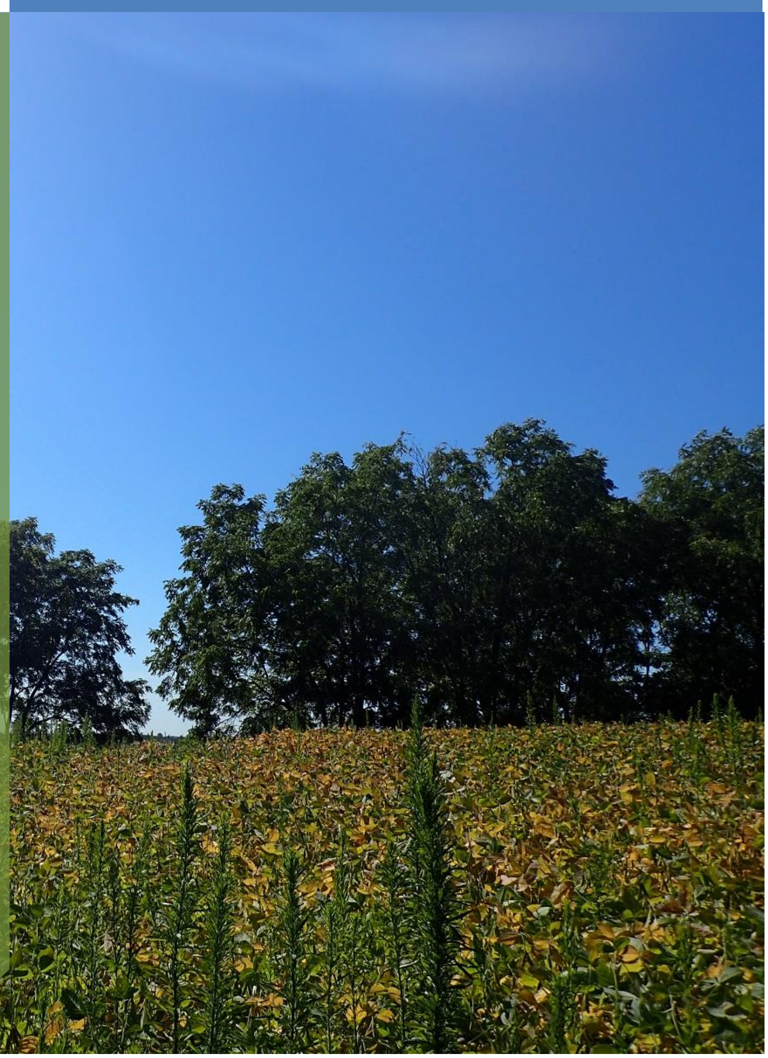
Submitted to:

Municipality of Clarington

Soper Creek Subwatershed Study

Phase 1 Report



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May 2023

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1.0 Introduction

1.1 Preamble

The Municipality of Clarington is a rapidly growing population center located on the shores of Lake Ontario on the eastern side of the Greater Toronto Area (GTA). With a 2021 population of 105,300, growth is expected to push the population to 124,685 by 2031 (Municipality of Clarington Official Plan, 2018). This represents a growth of 19,385 people, or an increase in the population of 18.4%. While this growth represents an opportunity, it also has the potential to cause significant impact to the local environment which has already been greatly influenced by agricultural cultivation and expanding urban development.

The Soper Creek subwatershed is located entirely within the Regional Municipality of Durham, which includes the Municipality of Clarington. Soper Creek watershed is one of the larger watersheds within the Municipality of Clarington with an area of approximately 7729 ha.

In cooperation with Conservation Ontario and Durham Region, Central Lake Ontario Conservation (CLOCA) prepared an Existing Conditions Report (2011) and Watershed Plan (2013) for Bowmanville and Soper Creek.

This document constitutes Phase 1 of Soper Creek Subwatershed Study (SWS), which investigates and inventories the natural resources which could potentially be impacted by future urban development. Along with characterization of natural resources this document identifies preliminary constraints and opportunities which will be considered as secondary plans within the study area are developed. The findings documented in this report will be used to develop a comprehensive Subwatershed Management Plan, including stormwater management and natural heritage strategies, which will protect, rehabilitate, and enhance the environment within the study area limits.

The SWS will fulfill the requirements of the Clarington Official Plan (OP) and also inform the preparation of the following Secondary Plans by guiding development in a manner that respects the local natural heritage system, natural hazards and supports long-term environmental sustainability:

- Soper Springs Secondary Plan; and
- Soper Hills Secondary Plan.

The study area also contains portions of the Bowmanville East Urban Centre Secondary Plan that is currently being updated, as well as portions of the existing Clarington Technology Business Park Secondary Plan.

1.2 Study Area and Land Uses

1.2.1 Subwatershed Study Area

Soper Creek flows out of the Oak Ridges Moraine and then southeast into Lake Ontario. The Watershed is divided into four subwatersheds: Mackie, Soper North, Soper East, and Soper Main. This study focuses more intently on Soper East and Soper Main subwatersheds in order to provide characterization of areas of planned urbanization in the Soper Hills Secondary Plan Area and the Soper Springs Secondary Plan Area. Land use within the Bowmanville Urban Boundary of the Soper Creek subwatersheds is mainly existing residential, active agriculture, and expanding urban development progressing from the west and north. Field studies conducted as part of the SWS were targeted within the Bowmanville Urban Boundary (outlined in red on **Figure 1.1**).

1.2.2 Land Uses

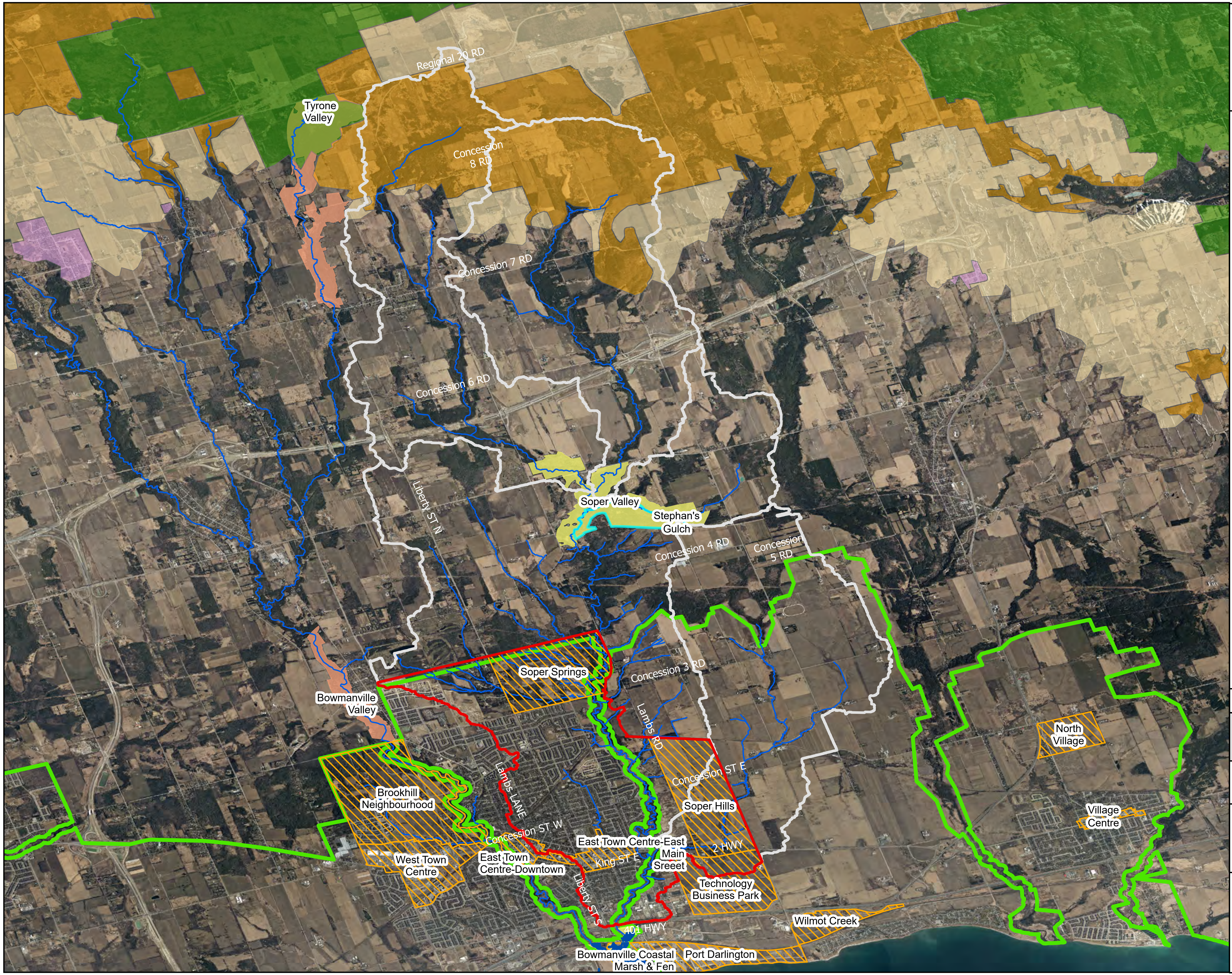
The Soper Creek watershed, as illustrated in **Figure 1.1**, has an approximate area of 7728 ha, 4542 ha of which is within the Bowmanville Urban Boundary. The headwaters of Soper Creek originate north of Concession Road 8. Soper Creek ultimately drains into Bowmanville Creek approximately 900 m upstream of its confluence with Lake Ontario.

Historically, land use throughout this subwatershed was predominately agricultural and residential, with portions of natural and naturalized cover. The Oak Ridges Moraine (ORM) and Greenbelt cover the northern portions of the subwatershed, restricting urban development through these areas. Two major highways (401 and 407) cross the subwatershed; the Highway 407 corridor was completed in 2019. Presently, agriculture is the primary land use designation, followed by natural areas and residential (CLOCA, 2013).

1.2.3 Provincially Designated Areas

Four provincially designated or recognized areas are present within or directly adjacent to the study area. They include:

- **Bowmanville Coastal Wetland Complex/Bowmanville Coastal Marsh & Fen Candidate Life Science ANSI**– Provincially Significant Wetland (PSW) located where Soper Creek meets Bowmanville Creek. The majority of the wetland is found outside of the Soper Creek subwatershed boundary, southward from the Bowmanville Creek confluence point to Lake Ontario.
- **Stephan's Gulch Earth Science ANSI** – This feature is located approximately 2 km north of the Urban Boundary.
- **Soper Valley Life Science ANSI** – This feature is located approximately 1.5 km north of the Urban Boundary.
- **Greenbelt** – Lands included in the provincial Greenbelt are located within the Soper Creek subwatershed boundary and along the very north edge of the Bowmanville Urban Boundary.



Clarington

Legend

- Subwatersheds
- Secondary Plan Areas
- Greenbelt Boundary

Oak Ridges Moraine (ORM)

- Countryside Area
- Natural Core Area
- Natural Linkage Area
- Palgrave Estates Residential Community
- Rural Settlement
- Settlement Area
- Watercourse

MNRF Evaluated Wetlands

- Evaluated-Other
- Evaluated-Provincial

Area of Natural and Scientific Intrerest (ANSI)

- Provincial
- Regional
- Study Area

Figure 1.1

Site Context

Date: October 2020
Projection: UTM_Zone_17N
Source: Municipality of Clarington, MNRF, CLOCA, LIO

0 2,000 4,000
Metres

N

Aquafor Beech Limited

1.3 Existing Policy Framework

The following subsections outline the environmental policy framework relevant to the Soper Creek subwatersheds.

1.3.1 Provincial Policy Statement

The 2020 Provincial Policy Statement (PPS), in effect May 1, 2020, promulgated under the Planning Act, directs municipal land use planning activities related to matters of provincial interest. Section 2.1.2 of the PPS states that:

> *The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features (Ministry of Municipal Affairs and Housing, 2020).*

The PPS supports not only the protection of individual natural heritage features (woodlands, wetlands, watercourses, valleylands, wildlife habitat, etc.) but also the linkages that connect them into a broader Natural Heritage System (NHS). The NHS approach is effective because it acknowledges that natural heritage features have strong functional ties to one another, and that this functionality may be compromised when individual features become isolated within a predominately agricultural or urban matrix.

The PPS defines a Natural Heritage System as:

> *A system made up of natural heritage features and areas, and linkages intended to provide connectivity (at the regional and site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include natural heritage features and areas, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored and areas with the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The Province has a recommended approach for identifying natural heritage systems, but municipal approaches that achieve or exceed the same objective may also be used.* (Ministry of Municipal Affairs and Housing, 2020).

The NHS approach is a useful method for the protection of natural heritage features and areas because it reinforces an understanding that the elements of the system have strong ecological ties to each other, as well as to other physical features and areas in the overall landscape. The NHS approach also addresses a number of important land use planning concerns, including biodiversity decline, landscape fragmentation and the maintenance of ecosystem health. The Natural Heritage Reference Manual (NHRM) describes these planning concerns in greater detail and outlines the potential benefits of an NHS (MNRF 2010).

Section 2.1 of the PPS provides specific requirements for the protection of natural features and the restrictions that apply to development and site alteration in association with those features. Sections 2.1.4 through 2.1.8 have been included in this report for reference.

> ***2.1.4*** *Development and site alteration shall not be permitted in:*
> *a) significant wetlands in Ecoregions 5E, 6E and 7E1; and*
> *b) significant coastal wetlands.*
>
> ***2.1.5*** *Development and site alteration shall not be permitted in:*
> *a) significant wetlands in the Canadian Shield north of Ecoregions 5E, 6E and 7E1;*
> *b) significant woodlands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Marys River);*
> *c) significant valleylands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Marys River);*
> *d) significant wildlife habitat;*
> *e) significant areas of natural and scientific interest; and*
> *f) coastal wetlands in Ecoregions 5E, 6E and 7E that are not subject to policy 2.1.4(b)*
> *unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.*
>
> ***2.1.6*** *Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.*
>
> ***2.1.7*** *Development and site alteration shall not be permitted in habitat of endangered species and threatened species, except in accordance with provincial and federal requirements.*
>
> ***2.1.8*** *Development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in policies 2.1.4, 2.1.5, and 2.1.6 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.*

The clauses in Section 2.1 of the PPS support the detailed NHS policies and constraints to development that are present in municipal Official Plans, which are discussed in **Sections 1.3.5** and **1.3.6**.

Section 3.1 of the PPS outlines policies related to Natural Hazards such as flooding and erosion hazards associated with both riverine systems and lakes. Sections 3.1.1 through 3.1.5 have been included in this report for reference.

> ***3.1.1*** *Development shall generally be directed, in accordance with guidance developed by the Province (as amended from time to time), to areas outside of:*

a) hazardous lands adjacent to the shorelines of the Great Lakes - St. Lawrence River System and large inland lakes which are impacted by flooding hazards, erosion hazards and/or dynamic beach hazards;

b) hazardous lands adjacent to river, stream and small inland lake systems which are impacted by flooding hazards and/or erosion hazards; and

c) hazardous sites.

3.1.2 *Development and site alteration shall not be permitted within:*
a) the dynamic beach hazard;

b) defined portions of the flooding hazard along connecting channels (the St. Marys, St. Clair, Detroit, Niagara and St. Lawrence Rivers);

c) areas that would be rendered inaccessible to people and vehicles during times of flooding hazards, erosion hazards and/or dynamic beach hazards, unless it has been demonstrated that the site has safe access appropriate for the nature of the development and the natural hazard; and

d) a floodway regardless of whether the area of inundation contains high points of land not subject to flooding.

3.1.3 *Planning authorities shall prepare for the impacts of a changing climate that may increase the risk associated with natural hazards.*

3.1.4 *Despite policy 3.1.2, development and site alteration may be permitted in certain areas associated with the flooding hazard along river, stream and small inland lake systems:*
a) in those exceptional situations where a Special Policy Area has been approved. The designation of a Special Policy Area, and any change or modification to the official plan policies, land use designations or boundaries applying to Special Policy Area lands, must be approved by the Ministers of Municipal Affairs and Housing and Natural Resources and Forestry prior to the approval authority approving such changes or modifications; or

b) where the development is limited to uses which by their nature must locate within the floodway, including flood and/or erosion control works or minor additions or passive non-structural uses which do not affect flood flows.

3.1.5 *Development shall not be permitted to locate in hazardous lands and hazardous sites where the use is:*
a) an institutional use including hospitals, long-term care homes, retirement homes, pre-schools, school nurseries, day cares and schools;

b) an essential emergency service such as that provided by fire, police and ambulance stations and electrical substations; or c) uses associated with the disposal, manufacture, treatment or storage of hazardous substances.

1.3.2 Greenbelt Plan (2017)

The Greenbelt Plan was developed out of the Greater Golden Horseshoe Growth Plan to work in tandem with the Oak Ridges Moraine Conservation Plan (ORMCP; 2017) and the Niagara Escarpment Plan (NEP; Updated 2020) to protect ecological and hydrological features along with agricultural lands. The Greenbelt Area includes lands within the NEP Area, the Oak Ridges Moraine Area, the Parkway Belt West Plan Area and lands designated as Protected Countryside and as Urban River Valley by this Plan. The Greenbelt Plan broadly sets out to:

a) *Protection, maintenance and enhancement of natural heritage, hydrologic and landform features, areas and functions, including protection of habitat for flora and fauna and particularly species at risk;*

b) *Protection and restoration of natural and open space connections between the Oak Ridges Moraine, the Niagara Escarpment, Lake Ontario, Lake Simcoe and the major river valley lands while also maintaining connections to the broader natural systems of southern Ontario beyond the GGH, such as the Great Lakes Coast, the Carolinian Zone, the Lake Erie Basin, the Kawartha Highlands and the Algonquin to Adirondacks Corridor;*

c) *Protection, improvement or restoration of the quality and quantity of ground and surface water and the hydrological integrity of watersheds; and*

d) *Provision of long-term guidance for the management of natural heritage and water resources when contemplating such matters as watershed/subwatershed and stormwater management planning, water and wastewater servicing, development, infrastructure, open space planning and management, aggregate rehabilitation and private or public stewardship programs.*

The Soper Creek SWS study area contains Protected Countryside along the northern border of the urban boundary and Urban River Valley extending along Soper Creek and Bowmanville Creek (**Figure 1.1**). Protected Countryside lands are “intended to enhance the spatial extent of agriculturally and environmentally protected lands covered by the NEP and the ORMCP while at the same time improving linkages between these areas and the surrounding major lake systems and watersheds.” Urban River Valley lands are river systems that provide “opportunities for additional connections to help expand and integrate the Greenbelt and its systems into the broader southern Ontario landscape”.

1.3.3 Oak Ridges Moraine Conservation Plan (2017)

The Oak Ridges Moraine Conservation Plan (2017) was developed under the Oak Ridges Moraine Act (2001) with the following objectives:

a) *protecting the ecological and hydrological integrity of the Oak Ridges Moraine Area;*

b) *ensuring that only land and resource uses that maintain, improve or restore the ecological and hydrological functions of the Oak Ridges Moraine Area are permitted;*

c) *maintaining, improving or restoring all the elements that contribute to the ecological and hydrological functions of the Oak Ridges Moraine Area, including the quality and quantity of its water and its other resources;*

d) *ensuring that the Oak Ridges Moraine Area is maintained as a continuous natural landform and environment for the benefit of present and future generations;*

e) *providing for land and resource uses and development that are compatible with the other objectives of the Plan;*

f) *providing for continued development within existing urban settlement areas and recognizing existing rural settlements;*

g) *providing for a continuous recreational trail through the Oak Ridges Moraine Area that is accessible to all including persons with disabilities;*

h) *providing for other public recreational access to the Oak Ridges Moraine Area; and*

i) *any other prescribed objectives. 2001, c. 31, s. 4.*

Within the Oak Ridges Moraine Conservation Plan (2017), it defines Natural Core Areas as areas with the "greatest concentrations of key natural heritage features which are critical to maintaining the integrity of the Moraine as a whole" and Natural Linkage Areas as areas that are "critical natural and open space linkages between the Natural Core Areas and along rivers and streams" (P.4). Key natural heritage features include wetlands, habitat of endangered and threatened species, fish habitat, areas of natural and scientific interest (life science), significant valleylands, significant woodlands, significant wildlife habitat (including habitat of special concern species), and Sand barrens, savannahs and tallgrass prairies.

The northern portion of the watershed is located within the Oak Ridges Moraine but this does not include the lands within the urban boundary (**Figure 1.1**).

1.3.4 Growth Plan for the Greater Golden Horseshoe

The portion of Ontario termed the Greater Golden Horseshoe includes most municipalities in a broad band around the shore of Lake Ontario from Peterborough to Niagara. This region contains many of Ontario's most significant ecological features and scenic landscapes, as well as productive farmland and a large proportion of the inhabitants of the province. Maintaining a balance between the demand for space and resources and the preservation of natural heritage features and functions presents a challenge that must be addressed through careful planning.

The 2020 Growth Plan for the Greater Golden Horseshoe, prepared under the *Places to Grow Act* (2005), is intended to "plan for growth and development in a way that supports economic prosperity, protects the environment, and helps communities achieve a high quality of life" (Ministry of Municipal Affairs and Housing, 2020). One of the key components of the Growth Plan is the development and implementation of an NHS and establishment of related policies such as those within Clause 3 of Section 4.2.2 of the Growth Plan (applicable to lands outside of settlement areas):

3. Within the Natural Heritage System:

a) new development or site alteration will demonstrate that:

i. there are no negative impacts on key natural heritage features or key hydrologic features or their functions;

ii. connectivity along the system and between key natural heritage features and key hydrologic features located within 240 meters of each other will be maintained or, where possible, enhanced for the movement of native plants and animals across the landscape;

iii. the removal of other natural features not identified as key natural heritage features and key hydrologic features is avoided, where possible. Such features should be incorporated into the planning and design of the proposed use wherever possible;

iv. except for uses described in and governed by the policies in subsection 4.2.8 [pertaining to Mineral Aggregate Resources], the disturbed area, including any buildings and structures, will not exceed 25 per cent of the total developable area, and the impervious surface will not exceed 10 per cent of the total developable area;

v. with respect to golf courses, the disturbed area will not exceed 40 per cent of the total developable area; and

vi. at least 30 per cent of the total developable area will remain or be returned to natural self-sustaining vegetation, except where specified in accordance with the policies in subsection 4.2.8.

Section 4.2.4 of the Growth Plan further discusses lands adjacent to the NHS.

1. *Outside settlement areas, a proposal for new development or site alteration within 120 metres of a key natural heritage feature within the Natural Heritage System or a key hydrologic feature will require a natural heritage evaluation or hydrologic evaluation that identifies a vegetation protection zone, which:*

   a) is of sufficient width to protect the key natural heritage feature or key hydrologic feature and its functions from the impacts of the proposed change;

   b) is established to achieve and be maintained as natural self-sustaining vegetation; and

   c) for key hydrologic features, fish habitat, and significant woodlands, is no less than 30 metres measured from the outside boundary of the key natural heritage feature or key hydrologic feature.

2. Evaluations undertaken in accordance with policy 4.2.4.1 will identify any additional restrictions to be applied before, during, and after development to protect the hydrologic functions and ecological functions of the feature.

3. Development or site alteration is not permitted in the vegetation protection zone, with the exception of that described in policy 4.2.3.1 or shoreline development as permitted in accordance with policy 4.2.4.5.

The amendment of municipal Official Plans to conform with this Growth Plan will take time, but the Planning Act requires that all decisions in respect of planning matters will conform with this Plan as of its effective date (subject to any legislative or regulatory provisions providing otherwise).

1.3.5 Region of Durham Official Plan

The Region of Durham Official Plan (ROP) (consolidated in May 2017) contains policies and maps, which guide the type and location of land uses in the Region to 2031. With respect to the environment (Section 2 of the ROP), the goals of the ROP are:

- To ensure the preservation, conservation and enhancement of the Region's natural environment for its valuable ecological functions and for the enjoyment of the Region's residents.
- To incorporate good community planning and design that enhances the Regional landscape and minimizes pollution of air, water and land resources.
- To preserve and foster the attributes of communities and the historic and cultural heritage of the Region.
- To undertake planning functions based on the understanding that there is a relationship between the natural and built environments and the principle of preserving resources and protecting the natural environment for future generations.
- To promote good community planning and design that enhances public health and safety.

The implementation of Subwatershed Planning is supported in the ROP through the following policy:

2.3.8: The preparation and implementation of watershed plans is supported as an effective planning tool in the protection of the Region's natural resources.

2.3.9: It is the intent of this Plan that watershed plans will be prepared or updated for each watershed on a priority basis recognizing development pressures, environmental urgency and fiscal constraints. Watershed plans shall be prepared or updated in accordance with currently accepted practices.

The ROP contains policies for the protection of Key Natural Heritage and Hydrologic Features (Sections 2.3.14 to 2.3.18 and Sub-Section 10A), Woodlands (Section 2.3.19), and water resources (Sections 2.3.20 to 2.3.25).

1.3.6 Municipality of Clarington Official Plan

The Municipality of Clarington Official Plan (OP), consolidated in June 2018, states that "for integrated and long-term planning and to make environmentally sound decisions that consider *cumulative impacts of development*, the Municipality will continue to support the need to undertake multi-stakeholder watershed planning studies in order to protect the integrity of *ecological and hydrological functions*" (Section 3.5.1). The OP identifies that "the many and diverse *natural heritage features* and *hydrologically sensitive features* found in Clarington, together with their *ecological functions*, collectively comprise the Municipality's Natural Heritage System" (OP Section 3.4.1).

The OP defines Natural Heritage System as:

> *a system made up of natural heritage features and areas, hydrologically sensitive features and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, hydrologically sensitive features, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue.*

According to Section 3.4.2, the following natural heritage features and hydrologically sensitive features make up the natural heritage system:

Natural Heritage Features

- *a) Wetlands;*
- *b) Areas of Natural and Scientific Interest;*
- *c) Significant Woodlands;*
- *d) All significant Valleylands;*
- *e) Fish habitat and riparian corridors;*
- *f) Habitat of endangered species and threatened species;*
- *g) Rare vegetation communities, including sand barrens, savannahs and tallgrass prairie; and*
- *h) Wildlife habitat.*

Hydrologically Sensitive Features

- *i) Wetlands;*
- *j) Watercourses;*
- *k) Seepage areas and springs;*
- *l) Groundwater features; and*
- *m) Lake Ontario and its littoral zones.*

In addition to those defined categories, Section 3.4.3 of the OP states: "*There are a number of other environmentally sensitive terrestrial features and areas, natural heritage features and hydrologically* *sensitive features and areas which, due to inadequate information or the nature of the feature or area, are not shown on Map D. These features are also important to the integrity of the natural heritage system and may be identified on a site-by-site basis for protection through the review of a development application or other studies*." This SWS has therefore taken the approach of identifying and evaluating all natural heritage features on the landscape and evaluating their significance/ sensitivity, not necessarily limited to the features previously identified as part of the NHS.

Additional guidance regarding the definition of features making up the NHS is provided in the Natural Heritage System Discussion Paper prepared for the Municipality of Clarington by Ganaraska Conservation and the Central Lake Ontario Conservation Authority (CLOCA) in 2013. Most notably, the category of "Fish Habitat and Riparian Corridors" was defined in this Discussion Paper as the area 30 m on either side of a watercourse. Therefore, the Fish Habitat and Riparian Corridor feature itself consists of a 60 m-wide swath around watercourses, and it is this feature to which any additional buffering or setback requirements are applied. At the direction of the Municipality, this is the definition of the "Fish Habitat and Riparian Corridors" feature that has been carried forward in this report but may be revised if determined acceptable through the completion of an Environmental Impact Study EIS.

The OP goes on to define the required minimum vegetation protection zone (VPZ) associated with the listed NHS features. Section 3.4.8 of the OP states that:

> *Development and site alteration with respect to land within a natural heritage feature and/or a hydrologically sensitive feature or within its vegetation protection zone is prohibited, except the following:*
>
> *a) Forest, fish and wildlife management;*
> *b) Conservation and flood or erosion control projects, but only if they have been demonstrated to be necessary in the public interest after all alternatives have been considered;*
> *c) Transportation, infrastructure and utilities, but only if the need for the project has been demonstrated by an Environmental Assessment, there is no reasonable alternative, and it is supported by a project specific Environmental Impact Study; and*
> *d) Low intensity recreation.*

In addition, Section 3.4.9 further explains that "Low-impact development stormwater systems such as bioswales, infiltration trenches and vegetated filter strips may be permitted within the vegetation protection zone provided that the intent of the vegetation protection zone is maintained and it is supported by the Environmental Impact Study." (Municipality of Clarington 2018).

Table 1.1 provides an overview of the minimum VPZ requirements for various aspects of the NHS per the OP. The OP states that "If more than one natural heritage system feature is identified on the subject lands, the provisions of [this table] that are more restrictive apply."

Table 1.1: Minimum Vegetation Protection Zones per Table 3-1 from the Municipality of Clarington OP (2018).

<table>
<tr><th rowspan="2">NHS Features</th><th colspan="2">Minimum Vegetation Protection Zone (VPZ) Requirements</th></tr>
<tr><th>Within Urban and Rural Settlement Areas</th><th>Outside of Urban and Rural Settlement Areas</th></tr>
<tr><td>Wetlands</td><td>30 m</td><td rowspan="7">All land within 30 m of:
• the outermost extent of the natural heritage feature
• the stable top of bank for valleylands
• the dripline of the outermost tree within the woodland
• meander belt</td></tr>
<tr><td>Fish Habitat and Riparian Corridors</td><td rowspan="6">15 m</td></tr>
<tr><td>Valleylands</td></tr>
<tr><td>Significant Woodlands</td></tr>
<tr><td>Watercourses</td></tr>
<tr><td>Seepage Areas and Springs</td></tr>
<tr><td></td></tr>
<tr><td>Habitat of Endangered and Threatened Species</td><td colspan="2" rowspan="4">As determined by an Environmental Impact Study or a Natural Heritage Evaluation in accordance with Provincial and Federal requirements.</td></tr>
<tr><td>Areas of Natural and Scientific Interest (Life Science)</td></tr>
<tr><td>Wildlife Habitat</td></tr>
<tr><td>Rare Vegetation Communities</td></tr>
<tr><td>Areas of Natural and Scientific Interest (Earth Science)</td><td colspan="2">As determined by an Earth Science Heritage Evaluation.</td></tr>
<tr><td>Beach/Bluff</td><td colspan="2">As determined by a Geotechnical Evaluation and/or a Slope Stability Assessment.</td></tr>
</table>

The requirement for a Subwatershed Study to ensure "*integrated and long term planning*" that makes "*environmentally sound decisions that consider cumulative impacts of development*" is identified in Section 3.5 of the OP. It is stated that the recommendations of Subwatershed Studies "*shall guide the Municipality in maintaining, improving, and enhancing the health of the watersheds*" and that subsequent Secondary Plans and development applications shall consider and incorporate the applicable objectives and requirements of the SWS as appropriate. It is further stated that, through the preparation of a SWS, the limits of the previously-established NHS (as depicted on Map D of the OP) may be refined, and linkages and restoration opportunities will be identified for further evaluation during the Secondary Plan or development application stage, as part of a site-specific study such as an EIS. This SWS will therefore evaluate the existing natural heritage features in the study area (building upon but not necessarily limited to the existing NHS as depicted in the OP), identify linkages and restoration opportunities, and provide guidance regarding developmental constraints that may be further evaluated and developed through the preparation of Secondary Plans, in keeping with the policies of Section 3.5 of the OP.

Definitions

In the preparation of this document, applicable definitions from the Municipality of Clarington OP were used, including:

- *Areas of Natural and Scientific Interest: means areas of land and water containing natural landscapes or features which have been identified by the Ministry of Natural Resources [and Forestry] as having values related to natural heritage protection, scientific study, or education.*

- *Fish Habitat: the spawning grounds and nursery, rearing and food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes as further identified by the Department of Fisheries and Oceans (Canada).*

- *Ground Water Features: means water-related features in the earth's subsurface, including recharge/discharge areas, water tables, aquifers and unsaturated zones that can be defined by surface and subsurface hydrogeologic investigations.*

- *Habitat of Endangered Species and Threatened Species:*

    a) *With respect to a species listed on the Species at Risk in Ontario List as an endangered or threatened species for which a regulation made under clause 55(1)(a) of the Endangered Species Act, 2007 is in force, the area prescribed by that regulation as the habitat of the species; or*
    b) *With respect to any other species listed on the Species at Risk in Ontario List as an endangered or threatened species, an area on which the species depends, directly or indirectly, to carry on its life processes, including life processes such as reproduction, rearing, hibernation, migration or feeding, as approved by the Ontario Ministry of Natural Resources [and Forestry]; and*
    c) *Places in the area described in clause (A) or (B), whichever is applicable, that are used by members of the species as dens, nests, hibernacula or other residences.*

- *Linkage: means natural areas within the landscape that ecologically connect the Natural Heritage System. They are avenues along which plants and animals can propagate, genetic interchange can occur, populations can move in response to environmental changes and life cycle requirements, and species can be replenished from other natural areas. Conserving linkages also protects and enhances the Natural Heritage System.*

- *<u>Rare Vegetation Community</u>: means either a provincially rare community or a vegetation community that is poorly represented in the Region of Durham as identified by the Natural Heritage Information Centre (NHIC), or local conservation authority having jurisdiction.*

- *<u>Riparian Corridors</u>: means the land adjacent to watercourses, lakes, ponds, and wetlands which are transitional areas between aquatic and upland habitats and as such can provide natural features, functions and conditions that support fish life processes and protect fish habitat.*

- *<u>Significant Woodland</u>: shall mean an old growth woodland, or a woodland, greater than 4 ha located outside of settlement areas, or greater than 1 ha in settlement areas. Significance of woodlands within the Oak Ridges Moraine is determined by the Ministry of Natural Resources using evaluation procedures established by that Ministry, or by a study conducted in accordance with this Plan. "Significant Woodland" may also include plantations.*

- *<u>Valleyland</u>: lands within a depression along either side of a watercourse as determined from top-of-bank plus any applicable buffers as required for slope stability.*

- *<u>Wetlands</u>: lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is at or close to the surface as defined by either the Ministry of Natural Resources, the Conservation Authority, or through a comparable evaluation. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens. Wetlands included in the natural heritage system are at least 0.5 hectares in size.*

- *<u>Wildlife Habitat</u>: means areas of the natural environment where plants, animals, and other organisms live, and find adequate amounts of food, water, shelter and space needed to sustain their populations. Specific wildlife habitats of concerns may include areas where species concentrate at a vulnerable point in their annual or life cycle; and areas which are important to migratory and non-migratory species.*

- *<u>Woodland</u>: shall mean a treed area that provides environmental and economic benefits such as erosion prevention, water retention, and the provision of habitat but shall not include a cultivated fruit or nut orchard or a plantation established for the production of Christmas trees.*

The Municipality of Clarington Official Plan (June 2018) outlines the definition of Natural Hazards and specific policies related to Natural Hazards in Sections 3.7.2 through 3.7.5. These are presented as reference below:

ii. *- Natural hazard lands are those lands which exhibit one or more hazards such as poor drainage, organic soils, flood susceptibility, susceptibility to erosion, steep slopes, or any other physical condition on which development could cause loss of life, personal injury,* *property damage, or could lead to the deterioration or degradation of the natural environment.*

iii. *- All lands, including lands that are covered in water, and the furthest landward limit of the flooding hazard, erosion hazard or dynamic beach hazard, are considered natural hazard lands.*

iv. *- To protect people, infrastructure, buildings, and properties and promote a healthy and resilient Municipality in the preparation of Secondary Plans, the Municipality shall consider the potential impacts of climate change that may increase the risk associated with natural hazards.*

v. *- No new buildings or structures shall be permitted on lands identified as natural hazard lands, save and except for those buildings or structures required for flood and/or erosion control which are approved by the Conservation Authority and the Municipality.*

1.3.7 Central Lake Ontario Conservation Authority

1.3.7.1 CLOCA Natural Heritage Methodology

CLOCA's methodology for developing an NHS within their jurisdiction (CLOCA, 2011a) was reviewed during the preparation of this document to provide context for the larger subwatershed within which Soper Creek is located. Similar to the Municipal Official Plan that guides this SWS study, CLOCA's NHS methodology emphasizes not only identifying the features and functions currently present in the study area but also determining where there is room for improvement (e.g., through establishment of corridors and implementation of restoration works), stating, "*despite good intentions, land use policies that focus on protecting only the most significant of habitats ultimately contribute to the overall loss of biodiversity and ecosystem function*" (CLOCA, 2011a).

CLOCA's document states that all wetlands/woodlands are valued and should be considered in the development of an NHS. As part of this study, Aquafor Beech Limited reviewed all wetlands and woodlands present in the Urban Boundary study area and assessed not only whether they warranted inclusion in the municipal NHS (as defined by the Municipality of Clarington's OP) but whether they contained important features or functions that would warrant protection (as previously discussed in **Section 1.3.6**). CLOCA's NHS guidance proposes a 30 m buffer surrounding watercourses. This proposed buffer area would be included in the 60 m swath defined by the Municipality as the "Fish Habitat and Riparian Corridor" NHS feature, as outlined in **Section 1.3.6**. In both of these cases, therefore, the current SWS completed in compliance with the municipal OP is also compliant with this component of CLOCA's natural heritage methodology.

1.3.8 Endangered Species Act

The protection of Species at Risk (SAR) in Ontario is dictated primarily by the *Endangered Species Act* (ESA). The stated purposes of the ESA are:

2. To identify SAR based on the best available scientific information, including information obtained from community knowledge and aboriginal traditional knowledge;
3. To protect species that are at risk and their habitats, and to promote the recovery of species that are at risk; and
4. To promote stewardship activities to assist in the protection and recovery of species that are at risk.

A scientific body known as the Committee on the Status of Species at Risk in Ontario (COSSARO) is tasked with identifying threats to species in Ontario and classifying those deemed at risk as Extirpated, Endangered, Threatened, or Special Concern. For Endangered and Threatened species, the preparation of a recovery strategy is required; these offer science-based recommendations that aid in their protection and future recovery. These species are also protected from being killed, harmed or harassed (ESA s. 9) and receive habitat protection (s. 10). Special Concern species receive management plans rather than recovery strategies and are not subject to species or habitat protection under the Act. Rather, their habitat is protected under the Planning Act as it is considered a type of Significant Wildlife Habitat per provincial criteria (MNRF, 2015).

The Municipality of Clarington's NHS includes the habitat of Endangered and Threatened species, and Significant Wildlife Habitat which includes habitat of Special Concern species (as discussed further in **Sections 3.3.5** and **3.3.6**). These components of the NHS were assessed in this SWS using the ESA and its supporting resources (e.g., recovery strategies) to identify SAR and SAR habitat.

1.4 Subwatershed Study Goals, Objectives, and Phasing

The overall goal of this SWS may be defined as follows:

> "***Development of a management plan that allows sustainable urban growth, while ensuring maximum benefits to the natural and human environments on a watershed basis.***" – Watershed Planning in Ontario

The SWS is undertaken in three phases. The objectives of this study are summarized below, according to the three study phases. This report has been prepared to present the results for Phase 1 of the process.

<u>Phase 1: Subwatershed Characterization</u>

- Identify and evaluate the location, extent, significance, and sensitivity of the existing natural features of the study area, together with their potential interrelationship with other natural features;
- Identify sensitive areas and natural hazard lands, together with recommended buffers, and select preliminary management practices for these lands; and
- Develop preliminary constraints and opportunities mapping to identify developable and non-developable lands which will inform the development and update of Secondary Plans within the Urban Boundary study area.

Phase 2: Subwatershed Management Strategies

- Identify potential land use impacts to natural features and functions (Impact Assessment);
- Identify protective measures (best management practices, or BMPs) that, when implemented, will protect, enhance or restore environmental features and functions;
- Identify actions and strategies to build resiliency to climate change into the community;
- Formulate alternative subwatershed management strategies;
- Evaluate each strategy, based on a range of environmental, social and cost considerations together with stakeholder input; and
- Select from among the alternatives a recommended subwatershed strategy (or plan).

Phase 3: Implementation and Monitoring Plans

- Develop an Implementation Plan to ensure the long-term integrity of the Recommended Plan, including the identification of issues and areas where further detailed studies may be required at the draft plan of subdivision stage of the planning process;
- Identify any future recommended monitoring studies or contingency plans; and
- Integrate the Subwatershed Study findings with Municipal Official Plan Policy and ongoing Secondary Plans.

1.5 Class Environmental Assessment (EA) Process

This Subwatershed Study is being conducted in the spirit of a Municipal Class Environmental Assessment (Class EA). In order to meet the intent of the Environmental Assessment Act, the study will satisfy Phases 1 and 2 of the Class EA process:

- Phase 1 – identification of the problem (deficiency) or opportunity; and
- Phase 2 – identification of alternative solutions to address the problem or opportunity by taking into consideration the existing environment, and establish the preferred solution taking into account public and review agency input.

The relationship between the components of the Subwatershed Study process and the Class EA process is depicted in **Figure 1.2**.

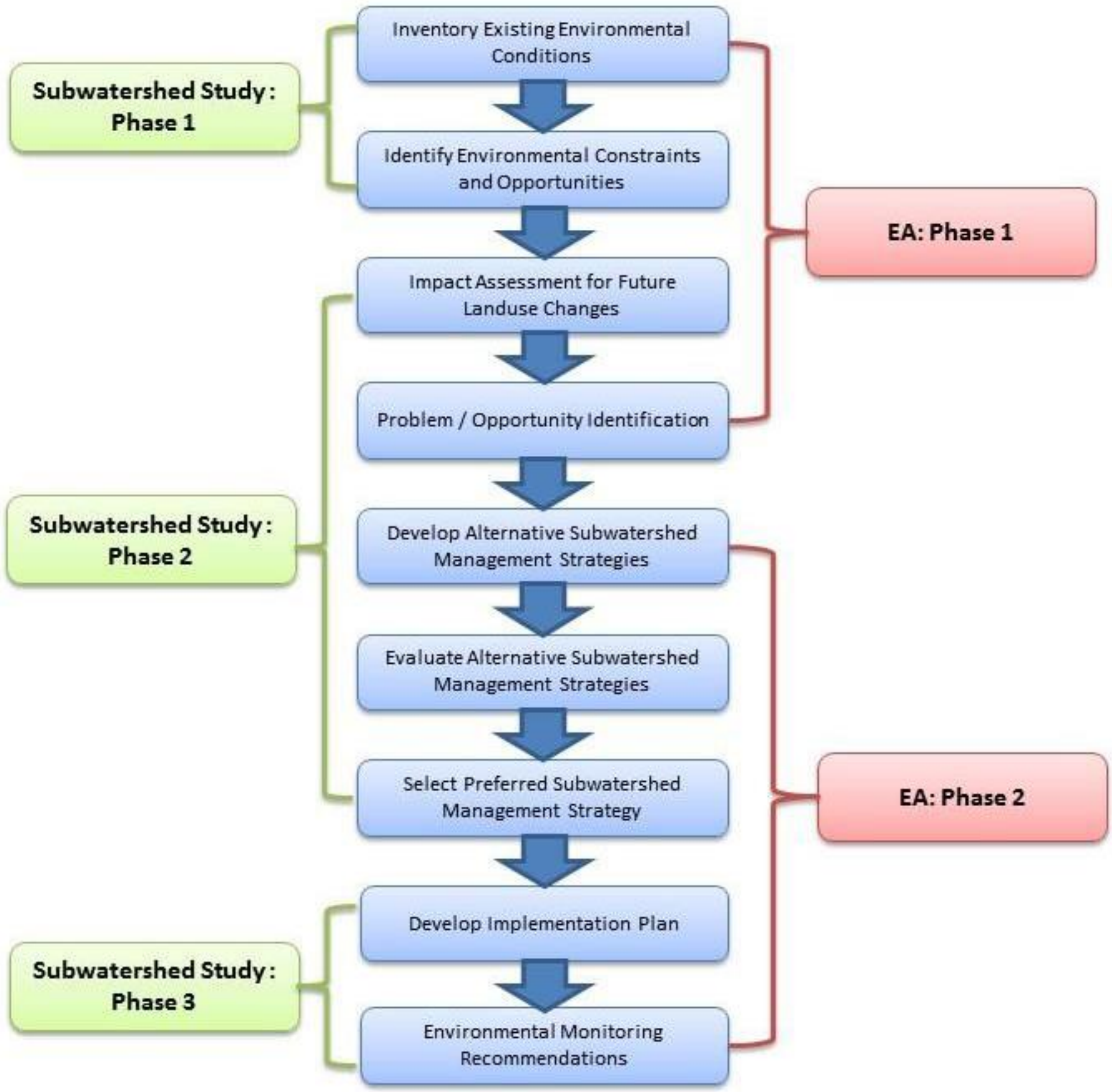


Figure 1.2: Subwatershed Study & Environmental Assessment Study Process

1.6 Secondary Planning within the Soper Creek Subwatershed

Secondary Plans are land use planning tools that formally address specific opportunities and constraints related to land use in certain defined geographic areas. They are typically undertaken in areas where detailed direction is needed for matters beyond the general framework provided by the Official Plan. Secondary Plans play an important role in the Municipality of Clarington's Official Plan. The preparation or amendment of a Secondary Plan follows the same procedures as an Official Plan Amendment under the Planning Act. This includes the preparation of supporting technical studies, public engagement, notice and holding of public meetings and adoption procedures.

