Creek as part of its on-going program. The RVCA will conduct targeted monitoring in support of any stream rehabilitation or enhancement projects.
Continue baseline water quality monitoring program.	RVCA	RVCA staff will continue to collect baseline water quality data at two long-term sites on Beckett's Creek (at Old Montréal Road and at Birchgrove Road). The City is currently providing funding to support this data collection.
Update land cover mapping (including forest cover) and evaluate long-term trends.	City of Ottawa	City to acquire updated geospatial mapping of land cover on a regular basis.

6 References

AECOM. 2016. Ottawa Road 174 / County Road 17 Environmental Assessment Study – Environmental Study Report.

Armstrong, D.K. and J.E.P. Dodge. 2007. Paleozoic geology of southern Ontario. Ontario Geological Survey, Miscellaneous Release – Data 219.

Bishop, P.L., W.D. Hively, J.R. Stedinger, M.R. Rafferty, J.L. Lojpersberger, and J.A. Bloomfield. 2005. Multivariate analysis of paired watershed data to evaluate agricultural best management practice effects on stream water phosphorus. J. Environ. Qual. 34:1087-1101.

Brunton, F.R. and J.E.P. Dodge. 2008. Karst of southern Ontario and Manitoulin Island. Ontario Geological Survey, Groundwater Resources Study 5.

Chapman, L.J. and D. F. Putnam. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2.

Charron, J.E. 1978. Hydrochemical study of groundwater flow in the interstream area between the Ottawa and St. Lawrence Rivers. Scientific Series No. 76. Inland Waters Directorate, Water Resources Branch, Ottawa, Canada.

City of Ottawa. 2021 (as amended). Official Plan. Available online at https://ottawa.ca/en/planning-development-and-construction/official-plan-and-master-plans/official-plan.

City of Ottawa and National Capital Commission. 2020 Climate Projections for the National Capital Region. Available online at https://ottawa.ca/en/living-ottawa/environment-conservation-and-climate/climate-change-and-energy/climate-resiliency#climate-projections-national-capital-region-report.

City of Ottawa. 2020. Climate Change Master Plan. Available online at https://ottawa.ca/en/living-ottawa/environment-conservation-and-climate/climate-change-and-energy#climate-change-master-plan.

City of Ottawa. 2013. Transportation Master Plan. Available online at https://ottawa.ca/en/planning-development-and-construction/official-plan-and-master-plans#section-3db7e64d-70a3-46e9-a94c-ecefe23d4079.

Cummings, D.I. and H.A.J. Russell. 2007. The Vars-Winchester esker aquifer, South Nation River watershed, Ontario: CANQUA Fieldtrip, June 6, 2007. Geological Survey of Canada, Open File 5624.

Easton, Z.M., M.T. Walter, and T.S. Steenhuis. 2008. Combined monitoring and modeling indicate the most effective agricultural best management practices. J. Environ. Qual. 37:1798-1809.

Fisheries and Oceans Canada. 2020. Standards and Codes of Practice. Available online at https://www.dfo-mpo.gc.ca/pnw-ppe/practice-practique-eng.html.

Gassman, P.W., J.A. Tisl, E.A. Palas, C.L. Fields, T.M. Isenhart, K.E. Schilling, C.F. Wolter, L.S. Seigley, and M.J. Helmers. 2010. Conservation practice establishment in two northeast Iowa watersheds: Strategies, water quality implications, and lessons learned. J. Soil Water Conserv. 65:381-392.

Golder Associates. 2003. Final Report on Water and Wastewater Alternative Servicing Solutions Study, Village of Cumberland. City of Ottawa, Ontario. Two volumes.

Hunter, J.A., H.L. Crow, G.R. Brooks, M. Pyne, D. Motazedian, M. Lamontagne, A.J.M. Pugin, S.E. Pullan, T. Cartwright, M. Douma, R.A. Burns, R.L. Good, K. Kaheshi-Banab, R. Caron, M. Kolaj, I. Folahan, L. Dixon, K. Dion, A. Duxbury, A. Landriault, V. Ter-Emmanuil, A. Jones, G. Plastow, and D. Muir. 2010. Seismic Site Classification and Site Period Mapping in the Ottawa Area Using Geophysical Methods. Geological Survey of Canada, Open File 6273.

Jaynes, D.B., D.L. Dinnes, D.W. Meek, D.L. Karlen, C.A. Cambardella, and T.S. Colvin. 2004. Using the late spring nitrate test to reduce nitrate loss within a watershed. J. Environ. Qual. 33:669-677.

Lee, V.L. 2013. Aggregate resources inventory of the City of Ottawa, southern Ontario. Ontario Geological Survey, Aggregate Resources Inventory Paper 191, 80p.

