PLANNING AND GROWTH MANAGEMENT
URBANISME ET GESTION DE LA CROISSANCE

Mud Creek
Subwatershed Study

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Cover photo: Mud Creek upstream of pedestrian footbridge in Manotick (Amy MacPherson)

Preface

This Subwatershed Study has been completed by the City of Ottawa in cooperation with the Rideau Valley Conservation Authority. The project was led by staff from the City's Land Use and Natural Systems unit, in the Planning and Growth Management 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, City Stream Watch, and the Ministry of the Environment and Climate Change.

The original Existing Conditions report for the project was completed in 2009 by the City's consultant team, and is available under separate cover. Updated information used in this report was provided by the Rideau Valley Conservation Authority through its 2012 subwatershed reporting program and the 2014 City Stream Watch monitoring program.

Staff would like to thank the residents of the study area for their participation in the various public open houses, 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 Land Use and Natural Systems unit (LUNS) at the City of Ottawa.

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Executive Summary

The City of Ottawa initiated the Mud 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. Information was obtained from various reports and studies undertaken by the City and the Rideau Valley Conservation Authority. The Mud Creek subwatershed drains to the Rideau River just north of the Village of Manotick. The study area also includes Mahogany Creek, a small catchment adjacent to the Mud Creek system that drains to the Rideau River at Mahogany Harbour. Crop farming is the predominant land use in the study area, followed by natural areas (woodlands, wetlands and valleylands). Manotick is the largest settlement in the study area.

Issues and Opportunities

- Mud Creek is primarily a coolwater system with many species of fish, but water quality is being impacted by runoff from adjacent land uses. Vegetated buffers along the creek and its tributaries would help to reduce these impacts.
- The Kars Esker is a valuable source of groundwater, and is recognized in the Mississippi-Rideau Source Protection Plan as a highly vulnerable aquifer.
- Several woodlands and valleylands have been identified as significant features in the City's natural heritage system. There are also many unevaluated wetlands associated with the significant woodlands in the study area.
- Setbacks have been previously established in several locations within the Village of Manotick due to steep, unstable slopes along Mud Creek and its tributaries.
- The City has identified potential retrofit opportunities to improve stormwater management in existing developed areas within the Village of Manotick.

Recommendations

- Stewardship of the creeks and other natural features should be encouraged, using existing programs at the City and the Rideau Valley Conservation Authority (e.g., Ottawa Rural Clean Water Grants Program, RVCA Shoreline Naturalization Program, Green Acres, City Stream Watch).
- The significant groundwater recharge area (including the feature known as the Kars Esker) should be appropriately protected during the development review process.
- Additional sections of Mud Creek and its tributaries in and around Manotick that have been identified as significant valleylands or linkages should be added to the Natural Heritage System Overlay in the City's Official Plan. The unevaluated wetlands are not being added to the Overlay, but should still be considered subject to the Official Plan policies for protection of the Natural Heritage System.
- Existing setbacks along the creeks within Manotick must be respected, to reduce risks of property damage and environmental impacts.
- The City should consider opportunities to improve stormwater management in existing developed areas within the Village of Manotick as part of future renewal projects involving roads and other public facilities.

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1.0 Introduction and Background

1.1 Study Purpose

The Mud Creek Subwatershed Study (the Study) will 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'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.
- Section 5 – Presents the subwatershed plan, with recommendations for preserving and enhancing natural features within the study area.

The Mud Creek Subwatershed Study was completed in parallel with the Manotick Secondary Plan update (see Section 1.4 below). Information obtained through this Study has been used in the review of the Secondary Plan's policies and schedules, and vice versa.

1.2 Study Area

The study area, located in the southwestern part of the City of Ottawa, is shown on Figure 1. It is comprised primarily of the Mud Creek subwatershed, which drains into the Rideau River near the northern limit of the Village of Manotick. The study area also includes the adjacent Mahogany Creek catchment that drains into the Rideau River within the Village of Manotick. The boundaries of these catchment areas have been reviewed as part of this study, using recent (2014) aerial photography and Lidar data along with field observations in 2014 and 2015. The total study area is approximately 6,351 hectares (ha) in size. It includes part of Manotick (west of the Rideau River) and extends westwards approximately to Malakoff Road, south to Pollock Road and north to Trail Road (at Highway 416). Highway 416 bisects the subwatershed, crossing over Mud Creek and several of its tributaries.

1.3 Study History

The City of Ottawa (City) initiated the joint Jock River Reach 2 / Mud Creek Subwatershed Study in late 2003 with support from the Rideau Valley Conservation Authority (RVCA) and other regulatory agencies. Marshall Macklin Monaghan Limited (MMM) and Water & Earth Sciences Associated (WESA) were retained to develop the existing conditions report and subsequent subwatershed plan.

Based on background research, field investigations and consultation with residents and relevant agencies, a draft existing conditions report was prepared in 2005. At about this time, a public controversy arose regarding the proposed designation of additional significant wetlands in Goulbourn. The proposal was not part of the subwatershed study process, but did have significant implications for the Jock River Reach 2 portion of the study area. The study was put on hold pending resolution of the wetland issue, then was subsequently split to allow

the Mud Creek Subwatershed Study to proceed separately from the Jock River Reach 2 Subwatershed Study.

The draft existing conditions report for both subwatersheds was finalized and submitted to the City in 2009. The subwatershed plan did not proceed at that time, however, and the contract with the consulting team was terminated. That report, including the Figures (Volume 2) and the Appendices (Volume 3) can be obtained from City staff upon request along with other documentation reviewed during the preparation of this subwatershed study.

City staff reviewed the existing conditions report in 2011, and began identifying environmental issues and opportunities for improvement in 2012. However, staff recognized that the existing conditions information was becoming outdated, given the changes in local conditions, land uses and applicable policy framework over time. The Rideau Valley Conservation Authority's subwatershed report card for the Lower Rideau River (including the Mud Creek catchment) provided some new information in 2012. Further research and field work was carried out by the City and RVCA in 2014. The development of the subwatershed plan was officially re-started in late 2014, with a public Open House held in conjunction with the Manotick Secondary Plan Review project in November. A technical working group meeting was held in May 2015 with representatives from various City departments, the Rideau Valley Conservation Authority, and the Ministry of Environment and Climate Change. The draft subwatershed study report was circulated to the working group for review in fall 2015.

1.3.1 Public Consultation Overview

The initial Jock River Reach 2 / Mud Creek Subwatershed Study terms of reference called for an extensive public consultation program through a communications plan. The intent of the communication plan was to engage the community in the subwatershed planning process by receiving their input on subwatershed issues, local knowledge, community interests and activities, and public perception of the subwatershed areas. The terms of reference described two open houses, community bulletins, a workshop, a community survey, a subwatershed tour, and community representation on the steering committee. All of these measures, plus others in a more current communications plan, were completed.

Two public open houses (POHs) and a mail-out survey were conducted in the early stages of this study, before it was put on hold. The first POH was held in December 2003, before the field surveys began, to announce the study. The second POH was held in June 2005 to present the draft existing conditions report's findings and obtain feedback from residents. Public comments received are documented in the appendices of the Jock Reach 2 & Mud Creek Subwatershed Existing Conditions Report (MMM/WESA, 2009).

The early phases of this study also involved a Steering Committee (comprised of City staff and agencies) and a Public Advisory Committee formed of interested community representatives. Both of these committees had a Terms of Reference, and various meetings and workshops were held between 2003 and 2005. More information can be found in the existing conditions report (MMM/WESA, 2009).

When the project was re-launched in 2014, public consultation resumed in conjunction with the ongoing Manotick Secondary Plan Review. Ninety-three people attended a joint POH on November 29, 2014 at the Rideau Valley Conservation Authority headquarters. City and RVCA staff were on hand to explain the display boards for both studies, answer questions, and solicit feedback. Copies of the Mud Creek displays and a summary of feedback received are presented in Appendix A.

Approximately 43 people attended the final joint open house at the RVCA headquarters on June 27, 2015. Draft recommendations for the subwatershed plan were presented, along with maps showing the revised study boundaries, proposed changes to the natural heritage system, and hydrogeological features (see Appendix A).

After each open house, the materials shown at the meeting were made available on the project website for residents to review and provide comments. In late July 2015, the draft Manotick Secondary Plan and associated Official Plan and Zoning By-law amendments were made available for review on that project's website. This included the proposed Official Plan Amendment to update Schedule L, the Natural Heritage System Overlay, which can be found in Appendix A. All property owners affected by the proposed changes to Schedule L were mailed a copy of the proposed amendment. The amendment was proposed to implement certain recommendations contained in this report regarding the identification of natural heritage features.

1.4 Manotick Secondary Plan Review

Manotick is one of the largest villages in the City of Ottawa. It is located along the Rideau River, south of the urban boundary, and east of First Line Road (see Figure 1). Development within the Village is guided by a Secondary Plan, which includes strategies and policies to implement higher-level planning policies in the Official Plan. City Council directed staff in 2012 to undertake a review of Manotick's Secondary Plan as a result of a broader review of all of the rural village plans.

Starting in 2014, the City worked with the residents of Manotick to review and update their Secondary Plan. Extensive public consultation was undertaken to identify and resolve local planning issues. The Mud Creek Subwatershed Study's findings were used to inform the environmental policies in the new Secondary Plan. The review also ensured that the Secondary Plan's policies aligned with the policies of the Official Plan, which had been reviewed and amended in 2013.

An Official Plan Amendment was required to replace the existing secondary plan with the new Manotick Secondary Plan. It also included amendments to Official Plan schedules and policies related to Permitted Uses in Villages, such as:

- Providing ways to strengthen the character areas that comprise the Village Core;
- Identifying areas suitable for increased residential densities, subject to provision of public servicing;
- Identifying future networks to improve connectivity throughout Manotick;
- Identifying strategies to improve parking and traffic in the core;
- Identifying policies to guide expansion of central services (water and wastewater); and
- Amending the Official Plan Schedule L – Natural Heritage System Overlay with an updated schedule, to reflect changes identified through this subwatershed study.

1.5 Manotick Special Design Area Environmental Management Plan

The Manotick Special Design Area (SDA) consists of several large parcels of land located in the northwestern part of the Village, between Mud Creek and First Line Road, and south of Bankfield Road. The original secondary plan for the Village of Manotick designated this area for development as single family estate housing on large lots, with private servicing, and open

space. As part of the original Jock River Reach 2 / Mud Creek Subwatershed Study, an Environmental Management Plan (EMP) was prepared to address environmental issues within the Special Design Area and provide guidance to subsequent subdivision planning.

The Manotick SDA EMP was initiated in February 2005. Originally, the goal was to complete the EMP in parallel with the finalization of the existing conditions report for the Jock River Reach 2/ Mud Creek Subwatershed Study. The purpose of the EMP was to provide detailed recommendations specific to the needs of the developing SDA lands, within the broader framework established by the subwatershed study (MMM/WESA, 2006).

The EMP followed the Master Plan approach of the Class Environmental Assessment process; and included recommendations for the protection of natural features such as the Kars Esker, the Mud Creek valley and the associated woodlands, as well as conceptual stormwater management design criteria. These recommendations are being implemented through the development review process for the various plans of subdivision in the Special Design Area.

The Environmental Management Plan specifically addressed the private servicing needs of development and the hydrogeological conditions of the Special Design Area. It was determined through significant examination and study that a portion of lands that run along First Line Road on the westerly boundary of the SDA are part of the Kars Esker (a hydrogeologically sensitive feature) and should be protected as a groundwater recharge area.

The recommendations from the EMP were incorporated into the SDA Concept Plan. The Concept Plan and the EMP were both approved by City Council July 11, 2006.

The Manotick SDA EMP, as originally intended, has now been integrated with the Manotick Secondary Plan (2015) and the Mud Creek Subwatershed Study. The EMP only dealt with the SDA lands and provided a summary of recommendations related to environmental constraints and opportunities, and stormwater management recommendations applicable to that area. The recommendations were site-specific but where appropriate, have been incorporated into the overall Manotick Secondary Plan and subwatershed plan recommendations, which can be found in Section 5.0 of this report.

1.6 Mahogany Community Plan (Manotick)

The Mahogany Community is located in the southern part of the Village of Manotick, between Manotick Main Street and Mud Creek, and north of Century Road East. It consists of approximately 194 hectares of former farm fields and forests, and includes parts of both the Mahogany Creek and Mud Creek subwatersheds. A concept plan for this area was developed in 2008 and incorporated into the Manotick Secondary Plan. It can be found on Schedule C in the Manotick Secondary Plan (2015).

The area will be developed over many years, with a mix of low- to mid-density residential uses on municipal services, along with supporting uses such as schools, parks and open spaces. Measures for the protection of Mahogany Creek, Mud Creek and the various tributary watercourses that traverse the property were established in the concept plan. The Manotick Drumlin Woods, located in the middle of the property, was also identified in the plan as a significant feature that should be protected through acquisition by the City; or, if acquisition is not feasible, through the development review process.