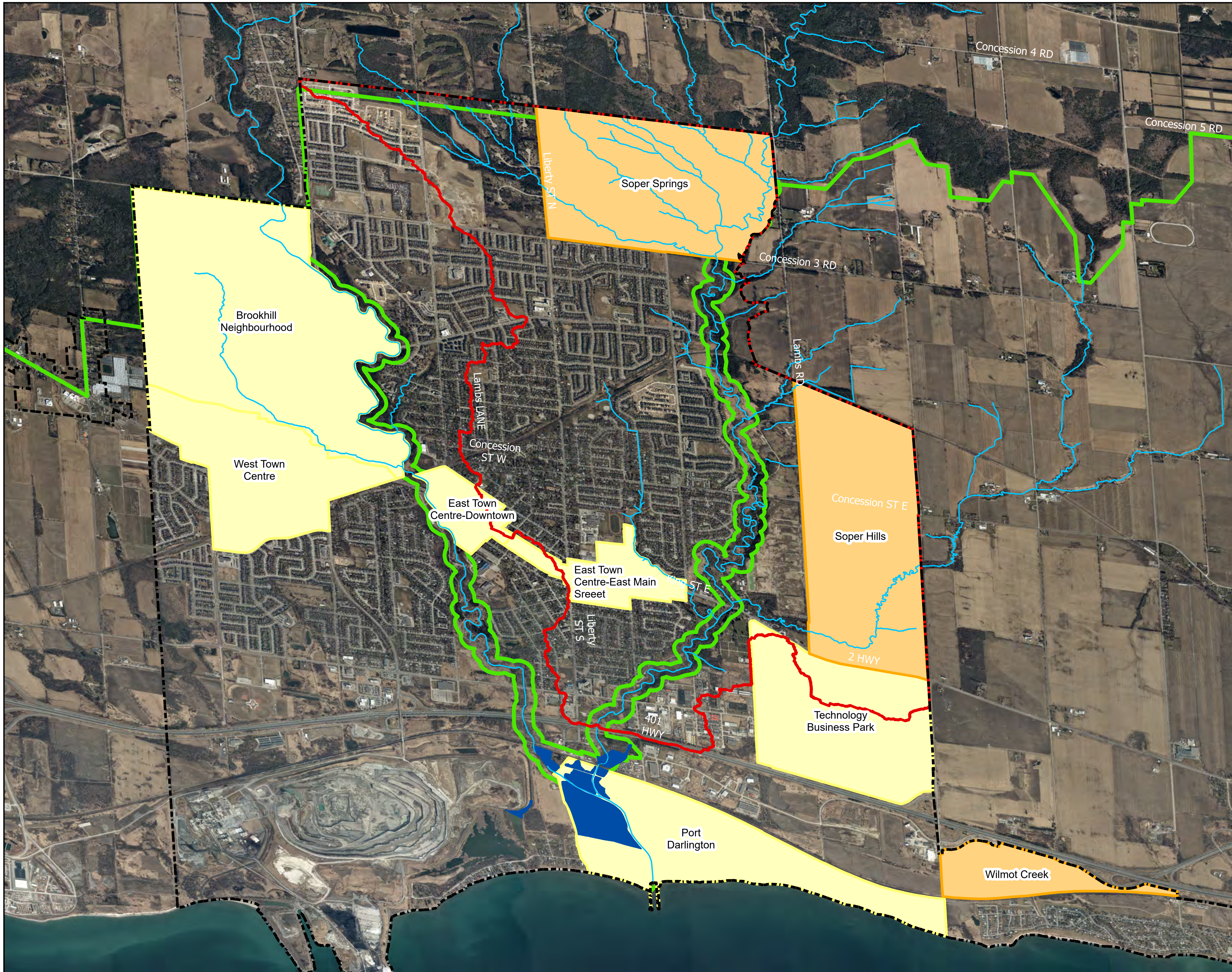
The Clarington Official Plan (Consolidated June 2018), requires that new residential areas greater than 20 ha are to be planned by means of Secondary Plans. This neighbourhood scale planning allows for a more detailed analysis of land use and transportation issues and specific ways to achieve the objectives of the Clarington Official Plan, including meeting density and infill targets.

The preparation of any Secondary Plan requires input from supporting technical studies. The collective recommendations (opportunities and constraints) from these technical studies will influence the developable area of the Secondary Plan, influence the mix and location for the various land uses, as well as recommend design and development parameters. Subwatershed studies are important supporting technical documents to the Secondary Planning process because they establish the base environmental parameters for neighbourhood planning, including not only the natural heritage and hydrological systems but also establish high-level drainage planning for the Secondary Plan Areas. Subwatershed studies include strategies to support the Municipality's Official Plan and identify the responsible management strategies for subwatershed areas with the primary focus of protecting natural ecosystem functions, flooding and erosion. Subwatershed studies analyse the cumulative effects of changes in land use, identify areas of risk, and make recommendations on areas for enhancement to allow for a protected and connected Natural Heritage System.

Three Secondary Plans fully or partially within the Soper Creek Subwatershed boundary have already been completed: the East Town Center – East Main Street, East Town Center – Downtown, and Technology Business Park Secondary Plans. This Soper Creek SWS will inform the preparation of two additional Secondary Plans, depicted on **Figure 1.3** and described as follows:

1) The **Soper Springs Secondary Plan** area is located entirely within the Soper Creek subwatershed, and is bounded by Liberty St. N. to the west, Lambs Rd. to the east, Concession Rd. 3 to the south, and the Bowmanville Urban Boundary to the north. The Secondary Plan area as a whole includes Environmental Protection lands associated with forested tributaries to Soper Creek. The total land area is approximately 186 ha.

2) The **Soper Hills Secondary Plan** area is located entirely within the Soper Creek subwatershed, on the east side of the Bowmanville Urban Area (i.e., east of the main channel and existing Bowmanville developments). It is bounded by Lambs Rd. to the west, the Bowmanville Urban Boundary to the east, Durham Highway 2 to the south, and a CP Rail line to the north. The total area of the Secondary Plan lands is approximately 193 ha.



Clarington

Legend

- Urban_Boundary
- Completed Secondary Plans
- Incomplete Secondary Plans
- Watercourse
- Evaluated Wetland
- Provincially Significant Wetland
- Greenbelt Boundary
- Study Area

Figure 1.3

Secondary Plan Areas

Date: October 2020
Projection: UTM_Zone_17N
Source: Municipality of Clarington, CLOCA, LIO

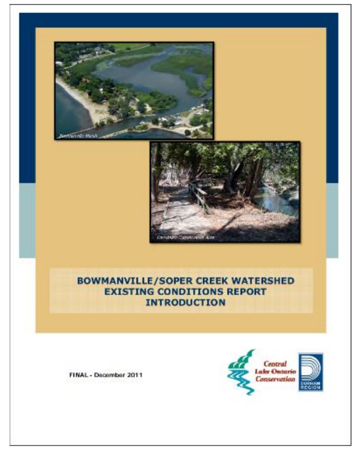
0 500 1,000
Metres

N

Aquafor Beech Limited

2.0 Background Information

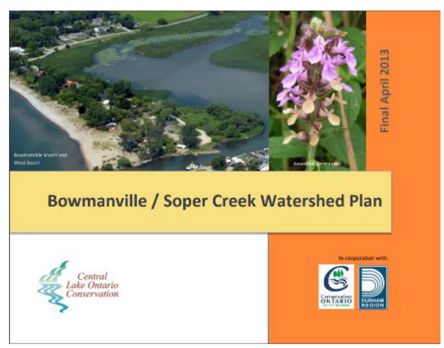
A series of historical study reports and background information was provided by the Municipality of Clarington, Central Lake Ontario Conservation Authority (CLOCA), and the Region of Durham, for background review and consideration during the Soper Creek Subwatershed Study. Key documents are summarized below.



Bowmanville / Soper Creek Watershed Existing Conditions Report (CLOCA, December 2011)

This study documents and summarizes the natural environment of Soper Creek subwatersheds. This report is an assessment of the existing conditions, including policy and land use, climate, water budget, surface water quality, stormwater management, fluvial geomorphology, hydrogeology, water quantity, aquatic habitat, terrestrial natural habitat, and wetlands. The purpose of the report was to establish the existing conditions for Soper Creek Watershed Plan, and to conserve, enhance, and manage the watersheds.

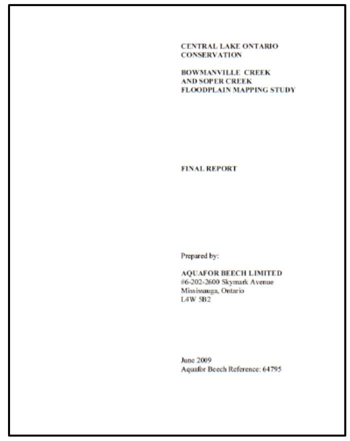
The report establishes that Soper Creek watershed is dominated by agricultural land use, followed by natural areas and residential. As one of the larger subwatersheds in the Municipality of Clarington, the Soper Creek subwatershed drains 7728 ha. The report often groups Bowmanville and Soper Creek subwatersheds (e.g., in stating that 37% of the two subwatersheds is naturally vegetated). Soper Creek and its tributaries primarily support cold/cool-water fisheries.



Bowmanville / Soper Creek Watershed Plan (CLOCA, April 2013)

The purpose of this report was to be the definitive tool for decision-makers to effectively manage watershed resources within the subwatershed while responding to a changing environment. Watershed health targets were developed, as was a watershed management plan to achieve these targets. The watershed management plan includes the Natural Heritage System; High Volume Recharge Areas; waterbodies and water courses; and regional wildlife corridors on the Oak Ridges Moraine, Lake Iroquois Beach, and the Lake Ontario Shoreline.

Bowmanville Creek and Soper Creek Floodplain Mapping Study (Aquafor Beech Ltd, June 2009)


CENTRAL LAKE ONTARIO
CONSERVATION

BOWMANVILLE CREEK
AND SOPER CREEK
FLOODPLAIN MAPPING STUDY

FINAL REPORT

Prepared by:

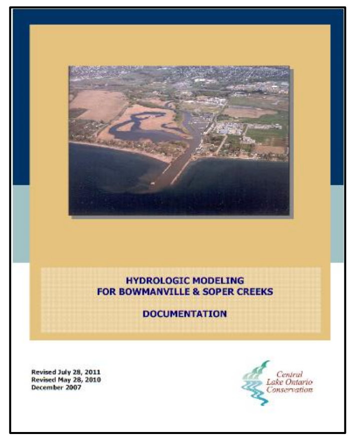
AQUAFOR BEECH LIMITED
#6-202-2600 Skymark Avenue
Mississauga, Ontario
L4W 5B2

June 2009
Aquafor Beech Reference: 64795

This study updated floodplain mapping for Soper Creek for the first time since the mid-1970s. Design flow information was obtained from the CLOCA report “Hydrologic Modeling for Bowmanville and Soper Creeks.” Bank-full channel measurements were taken and a bridge/culvert structure inventory was completed to help develop the hydraulic model. HEC-RAS and HEC-GeoRAS were used to conduct the hydraulic analysis.

Water surface profiles were developed for each of the 2-year through 100-year design storm flows as well as for the Regional Storm flow, and the resulting Regulatory Floodplain was mapped based on the greater of the 100-year storm or the Regional Storm. Structures at risk of flooding were identified.

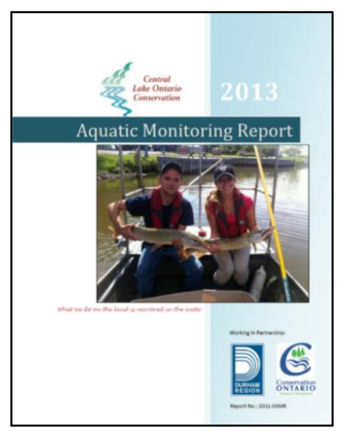
Hydrologic Modeling for Bowmanville and Soper Creeks Documentation (CLOCA, Revised July 2011)



This study updated hydrologic models of Soper Creek from 1974. The hydrologic model was created in two stages using Visual Otthymo 2. Five subwatersheds were delineated in Soper Creek subwatershed. The first stage modelled existing land use from 2005, while the second stage modelled the future land use from the Municipality of Clarington’s Official Plans. The results from this modelling were used to complete the floodplain mapping study by Aquafor Beech Ltd.

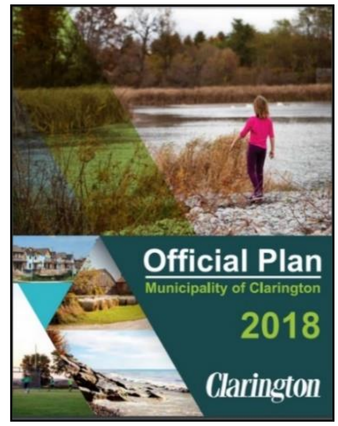
The study also identified catchments with significantly higher peak flows due to changes in land use, and implemented theoretical stormwater management controls.

2006, 2007, 2008, 2009, 2013 - Aquatic Monitoring Reports *(Central Lake Ontario Conservation Authority)*



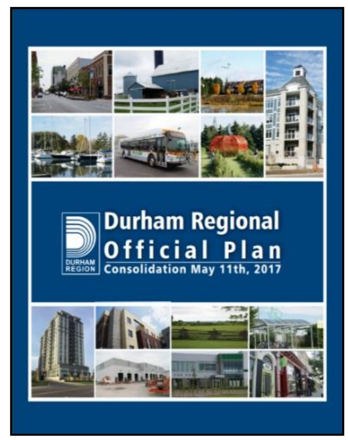
Annual reports for the years of 2006, 2007, 2008, 2009, and 2013 were reviewed. These reports are part of CLOCA’s long-term subwatershed health monitoring programs of the entire CLOCA jurisdiction. The purpose of these reports is to identify current conditions, and ecological trends, as well as to provide guidance for land-use decisions. The Aquatic Monitoring Reports focus on spawning surveys, stream temperature, biological water quality, and fisheries sampling, using standardized protocols whenever possible. Annual recommendations are provided for each monitoring program.

Official Plan Amendment 107 (Municipality of Clarington, June 2018)



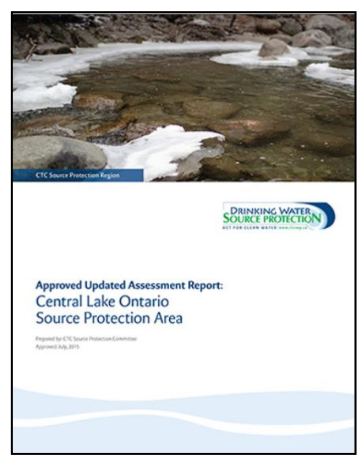
The Planning Act of Ontario requires that each municipality in Ontario review its Official Plan every five years to ensure that it remains current with Provincial plans and policies. The Municipality of Clarington provided Draft Official Plan Amendment 107 in May, 2016, for public review and comment. The final Official Plan was adopted by the Clarington Council on November 1, 2016, and approved by the Commissioner of Planning and Economic Development for the Regional Municipality of Durham on June 19, 2017. The Official Plan Amendment 107 introduces new policies and plans for the future development of Clarington which forecasts 140,300 residents in 2031. The Official Plan plans for new development for into urban areas, a pedestrian-friendly and transit-friendly urban form, as well as a natural heritage system and natural resources which are protected.

Durham Regional Official Plan (Regional Municipality of Durham, May 11, 2017)



The Region's Official Plan was adopted by Regional Council on June 5, 1991, and was approved by the Minister of Municipal Affairs and Housing on November 24, 1993. The 2017 Durham Regional Official Plan contains the policies, maps, and plans, for the type and location of land uses within the Region up to 2031.

Central Lake Ontario Source Protection Area Assessment Report (CTC Source Protection Committee, June 24, 2015)



The Central Lake Ontario Source Protection Area Assessment Report was submitted and approved by the MOECC in 2012. This report identifies the location and nature of threats to the quality and quantity of groundwater and surface water sources of drinking water.

The report includes a Water Budget and Stress Assessment which includes four levels of analysis, depending on the level of stress, including:

- Conceptual Water Budget;
- Tier 1 Water Budget;
- Tier 2 Water Budget; and,
- Tier 3 Water Budget.

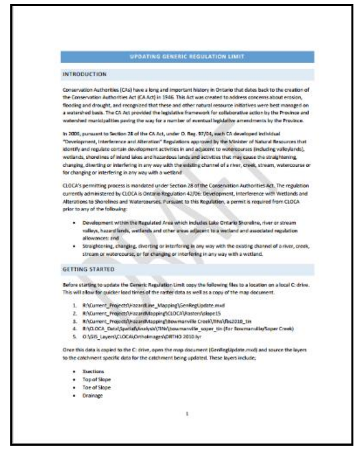
Stress was measured as more demand than supply, as it relates to municipal water drinking supplies. Lake Ontario was excluded from the water budget studies. As per the Tier 1 analysis, the

Soper Creek watershed experiences significant surface water stress during summer months, but low groundwater stress throughout the year.

Updating Generic Regulation Limit (Central Lake Ontario Conservation Authority)

Under Section 28 of the Conservation Authority Act, CLOCA has a mandated permitting process. Pursuant to O. Reg. 42/06, a permit is required from CLOCA for development within the Regulated Area, or straightening, changing, diverting, or interfering in any way with the existing channel or a river, creek, stream, or watercourse, or wetland.

This report describes the CLOCA process of upgrading the Generic Regulation Limit.



UPDATING GENERIC REGULATION LIMIT

INTRODUCTION

Conservation Authorities (CAs) have a long and important history in Ontario that dates back to the creation of the Conservation Authorities Act (CA Act) in 1946. This Act was created to address concerns about erosion, flooding and drought, and recognized that these and other natural resource initiatives were best managed on a watershed basis. The CA Act provided the legislative framework for collaborative action by the Province and watershed municipalities paving the way for a number of eventual legislative amendments by the Province.

In 2006, pursuant to Section 28 of the CA Act, under O. Reg. 97/04, each CA developed individual "Development, Interference and Alteration" Regulations approved by the Minister of Natural Resources that identify and regulate certain development activities in and adjacent to watercourses (including valleylands), wetlands, shorelines of inland lakes and hazardous lands and activities that may cause the straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream, watercourse or for changing or interfering in any way with a wetland.

CLOCA's permitting process is mandated under Section 28 of the Conservation Authorities Act. The regulation currently administered by CLOCA is Ontario Regulation 42/06: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses. Pursuant to this Regulation, a permit is required from CLOCA prior to any of the following:

- Development within the Regulated Area which includes Lake Ontario Shoreline, river or stream valleys, hazard lands, wetlands and other areas adjacent to a wetland and associated regulation allowances; and
- Straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream or watercourse, or for changing or interfering in any way with a wetland.

GETTING STARTED

Before starting to update the Generic Regulation Limit copy the following files to a location on a local C: drive. This will allow for quicker load times of the raster data as well as a copy of the map document.

1. R:\Current_Projects\HazardLine_Mapping\GenRegUpdate.mxd
2. R:\Current_Projects\HazardMapping\CLOCA\Rasters\slope15
3. R:\Current_Projects\HazardMapping\Bowmanville Creek\TINs\fbs2010_tin
4. R:\CLOCA_Data\Spatial\Analysis\TINs\bowmanville_soper_tin (For Bowmanville/Soper Creek)
5. O:\GIS_Layers\CLOCA\OrthoImages\ORTHO 2010.lyr

Once this data is copied to the C: drive, open the map document (GenRegUpdate.mxd) and source the layers to the catchment specific data for the catchment being updated. These layers include;

- Xsections
- Top of Slope
- Toe of Slope
- Drainage

1

3.0 Existing Subwatershed Conditions

Environmental features within the Soper Creek subwatershed that were explored through this study include:

- Groundwater resources, including the quantity and quality of water which is recharged and discharged from the groundwater table;
- Surface water resources, including assessment of Headwater Drainage Features (HDFs), the quantity and quality of water in the watercourses and floodplains, and stream morphologic features, including areas subject to erosion;
- Aquatic features, including aquatic habitat, benthic macroinvertebrate communities, fish communities, fish barriers, crossings, and online ponds; and
- Terrestrial features, including vegetation communities, flora, and wildlife.

It is important to recognize that these environmental features are highly inter-related because of their ecological functions and environmental pathways or linkages. For example, a vegetated floodplain feature may provide conveyance for floods and spring meltwater, provide habitat for plants and animals, and provide shade for the watercourse which maintains optimal water temperatures for fish. Maintaining the function of one feature may require maintaining the form of all inter-related or overlapping features and the linkages to adjacent areas.

The following sections provide an overview of the environmental features and functions within the study area. The natural ecosystem that existed prior to human settlement has been altered. Activities that have resulted in change include agricultural practices and the construction of roads, highways, and buildings. Defining the current state of the environment, as well as the relationship between each environmental feature that is present, is necessary in order to characterize key environmental functions, define opportunities and constraints associated with future development, and ultimately establish strategies to protect, enhance, or restore environmental features over time.

3.1 Groundwater Resources

Groundwater discharge to streams and wetlands provides ecologically significant flows that are generally more consistent in flow rate, water quality and temperature than either surface runoff or shallow interflow. Preserving groundwater recharge is also critical to attenuating storm flows related to urbanization and impervious cover. Maintaining groundwater recharge and discharge is therefore a key aspect of subwatershed protection and management.

The Soper watershed spans the entire regional flow system dominated by groundwater flow between the Oak Ridges Moraine, to the north, and Lake Ontario to the south. Very high groundwater recharge occurs in the north, and recharge from north of the watershed crosses the enters the watershed from the north and east (as discussed later in this section).. Local conditions, both within and surrounding the study area, significantly affect the flow system, so it is important for subwatershed management to understand how specific subwatershed features interact and interconnect with the regional hydrogeologic setting.

The first objective of this analysis is to summarize the groundwater resources and understanding of the groundwater flow system in the study area. Considerable work, largely related to Source Water Protection (SWP), has been undertaken in CLOCA and Regional Municipality of Durham jurisdiction watersheds over the last ten years, and are presented in the various Source Water protection reports.

The second objective is to utilize groundwater models created by EarthFX and later updated by Geoprocess to identify, evaluate, and develop plans and measures to protect the natural functions of the watersheds. The quantitative analysis includes calculation of water budget elements (recharge, runoff, Evapotranspiration, groundwater discharge to streams) to estimate baseline conditions for current and future assessment and monitoring.

Specific analysis tasks include:

- Summary of the 3D geologic model layers in plan and cross section.
- Assessment of the groundwater flow system using 3D particle tracking.
- Review of predicted groundwater discharge to streams to identify groundwater supported ecosystems
- Review of Ecologically Significant Groundwater Recharge Areas (ESGRA) analysis

3.1.1 Background Groundwater Studies in the Study Area

In 2006, EarthFX completed regional and sub-regional scale 3D geologic and groundwater modelling study of the Oak Ridge Moraine and CLOCA watersheds for the Conservation Authority Moraine Coalition (Kassenaar and Wexler, 2006). Building on that work, local groundwater and recharge models were developed for Tier 1/2 Source Water Protection water budget studies (EarthFX, 2008).

Subsequent to those reports, EarthFX completed the following additional studies:

- Durham Region Groundwater Model (EarthFX, 2010)
- Oak Ridges Moraine Conservation Plan Study (EarthFX, 2011)
- Ecologically Significant Groundwater Recharge Area (ESGRA) Delineation (EarthFX, 2014)
- Highly Vulnerable Aquifers, Ecologically Significant Groundwater Recharge Areas, Significant Groundwater Recharge Areas (CLOCA)
- Groundwater Modelling Update to Meet Source Protection Requirements, Highly Vulnerable Aquifers, Ecologically Significant Groundwater Recharge Areas, Significant Groundwater Recharge Areas – Final Report (Geoprocess, 2022)

These studies addressed various components of the hydrogeologic layering, groundwater flow system, significant groundwater recharge areas and estimates of groundwater discharge to streams and wetlands. For the purpose of this study, the key elements of those studies have been compiled and integrated into this single assessment focusing on the Soper Watershed.

The benefit of this integration is that the watershed is assessed within the regional, sub-regional and local scale framework.

3.1.2 Topography and Physiography

Land surface topography, based on a 10-metre (m) DEM provided by MNR, is shown in **Figure 3.1**. Land surface topography in the study area varies from a minimum elevation of 75 metres above sea level (masl) at Lake Ontario to a maximum of about 400 masl north of the study area watersheds. These higher elevations are associated with an east-west ridge formed by the oak Ridges Moraine.

3.1.2.1 ORM South Slope

The majority of the Soper watershed is classified as the Oak Ridges Moraine (ORM) "South Slope" physiographic region. Chapman and Putman (1984) describe the South Slope as a drumlinized plain, consisting of areas of thin aeolian sand deposits underlain by glacial deposits, mainly till. The South Slope is characterized by south trending drainage with sharply incised valleys.

3.1.2.2 Iroquois Shore

The south-central portion of the study area is located within the "Iroquois Shore" physiographic region (Chapman and Putnam, 1984). An east-west trending band of sandy beach deposits is located through the center of the watershed and this marks the northern extent of a plain covered by fine-grained lacustrine deposits (**Figure 3.2**). Both are remnants of Glacial Lake Iroquois. Because of the difference in material and hydrologic function, this physiographic region is often separated into two areas: the Iroquois beach and the Iroquois plain regions. The Iroquois beach region is marked by low-lying bluffs and gravel bars. These deposits serve as a source of groundwater for domestic use and provide groundwater discharge to streams. The Iroquois plain region is generally flatter and composed of much finer-grained deposits.

3.1.3 Groundwater Wells and Permits to Take Water

The MECP Water Well Record Information System is the primary source of subsurface information in the study area. A second data source, the Urban Geology Automated Information System (UGAIS) provides shallow geotechnical borehole data. The location of the wells is shown in **Figure 3.3**. Much of the southern portion of the study area is serviced by municipal water supply, so the water well distribution is limited in the south. These boreholes have been used to develop the 3D geologic model presented in the following chapters.

3.1.4 Geologic Setting

The geology of study area consists of Quaternary sediments of variable thickness overlying bedrock.

3.1.4.1 Bedrock Geology

Bedrock is comprised of a succession of Middle to Late Ordovician carbonate rocks and shales, typically with gradational unit contacts, which rest unconformably on the Precambrian basement. A map of the bedrock units that subcrop in the area is shown in **Figure 3.4**.

The basement complex is composed of metamorphic rocks of the Grenville Province's Central Metasedimentary Belt, possibly a southerly extension of the Elsevier Terrane (Easton, 1992). The Precambrian rock in deep drill holes in south Durham Region is described as pink to grey, medium-grained granitic gneiss with poorly developed gneissic foliation. The depth of the Precambrian unconformity in Durham Region probably ranges from 200 to 250 metres below ground surface; at Darlington, three deep drill holes intersected Precambrian rock at 116.3, 125.2 and 129.8 metres below mean sea level with ground elevations between 75 and 83 masl.

The Ordovician sedimentary rocks of the study area make up most of Sequence 2 of Johnson, *et al*. (1992). These rocks are essentially undeformed and dip gently to the south or southwest.

The Lindsay Formation subcrops in most of northern and eastern Durham Region (**Figure 3.4**). It has two members: (1) the Collingwood Member and (2) an unnamed lower member. The lower member is argillaceous, fine- to coarse-grained limestone with a distinct nodular appearance and is very fossiliferous. The Collingwood member, which underlies the majority of the Study area watersheds is also noted for its high fossil content and consists of up to 10 m of interbedded black organic-rich limestone and calcareous shale. This unit was formerly assigned to the Whitby Formation of Liberty (1969) but was reassigned to the Lindsay by Russell and Telford (1983) based on the gradational contact with the underling Lindsay strata and its calcareous nature. However, the names "Whitby Formation" and "Whitby shale" are still in common use by many geologists and often appear in drillers' logs.

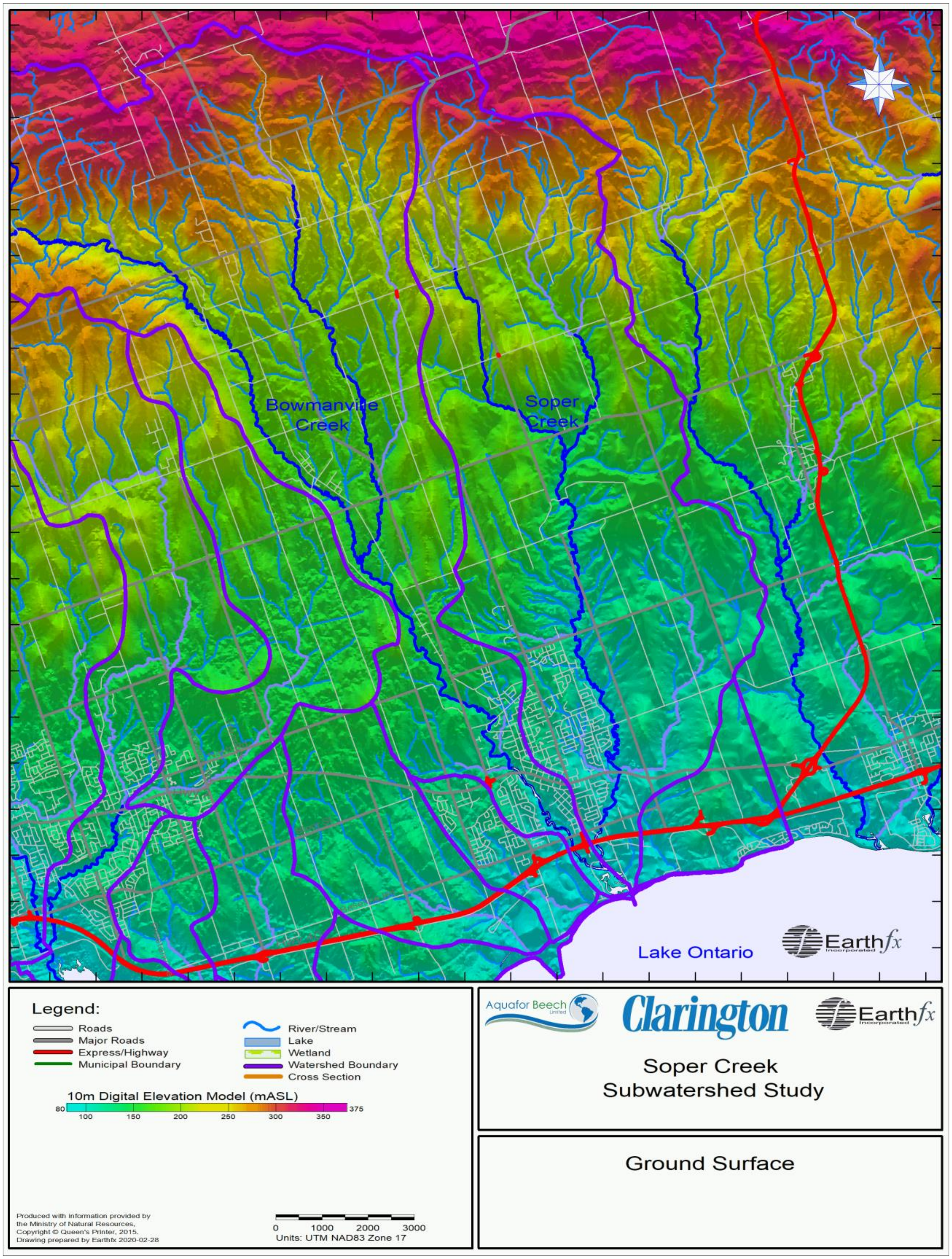


Figure 3.1: Ground Surface Elevation

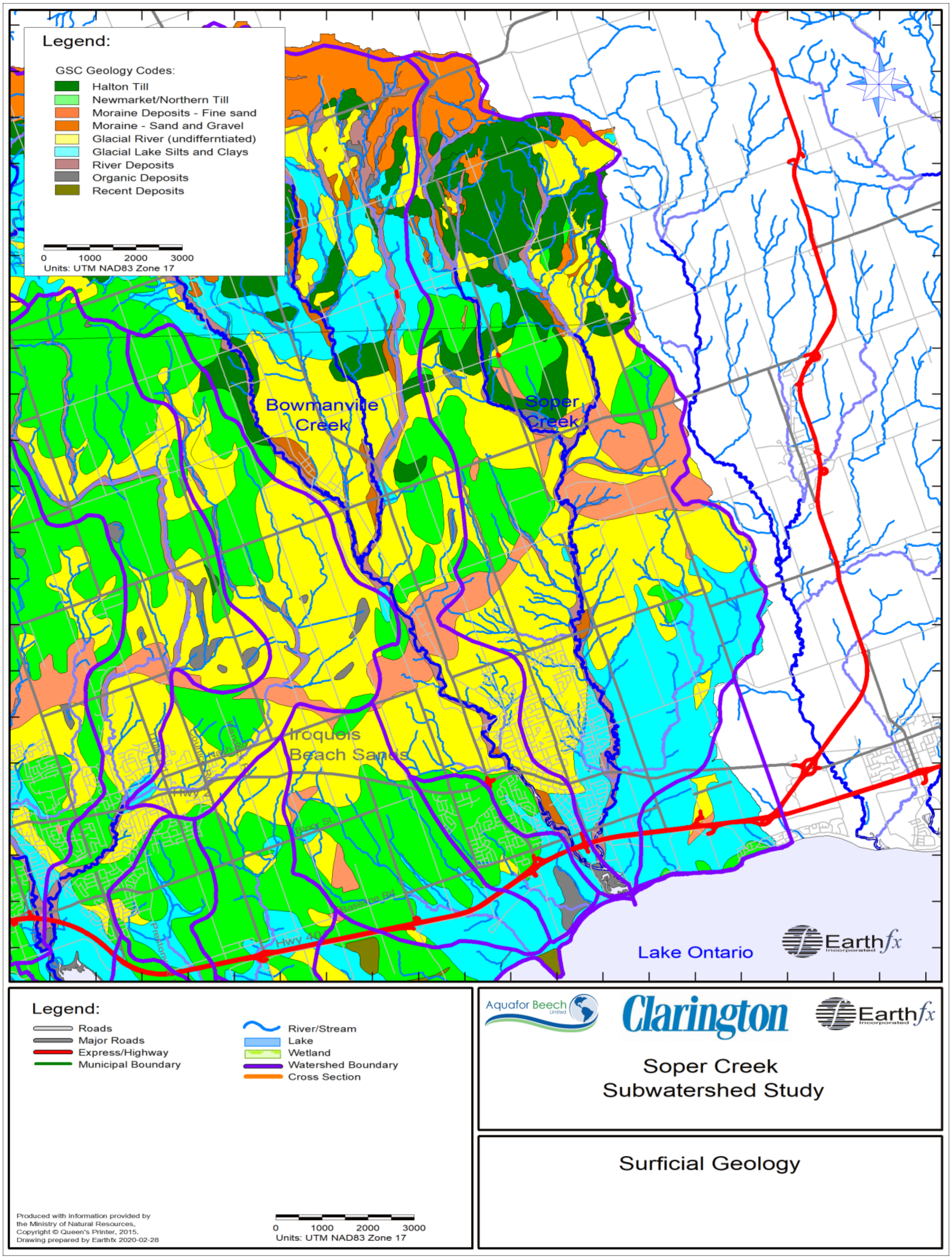


Figure 3.2: Surficial Geology

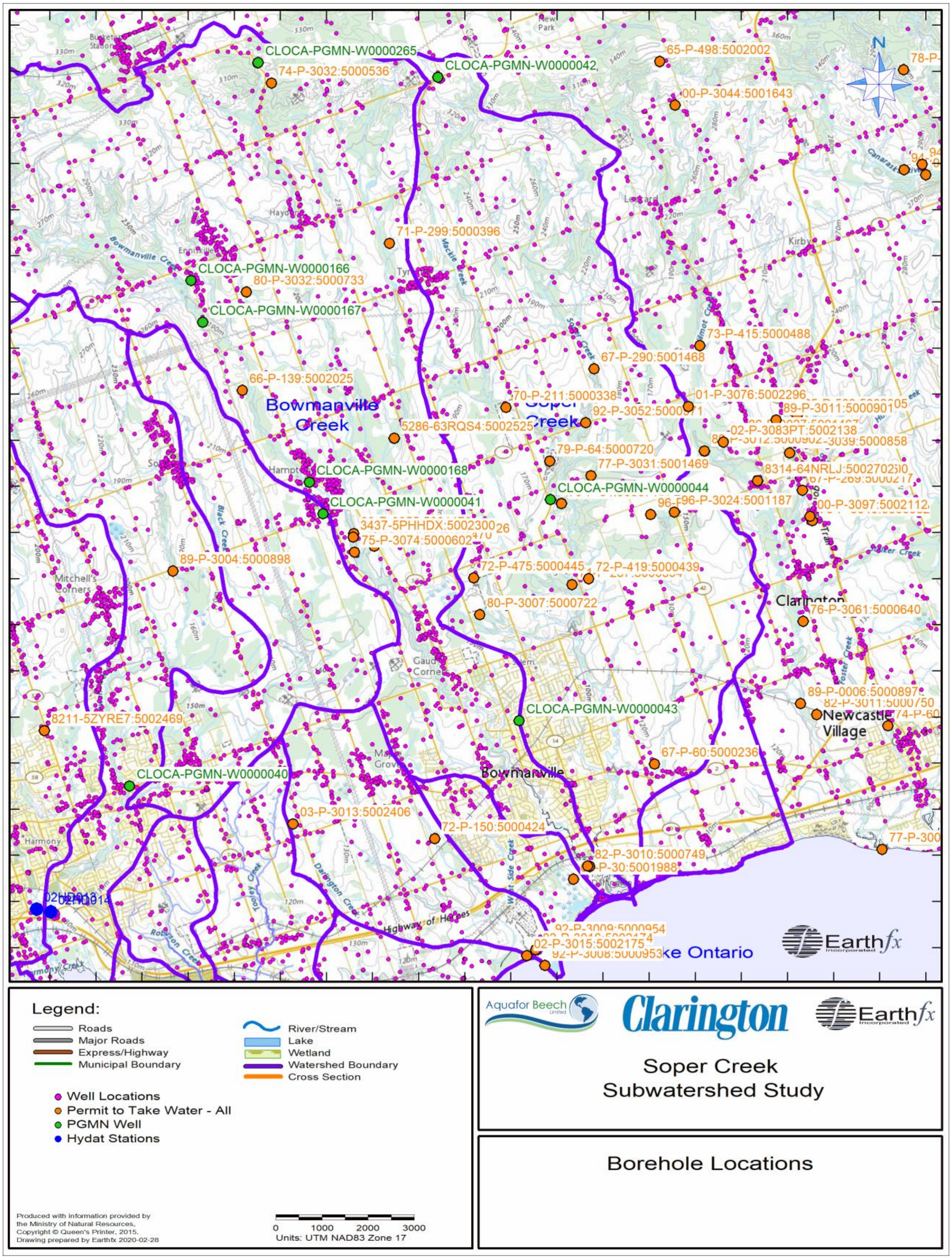


Figure 3.3: Water Wells and Permit Locations

The youngest rock unit in the area is the Blue Mountain Formation (**Figure 3.4** and **Figure 3.6**). The lower contact with the Lindsay Formation is sharp and disconformable and it marks the start of Sequence 3 of Johnson *et al*. (1992). Generally, these rocks are blue-grey, poorly fossiliferous, noncalcareous shale with minor limestone.

The bedrock surface dips gently to the south under the study area, as shown in **Figure 3.7**. The overburden thickness in the study area watersheds varies from 10 to 50 m (**Figure 3.8**), with the main branch of Soper Creek incised into, but not through, the overburden.

3.1.4.2 Quaternary Geology

The bedrock is overlain by a succession of sediments deposited by glacial, fluvial, and lacustrine processes over the last 135,000 years. The Quaternary geology of the study area has been mapped by the Ontario Geological Survey (Barnett, 1996b) and the GSC (Brennand, 1997) and is included on the compilation maps of Sharpe *et al*. (1997) and the OGS (2003).

Like all of southern Ontario, the study area was repeatedly glaciated during the Pleistocene Epoch, although locally there is only clear evidence for glacial activity during the Wisconsinan, the final major glacial episode. Regionally, sediments of Quaternary age form a complex blanket of unlithified deposits on the bedrock surface. Most of these sediments were deposited either directly from glacier ice, in meltwater streams, or in ice-marginal or ice-dammed lakes. The pattern of glaciation in the Great Lakes region is typically lobate, with relatively thin glacier ice flowing from the north filling the lake basins and then spreading out radially as the ice mass became thicker (**Figure 3.9**).