Ministry of the Environment and Energy. 1994. Water Management Policies Guidelines Provincial Water Quality Objectives of the Ministry of Environment and Energy.

Ministry of the Environment, Conservation and Parks (MECP). 2019. 2017 Technical Rules Under the Clean Water Act (as amended). Available online at https://www.ontario.ca/page/2017-technical-rules-under-clean-water-act.

Ministry of the Environment, Conservation and Parks (MECP). 2019. Map: Permits to take water. Available online at https://www.ontario.ca/environment-and-energy/map-permits-take-water.

Ministry of the Environment, Conservation and Parks (MECP). 2018. Water Well Information System (Well Location and Summary). Available online at https://www.ontario.ca/environment-and-energy/map-well-records.

Ministry of the Environment, Conservation and Parks (MECP). 1996. D-5-5 Private Wells: Water Supply Assessment. Available online at https://www.ontario.ca/page/d-5-5-private-wells-water-supply-assessment.

Ministry of Municipal Affairs and Housing (MMAH). 2020. Provincial Policy Statement. Available online at https://www.ontario.ca/page/provincial-policy-statement-2020.

Ministry of Natural Resources (MNR). 1996. Hazardous Sites Technical Guide (Sensitive Marine Clays, Organic Soils and Unstable Bedrock).

Mississippi-Rideau Source Protection Region (MRSPR). 2007. Conceptual Understanding of the Water Budget. Available online at http://www.mrsourcewater.ca/en/library/reports.

Mississippi-Rideau Source Protection Region (MRSPR). 2009. Tier 1 Water Budget and Water Quantity Stress Assessment. Available online at http://www.mrsourcewater.ca/en/library/reports.

Mississippi-Rideau Source Protection Region (MRSPR). 2011. Assessment Report – Rideau Valley Source Protection Area. December 19, 2011. Available online at http://www.mrsourcewater.ca/en/library/reports.

Mississippi-Rideau Source Protection Region (MRSPR). 2014. Source Protection Plan, as approved August 27, 2014. Available online at http://www.mrsourcewater.ca/en/library/reports.

Ontario Geological Survey. 2010. Surficial geology of southern Ontario. Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised.

Raisin-South Nation Source Protection Region (RSNSPR). 2016. Assessment Report – South Nation Source Protection Area. Available online at https://yourdrinkingwater.ca/.

Raisin-South Nation Source Protection Region (RSNSPR). 2016. Source Protection Plan. Available online at https://yourdrinkingwater.ca/.

Regional Municipality of Ottawa-Carleton (RMOC). 1997. Natural Environment System Strategy (NESS).

Rideau Valley Conservation Authority (RVCA). 2007. City Stream Watch 2007 Annual Report. Available online at https://www.rvca.ca/watershed-monitoring-reporting/reporting/city-stream-watch-reports.

Rideau Valley Conservation Authority (RVCA). 2011. Becketts Creek 2011 Summary Report. City Stream Watch. Available online at https://www.rvca.ca/watershed-monitoring-reporting/reporting/city-stream-watch-reports.

Rideau Valley Conservation Authority (RVCA). 2014. Ottawa River Flood Risk Mapping from Shirley's Bay to Cumberland. Available online at https://www.rvca.ca/media/k2/attachments/Ottawa2014Mapping.pdf.

Rideau Valley Conservation Authority (RVCA). 2017. Becketts Creek 2017 Catchment Report. City Stream Watch. Available online at https://www.rvca.ca/watershed-monitoring-reporting/reporting/city-stream-watch-reports.

Rideau Valley Conservation Authority (RVCA). 2018. Becketts Creek Flood Risk Mapping from Sarsfield Road to Ottawa River. Technical Memorandum. Available online at https://www.rvca.ca/flood-risk-mapping-reports/becketts-creek-hazard-mapping-study.

Rao, N.S., Z.M. Easton, E.M. Schneiderman, M.S. Zion, D.R. Lee, and T.S. Steenhuis. 2009. Modeling watershed-scale effectiveness of agricultural best management practices to reduce phosphorus loading. J. Environ. Manage. 90:1385-1395.

Toronto and Region Conservation Authority and Credit Valley Conservation. 2014. Evaluation, Classification and Management of Headwater Drainage Features Guideline. Available online at https://files.cvc.ca/cvc/uploads/2021/06/HDFA-final.pdf.

Udawatta, R.P., J.J. Krstansky, G.S. Henderson, and H.E. Garrett. 2002. Agroforestry practices, runoff, and nutrient loss: A paired watershed comparison. J. Environ. Qual. 31:1214-1225.

Water Survey of Canada. 2019. Real-Time Hydrometric Data. Available online at https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html.