1.7 Greenbank Road / Southwest Transitway Extension Environmental Assessment

The City of Ottawa conducted a Schedule C Municipal Class EA for the extension of the realigned Greenbank Road and Southwest Transitway, and operational improvements to three intersections near the Village of Manotick (MMM Group, 2014). The purpose of this study was to develop a plan for the southward extension of the realigned Greenbank Road and Southwest Transitway through the designated Urban Expansion Study Area in Barrhaven South. The study also needed to identify ways to improve traffic flow through three key intersections between Manotick and Barrhaven: Prince of Wales Drive and Bankfield Road, Prince of Wales Drive and Greenbank Road, and Bankfield Road and First Line Road. These transportation projects have all been proposed in response to the planned growth in Barrhaven South and Manotick, and anticipated increases in associated traffic volume in the area.

The southernmost end of the new roadway, and the three intersection improvement projects, are located within the Mud Creek subwatershed, on or in the vicinity of the Kars Esker. The existing four-way signalised intersection at Prince of Wales Drive and Bankfield Road will be replaced with a two lane roundabout, to promote better traffic flow through this busy crossroads. To the north, the Prince of Wales Drive and Greenbank Road intersection will be modified to correct its geometry and promote better operational performance and safety. Traffic flow through the existing T-intersection at Bankfield Road and First Line Road will be reduced by providing a new direct connection between First Line Road and Prince of Wales Drive, south of Bankfield Road (across the esker). The new intersection on Prince of Wales Drive will be a two-lane roundabout.

The implementation of these transportation projects will depend on available funding and Council priorities. None of them were included in the affordable network proposed in the City of Ottawa Transportation Master Plan, 2013. Therefore, they may not occur until after the current planning horizon of 2031.

1.8 Manotick Water Main Environmental Assessment

The City of Ottawa has initiated the Manotick Watermain Link (MWL) Class Environmental Assessment (Class EA) and Functional Design Study. The main objective of the study is to provide reliability and additional capacity to the central water supply in the Village of Manotick. Capacity is needed to facilitate new development as well as to provide for servicing of existing residents wanting access to the central water supply. Reliability will be achieved by providing an alternative supply to the existing feedermain from Barrhaven, past Riverside South to Manotick. The project is identified in the City's current Infrastructure Master Plan.

The Environmental Assessment identified the preferred route in late 2014, and preparation of the functional design is now under way. Key issues considered during the EA were waterbody crossings, secondary connections, extent of watermains, species at risk protection, and environmental sensitivities such as geotechnical and hydrogeological constraints.

2.0 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 2009. The Provincial Policy Statement was updated in 2014. The City's Official Plan and its schedules have also been updated, and the Official Plan now contains more comprehensive polices regarding urban boundary expansions, the natural heritage system, agriculture, aggregate resources, stormwater management, and environmental protection.

2.1 Provincial Policy Statement

The Provincial Policy Statement (PPS), which came into effect on April 30, 2014, is issued by the Ministry of Municipal Affairs and Housing (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, 2014).

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 ground water 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, among other things.

2.2 City of Ottawa Official Plan

The City's 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 Provincial Policy Statement. Section 2.4.2 of the Official Plan describes the City's natural heritage system, its features and functions, and how the City will protect this system. Section 2.4.3 of the Official Plan establishes the goals and requirements for subwatershed studies. Environmental policies relating to development review, including recognition of environmental constraints, are found in Section 4.7 of the Official Plan.

Policies governing designated land uses are found in Section 3 of the Official Plan. Land use is one of the primary factors determining the hydrologic response and overall health of a subwatershed. Figure 2 illustrates that the majority of the land within this study area is designated Agricultural Resource Area (Section 3.7.3 of the Official Plan). Farming practices can affect the quantity and quality of water resources. Other land uses in the Mud Creek subwatershed include aggregate extraction and various other rural uses.

The Village of Manotick is the largest settlement within the study area. Settlement areas can have significant impacts on water quantity and quality, as a direct result of development and associated changes in stormwater runoff. Land uses within the village are governed by a Secondary Plan, which has just undergone a comprehensive review. The Secondary Plan is consistent with the City's Official Plan, but provides more detailed guidance on land uses and development within the Village.

2.2.1 Natural Heritage System

The following components of the City's natural heritage system, as defined in Section 2.4.2 of the Official Plan, have been identified within or in proximity to the study area, and are addressed in this report:

- Significant habitat for endangered and threatened species (potential to be confirmed through an Environmental Impact Statement (EIS));
- Significant woodlands (see note below);
- Wetlands found in association with significant woodlands;
- Significant valleylands (Mud Creek and various tributaries, primarily in the vicinity of the Village of Manotick);
- Significant wildlife habitat (potential to be confirmed through an EIS);
- Life and earth science areas of natural and scientific interest (candidate only – Manotick Drumlin Forest);
- Linkages (primarily along the Wilson Cowan Drain and its tributary);
- Groundwater features; and,
- Surface water features.

Significant woodlands have been previously identified in the rural area using the City's criteria in Section 2.4.2 of the Official Plan, and mapped as part of the Natural Heritage System overlay on Schedule L in the Plan. However, with the adoption of the new Provincial Policy Statement in 2014, the criteria for determining woodland significance need to be updated. Significant woodlands will therefore need to be redefined and remapped throughout the City using the provincial criteria. Information gathered as part of this subwatershed study will be considered when applying the criteria to this part of the City. The new definition and mapping will be brought to Council for approval as an amendment to the City's Official Plan.

3.0 Existing Conditions Summary

Numerous field investigations by various parties have occurred during the course of this study. The original study's consulting team conducted field work in 2004, as part of their work plan to develop the existing conditions report. Their methods and findings are detailed in that report (MMM/WESA, 2009).

City and RVCA staff have conducted field investigations on various dates between 2003 and fall 2015, to inform this study and to support the development review process for local applications. RVCA staff also worked with community volunteers to assess the condition of Mud Creek through the City Stream Watch program in the summer of 2014.

Field work was conducted on the Mahogany Community lands by EcoTec Environmental Consultants, to support the community planning process in that area. Preliminary investigations began in late 2006, and were followed up with detailed terrestrial and aquatic habitat assessments in 2007.

MMM Group carried out field investigations in the summer of 2013, to support the Greenbank Road / Southwest Transitway extension. These investigations included terrestrial and aquatic habitat assessments in the northeastern part of the Mud Creek Subwatershed.

Relevant information from all of these sources, along with existing background information, has been included in the following sections. A selection of photographs taken during the fieldwork is included in Appendix B.

3.1 Land Cover

Land cover mapping was obtained from the Rideau Valley Conservation Authority, from their 2012 watershed report card work. More recent information on the unevaluated wetlands in the area was obtained by reviewing the City's 2014 aerial photography and Lidar mapping. Figure 3 shows both the RVCA land cover information from 2012, and the City's wetland cover mapping from 2014.

Agriculture is by far the largest land use in the subwatershed (63%). This category includes both cropland and pasture. Based on the City's field observations in 2014-2015, most of the agricultural lands in the study area are cultivated, with relatively little livestock farming. Several fields had recently been improved with tile drainage (see Appendix B, Photos 37 and 38) and some reclamation of previously wooded or shrubby lands to active production was also noted. Grassy or otherwise vegetated buffers were present along the creeks and their tributaries in agricultural areas, but these tended to be extremely narrow, particularly along the smaller tributaries (see photos in Appendix B).

The second largest land cover category is woodlands (19%) which are scattered throughout the study area. The largest woodlands are located in the Mud Creek subwatershed. Settlement areas (including the Village of Manotick) are the third largest land use (almost 10%). Unevaluated wetlands cover 9% of the study area, mostly in the Mud Creek subwatershed. As shown on Figure 3, many of these wetlands coincide with woodland areas, which may account for the apparent discrepancy between the RVCA's wetland mapping and the City's (i.e., the RVCA chose to categorise these lands as woodlands rather than wetlands in their analysis). Several large wooded wetlands (swamps) located around the edges of the Mud Creek subwatershed appear to function as headwater features (see Section 3.3.3 below).

3.2 Surface Water Features

As noted previously, the study area includes the Mud Creek subwatershed and the much smaller Mahogany Creek subwatershed, both of which drain into the Rideau River in Manotick (Figure 4). The hydrologic regime of Mud Creek influences all aspects of subwatershed health, e.g., aquatic habitat, water quality, and geomorphology. The regime is partially controlled by natural factors (e.g., climate, heavy clay soils) and partially by man-made factors (e.g., village development, municipal drains and tile drainage).

The Mud Creek system features a combination of natural, meandering creeks and modified drainage channels. Mud Creek itself is mostly meandering, with a well-defined valley downstream of Second Line Road. The valley's slopes are known to be unstable and prone to erosion, particularly within the Village of Manotick. Extensive portions of Mud Creek and its tributaries are legally defined as municipal drains under the Drainage Act (see Figure 5, and Section 3.2.3 below). Headwater features in some parts of the subwatershed have been replaced with tile drainage systems. While many of the headwater features and minor tributaries are intermittent, persistent late-summer flow was observed in a few locations during City field work in 2014.

Flood plain mapping of the main branch of Mud Creek from First Line Road to the Rideau River was completed as part of the Manotick SDA EMP, but has generally not been undertaken upstream of First Line Road. Flooding under 1:100 year conditions will be contained within the watercourse's well-defined valley, in the reach where mapping is available (RVCA, 2012).

The Mahogany Creek system has been extensively modified through private efforts to improve drainage from the agricultural lands south of the Village of Manotick. It is a small creek with limited natural cover. The downstream end of the creek acts as a backwater for the Rideau River. Within the Village, this creek is undergoing habitat restoration work associated with the development of the Mahogany Community lands (J. Lamoureux, RVCA, pers. comm. May 2015).

3.2.1 Surface Water Quality

Water quality and biological sampling programs are carried out in the main channel of Mud Creek on a regular basis by the City and the RVCA. The City's permanent water sampling location for Mud Creek is at Bankfield Road. The RVCA catchment report (2012) included an assessment of the water quality data for the creek, and concluded that water quality in the creek had declined from "fair" in 2000-2005 to "poor" in 2006-2011. Issues with nutrient loading, bacterial counts and metals concentrations were noted. Similarly, benthic macroinvertebrate sampling on Mud Creek at Bankfield Road has also shown "poor" results for the 2006-2011 time period (RVCA, 2012). Benthic surveys by the original study team showed "fairly poor" to "fair" results at all sampling stations (MMM/WESA, 2009).

The previous existing conditions report for Mud Creek had also identified issues with bacterial contamination and nutrients in some locations within the subwatershed (MMM/WESA, 2009). The consultants' analysis was based on data from 27 sampling locations within the subwatershed completed by the City over the period since 1998. Data are collected monthly and are predominantly dry weather flow related.

To provide an overview of the status of water quality across the subwatershed, an index of water quality developed by the Canadian Council of Ministers of the Environment (CCME) was

calculated from the available data. This uses information on 13 varied water quality parameters to provide an index which ranges from “poor” (values between 0 and 44) to “excellent” (values 95 to 100). Data for several individual representative water quality parameters (total suspended solids, phosphorus, nitrate and nitrite, copper, E-coli and temperature) were analysed and mapped for Mud Creek as part of the 2009 existing conditions report.

The results indicated:

- There had been no obvious change in values over the past 10 years of sampling;
- There was no significant difference between wet and dry weather samples, except for E-coli, which were 3 – 4 times higher under wet conditions;
- There was contamination of surface water by fecal material, likely from livestock and septic systems;
- Nutrient levels (represented by total phosphorus, and nitrate and nitrite) generally exceeded Provincial Water Quality Objectives (PWQO) but less frequently and less severely east of First Line Road;
- Levels of suspended solids were low. This is probably due to low flows during the sampling period and low stream gradients which cause the suspended material to settle in the channels during dry periods rather than be transported downstream. This is substantiated by the geomorphic surveys that showed many areas where sediment was accumulating;
- There were no major concerns over heavy metals (represented by copper) which generally met PWQO east of First Line Road, but were slightly higher to the west;
- Water temperatures were relatively cool (< 22^{o}C) across the subwatershed and very cool (<18^{o}C) east of First Line Road, due to the groundwater influence of the Kars Esker.

The existing conditions report concluded that Mud Creek surface water quality, based on the Canadian Council of Ministers of the Environment Water Quality Index was “marginal” for all areas west of First Line Road. Individual stations in the Mud Creek subwatershed fell either in the “marginal” or “poor” range in most reaches. Water quality conditions improved somewhat east of First Line Road and fell in the “fair” range. Individual stations were classified as either “fair” or “good” on the main branch east of First Line Road. This appeared to be related to inputs of cooler clean water from the Kars Esker which Mud Creek intersects in this area. The consultants’ analysis of surface water quality over several years and in drier and wetter flow conditions did not indicate a trend toward declining water quality in the subwatershed. However, as the RVCA’s more recent analysis shows, there may now be evidence of a decline occurring (RVCA, 2012).

Mahogany Creek and Mud Creek’s tributaries are not subject to ongoing water quality monitoring, but sampling was undertaken at a few locations as part of the field work by the original study team. According to the 2009 existing conditions report, water quality data for Mud Creek’s tributaries and for discharges from individual storm sewer outfalls were generally in the “marginal” range (MMM/WESA, 2009). In one case along the Wilson Cowan Drain, however, the index fell into the “poor” range, with notably higher copper levels, likely due to discharge of untreated storm runoff from the adjacent developed area. The unnamed tributary below the Thomas Baxter Drain, downstream of Prince of Wales Drive, was rated as “fair”.