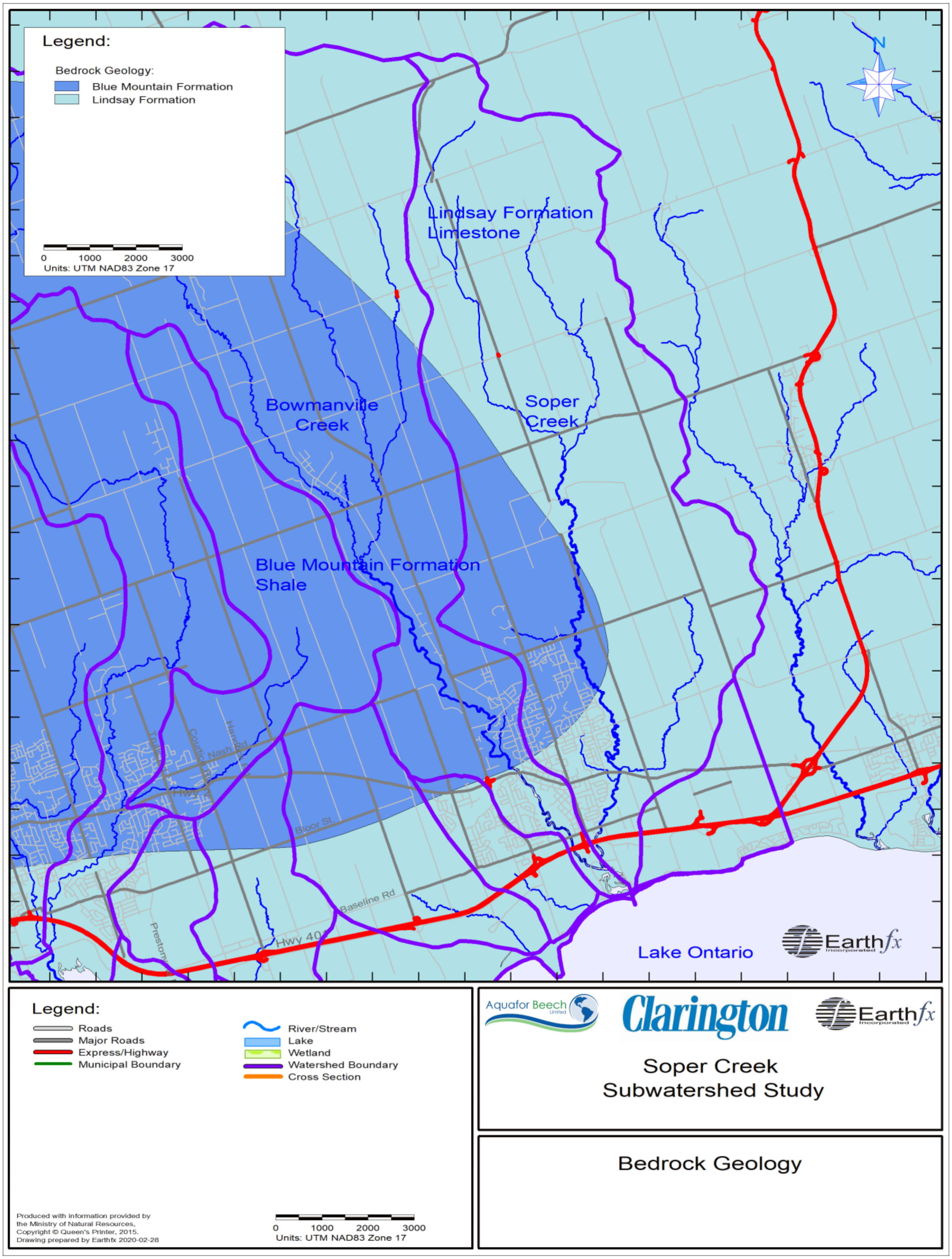


Figure 3.4: Bedrock Geology

Figure 3.5: Lindsay Formation exposed in Oshawa Creek at Mill Street (after OGS, 2006)

Figure 3.6: Blue Mountain Shales Exposed at the Mouth of Lynde Creek (after OGS, 2006)

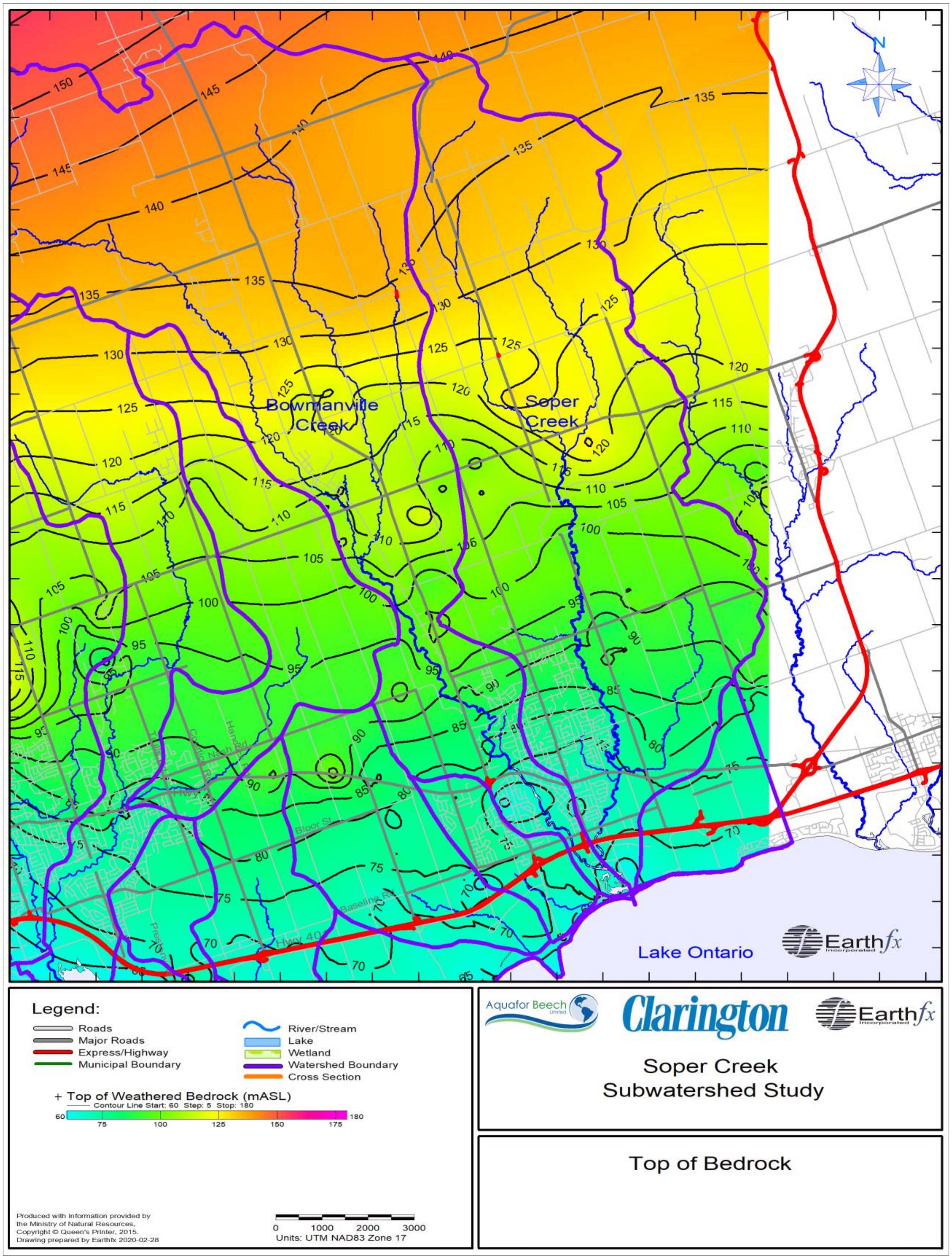


Figure 3.7: Top of Bedrock Elevation

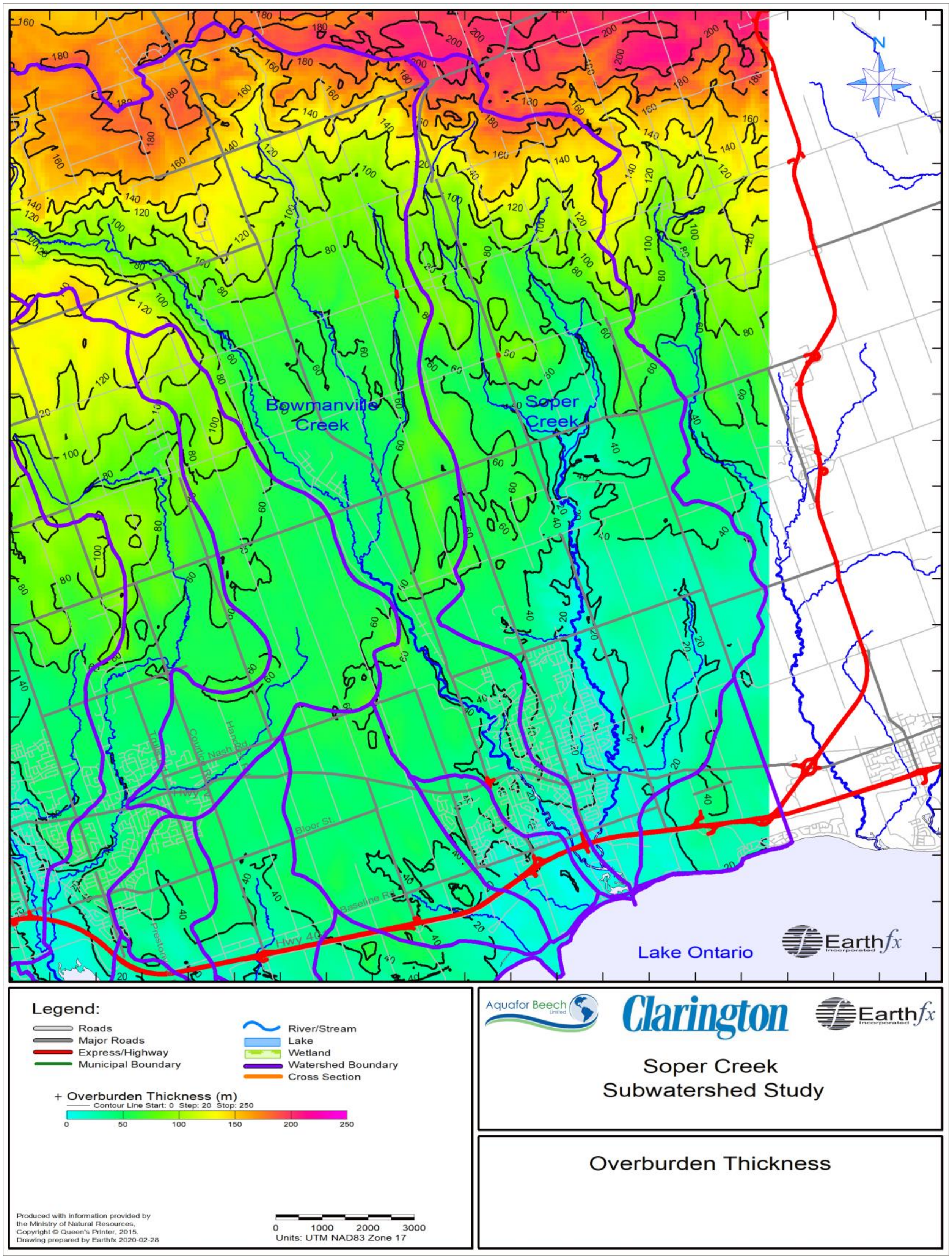


Figure 3.8: Overburden Thickness

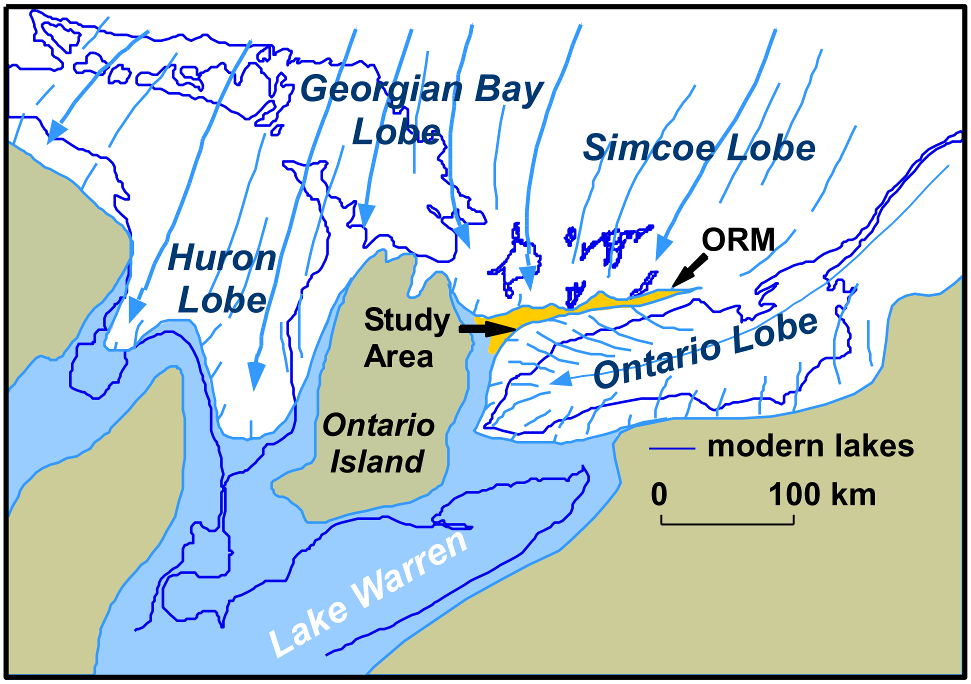


Figure 3.9: Deposition of the Oak Ridges Moraine between the Simcoe and Ontario Lobes (Chapman and Putnam, 1984).

The resulting Quaternary deposits of the ORM are shown schematically in **Figure 3.10** and with depositional age in **Figure 3.11**. A detailed presentation of the geology of the Oak Ridges Moraine area is presented in Kassenaar and Wexler (2006), while a summary is provided below.

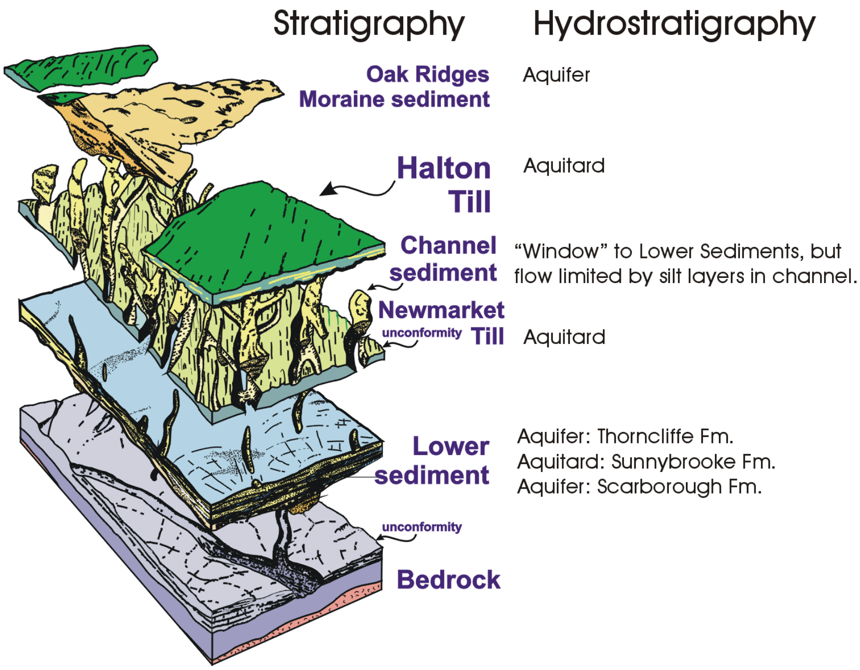


Figure 3.10: GSC Stratigraphic Model of the ORM Area (from Sharpe et al., 1999)

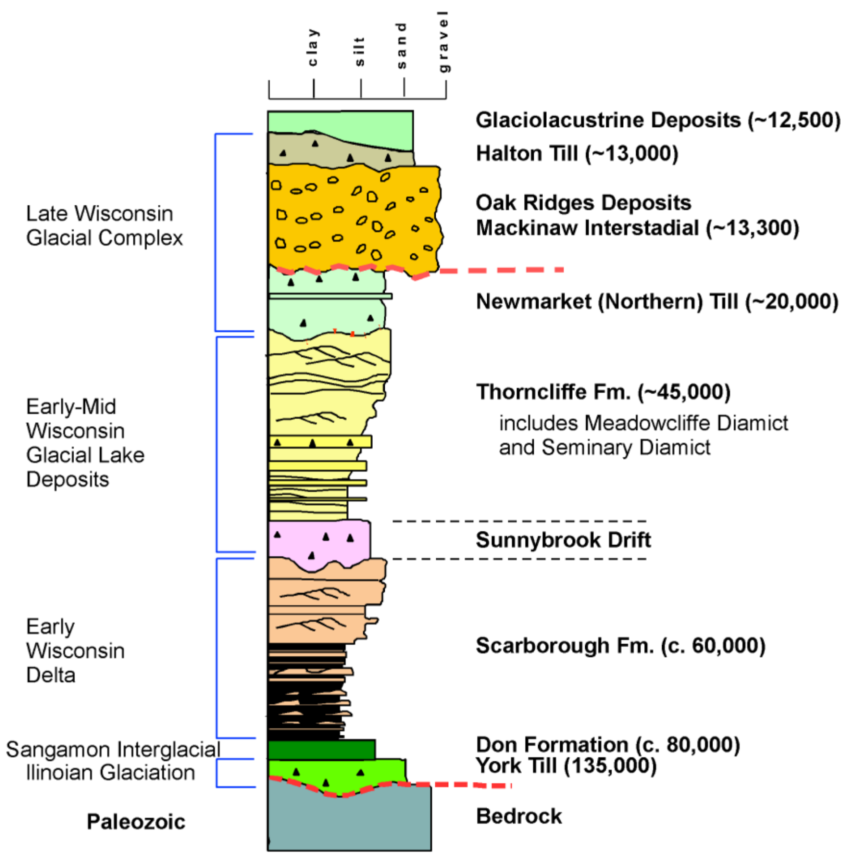


Figure 3.11: Quaternary Deposits Found Within the Model Area (modified from Eyles, 2002).

Lower Sediments: Scarborough, Sunnybrooke and Thorncliffe Formations
The best record in Ontario of the Early Wisconsinan is from the Toronto area where it is represented by the deltaic and fluvial sediments of the Scarborough and Pottery Road formations and the fine-grained diamictons and lacustrine sediments of the Sunnybrook Drift (Karrow 1967, 1974; Barnett, 1991). Kelly and Martini (1986) studied the Scarborough Formation was in some detail and concluded that it represents a lacustrine-deltaic sequence strongly affected by a nearby glacier. The Thorncliffe Formation makes up the major package of Middle Wisconsinan (Elgin Subepisode) sediments in the study area; it is composed of stratified sand, silt, and clay of glaciolacustrine and glaciofluvial origin. The high level lakes in which the Scarborough and Thorncliffe formations were deposited required ice blockage of the St Lawrence valley; the ice margin was within the Lake Ontario basin during those lake phases (Barnett, 1992).

Late Wisconsinan Regional Till Aquitard: Newmarket Formation
The geological record of the Late Wisconsinan (Michigan Episode), which began roughly 25,000 years before present, is clearly the best understood and most continuous in Ontario. Within Durham Region and the ORM area, a dense coarse-grained till referred to as the Newmarket or Northern Till has been recognized in boreholes and regionally correlated across all of Durham Region.

Mackinaw Phase: Erosion Events and Oak Ridges Moraine Deposition
Around the beginning of the Mackinaw Phase - roughly 13,500 years before present – large scale, high energy subglacial drainage events created a system of major erosional features known as tunnel channels (Shaw and Gilbert, 1990; Brennand and Shaw, 1994; Barnett *et al.,* 1998). The tunnel channels dissected the Newmarket Till plain, leaving the discrete till upland areas visible north of the ORM. This erosional surface is considered an important regional unconformity (Barnett *et al*., 1998). Tunnel channel erosion and sedimentation was followed by or was partly contemporaneous with the formation of the east-west trending Oak Ridges Moraine, which is an important regional physiographic and hydrogeologic feature. This moraine formed as a re-entrant which developed between Lake Ontario basin glacier ice and northern ice (**Figure 3.9**).

During the later Port Huron Phase, glacial ice again advanced both from the north and out of the Lake Ontario basin. The Lake Ontario lobe advanced as far north as the crest of the Oak Ridges Moraine and deposited the Halton Till, a texturally variable diamicton that ranges from a sandy silt till to a silty clay till depending on the overridden substrate (Barnett, 1992).

Erosion and Deposition associated with Fluctuations in Lake Ontario Water Levels
With the recession of the last ice sheet near the close of the Wisconsinan, the southern parts of Durham were inundated by Glacial Lake Iroquois, which was formed by an ice dam in the St. Lawrence outlet. The higher lake water levels formed prominent wave cut bluffs and terraces and raised beaches, modified drumlins and other positive relief features, and deposited extensive sheets of fine sand, as well as deeper water deposits of silt and clay.

With subsequent lowering of the postglacial lake levels, geological processes in the region were mainly erosion and sedimentation along streams. During the Admiralty stage of Lake Ontario (approximately 7,000 years before present) lake water levels were significantly lower than the modern lake (Mirynech, 1962), and streams flowing into the basin would have eroded their beds significantly in response to the low base level, possibly breaching surface or near surface till aquitards. The lake level subsequently rose to the modern level, and rivers regraded themselves by depositing thick vertical sequences of alluvial sediments – sand, gravel and silt. Wetlands such as those at the mouth of Harmony Creek and McLaughlin Point reflect deposits associated with the rise in water levels after the Admiralty period. The depth of erosion by Soper creek during this lowering and subsequent rise in lake levels is unknown, but it is possible that the creeks incised through the Newmarket till in the southern portions of the subwatershed resulting in enhanced groundwater discharge in those areas.

Singer (1974) carried out a hydrogeologic study of the Bowmanville-Newcastle area with special emphasis on Quaternary stratigraphy. He correlated his Unit 1 with the Sunnybrook Till of the Scarborough area (Karrow, 1967). Mapping of the outcrops along the Lake Ontario shoreline identified numerous caves and seepage faces associated with groundwater discharge from the Thorncliffe and Scarborough formations.

The geologic characterization presented in this section can be used as a foundation for modelling which characterizes the interaction between hydrologic and hydrogeologic processes.

3.1.4.3 3D Geologic Model

The following 3D analysis has been developed from the previous studies to determine the extent of groundwater surface water interaction. Characterizing these processes and preserving identified hydrologic functions are important to ensure key environmental features are sustained as these subwatersheds are developed. Select geologic cross sections (section locations shown in **Figure 3.12**) and maps illustrate the following:

- The Oak Ridges Moraine sediments are in places thinly confined by Halton Till but are in general exposed and act as a high recharge area. (**Figure 3.13**).
- The Oak Ridges Moraine Aquifer Complex (ORAC) is present as a discontinuous upper aquifer, but can be locally significant (**Figure 3.13** through **Figure 3.15**).
- The ORAC sands can significantly subcrop in the stream channels.
- The top of the Newmarket till (**Figure 3.19**) defines the base of the upper aquifer system (**Figure 3.20**).
- The thickness upper aquifer system (**Figure 3.20**) is highly variable and may reflect infill sediments deposited into erosional channels in the Newmarket Till.
- The streams have eroded through the ORAC aquifer and the ORAC thins to the south and eventually disappears (**Figure 3.20**).
- The main branch of Soper Creek has eroded into the Newmarket Till (**Figure 3.18** and **Figure 3.19**).

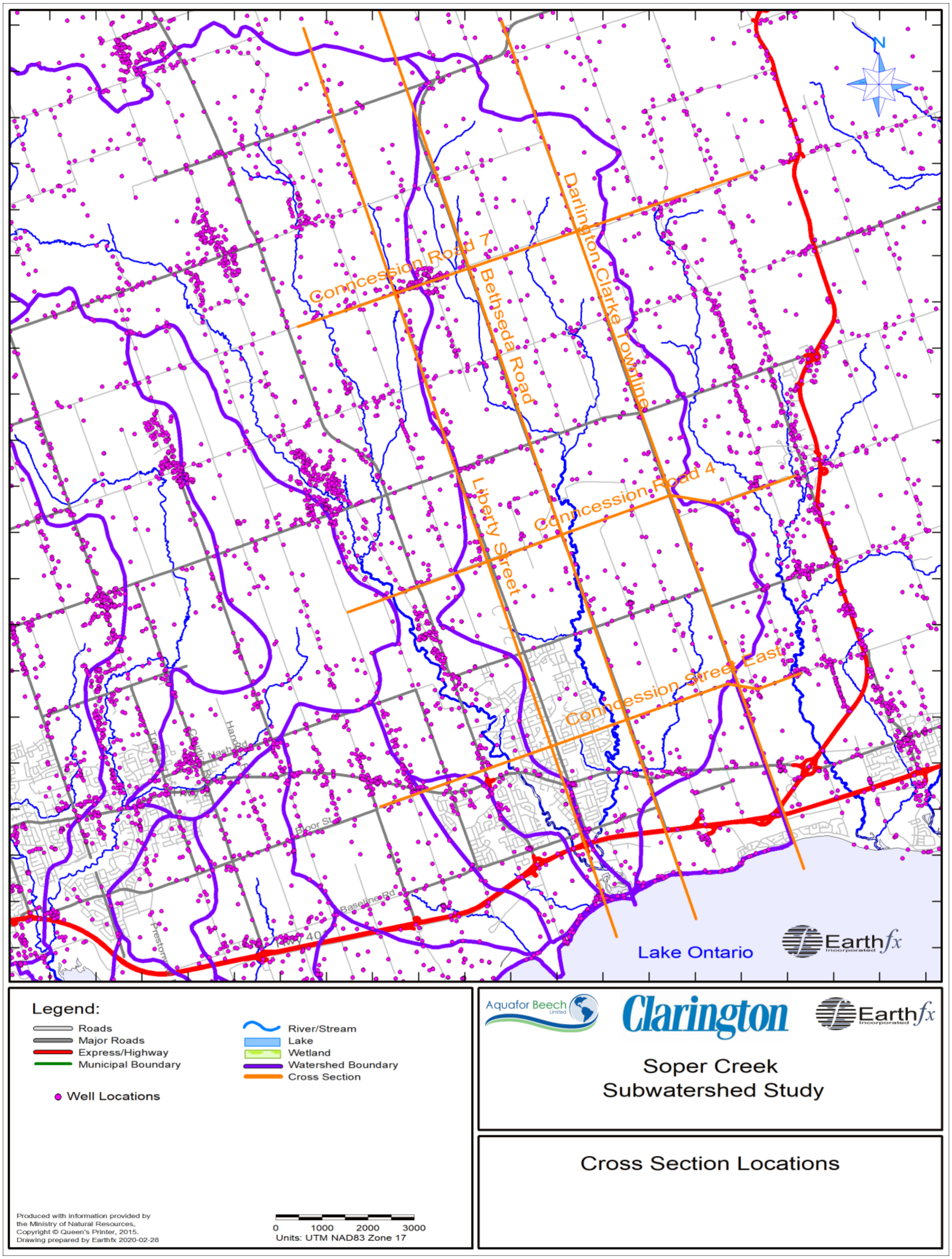


Figure 3.12: Cross Section Locations

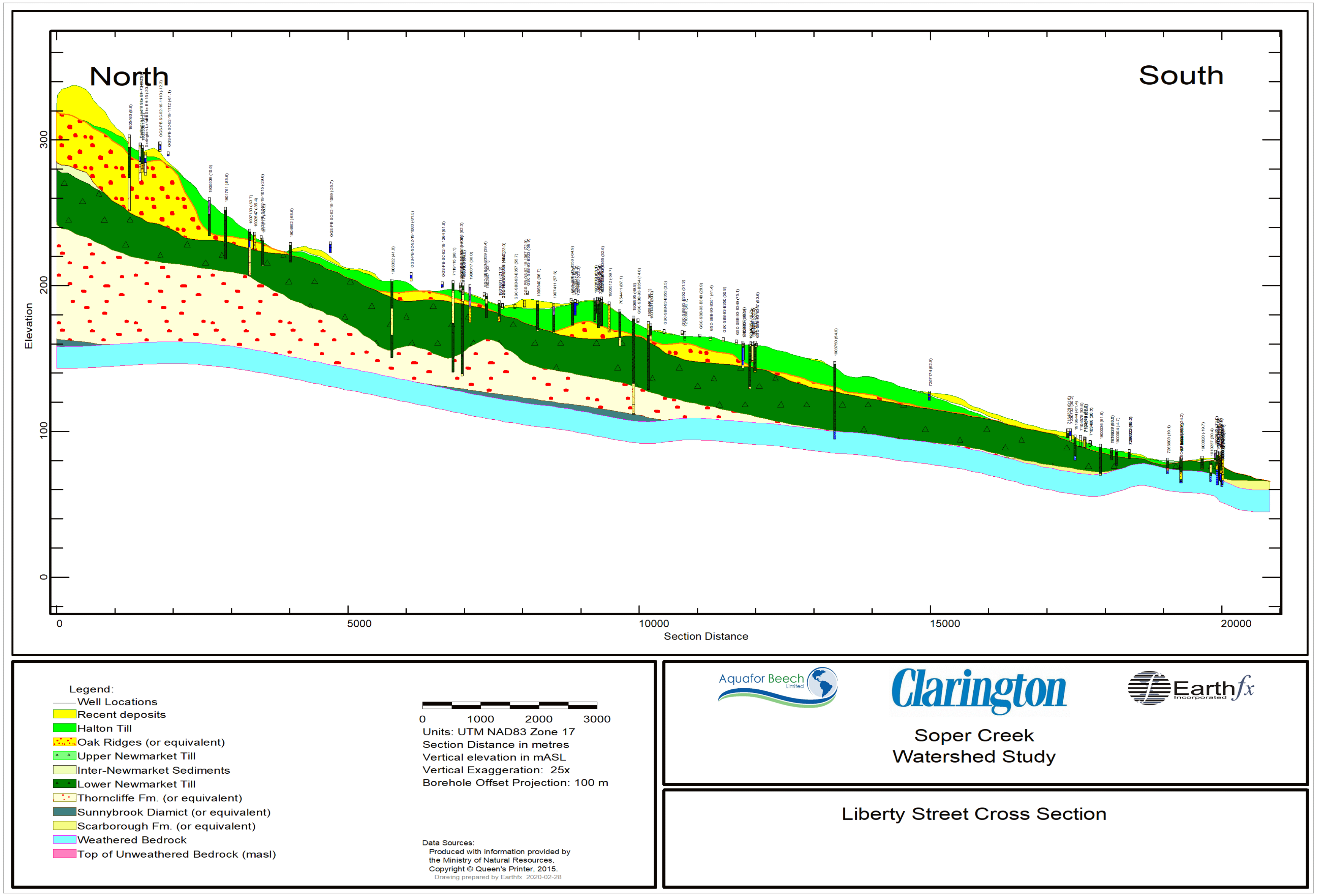


Figure 3.13: Liberty St. Cross Section

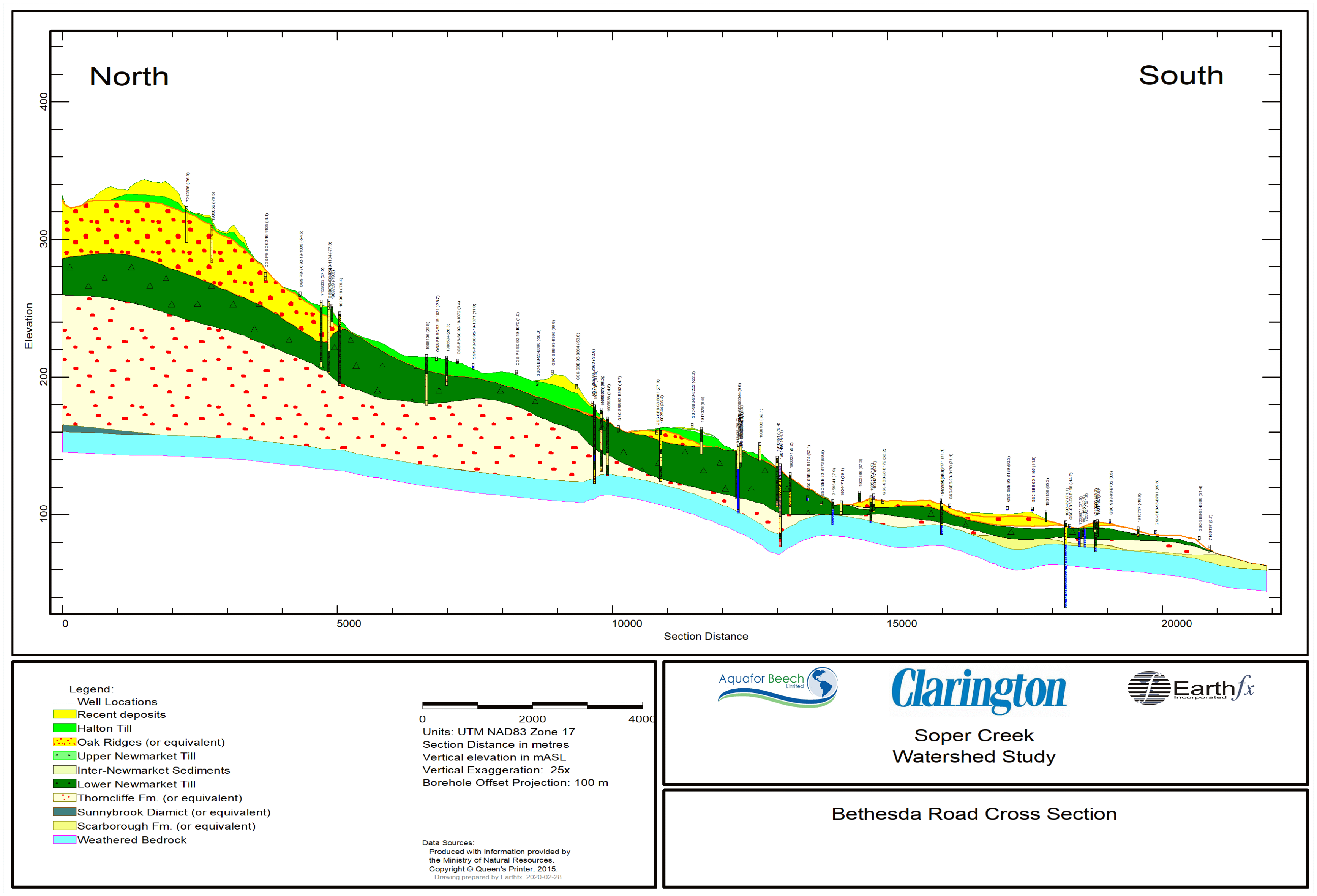


Figure 3.14: Bethesda Road Cross Section

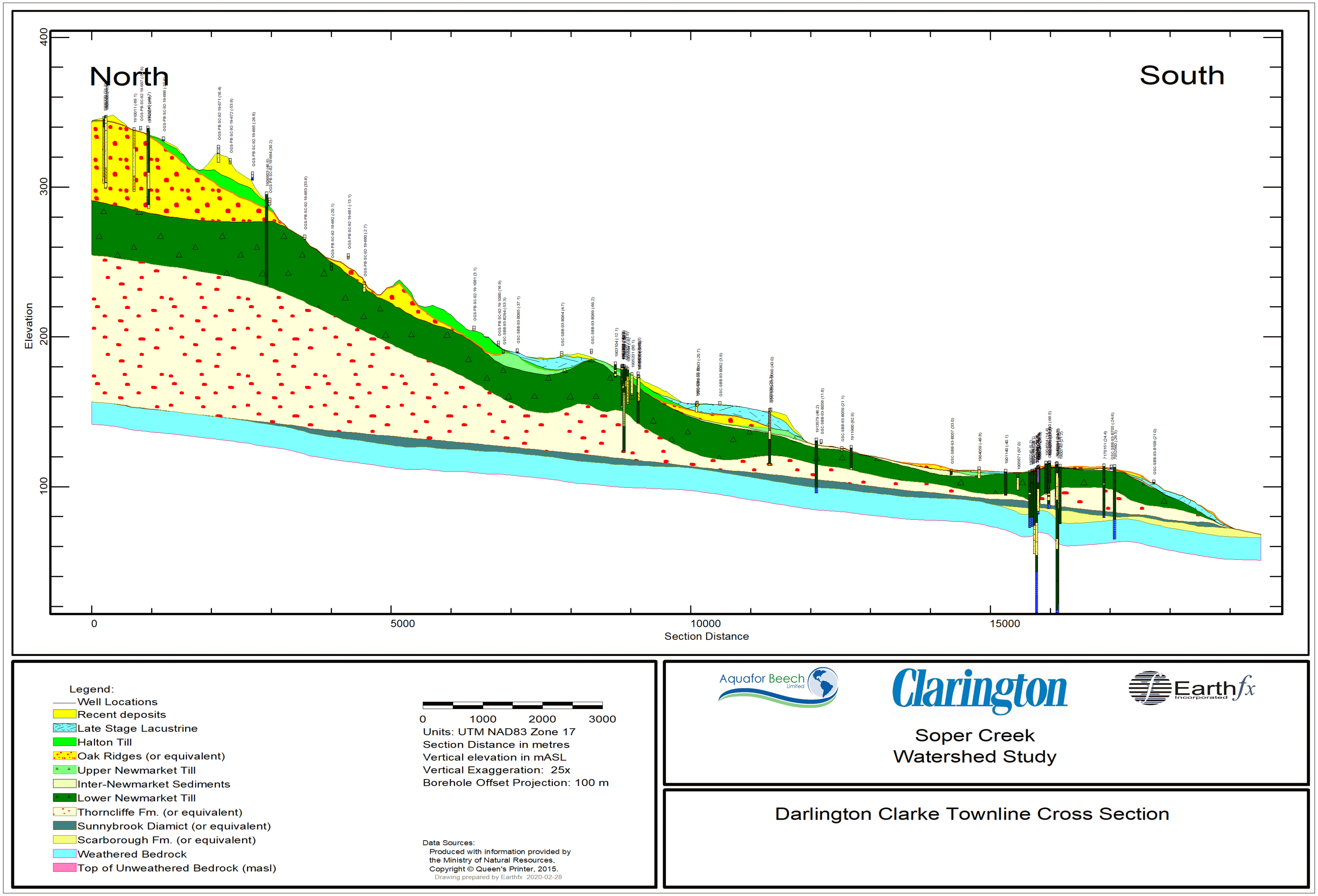


Figure 3.15: Darlington Clarke Townline Cross Section

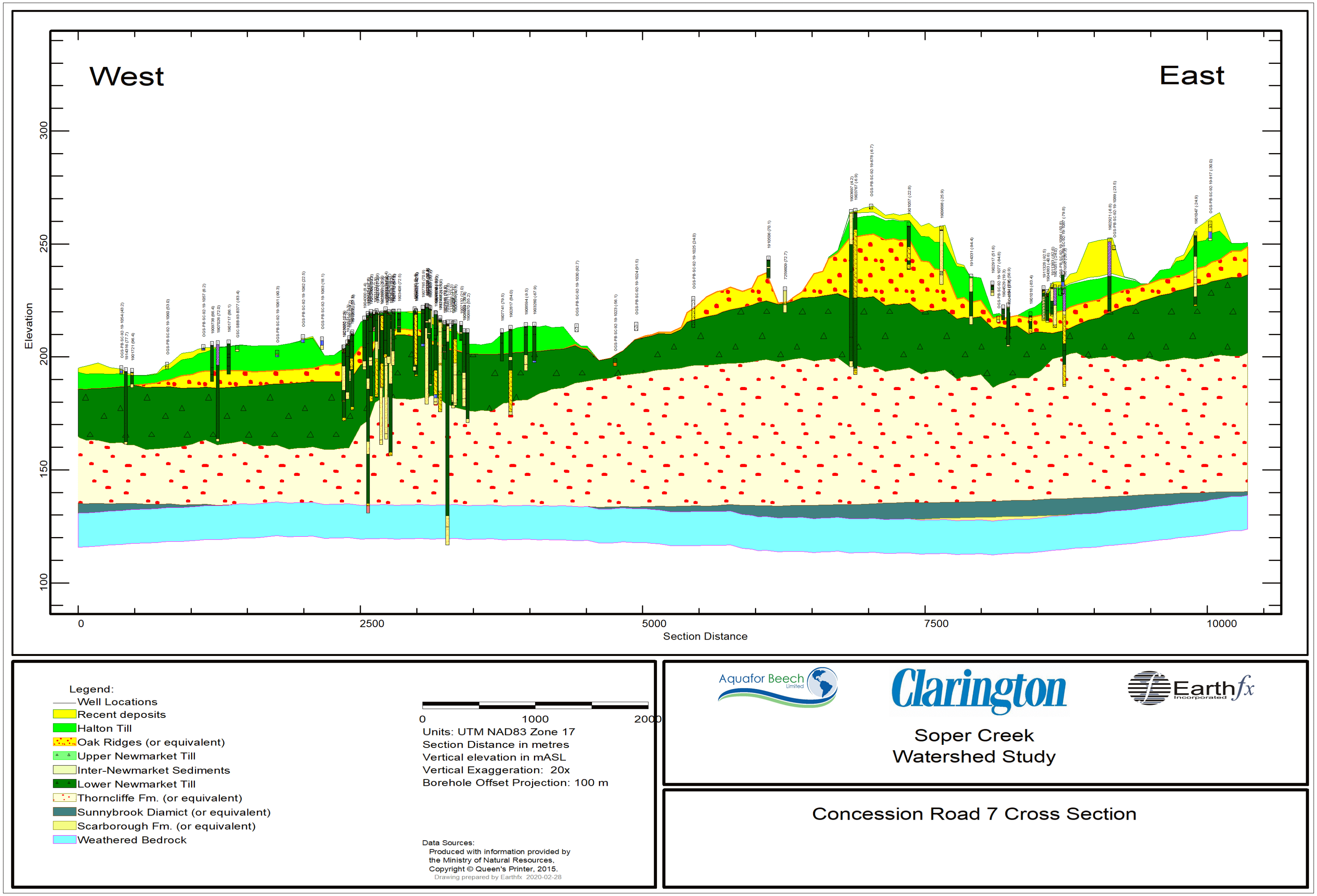


Figure 3.16: Concession Road 7 Cross Section

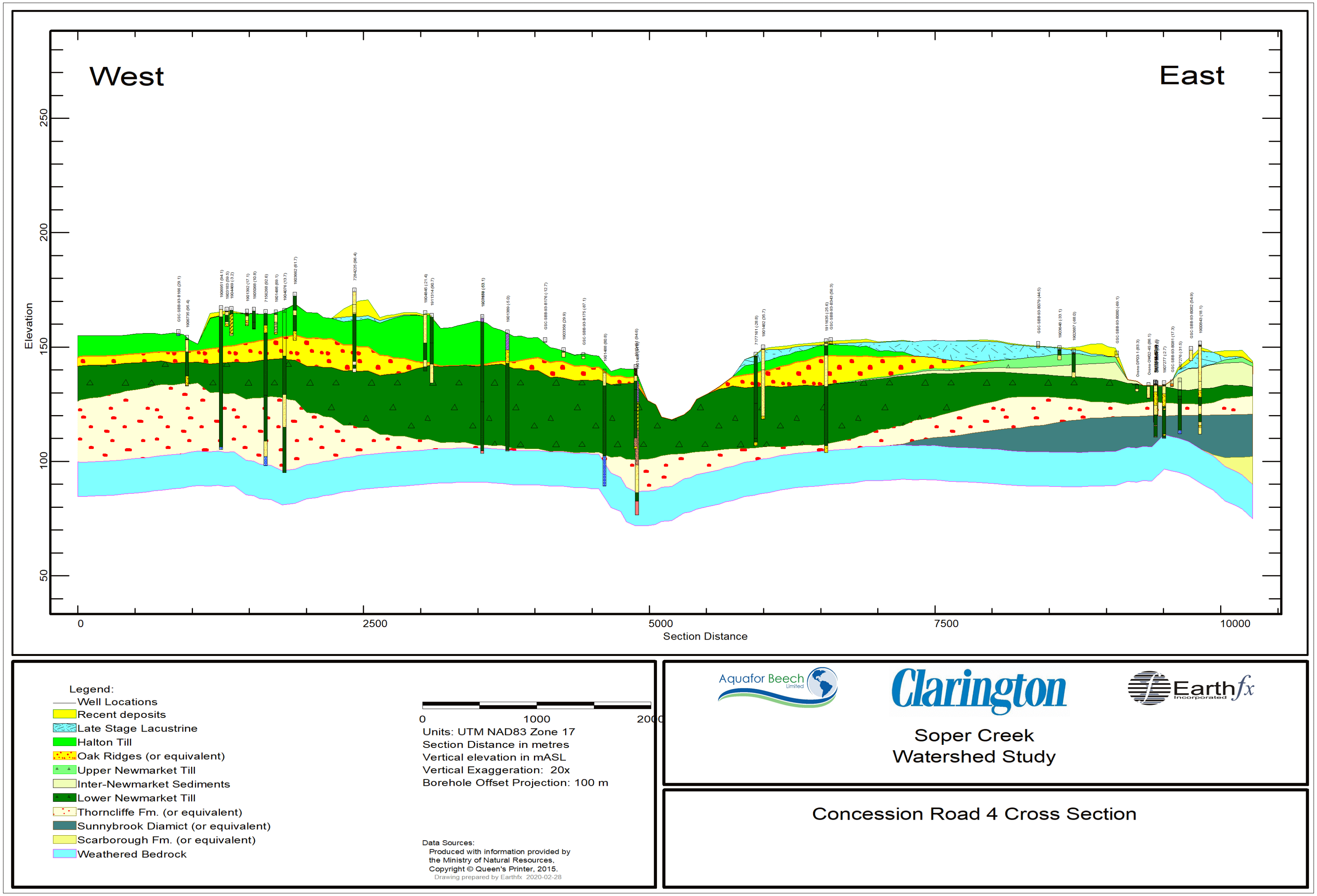


Figure 3.17: Concession Road 4 Cross Section

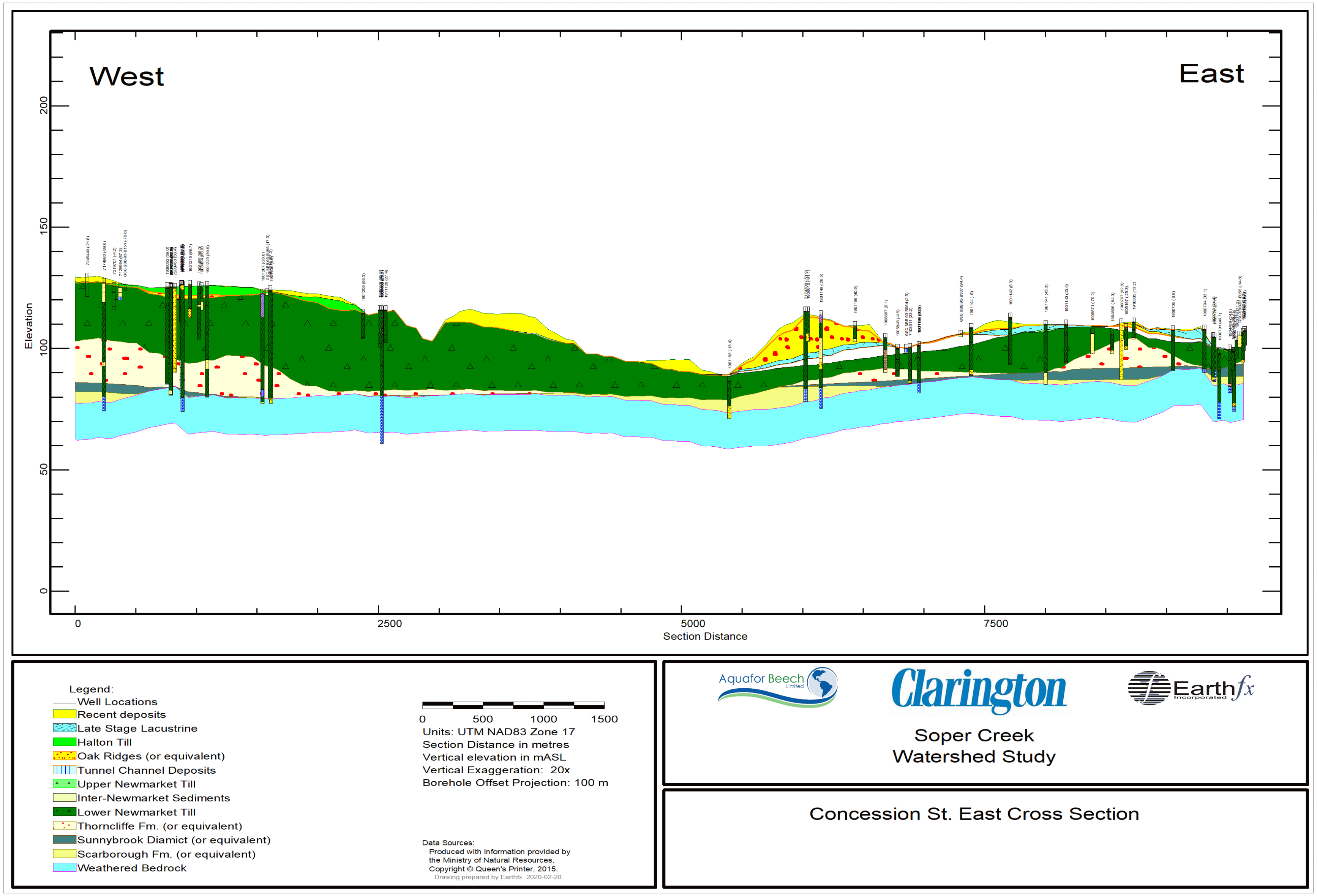


Figure 3.18: Concession St. East Cross Section

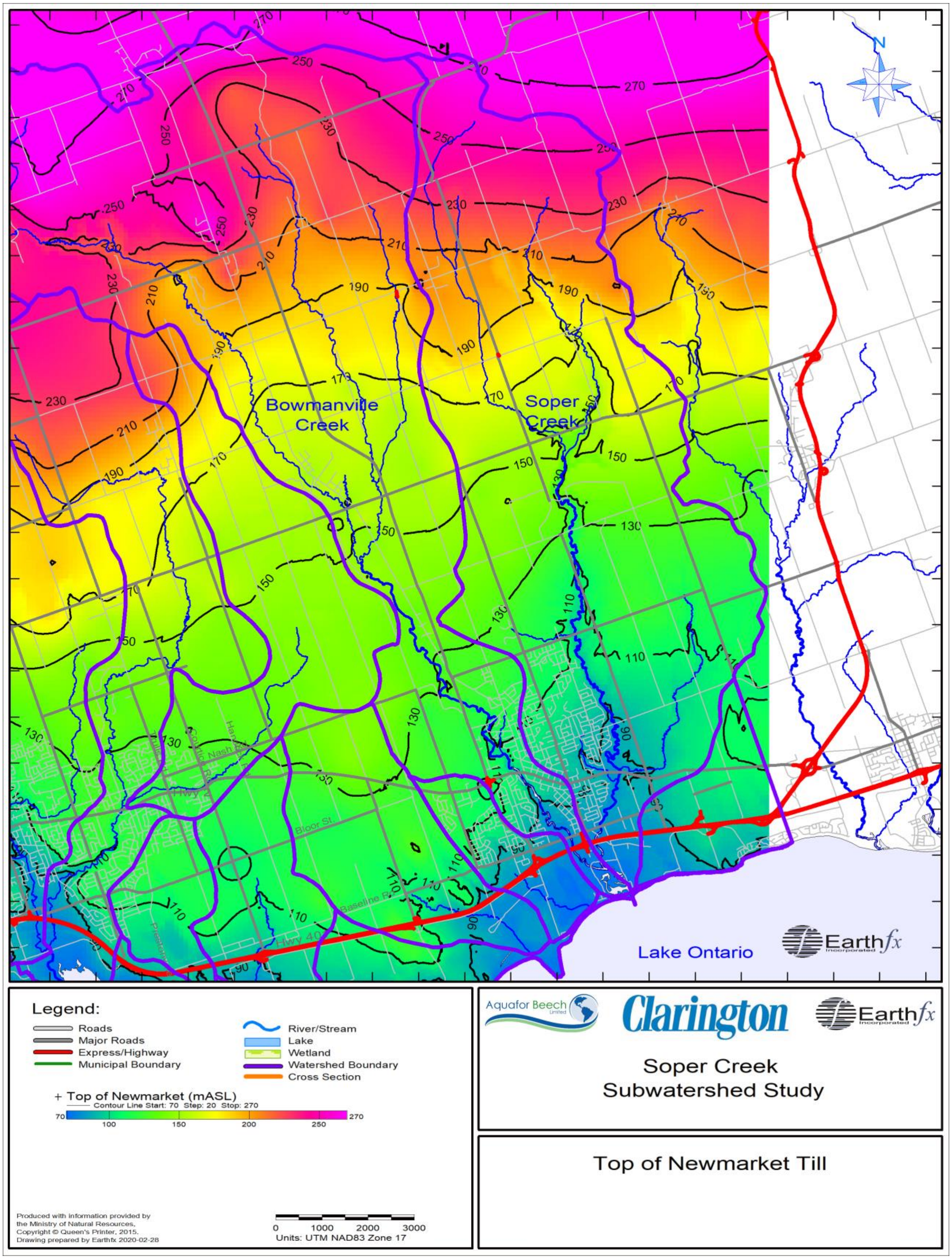


Figure 3.19: Top of Newmarket Till Aquitard

3.1.5 Hydrogeologic Setting and Subwatershed Drainage Characteristics

The cross sections and maps illustrate that there are four aquifer systems of variable significance in the study area. These include:

Bedrock Aquifer
The Blue Mountain shales may act as a weak aquifer where the upper surface is weathered and fractured, however there is limited water supply potential in this unit. The laterally extensive nature of the bedrock surface weathering may serve to interconnect any Scarborough sands that lie on the bedrock, allowing local wells to collectively draw from permeable overburden materials in contact with the bedrock.

The Lindsay Formation is relatively more permeable and is known to provide groundwater discharge into the St. Mary's quarry west of the Soper Creek subwatershed.

Lower Aquifer System: Thorncliffe and Scarborough
The Lower Aquifer System, including the Thorncliffe and Scarborough sands and silts, is laterally extensive and generally thick under the study area (**Figure 3.21**). The aquifer appears to be fully confined under the majority of the Soper watershed but likely outcrops in the incised valleys to the south. Groundwater flow in the lower aquifer reflects regional flow patterns emanating from the Oak Ridges Moraine (**Figure 3.23**).

Upper Aquifer System: Oak Ridges Aquifer Complex (ORAC)/Mackinaw Interstadial
While the ORAC is thick to the north it also entirely pinches out in the southern portion of the study area (**Figure 3.20**). Water levels reflect this variability and suggest that ORAC discharge can significantly support streamflow (**Figure 3.22**). ORAC streamflow reflects longer intermediate scale flow paths from the ORM and would likely appear as cold water upwelling. The variable thickness of the ORAC would suggest that the effects on streamflow are also highly variable.

Surficial Aquifer System: Iroquois Beach Sands
The surficial sands and gravels of the Iroquois Beach deposits provide a significant but seasonally intermittent groundwater resource. The sands likely saturate with spring snowmelt, and locally discharge this water through the remainder of the year. The complex seasonally intermittent nature of the response has only recently been simulated in fully integrated SW/GW models developed by EarthFX, so its seasonal function is still being assessed. This unit is ecologically very significant in the study area.

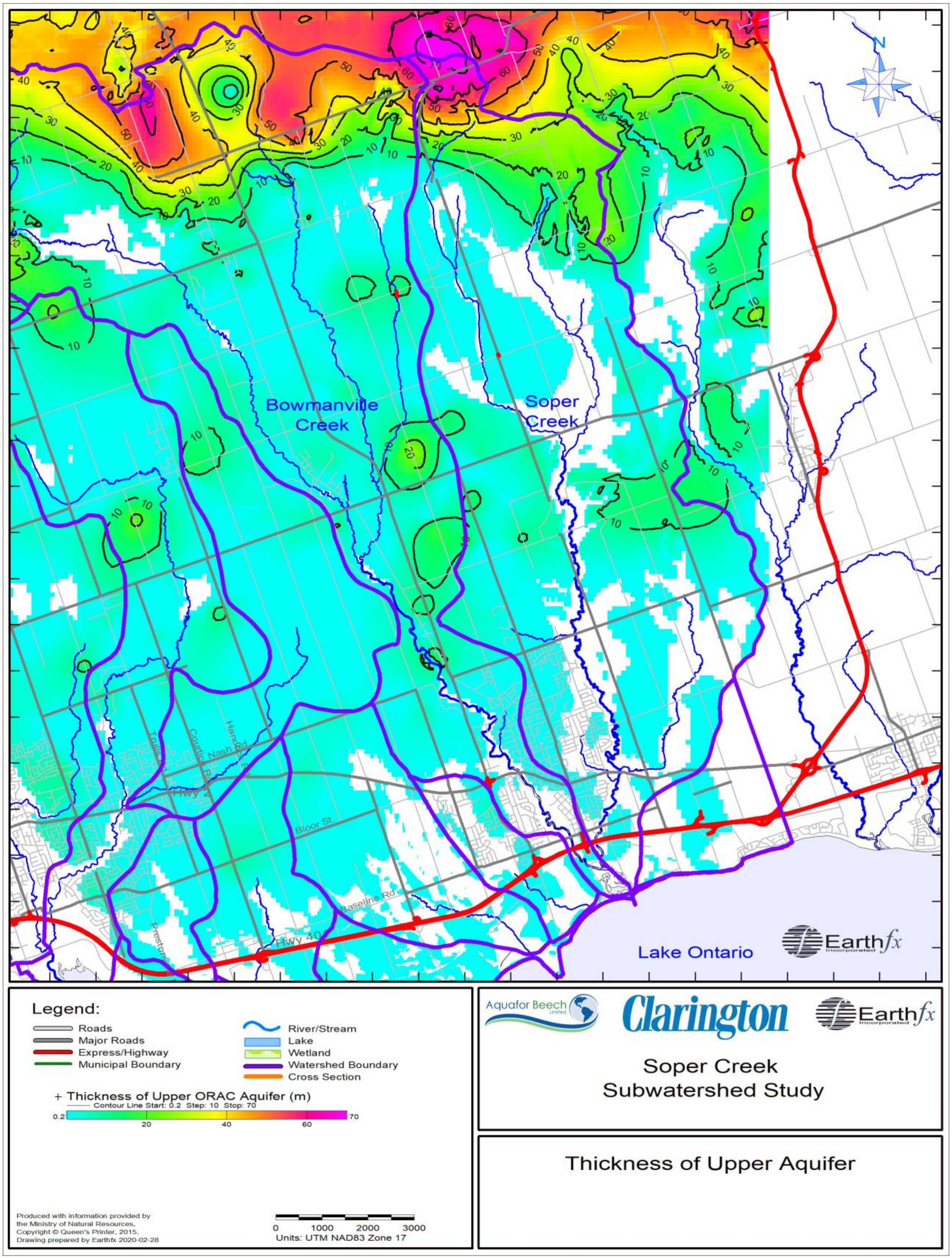


Figure 3.20: Thickness of the Upper Aquifer

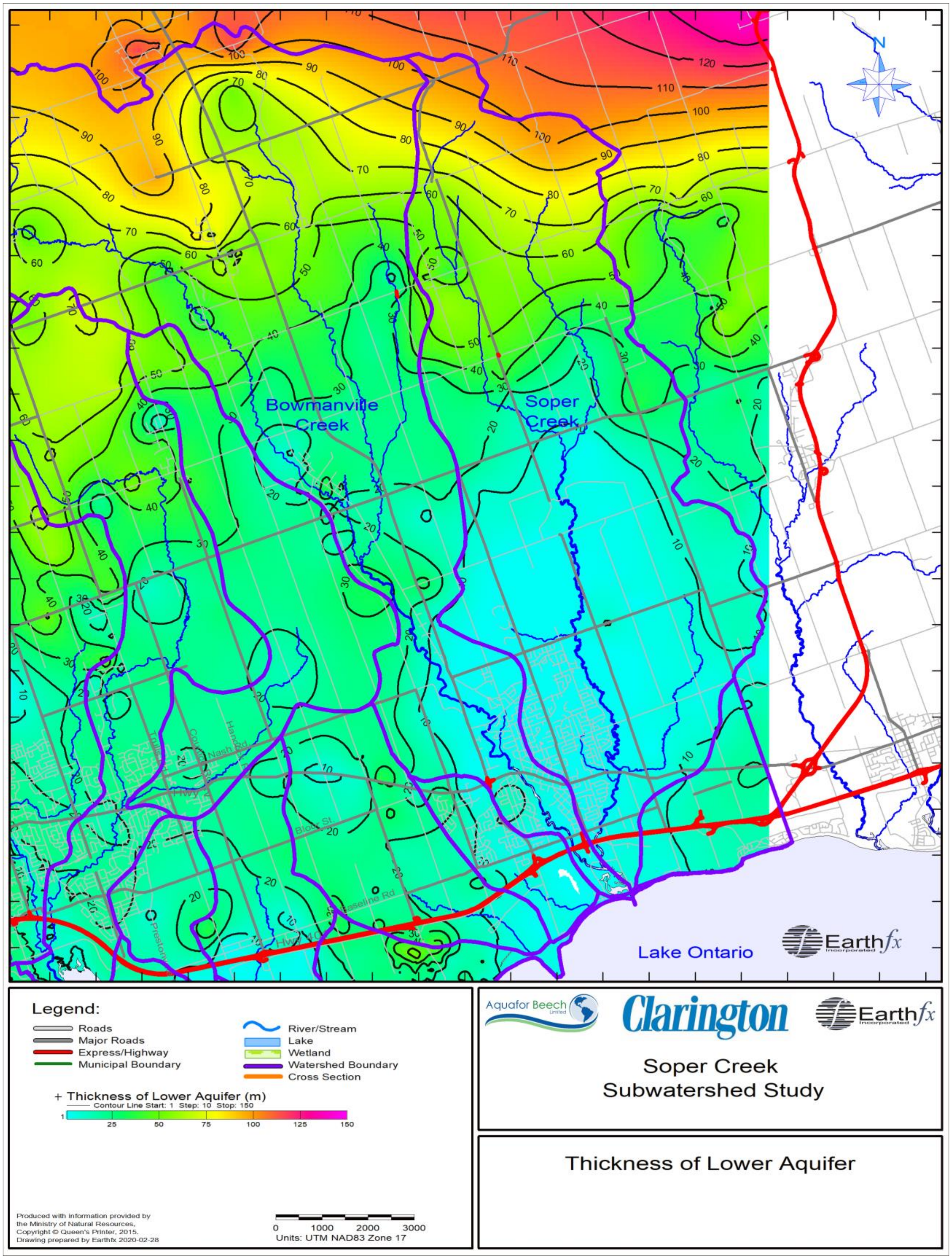


Figure 3.21: Thickness of the Lower Aquifer

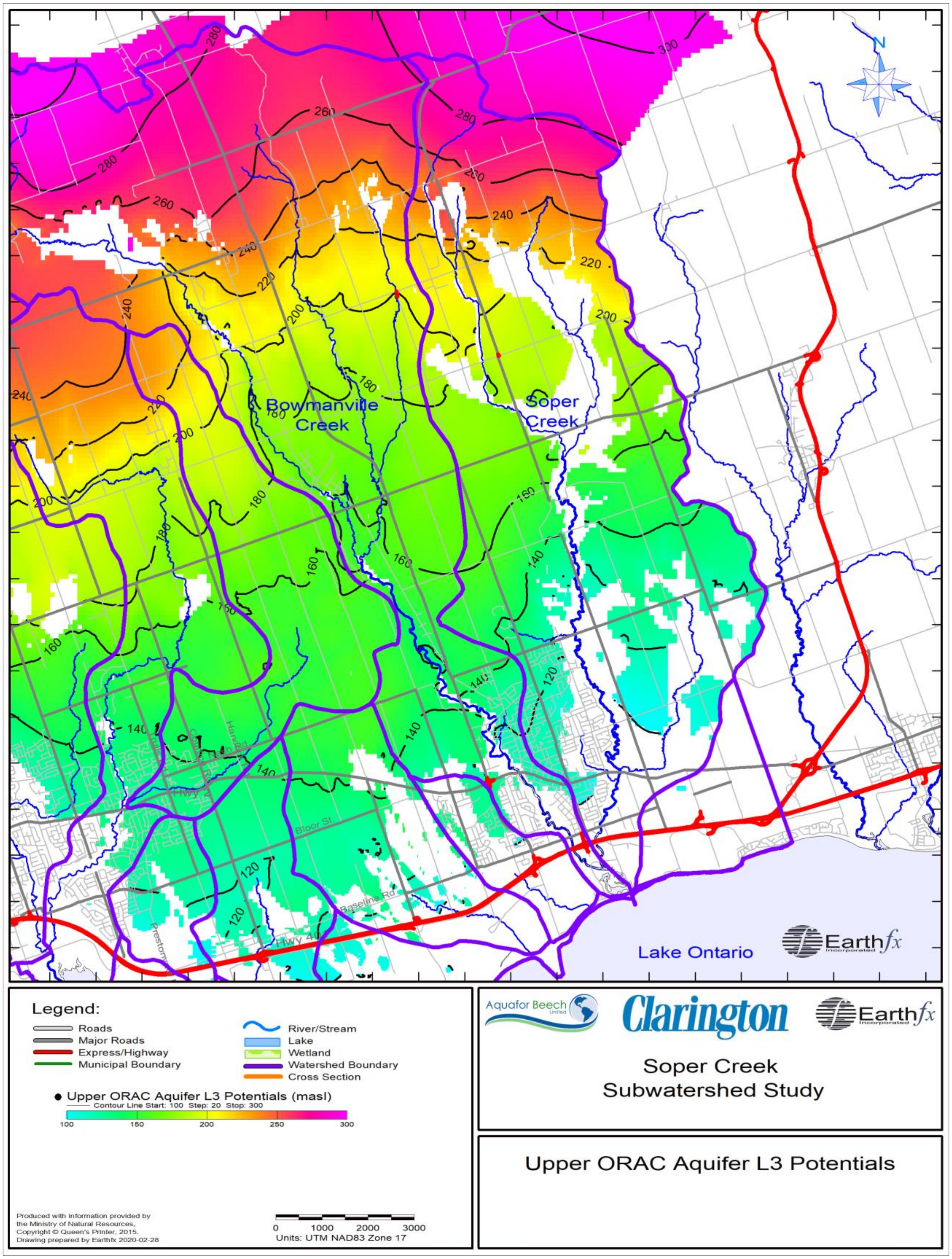


Figure 3.22: Upper Aquifer (ORAC) Water Levels

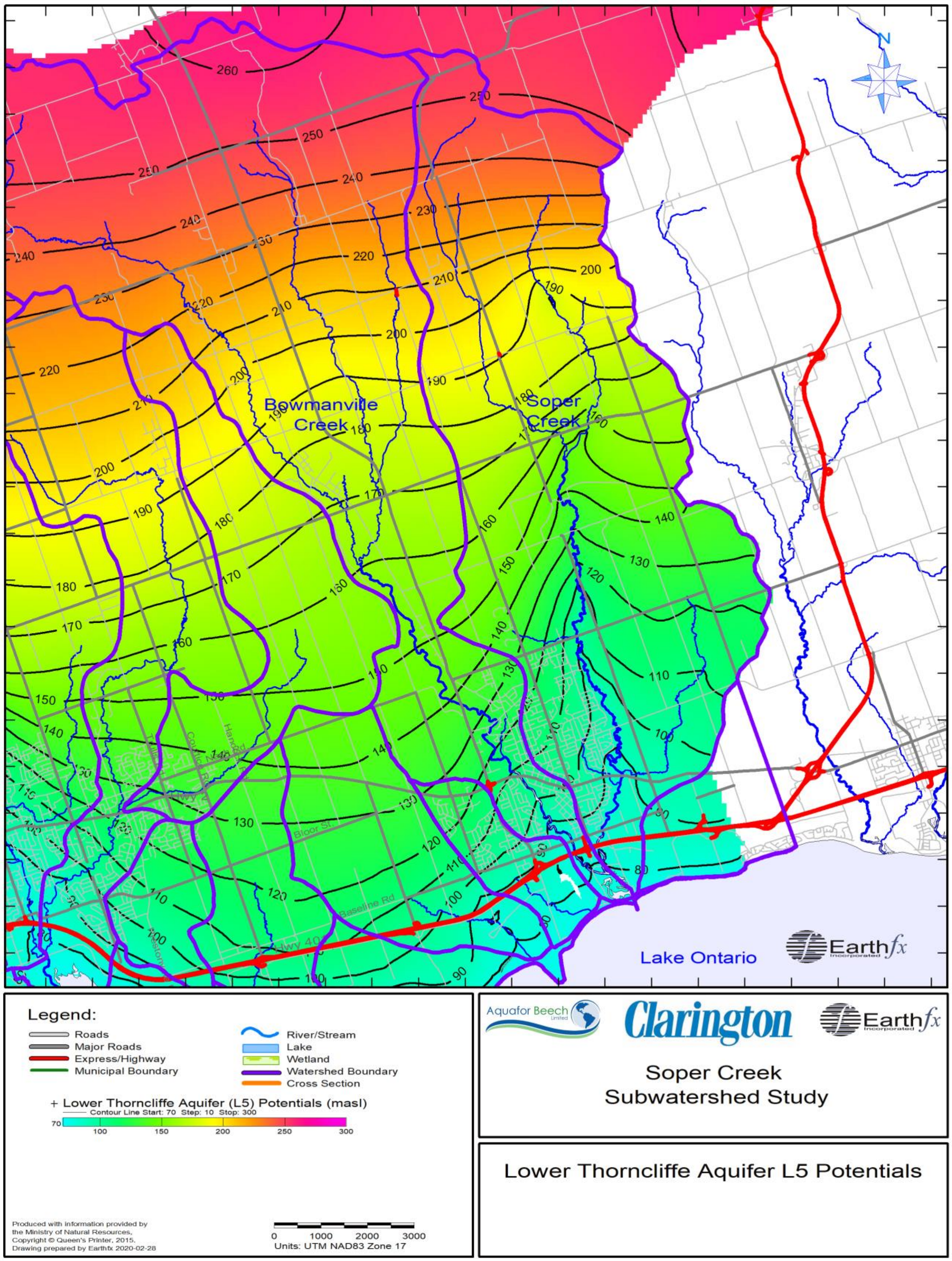


Figure 3.23: Lower Aquifer (Thorncliffe) Water Levels

3.1.5.1 PGMN Water Levels

One provincial Groundwater Monitoring Network (PGMN) well is located in the center of the Soper subwatershed. Well W0000044 is west of Soper Creek, north of the intersection of Stephens Mills Road and Bethesda Road (**Figure 3.3**). The well exhibits approximately 1.5 m of seasonal and inter-annual fluctuation, which is slightly higher than typical (1.0 m) of southern Ontario wells in these materials (**Figure 3.24**).

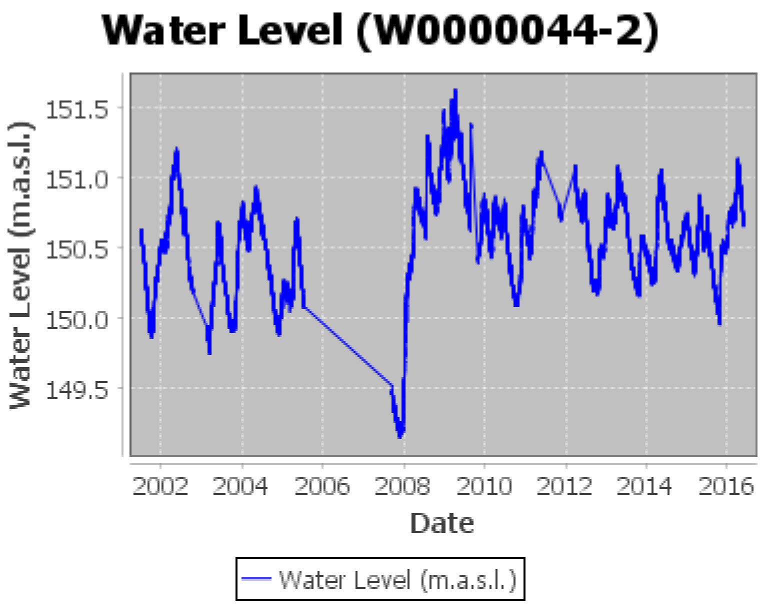


Figure 3.24: Water levels from PGMN Well W0000044

3.1.5.2 Groundwater/Surface Water Interaction and Flow Paths

The numerical models created by EarthFX (PRMS and MODFLOW) can be used to evaluate and illustrate groundwater and surface water interactions and the underlying flow paths that support these processes. The simulated groundwater discharge to streams shown in **Figure 3.25** illustrates that groundwater discharge varies significantly across the study area.

The groundwater flow system can be illustrated by releasing imaginary particle into the flow field and tracking those flow paths to a point of discharge. **Figure 3.26** was created by releasing particles in the headwaters of the ORM and tracking them to point of discharge. This primarily illustrates the deep flow system, but some GW discharge to streams is evident.

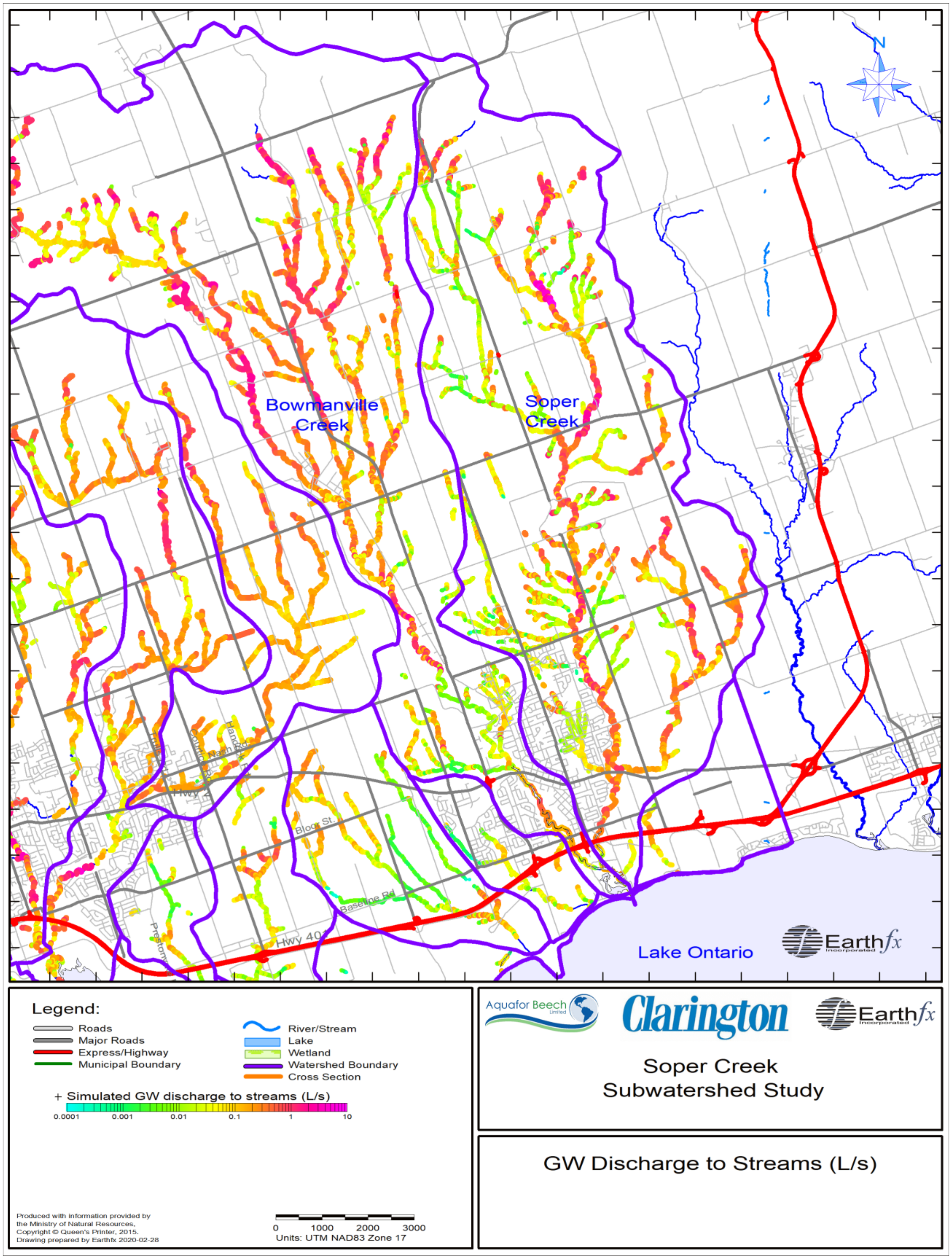


Figure 3.25: Groundwater Discharge to Streams

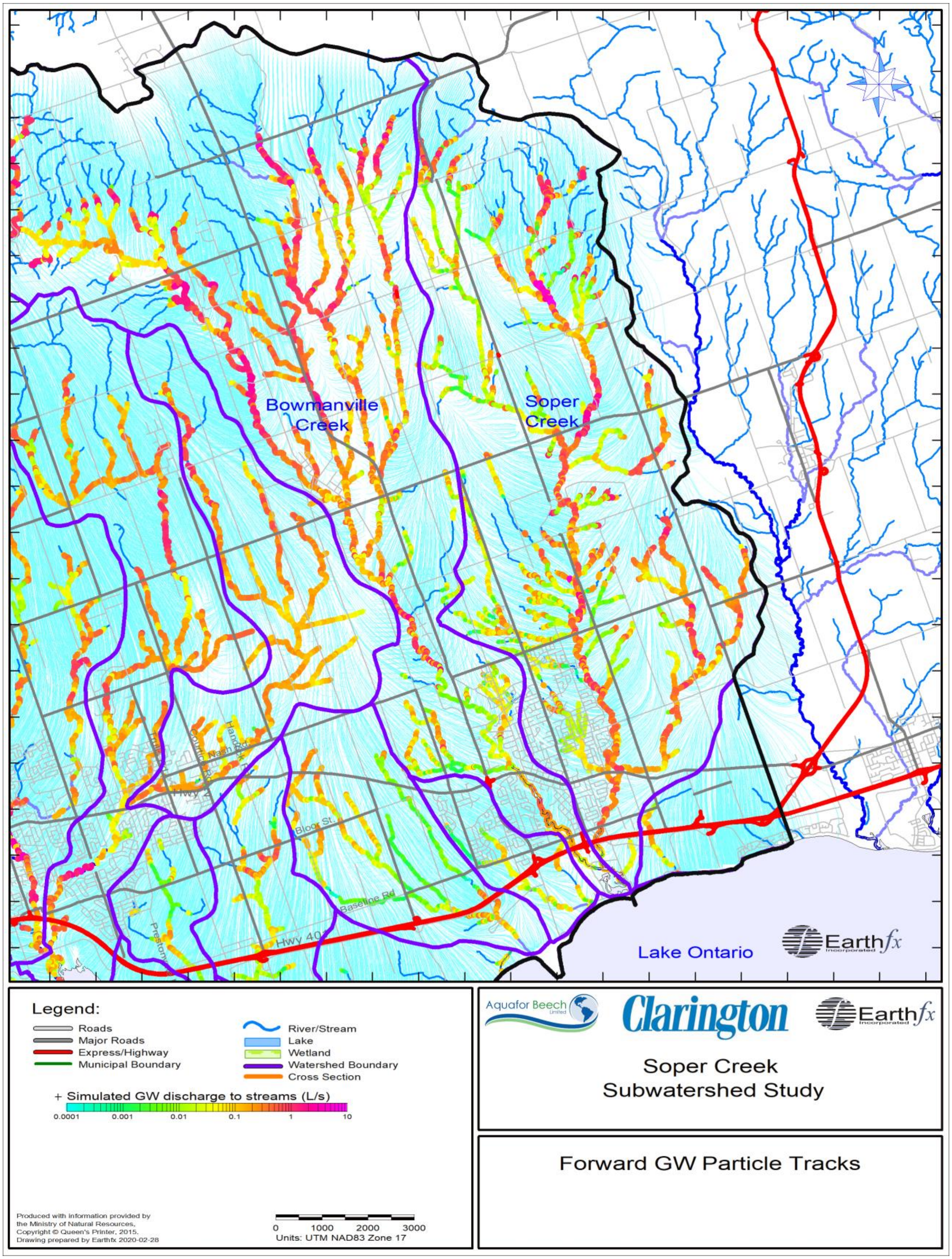


Figure 3.26: Regional Groundwater Flow Paths

Figure 3.27 illustrates the results of reverse particle tracking, where particles were released in streams and wetlands and allowed to track in a reverse manner to the point of recharge. This figure illustrates how Soper Creek receives water from both the local area around the creek in addition to some deeper, longer flow paths.

Figure 3.28 illustrates the importance of groundwater recharge to the Iroquois Beach sands and how that supports the shallow and intermediate depth flow system. Particles were released at the water table in the sands and while many particles locally discharge into Soper creek, many others do manage to flow under the study watersheds.

3.1.6 Water Balance and Water Use

In addition to the groundwater model, a fully distributed hydrologic model was developed for the study area (EarthFX, 2008, and EarthFX, 2011 and Geoprocess 2022). This model provides estimates of the components of the water budget and, together with the groundwater model estimate of discharge, an overall estimate of the major inflows and outflows into the study area.

In addition to the natural inflows and outflows, Permit to Take Water locations are shown in **Figure 3.3**.

The major components of the water budget are shown in **Figure 3.29** through **Figure 3.31**. The maps show the distribution of the key components. From an ecological perspective, the high recharge to the Oak Ridges and Iroquois Beach in the northern and central portion of the Soper subwatershed (**Figure 3.31**) provide significantly more recharge than the till plain.

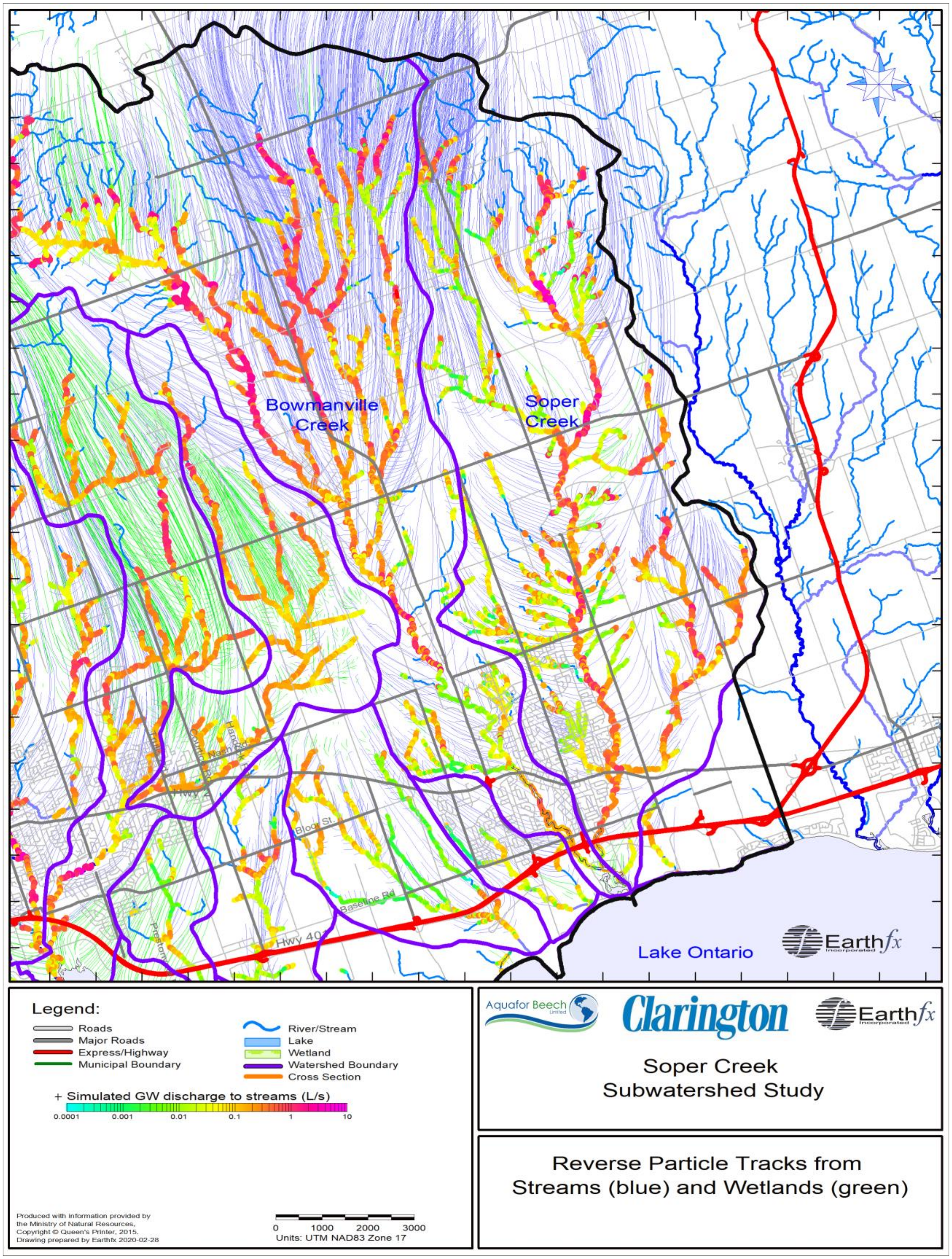


Figure 3.27: Reverse Particle Tracks from Stream and Wetland Discharge Areas

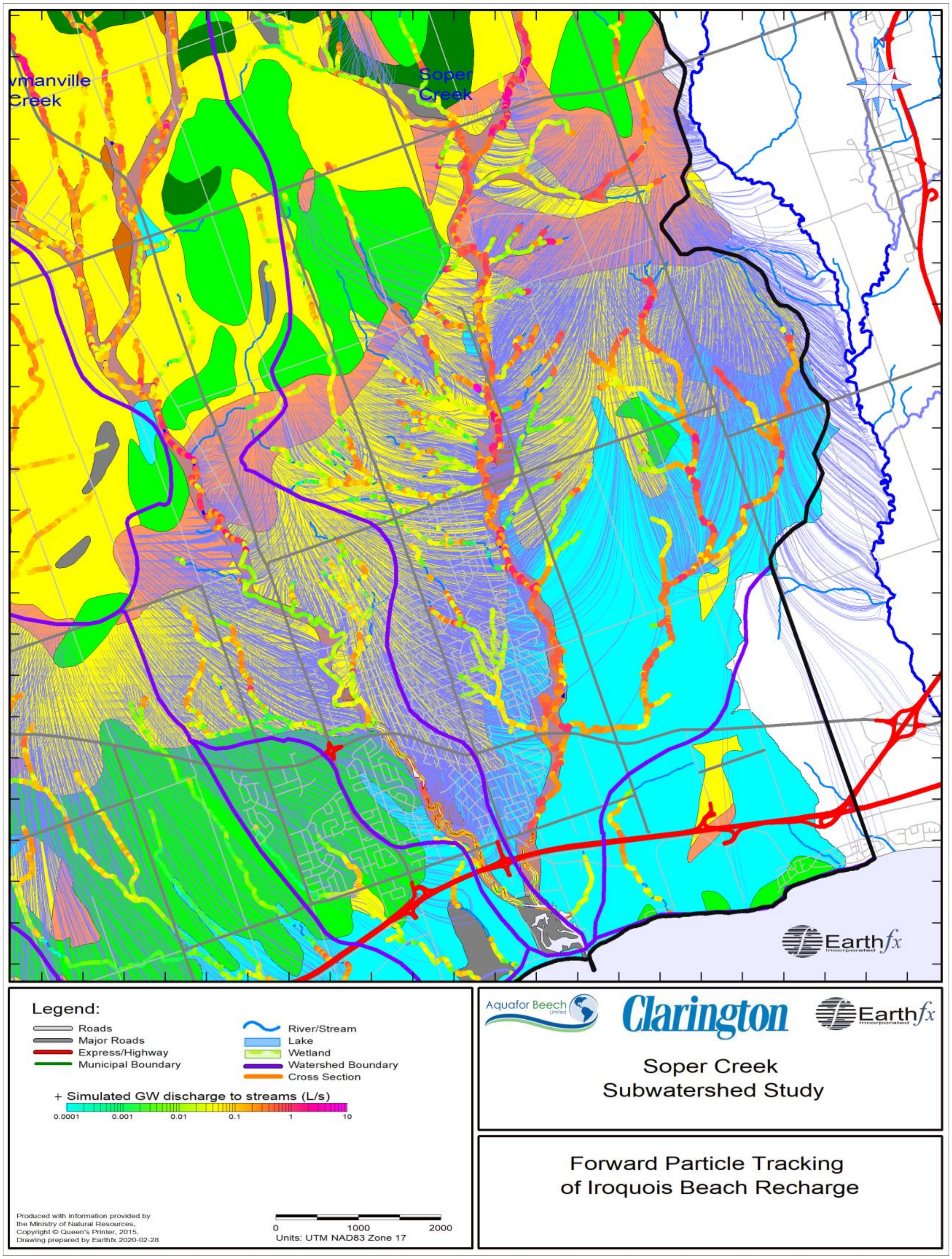


Figure 3.28: Shallow Groundwater Flow Paths from Recharge to Iroquois Beach Sands

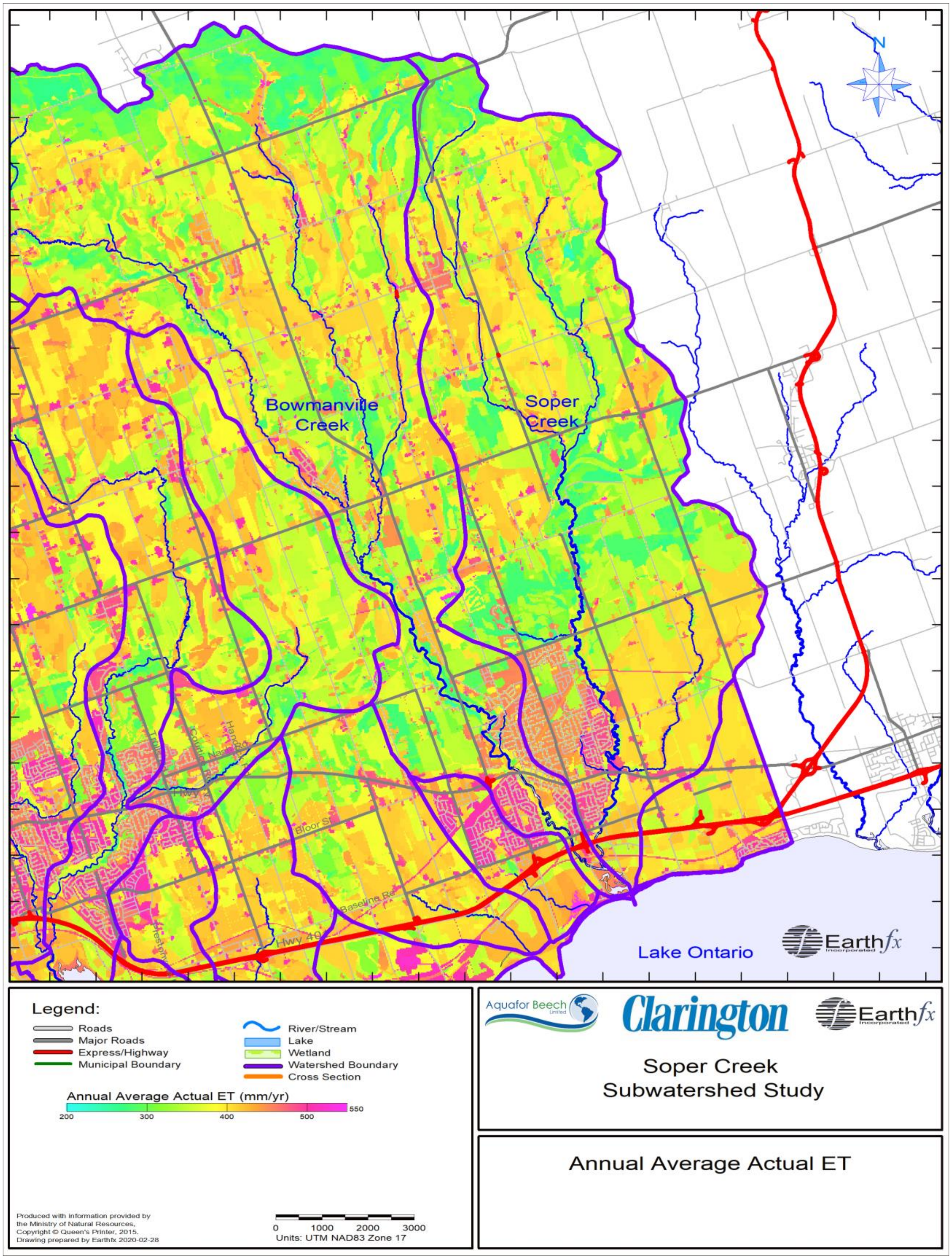


Figure 3.29: Average Annual Actual Evapotranspiration (ET)

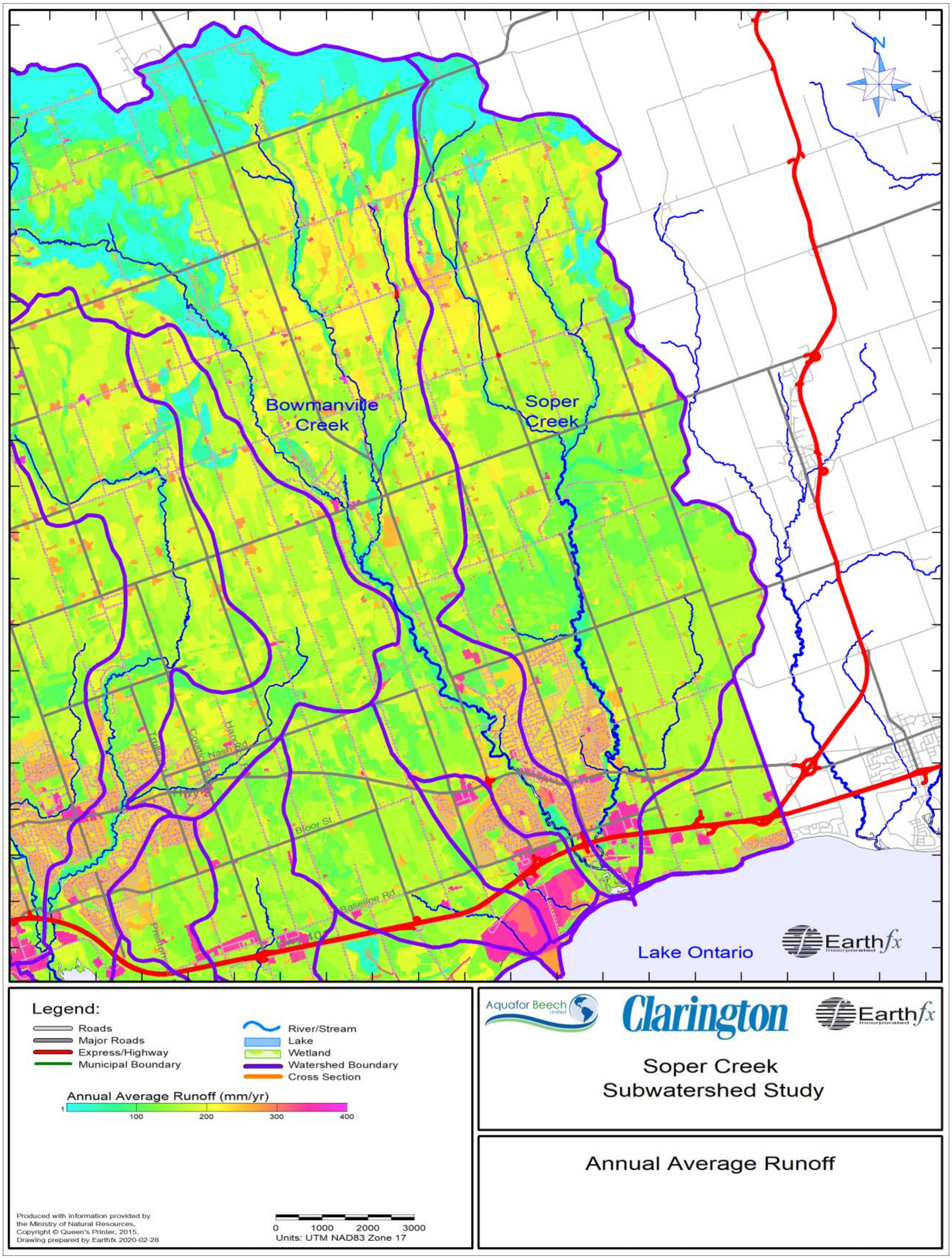


Figure 3.30: Annual Average Runoff

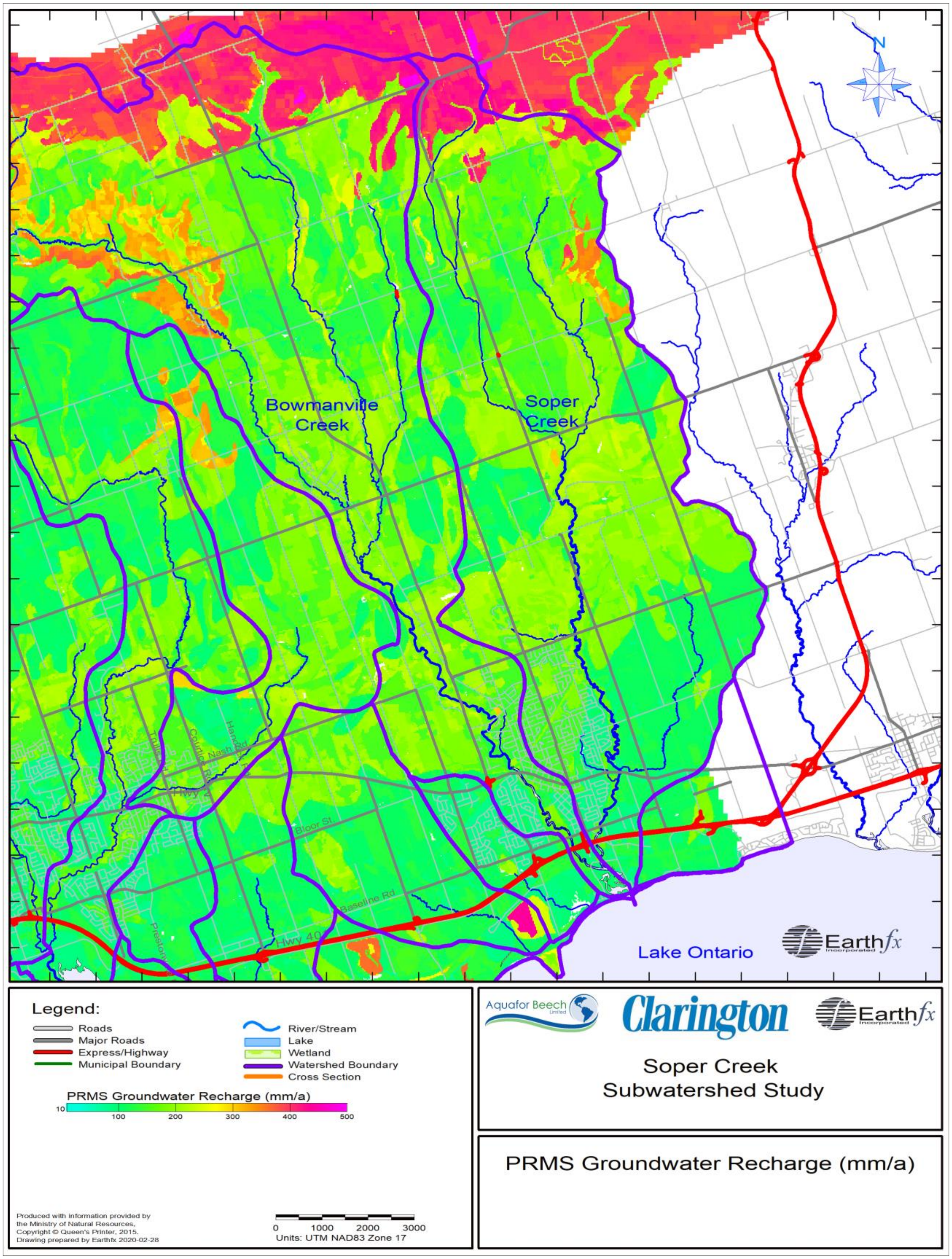


Figure 3.31: Average Annual Groundwater Recharge

3.1.6.1 Areas of Significant Groundwater Recharge (HVRAs)

The regional Source Water Protection work completed by EarthFX in the basin has provided a map of High-Volume Recharge Areas (**Figure 3.32**). This map was developed from the groundwater recharge estimate shown in **Figure 3.31** using MECP Source Water Protection Method 5. Under this method, the average recharge in each subwatershed is calculated, and any areas where the recharge exceeds 1.15 times the average are assigned as a locally High Volume Recharge Area. In summary, it is a map of recharge that is locally normalized to the average recharge in the subwatershed.