There has been very little analysis of benthic macroinvertebrates in Mud Creek’s tribututaries. The MMM/WESA existing conditions report identified only two sampling stations, one on the Wilson Cowan Drain (very close to its outlet to Mud Creek) and one on the unnamed tributary

that crosses First Line Road near the south end of the Special Design Area (upper reaches of this tributary include the Thomas Baxter Drain). Results from those stations indicated "poor" water quality on the unnamed tributary at First Line Road, and "fairly poor" quality on the Wilson Cowan Drain (MMM/WESA, 2009).

3.2.2 Surface Water Quantity

The existing conditions report for Jock Reach 2/Mud Creek (MMM/WESA, 2009) assessed streamflow at two locations within the Mud Creek subwatershed: Mud Creek (main branch) at Bankfield Road; and Wilson Cowan Drain at Bankfield Road. A majority of the flow volume and the highest peak flows occur in the spring time. 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 till which have low infiltration capacity – hence there is a high proportion of runoff to infiltration;
- The majority of the area is cleared and therefore there is little water retention by vegetation, particularly in the spring when soils are frozen and saturated before the crops grow;
- A significant part of the area (22%, at that time) is drained by tile drains and municipal drains. These promote more rapid removal of water to extend the growing season, and result in lower moisture content in summer.

Hydraulic models are used to estimate the potential for flooding, prepare floodplain mapping, and to complete stormwater management studies and water budgets. The 2009 existing conditions report detailed the preparation and testing of a hydraulic model for the Mud Creek subwatershed (MMM/WESA, 2009), in Volume 2: Figures; and also Volume 3: Appendices.

The Manotick SDA EMP (MMM/WESA, 2006) also included a hydraulic model for the study area, which is detailed in that report.

3.2.3 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 5, many of the watercourses within the study area, including long segments of Mud Creek itself, are municipal drains. Mud Creek has approximately 107 km of stream of which about 64 km (60%) are municipal drains. Municipal drains and tile drainage rapidly remove water from fields in spring, permitting earlier planting. Without this, many fields would be unproductive due to water logging and reduced growing season. In some cases, as for Mud Creek, natural watercourses have been converted into municipal drains. In other cases, the drain was constructed specifically to facilitate the conveyance of water out of an area.

While many of the municipal drains within the study area were established decades ago (Mud Creek itself was converted into a municipal drain as early as 1900) a few drains have also been established more recently (e.g., David Adams, converted in 2013). 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 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 Mud Creek subwatershed, several drains have been altered in recent years through realignment, or have been formally abandoned in favour of tile drainage. Figure 5 reflects the most current information available at the time this study was prepared. The City's Municipal Drainage unit maintains this information and should be consulted prior to undertaking any works involving municipal drains.

3.2.4 Geomorphology

A detailed study of the geomorphology of Mud Creek (Parish, 2004) indicated that the majority of first and second order streams were either man-made or had been modified (straightened) to create agricultural drains. These first and second order streams were found to be dynamically unstable, i.e., out of balance with their natural flow and sediment transport regimes.

High migration rates on the main branch of Mud Creek indicated possible instabilities. As with the smaller order streams, Mud Creek and many of its tributaries have been altered in form due to land use practices including agriculture and to a lesser extent residential development. These alterations include channel realignment (i.e., straightening) and loss of in-water habitat diversity including in-water cover habitat and channel morphology.

Many of the tributaries to Mud Creek have low gradients which limit flow velocities and sediment transport, resulting in aggradation (sediment accumulation) in many reaches. This reduces the flow capacity of the drains and any potential fish habitat. Some of the lower reaches exhibited signs of erosion of the stream banks and valley walls, probably due to high spring flow rates.

Meander belt widths were estimated for the remaining natural sections of Mud Creek. They vary between 15m and 60m, being generally greater at the downstream end of the subwatershed than at the upper end, with 60m meander belts around Bankfield Road and further south (upstream) of Century Road East.

3.2.5 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, stream and creeks. Erosion and the formation of slopes is a natural part of the evolution of the topography.

Large portions of the Mud Creek system are considered to have unstable slopes as shown on Schedule K – Environmental Constraints of the City's Official Plan. This includes Mud Creek itself as far upstream as Prince of Wales Drive, the Wilson Cowan Drain and its tributary within

the Village of Manotick, and the David Adams Municipal Drain. Within the Village of Manotick, these constraints are included on Annex 2 of the Secondary Plan. Schedule K and Annex 2 provide for early identification of slope stability concerns but do not provide enough detail to assess constraints on specific sites. Under the policies of the Official Plan, therefore, site-specific slope stability assessments will be required to support development applications on properties identified as being affected by unstable slopes.

3.3 Fish and Aquatic Habitat Assessment

3.3.1 Mud Creek

Mud Creek is considered a cool water system, particularly in the lower reaches due to groundwater inputs from the Kars Esker. As previously stated, the 2009 existing conditions report noted maximum temperatures were generally less than 22°C, with only a few stations ranging as high as 28°C. The coolest temperatures (<18°C) were found between First Line Road and Bankfield Road. The RVCA catchment report used temperature data from three stations sampled in 2008 to classify the creek as a cool water system (RVCA, 2012). More recent temperature data obtained by the City Stream Watch program (CSW, 2014) indicated that the creek ranges from cool to warm water in most of the reaches studied (i.e., Third Line Road, Prince of Wales, Bankfield Road crossings) with cool water in the vicinity of the esker (i.e., Century Road East crossing). These results are supported by the fish communities present, which are dominated by cool water species and include cold water indicator species (e.g., mottled sculpin) in the coolest reaches (MMM/WESA, 2009; CSW, 2014).

Surveys by various study teams over the years have shown that Mud 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's 2014 field work). Up to 36 species of fish have been reported from the lower reaches of Mud Creek, downstream of First Line Road; however, even the upper reaches sampled (at Third Line Road North and Century Road West) support several different species, including muskellunge (RVCA, 2012; CSW, 2014). See Figure 6 for the locations of the fish sampling stations included in Table 3-1.

The habitat characterization work done by the City Stream Watch program (CSW, 2014) shows that in-stream habitat along the main channel of Mud Creek is predominantly characterized by shallow runs (rather than pools or riffles) over clay and silt substrate, with some sandy areas in the vicinity of the Kars esker. Cobble and boulders are present in many parts of the creek but do not dominate the substrate. Shade from grasses and overhanging trees is generally low to moderate for most of the creek's length, with a few well-shaded locations scattered throughout. Vegetation and woody debris provide cover for fish and other aquatic organisms within the creek, along with some undercut banks in the valley segments downstream of Century Road East. The RVCA has identified several opportunities for aquatic habitat restoration or enhancement along Mud Creek as described in Section 5.0, Subwatershed Plan, and shown on Figure 10.

Table 3-1: Fish Species Reported from Mud Creek

Species	Rideau Valley Dr.	Bankfield Rd.	Pedestrian Bridge	Gray Willow Dr.	First Line Rd.	Century Rd. East	Second Line Rd.	Prince of Wales Dr.	Third Line Rd.	Century Rd. West
Banded killifish	-	-	-	-	-	-	1, 2	2	-	-
Blackchin shiner	2	2	-	2	-	-	2	-	-	-
Blacknose dace	2	-	1, 2	-	-	-	-	-	-	-
Blacknose shiner	1, 2	1	-	1	1, 2	-	1	-	-	-
Bluegill	2	2	-	-	-	-	-	-	-	-
Bluntnose minnow	2	2	2	1, 2	1, 2	2	-	-	2	-
Brook stickleback	1, 2	1, 2	2	1, 2	1, 2	2	1, 2	1, 2	1, 2	1, 2
Brown bullhead	2	2	-	-	-	-	-	-	-	-
Central mudminnow	1, 2	2	2	1, 2	2	2	1, 2	1, 2	1, 2	1, 2
Common shiner	2	1, 2	1, 2	1, 2	1, 2, 3	-	-	-	-	1, 2
Cottus sp. (sculpins)	-	2	2	2	-	-	2	-	-	-
Creek chub	1, 2	1, 2	1, 2	1, 2	1, 2, 3		1, 2		1, 2	1, 2
Cyprinidae (minnows)	2	2	-	-	-	-	-	-	2	-
Etheostoma sp. (darters)	1, 2	1, 2	1, 2	2	1	-	-	-	-	-
Fallfish	1, 2	2	-	-	-	-	-	-	-	2
Fathead minnow	-	-	-	-	3	2	1, 2	1, 2	2	1, 2
Finescale dace	-	-	-	-	3	-	-	-	-	-
Golden shiner	1, 2	1, 2	-	-	-	2	-	2	2	2
Hornyhead chub	-	2	-	-	-	-	-	-	-	-
Lepomis sp. (sunfishes)	-	1, 2	-	-	-	-	-	-	-	-
Largemouth bass	1, 2	-	-	-	-	-	-	-	-	-
Logperch	1, 2	-	-	-	-	-	-	-	-	-
Longnose dace	2	2	2	-	1, 3	-	-	-	-	-
Mottled sculpin	2	1, 2	1, 2	1	1, 2, 3	-	1	-	-	-
Moxostoma sp. (redhorse)	2	-	-	-	-	-	-	-	-	-
Muskellunge	-	-	-	-	-	-	-	-	-	2
Northern pike	-	-	-	-	3	-	-	-	-	-
Northern redbelly dace	-	2	2	1, 2	2	2	1, 2	1, 2	2	1, 2
Pearl dace	-	-	-	2	1	-	-	1, 2	-	-
Pumpkinseed	2	1, 2	2	-	-	-	-	-	-	2
Rock bass	1, 2	1, 2	1, 2	1, 2	1, 3	-	-	-	-	-
Smallmouth bass	2	-	-	-	-	-	-	-	-	-
Walleye	1, 2	-	-	-	-	-	-	-	-	-
White sucker	1, 2	1, 2	1, 2	2	1, 2	-	1, 2	1, 2	1, 2	1, 2
Yellow perch	2	2	-	-	-	-	-	-	-	-
Unknown	-	1	-	-	-	-	1	-	-	-
Total Species: 36	**25**	**24**	**14**	**14**	**16**	**6**	**12**	**8**	**9**	**11**

Note: Station locations approximated to nearest road/bridge crossing for the stream reach (see Figure 6). For precise locations, refer to source documents.
1 – Existing conditions report (MMM/WESA, 2009) comprising records from City / RVCA sampling in 1995, 2002, 2003 and 2004.
2 – City Stream Watch (CSW, 2014) comprising records from RVCA sampling, 2003-2014.
3 – EcoTec (2007).

3.3.2 Mud Creek Tributaries

Temperature monitoring during the early years of the study revealed cool water conditions in many of Mud Creek's tributaries, with major tributaries like the Wilson Cowan Drain and the Thomas Baxter Drain reaching a maximum temperature of 18°C (MMM/WESA, 2009). However, later studies of the Wilson Cowan Drain on the Mahogany Community lands have shown temperatures up to 28°C (EcoTec, 2007). Other persistent tributaries such as the David Adams Drain, Mud Creek (McEwen Branch) Drain, and Crawford Hill Drain reached a maximum of 22°C (MMM/WESA, 2009). Cool inputs were also provided by various ephemeral tributaries in the headwater areas. One persistent tributary, the Hill Drain, reached a maximum of 28°C but the receiving downstream system remained cooler with a maximum of 22°C (MMM/WESA, 2009).

City staff observed brook stickleback and other small fish in various headwater areas with persistent late-summer flow or remnant pools during the 2014 fieldwork (e.g., Hill Drain at Malakoff Road, see Photo 51). Fish sampling results from previous surveys are available for the Wilson Cowan Drain and Thomas Baxter Drain systems (see Table 3-2, below). The presence of mottled sculpin in the unnamed tributary downstream of the Thomas Baxter Drain, near First Line Road, reflects the cool to cold water temperatures found there (MMM/WESA, 2009).

Table 3-2: Fish Species Reported from Tributaries to Mud Creek

Species	WCD at Mud Ck.	WCD at Potter Dr.	WCD on Mahogany Lands	TBD at First Line Rd.	TBD at Prince of Wales Dr.	TBD at Bankfield Rd.
Blackchin shiner	-	-	-	-	2	-
Blacknose shiner	1	-	4	-	-	-
Bluntnose minnow	-	-	-	-	-	5
Brook stickleback	1	2	4	1	2	3, 5
Central mudminnow	-	-	4	-	2	3, 5
Creek chub	-	-	4	-	2	5
Cyprinidae (minnows)	-	6	-	-	-	-
Longnose dace	-	-	-	-	-	5
Mottled sculpin	-	-	-	1	-	-
Northern pike	-	-	-	-	-	3
Northern redbelly dace	-	-	-	-	2	-
Spottail shiner	-	-	-	-	2	-
White sucker	1	-	-	-	-	-
Total Species: WCD = 6 TBD = 9	**3**	**2**	**4**	**2**	**6**	**5**

Note: Station locations approximated to nearest road/bridge crossing for the stream reach. For precise locations, refer to source documents.
WCD = Wilson Cowan Drain
TBD = Thomas Baxter Drain / unnamed tributary to Mud Creek
1 – Existing conditions report (MMM/WESA, 2009) comprising records from City / RVCA sampling in 1995, 2002, 2003 and 2004.
2 – City Stream Watch (CSW, 2014) comprising records from RVCA sampling, 2003-2014.
3 – RVCA (2009) results, J. Lamoureux, RVCA, pers. comm., Sept. 2015.
4 – EcoTec (2007).
5 – MMM Group (2014).
6 – City of Ottawa field observations (2014).

3.3.3 Headwater Drainage Features

Headwater drainage features are small, temporary streams, swales, and wetlands. 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. Headwater drainage features are important sources of food, sediment, nutrients, and flow to downstream aquatic systems, and they also provide water quality, storage and attenuation functions as well. These features may provide direct, both permanent and seasonal, habitat for fish by the presence of refuge pools, seasonal flow or groundwater discharge (CSW, 2014).

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 contribute to 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 in streams 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 Headwater Drainage Features (part of the Ontario Stream Assessment Protocol) to the program in 2013. The Stream Characterization components included fish community sampling (spring and early summer), thermal sampling; and instream and riparian surveys. Headwater Sampling Indicators included feature type, flow type, riparian conditions, fish communities, total length and total loss of headwater drainage features in a catchment.

The Mud Creek headwaters were sampled in 2014 by RVCA, as depicted on Figure 6. The subwatershed's headwaters consist mainly of agricultural drains, tile drained fields and some forested unevaluated wetlands (swamps). Some of these headwater swamps, notably, appear to support summer base flows in several Mud Creek tributaries (e.g., Mud Creek – Crawford Branch, Crawford Hill, Mud Creek – Brownlee Branch and its tributaries, the Thomas Baxter Drain, and the David Adams Drain). Some of the headwater locations identified were not sampled due to being a 4th order stream or unsampleable at the time due to low flow (e.g., at Century Road East, Carsonby Road East). Information on this sampling can be found in the City Stream Watch – Mud Creek 2014 Summary Report found in Appendix D. Detailed information on the headwater sampling may be obtained from RVCA upon request.

3.3.4 Mahogany Creek

The lower end of this small creek acts as a marshy backwater embayment of the Rideau River itself, and supports a rich assemblage of fish and other aquatic life. During the City's 2014 field observations, several species of sport fish (e.g., smallmouth bass, rock bass, yellow perch) were seen downstream of the Manotick Main Street crossing, along with evidence of recreational fishing at the culvert (e.g., discarded lines, bobbers, etc.). Schools of young fish were present in the marsh upstream of the road, indicating that this area provides spawning and nursery habitat. Painted turtles were also observed basking at the creek's mouth.

Farther upstream, the creek passes through the developing Mahogany Community. A 30 m wide setback has been established on either side of the creek in this area, providing a broad riparian corridor that will be enhanced with additional vegetation plantings as part of the development. The aquatic habitat in the creek will also be improved through restoration and

enhancement measures. This work is being carried out by the developer (Minto) under the terms of a permit from RVCA.

Outside of the Village of Manotick, in its agricultural headwaters, the creek provides limited habitat. It was observed to be still flowing in early August 2014 at the Century Road East crossing, but its volume and velocity were very low. Several frogs and small fish were taking refuge in the culvert crossing under Century Road East.

EcoTec (2007) classified this creek as a warm water system, with temperatures up to 27°C downstream of Century Road, and 23°C at the mouth of the creek. They reported finding pumpkinseed near the mouth of the creek, and central mudminnow throughout. They also noted the potential for several species found in the Rideau River, including northern pike, to migrate upstream into Mahogany Creek during spring spawning season.

3.4 Groundwater Features and Surficial Geology

3.4.1 Surficial Geology

The study area lies within the St-Lawrence Lowlands. This region is underlain by relatively flat-lying sedimentary rocks of Paleozoic age overlying the Precambrian basement which underlies all the study area. The Precambrian does not outcrop within the Mud Creek subwatershed. The Precambrian is overlain by the Nepean Formation Sandstone and the March and Oxford Formations of the Beekmantown Group. The overlying quaternary deposits in this region consist of glacial and related materials from the late Wisconsin glaciation. The Nepean Formation is composed of alternating beds of calcareous sandstone and quartzite. In the Ottawa area, the Oxford, March and Nepean Formations are important sources of drinking water.

Within the Mud Creek subwatershed, the predominant surficial materials are marine clays, and till; the remainder being distributed between gravel deposits, nearshore glaciofluvial deposits and wetlands. The topmost layer of soil deposits consist of glacial and related materials from the last glacial period, ending approximately 14,000 years ago. These deposits consist mostly of glacial till, sand and a mixture of sandy and finer grained sediments. Following glaciation, the Ottawa area was flooded for several thousand years by the Champlain Sea; during which period the dense marine clays were deposited.

One feature of particular importance is the Kars Esker, located west of Manotick, which is a linear ridge formed of glacial till, sand and gravel at or near the surface. This is one of only two eskers in the City of Ottawa, with the other being located in the east end of the City near the Village of Sarsfield. For more information on the Kars Esker, see Section 3.4.3 below. Much of the remaining area, underlying the Village of Manotick, and west of the esker, is overlain by marine clays and silts from the post-glacial Champlain Sea.

The Ontario Geological Survey (OGS) regularly publishes maps, reports and digital data on Ontario's geology. Their mapping layer is from the Ontario Geological Survey's ARIP 191 study for Ottawa and their surficial geology mapping. Figure 7 illustrates the surficial geology in the study area, as provided by the OGS, illustrating:

- Overburden thickness: there are generally no issues with overburden that is too thin within the study area – otherwise, private servicing might be an issue;
- Significant sand and gravel resources associated with the geological feature known as the Kars Esker. The exact limits of the esker are not known, due to the lack of on-site

studies along its length and breadth, however it is approximately consistent with the areas identified on the figure as glaciofluvial deposits (7) and littoral and foreshore deposits (11b and 11c).

3.4.2 Mineral Aggregate / Sand and Gravel Resource Areas

Lands designated for mineral aggregate extraction are illustrated on Schedules A and B of the Official Plan. The function of this designation as stated in the Official Plan is to "Protect non-renewable mineral aggregate resources, located close to markets, for future use" and "Minimize community and environmental disruptions from aggregate extraction activities". From time to time the former Region and now the City have studied the local geological resources, with the goal of updating the Official Plan designations so that they reflect an up to date knowledge of the landscape and also land uses in the rural area. The preparation of the mapping for the Official Plan in 2013 has closely followed the process and method that was completed in the 1995 Ottawa-Carleton Mineral Aggregate Resource Study.

Ottawa is relatively rich in bedrock mineral aggregate resources (as compared to many other Ontario municipalities). In particular the City has pronounced deposits of bedrock for crushed stone manufacture of aggregate products, such that there is already many decades of potential supply. Sand and gravel resources are scarcer, particularly sands suitable for concrete manufacture. The City estimates that 70% of the primary and secondary sand and gravel resources are currently designated and only 30% remains undesignated (not including the resources extracted to date). There are no primary sand and gravel resources in the study area, just secondary and tertiary significance materials (Ottawa, 2013).

As shown on Figure 2, several Sand and Gravel Resource Areas have been designated within and adjacent to the Mud Creek subwatershed, primarily associated with the geological feature known as the Kars Esker. The City permits pits as the main land uses in Sand and Gravel Resource Areas, subject to the provisions of the Aggregate Resources Act (Official Plan Section 3.7.4). Several active gravel pits exist within these designated areas, particularly along First Line Road and Carsonby Road East near the southern boundary of the Mud Creek subwatershed, and near the intersection of Greenbank Road and Prince of Wales Drive. All existing pit licences require development setbacks and buffers for aggregate operations.

Sand and gravel deposits may play an important role in maintaining quantity and temperature of water in the streams. Once sand and gravel is removed, this function is lost and streams may become warmer with less base flow. The result is a less healthy aquatic system, which is less resistant to impact and less able to support fish and other wildlife. However, the existing conditions report for Jock Reach 2/Mud Creek (MMM/WESA, 2009) concluded that there was no evidence of impacts on surface water or groundwater from the sand and gravel quarries.

3.4.3 Kars Esker

Detailed information on the Kars Esker is limited, such as the exact delineation of the esker, the groundwater-surface water interaction, groundwater elevation and flow. The most recent study is from 1991 by G.A. Gorrell, the Ontario Geologic Survey Open File Report 5801; Buried sand and gravel features and blending sands of Eastern Ontario.

As previously stated, the general location of the Kars Esker is immediately west of Manotick, running in a north-south direction, bisecting the subwatershed study area (Figure 7). The Jock Reach 2/Mud Creek existing conditions report stated that the esker feature is approximately

21km in length (MMM/WESA, 2009). The esker crosses Mud Creek in a north-south direction and then intersects the Rideau River.

An outlying portion of the esker feature was originally identified as the "Manotick Drumlin" by the Ministry of Natural Resources, and was considered as a "regionally to provincially significant" candidate earth science area of natural and scientific interest (ANSI) in 2001. This status, however, has never been formally confirmed. This feature, which underlies the significant woodland in the Mahogany Community at the south end of Manotick, was also identified in the Region of Ottawa-Carleton's Natural Environment Systems Strategy (NESS) as part of the moderately significant NESS area #506 in 1997.

Eskers in the region are composed of sand and gravel, and have been identified as important groundwater features. These geological features play a significant role in both local groundwater supply and maintenance of base flows in watercourses. The Kars Esker also provides a sustained flow of cool groundwater into Mud Creek that is of great importance to the aquatic system and the fisheries that it supports. For example, as previously discussed in Section 3.2.1, the water quality in Mud Creek improves east of First Line Road due to inputs of clean, cool groundwater from the esker.

The Characterization of Ottawa's Watersheds (City of Ottawa, 2011) included this information about the role of the eskers:

> *"Eskers are a minor surface deposit in terms of area, but are important surficial deposits in terms of groundwater function. There are two significant eskers in Ottawa – the Vars-Winchester Esker and the Flowing Creek-Mud Creek-Rideau Esker (Kars Esker) – that provide significant local storage that supports both drinking water supplies and influences local stream flows and stream water temperature through the summer months. "*

The Kars Esker was identified as having "regional to provincial" significance in a 2001 earth science study commissioned by the Ministry of Natural Resources.

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 3.4.4 below.

3.4.4 Significant Groundwater Recharge Area

Recharge areas occur where a relatively large percentage of water recharges from the ground surface to an aquifer. Several Significant Groundwater Recharge Areas have been identified in the study area, including the Kars Esker and three smaller areas in the western portion of the Mud Creek subwatershed (see Figure 8). 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 also includes, but is not limited to, seepage areas, springs, headwater wetlands and groundwater fed streams.

Source Water Protection SGRAs have been delineated for the entire Mississippi Rideau Source Protection Region (MRSPR) as required by the Clean Water Act, 2006 and in accordance with the Ministry of Environment's Technical Rules 44-46, 80-81 (MOE, 2008). The MOE Technical Rules define significant groundwater recharge areas as areas with a hydrological connection to a surface waterbody or aquifer that is a source of water for a

drinking water system in which the annual recharge volume is at least 55% of the annual water budget surplus (precipitation minus actual evapotranspiration) of the area under consideration.

The MRSPR Source Protection Plan was approved in August 2014 by the Ministry of the Environment. Figure 8 illustrates the Significant Groundwater Recharge Areas within the Mud Creek subwatershed study area and beyond. Although this study was done at the regional scale, and was not site-specific, the data generally correspond to the geological features found on the Ontario Geological Survey mapping, as described above and shown on Figure 7.

Much of the esker feature is also considered a Highly Vulnerable Aquifer (HVA), as noted in the MRSPR Assessment Report. Highly vulnerable aquifers are defined as subsurface, geologic formations that are sources of drinking water, which could relatively easily be impacted by the release of pollutants on the ground surface. Some of the esker is only likely of medium vulnerability, so the MOE's D-series guidance would allow for septic systems (depending on site specific investigations).

To establish the ecological significance of a recharge area, a linkage must be present between the recharge area and a natural feature (e.g., coolwater stream, wetland, etc.). The Kars Esker feature and the associated Significant Groundwater Recharge Area replenishes groundwater systems that directly support and sustain sensitive features like coolwater streams and headwater swamps, as discussed in Section 3.3.3 above.

3.4.5 Groundwater Features

Groundwater is the primary source of drinking water in the subwatershed, due to the rural private servicing, with parts of the Village of Manotick as an exception. Groundwater is also the primary source of streamflow in Mud Creek in between periods of precipitation and snowmelt.

Well studies and well records show that the direction of groundwater flow across the Mud Creek subwatershed is generally from west to east (MMM/WESA, 2009). The Jock River Reach 2/ Mud Creek Existing Conditions report (Figure 3.5.5.1) shows the shallow groundwater elevations and flow pattern (water flows from the higher elevations to the lower elevations).

Groundwater is predominantly taken from the bedrock within the Mud Creek subwatershed. Within the bedrock there are different units with different water bearing capacities. Most wells are completed within the top 25 m of the bedrock surface within the lower Ordovician Limestones of the Oxford and March Formations. These formations generally yield sufficient water for domestic use. In the Mud Creek subwatershed area, the Nepean Formation sandstone aquifer is the primary aquifer for water supply. The underlying Nepean Formation sandstone has a greater potential groundwater yield and is exploited when greater quantities are required. Use of groundwater based on the number of wells and Permits To Take Water (PTTW) was estimated as only 0.5% of watershed wide recharge.