The HVRA map areas generally correspond to the location of surficial sand and gravel deposits, however as these are based on the average recharge in the local subwatershed, some silt deposits in Soper Creek are also considered locally important.

3.1.7 Groundwater Resource Conclusions

The Soper Creek watershed spans the entire regional groundwater flow system that is driven by flow between the ORM and Lake Ontario. The low permeability till that underlies the watersheds, however, limits regional upwelling and particle tracking demonstrates that there is considerable underflow beneath the watersheds.

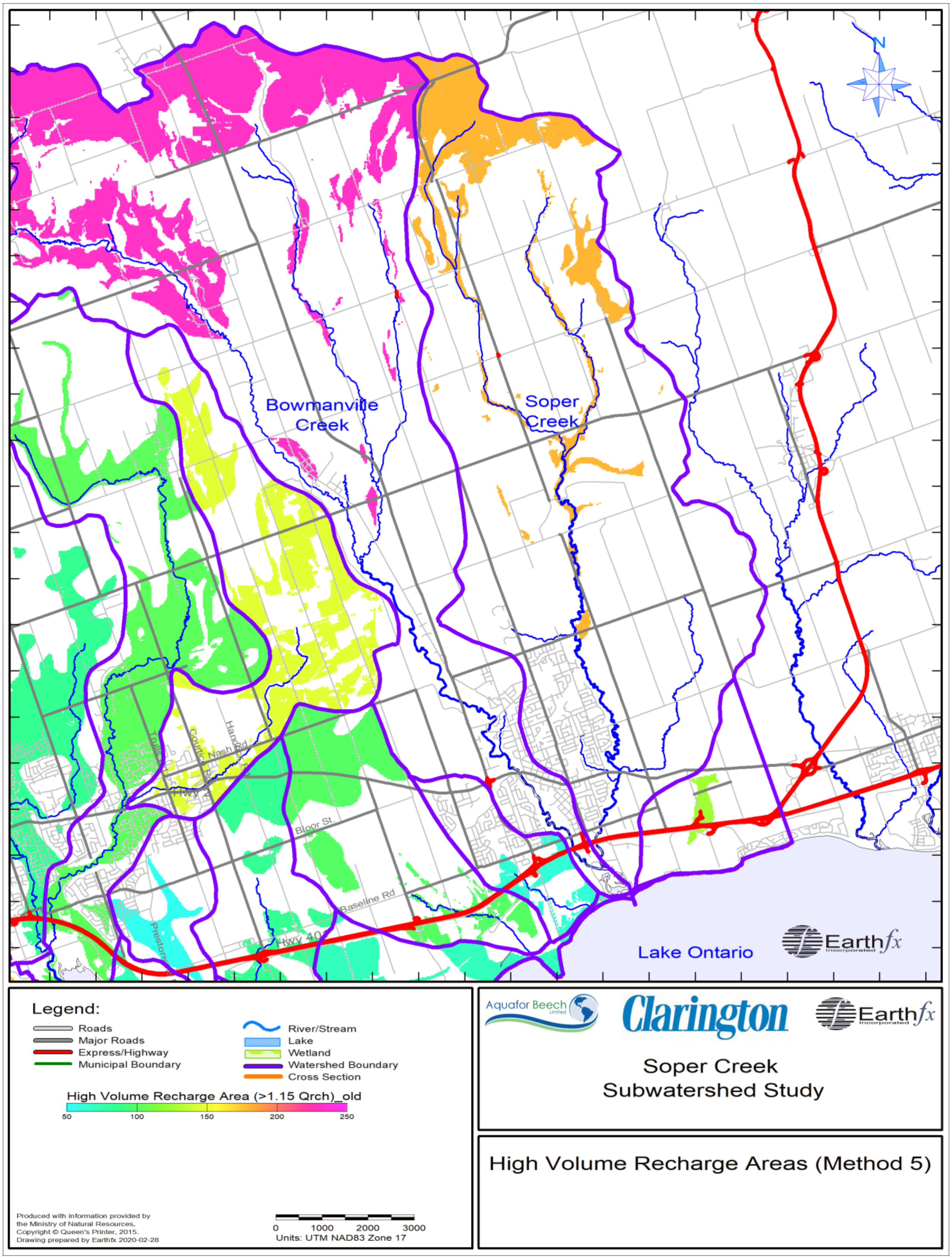


Figure 3.32: High Volume Recharge Areas

3.2 Surface Water Resources

The surface water component of this study inventories the network of existing drainage channels through the study area. Further field analyses and modeling is completed to determine the environmental function of these drainage features and to establish any associated flooding and erosion hazards. The resulting environmental features and natural hazards are then used to identify constraints to future development, as well as restoration opportunities.

Soper Creek flows south to Lake Ontario with a drainage area of approximately 7728 ha. The headwaters of Soper Creek are in the Oak Ridges Moraine (ORM) north of Concession Road 7. The creek joins Bowmanville Creek in the provincially significant Bowmanville Coastal Wetland Complex before flowing into Lake Ontario. The glacial Lake Iroquois shoreline bisects the watershed where significant deposits of sand and gravel now exist. There are four subwatersheds within Soper Creek, including Mackie, Soper North, Soper Main, and Soper East.

Constraints to future development related to surface water resources are defined in the subsequent report sections under the following topics:

- Headwater Drainage Features – defines management recommendations for the small headwater drainage channels throughout the study area;
- Fluvial geomorphologic resources – defines erosion hazard considerations for the streams as well as restoration opportunities; and
- Hydrology/hydraulics and flooding – defines the estimated flood flows, flood levels, and associated floodplain hazard lands.

3.2.1 Headwater Drainage Feature Assessment

Headwater Drainage Features (HDFs), as noted in the Ontario Stream Assessment Protocol (OSAP), are depressions in the land that convey surface flow (Stanfield, 2017). OSAP and The Evaluation, Classification, and Management of Headwater Drainage Features Guidelines (CVC & TRCA, 2014) notes that HDFs vary in both form and function and may provide direct (both permanent and seasonal) habitat for fish and/or indirect habitat for fish by transporting food and sediment to downstream waters. Examples of aquatic habitat types present in HDFs include refuge pools, seasonal spawning and nursery areas, and thermal refugia in areas of groundwater discharge. Further descriptions of HDF form and function are contained below in **Section 3.2.1.1**.

Examples of HDFs include small streams, springs, wetlands, swales, and ditches (natural or human-modified). These features are also important sources, conveyors, or sinks of sediment, nutrients, and flow. Some HDFs may function as important habitat for terrestrial and wetland species as breeding areas or corridors for travel.

HDFs have not traditionally been a part of most aquatic monitoring efforts. However, understanding of the importance of such features has been growing and HDFs are now protected features under certain local and provincial regulations. The *2020 Growth Plan for the Greater Golden Horseshoe*, prepared under the *Places to Grow Act* (2005), considers HDFs to be a component of the "significant surface water contribution areas" and recommends their protection as Key Hydrologic Features. Furthermore, HDFs providing direct or indirect fish habitat would qualify for protection as Fish Habitat under municipal policy. This study therefore included an assessment of HDFs to identify features and determine the appropriate level of management applicable to each, as detailed in see Section 3.2.1.2.

3.2.1.1 Methodology

The Evaluation, Classification, and Management of Headwater Drainage Features Guidelines (CVC & TRCA, 2014), hereafter "the Guidelines", were used to classify HDFs within the study area. The Guidelines were developed to provide direction to practitioners for aquatic features that are not clearly covered by existing policy and legislation as being important eco-hydrological features (e.g., perennial streams and provincially significant wetlands) but may contribute to the overall health of a subwatershed. The Guidelines attempt to evaluate, in a consistent way, the contribution of sediment, food and flow transport to downstream reaches, as well as the use of these features by biota (CVC & TRCA, 2014).

To distinguish HDFs from watercourses, the following definitions were utilized per the Ontario Stream Assessment Protocol (OSAP) and the CVC & TRCA document:

- HDFs are non-permanently flowing drainage features that may not have defined bed or banks; they are first-order and zero-order intermittent and ephemeral channels, swales, and connected headwater wetlands, but do not include rills or furrows.
- Features within a valley are typically not considered HDFs.
- A HDF has a catchment of at least 2.5 ha in size.

In order to identify possible HDFs, a drainage network for the Soper Creek SWS study area was created using Arc Hydro in ESRI's ArcMap 10.1. Firstly, a Digital Terrain Model (DTM) was obtained from the Ontario Ministry of Natural Resources and Forestry. The DTM with a spatial resolution of 0.5 m x 0.5 m was derived from a classified lidar point cloud. Using Arc Hydro Tools in ESRI's ArcGIS 10.5: the regulatory watercourse drainage pattern was 'burned' into the DTM and depressions were filled to correct potential raster processing problems. Flow direction and flow accumulation rasters were then processed from the reconditioned DTM. Utilizing the flow accumulation raster, a stream network raster was defined such that any streams with a catchment area of 2.5 ha would be accounted for. After the stream network was defined, the stream raster was then converted to vector feature layer. Lastly, field maps were prepared for Aquafor Beech biologists by overlaying the stream layer on aerial imagery to be assessed during field investigations.

A Standard Survey Type was applied, according to the recommendations in the Guidelines. This requires the use of the Ontario Stream Assessment Protocol (OSAP) to assess HDFs. The following modules were used:

- Section 4: Module 10 (Constrained Headwater Sampling); and
- Section 4: Module 11 (Unconstrained Headwater Sampling).

HDF sampling locations were chosen based on land access and road crossings, where possible. However, due to the size of the study area, land access was not granted for all HDF assessment areas and road crossings were not always available. Where land access was not granted, Section 4: Module 10 of OSAP was used. Features identified as watercourses in the regulatory watercourse drainage pattern layer were followed to a point where a potential HDF was identified in the prepared field mapping. At this point, HDF assessments were conducted. Smaller features identified as watercourses were assessed using the same HDF assessment protocol but were left as watercourses if feature characteristics did not match those discussed above. This was done in order to maintain a conservative management recommendation.

Per the CVC & TRCA Guidelines, the OSAP Headwater module was completed three times at each sampling location to assess the HDFs throughout the year:

<u>Site Visit #1:</u>

- Conducted from March-April, during the spring melt (frost-free conditions); and
- ArcHydro segments were confirmed in the field.

<u>Site Visit #2</u>:

- Conducted in April-May, when high melt flows have ceased;
- This visit ideally occurs before leaf-out, so that features can be easily observed; and
- Fish community sampling was conducted using the Ontario Stream Assessment Protocol (OSAP).

Site Visit #3:

- Conducted in July-August, or when temperatures are consistently warm and conditions are dry; and
- The purpose is to confirm hydrology, fish presence, and groundwater indicators.

Using the Guidelines, the results of the HDF assessments were integrated with aquatic/terrestrial habitat observations, amphibian surveys, hydrology, and Species at Risk data. Due to the dynamic nature of these features, an extensive photo database was compiled to ensure proper classification of these watercourses (see **Appendix A**).

Once field surveys were complete, the HDFs were assessed in four steps, based on criteria outlined in the Guidelines, to classify each HDF:

Step 1: Hydrology Classification: Flow conditions are classified into hydrology types

Step 2: Riparian Classification: The feature is classified with regard to riparian conditions

Step 3: Fish and Fish Habitat Classification: Fish and fish habitat is classified based on the presence of fish

Step 4: Terrestrial Habitat Classification: Features are classified based on the presence of breeding amphibians and wetlands

Finally, the results of Steps 1-4 were summarized and used in the Flow Chart within the CVC & TRCA Guidelines to assign a Management Recommendation (**Figure 3.33**).

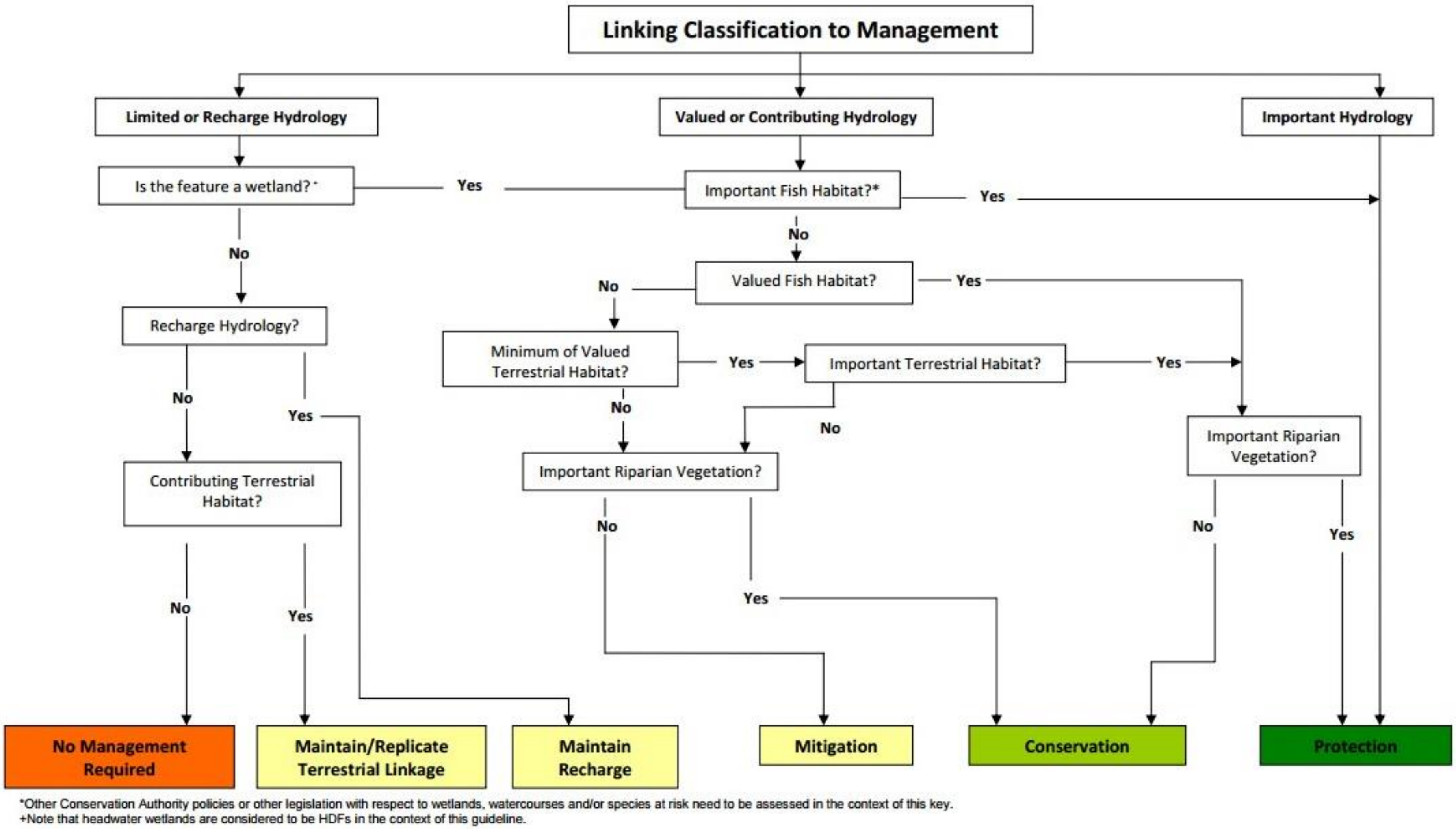


Figure 3.33: Headwater Drainage Feature Management Recommendations (CVC & TRCA 2014)

3.2.1.2 HDF Classifications and Management Recommendations

Photographs of each HDF taken during the three site visits are located in **Appendix A.** All OSAP field sheets and detailed criteria of the 4-Step Classification are located in **Appendix B**.

Table 3.1 to **Table 3.3**, below, provide the results of the 4-Step Classification process for the study area, as well as the assigned Management Recommendation.

Figure 3.34 displays the HDF Assessment Areas and **Figure 3.35** shows these areas in detail with the associated Management Recommendations. Definitions and requirements associated with each Management Recommendation are listed in **Table 3.4**.

According to the Guidelines, in the event that a lower level of protection is identified for a segment downstream of a segment with a higher level of protection, the more conservative approach shall be adopted for both segments and the downstream segment should be reclassified to match the upstream segment. This situation was encountered two times in the study area. Segment SOP3-1, which was given a Management Recommendation of “Conservation” based on the results of assessment, was located downstream of segment SOP3-2 which was given a Management Recommendation of “Protection”. Therefore, the more conservative category of “Protection” was applied to segment SOP3-1 as noted in the table below. Similarly, segment SOP3-3, which was initially given a Management Recommendation of “Mitigation”, was located downstream of segment SOP3-4 which was given a Management Recommendation of “Conservation”. Therefore, the more conservative category of “Conservation” was applied to segment SOP3-3.

Other considerations include an online pond (SOP3-7), which was upstream of a documented watercourse and downstream of groundwater inputs. The HDF Guidelines note that, “on-line or in-line ponds are typically created on headwater features to provide a source for irrigation or water for livestock. Although these features can provide flow retention, extended discharge, permanent fish habitat, and amphibian breeding areas, their disruption to natural geomorphological processes and thermal impacts are generally not desirable” (CVC & TRCA, 2014). As such, SOP3-7 was given a management recommendation of “No Management Required”. However, the dam structure that controlled the water levels of this pond should be considered for removal to improve connectivity throughout the watercourse. By removing this dam and restoring SOP3-7 to a state that is more representative of SOP3-8 and the downstream watercourse, groundwater influences would have a direct and positive impact on the downstream watercourse and Soper Creek as a whole as the groundwater sources and thermal impacts would not be disrupted by the pond, as noted above.

Table 3.1: HDF Classification: Soper Creek Area 1 (SOP1)

Drainage Feature Segment	STEP 1 Hydrology	STEP 2 Riparian	STEP 3 Fish Habitat	STEP 4 Terrestrial Habitat	Management Recommendation
SOP1-1	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP1-2	Limited or Recharge	Contributing Functions	Contributing Functions	Limited Functions	**No Management Required**
SOP1-3	Limited or Recharge	Important Functions	Contributing Functions	Limited Functions	**No Management Required**
SOP1-4	Valued or Contributing	Important Functions	Valued Functions	Contributing Functions	**Protection**
SOP1-5	Limited or Recharge	Limited Functions	Contributing Functions	Limited Functions	**No Management Required**
SOP1-6	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP1-7	Limited or Recharge	Important Functions	Contributing Functions	Contributing Functions	**Mitigation**
SOP1-8	*Tile*				*No Management Required*
SOP1-9	Limited or Recharge	Important Functions	Contributing Functions	Contributing Functions	**Mitigation**
SOP1-10	*Tile*				*No Management Required*
SOP1-11	*Tile*				*No Management Required*
SOP1-12	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP1-13	Limited or Recharge	Limited Functions	Contributing Functions	Limited Functions	**No Management Required**
SOP1-14	*Floodplain*				*Not an HDF*
SOP1-15	Limited or Recharge	Limited Functions	Contributing Functions	Limited Functions	**No Management Required**
SOP1-16	Valued or Contributing	Important Functions	Contributing Functions	Valued Functions	**Conservation**
SOP1-17	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP1-18	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**

Table 3.2: HDF Classification: Soper Creek Area 2 (SOP2)

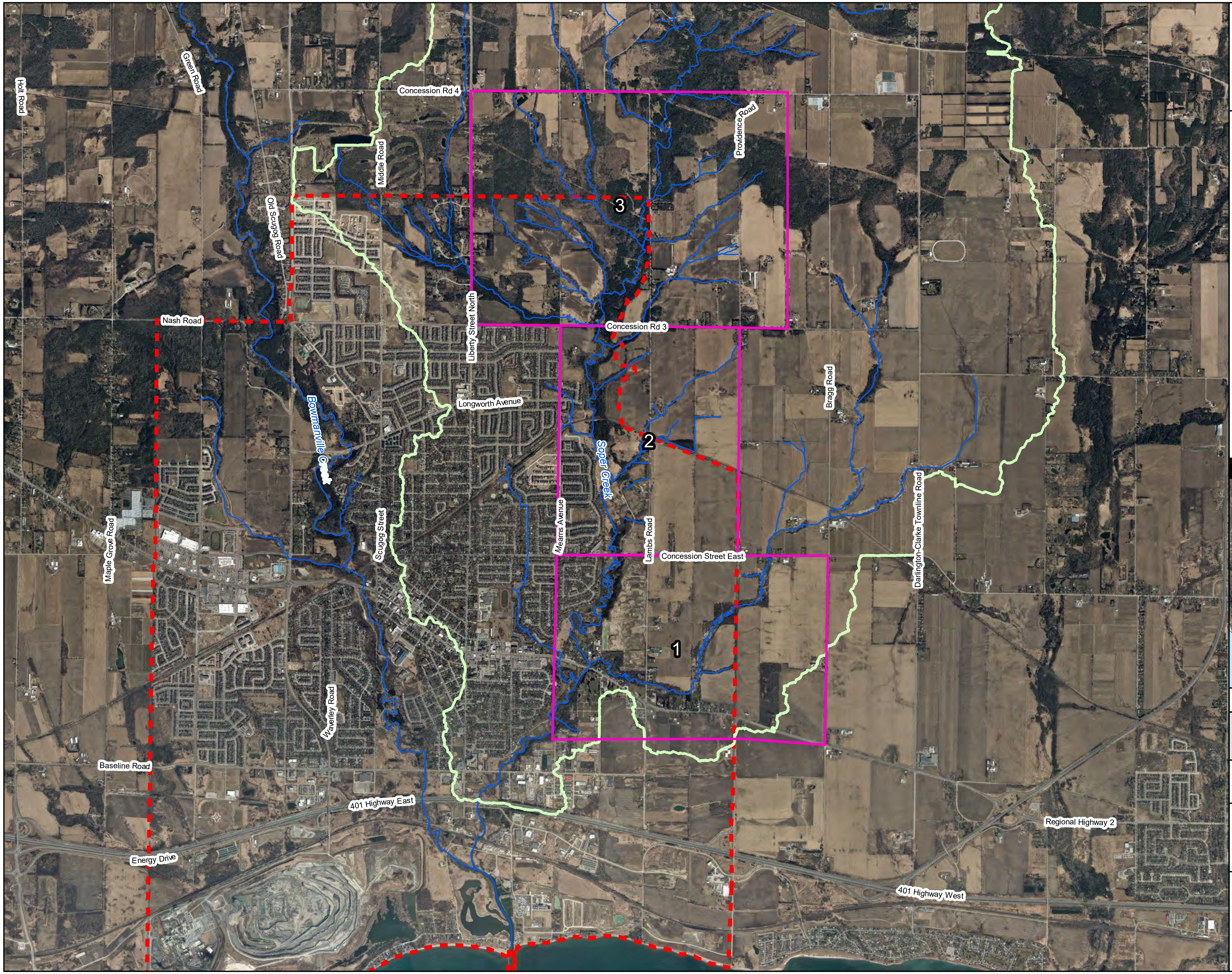
Drainage Feature Segment	STEP 1	STEP 2	STEP 3	STEP 4	Management Recommendation
	Hydrology	Riparian	Fish Habitat	Terrestrial Habitat	
SOP2-1	*Floodplain*				*Not an HDF*
SOP2-2	*Watercourse*				*Not an HDF*
SOP2-3	*Tile*				*No Management Required*
SOP2-4	*Tile*				*No Management Required*
SOP2-5	*Watercourse*				*Not an HDF*
SOP2-6	*Watercourse*				*Not an HDF*
SOP2-7	*Tile*				*No Management Required*
SOP2-8	*Watercourse*				*Not an HDF*
SOP2-9	*Tile*				*No Management Required*
SOP2-10	*Watercourse*				*Not an HDF*
SOP2-11	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP2-12	Valued or Contributing	Important Functions	Contributing Functions	Valued Functions	**Conservation**
SOP2-13	*Floodplain*				*Not an HDF*
SOP2-14	*Tile*				*No Management Required*
SOP2-15	*Tile*				*No Management Required*

Table 3.3: HDF Classification: Soper Creek Area 3 (SOP3)

Drainage Feature Segment	STEP 1	STEP 2	STEP 3	STEP 4	Management Recommendation
	Hydrology	Riparian	Fish Habitat	Terrestrial Habitat	
SOP3-1	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Protection (Up classed to upstream recommendation)** (Conservation)
SOP3-2	Important	Important Functions	Contributing Functions	Contributing Functions	**Protection**
SOP3-3	Limited or Recharge	Contributing Functions	Contributing Functions	Limited Functions	**Conservation (Up classed to upstream recommendation)** (Mitigation)
SOP3-4	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-5	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-6	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-7	Limited or Recharge	Contributing Functions	Important Functions	Limited Functions	**No Management Required**
SOP3-8	Important	Valued Functions	Contributing Functions	Limited Functions	**Protection**
SOP3-9	Valued or Contributing	Important Functions	Contributing Functions	Limited Functions	**Conservation**
SOP3-10	Limited or Recharge	Valued Functions	Contributing Functions	Limited Functions	**Mitigation**
SOP3-11	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-12	Valued or Contributing	Important Functions	Contributing Functions	Valued Functions	**Conservation**
SOP3-13	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-14	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-15	*Tile*				*No Management Required*
SOP3-16	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-17	Valued or Contributing	Valued Functions	Contributing Functions	Limited Functions	**Mitigation**
SOP3-18	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-19	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-20	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-21	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**

Drainage Feature Segment	STEP 1	STEP 2	STEP 3	STEP 4	Management Recommendation
	Hydrology	Riparian	Fish Habitat	Terrestrial Habitat	
SOP3-22	Important	Important Functions	Contributing Functions	Valued Functions	**Protection**
SOP3-23	Valued or Contributing	Valued Functions	Contributing Functions	Limited Functions	**Mitigation**
SOP3-24	Valued or Contributing	Important Functions	Contributing Functions	Limited Functions	**Conservation**
SOP3-25	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-26	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-27	Valued or Contributing	Important Functions	Contributing Functions	Contributing Functions	**Conservation**
SOP3-28	*Tile*				*No Management Required*

Clarington



Legend

- Bowmanville / Newcastle Urban Boundary
- Headwater Drainage Feature Grid Index
- Soper Subwatershed Boundary
- Watercourse

LOCATOR MAP

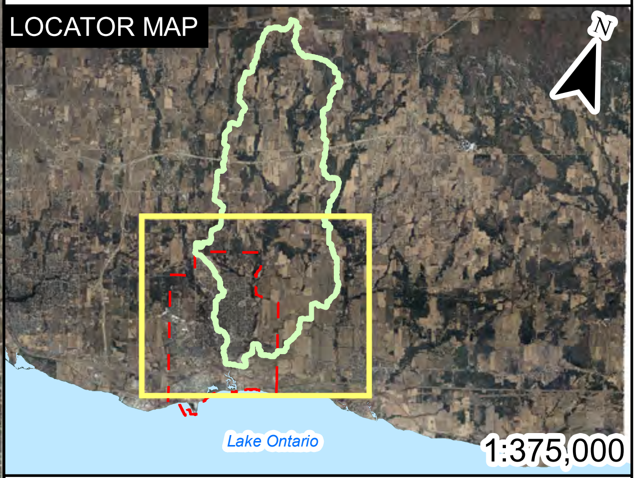


Figure 3.34

HDF Management Recommendations (Overview)

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 250 500 1,000 1,500
Meters

N

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Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Regulatory Floodline

HDF Managment Recommendation:

- Protection
- Conservation
- Mitigation
- No Management Required
- Tile
- Watercourse (Buried)
- Watercourse

LOCATOR MAP

Lake Ontario

1:375,000

Figure 3.35 (1 of 3)

HDF Management Recommendations

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 100 200 400
Meters

N

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Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Regulatory Floodline

HDF Managment Recommendation:

- Protection
- Conservation
- Mitigation
- No Management Required
- Tile
- Watercourse (Buried)
- Watercourse

LOCATOR MAP

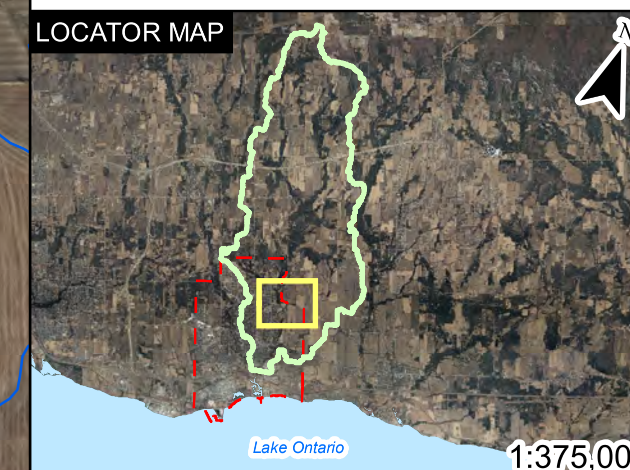


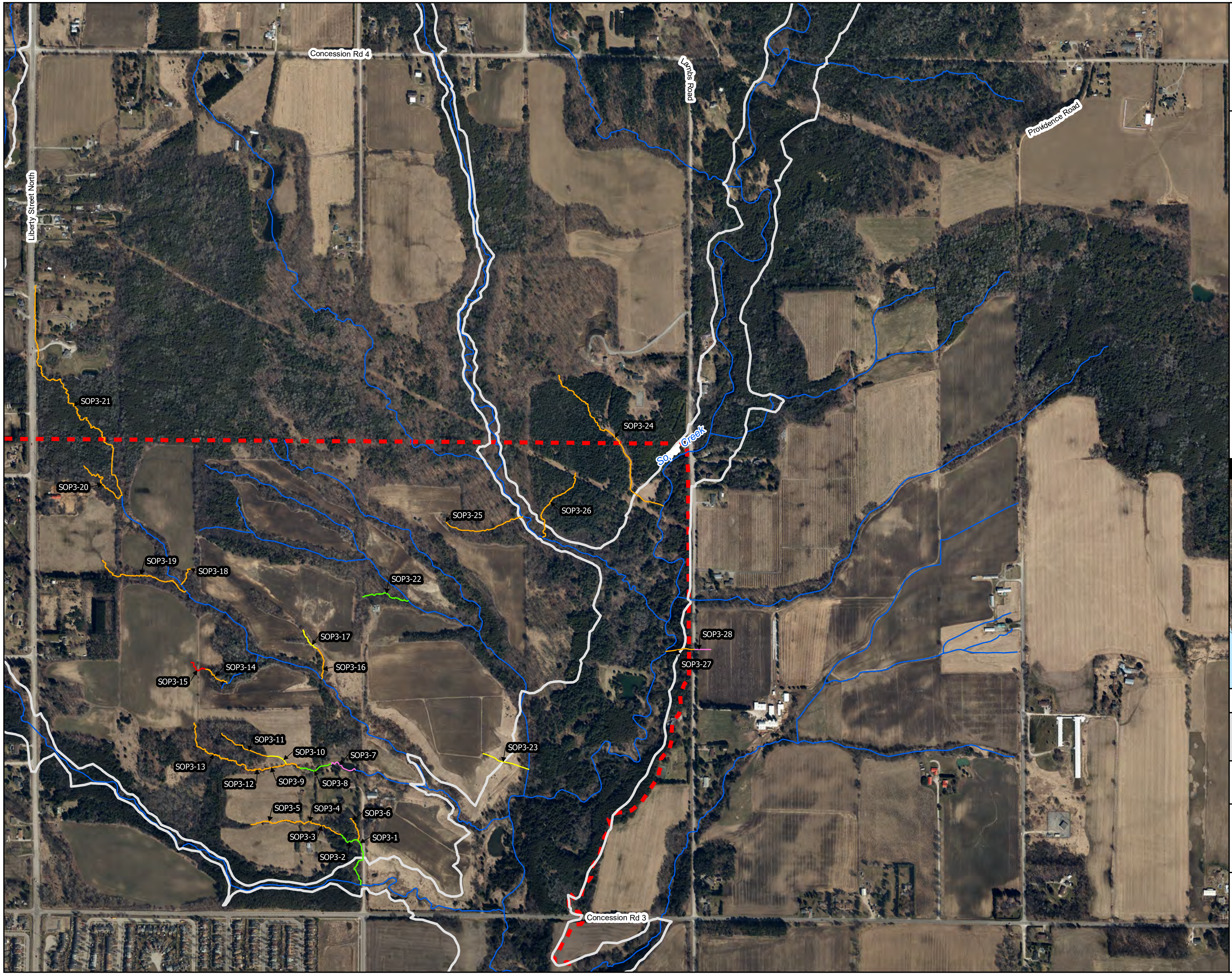
Figure 3.35 (2 of 3)

HDF Management Recommendations

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 105 210 420
Meters

Aquafor Beech Limited



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Regulatory Floodline

HDF Managment Recommendation:

- Protection
- Conservation
- Mitigation
- No Management Required
- Tile
- Watercourse (Buried)
- Watercourse

LOCATOR MAP

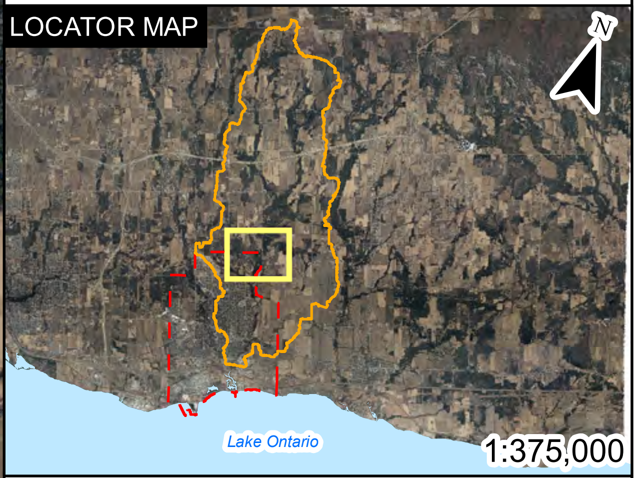


Figure 3.35 (3 of 3)

HDF Management Recommendations

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 115 230 460
Meters

Aquafor Beech Limited

Table 3.4: Definitions of Management Recommendations (CVC & TRCA, 2014)

HDF Management Recommendation	Definition
Protection (Important Functions)	• Protect and/or enhance the existing feature and its riparian zone corridor, and groundwater discharge or wetland in-situ; • Maintain hydroperiod; • Incorporate shallow groundwater and base flow protection techniques such as infiltration treatment; • Use natural channel design techniques or wetland design to restore and enhance existing habitat features, if necessary; realignment not generally permitted; and • Design and locate the stormwater management system (e.g., extended detention outfalls) are to be designed and located to avoid impacts (i.e., sediment, temperature) to the feature.
Conservation (Valued Functions)	• Maintain, relocate and/or enhance drainage feature and its riparian corridor; • If catchment drainage has been previously removed or will be removed due to diversion of stormwater flows, restore lost functions through enhanced lot level controls (i.e., restore original catchment using clean roof drainage), as feasible; • Maintain or replace on-site flows using mitigation measures and/or wetland creation, if necessary; • Maintain or replace external flows; • Use natural channel design techniques to maintain or enhance overall productivity of the reach; and • Drainage feature must connect to downstream.
Mitigation (Contributing Functions)	• Replicate or enhance functions through enhanced lot level conveyance measures, such as well-vegetated swales (herbaceous, shrub and tree material) to mimic online wet vegetation pockets, or replicate through constructed wetland features connected to downstream; • Replicate on-site flow and outlet flow at the top end of the system to maintain feature functions with vegetated swales, bioswales, etc. If catchment drainage has been previously removed, due to diversion of stormwater flows, restore lost functions through enhanced lot level controls (i.e., restore original catchment using clean roof drainage); and • Replicate functions by lot level conveyance measures (e.g., vegetated swales) connected to the natural heritage system, as feasible and/or Low Impact Development (LID) stormwater options (refer to Conservation Authority Water Management Guidelines for details).

HDF Management Recommendation	Definition
Mitigation (Recharge Functions)	• Maintain overall water balance by providing mitigation measures to infiltrate clean stormwater, unless the area qualifies as an Area of High Aquifer Vulnerability under the Oak Ridges Moraine Conservation Plan (ORMCP) or Significant Recharge Areas under the Source Water Protection Act. These areas will be subject to specific policies under their respective legislation. • Terrestrial features may need to be assessed separately through an Environmental Impact Study to determine whether there are other terrestrial functions associated with them.
Mitigation (Terrestrial Functions) (note: HDF type not present in the study area)	• Maintain the corridor between the other features through in-situ protection or if the other features require protection, replicate and enhance the corridor elsewhere • If the feature is wider than 20 m, it may need to be assessed separately through an Environmental Impact Study to determine whether there are other terrestrial functions associated with it.
No Management Required (Limited Functions)	• The feature that was identified during desktop pre-screening has been field verified to confirm that no feature and/or functions associated with HDFs are present on the ground and/or there is no connection downstream. These features are generally characterized by lack of flow, evidence of cultivation, furrowing, the presence of a seasonal crop, and lack of natural vegetation. No management recommendations required.

HDFs identified by this study provide indirect fish habitat function. Fish Habitat and Riparian Corridors are components of the municipal Natural Heritage System; however, it is recognized that the Evaluation, Classification, and Management of Headwater Drainage Features Guidelines set forth by the CVC and TRCA (CVC & TRCA, 2014) was developed with guidance from multiple stakeholder groups and is recognized by municipalities as a tool to provide direction specifically with regard to HDF management. This study has therefore utilized the Management Recommendations set forth by the Guidelines when developing land-use constraints; see **Section 4.3.2** for further discussion of HDF management as related to municipal natural heritage policies and developmental constraints.

The HDF assessment protocol is limited to field observations and is inherently biased, limiting the scope of observations to a number of external factors such as weather, timing, resources and land access among other factors. Additional HDFs may have been overlooked during this exercise and should therefore be considered in future exercises. Any appropriate confirmation or refinement of the HDFs identified herein or identification of previously-unidentified HDFs shall be completed through site-specific studies such as an EIS, and appropriate Management Recommendations applied accordingly.

It should also be noted that the Guidelines and Classification process recommends that features defined by, "…evidence of cultivation, furrowing, presence of a seasonal crop, lack of vegetation, and fine textured soils," should be considered to provide Limited or Recharge Hydrologic Functions (CVC & TRCA, 2014). These defining characteristics are typical of agricultural fields, of which contain some of the larger and potentially hydrologically significant drainage features. This is the case for features given the lowest management recommendations within the two subwatersheds, that are not ponds. Furthermore, these assessments do not account for agricultural features that are tiled. In these cases, management recommendations would be up-ranked if the agricultural fields would be left to re-naturalize making these areas suitable for restoration works. It is the opinion of Aquafor Beech Limited that additional HDF Assessments be undertaken on features identified on agricultural properties prior to any development approval in order to accurately assess hydrologic functions of these features. This is especially the case if cultivated lands are allowed to go fallow in the intervening time.

3.2.1.3 Conclusions

Figure 3.34 displays the HDF Assessment Areas and **Figure 3.35** shows these areas in detail with the associated Management Recommendations. Definitions of Management Recommendations applicable to each category of HDF are listed in **Table 3.4**. Management Recommendations as defined in this section will be used to inform the developmental constraints and opportunities which are discussed in detail in **Section 4.3.2**.

3.2.2 Fluvial Geomorphologic Resources

The river drainage network and channel landforms that make up the watershed develop over long timescales as the integrated product of hydrological and biological stream processes interacting on the geological template of the landscape. Fluvial geomorphology is the study of the processes and landforms that shape stream and river channels, including flow hydraulics and sediment transport. The fundamental environmental variables that control the morphology (or changing shape) of a river channel include the discharge (Q), channel slope (S), sediment load (Q_s), and sediment size (D). Conventionally referred to as the Lane balance ($Q \cdot S \sim Q_s \cdot D$), a significant change in one of these variables will eventually alter another variable causing the channel to adjust. Land-use changes within a watershed can alter the amount of surface runoff and the amount of sediment reaching a river. Historic alterations and aged river engineering structures may also have unintended consequences and deteriorate if left unmaintained for decades. Cumulatively, these historic changes to the river channel and environmental controls can result in erosion and flooding problems, as well as degraded aquatic and riparian habitat. Recent advances in river engineering and stream restoration practices can help mitigate the impacts of historic land-use change—through natural channel design and other environmentally sensitive river engineering approaches—balancing self-sustaining natural processes with long-term maintenance requirements for engineering controls.

Study Objectives
Within the overall study goal of responsible environmental and economic management of water resources, the objective of the fluvial geomorphology component is to characterize stream and river channels, particularly with respect to erosion and channel stability. As such, detailed geomorphic assessments of watercourses have been completed for Soper Creek within the Urban Boundary. For the Soper Creek subwatershed, the geomorphic assessments provide a basis for recommendations with respect to development constraints, stormwater management erosion control, mitigation of existing erosion problems, and opportunities for stream restoration that will improve future channel stability, protect infrastructure and property, and enhance ecological habitat.

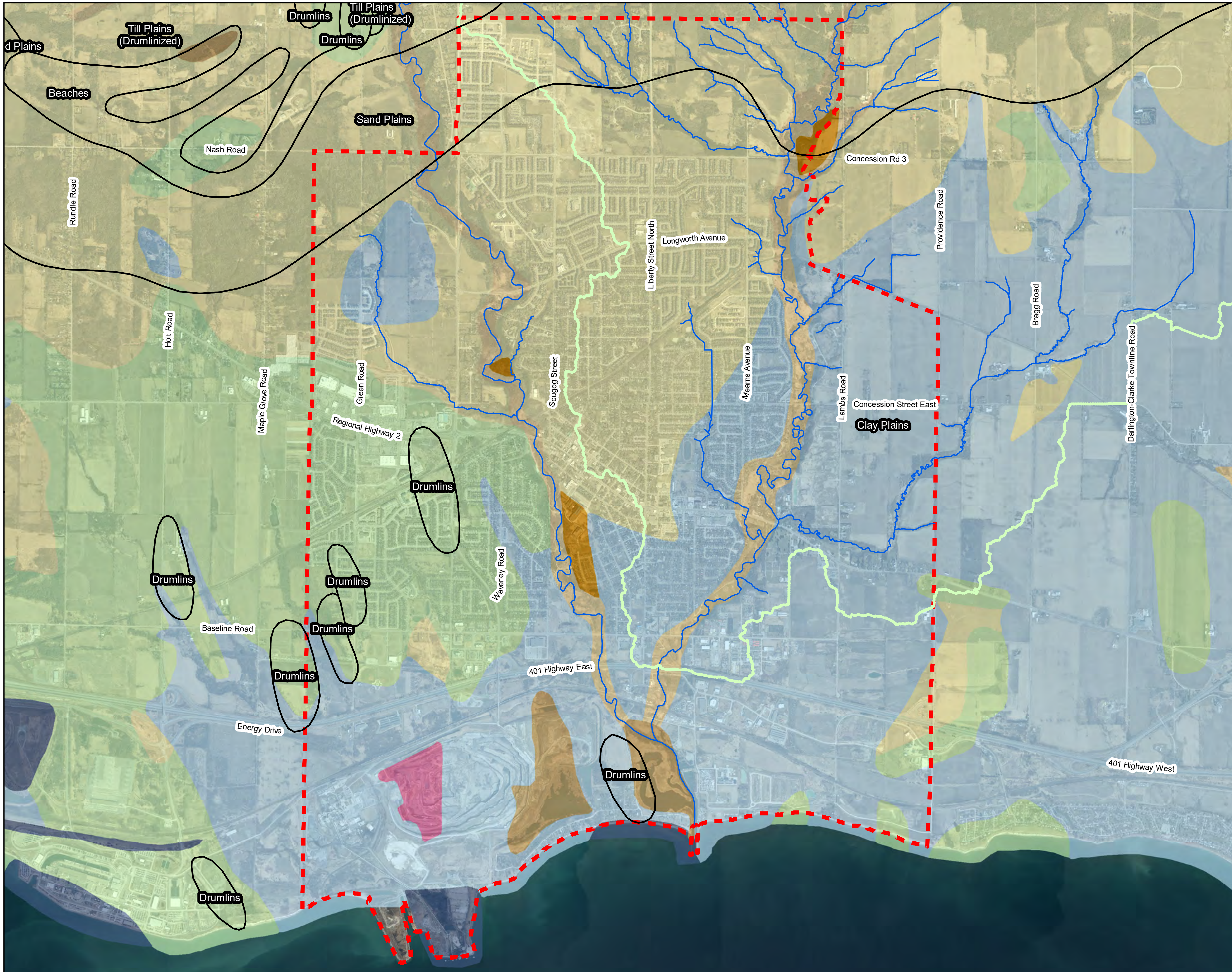
The following is presented in this section:

- Reach delineations and characterizations for Soper Creek including classification of geomorphic stability through use of a Rapid Geomorphic Assessments (RGAs) tool;
- Erosion hazard assessment based on meander belt delineation and identification slope hazard areas requiring geotechnical long-term stable slope setbacks; and
- In-stream restoration opportunities and erosion issues identified during field assessments.

3.2.2.1 Fluvial Geomorphic Setting

Surface Geology and Drainage Network
Like many stream systems in southern Ontario, Soper Creek is incised into the land surface—carved into a landscape of glacial sediments—with most reaches flowing through valley settings defined by slopes on one or both sides of the watercourse. The surface geology of the study area is dominated by glacial till and glacial lake sediments (**Figure 3.36**) that were deposited under and in front of the Late Pleistocene continental ice sheet about 20 thousand years ago (Chapman and Putnam, 1984). Situated south of the Oak Ridges Moraine on a regional-scale slope to Lake Ontario, the surface geology is a patchwork of sandy silt till and lake deposits from the Newmarket and Glacial Lake Iroquois phases of ice history, respectively (Sharpe et al., 2006). The regional slope exhibits some hummocky topography which transitions to drumlinized till features to the north and east. The Soper Creek watershed is bound by the Bowmanville Creek to the west and Wilmot Creek to the east, each with headwaters to the north draining the Oak Ridges Moraine.

Collectively, these characteristics of the glacial surface geology play an important role in dictating the geomorphology and fluvial processes of the stream systems, representing the geologic template upon which the watercourses have evolved over time. Thus, the surface geology has strongly shaped the patterns of stream erosion and valley formation over centuries and millennia, resulting in modern day erosion hazards by stream channels within the floodplains and by hillslopes along the valley sides.



Clarington

Legend

- Watercourse
- Soper Subwatershed Boundary
- Bowmanville / Newcastle Urban Boundary
- Physiography Boundary

Geologic Deposit:

- Fluvial, older alluvium
- Fluvial, recent alluvium
- Glacial till
- Glaciolacustrine, clay and silt
- Glaciolacustrine, sand and gravel
- Lake deposits, sand and gravel
- Organic deposits, wetlands
- Paleozoic bedrock

LOCATOR MAP

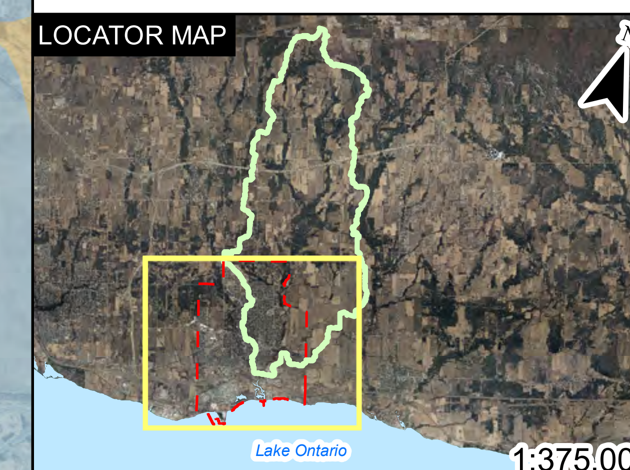


Figure 3.36

Physiography & Surficial Geology

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 375 750 1,500
Meters

Aquafor Beech Limited

3.2.2.2 Fluvial Geomorphic Assessment of Stream Reaches

Aquafor undertook a field-based geomorphic assessment of the Soper Creek Subwatershed in November and December 2019 to confirm existing channel conditions and delineate stream reaches for future subwatershed planning and watercourse management. To complete the fluvial geomorphology assessment, the main channel and primary tributaries within the urban boundary were traversed to assess the existing conditions of each stream reach. Reaches located outside of the urban boundary were not included in the field investigation, and as such will not be covered in detail in the geomorphic assessment (**Figure 3.37**). During the field investigations four main tasks were completed for the fluvial geomorphic assessment:

1. Characterization of channel morphology and sediments, including photographs;
2. Rapid Geomorphic Assessments
3. Measurements of approximate channel dimensions; and
4. Erosion site identification and characterization.

This section summarizes the existing fluvial geomorphology for valley segments, reaches, and sub-reaches of the Soper Creek subwatershed.

Stream Reaches

Geomorphic stream reaches are relatively uniform lengths of channel in terms of surface geology, hydrology, channel slope, boundary materials, and vegetation that control dominant geomorphic processes and sediment transport dynamics. In other words, the physical channel processes and resulting river morphology are relatively consistent over the length of the reach as compared the differences between adjacent reaches. While in practice this requires that reaches be discretely divided by "reach breaks", in reality, reach changes may be abrupt or may transition gradually depending on changes in the controlling variables. For example, contact with bedrock may abruptly confine the channel vertically or horizontally modifying channel processes and thus can represent a distinct reach break. In contrast, a gradual change in the boundary materials (e.g., increasing or decreasing sand supply) would result in a gradual change in channel processes and the mapped reach break would only approximate the location of this transition.

Stream reaches for the Soper Creek subwatershed within the municipal boundary were initially defined using available base mapping data and were subsequently confirmed and refined in the field (**Figure 3.37** and **Figure 3.38**). In addition to first-order reach delineations, several reaches were further subdivided to account for secondary variations in reach characteristics (i.e., sub-reaches). For example, a primary reach break would be located at a major tributary confluence and a secondary reach break might delineate localized land use changes. As well, secondary reach breaks were occasionally placed where a small tributary enters the main branch, but that tributary (under current land use and hydrologic conditions) is not large enough to exert a discernable geomorphic impact on the hydraulics of the main branch. These sub-reaches are denoted with an alphabetic suffix (e.g., Reach R-1A). To summarize the overall physiographic setting of the Soper Creek subwatershed, larger-scale valley segments of multiple reaches are summarized below, with further detail characterizing each of the reaches and sub-reaches presented in **Appendix C**.

Lower Main Branch Reaches

The lower reaches of Soper Creek flow across a glaciolacustrine clay and silt plain within a well-defined valley of recent fluvial alluvium. In their current condition, the lower reaches of Soper Creek are moderately sinuous (1.16 - 1.32), due in part to historic channel realignments that are suspected to have occurred. The surrounding area is largely developed with urban residential and commercial land, and bank protection has been installed in several locations where development has encroached upon the river. The lower reaches receive stormwater inputs from several outfalls discharging to the channel. The main branch comes to a terminus at Bowmanville marsh on Lake Ontario, and the channel is backwatered for approximately 700 meters upstream from this point (Reach 1). Here, the channel is deep with shallow, with flood-prone banks. Continuing upstream into Reach 2, the river enters into a valley setting, where the channel is wide and generally shallow, and large woody debris is infrequent within the channel. The banks through Reach 2 are typically tall and steep—often vertical and showing signs of active erosion. Channel bed material is a mix of sand and gravel, with the banks being primarily organic and silt till. The Soper Creek East Branch joins the main branch north of King Road, where the valley expands and becomes less pronounced, marking the end of the lower main branch reaches.

Middle Main Branch Reaches

The middle reaches extend north from the East Branch to Concession Road 3, and includes Reaches 3B through 6. As Soper Creek passes through the urbanized portion of Bowmanville, the channel shows historical signs of straightening to accommodate development. The watercourse is partially confined through the middle reaches, with occasional valley wall contact. Sinuosity is higher (1.21 – 2.03) comparative to the downstream reaches, particularly in Reach 4. As noted through analysis of aerial photographs and confirmed during the field investigation, abandoned channels and oxbows are common within the floodplain, resulting from historic channel avulsions. The occurrence of large woody debris is moderate, with the exception of reaches 4D and 5A, where the floodplain is largely unforested. Nonetheless, the entirety of the middle main branch exhibits dynamic channel morphology and sediment transport rates of the sand and gravel are estimated to be high. These reaches receive inputs from several tributaries, particularly from the east.

Upper Main Branch Reaches

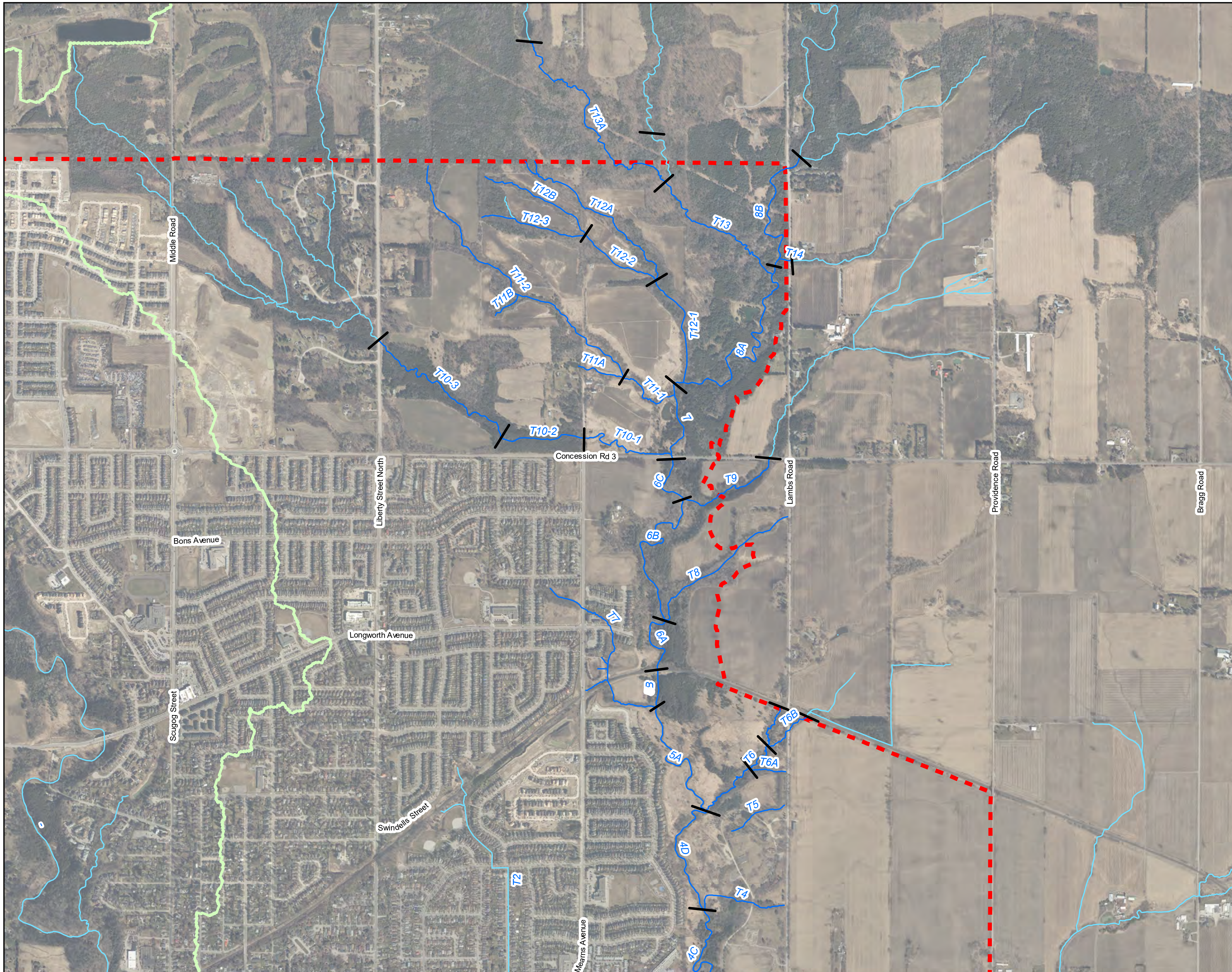
The upper main branch extends from Concession Road 3 north to Lambs Road, and encompasses Reach 7 and 8. This region of the watershed is largely undeveloped and is extensively forested. Soper Creek is generally wide and shallow through the upper reaches, although extensive woody debris causes frequent scour pools and cutoff channels. Boundary material is primarily sand, with dune and ripple bedforms observed, and gravel riffles. Areas of naturally occurring scour frequently expose clay overburden.

Mearns Tributaries Reaches

The Mearns tributaries are a collection of smaller watercourses located to the north of Concession Road 3 and west of the main branch of Soper Creek. These systems have undeveloped catchment areas with wooded riparian valley corridors that are often separated by agricultural upland areas. The Mearns tributaries are typically confined within a valley setting before entering the Soper Creek valley, and valley wall contact is frequent in these segments of the stream system. Stream gradient is generally low, and the smaller of the channels become poorly defined amongst wetland vegetation as they traverse the floodplain of the main branch. The larger systems of the Mearns tributaries (T10 and T13) have moderately high sinuosity with riffle-pool bed morphologies. Channel substrate varies greatly between and within these watercourses, from large cobbles to fine sand and mud.

East Branch Reaches

The East Branch flows across flat glaciolacustrine clay and silt deposits before dropping down into the Soper Creek river valley at its downstream end, where the watercourse is within a confined valley setting. The East Branch catchment is not currently developed and is mainly agriculture lands. Reaches SE-1 and SE-3 have a high sinuosity, while SE-2 is straighter, with aerial photographs suggesting this reach may have historically been straightened as agriculture encroached right up to the channel banks. Beaver activity is noted to have caused avulsions and backwater effects that are felt for several hundred meters upstream. The East Branch generally has a low ratio of channel width to depth, while the channel substrate is comprised mainly of sand and fine gravel, with clay overburden occasionally exposed in deeper sections of the channel.



Clarington

Legend

- Soper Subwatershed Boundary
- Bowmanville / Newcastle Urban Boundary
- Reach Breaks

River Reach Assessed:

- Yes
- No

LOCATOR MAP

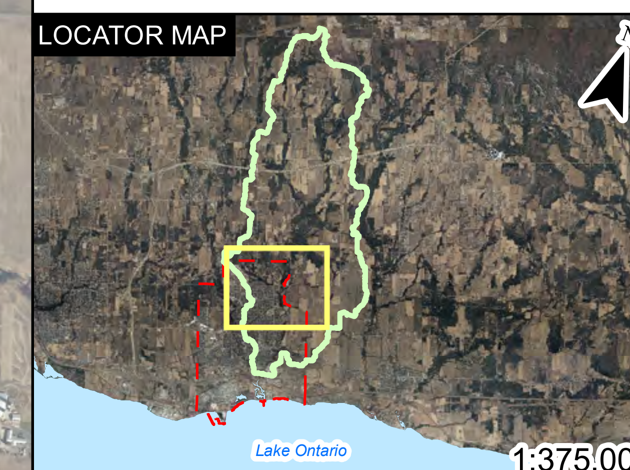


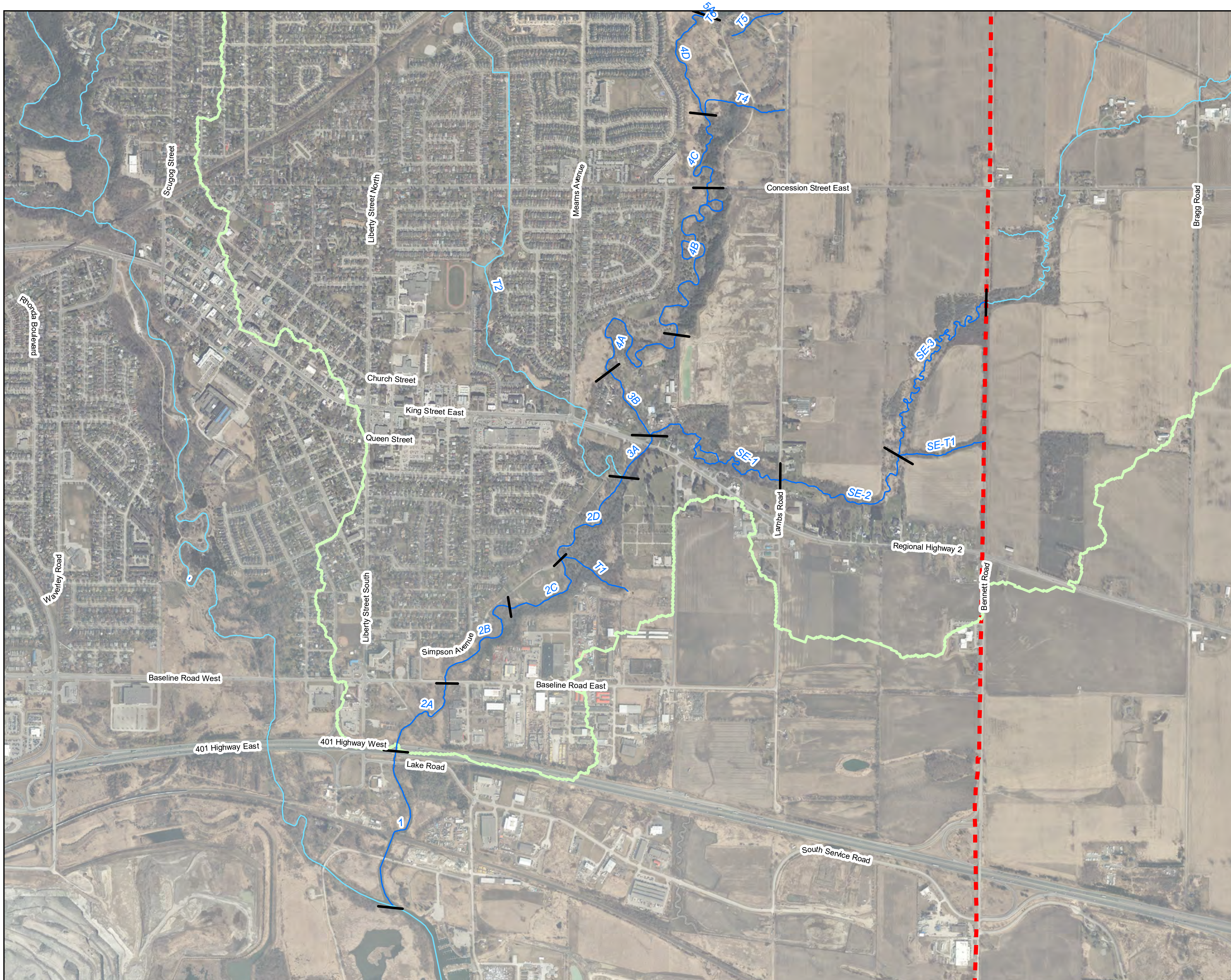
Figure 3.37

Reach Delineation with Reaches Assessed during Erosion Assessment Walks (1 of 2)

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 175 350 700
Meters

Aquafor Beech Limited



Clarington

Legend

- Soper Subwatershed Boundary
- Bowmanville / Newcastle Urban Boundary
- Reach Breaks

River Reach Assessed:

- Yes
- No

LOCATOR MAP

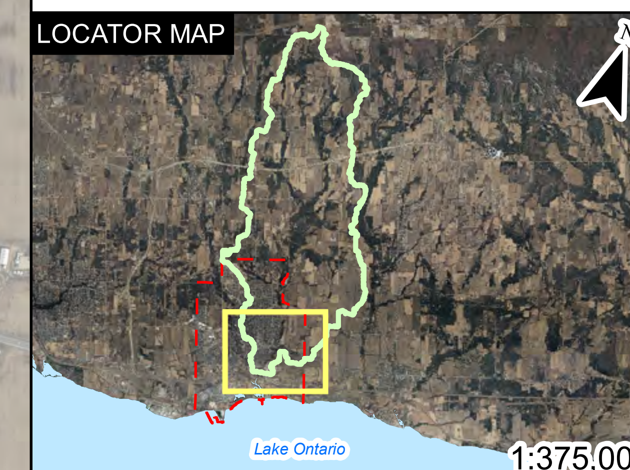


Figure 3.38

Reach Delineation with Reaches Assessed during Erosion Assessment Walks (2 of 2)

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 175 350 700
Meters

Aquafor Beech Limited

3.2.2.3 Historic Assessment

An assessment of historic aerial imagery was completed to gain an understanding of past watershed conditions; particularly how it has been modified and altered to accommodate surrounding urbanization. This analysis is also used to provide insight into historic channel patterns and processes, which can then be used to estimate future erosion and planform development. Aerial images from 1954, 1967, and 2018 were used in the historic assessment. All images have been orthorectified prior to use for the geomorphic analyses.

In 1954, the urban extent of Bowmanville was primarily contained to lands west of Liberty Street, bounded by Concession Rd 3 and Highway 401. The remaining watershed, including the area adjacent to tributaries T2 and T7 was extensively agricultural lands, often abutting right up to the edge of river systems. Since 1954, urban development has extended north and east towards Soper Creek and its tributaries. By 1967 the tributary T2 was subject to development pressure, and more recently tributary T7 has been piped in some areas as residential development has changed the previous channel alignment. The watershed has generally seen an overall increase in riparian buffer since 1954. A selection of site-specific observations is given below.

Comparison of aerial images from 1954 and 2018 (**Figure 3.39**) reveal a large alteration in the planform of the main branch of Soper Creek that has occurred in the years between. Located in Reach 4D near the intersection of Lambs Road and Concession Street, this change may have been due anthropogenic realignment of the watercourse, or a natural avulsion of the channel. Inspection of the aerial image from 1967 (not shown) and the digital terrain model indicate that regrading of the floodplain has occurred where the abandoned channel would have been located.

As residential development within the town of Bowmanville expanded north, the main branch of Soper Creek was hardened along an outside meander bend to constrain the watercourse. **Figure 3.40** illustrates that the area was used as agriculture land in 1967 before later being converted to a residential development. Bank protection has been constructed on the outside meander bend, as confirmed through the field assessment. These comparisons also highlight the extent of planform adjustments the watercourse underwent in the 51-year period between 1967 and 2018.

Figure 3.39: Evidence of Historic Channel Realignment Near Concession St and Lambs Rd.

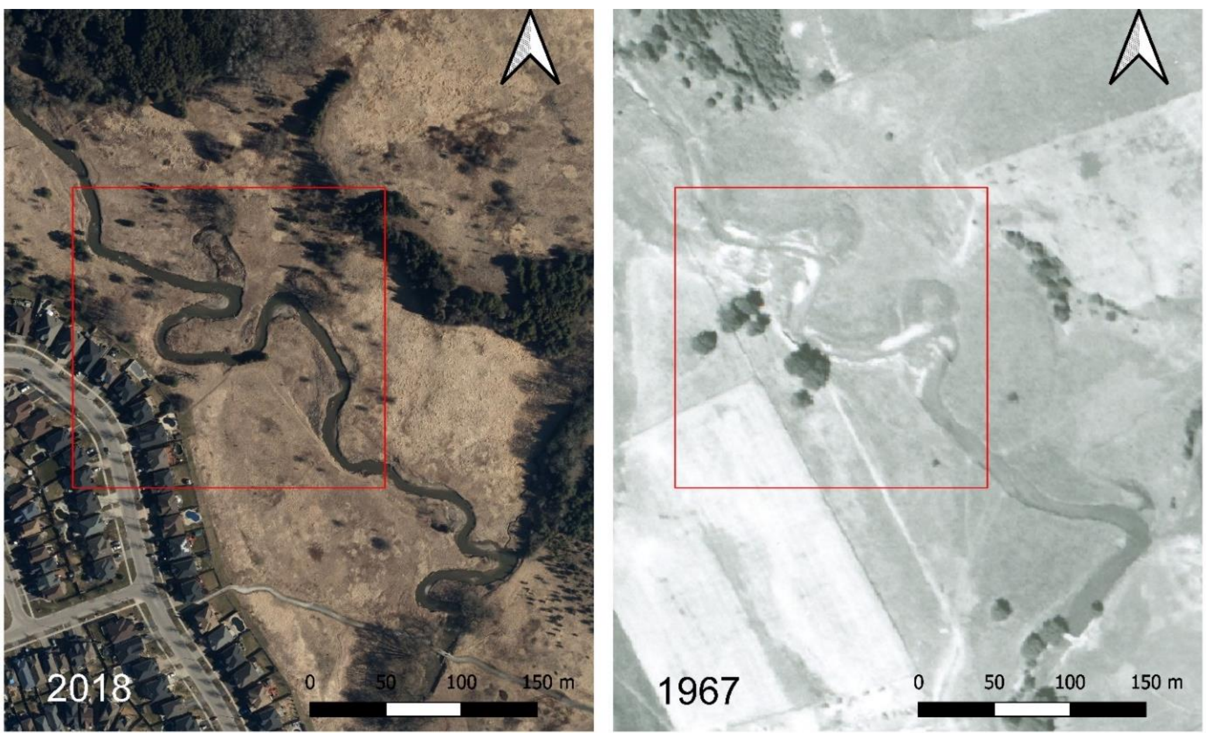


Figure 3.40: Evidence of Channel Hardening to Protect Residential Development

3.2.2.4 Rapid Geomorphic Assessment

As a tool to help evaluate the existing geomorphic conditions within the channel, Rapid Geomorphic Assessments (RGA) (MOE, 1999) were completed for relevant reaches. The RGA protocol uses a series of visual indicators to determine whether a given stream reach is stable or in adjustment based on a percentage score. The RGA procedure is comprised of four different factors that are used to assess channel sensitivity and stability:

1. Evidence of Aggradation (A)
2. Evidence of Degradation (D);
3. Evidence of Channel Widening (W); and
4. Evidence of Planimetric Form Adjustment (P).

Table 3.5 summarizes the stability classifications associated with the RGA index scores and detailed RGA results are provided in **Table 3.6**. Due to intermittent snow coverage during the field works (November and December, 2019), it is conceivable that some geomorphic indicators were obscured from sight and were not factored in to the RGA score. However, field staff put reasonable effort into clearing snow and ice to perform spot checks and to confirm the presence (or lack thereof) of geomorphic indicators and minimize this seasonal limitation.

The RGA method is most appropriate for systems with natural or semi-natural alluvial boundaries that are capable of adjusting to flow changes in water and sediment. Therefore, reaches where the channel was characterized as a drainage ditch or agricultural swale were omitted from the assessment because these types of systems are not capable of adjusting to flow changes in water and sediment. Furthermore, drainage ditches and swales by nature lack many the geomorphic indicators that are used to derive an overall stability score for the reach. For example, drainage ditches are artificially straightened, entrenched, and often cleared of standing and fallen trees. These anthropogenic impacts, acting at unpredictable temporal frequencies, eliminate the possibility of observing a large portion of the geomorphic indicators. Similarly, swales are often vegetation-dominated depressions lacking the alluvial characteristics that are assessed as part of the 34 geomorphic indicators and four process categories. Thus, in both these types of drainage features, the large number of geomorphic indicators that are not applicable (or have been removed) could lead to erroneous conclusions about the stability of the drainage feature.

Table 3.5: Guidelines for the Interpretation of RGA Results and SI Values.

Stability Index (SI) Value	Interpretation	Comment
0 ≤ SI ≤ 0.25	Stable	The morphological features do not show evidence of the progressive alterations. Variance in the dimensions of the morphological features is within acceptable levels
0.25 ≤ SI ≤ 0.4	Transitional	The type and variance of observed morphological features indicates that the stream channel is in, or about to begin, the initial stages of adjustment.
0.4 ≤ SI ≤ 1.0	In Adjustment	The type of morphological features suggests that the channel system has been de-stabilized and is in adjustment.

Results of the RGAs are illustrated in **Figure 3.41** and **Figure 3.42**. All of the assessed reaches in the Soper Creek subwatershed were classified as being transitional, with the dominant adjustment processes varying between reaches as either aggradation or widening. As the study area is largely undeveloped or set back from the watercourse, the “transitional” score is partly attributed to the dynamic nature of the watercourse, in addition to some local human alterations to the channels and the long-term legacy of historic land clearance for agriculture that would have altered the watershed hydrology.

Within the Soper Creek subwatershed, woody debris and non-cohesive bank material are the primary drivers behind channel widening. Channel widening is a source of sediment supply to the channel, which is transported downstream where it is selectively deposited. Correspondingly, aggradation was frequently observed as a dominant geomorphic process. Evidence of planform adjustment was observed most frequently within Reach 4, as well as all reaches within the East Branch. Degradation was not widely observed, which has been attributed to: A) the valley system maintaining an adequate supply of sediment; and B) the discrepancy between the relatively resistant bed materials to the non-cohesive bank materials. Local exposures of the underlying glacial sediments were generally limited to where channels were overdeepened by scour (e.g., around large woody debris) or where the channels impinged along the valley walls.

Table 3.6: Rapid Geomorphic Assessment Scores

Reach	Valley Segment	RGA Process Scores†				Stability Index Value
		A	D	W	P	
2	**Lower Main Branch**	0.43	0.15	**0.44**	0.21	0.31
3		0.22	0.25	**0.65**	0.14	0.32
4	**Middle Main Branch**	**0.57**	0.20	0.45	0.29	0.38
5		**0.43**	0.14	0.35	0.00	0.23
6		**0.57**	0.20	0.56	0.14	0.37
7	**Upper Main Branch**	**0.57**	0.30	0.35	0.00	0.31
8		**0.57**	0.20	0.45	0.19	0.35
SE-1	**East Branch**	**0.50**	0.35	0.44	0.29	0.40
SE-2		0.36	0.10	**0.56**	0.29	0.32
SE-3		0.29	0.20	**0.56**	0.33	0.34
T6	**Mearns Tributaries**	0.29	0.10	**0.44**	0.00	0.21
T10-1		0.29	0.23	**0.36**	0.00	0.22
T10-2		0.43	0.10	**0.44**	0.14	0.28
T10-3		0.44	0.00	**0.45**	0.29	0.29
T13		**0.71**	0.20	0.33	0.07	0.33

† A = Aggradation; D = Degradation; W = Widening; P = Planform Adjustment

Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Reach Breaks

RGA Process:

- W = Widening
- A = Aggradation
- RGA Not Assessed
- River Reach Not Assessed

RGA Condition:
All assessed reaches are classified as transitional

LOCATOR MAP

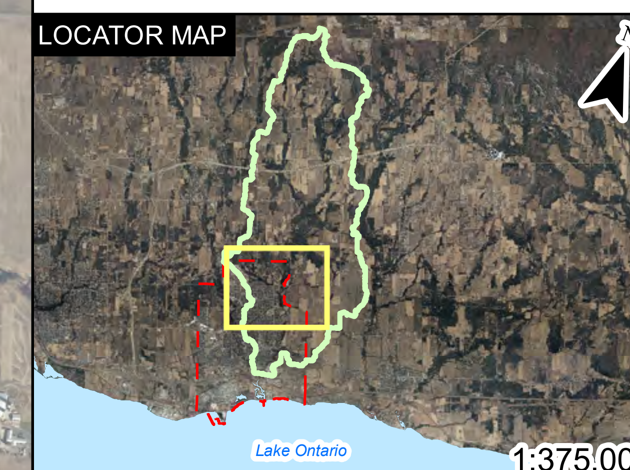


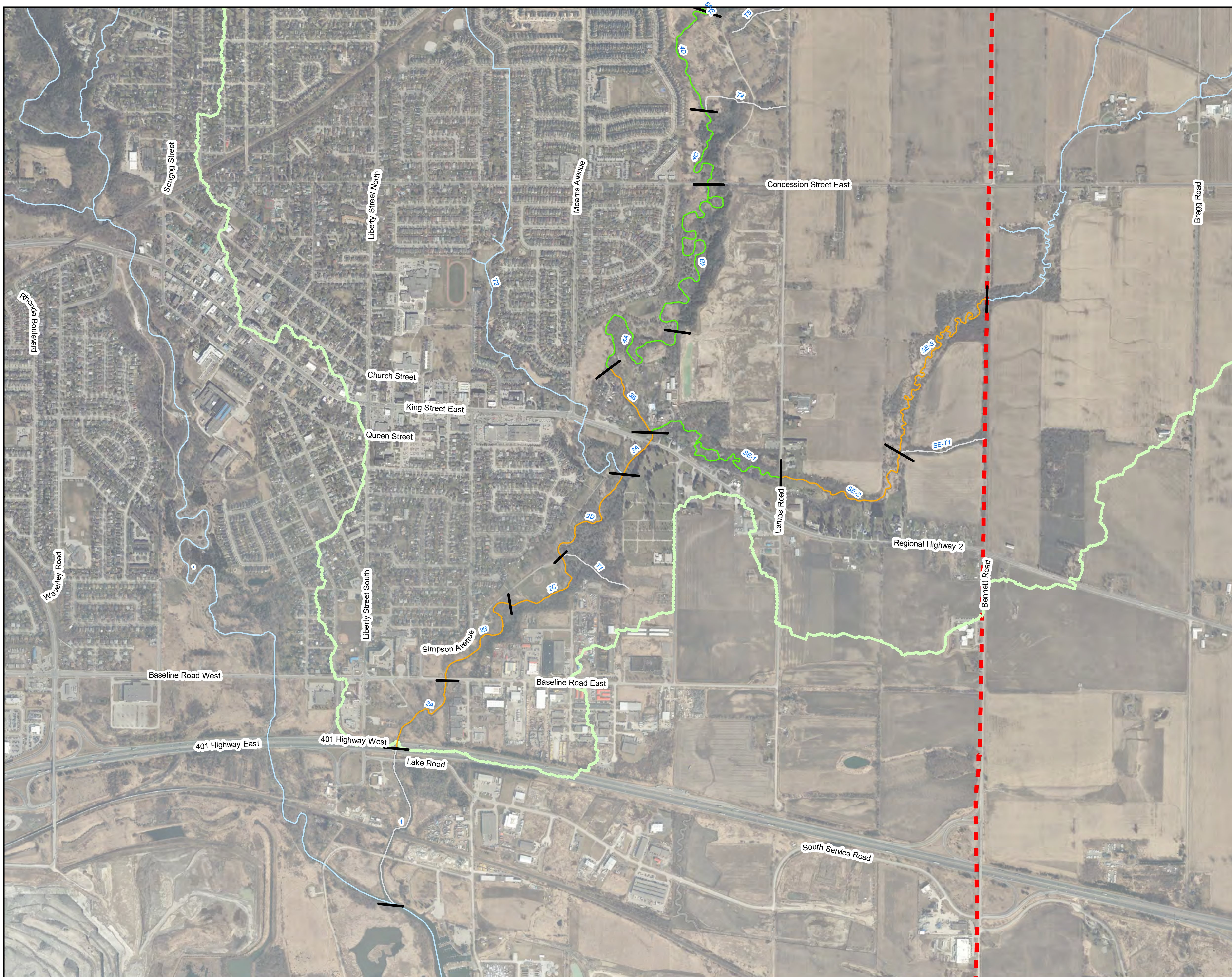
Figure 3.41

Dominant Geomorphic Adjustment Processes (Based on RGA Results) For Northern Study Area

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 200 400 800
Meters

Aquafor Beech Limited



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Reach Breaks

RGA Process:

- W = Widening
- A = Aggradation
- RGA Not Assessed
- River Reach Not Assessed

RGA Condition:
All assessed reaches are classified as transitional

LOCATOR MAP

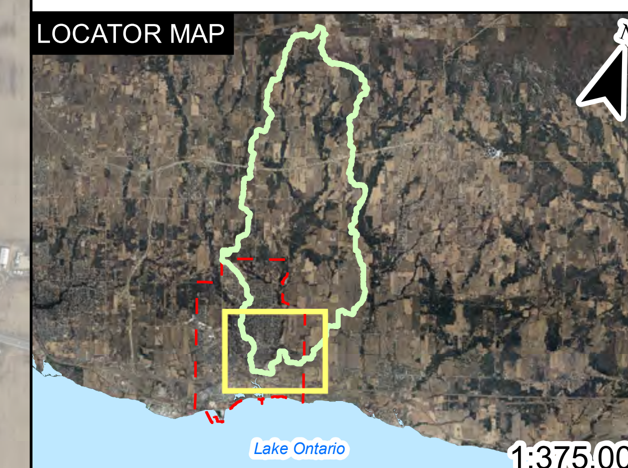


Figure 3.42

Dominant Geomorphic Adjustment Processes (Based on RGA Results) For Southern Study Area

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 200 400 800
Meters

Aquafor Beech Limited

3.2.2.5 Erosion Hazard Assessment

It is now recognized that sustainable long-term management strategies for watercourses should allow for natural fluvial processes to occur within an erodible corridor—a geomorphic hazard zone (Piégay et al., 2005). Also proposed as 'Freedom Space', there are long-term ecological, economic, and social benefits to allowing rivers and streams enough space to adjust within a natural corridor (Biron et al., 2014; Buffin-Bélanger et al., 2015).

Geomorphic erosion hazards for single-channel, perennial streams and rivers are typically evaluated as the corridor width of the "meander belt" plus a century-scale erosion allowance (TRCA, 2004), as well as the long-term stable slope limit plus access allowances in confined valley settings. The degree to which a channel will meander—through fluvial processes of lateral migration and avulsion—depends upon the channel's hydrological flow regime and environment controls such as geology and vegetation. A meander belt can be a useful conceptual tool for planning around watercourses, but the concept has fundamental limitations for representing geomorphic erosion hazards around headwaters and low-order streams (e.g., 1st and 2nd order). In ephemeral and intermittent headwaters, natural fluvial processes are complicated by poorly defined channels and seasonally vegetated channel boundaries. While natural headwaters may wind back-and-forth to some degree, the processes of lateral channel movement are different from meandering processes in perennial streams and rivers. Still, headwater channels will naturally exhibit some degree of lateral expression within a geomorphically active corridor. For historically straightened channels, the ultimate lateral "migration" zone might be re-attained if given enough time to recover (i.e., natural channels are rarely straight).

The Soper Creek subwatershed contains a diverse mix of confined, partially-confined, and unconfined reaches, as described in **Section 3.2.2.1**. This necessitates that the erosion hazard corridor be delineated through a combination of meander belt assessment and geotechnical stable slope hazard assessment, where locally appropriate. In order to inform the determination of erosion hazard limits, a meander belt assessment was undertaken. Areas requiring geotechnical stable slope hazard assessment were also identified. The following sections outline the methodology of each technique, with the overall erosion hazard lines consisting of both the meander belt and priority stable slope hazard areas mapped in **Figure 3.44**.

Meander Belt Delineation

Meander belt widths were estimated using Procedure 3 from the TRCA Belt Width Delineation Protocol (2004). Procedure 3 (Change in Hydrologic Regime – Flow Duration and Frequency) is recommended for use when the area will be experiencing changes to land use/cover.

The meander belt axis and preliminary belt width were delineated with reference to the CLOCA watercourse centerlines, which were modified to better reflect current channel alignments based on orthorectified aerial imagery from 2018 (and the digital terrain model), provided by CLOCA. Conventional methods for estimating meander belt width—including historic analysis, reference reaches, and empirical relationships—are not appropriate for headwaters and small watercourses draining less than 1-2 km^2. Howett (2017) is an up-to-date reference on the limitations of meander belt delineation in Ontario. Headwater reaches lacking a defined channel were assigned a minimum final meander belt width of 30 m was to account for the potential corridor erosion hazards. More detailed studies of specific reaches are not expected to provide final belt widths below the minimum 30 m considering the scientific uncertainty in extrapolating the conventional methods into headwater reaches. Development applications seeking to refine the preliminary meander belt below 30 m are recommended to undergo a thorough, scientific peer-review process.

The existing belt width was then calculated according to the TRCA Belt Width Delineation Protocol (2004) using:

$$Existing\ Belt\ Width = B + C$$

Where B is the Preliminary Belt Width, and C is the average bankfull channel width. Bankfull channel width was measured in the field for reaches assessed during field studies. For reaches not assessed in field studies, bankfull width was conservatively estimated from aerial images.