Bedrock aquifers recharge with water most rapidly where the bedrock is closest to the surface and where the surface materials are more porous and permeable. The bedrock in the Mud Creek subwatershed is relatively deep, and surface materials are generally of low permeability (silts and clays).

Most of the recharge to the bedrock aquifer, within the subwatershed, occurs along the Kars Esker. In many locations, the sand and gravels of the esker directly overlie the bedrock and therefore provide a direct pathway for recharge. Some of the water infiltrating along the esker

will also discharge to surface water. Mud Creek crosses the esker just west of Manotick. Although summer flows are relatively low, the streamflow for Mud Creek appears to be sustained at a specific minimum level (0.08 m3/s) through the dry periods. This indicates the effect of groundwater flow from the esker, which discharges into Mud Creek upstream of the streamflow gauge. This sustained flow of cool groundwater is of great importance to the aquatic system and the fisheries that it supports. In other areas, there is little connection between the aquifers and the watercourses which may explain the lower flows observed west of Highway 416.

3.4.6 Groundwater Quality and Water Use

In the 2009 existing conditions report, groundwater samples were surveyed from private wells, with major ion chemistry and bacteria analyzed. Based on the MOE well records, it appeared that they were from different geological formations including limestone bedrock, Nepean sandstone, and the esker feature. The results of groundwater quality monitoring showed that the groundwater was generally acceptable with regard to health related parameters. From an aesthetic perspective, local groundwater was considered to be hard (i.e., high in calcium and/or magnesium).

Anthropogenic (human) water use in the subwatershed includes drinking water, agriculture, and industrial/ commercial uses. It should be noted that water is also required for ecological needs. Anthropogenic consumptive groundwater demands are mostly from Permits to Take Water (PTTW), agriculture, aggregate extraction, and private wells.

3.4.7 Water Budget

A water budget estimates how much 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, such as precipitation, and removed from a watershed. They also account for changes in storage.

The two input sources into the water budget are the precipitation that falls over the entire watershed and the regional groundwater that flows across the outer boundaries of the watershed. Outputs from the watershed include surface runoff leaving the watershed, evapotranspiration (evaporation into the air and transpiration of water vapour by plants), and changes in storage within the aquifer and surface water. Usually water budgets make the assumption that water stored on the landscape in lakes and wetlands does not change over time.

As part of the Mississippi-Rideau Source Protection Plan process, a Tier 1 Water Budget was produced in conjunction with the MRSPR Assessment Report. A Conceptual Water Budget was completed in 2007; with the Tier 1 Water Budget and Stress Assessment Study completed in 2009 by MRSPR staff and Intera Engineering Ltd. The MRSPR was divided up into 22 subwatersheds based on the location of surface water flow gauges. The Mud Creek subwatershed was evaluated within the Rideau Valley Source Protection Authority “Rideau River Below Manotick” subwatershed (MRSPR, 2011).

The Tier 1 study refined the scale of the Conceptual study, by developing water budgets for each of the 22 subwatersheds in the region using monthly and annual data. Stress levels for surface water and groundwater were calculated for each of the subwatersheds in the MRSPR. The Technical Rules from the Ministry of the Environment indicated that subwatersheds

supplying municipal drinking water systems that were determined to have moderate or high stress required further study.

None of the Rideau River at Ottawa subwatersheds required further study. The water quantity in the Rideau River subwatersheds supplying municipal drinking water systems was not found to be moderately or highly stressed. Therefore, policies to address water quantity were not required of the MRSPR Source Protection Plan and mandatory policies were not written. Water conservation will, however, form part of the education programs as the MRSPR Source Protection Committee felt strongly that they would be remiss if they did not establish incentives that promote water conservation as the region can be vulnerable to seasonal shortages (MRSPR, 2014).

3.5 Terrestrial Natural Heritage Features

Figure 9 shows many of the natural heritage system features identified to date in and around the study area. Under the policies of Sections 2.4.2 and 4.7.8 of Ottawa's Official Plan, these features could trigger the requirement for an Environmental Impact Statement (EIS) for development applications proposed within the study area. It is important to note that some features, such as wetlands associated with significant woodlands, and habitat for endangered or threatened species, are not identified on this map even though such features may occur in or around the study area (see Sections 3.5.1 and 3.6 below). Also, future on-site investigations may reveal the presence of additional natural heritage features 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 natural heritage system but do contribute to the City's tree canopy and wildlife habitat. Such features are considered particularly valuable in settlement areas such as the designated Urban Expansion Study Area and the Village of Manotick. They should be addressed in any future development planning in those areas, as part of the Tree Conservation Report and Landscape Plan required under Section 4.7.2 of the Official Plan. In cases where both an EIS and a TCR are required, the two reports should be integrated.

The Urban Tree Conservation By-Law (By-law No. 2009-200) regulates tree cutting on private property within the City's urban area, including designated Urban Expansion Study Areas. Under that by-law, landowners need to obtain a permit prior to cutting trees on properties over 1 ha in size, or prior to cutting "distinctive trees" (those measuring over 50 cm in diameter) on properties 1 ha or less. The by-law does not apply to Ottawa's rural area.

3.5.1 Significant Woodlands and Associated Wetlands

As previously noted in Section 2.2.1 above, the City's definition and mapping of significant woodlands need to be revised based on changes in the Provincial Policy Statement (2014). However, while some woodland patches may gain or lose significance as part of this exercise, most are expected to remain as part of the natural heritage system. 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; and the draft significant woodlands mapping prepared by the Ministry of Natural Resources and Forestry (Kemptville District) in 2011. It is therefore likely that they will continue to be identified as significant woodlands in the future when Ottawa's new definition is approved.

Under the City's policies in Section 2.4.2 of the Official Plan, wetlands found in association with significant woodlands are also part of the natural heritage system. 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. None of the wetlands within the study area have been identified as provincially significant wetlands at this time; however, many of them are found in association with significant woodlands, and are therefore considered part of the City's natural heritage system. These wetlands are not currently included on the Natural Heritage System Overlay, Schedule L, due to the lack of City-wide mapping. For this study area, therefore, unevaluated wetlands are shown as part of the land cover mapping on Figure 3, rather than on Figure 9. They should still be considered as part of the natural heritage system, and therefore subject to the relevant Official Plan policies for the purposes of development review.

3.5.2 Mud Creek Corridor

As part of this study, staff reviewed the extent of the significant valleylands in and around the Village of Manotick, using the City's 2014 Lidar data. The majority of the Mud Creek corridor downstream (east) of Second Line Road has now been identified as a significant valleyland within the City, as shown on Figure 9. It is a meandering valley with discontinuous tree cover along its length, and its slopes are known to be unstable. Slope failures have occurred in recent years (RVCA 2012, CSW, 2014) illustrating the importance of respecting setback limits established during the planning process within the Village of Manotick. Property owners along the creek should take care to avoid encroaching on these setbacks (i.e., do not place sheds or other valued amenities in setback lands) to reduce their risks of property damage or loss.

The Mud Creek corridor may also function as a linkage between natural features within the study area. Due to the limited potential for development along the creek outside of the Village of Manotick, it has not been mapped as a linkage on Figure 9 or on Schedule L at this time. If development is proposed on properties within 120 m of the corridor, the potential impact on this linkage function should be evaluated through an EIS. Stewardship to maintain and enhance the ecological value of this corridor (e.g., through naturalisation or shoreline restoration) is encouraged. In general, the wider a natural linkage corridor is, the better.

3.5.3 Wilson Cowan Drain Corridor

The entire Wilson Cowan Drain corridor downstream (north) of Potter Drive has also been identified on Figure 9 as a significant valleyland within the Village of Manotick. Upstream (south) of Potter Drive, the drain and its unnamed tributary provide natural linkages between the significant valley and other features within the Mahogany Community lands. These linkages are generally fairly narrow within the established residential neighbourhoods of Manotick. However, the corridors identified in the Mahogany Community will be wider, with 30 metre setbacks established along both sides of each watercourse.

3.6 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 E). Under the policies of Ottawa's Official Plan, 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 within the study area are discussed in more 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.

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 in the Mahogany Community and the Manotick Special Design Area, and is expected to be present elsewhere in the study area's upland woods and hedgerows. It should be explicitly addressed in the preparation of all Environmental Impact Statements and/or Tree Conservation Reports in support of development applications, to confirm its presence or absence on or adjacent to the proposed development site. Similarly, the new alignment for Greenbank Road and the Southwest Transitway extension, and the intersection improvement locations, 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 Butternut Health Assessor. 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 Ministry of Natural Resources and Forestry (MNRF) to remove or harm any butternut trees that have been assessed as retainable, depending on how many such trees are affected. Trees that are assessed as archivable cannot be removed without a permit.

Two threatened species of birds that have been found in association with existing buildings within the study area are the barn swallow and the chimney swift. 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 (see Photo 47 in Appendix B). 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, which was listed as a provincially threatened species in June 2014, 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 swallows were observed nesting in piles of fill in Barrhaven South during the field work for the Greenbank Road / Southwest Transitway extension (MMM Group, 2014).

Two other threatened species of birds, the bobolink and the eastern meadowlark, have been found in open grasslands and hayfields within the study area. 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, 2007, development activities that could impact the birds or their habitat must comply with the relevant regulations.

The snapping turtle is a species of special concern in Ontario. It is not currently protected under the Endangered Species Act, 2007 but is afforded some protection as a game reptile 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 Rideau River, Mud Creek and their various tributaries provide habitat for snapping turtles (see Photo 48 in Appendix B). The threatened Blanding's turtle, which is a widespread species in the western part of Ottawa, may also use these watercourses and any adjacent woodlands and wetlands.

4.0 Environmental Opportunities and Constraints

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.

Policies have been incorporated into the Manotick Secondary Plan to address identified environmental constraints within the Village. Land uses within the Village are designated on Schedule A of the Secondary Plan, along with development setbacks; land uses within the Mahogany Community are designated on Schedule C. While most of the Village has been developed on private services to date, the Mahogany Community is being developed on the basis of central water and wastewater services. The Secondary Plan provides direction regarding how services could be extended to some previously developed parts of the Village.

4.1 Natural Heritage System

Most of the identified natural heritage features within the study area occur on private lands, and are therefore dependant on continued stewardship by the landowner. 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 within or adjacent to any natural heritage features unless an EIS indicates that there will be no negative impact on the features or their ecological functions. For the purposes of the Manotick Secondary Plan, "adjacent" means within 30 metres of the boundary of the natural feature, except where large-scale alterations to the landscape are proposed, in which case the requirement for an EIS may extend up to 120 m from the edge. Outside of the Village of Manotick, the adjacency distances specified in the Official Plan will apply (i.e., 30 m in the urban area, and 120 m in the rural area).

The additional sections of significant valleylands and the linkages identified through this subwatershed study, once approved, will be subject to these policies and added to Schedule L of the Official Plan. The natural heritage features mapped on Figure 9 are also included on Annex 2 (Natural Heritage Features and Constraints) of the Manotick Secondary Plan along with known environmental constraints such as unstable slopes and floodplains. As previously stated, however, not all components of the natural heritage system are shown on Figure 9, or on Schedule L in the Official Plan. Any natural features that are found to meet the City's criteria, as established in Section 2.4.2 of the Official Plan, should be considered part of the natural heritage system whether or not they are included on the City's mapping.

Setback limits and related study requirements within the Manotick Special Design Area (west of the creek, between Bankfield Road and First Line Road) were established through the Environmental Management Plan for that developing area. Similar requirements for the developing Mahogany Community at the southern end of Manotick have been established through the planning process for that area. However, the requirements in those two areas were established prior to the introduction of the significant valleyland and linkage definitions and related policies in the Official Plan, which require an EIS to demonstrate no negative impacts from development proposed within or adjacent to such features. The City's EIS Guidelines state: "Setbacks along significant valleylands must address geotechnical issues, fish habitat (if present) and wildlife habitat functions. The ecological contributions of any natural habitat areas on the adjacent tablelands must also be considered." In this specific case, the EIS must therefore consider the geotechnical limits, fish habitat, and linkage

functions as well as the ecological contributions of any associated tableland woods or other natural habitats when determining appropriate setbacks along the Mud Creek significant valleyland. Therefore, the Mud Creek setbacks established through the Manotick Special Design Area EMP and the Mahogany Community plans should be treated as a minimum distance during the development review process, with any additional setback width required for the protection of the valleyland and its ecological functions to be established through the completion of the required EIS.

The majority of the significant woodland on the Mahogany Community lands has been designated as a Natural Environment Area on Schedule C of the Manotick Secondary Plan. It is subject to all the policies of Sections 3.2.2 and 5.2.1 of the Official Plan, including the need for an Environmental Impact Statement to support adjacent development applications. The City has entered into negotiations with Minto in an effort to secure the woodland and retain it in its natural state. If an agreement to secure the woodland cannot be reached, then the developer will need to complete an EIS to demonstrate how development could occur within the woodland and still meet the "no negative impact" test established through the Provincial Policy Statement. Any development potential (over and above the 1,400 dwelling units permitted in Phases 1 to 5) arising from the approval of such an EIS would be added to the "Future Development Area". Schedule C and the relevant policies of the Manotick Secondary Plan would be amended as necessary, based on the outcome of the EIS.