A 100-year erosion allowance (i.e., factor of safety) was added to calculate the final belt width using the following equation from the TRCA Belt Width Delineation Protocol (2004):

$$Final\ Belt\ Width = Existing\ Belt\ Width * 1.20$$

Use of a factor of safety for the erosion allowance is necessary to account for the fact that the meander belt may not represent a quasi-equilibrium form, especially in consideration of future development that may occur within the watershed. TRCA Procedure 3 advises a 20% factor of safety be applied where there is an expected change to flow duration and frequency. The suitability of a 20% factor of safety was indirectly assessed through desktop and field-based methods. Results from the RGA (rapid geomorphic assessment) provide insight into the sensitivity of a given river reach to alterations in the sediment-flow regime. All reaches were determined to be in transition, which indicates a moderately stable channel that would have limited ability to absorb alterations to upstream land use. Therefore, the RGA results support the 20% factor of safety. To further confirm its applicability, a comparison of historic aerial imagery was performed to calculate approximate rates of lateral migration (i.e., bank erosion), which were extrapolated to 100-year erosion rates. While the error associated with air photo orthorectification limits the accuracy of erosion rate calculations, the derived values are high enough to support the application of a 20% factor of safety. Migration rates were calculated at six locations on the outside of meander bends along main branch of Soper Creek using the 1967 air photo acquisition. The 1654 air photo was not used due to its low resolution, which confounds the accurate positioning of the watercourse. The average migration rate across the six locations was calculated to be 0.15 m/yr, with the highest observed rate calculated to be as high as 0.37 m/yr. Accordingly, this factor of safety is considered appropriate as a century-scale erosion allowance to delineate a conservative belt width that accounts for potential alterations to the flow duration and frequency.

The results of the meander belt delineation are summarized in **Table 3.7** and illustrated in **Figure 3.44**. Under future development conditions, these erodible corridors (i.e., meander belts) are to remain as low-lying floodplain areas adjacent to the watercourse and are not to include side-slopes associated with development regrading (i.e., side slopes do not count in the meander belt width). It should be noted that the final belt widths account for a century-scale erosion allowance (factor of safety), but do not include a stable slope assessment, which has been evaluated separately.

Table 3.7: Meander Belt Delineation

Channel Reach	Preliminary Belt Width (m)	Bankfull Width (m)	Existing Belt Width (m)	Final Belt Width†† (m)	Slope Hazard Present
1	100	15†	215	258	No
2A-D	65	12	142	170	Yes
3A-B	90	13	193	232	Yes
4A	110	9	229	275	Yes
4B-D	70	9	149	179	Yes
5A	55	9	119	143	Yes
5B	55	9†	119	143	No
6A-B	51	9	111	133	Yes
6C	51	9	111	133	No
7	51	11	113	136	Yes
8A	50	9	109	131	Yes
8B	50	9	109	131	No
SE-1	21	5	47	56	Yes
SE-2	17.5	5	40	48	Yes
SE-3	30	5	65	78	Yes
T1	15	2	32	38	Yes
T4	15	2	32	38	Yes
T5	-	-	-	30	No
6-1	17.5	2	37	44	Yes
6-2	15	2	32	38	Yes
T6A	15	2	32	38	Yes
T6B	-	-	-	30	Yes
T8	-	-	-	30	Yes
T9	15	2	32	38	No
T10-1	30	4	64	77	Yes
T10-2	25	4	54	65	Yes

Channel Reach	Preliminary Belt Width (m)	Bankfull Width (m)	Existing Belt Width (m)	Final Belt Width†† (m)	Slope Hazard Present
T10-3	20	4	44	53	Yes
T11-1	15	2	32	38	Yes
T11-2	15	2	32	38	No
T11A	-	-	-	30	Yes
T11B	-	-	-	30	No
T12-1	17.5	2	37	44	Yes
T12-2	15	2	32	38	No
T12-3	-	2	-	30	No
T12A	15	2	32	38	No
T12B	-	-	-	30	No
T13-1	17.5	4	39	47	Yes
T13-2	17.5	4	39	47	No
T13A	17	5	39	47	Yes

Note: † Bankfull width was estimated from aerial imagery
†† Includes erosion allowance of existing belt width x 1.20

Erosion Hazard Long-Term Stable Slope Allowance
While the erosion hazards for unconfined systems can be defined based on meander belt delineation or similar techniques, confined systems require that a different methodology be applied to define erosion hazards, potentially having to integrate fluvial erosion with geotechnical assessments for some combination of unconfined, confined, or partially confined reaches. As defined by MNR (2002), confined stream systems are characterized by the physical barriers of valley walls that limit the lateral movement of fluvial channels within the valley bottom. The location of the river or stream channel may be at the base of the valley slope, in close proximity to the valley slope (i.e., within 15 m) or removed from the valley slope (i.e., a distance greater than 15 m). It should be noted the generic 15 m criteria to distinguish confined and unconfined reaches is based on provincial guidelines (MNR, 2002), but in theory the actual distance should vary by channel size and stability. Detailed erosion hazard assessments are needed to characterize site conditions on a reach basis to confirm where confined reaches require geotechnical slope stability assessments—priority areas are identified in the next section. Site-specific geotechnical and slope stability analysis will need to be undertaken with each development application. Erosion hazard limits for confined stream systems are to include a stable slope allowance that accounts for future channel erosion, long-term stable slope formation, and an erosion access allowance (or other factor of safety). The relative definitions for confined and unconfined erosion hazards from MNR (2002) are provided in **Figure 3.43**.

Specifically around confined and partially confined valley systems, the long term stable slope crest (LTSSC) is a component of the erosion hazards assessment required to determine development setbacks and constraints (MNR, 2002). Conservative estimates of the LTSSC may be delineated as part of the Subwatershed Study planning stage using generic provincial guidelines (MNR, 2002), but ultimately the LTSS is to be confirmed and/or refined with detailed geotechnical studies, typically including detailed topographic surveys and borehole investigations in the field. Site specific geotechnical analysis will be need to be undertaken with each development application. For slope hazard areas where the LTSSC is assessed, the erosion hazard limit will be required to include a “toe erosion allowance” associated with the creek channel and a “erosion access allowance” beyond the top of slope (**Figure 3.43**).

Priority stable slope hazard areas have been identified in addition to the meander belt assessment in **Figure 3.44**. These areas represent provisional assessments of the LTSSC hazards for confined and partially confined reaches where the channel is within 15 m of the toe of the valley slope for embankments with slopes steeper than 15% and heights greater than 3 metres (MNR, 2002). The generalized delineation of the priority stable slope hazard areas is based addition of the following setbacks as illustrated in **Figure 3.43**:

- Toe erosion allowance – 15 metres offset from the channel bank;
- Stable slope allowance – 3-horizontal to 1-vertical for slope height of 3-12 metres;
    - Range of 9 to 36 m for study area;
- Erosion access allowance – 6 metre offset from the LTSSC; and

Total stable slope hazard allowance – 30 to 57 m offset from channel bank

Ultimately, detailed geotechnical studies for each development application are necessary to delineate the final erosion hazard limit around confined valley systems where the LTSSC component is required. The results of those studies may also be used to confirm or refine the boundaries of Valleylands designations under municipal policy, as appropriate. For constraint mapping developed for this Subwatershed Study (see **Section 4.1**), the erosion hazard limit is the greater of the meander belt and priority stable slope hazard lines, and the limits of valleylands have been based on existing LTSSC information. These mapped constraint boundaries may be modified based on the results of site-specific studies.

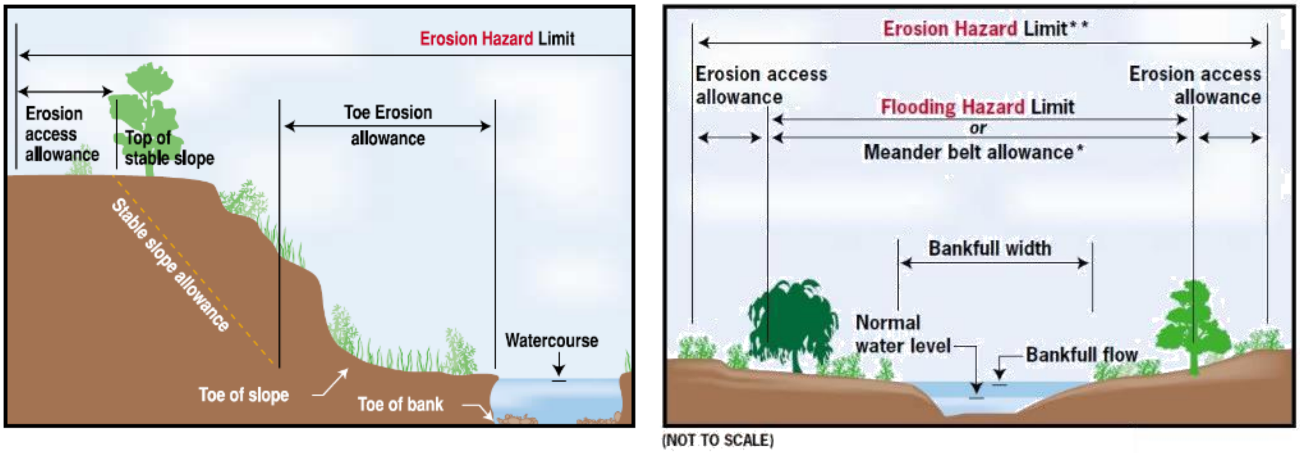
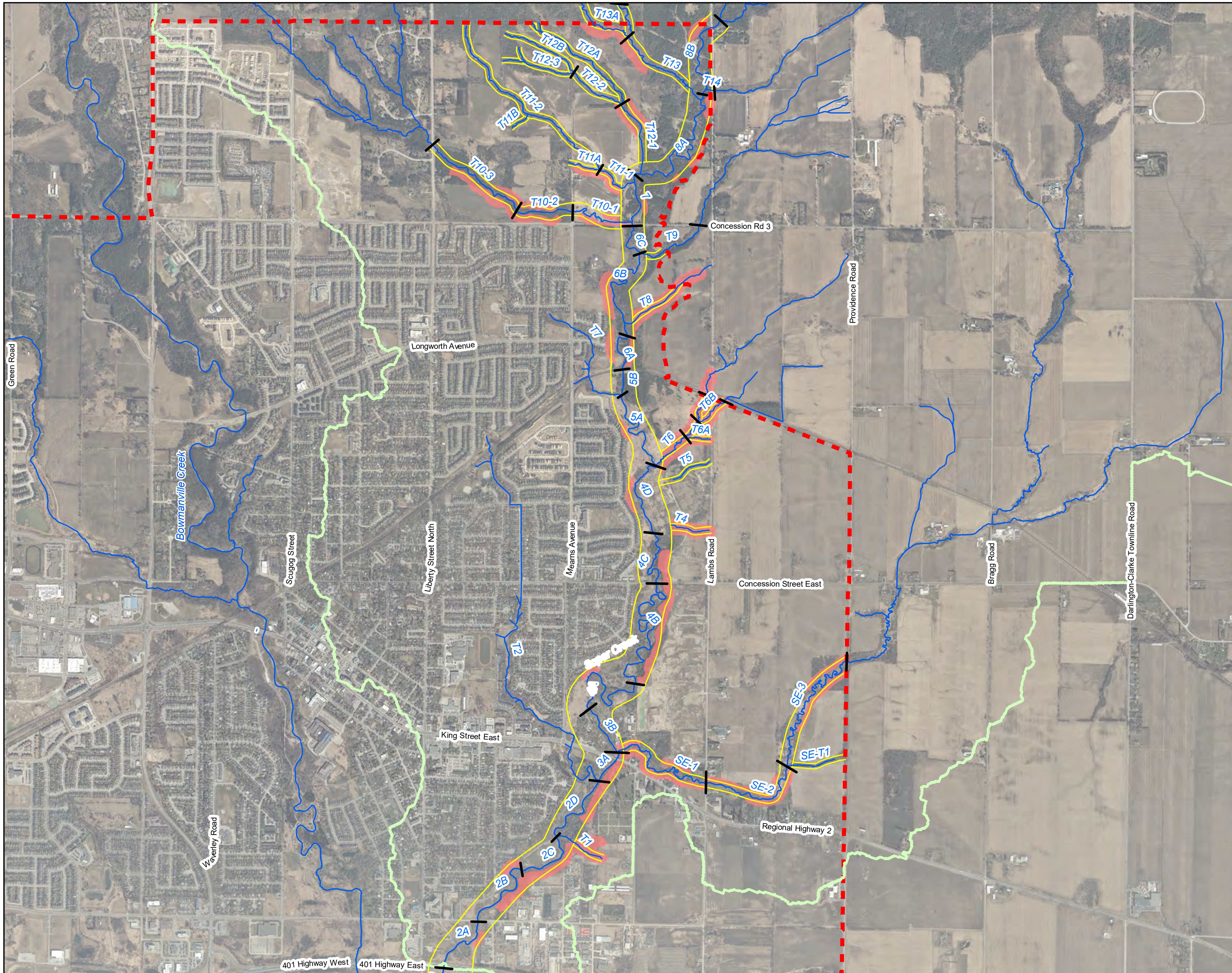


Figure 3.43 Erosion Hazard Limit in Confined System (left) where Toe of Valley Slope is < 15m from Watercourse (MNR, 2002); Compared to Erosion Hazard Limit for Unconfined System (right).



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Priority Slope Hazard Areas (for LTSSC geotechincal assessment)
- Meander Belt Width (including partially confined reaches)
- Watercourse
- Reach Breaks

LOCATOR MAP

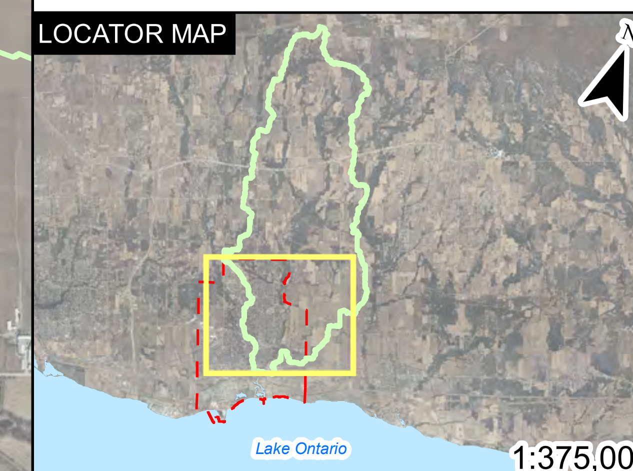


Figure 3-44

Erosion Hazards – Meander Belt and Stable Slope Combined

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 250 500 1,000
Meters

Aquafor Beech Limited

3.2.2.6 Erosion Sites and Maintenance Issues

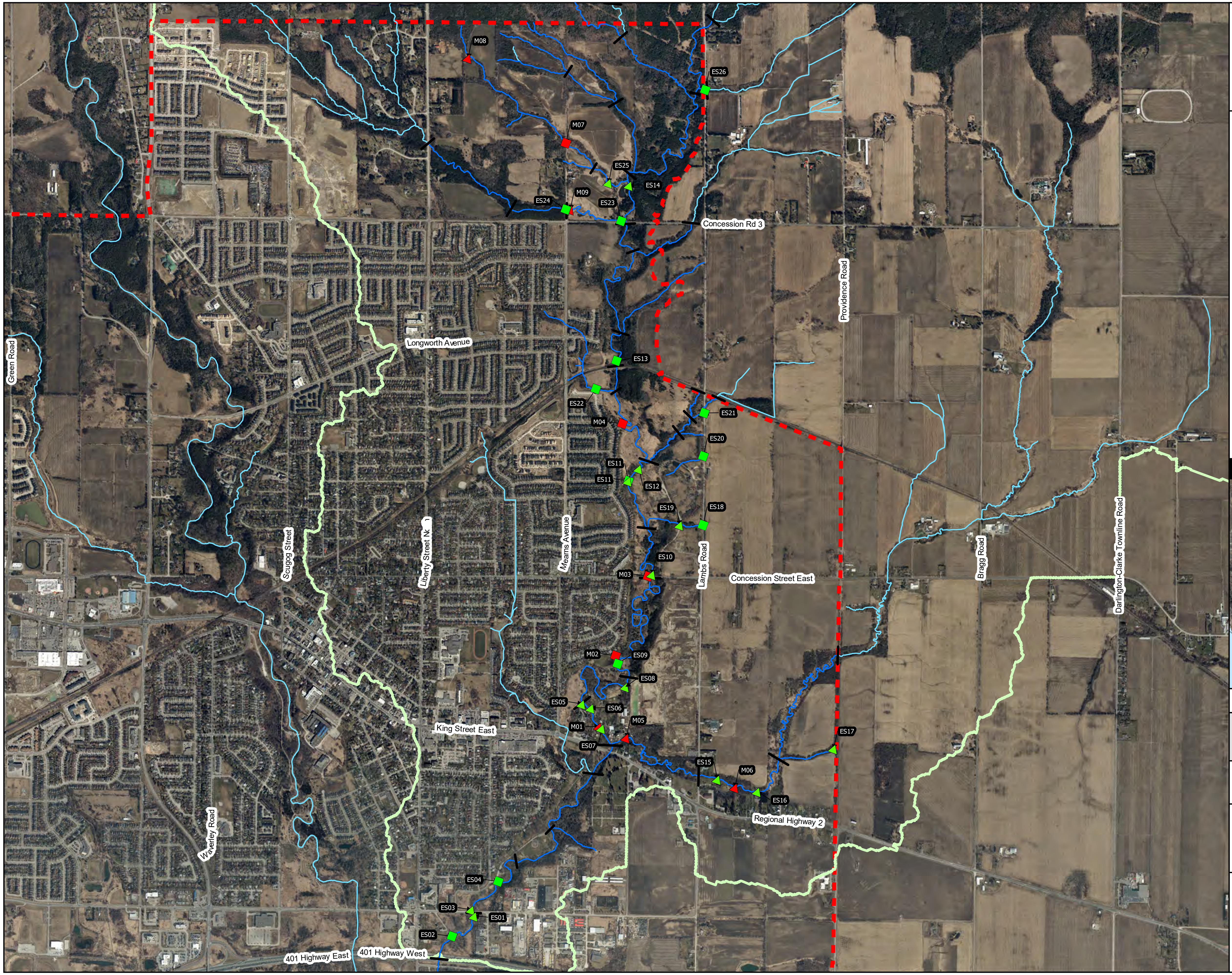
Erosion sites and maintenance issues were identified on both public and private property during the field-based geomorphic assessment (**Figure 3.45**), with the purpose of identifying erosion mitigation, in-stream restoration, and infrastructure maintenance opportunities. Erosion sites (ES) were identified as locations with potential erosional issues that might pose a risk to surrounding infrastructure or public health and could require mitigative measures. High level in-stream restoration opportunities were identified for each erosion site, as discussed further in **4.1.3.**

Twenty-six (26) erosion sites were identified, as summarized in **Table 3.8** below and illustrated in **Figure 3.45**. Five (5) erosion sites on public property have been highlighted as higher priority, as they impart greater risk to public infrastructure and/or public health and safety. Further detail is provided for each erosion site in **Appendix Q**.

Table 3.8: Soper Creek Erosion Sites. Higher Priority Public Erosion Sites are Highlighted.

Erosion Site	Channel Reach	Property Ownership	Description of Issue
ES01	2A	Private	Bank is eroding towards private property.
ES02	2A	Public	Bridge imparts constriction on channel corridor.
ES03	2B	Private	Embankment is eroding towards fence at top of slope.
ES04	2B	Public	Bank is eroding towards public park lands.
ES05	3B	Private	Undercut tree at risk of falling is posing risk to adjacent fence and building.
ES06	3B	Private	Fence running along eroding channel bank is falling towards the creek.
ES07	3B	Private	Bank is eroding towards fence. Outfall is becoming undercut.
ES08	4A	Private	Outer channel bank is eroding towards fence.
ES09	4B	Public	Weir at outlet of stormwater outfall channel is outflanked.
ES10	4C	Public & Private	Bank erosion poses long term risk to natural gas line and road. Runoff flows overland from roadside ditch to creek, causing eroding headcut.
ES11	4D	Public & Private	Slope is failing and old abutment is outflanked.
ES12	4D	Private	Old dam poses potential passage barrier to small fish.
ES13	6A	Public	Bank erosion upstream of railway culvert poses long term risk to bank hardening at culvert.

Erosion Site	Channel Reach	Property Ownership	Description of Issue
ES14	7	Private	Grade control structure is causing potential fish passage barrier.
ES15	SE-2	Private	Lack of vegetation along southern channel bank may increase rates of bank erosion.
ES16	SE-2	Private	Old weir structure imparts channel constriction.
ES17	SE-T1	Private	Channel crossing structure is perched and deteriorating.
ES18	T4	Public	Culvert is perched.
ES19	T4	Private	Concrete culvert under private drive crossing is damaged.
ES20	T5	Public	Ditch is eroding towards road on both sides of road.
ES21	T6B	Public	Culvert is perched and car tire is wedged into inlet. Channel approaches culvert at sharp angle.
ES22	T7	Public	Channel crossing imparts constriction on channel corridor.
ES23	T10-1	Public	Bank erosion is posing risk to guardrail and road.
ES24	T10-2	Public	Road embankment is failing, culvert inlet is outflanked.
ES25	T11-1	Private	Channel is confined to small culvert.
ES26	T14	Public	Culvert is perched.



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Reach Breaks

River Reach Assessed:

- Yes
- No

Maintenance Issue Ownership:

- Private
- Public

Erosion Site Ownership:

- Private
- Public

LOCATOR MAP

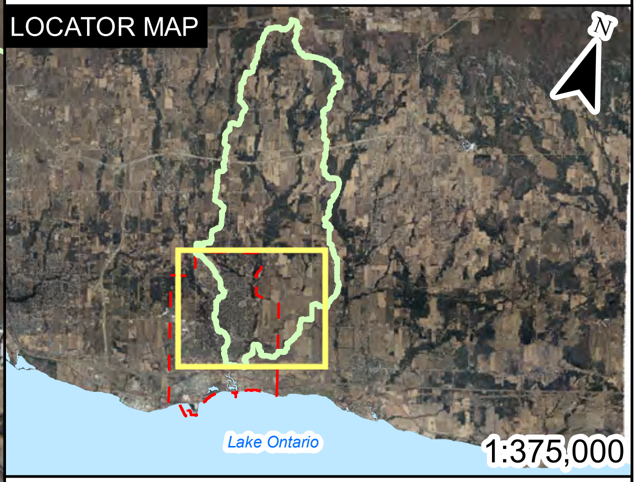


Figure 3.45

Erosion Sites & Maintenance Issues

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 250 500 1,000
Meters
N

Aquafor Beech Limited

Maintenance issues (MI) were identified as localized structural failures or disrepairs. The maintenance issues differ from the erosion sites in that the effects of the maintenance sites were very localized and/or associated with municipal infrastructure typically included within regular operations and maintenance responsibilities. Nine (9) maintenance issues were identified, as summarized in **Table 3.9** below and illustrated in **Figure 3.45**. Further detail is provided for each maintenance issue in **Appendix Q**.

Table 3.9: Maintenance Issues on Soper Creek

Maintenance Issue	Channel Reach	Ownership	Description of Issue	Maintenance Works
M01	3B	Private	Private bridge abutment is undercut and embankments are eroding.	Embankment protection works and abutment maintenance.
M02	4B	Public	Fallen trees on top of stormwater outfall.	Remove fallen trees.
M03	4C	Public	Minor outflanking of bridge abutment.	Maintenance of embankment protection works (stone application).
M04	5A	Public	Upstream edge of crib wall is beginning to be outflanked.	Minor bank protection works at crib wall tie in.
M05	SE-1	Private	Crossing structure is eroding.	Crossing repair works.
M06	SE-2	Private	Private crossing is damaged.	Remove, repair, or replace structure.
M07	T10-1	Private	Fence crossing channel is slumped and causing debris jams.	Remove fence if possible, otherwise repair and remove debris.
M08	T11-2	Public	Culvert inlet is embedded.	Culvert maintenance works.
M09	T11-2	Private	Culvert is completely embedded with major ponding and road overtopping.	Culvert maintenance works.

3.2.2.7 Conclusions

Based on the above geomorphic assessment, key items related to future development constraints and opportunities are summarized below:

- Assessed reaches throughout the Soper Creek subwatershed were determined to be in a transitional state of geomorphic stability. In order to protect against increased rates of erosion, and thus unstable channel adjustments, stormwater management facilities—including LIDs—will be a necessary part of future development to prevent increased peak flow rates and increased durations of critical discharge exceedance.

- The geomorphic erosion hazards have been assessed based on the combination of meander belt and long-term stable slope hazards. The erosion hazard limit is the greater of the meander belt and the long-term stable slope hazard.
    - Meander belt delineation identifies an erodible corridor in which natural fluvial processes may occur over a 100-year period. The meander belt also represents an erosion hazard zone. Final meander belts were delineated for Soper Creek and include a century-scale erosion allowance. Under future development conditions, these erodible corridors are to remain as low-lying floodplain areas adjacent to the watercourse.
    - The long-term stable slope is a component of the erosion hazards assessment required to determine development setbacks and constraints, specifically around confined valley systems. Priority stable slope hazard areas have been identified as provisional assessments of the Long-term Stable Slope Crest (LTSSC) setbacks for confined and partially confined reaches. Final stable slope hazard setbacks should be confirmed based on detailed geotechnical field investigations after completion of the Subwatershed Study.
- Within the Soper Creek subwatershed, stream erosion and maintenance sites have been identified, including high priority sites within public property. The erosion sites identified represent opportunities to mitigate historic impacts and/or restore stream forms and functions from both geomorphological and ecological perspectives, including local reestablishment of riparian buffers and removal of invasive species within riparian corridor.

3.2.3 Hydrology & Hydraulics

Hydrology is the science which deals with the interaction of water and land. Hydrology focuses on the processes by which precipitation is transformed into runoff to the receiving watercourses, returned to the atmosphere via evapotranspiration, or infiltrated into the shallow and deep groundwater systems. One of the most dramatic changes brought about by urbanization is the change in stream hydrology. For example, the replacement of vegetation and undisturbed terrain with impermeable surfaces (i.e., pavement and roof tops), landscapes graded for rapid drainage and the construction of an underground storm drainage network results in the greater interception of water that would naturally infiltrate into the ground and instead provides a direct and rapid transport of surface runoff to streams. As a result, groundwater recharge diminishes, which in turn could potentially affect baseflows within streams which rely on groundwater discharge. A more rapid rate of stormwater runoff from rainfall and melt events can result in an increase in the total volume, peak flow, and frequency of runoff occurrences. Uncontrolled, these hydrologic changes can result in increases in flooding, channel erosion, sediment transport, and pollutant loadings. These changes can also cause deterioration in natural channel morphology, fish and wildlife habitats, recreational opportunity and aesthetics. It is important that the existing hydrologic characteristics of the study area and its watercourses be established. This information is critical in defining existing flood characteristics, defining regulatory floodplain limits, and providing key information on the selection and design of stormwater management facilities for future urban development lands.

River hydraulics is the science of flow conveyance through a channel system. Hydraulic analysis uses the runoff output from hydrologic models along with channel and floodplain characteristics including river crossing details to establish flood elevations for specific return period events. The primary function of a floodplain is the conveyance of flood waters during extreme runoff events resulting from intense precipitation events and extreme spring melts. The results of a hydraulic analysis are dependent upon the shape and slope of the channel and associated floodplain, the flow rate and the location of structures (buildings, roads, etc.). Central Lake Ontario Conservation Authority (CLOCA) regulates development applications within flood-susceptible areas such as the floodplains of watercourse systems.

3.2.3.1 Soper Creek Subwatershed Hydrology

Soper Creek is made up of four (4) constituent subwatersheds, each with unique hydrologic characteristics. These constituent subwatersheds are identified in **Figure 3.49**. Considerable hydrologic analysis was undertaken to characterize these subwatersheds through the 2011 Bowmanville/Soper Creek Watershed Existing Conditions Report. A summary of each constituent subwatersheds based on data from the 2011 study is provided below.

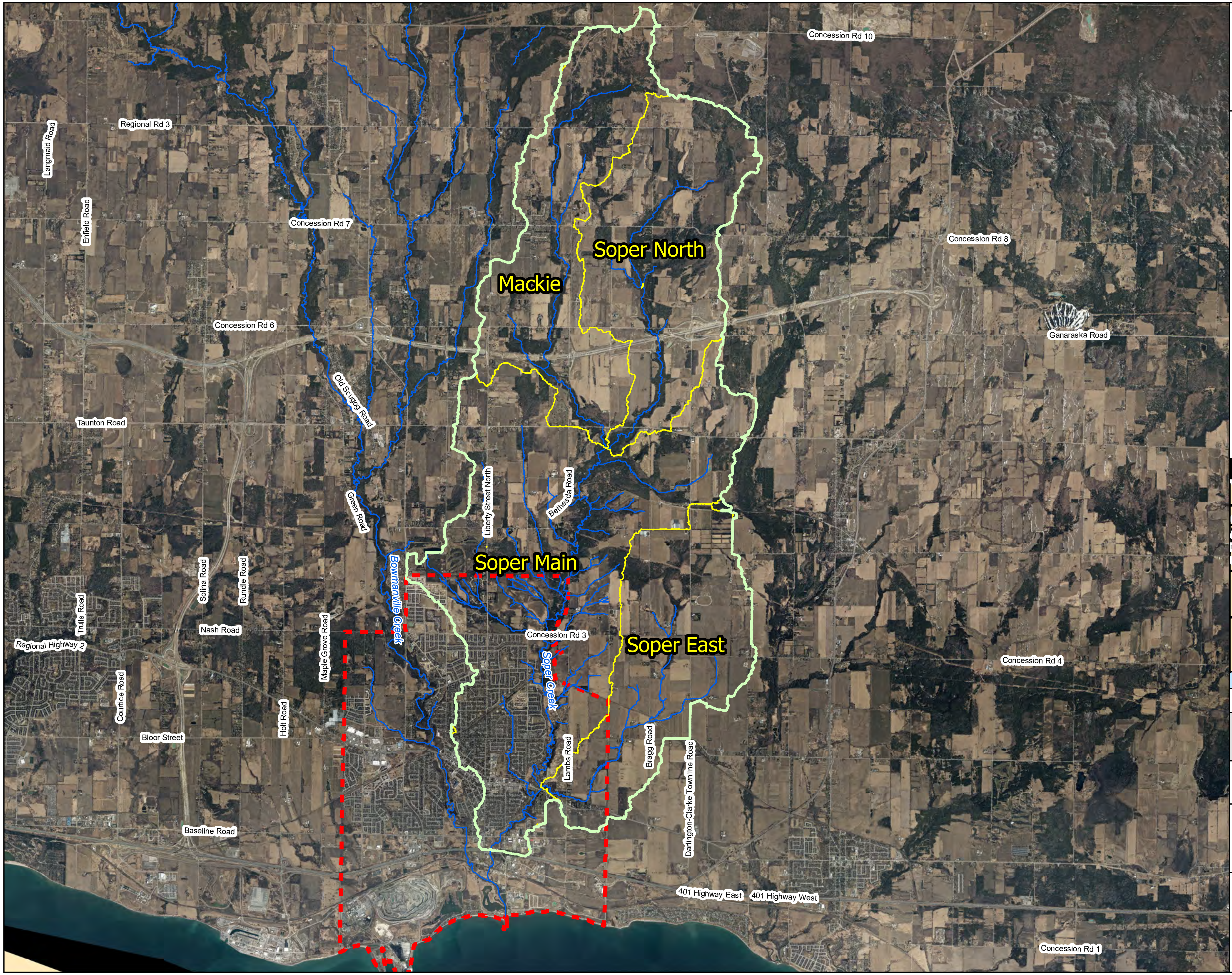
Mackie Subwatershed: This subwatershed is located in the northwest of the larger Soper Creek subwatershed and extends to its confluence with the Soper North subwatershed south of Taunton Road. The Mackie subwatershed has a long-term average annual runoff estimated at approximately 172 mm/year; well below the Soper Creek Subwatershed average of 190 mm/year. This can be attributed to lack of major development and high infiltration capacity in the sandy soils of the headwaters. There is a Water Survey of Canada stream gauge (ID 02HD023) at Taunton

Road. Average monthly flowrates at this station ranged from an April-high of approximately 0.53 m^3/s to a September-low of approximately 0.16 m^3/s. Baseflow monitoring within this subwatershed identified baseflow rates between 0.04 and 0.21 m^3/s. The Regional flow rate at the mouth of the subwatershed was determined to be 114.52 m^3/s using the hydrologic model.

Soper North Subwatershed: This subwatershed is located in the northeast of the larger Soper Creek subwatershed and extends to its confluence with the Mackie subwatershed south of Taunton Road. Due to it rural land use, the Soper North subwatershed exhibits a low average runoff rate, with a long-term average annual runoff estimated at approximately 173 mm/year; well below the Soper Creek Subwatershed average of 190 mm/year. A stream gauge (not Water Survey of Canada gauge) was used to establish monthly averages for the 2011 study. Average monthly flowrates at this station ranged from a January-high of approximately 1.0 m^3/s to a July-low of approximately 0.22 m^3/s. Baseflow monitoring within this subwatershed identified baseflow rates between 0.01 and 0.19 m^3/s. The Regional flow rate at the mouth of the subwatershed was determined to be 125.37 m^3/s using the hydrologic model.

Soper Main Subwatershed: This subwatershed extends from the confluence of the Mackie and Soper North Subwatersheds to the mouth of the creek system at Highway 401. Due to urbanization, this subwatershed exhibits the highest average runoff rate (197 mm/year) when compared to other Soper Creek constituent subwatersheds. At the time of the 2011 Study there were not any long-term flow monitoring stations on the main branch of Soper Creek. Four (4) baseflow monitoring stations in the watershed identified baseflow rates between 0.31 and 0.55 m^3/s. The Regional flow rate at the mouth of the subwatershed (Highway 401) and upstream of Highway 2 were determined to be 510.28 m^3/s and 504.08 m^3/s respectively, using the hydrologic model.

Soper East Subwatershed: This subwatershed is bounded by the Soper Main subwatershed to the north and west. It flows into the Soper Main subwatershed immediately upstream of Highway 2. Of the four (4) Soper Creek constituent subwatersheds, this rural subwatershed has the smallest estimated average annual runoff at approximately 169 mm/year. At the time of the 2011 Study there were not any long-term flow monitoring stations in the Soper East Subwatershed. A baseflow monitoring station at Concession Street East identified baseflow rates of approximately 0.04m^3/s. The Regional flow rate at the mouth of the subwatershed (Highway 2) and at Bragg Road were determined to be 107.81 m^3/s and 75.17 m^3/s respectively, using the hydrologic model.



Clarington

Legend

- Municipal Boundary
- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Constituent Subwatershed Boundary
- Watercourse

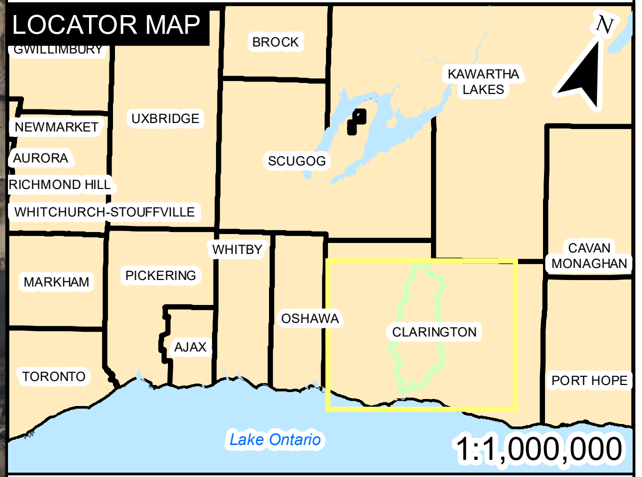


Figure 3.46

Constituent Subwatersheds of Soper Creek

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 1 2 4
Kilometers

Aquafor Beech Limited

3.2.3.2 Relationship to Background Reports and Models

The hydrologic modelling discussed in this section was developed in 2009 by Aquafor Beech Limited as part of the Bowmanville Creek and Soper Creek Floodplain Mapping Study and updated by CLOCA in 2011 for use in the establishment of flows associated with specific storm events (1:2, 1:5, 1:10, 1:25, 1:50, 1:100-year and Hurricane Hazel). The existing hydrologic models were developed in Visual Otthymo and have been approved through CLOCA for establishing the regulator flood limits. The CLOCA Hydrologic technical report has been provided as **Appendix P** of this document. Future conditions models were developed through CLOCA's Bowmanville/Soper Creek Watershed Existing Conditions Report to assess the potential impacts of development associated with land use changes that were being considered in 2011. In Phase 2 of the Soper Creek Subwatershed Study, a new future conditions hydrologic model will be developed based on land use scenarios as agreed to by CLOCA and the Municipality of Clarington. These land use scenarios will include updated natural heritage systems (**Section 3.3**) and will take into consideration development associated with the up-to-date Official Plan land use schedules and the secondary planning processes discussed in **Section 1.6**.

The hydraulic modelling (Hec-GeoRAS) discussed in this section has been developed by Aquafor Beech in 2009, and updated by CLOCA in 2011 with "future scenarios" to assess the potential impacts of development associated with land use changes that were being considered in 2011. The 2011 updates are approved for use in the establishment of water surface elevations associated with specific flow events including the regulatory flood scenario. The current regulatory flood hazard limits as approved by CLOCA for the use of applying planning and regulations policies is based on 2011 "future scenario". In Phase 2 of the Soper Creek Subwatershed Study, an updated future conditions hydraulic model will be developed based on flows from the land development scenarios as agreed to by CLOCA and the Municipality of Clarington.

3.2.3.3 Hydrologic Model

The hydrologic model used to define the regulatory flows for the Soper Creek Subwatershed was developed by Aquafor Beech Limited in 2009 and last updated in 2011 by CLOCA. This model replaced the original hydrologic model prepared in 1974.

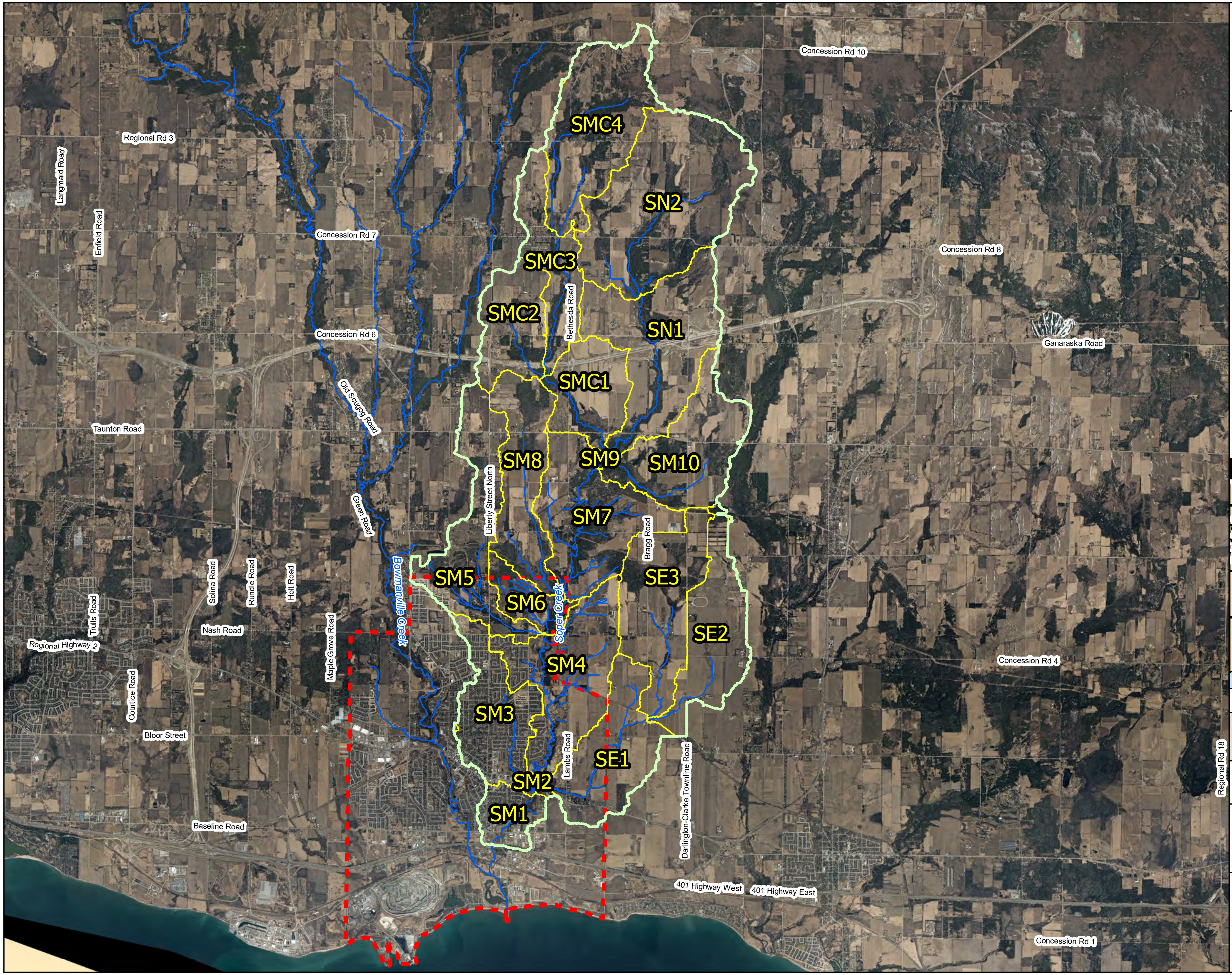
The hydrologic model was created in two stages, using Visual Otthymo 2. Subwatersheds with an imperviousness of 20% or more were modelled as urban, with the remainder of subwatersheds modelled as rural (CLOCA, 2011c). A total of twenty-five (25) subwatersheds were delineated, based on the DEM provided by First Base Solutions Digital Ortho Mapping and by surface drainage mapping for the developed areas of Bowmanville. The delineated catchments from the 2011 Study are shown in **Figure 3.49.** Overall, the rural subwatersheds were modeled using the Nashyd command, and the urban subwatersheds were modeled using the Standhyd command.

Two stages of the hydrologic model were created: existing conditions, and future conditions. The first stage of the hydrologic model created an existing land use model using land use data from 2005. The second stage of the model was to edit the existing land use parameters with a future land use model from the Municipality of Clarington's Official Plan (CLOCA, 2011c). The input parameters and peak flows of the two models were then compared (CLOCA, 2011c).

Both models were run for the 12-hour Chicago and 24-hour SCS distribution for 1:2, 1:5, 1:10, 1:25, 1:50, and 1:100-year return periods, as well as for the Regional Storm (Hurricane Hazel). For the regional storm event, the CN values were increased to reflect Antecedent Moisture Condition III (CLOCA, 2011c). The Regional Storm generally produces higher flows than the 1:100-year storm and is used as the regulatory event by CLOCA.

The results of the two hydrologic models prepared for the Soper Creek subwatershed are illustrated in **Table 3.10**. The hydrologic model concluded that one catchment (SM10) showed a significant increase in peak between the existing and future conditions. This catchment's land use transitioned to urban residential from pasture and crop, resulting in the increased peak flow.

Running the model again after adding theoretical quantity control ponds for the SM10 catchment showed that these ponds were able to control both the 12-hour Chicago storm and the 24-hour SCS storm to predevelopment levels (**Table 3.11**).



Clarington

Legend

- Municipal Boundary
- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Catchment Boundary
- Watercourse

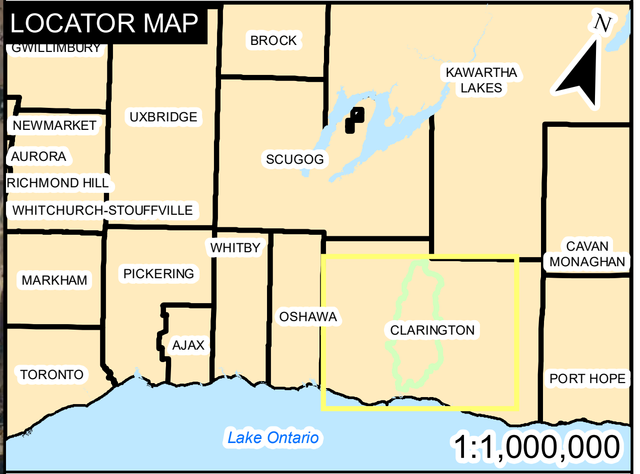


Figure 3-47

Delineated Subwatersheds for Soper Creek from 2011 Hydrologic Modelling (CLOCA, 2011c)

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 1 2 4
Kilometers

Aquafor Beech Limited

Table 3.10: Regional Peak Flow Results (CLOCA, 2011c)

HYD	Catchment ID	Peak Flows		
		Existing	Future	% Change
110	SC1	3.96	3.96	0.0%
99	SE1	35.67	36.23	1.57%
95	SE2	40.08	40.08	0.0%
94	SE3	37.70	37.7	0.0%
107	SM1	16.80	16.78	-0.10%
93	SM2	6.10	6.10	0.0%
90	SM3	3.71	3.75	0.94%
89	SM4	25.90	26.00	0.39%
81	SM5	2.07	2.07	0.0%
71	SM6	40.67	41.00	0.82%
82	SM7	13.49	13.55	0.43%
74	SM8	7.79	7.81	0.28%
69	SM9	36.01	36.67	1.84%
67	SM10	9.17	10.12	10.34%
64	SM11	32.10	32.10	0.0%
62	SM12	25.88	25.88	0.0%
59	SM13	30.60	30.60	0.0%
57	SM14	0.75	0.72	-3.74%
103	SM15	1.07	1.07	0.0%
49	SMC1	26.33	26.58	0.97%
46	SMC2	2699	27.63	2.38%
44	SMC3	16.46	16.55	0.57%
41	SMC4	50.90	50.90	0.0%
53	SN1	48.54	49.04	1.03%
50	SN2	80.32	80.32	0.0%

Table 3.11: Existing, Future, and Future Controlled Peak Flows for SM10

Storm Event	12-Hour Chicago			24-Hour SCS		
	Existing	Future	Future Controlled	Existing	Future	Future Controlled
2	0.34	0.52	0.22	0.31	0.44	0.23
5	0.65	0.93	0.42	0.74	0.74	0.41
10	0.89	1.26	0.61	0.96	0.96	0.58
25	1.25	1.73	0.83	1.28	1.28	0.76
50	1.54	2.11	1.03	1.53	1.53	0.92
100	1.89	2.52	1.24	1.81	1.81	1.10

3.2.3.4 Hydraulic Model

The hydraulic models used to define the regulatory floodplain for the Soper Creek Subwatershed was last updated in 2011 by CLOCA. This model replaced the 2009 hydraulic model. The hydraulic model was developed using the US Army Corp of Engineer's Hec-GeoRAS Version 4.0. A field survey was conducted as part of the 2009 hydraulic modelling component consisting of a bridge/culvert structure survey and the collection of bank-full channel measurements. The structure survey included topographic surveys that included the opening shape and dimensions, and the upstream and downstream invert elevations of all structures (Aquafor Beech, 2009).