Mud Creek and its tributaries provide potential linkages between the various features that comprise the City's natural heritage system, but in many cases these linkages are extremely long and narrow. This reduces their ecological functionality as viable connections. The creation or enhancement of riparian buffers would increase the connectivity of the natural heritage system, and should be encouraged. Buffers are also useful to protect water quality and aquatic habitat (see discussion on watercourse setbacks and buffers, below).

4.2 Watercourses

4.2.1 Watercourse Setbacks and Buffers

Protecting stream corridors and surface water functions serves a dual purpose of preserving and enhancing aquatic habitat, as well as reducing risks from natural hazards associated with watercourses. Ensuring that development is set back an appropriate distance from watercourses, helps serve these purposes by allowing for the preservation of a natural riparian buffer zone and providing a margin of safety from natural hazards such as flooding and unstable slopes. Development setbacks have therefore already been imposed along Mud Creek and the other watercourses in the study area, as per the policies in Section 4.7.3 (Erosion Prevention and Protection of Surface Water) of the Official Plan. These setbacks must be respected during the development of properties adjacent to watercourses.

Mud Creek is primarily a coolwater system with many species of fish, but it is being impacted by runoff from adjacent land uses and ongoing erosion issues. 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 run-off from adjacent land uses. They also help to reduce 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.

Section 4.7.3, Policy 2 in the Official Plan outlines the minimum setback to watercourses which will be the greater of the following:

a. Development limits as established by the regulatory flood line (see Section 4.8.1);
b. Development limits as established by the geotechnical limit of the hazard lands;
c. 30 metres from the normal high water mark of rivers, lakes and streams, as determined in consultation with the Conservation Authority; or
d. 15 metres from the existing top of bank, where there is a defined bank. [OMB decision #1754, May 10, 2006]

The extent of any potential impacts of development or other activities on fish and fish habitat must also be considered, using the self-assessment process established by the Department of Fisheries and Oceans.

Outside of the Village of Manotick, watercourse setbacks are implemented through the general provisions of the zoning by-law and any change in the setback would require a zoning by-law amendment or variance that is consistent with the policies of the Official Plan. However, these setbacks do not apply to agricultural land uses (unless a building permit or other development approval is required). The farming community should be encouraged to implement best management practices for the protection of watercourses, such as the use of vegetated buffers to reduce runoff and sedimentation, fences to control livestock access, and tile drain control structures to retain water in the soil where appropriate. The City provides funding to rural landowners for projects that improve surface water and groundwater quality through programs such as the Ottawa Rural Clean Water Grants Program.

Within the Village, setbacks have been established through previous planning processes for the SDA, the Mahogany Community and the existing subdivisions, as shown on Schedule A of the Manotick Secondary Plan. A variety of methods has been used to implement these setbacks. Many older subdivisions retained the setbacks in private ownership, although in some cases the setback lands have been identified as separate property parcels (e.g., north of Bankfield Road) while in others they have been zoned differently from the rest of the parcel (e.g., along the Wilson Cowan Drain south of Bankfield Road). Most landowners appear to respect these setbacks and are maintaining well-vegetated buffers along the watercourses. Others may benefit from targeted outreach campaigns regarding the importance of setbacks and buffers.

In the SDA and Mahogany Community the setbacks have been (or will be) transferred to the City and form part of the public Greenspace network. The location and design of any proposed trails or pathways within these Greenspace lands requires approval by the City and the Rideau Valley Conservation Authority. The SDA lands in particular may not be suited to the development of a continuous pathway along the Mud Creek valley due to its steep and unstable slopes. Encroachment into the SDA setbacks by the adjacent private landowners has also begun to occur in some places (i.e., private landscaping extending onto City property).

The Rideau River corridor within the Village of Manotick is subject to additional policy considerations under the Secondary Plan. For new subdivisions adjacent to the Rideau River shoreline, the City will secure public access along the river through the development application review process unless there are compelling reasons not to do so. This will be undertaken by requiring land to be dedicated for public purposes at the shoreline or adjacent to environmental constraints. These dedicated lands should be accessible from a public road.

4.2.2 Headwater Drainage Features

The headwater drainage features identified in the study area (and elsewhere), 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 headwater swamps, in particular, could result in significant changes to the watercourses that depend on them.

The Rideau Valley Conservation Authority utilizes the Headwater Drainage Features Guideline as a standardized approach to inform decision making, with respect to the status and management actions for watercourses and wetlands in the RVCA watershed. The baseline information, evaluation, classification and management recommendations assist with the protection of aquatic functions from a watershed management perspective, when evaluating master servicing studies and applications under the *Planning Act*. RVCA also utilizes the Headwater Drainage Features Guideline as a tool for the assessment of alteration to waterways applications under Section 28 of the *Conservation Authorities Act*. The guideline provides a consistent approach to assessing the value of headwater drainage features.

It is to be noted, however, that the Headwater Drainage Features 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. 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. The City can encourage this through programs such as Environmental Farm Plans and the Ottawa Rural Clean Water Grants Program.

Section 4.7.3 of Ottawa's Official Plan recognizes that in addition to watercourse setbacks defined in the policy, development next to municipal drains and other works under the Drainage Act must also 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 (Ottawa, 2003). Usually, this working space extends up to 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.

4.2.4 Natural Hazards and Regulations

When determining setback limits as part of the development application process, other technical studies may also be required to address constraints such as unstable slopes and floodplains, in keeping with the policies of the Official Plan (Sections 4.7.3, 4.8.1 and 4.8.3).

Large portions of the Mud Creek system are considered to have unstable slopes as shown on Schedule K – Environmental Constraints of the City's Official Plan. This includes Mud Creek itself as far upstream as Prince of Wales Drive, the Wilson Cowan Drain and its tributary within the Village of Manotick, and the David Adams Municipal Drain. Within the Village, these

constraints are included on Annex 2 of the Secondary Plan. Schedule K and Annex 2 provide for early identification of slope stability concerns but do not provide enough detail to assess constraints on specific sites.

City Council adopted the *Slope Stability Guidelines for Development Applications in the City of Ottawa*, 2004 (rev. 2012) to guide slope stability assessments and requirements of setbacks. Slope stability assessments identify the geotechnical limit of the hazard lands, which includes the stable slope allowance plus, where appropriate, an allowance for future erosion and in some cases, and additional allowance to permit access in case of a slope failure.

Any area that is identified on Schedule K of the Official Plan, and with additional site specific information from applicants and the Conservation Authority, is required to complete a Slope Stability Assessment depending on the development application and proposal (Ottawa, 2003).

Floodplain mapping for Mud Creek has only been completed for developing areas downstream (east) of First Line Road. In these areas, flooding under 1:100 year conditions is expected to remain contained within the creek's well-defined valley (RVCA, 2012). Similarly, floodplain mapping was completed for Mahogany Creek, the Wilson Cowan Drain and its unnamed tributary downstream (north) of Century Road as part of the planning for the Mahogany Community lands. The 30-m setbacks applied to those watercourses through the Mahogany concept plan, and incorporated into the Secondary Plan for the Village, are expected to contain the 1:100 year flood conditions.

A permit under Ont. Reg. 174/06, *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*, administered by the Rideau Valley Conservation Authority may be required for works such as site grading, the placement of fill, the alteration of existing channels of watercourses, and certain construction projects. The Conservation Authority should be consulted for any project where development may be subject to flooding, erosion, and/or interference with wetlands and alterations to shorelines and watercourses which may have an adverse environmental effect.

The Rideau Canal is a federal waterway and as such all shoreline and in-water works along the canal system will also require approval from Parks Canada, as any in-water and shoreline works, such as docks, shoreline stabilization and re-naturalization, will require an approved work application before work can commence.

4.3 Kars Esker and Significant Groundwater Recharge Area

The Significant Groundwater Recharge Area, illustrated on Figure 8, identifies a large area of land that is responsible for supporting groundwater resources and sustaining sensitive areas like coolwater streams and headwater wetlands. This directly contributes to the quantity and quality of groundwater, which is used extensively throughout the study area as a source of drinking water and for watering livestock. These areas should be appropriately protected during future development that can impact groundwater quality and quantity.

The Kars Esker plays a significant role in both local groundwater supply and maintenance of base flows, as well as improving water quality and aquatic habitat conditions in Mud Creek. Protecting the form and function of the Kars Esker through policies in the Official Plan is therefore a priority for the subwatershed plan. Besides the site specific study completed for the Manotick Special

Design Area, more information is required from site specific studies on where the esker is vulnerable from development, and what activities might affect its form and function.
Since it has not been fully delineated, additional hydrogeological testing will be required for future development to determine the exact limit of the hydrogeological constraint area.

4.3.1 Manotick Special Design Area – Estate Residential and Open Space

The recommendations from the Manotick SDA EMP were incorporated into the SDA Concept Plan, approved in 2006, and implemented through development conditions and stormwater site management plans. A small portion of the Kars Esker within this area was delineated by hydrogeological investigation, along with a 30m buffer, and zoned as open space (O1).

Development in the SDA is entirely comprised of single detached residential lots on private servicing. Precise lot sizes in individual developments will be based upon findings detailed in hydrogeological studies that will be required for approval for each plan of subdivision proposed. These recommendations have also been incorporated into the Manotick Secondary Plan, in the section addressing permitted land uses in the designated Manotick SDA – Estate Residential and Open Space lands.

4.4 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 man-made disturbances such as development, agriculture and aggregate extraction. There are opportunities to improve water quality by controlling pollutant laden stormwater runoff.

Mud Creek and its tributaries provide a combination of warmwater and coolwater fish habitat that supports up to 36 species. The factors that contribute to the existing aquatic habitat include groundwater recharge and discharge, riparian habitat, wetland habitat and headwater forests. 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 Mud Creek as well as on the Rideau River, the receiving water body.

To improve water quality within Manotick and other rural residential developments, storm runoff from both ongoing/future development and past development can be treated for quality and quantity where warranted. Groundwater quality will be most sensitive in areas of high recharge such as the Kars Esker. Protection of that area from land use related impacts such as contamination from fuel/chemicals and improper manure containment is essential to the preservation of drinking water supplies and in-stream water quality east of First Line Road.

4.4.1 Agricultural Best Management Practices

As part of the City's review of the Ottawa Rural Clean Water Grants Program in 2009, a literature review was conducted to assist identification of effective agricultural best practices and other projects that should be considered for funding. The review found that several studies have measured rates and magnitudes of pollutants from agricultural runoff, the specific impacts of these pollutants on surface water and the ability of best management practices to mitigate these impacts (Watzin and McIntosh, 1999). Most contaminant inputs from agricultural land are a form of non-point pollution and are therefore difficult to measure. Consequently, cumulative, synergistic and chronic impacts can result in significant changes to

aquatic systems (Spaling and Smit, 1995; Cooper, 1993). Non-point source runoff also has the potential to contaminate groundwater sources.

Of all the non-point 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, as the prevention of soil loss from farmland should be a long-term goal.

The Lower Rideau Watershed Strategy (Aquafor Beech/Robinson, 2005) recommended:

"Implementing a program to control nutrient runoff on agricultural lands by controlling livestock access to streams, expanding use of conservation tillage and nutrient management practices, and installing rural BMP's to address point sources such as feedlot and manure storages."

This can extend to encouraging agricultural practices which reduce the opportunities for sediment, containing nutrients and bacteria to enter the surface water system.

Best management practices on farms are primarily encouraged through two programs, the City's Rural Clean Water Grants Program and the Province's Environmental Farm Plan Program.

The Ottawa Rural Clean Water Grants Program (ORCWGP) 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 ORCWGP has supported more than 1,000 grants since it began in 2000. Projects delivered in the Mud Creek subwatershed study area since 2011 include several well upgrades/decommissionings and three buffer/windbreak plantings. Several erosion control projects have also been funded along the Rideau River. The program is delivered in partnership with the Mississippi Valley, Rideau 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 the EFP local workshop process, farmers highlight their farm's environmental strengths, identify areas of environmental concern, and set realistic action plans with time tables to improve environmental conditions. The EFP is delivered locally by the Ontario Soil and Crop Improvement Association (OSCIA) and technical expertise is provided by Ontario Ministry of Agriculture, Food and Rural Affairs. The local OSCIA offers EFP workshops and EFPs are submitted to the association for confidential peer review. An EFP is typically required to be eligible for provincial and local grants.

4.5 Stormwater Management and Servicing

Most of Manotick was developed before there was a requirement for municipalities to manage stormwater. For this reason, there are no facilities to treat stormwater in those parts of the village. The engineered drainage within the village 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 through storm sewers and/or ditches and outlets to Mud Creek, the Rideau River and their tributaries. In older portions of the community, roadside ditch systems dominate. In newer subdivisions, storm sewers are predominant.

Within the Manotick SDA, the residential estate subdivisions are being developed using stormwater infiltration measures specifically designed to avoid the need for a stormwater management pond. Fees are being collected on a per building permit basis to fund a stormwater quality monitoring program for the SDA.

New developments in the Village of Manotick, whether greenfield or infill, will be subject to stormwater management requirements established through provincial legislation and policies in the Manotick Secondary Plan and the City's Official Plan. City staff have conducted an analysis to identify retrofit opportunities within the Village that could be implemented through infill development or through municipal asset management (e.g., infrastructure renewal projects). These opportunities are discussed in more detail below.

4.5.1 Stormwater Management Retrofit Opportunities

Stormwater management (SWM) "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.

There are four general types of retrofits:

- **Lot level measures** are located at the source of runoff – "on the lot." They reduce the amount of rainfall that runs off and prevent pollutants from being carried off the lot. Lot level measures are considered to be the first line of protection in maintaining or restoring the health of a watershed. Though each lot may be relatively small in size, the use of lot level measures across many properties produces a cumulative benefit. Typical lot level measures include :
    - Rain barrels or cisterns that harvest rainfall for later use on the property;
    - Rain gardens and other absorbent landscaping measures that capture and infiltrate runoff;
    - Green roofs that supplement standard roofing materials with soil and plants to absorb and use rainwater; and,
    - Using permeable materials for the construction of driveways and parking lots, which allows stormwater to be absorbed into the soil instead of becoming runoff.
- **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 (or "leaky" pipes) that allow water to exfiltrate (leave the pipe) and enter the surrounding soil;
    - Curb extensions that treat and absorb runoff through the use of soils and plantings (bioretention).
- **End of pipe (EoP) measures** are located at the end of the storm sewer system, where it outlets to the nearest creek or river. End of pipe measures are larger scale facilities that receive the accumulated runoff collected by storm sewers. They provide treatment to improve the quality of runoff before it is discharged and can also store the runoff to avoid flooding impacts. End of pipe measures include:
    - Stormwater ponds and constructed wetlands, which treat runoff before it enters the watercourse;
    - Oil/grit separators (OGS) that are smaller underground devices that treat runoff before it enters the watercourse.

- **Stream rehabilitation measures** may be necessary at times to improve a stream's ability to receive runoff from developed areas, at the same time as enhancing its natural features and functions. Such measures can include re-building sections of the stream, creating off-line pools for floodplain storage, and cutting down banks to re-connect an eroded channel with its floodplain. While the intent is to avoid hardening the stream as much as possible, this is sometimes unavoidable if infrastructure or property is threatened by ongoing erosion.

The City's stormwater retrofit analysis has identified several lot level and end of pipe measures that could be used within the existing developed areas of Manotick.

Lot Level Retrofit

While the potential benefits of lot level retrofits on private properties were not explicitly addressed in the City's analysis, there are various measures that individual homeowners can implement to improve water quality and reduce runoff volumes. Below are some further examples of lot level retrofit measures:

- Rain barrels and cisterns capture roof runoff from frequent storm events and temporarily store it for reuse on site. This practice reduces runoff and pollutants, and can provide a benefit in terms of reduced water consumption.
- Downspout disconnection/redirection is the diversion of flow from roof tops to pervious areas. This measure prevents the routing of stormwater onto impervious surfaces which drain directly to the storm sewer system. To produce a measurable benefit, simple downspout disconnection requires a minimum flow path length of 5 m across a pervious area before flowing onto an impervious surface or into the storm sewer system.
- Rain gardens, or bioretention areas, are designed to include hydrophilic (water-loving) native species and amended soils in human-made depressions to aid in capturing rainfall runoff. This lot level measure decreases peak flows through additional on-site storage, and reduces pollutant loads through both runoff volume reduction and filtration prior to discharge.
- Porous or permeable pavement or concrete, an alternative to impervious products, allows some surface runoff to flow through its surface to be stored in a granular base prior to being released slowly to the storm sewer system or infiltrated into the native soil beneath.

For more information, the Low Impact Development Stormwater Management Planning and Design Guide, developed by Credit Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA) provides tools to help developers, consultants, municipalities and landowners to understand and implement more sustainable rainwater/stormwater management planning and design practices (CVC/TRCA, 2011).

A preliminary screening of potential lot level retrofit opportunities on City owned properties was undertaken using the 2012 Life Cycle Plan. Any major flat roof renovation or pavement replacement (> 20,000$) has been flagged as having potential for a green roof, pervious pavement and/or rain barrel/cistern implementation. A desktop survey of the study area was performed using available GIS data, Google Maps (Street view) and Bing Maps (Aerial and Bird's Eye View).

Appendix C (Part 1 and Table A) provides a description of the location and the replacement cost and scheduling of four potential sites. These potential retrofits have been identified at a screening level only. Further detailed investigations would be required to confirm their

feasibility. These retrofits would further have to be considered in the context of City-wide retrofit priorities.

End of Pipe Retrofit

An analysis was conducted for the 700 ha of existing developed area in Manotick.
A preliminary selection of potential end of pipe retrofit locations and opportunities was based upon a desktop analysis using available information. Details are provided in Appendix C (Part 2 and Table B).

Potential retrofit locations were screened based on available space, contributing drainage area, storm sewer inverts, space limitations, mature vegetation impacts, existing servicing conflicts and ease of location access. Complete information was not available for the existing storm sewer system; therefore this review is based upon only about one third of the study area where information was available. The following screening criteria were developed through the desktop analysis:

- Minimum drainage area for consideration of an EoP retrofit was set at 20 ha;
- When no space was available at the storm outfall proper, opportunities further up the storm sewer system were also considered. The remaining drainage area connected to the potential retrofit facility had to equal or exceed 20 ha;
- Preference was given to wet pond implementation over oil/grit separator (OGS) devices when space was available;
- Only publicly–owned lands were considered for potential EoP retrofit opportunities. Further consultation with appropriate City departments will be required to confirm retrofit opportunities identified through this exercise;
- No wet pond or OGS implementation was considered where substantial mature vegetation would be affected.

Appendix C (Part 2) presents the figures associated with the storm outfalls and Table B of the Appendix provides a summary of the screening exercise.

One potential EoP retrofit was identified: an oil/grit separator at the Outlet M10 (Potter Drive, just upstream of Mahogany Creek; see Appendix C). The feasibility of this retrofit requires further assessment beyond a screening level and would further have to be considered in the context of City–wide retrofit priorities. .

5.0 Subwatershed Plan

The environmental health and ecological integrity of the study area and its component 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 potential action items along with recommendations for implementation.

5.1 Identification of Natural Heritage Features

In conjunction with the Manotick Secondary Plan Review, this study has identified additional sections of Mud Creek and its tributaries in and around Manotick as significant valleylands or linkages. An Official Plan amendment has been proposed to update Schedule L, the Natural Heritage System Overlay, to reflect these changes. The proposed changes have also been reflected in Figure 9 of this report and Annex 2 of the Manotick Secondary Plan.

This study has also identified several unevaluated wetlands that occur in association with significant woodlands in the study area (Figure 3). These wetlands should be considered as part of the City's natural heritage system, and addressed in any EIS required to support a development application in or adjacent to the system.

5.2 Respecting Watercourse Setbacks

Development setbacks have been applied in several locations within the Village of Manotick, primarily due to the steep, unstable slopes along Mud Creek and its tributaries. Locations affected by setbacks are shown on Schedule A of the Manotick Secondary Plan. These setbacks are intended to protect both the aquatic habitat in the creeks, and the abutting landowners from property damage due to the 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 the setbacks that affect their property, and why they should be respected. Sheds and other valuable amenities should not be placed within setback areas.

5.3 Creek Restoration and Naturalization

Currently, RVCA and its partners are working to protect and enhance environmental conditions in the Lower Rideau Watershed (RVCA, 2012).

Several locations along Mud Creek have been identified as potential sites for restoration and enhancement projects through the RVCA and City Stream Watch Program, as shown on Figure 10 – Potential Restoration Opportunities. These projects could include riparian plantings, erosion control works and/or fish habitat enhancement. Figure 10 also shows the locations of City-owned properties along the watercourses in the study area, which could provide additional opportunities for riparian planting and other restoration or enhancement works. These projects could be implemented through existing initiatives such as the RVCA's Shoreline Naturalisation Program, or as compensation for development-related impacts to aquatic habitat in the study area (or potentially elsewhere in the Rideau River watershed). A list of the potential projects, along with recommendations for implementation, is provided in Table 5-1 below.

5.4 Protection of the Kars Esker

The geological feature known as the Kars Esker has not been fully delineated, therefore additional hydrogeological testing will be required for future development within the Significant Groundwater Recharge Area, to determine the exact limit of the hydrogeological constraint area.

Development and site alteration should be limited within and adjacent to the significant groundwater features already identified through this study and previous analyses undertaken to support existing development. When development cannot be avoided in areas of groundwater sensitivity, it is recommended that pre-development recharge areas should be maintained through the completion of a water balance.

The Significant Groundwater Recharge Area, illustrated on Figure 8, identifies a large area of land that is responsible for supporting groundwater resources and sustaining sensitive areas like coolwater streams and headwater wetlands. These areas should be appropriately protected during any future development that could impact groundwater quality and quantity.

Additional measures to protect groundwater resources are recommended within the Significant Groundwater Recharge Area such as:

- Avoid infiltrating poor quality runoff from paved surfaces such as parking lots and roads without pre-treatment. Promote infiltration from clean water sources, such as rooftops and downspouts.
- Use Low Impact Development and Best Management Practices for stormwater management quality and quantity control, by stormwater retrofit opportunities and upgrades.
- Reduce the impact of winter salt application; consider updates to salt management plans, and education and outreach.

5.5 Stormwater Management Retrofit in Manotick

The City should consider opportunities to improve stormwater management in existing developed areas within the Village of Manotick, as identified in Appendix C – Manotick Stormwater Management Retrofit, as part of future renewal projects involving roads and other public facilities.

New development within the Village will be subject to the policies in the Secondary Plan regarding stormwater management.

5.6 Surface Water Quantity and Quality

The retention of existing natural watercourse form and function (where it currently remains intact) will assist in maintaining the existing aquatic communities that include coolwater fish communities as well as warmwater species 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.

5.7 Landowner Stewardship

The City and RVCA should continue to work together to promote good environmental stewardship in the study area, through ongoing initiatives and programs such as the Ottawa Rural Clean Water Grants Program, the RVCA Shoreline Naturalization Program, and Green Acres (which provides advice and subsidized tree seedlings to landowners wishing to reforest rural properties at least 0.4 ha in size), and the RVCA Tree Planting Program. Community-

based stewardship can also be promoted through the City Stream Watch program, and the twice-annual Cleaning the Capital program. The City should also consider opportunities to demonstrate good stewardship on its own properties in the study area.

Eligible projects under the ORCWGP that could be particularly beneficial in this study area include:

- Installation of tile drain control structures (where appropriate) and outlet protection;
- Development of nutrient management plans and acquisition of Global Positioning System units or other devices to assist with implementation of the plans;
- Fencing to keep livestock out of watercourses;
- Land retirement;
- Demonstration projects and other educational initiatives;
- Streambank stabilisation, planting of buffer strips and natural windbreaks;
- Chemical or fuel storage;
- Manure storage treatment; and,
- Well decommissioning.

Additional projects will be available starting in 2016 including:

- Cover crops;
- Development of forest or wetland management or conservation plans;
- Septic system repairs within 50 m of a watercourse; and,
- Innovative projects that protect water quality.

Several opportunities for other eligible projects such as riparian restoration and erosion control have been identified on Figure 10 – Potential Restoration Opportunities. However, these are not the only places where such projects could occur. Landowners can request a site visit through the ORCWGP to discuss possible projects on their property. Applications will be accepted from:

- Any property in rural Ottawa (including villages);
- Farms within Ottawa's urban boundary;
- Landowners within Ottawa's urban boundary for well decommissioning projects; and,
- Not-for-profit groups for educational initiatives.

Grants of up to $15,000 are available covering 50 to 90 percent of eligible costs. Landowners must contact the Landowner Resource Centre (located at RVCA headquarters near Manotick) prior to starting their projects in order to be eligible for funding.

Other sources of funding and support are also available for rural landowners interested in restoring and conserving natural habitat on their property, from organisations such as 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.

5.8 Municipal Drains

Improvements to any municipal drains will be focused on the retention and naturalization of buffer strips, where appropriate working with landowners and the City's Municipal Drains unit. The City will encourage environmentally friendly farming practices and buffer retention through programs such as Environmental Farm Plans and the Ottawa Rural Clean Water Grants Program.

In cases where riparian plantings or other creek restoration projects are proposed along municipal drains, the City's Municipal Drains unit should be consulted to ensure that the proposed works will not conflict with the continued function and maintenance of the drain. For example, planting plans may need to be adapted to ensure that the required access to the drain is maintained, either by planting on one side of the drain only, or by using species such as willows or dogwoods that can be cut back periodically to allow access. It may also be possible to coordinate the implementation of restoration projects with municipal drain maintenance works in some cases.

5.9 Monitoring

Ongoing monitoring of the environmental conditions within the study area should be continued. This includes the City's own monitoring work through the Water Environment Protection branch, as well as the RVCA Subwatershed Reporting, and the City Stream Watch volunteer program. These complementary programs provide valuable information necessary to guide management actions, support development review, and address environmental issues.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
Considerations for Development Review		
Natural Heritage System Add newly identified significant valleylands and linkage features to Schedule L1 – Natural Heritage System Overlay.	City of Ottawa	Schedule L of the Official Plan illustrates the Natural Heritage System This study; to be implemented through Council approval of Mud Creek Subwatershed Study, Village of Manotick Secondary Plan and associated Official Plan Amendment.
Environmental Impact Statements Development and site alteration will not be permitted within or adjacent to any natural feature, or adjacent to the designated Natural Environment Area on Schedule C – Mahogany Land Use, unless an Environmental Impact Statement (EIS) has been prepared as part of the development application process, which indicates that there will be no negative impacts on the natural features or their ecological functions.	City of Ottawa Development Industry/ Private Landowners	Section 4.7.8 of the Official Plan outlines Environmental Impact Statements In Manotick and in the urban area, “adjacent” is generally defined as within 30 m of the edge of the feature. In the rural area outside Manotick, or in cases where large-scale alterations to the landscape are proposed, such as for general site grading or pre-loading, this requirement for an EIS may extend up to 120 m from the edge of the feature.
Protection of Surface Water Features – Watercourse Setbacks Respect watercourse setbacks within the Village of Manotick and within the subwatershed area. Rideau Valley Conservation Authority Ontario Regulation 174/06; Section 28 of the *Conservation Authorities Act*.	City of Ottawa RVCA Development Industry/ Private Landowners	Section 4.7.3 of the Official Plan outlines the protection of surface water features and erosion prevention. Section 69 of the Comprehensive Zoning By-law (2008-250) is the general provision for Setback from Watercourses. Within the Village, setbacks have been established through previous planning processes for the SDA, the Mahogany Community and the existing subdivisions, as shown on Schedule A of the Manotick Secondary Plan. Any alteration proposed to any watercourse within the study area may require a permit from RVCA under their *Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*, Ontario Regulation 174/06.
Identify and promote the preservation of low order and/or headwater streams Headwater Drainage Features Analysis: Urban Expansion Areas, Village Expansion Areas and large-scale development proposals to require a Headwater Drainage Feature Analysis as part of the study requirements.	City of Ottawa Development Industry	Sections 2.2.1 of the Official Plan outlines Urban Area and Village Boundaries; Section 3.11 & 3.12 of the Official Plan outlines Urban Expansion Areas Require a Headwater Drainage Feature Analysis, using the TRCA/CVC Headwater Drainage Feature Analysis Guideline for any Urban Expansion Study Area, as part of the Environmental Management Plan process; and as a standard approach when reviewing development proposals as part of RVCA Ont. Reg. 174/06.
Geotechnical Setbacks Respect geotechnical setbacks within the Village of Manotick and	City of Ottawa Development	Schedule K of the Official Plan illustrates unstable slopes along the Mud Creek valley.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
within the subwatershed area.	Industry/ Private Landowners	Any area that is identified on Schedule K of the Official Plan, and with additional site specific information from applicants and the Conservation Authority is required to complete a Slope Stability Assessment depending on the development application and proposal - in keeping with the Slope Stability Guidelines for Development Applications in the City of Ottawa (rev. 2012).
Municipal Drains City of Ottawa, for Mud Creek subwatershed area municipal drain maintenance program, to balance the legal working space and riparian buffer/setback to municipal drains.	City of Ottawa	Municipal Drain maintenance within the Mud Creek subwatershed.
Protection of Groundwater Features Ensure pre-development recharge conditions are maintained.	City of Ottawa Development Industry	A Water Budget Assessment will be prepared as per the MOE Guidelines; and in conjunction with Ottawa's Official Plan Section 2.4.2.1.(l), 2.4.4 & 4.7.5 – Protection of Groundwater Features; to support any large-scale development (i.e. subdivision) in the Mud Creek SWS area, to ensure pre-development recharge conditions are maintained through the completion of a water balance and hydrogeological assessment.
Kars Esker – Significant Groundwater Recharge Area		
Limit development and site alteration within and adjacent to significant groundwater features identified within the subwatershed. Lands shown within the Significant Groundwater Recharge Area should be appropriately protected during future development through additional hydrogeological testing to determine and delineate the limit of the hydrogeological constraint area. Development and site alteration adjacent to identified significant groundwater features should be protected with an appropriate buffer.	City of Ottawa Development Industry/ Private Landowners	Significant groundwater features identified include the Kars Esker, and the Significant Groundwater Recharge Area. This also includes, but is not limited to: seepage areas, springs, headwater wetlands and groundwater fed streams. Implemented through conditions of subdivision and site plan control approval under *Planning Act* applications, for areas shown within the Significant Groundwater Recharge Area on Figure 8.
Within the Manotick Special Design Area (SDA), the groundwater recharge area (feature known as the Kars Esker) shall be appropriately protected during development through additional hydrogeological testing to delineate the limit of the hydrogeological constraint area.	City of Ottawa Development Industry/ Private Landowners	Implemented through conditions of subdivision and site plan control approval under *Planning Act* applications, for areas shown within the Significant Groundwater Recharge Area on Figure 8. The Manotick EMP SDA Component report (MMM/WESA, 2006) will be referenced, along with the Manotick Secondary Plan (2015).
Additional measures to protect groundwater resources are recommended within the area of significant groundwater recharge such as: • Avoid infiltrating poor quality runoff from paved surfaces	City of Ottawa Development Industry/ Private	Implemented through conditions of subdivision and site plan control approval under *Planning Act* applications, for areas shown within the SGRA on Figure 8.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
such as parking lots and roads without pre-treatment. Promote infiltration from clean water sources , such as rooftops and downspouts. • Using Low Impact Development and Best Management Practices for stormwater management quality and quantity control, by stormwater retrofit opportunities and upgrades.	Landowners	
Consider impacts of road salt application for the area within the identified Significant Groundwater Recharge Area on Figure 8.	City of Ottawa	Adopt a multipronged approach to reducing the impact of winter salt application in areas. Approach to consider updates to salt management plans and education and outreach to contractors.
Stormwater Management		
Opportunities to improve stormwater management within existing developed areas in the Village of Manotick.	City of Ottawa	Promote and implement stormwater management retrofit measures to improve the quality of runoff from areas that developed without stormwater treatment. Manotick SWM Retrofit to be considered in conjunction with renewal projects involving roads and other public facilities.
Opportunities to implement stormwater management and drainage solutions that do not impact natural features identified for protection.	City of Ottawa	Promote the rehabilitation of degraded streams in combination with the implementation of stormwater management to maximize benefits to servicing solutions and habitat improvement.
Water quality improvements: Reduce the impact of runoff from development areas into receiving watercourses.	City of Ottawa Development Industry	Greenfield areas: Implement stormwater management measures to improve the quality of runoff to acceptable levels. Infill and Redevelopment Areas: Promote and implement retrofit stormwater management measures to improve the quality of runoff from areas that developed without stormwater treatment. * Implement non-structural and structural BMPs to meet above criteria. * Preparation of detailed erosion & sediment control (ESC) plans required for all development areas.
Water quantity improvements: Reduce erosion impacts that are detrimental to property and stream habitat.	City of Ottawa	Implement stormwater management measures to mitigate the impacts of runoff from developed areas on existing erosion rates. Incorporate habitat improvements to the extent possible when implementing erosion protection works.
Lot level measures can prevent pollutants from being picked up by runoff and minimize the amount of off-site drainage.	City of Ottawa Residents, Manotick Community Groups	It is recommended that the City encourage private property owners to direct downspouts to lawn surfaces, install rain barrels, plant trees, and other lot level measures.
Surface Water Protection		
Manage surface water contamination from point and non-point source runoff.	Private Landowners Ottawa Rural Clean	Complete Environmental Farm Plans (EFP) to increase environmental awareness and qualify for grants.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
	Water Grants Program (ORCWGP) Ontario Soil and Crop Improvement Association (OSCIA)	Promote grants available through the Ottawa Rural Clean Water Grants Program (ORCWGP) and province (through OSCIA).
Potential In-stream Restoration Opportunities RVCA 2012 Mud Creek catchment report identifies several in-stream restoration opportunities in Manotick (see Appendix D, their Figures 30 and 31) for fish habitat restoration and removal of invasive species (purple loosestrife, European frogbit, oxeye daisy, rusty crayfish, flowering rush).	RVCA Shoreline Naturalization Program Residents, Community Groups	Target riparian and in-stream restoration at sites identified in the report, and supplemental reports from RVCA. It is recommended vegetation be increased along watercourse shorelines; along with aquatic habitat enhancement. Erosion control opportunities as identified through shoreline naturalization. Further follow-up required with RVCA to identify specific sites and projects and confirm property ownership. Seven shoreline planting projects have been completed.
Ensure that abandoned wells are properly decommissioned, either privately or as a condition of development approval.	Private Landowners City of Ottawa Ottawa Rural Clean Water Grants Program (ORCWGP)	Promote well decommissioning grants either as part of a development application from well water assessment; or private abandoned wells.
Farming operations adjacent to watercourse/ ditches should include appropriate buffer strips and/or barriers to help minimize disturbances and provide water quality management benefits.	Private Landowners Ottawa Rural Clean Water Grants Program (ORCWGP) Ontario Soil and Crop Improvement Association (OSCIA)	Promote grants: fencing and alternate watering to keep livestock out of watercourses, buffer strips, windbreaks, land retirement, manure storage and treatment, nutrient management plans and GPS units, and cover crops.
Educate landowners about appropriate Agricultural Best Management Practices, and available projects through the Rural Clean Water Program (e.g., controlled tile drainage, buffers, well decommissioning, etc.).	Ottawa Rural Clean Water Grants Program (ORCWGP) Ontario Soil and Crop Improvement Association (OSCIA)	Best management practices on farms are primarily encouraged through two programs, the City's Rural Clean Water Grants Program and the Province's Environmental Farm Plan Program, implemented by OSCIA.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
Groundwater Protection		
Groundwater Quality protection and improvements (non-point source pollution)	Private Landowners Ottawa Rural Clean Water Grants Program (ORCWGP)	Any rural property within the City of Ottawa. Landowners must contact the Landowner Resource Centre (LRC) prior to starting their projects in order to be eligible for funding. To find out more, please see the Ottawa Rural Clean Water Grants Program on Ottawa.ca.
Promote proper abandonment of unused wells to prevent cross contamination between aquifers.	Private Landowners Ottawa Rural Clean Water Grants Program (ORCWGP)	Any rural property (including village properties) within the City of Ottawa is eligible. Landowners must contact the LRC prior to starting their projects in order to be eligible for funding. To find out more, please see the Ottawa Rural Clean Water Grants Program on Ottawa.ca.
Promote proper construction and maintenance of private septic systems to protect groundwater and surface water quality.	Private Landowners Ottawa Septic System Office	Grants are available through the Ottawa Rural Clean Water Grants Program for repairs to septic systems within 50m of watercourse or within a wellhead protection area (effective 2016).
Groundwater Levels and Baseflows (Groundwater Discharges to Streams) to Sustain Subwatershed Functions	City of Ottawa	The City of Ottawa Official Plan specifies that where monitoring and characterization of the groundwater resource has indicated degradation of the resource function, the zoning by-law will restrict uses to prevent further impacts on that function. (Policy 1, Section 2.4.4).
Landowner Stewardship		
Potential Riparian Restoration Opportunities Shoreline Naturalization - Riparian plantings and creek side restoration on privately owned portions of Mud Creek RVCA's 2012 Mud Creek Catchment report identifies the entire portion of the creek within the Manotick study area for riparian restoration.	RVCA Shoreline Naturalization Program	Waterfront properties along wetlands, streams, rivers, lakes within the Rideau watershed, as identified on Figure 10. Further follow-up required with RVCA and Forestry to identify specific sites and projects and determine if these are public or private lands
Tree Planting Opportunities – Private Property Reforestation & Tree Planting and restoration on privately owned portions of Mud Creek	Green Acres Program; RVCA Tree Planting Program; Ottawa Stewardship Council	Any empty, idle fields in the rural area that are privately owned. Minimum of 0.4 ha of suitable land; and minimum of 500 tree order.
Tree Planting Opportunities – City of Ottawa owned properties Tree Planting and shoreline naturalisation on City-owned portions of	City of Ottawa Forestry Services	Any City property in Ottawa, meeting criteria for tree planting/ naturalization projects.

Table 5-1 – Mud Creek Subwatershed Study Action Plan and Responsibilities

Recommendation	Responsibility	Action - Trigger
the study area, such as: • Millers Point Park: 474 Lockmaster Crescent (Wilson Cowan Municipal Drain) • Rideau Valley Depot - City of Ottawa Public Works Yard: 4244 Rideau Valley Drive (Mud Creek) • Mahogany Creek upstream (west) of Manotick Main St.: 1160 Potter Drive • City-owned property along west bank of Mud Creek, south of Bankfield Road (SDA Lands) • City-owned property along unnamed tributary to Mud Creek, behind 110 Gray Willow Place	Department Rideau Valley Conservation Authority	
Monitoring		
Subwatershed Reporting Aquatic water quality and aquatic habitat monitoring.	City Stream Watch Program – Conservation Authorities + Partners	The City Stream Watch program will continue to monitor and evaluate Mud Creek as part of its on-going program. The City or the Conservation Authority will conduct targeted monitoring of water quality and aquatic habitat in support of any stream rehabilitation or enhancement projects.
Water Quality and Baseline Data Reporting	City Water Environment Protection Branch	The Water Environment Protection Unit will continue baseline water quality and aquatic habitat monitoring at two sites as part of the City's baseline monitoring program. Ongoing monitoring of the environmental conditions within the study area should be continued.

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