GIS data was imported into the project, and then updated with regards to information gathered from the field investigation. The information gathered from the field surveys was added to the model as bridge or culvert elements.

Design flow rates for the 2-year through 100-year storms and Regional storm were established at various locations throughout the watershed by CLOCA in the 2011 report titled "Hydrologic Modeling for Bowmanville and Soper Creeks". However, flood flow rates were also required for other intermediate locations for use in the hydraulic model. Additional flow estimates were interpolated, where required, from the supplied flows, on drainage area basis.

Several spills between adjacent subwatersheds were noted during the floodplain mapping process, including:

- 73 m^3/s spill from Bowmanville Creek to Soper Main upstream of the CN Railway near the mouth of Soper Creek;
- 135 m^3/s spill from Soper Main to a small tributary just south of King Street East; and
- 9.03 m^3/s spill from a tributary to Soper East just upstream of the CP Railway.

Other spills were noted where the flows spilled from the channel and along adjacent roads or railways, including:

- A westerly spill occurs upstream of the CP Railway crossing in Soper East. The spill waters return to the same creek branch through a different culvert 500 m to the west; and
- A southerly spill occurs where Soper East flows beneath the Darlington-Clarke Townline Road and flows out of the Soper Creek watershed.

Forty-five (44) bridge/culvert structures are flooded up to the Regional event, including:

- 4 structures flood at less than the 2-year flood flow rate;
- 4 structures flood between the 2- and 5-year flood flow rates;
- 2 structures floods between the 10- and 25-year flood flow rates;
- 6 structures flood between the 25- and 50-year flood flow rates;
- 2 structures flood between the 50- and 100-year flood flow rates; and
- 26 structures flood between the 100-year and the Regional flood flow rates.

In addition to the structures, a number of buildings are also within the regulatory floodplain limits. These buildings were typically constructed within the floodplain but also experienced backwater from downstream bridge and culvert structures.

3.2.3.5 Hydrology and Hydraulic Recommendations

3.2.3.5.1 Hydrologic Model Updates (Phase 2 of Subwatershed Study)

As part of Phase 2 of the Soper Creek SWS, the Visual Otthymo hydrologic model will be updated with revised land uses developed through the Soper Hills Secondary Plan and Soper Springs Secondary Plan. Additional to these updates, there have been some land use changes that have occurred in the watershed since the most recent update of the hydrologic model in 2011. These have largely been captured by the "future conditions" scenario developed in 2011; however, the land use intensity will be confirmed as the hydrologic model is updated. These land use changes consist of:

a) The extension Elephant Hill Drive to Mearns Avenue and the development of Lyle Drive (Agricultural transition to Residential Development).

b) The 20 ha subdivision development centered on Swindells Street north of Meadowview Boulevard (Wooded and Pastureland to Residential Development).

c) Residential development west of Liberty Street North and south of Concession Road 3 extending to western extent of the Soper Creek subwatershed boundary.

Additional to the land use changes resulting from urban development, the construction of Highway 407 has the potential to increase runoff rates in the southern reaches of Mackie and Soper North subwatersheds Mackie and Soper North subwatersheds. The impact of this development on runoff response as well as impacts of stormwater detention facilities constructed as part of the drainage control system of Highway 407 will be incorporated into the updated model where applicable.

3.2.3.5.2 Hydraulic Model Updates in Secondary Plan Areas (ongoing)

The methodology of the 2009 Bowmanville Creek and Soper Creek Floodplain Mapping Study set the lower drainage area threshold for floodplain mapping at 125 ha, a standard practice for floodplain mapping studies. The 2011 update did not set a smaller drainage area threshold. As part of the Soper Creek Subwatershed Study, mapping is being extended upstream of the 125 ha threshold to better define flood hazard in the Soper Hills Secondary Plan Area and Soper Springs Secondary Plan Area. Once finalized and approved by CLOCA, this flood line will be extended upstream on the natural hazards mapping. Due to the small contributing drainage areas generating proportionally small flows, it is unlikely that these flood lines will extend beyond the constraints developed as part of the natural heritage study.

3.2.3.5.3 Hydraulic Model Updates (Phase 2 of Subwatershed Study)

The output flows rates from the Phase 2 hydrologic model will be used as input to the GeoHECRAS hydraulic model to determine the impact to floodplain elevations and extents. Where there are impacts to the floodplain that are deemed to be unacceptable, mitigation measures will be necessary. Where new creek crossings are proposed and plans are available, these will be incorporated into the hydraulic model.

3.2.3.5.4 Flooding Hazard

Throughout the study area, the regulatory floodplain mapping developed and/or approved by CLOCA and consistent with the MNRF 2002 Guidelines for determining hazard lands shall be used to help establish development constraints. Per the Municipality of Clarington's Official Plan, no new buildings or structures shall be permitted on lands identified as natural hazard lands including regulatory floodplain. Development within the flood hazard limit is restricted to ensure flooding hazards are not aggravated and that new hazards are not created. This also provides CLOCA and the partner municipalities with the opportunity to maintain and enhance the natural features and ecological functions of the river or stream valley.

3.2.3.5.5 Water Balance Analysis

LIDs consisting of conveyance and source controls (along with end of pipe SWM facilities) will play a significant role in ensuring the runoff regime is not significantly altered. The groundwater analysis described in **Section 3.1** also identifies that maintaining recharge through LID stormwater practices will especially be important where groundwater supports wetland ecology.

To properly identify the long-term impact of urban development on hydrologic pathways of runoff, infiltration and evapotranspiration, a continuous hydrologic model is preferable to that of the exiting single-event model. For Phase 2, a PCSWMM model will be created to analyze the annual volumetric impact of urbanization with and without LID stormwater control measures. The Visual Otthymo model will continue to be used for flood hazard analysis and be used to identify climate change response via IDF modification for both existing and future scenarios during Phase 2 of this study.

3.2.4 Water Quality

Water quality, including the pollutant levels found in surface runoff, can impact both human and ecological well-being. The modification of natural environments to agricultural and urban land uses can impact the landscape, vegetation, and ecological functions within a subwatershed, which in turn can contribute to increases in the levels of pollutants in the receiving watercourses. There are a variety of pollutants as well as other physical, chemical and biological characteristics used to measure water quality. Some of the most common categories include:

- Solids (e.g., suspended solids, volatile solids, turbidity);
- Nutrients (e.g. phosphorus, nitrogen) ;
- Bacteria (e.g., coliforms);
- Metals (e.g., copper, zinc);
- Temperature;
- Chlorides; and
- Dissolved oxygen.

Provided below is an overview of these water quality parameters, their importance and influence in terms of aquatic and ecosystem health, and the potential impacts of urban development.

Solids and Turbidity

Suspended solids concentrations and turbidity both indicate the amount of solids suspended in the water, whether mineral (soil particles) or organic (algae). High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can degrade/impact important habitat areas for fish and other aquatic life. Elevated levels of suspended solids can also negatively affect water quality by absorbing light, thereby warming the water. Warm water holds less dissolved oxygen than cool water. The suspended particles also provide attachment places for other pollutants, such as metals and bacteria. High suspended solids or turbidity readings thus can be used as indicators of other potential pollutants.

Land use is probably the greatest factor influencing changes in TSS or turbidity in streams. Agricultural and urban land use results in an increase in disturbed areas, a decrease in vegetation, and an increase in the rate of runoff. These all cause increases in erosion, particulate matter, and nutrients, which promote increased algal growth. For example, loss of vegetation due to urbanization exposes more soil to erosion, allowing more runoff to form, and simultaneously reduces the subwatershed's ability to filter runoff before it reaches the stream.

Nutrients

Instream nutrients are essential for growth. The additional algae and other plant growth supported by nutrients may be beneficial up to a point but may easily become a nuisance or negatively impact aquatic species/habitat. The main nutrients of concern are phosphorus and nitrogen. Nutrient loading can result in increased algae growth. Excessive growths of attached algae can cause low dissolved oxygen (DO), unsightly conditions, odors, and poor habitat conditions for aquatic organisms. Pollution from urban development can impact instream nutrient concentrations in a number of ways. Municipal and industrial discharges usually contain nutrients, and overland flow from developed watersheds contains nutrients from lawn and garden fertilizers as well as the additional organic debris, which is washed from urban surfaces. Increased runoff from urban surfaces may result in increased rates of erosion, which can also be a significant source of nutrients to receiving streams, as nutrients are also naturally present in many soils in Ontario. Agricultural areas also contribute to nutrient increases through poor manure and fertilizing practices and increased erosion from plowed surfaces.

Pathogens (Bacteria)

Fecal coliform bacteria are microscopic organisms that live in the intestines of warm-blooded animals, as well as in the waste material, or feces, excreted from the intestinal tract. When fecal coliform bacteria are present in high numbers in a water sample, it means that the water has received fecal matter from one source or another. Although not necessarily agents of disease, fecal coliform bacteria may indicate the presence of disease-carrying organisms, which live in the same environment as the fecal coliform bacteria. Bacteria levels do not necessarily decrease as a subwatershed develops from rural to urban. Instead, urbanization usually generates new sources of bacteria. Farm animal manure and septic systems are replaced by domestic pets and leaking sanitary sewers.

Metals

Urban transportation systems are a primary source of metals in stormwater runoff to urban streams and groundwater. All cars, even the cleanest vehicles, shed small amounts of metals, fluids, and other pollutants. Cadmium, copper, cobalt, iron, nickel, lead and zinc are deposited into the environment by vehicle exhaust, brake linings, and tire and engine wear. They accumulate on road surfaces and are then washed into storm drains with the next rainfall. Galvanized metal rooftops, gutters and downspouts, and moss killer are also a source of zinc in stormwater. Some copper comes from architectural uses and treated wood, and a primary source is brake pads. The erosion of soils can also be a significant natural source of metals within stormwater runoff.

The effects of a number of metals are reviewed below:

- Lead, which is often used as an indicator for other toxic pollutants in stormwater, can be harmful or deadly for human and aquatic life.
- Zinc, although not harmful to humans at concentrations normally found in stormwater, can be deadly for aquatic life.
- Cadmium can bioaccumulate in an ecosystem.
- Soil microorganisms are especially sensitive to it, and it is harmful to human health.
- Chromium damages fish gills and causes birth defects in animals. It is also dangerous to human health.
- Mercury is a neurotoxin that bioaccumulates.
- Low levels of copper inhibit the olfactory systems of salmonid fish, decreasing their ability to hide in response to warning signals.
- Some metals bind to soils and organic matter and are transported in sediment, while other metals dissolve in water. Rainwater is slightly acidic, which increases its ability to dissolve heavy metals and compounds the health and environmental effects of

stormwater runoff from urban areas.

Temperature

Water temperature is important because it governs the kinds of aquatic life that can live in a stream. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. If temperatures get too far above or below this preferred range, the number of individual species decreases until finally there are none.

Additional to point sources of heat pollution such as of heated municipal and industrial discharges, the process of subwatershed development also can affect temperatures in nearby streams. Streambank vegetation is lost when land is cleared, thereby exposing the stream to increased warming by sunlight. A less obvious impact is that runoff water may be warmer, especially during the summer months when it flows over hot asphalt or concrete.

Chlorides

Chloride is a conservative pollutant, in that it is not degraded or removed from water by any natural process. High levels of chlorides can inhibit plant growth and impair reproduction. They also reduce the diversity of fish and other aquatic organisms in streams. Chloride is a general surrogate for development pressures, from road salting and septic systems.

Dissolved Oxygen (DO)

Like terrestrial animals, fish and other aquatic organisms need oxygen to live. As water moves past their gills (or other breathing apparatus), microscopic bubbles of oxygen gas in the water, called dissolved oxygen (DO), are transferred from the water to their blood. In addition to being required by aquatic organisms for respiration, oxygen also is used for decomposition of organic matter and other biological and chemical processes. Unlike other water quality parameters discussed in this section, higher values of DO are typically considered indicative of good water quality.

Stormwater runoff delivers oxygen-demanding substances to streams. When a subwatershed becomes developed, greater quantities of pollutants are released and the total volume of runoff increases. Most conventional pollutants (sediments, nutrients, organic matter) require oxygen for decomposition or for chemical reactions. Consequently, instream DO concentrations often decrease in a developed or developing subwatershed.

A water quality parameter closely related to DO is Biological Oxygen Demand (BOD). BOD_5 is a measure of the dissolved oxygen required by microorganisms to oxidize or decompose the organic matter within a water sample over a five-day laboratory test. It is used as a means to describe the amount of organic matter present in the water. The higher the BOD_5, the more demand on dissolved oxygen within a water system.

3.2.4.1 Soper Creek Water Quality

The collection and analysis of instream water quality was not within the scope of this project. The most comprehensive analysis of water quality within the Soper Creek subwatershed was reported in the Bowmanville / Soper Creek Watershed Existing Conditions Report (CLOCA, 2011b). Water quality results from five sampling locations across the subwatershed were reported. The sampling locations are shown in **Appendix D**. Results were available at SWQ5 (Soper Main) from 1967-1994 and from 2003-2008; at SWQ19 (Soper North) from 2004-2008; at SWQ20 (Soper North) from 2004-2005 and 2008; SWQ21 (Soper East) from 2005-2008); and SWQ18 (Mackie) from 2004-2008.

Reported parameters included:

- Chloride;
- Total Phosphorus;
- Total Nitrate;
- Nitrate as N;
- Copper;
- BOD5; and
- Dissolved oxygen.

The water quality monitoring results from CLOCA (2011b) are presented in **Table 3.12**, along with the appropriate guidelines.

While chloride concentrations are typically low, only exceeding 150 mg/L a small number of times at SWQ5 since 1967. Chloride concentrations are increasing at SWQ5, but no trend has been observed at the other four monitoring station.

Phosphorus contributes to impaired water quality in Soper Creek, with samples throughout the watershed exceeding the PWQO of 30 µg/L 63% of the time. At SWQ5, 93% of the samples exceeded the limit, although there is a decreasing trend in concentrations at this location. Phosphorus concentrations have been increasing at SWQ19 in the Soper North subwatershed.

Nitrate concentrations are increasing at SWQ19, but no trends were apparent from the other stations. Nitrate and nitrate-N are generally below the CCME (2012) guidelines of 13 mgNO3-/L and 3.0 mg NO3--N/L, except for at SWQ21 in the Soper East subwatershed, where the mean and median nitrate-N concentrations exceed 3.0 mg/L.

The PWQO for copper is 5 µg/L (hardness >20 mg/L CaCO3) and 1 µg/L (hardness <20 mg/L CaCO3). Approximately 12% of samples exceeded the 5 µg/L threshold, all at SWQ5, but predominantly before 1991. However, hardness was not reported by the 2011 Existing Conditions Report, so if the more stringent 1 µg/L is applied, exceedances occur in all monitoring stations except SQW18 (Mackie).

86% of dissolved oxygen (DO) samples were above 8 mg/L. No trend was observed over time for DO concentrations at any monitoring station. However, at SWQ5, the BOD decreased over time, suggesting an improvement in water quality, while the BOD increased at SWQ18 (Mackie) and SWQ19 (Soper North).

Temperature was monitored in 1998/1999 and again from 2005-2010. Mackie and Soper North were both found to be coldwater streams, although in the 1998/1999 both subwatersheds were found to be coolwater at the lower reaches. This difference was largely attributed to changes in methodology. Soper Main and Soper East are both coolwater streams, although Soper Main has some coldwater reaches.

Other parameters were analyzed, some of which exceeded PWQO guidelines at times, including cadmium, chromium, iron, lead, and zinc. Lead and iron exceeded the most frequently, at 45% and 35%, respectively. These exceedances were primarily at SWQ5.

Table 3.12: Soper Creek Water Quality (ORCA, 2011)

	Objective	SWQ5 (Soper Main)			SWQ19 (Soper North)			SWQ20 (Soper North)			SWQ21 (Soper East)			SWQ18 (Mackie)		
		Min	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
Chloride (mg/L)	120[1]	1.3	292	26.2	8.18	62.8	12.08	6.01	9.8	7.54	27.6	37.1	33.9	8.6	23.9	19.2
Total Phosphorus (µg/L)	30[2]	6	2300	237.6	6	**62**	16.56	14	7.67	20	100	54.3	6	72	16.4	14
Total Nitrate (filtered) (mg/L)	13[3]	0.265	5.95	1.952	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate as N (mg/L)	3[3]	0.81	3.95	1.66	0.79	2.28	1.41	0.75	1.08	0.93	3.06	5.96	4.34	0.81	2.2	1.225
Copper (µg/L)	5[2]	0.2	140	4.91	0.1	2.6	0.3705	0.2	1.2	0.533	0.2	1.1	0.678	0.1	1	0.3455
BOD5	-	0.04	18	2.12	0.2	1.5	0.743	0.2	1.1	0.6	0.5	1.6	1.067	0.2	1.4	0.76
Dissolved Oxygen (mg/L)	4 to 8[4]	**3.3**	20.4	10.25	3.96	16.5	11.45	-	-	-	-	-	-	3.93	15.95	11.52

[1] CCME (2011) – long-term exposure
[2] PWQO (2016)
[3] CCME (2012) – long-term exposure
[4] PWQO (2016) – dependent on water temperature and stream classification.

3.2.4.2 Water Quality Conclusions and Recommendations

Though the existing water quality data can inform baselines conditions; a water quality monitoring program will need to be developed as part of the Subwatershed Management Plan. It is recommended that the water quality monitoring program to be developed take an Adaptive Management Approach (AMA) and span pre-construction, construction and post-construction phases. This approach allows adjustments to monitoring sites, parameters and protocols to be made over time, as gaps are identified in order to optimize the program. The monitoring program will likely require extensive coordination and collaboration through annual monitoring meetings among representatives of CLOCA, the Municipality of Clarington, the Region of Durham, the development community and their consulting teams.

3.3 Ecological Resources

Natural heritage features within the Soper Creek subwatershed were characterized using a combination of primary and secondary information sources, as outlined in **Section 3.3.1** and **3.3.2**. The results of this baseline data collection are presented in **Section 3.3.3**, Aquatic Resources and **Section 3.3.3.1**, Terrestrial Resources. Further assessment was carried out to address Species at Risk (**Section 3.3.5**) and Significant Wildlife Habitat (**Section 3.3.6**). The results of this baseline assessment were used to update and refine the existing Municipality of Clarington's Natural Heritage System (**Section 4.2.1**), and to identify areas and/or features which constitute developmental constraints or opportunities (**Section 4.4**).

3.3.1 Background Information Sources

Background information was obtained from a variety of sources to provide context of the setting and sensitivity of the study area and surrounding lands. Background information sources include:

- Historical air photos (2018, 2017, 2002, and 1954);
- Municipality of Clarington Official Plan (Consolidated June 2018);
- Aurora District Ministry of Natural Resources (MNRF) (J. Andersen);
- MNRF's Natural Heritage Information Centre (NHIC) Make A Map online database records and mapping of significant species and natural areas;
- Atlas of the Breeding Birds of Ontario;
- ELC mapping prepared by CLOCA, Ganaraska Region Conservation Authority (GRCA), and Kawartha Region Conservation Authority (KRCA);
- Ontario Reptile and Amphibian Atlas online database (Ontario Nature); and
- Citizen science flora and fauna records obtained from various sources (e.g., eBird, iNaturalist).

3.3.2 Overview of Ecological Field Studies

In addition to the use of the background resources listed above, existing conditions in the subwatershed study area were characterized through field investigations. Due to the large size of the study area, field investigations were by necessity scoped. It is acknowledged that future, site-specific studies may complete more detailed investigations for individual properties and, where appropriate, the results of those detailed, site-specific investigations may amend or refine the results shown in this study report (see **Section 5.3**).

Table 3.13 details the survey types conducted, provides an overview of the methodologies used, and lists the dates for the natural heritage field investigations completed by Aquafor Beech staff as part of this SWS.

Land access permission was not received for all properties within the study area. Features on lands not accessed during this study were evaluated from adjacent lands, if possible, and through air photo interpretation and background information review. Lands not accessed as part of this study will need to be further assessed at a subsequent planning stage.

Table 3.13: Summary of Ecological Field Surveys

Survey Type	Methodology	Date(s) Completed
Aquatic Ecology		
Aquatic Habitat Assessment **(Section 3.3.3.1)**	Aquatic habitat was assessed using Ontario Stream Assessment Protocol (OSAP) Version 10 (2017): Section 1: Module 1 (Defining Site Boundaries and Key Identifiers); Module 2 (Screening Level Site Documentation), and; Module 3 (Assessment Procedures for Site Features Documentation) Section 4: Module 2 (Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions), and; Module 3 (Bankfull Profiles and Channel Entrenchment)	July 11, 12, and 13, 2018
Benthic Invertebrates (**Section 3.3.3.2**)	Benthic macroinvertebrates were collected using the traveling kick-and-sweep method in accordance with the OSAP Version 10 (2017).	June 22 and July 11, 2018
Fish Communities (**Section 3.3.3.3**)	Fish communities were sampled using OSAP Version 10 (2017): Section 3: Module 1 (Fish Community Sampling using Standard, Single Pass Electrofishing Techniques)	July 25, 26 and 27, 2018
Fish Barriers, Watercourse Crossings & Ponds **(Section 3.3.3.4)**	An inventory of fish barriers and online ponds was compiled based on observations made during HDF Assessment field work and through an analysis of aerial photographs of the study area.	March 20 and 21, May 21 and 22, and Aug 22 and 23, 2019
Terrestrial Ecology		
Vegetation Community Classification **(Section 3.3.4.1)**	Vegetation community surveys were completed in accordance with the Ecological Land Classification (ELC) system for Southern Ontario, First Approximation (Lee, et al., 1998).	September to October, 2019

Survey Type	Methodology	Date(s) Completed
Botanical Inventories **(Section 3.3.4.2)**	Botanical inventory was conducted concurrently with Ecological Land Classification surveys, using an area search methodology.	September to October, 2019
Breeding Bird Surveys **(Section 0)**	Breeding birds were surveyed in accordance with the Atlas of the Breeding Birds of Ontario Guidelines for Participants (Ontario Breeding Bird Atlas, 2001).	June 4, 5, 6, 7, 8, 25, 26, 27, and 28, 2018
Amphibian Calling Surveys **(Section 3.3.4.5)**	Amphibian calling surveys were conducted at the study site in accordance with the methodology of the Marsh Monitoring Program (Bird Studies Canada, 2009).	April 30, May 16, and June 26, 2018
Salamander Habitat Review **(Section 3.3.4.5)**	Identification of vernal pools in suitable habitat and egg mass survey per protocol obtained from MNRF.	March 20 and 21, 2019
Other Wildlife **(Section 3.3.4.6)**	Incidental observations of wildlife were recorded during all other field surveys.	All dates listed

3.3.3 Aquatic Resources

Aquatic resources play an important role in a natural heritage system, and both human health and ecosystem health are largely dependent on stable aquatic resources. It is the role of the municipal OP to support the protection of the Natural Heritage System, including aquatic resources such as *watercourses, fish habitat and riparian corridors*. Understanding these resources provides a better idea of overall ecosystem health and aids decision makers when applying the OP to the protection of both aquatic resources and the overall NHS. The following sections discuss these resources in four parts: aquatic habitat; fish communities; benthic macroinvertebrate communities; and fish barriers, watercourse crossings and online ponds. These resources aid in the delineation of watercourses, as well as *fish habitat and riparian corridors*, which are protected as part of the Municipal NHS, as discussed further in **Section 3.3.7**.

3.3.3.1 Aquatic Habitat

Aquatic habitat characteristics, as described in the following section, are major determinants for biotic composition, which is an indicator of aquatic ecosystem health. Understanding aquatic habitat can therefore determine relationships with biotic composition, providing a better understanding of subwatershed health and integrity. While aquatic habitat changes constantly, anthropogenic disturbance can impact habitat, stressing the relationship with aquatic habitat and biological/chemical indicators. The habitat characteristics investigated within the Soper Creek subwatershed include:

- Bank characteristics;
- Stream width (wetted and bankfull);
- Instream cover (e.g., woody debris, undercut banks, boulders, vegetation);
- Riparian cover (vegetation composition, quality and width); and

- Physical barriers to fish movement (e.g., woody or debris jams, knickpoints, etc.)

3.3.3.1.1 Methodology

Aquatic habitat assessment methodology followed by this study is as follows:

- OSAP Version 10 (Stanfield, 2017) was used for habitat assessments by certified Aquafor Beech Limited biologists;
- Site limits were located using OSAP Section 1: Modules 1 and 2 (Defining Site Boundaries and Key Identifiers; Screening Level Site Documentation);
- Habitat features including barriers to fish movement and other channel disturbances were recorded using OSAP Section 1: Module 3 (Assessment Procedures for Site Features Documentation);
- Depth, wetted width, habitat type, instream cover, instream vegetation, riparian vegetation, width/depth ratio, bank stability, substrate, and entrenchment were assessed using OSAP Section 4: Modules 2 and 3 (Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions; Bankfull Profiles and Channel Entrenchment);

Proof of staff's OSAP certification is provided in **Appendix E**. OSAP data was summarized using the Flowing Waters Information System (FWIS) and is outlined in **Table 3.14**. Aquafor Beech Limited biologists received FWIS training (conducted by Les Stanfield). All field sheets are located in **Appendix F** and FWIS data summaries are located in **Appendix G**. Aquatic sampling sites are illustrated in **Figure 3.48**, below with photographs of sampling sites shown in **Appendix H**.

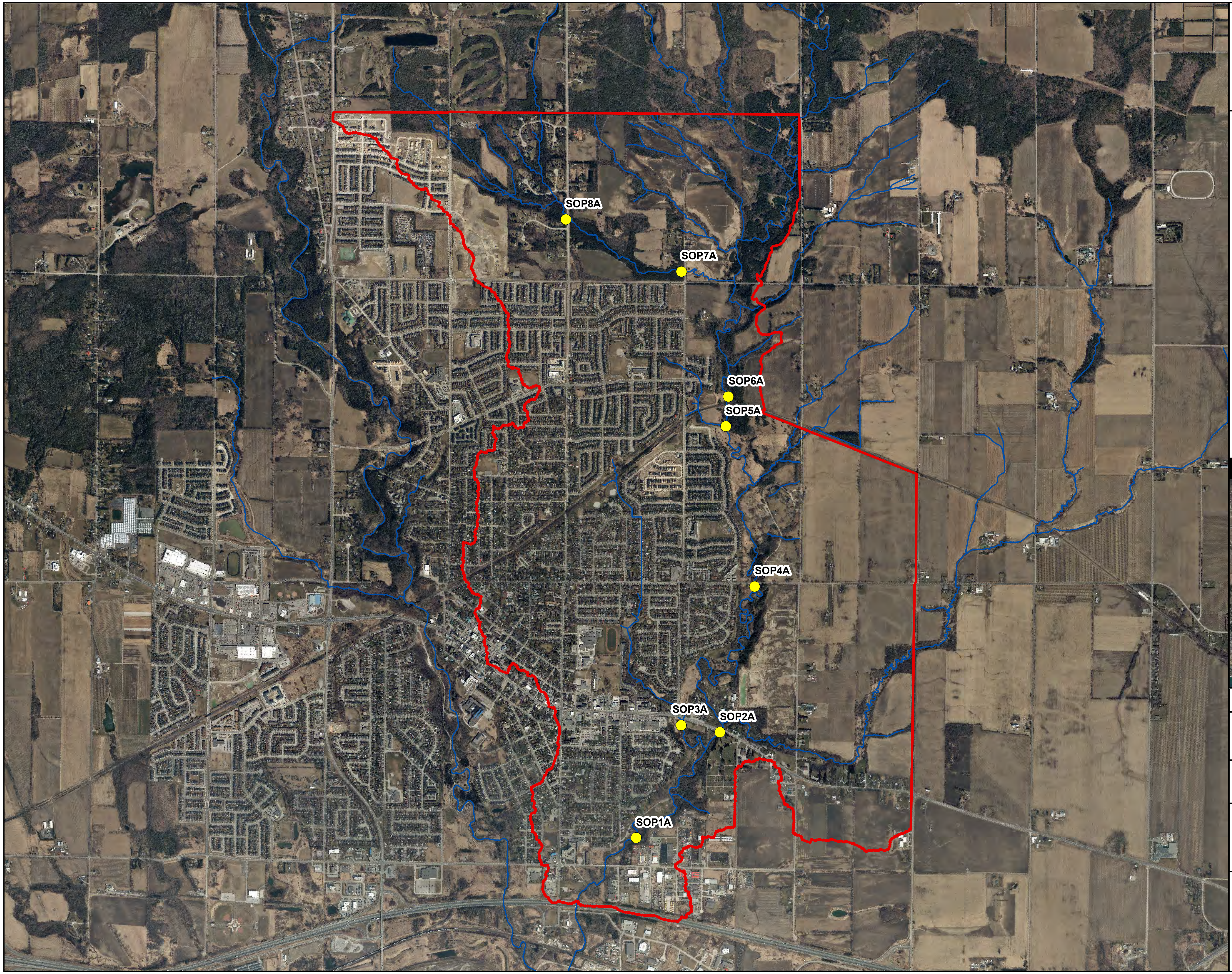
Table 3.14: OSAP Channel Structure Summaries

Habitat Characteristics	General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
SOP1A	Permanent	SOP1A was the furthest, most downstream site within the main Soper Creek branch, located approximately 319 m upstream of the Baseline Road E crossing.	Site length was 44 m. Minimum wetted width at the time of sampling was 5.8 m, and the average wetted width was 7.41 m. The average depth was 329.63 mm and the maximum depth sampled was 935 mm. The site observed engineered features with evidence of past restoration efforts, such as armourstone lined banks and riparian plantings. The site fell adjacent to a busy public park.	This site was evenly distributed among riffles and runs, with a large pool observed at the downstream extent of the site. Cover was provided throughout by canopy cover, as well as instream substrate and downcutting near the downstream extent. The greatest number and weight of fish observed were throughout the fast runs with overhanging canopy cover. Multiple large fish were observed "rising" near the downstream pool; however, it was unsampleable due to depth.	This site was well distributed between sands, gravels, cobbles and some large boulders, with areas of consolidated clay and bedrock. The mean point particle was 47.35 mm and maximum particle size was 710 mm.	The left bank consisted entirely of sands while the right bank observed some larger cobbles and boulders near adjacent to areas of erosion. 1 undercut was observed on the right bank (120 mm). Right bank observed evidence of large-scale erosion with no risk to adjacent infrastructure. Left bank observed erosion near the downstream extent.	Instream vegetation was minimal throughout this site, consisting of emergent macrophytes and moss. Riparian vegetation was moderate, with the right bank consisting of a well-established mixed forest ~30 m riparian zone deep. The left bank was less established as the adjacent parkland/mowed lawn encroached the watercourse in sections.	A number of road crossings and a CP Rail crossing existed upstream of the site, along with multiple residential areas and residential developments. A well-used park existed on the left bank with maintain lawn and sports fields. An industrial area existed beyond the 30 m riparian zone on the right bank. No fish barriers were observed.
SOP2A	Permanent	SOP2A was approximately 1.2 km upstream of SOP1A, and immediately downstream of the King St E right-of-way within the main Soper Creek branch.	Site length was 48.8 m. Minimum wetted width at the time of sampling was 7.3 m, and the average wetted width was 8.37 m. The average depth was 286.05 mm and the maximum depth sampled was 580 mm.	This site was mainly medium depth runs, with few riffles and even fewer pools available for fish refuge. Cover was not in abundance at the time of investigation with in-stream vegetation very limited and substrate consisting mainly of fines and sands. Cover was largely provided by overhanging terrestrial vegetation and canopy cover, though not abundant.	This site almost entirely consisted of silts and sands, with some larger cobbles and boulders found throughout. The mean point particle was 19.08 mm and the maximum particle size was 580 mm.	The left bank consisted almost entirely of silt with some larger cobbles and boulders observed throughout, likely introduced by the adjacent landowner. The right bank was better sorted between silts and cobbles with few boulders. The left bank observed one small undercut (70 mm) and the right observed two (170 & 430 mm). Right bank observed small scale erosion in places.	Instream vegetation was very limited to only moss. Riparian vegetation consisted of terrestrial grasses on the left bank with limited, large deciduous trees and encroaching, well-maintain lawn. The right bank consisted of willow and dogwood shrubs and a small swath of well-established mixed trees. A cemetery and well-maintained lawn was observed beyond the narrow right bank riparian zone.	The site was immediately downstream of King St E, a well-travelled regional road which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely adjacent lawns, as well as upstream residential areas, residential developments and agricultural lands. No barriers to fish were observed.

Habitat Characteristics	General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
SOP3A	Permanent	SOP3A was located within a contributing tributary of Soper Creek (Bowman Creek), east of SOP2A and immediately downstream of King St E.	Site length was 53.5 m. Minimum wetted width was 0.7 m and the average wetted width was 1.49 m. The average depth was 112.88 mm and the maximum depth sampled was 255 mm. The site fell adjacent to a maintained park with a paved pedestrian path crossing the upstream extent.	This site was slow moving at the time of assessment with very little hydraulic head throughout. Riffles were few and far between, with no pool habitat observed. The site was uniform in habitat characteristics, with evidence of past realignment. Instream vegetation was very limited, with only moss observed near the downstream extent. Cover was provided by overhanging terrestrial vegetation throughout, as well as some cobbles where sedimentation wasn't evident.	Substrate was very poorly sorted, with evidence of sedimentation throughout. Silts and sands dominated, with the D50 represented by sand. Few cobbles were observed throughout. The maximum particle size was observed at 245 mm which was uncharacteristic to the rest of the reach. The mean max particle was 51.69 mm.	Both banks were stable, with low bank angles and no evidence of erosion. No undercuts were observed on either bank.	Instream vegetation was very limited consisting entirely of moss near the downstream extent, likely due to substrate composition and low flow. Riparian vegetation consisted of a well-established deciduous forest that provided the site with abundant canopy cover, along with wetland vegetation that also provided cover.	The site was immediately downstream of King St E, a well-travelled regional road which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely adjacent park lawns, as well as upstream residential areas. No barriers to fish were observed.
SOP4A	Permanent	SOP4A was immediately downstream of the Concession St E right-of-way within the main Soper Creek branch.	Site length was 42 m. Minimum wetted width was 6.1 m and the average wetted width was 8.11 m. The average depth was 208.89 mm and the maximum depth sampled was 640 mm. The site fell within the relatively un assumed natural area, bordered between a residential area to the west and a residential development to the east, which at the time of observation had begun land alteration.	This site was well distributed between riffles and runs, with one large pool observed downstream of a sharp meander bend and a large woody material jam. Evidence of aggradation was observed upstream of the jam, with fines accumulating on the left bank and into the thalweg. Aquatic vegetation was minimal at the time of observation, consisting only of moss where substrate allowed. Terrestrial plants provided cover, as well as abundant canopy cover through most of the upstream run of the site.	Substrate was very poorly sorted, with evidence of sedimentation throughout the majority of the site. Substrate was observed with better sorting near the upstream and downstream extents, with aggradation observed near the pool habitat and large woody material jam mid-site. Two points fell on islands, demonstrating aggradation. Silts and sands dominated, with the D50 represented by sand. Few cobbles were observed throughout. The maximum particle size was observed at 640 mm. The mean max particle was 20.43 mm.	Evidence of bank instability was observed throughout the site, with steep angles observed on both banks and a riverbed elevation well below the top of bank indicating downcutting. Undercuts were observed on both banks, with the greatest demonstrated on the right bank (480 mm) near the middle of the site. Uprooted trees at the banks also supported the evidence of bank instability and a widening channel.	Instream vegetation was very limited consisting entirely of moss where substrate allowed. Riparian vegetation consisted forest up to 10 m and on both banks with meadow beyond. The forested areas near the upstream half of the site provided ample canopy cover, with the downstream section left relatively unshaded on the left bank.	The site was immediately downstream of Concession St E, a well-travelled regional road which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely the adjacent landuse development on the right bank beyond the ~80 m riparian zone on the right bank and the residential area to the left. Upstream residential areas were also likely contributors as well as upstream agricultural land. No barriers to fish were observed.

Habitat Characteristics	General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
SOP5A	Permanent	SOP5A was approximately 140 m downstream of the CP Railway right-of-way within the main Soper Creek branch.	Site length was 63.5 m. Minimum wetted width was 5.8 m and the average wetted width was 6.84 m. The average depth was 175 mm and the maximum depth sampled was 390 mm. The site fell within the relatively un assumed natural area, bordered between a residential/development area to the west and a large natural area to the east. The site was located immediately downstream of a contributing tributary to the main branch of Soper Creek (unnamed).	This site was dominated by fast moving riffles and runs, with no pool habitat observed. Fish were observed throughout the fast-moving water, behind larger substrate where available. Aquatic vegetation cover was minimal at the time of observation, consisting only of moss. Cover was mainly provided by surface turbulence attributed to the fast-moving water and shallow water depths.	Substrate was very poorly sorted and was extremely uniform with no meander forms throughout the sit. Sands represented up to the D84 and cobbles representing the upper percentile. There was no evidence of aggradation. The maximum particle size was observed at 290 mm. The mean max particle was 71.68 mm.	Evidence of bank instability was observed throughout the site, with steep angles observed on both banks and a riverbed elevation well below the top of bank (1 – 3 m) indicating downcutting throughout the system. Undercuts were observed on both banks. Five were observed on the left bank ranging from 30 mm to 230 mm and three were observed on the right (70 – 230 mm).	Instream vegetation was dominated by moss. Riparian vegetation consisted almost entirely of meadow on both banks, with some forest canopy cover provided on the right bank near the upstream extent.	The site was immediately downstream of the CP Rail crossing which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely the agricultural land. No barriers to fish were observed within the site, however a historic dam was observed approximately 780 m downstream of the site, representing the first fish barrier observed in the Soper Creek system. Fish were observed both up and downstream of this barrier, indicating that it is navigable by multiple fish species, dominated mainly by salmonids (Rainbow trout and Chinook salmon).
SOP6A	Permanent	SOP6A was approximately 200 m upstream of SOP5a and approximately 40 m upstream of the CP Railway right-of-way within the main Soper Creek branch.	Site length was 45.5 m. Minimum wetted width was 4.4 m and the average wetted width was 5.4 m. The average depth was 228.67 mm and the maximum depth sampled was 985 mm. The site fell within one of the widest parts of the watercourse corridor, with a residential area to the west and an agricultural area to the west.	This site was dominated by fast moving riffles and runs, with one of the largest pools within the system observed downstream of a steep riffle mid-site. Cover was provided by overhanging cedars on the right bank and large cobbles and boulders near the upstream reach and within the pool. Large rainbow trout were observed within the pool throughout most of the year, with a large specimen observed during electrofishing (July) but was unsampleable. Aquatic vegetation cover was minimal at the time of observation, consisting mainly of moss with some rooted macrophytes.	Substrate demonstrated better sorting than other downstream sites but remained relatively poor. Similar to downstream sites, sands represented up to the D50 for point substrate, with larger cobbles representing the D84. Cobbles and larger boulders represented the maximum substrates throughout the site. Evidence of aggradation existed on the right bank, downstream of the steep riffle on the eddy side of the pool habitat. The maximum particle size was observed at 620 mm. The mean max particle was 208.31 mm.	Evidence of bank instability was observed in moderation throughout the site, with steep angles observed on both banks throughout the middle of the site where flow direction shifted after the pool habitat. Less evidence of downcutting was observed here than at the downstream sites. Undercuts were observed mainly on the right bank, where overhanging cedars kept topsoil intact. Four were observed on the right bank ranging from 100 mm to 720 mm.	Instream vegetation was dominated by moss with some rooted macrophytes throughout. Riparian vegetation consisted almost entirely of meadow on the left bank, with the right dominated by well-established cedar forest which provided much of the site with canopy cover. One large willow provided cover on the pool habitat from the left bank.	SOP6A was not immediately downstream of any major crossings or in the immediate vicinity of major disturbances. The nearest crossing (Concession Road 3) was approximately 1.15 km upstream. A small residential area existed on the left bank buffered by ~ 120 m of meadow. Evidence of ATV and other motorized vehicles using the meadow existed, with trails extending down to the watercourse. Evidence of fishing pressure also existed at the large pool habitat. Two offline ponds existed upstream of Concession Road 3 which may contribute to thermal impacts. Other contributions to nutrients and pollutant loading include adjacent and upstream agricultural lands.

Habitat Characteristics	General Flow Regime	Site Location	Site Characteristics	Habitat Description	Substrate Composition	Bank Stability	Instream and Riparian Vegetation	Fish Barriers and Other Disturbances
SOP7A	Permanent	SOP7A was located within a contributing tributary, approximately 400 m upstream of the confluence with the main branch Soper Creek. The site was the second-most upstream site.	Site length was 49.5 m. Minimum wetted width was 1.6 m and the average wetted width was 2.59 m. The average depth was 62.87 mm and the maximum depth sampled was 270 mm. The site was surrounded by very little landuse development, with surroundings typical of a coldwater, thick cedar-swamp, headwater stream.	This site was dominated by slow moving riffles and runs, with few small pools observed throughout the site. In general, abundant large substrate minimized open water habitat and overall fish habitat. Cover was provided by thick overhanging cedars on both banks, as well as abundant large cobbles and boulders throughout the reach. Five points sampled fell on islands, indicating areas of aggradation.	Substrate was poorly sorted, varying completely from downstream observations in the main branch of Soper Creek. Sands represented up to the D50 for point particles, with larger cobbles and boulders representing the majority of substrate. Evidence of aggradation existed in areas with sandy point bars observed throughout. The maximum particle size was observed at 670 mm. The mean max particle was 219.34 mm.	Evidence of erosion was observed throughout the reach, but to a much lesser extent than in the main Soper Creek branch. Cedar roots provided bank stability throughout much of the site; however, downcutting up to 1250 mm was observed on both banks with 3 transects falling on undercuts on the left bank (180 – 250 mm) and 4 on the right bank (80 – 260 mm).	Instream vegetation was non-existent at the time of investigation, likely due to substrate composition. Riparian vegetation consisted entirely of thick cedars, which provided the site with ample canopy cover. No understory existed.	The site was approximately 900 m downstream of Liberty St N, buffered by thick cedar forest that likely mitigated any potential nutrient or pollutant loading. Upstream residential areas and lawns, along with a large residential development (upstream of Liberty St N) likely contribute to loading. Other contributions include adjacent and upstream agricultural lands. A culvert downstream of the site servicing Mearns Avenue has been identified by CLOCA as a potential fish barrier. This is supported by low species diversity and abundance compared to downstream and upstream sites. This can also likely be attributed to the lack of aquatic habitat.
SOP8A	Permanent	SOP8A was the furthest, most upstream location in the Soper Creek system, located within a contributing tributary immediately upstream of the Liberty St N right-of-way.	Site length was 35.8 m. Minimum wetted width was 1.5 m and the average wetted width was 1.79 m. The average depth was 94.25 mm and the maximum depth sampled was 205 mm. The site was fell within a headwater stream of Soper Creek, with a large residential development upstream and adjacent to the site. The site shared characteristics typical of a coldwater, thick cedar-swamp, headwater stream with more evidence of impacts observed when compared to the downstream SOP7A site.	This site was dominated by slow moving riffles and runs, with few small pools observed throughout the site. Open water was more abundant that SOP7A, with aquatic and fish habitat more appropriate for fish communities. Cover was provided by thick overhanging cedars on both banks, as well as abundant large cobbles and boulders throughout the reach. No points sampled fell on islands.	Substrate demonstrated better sorting than SOP7A, with much fewer large cobbles and boulders, but a more abundance of fines. Sorting remained poor. Sands represented up to the D50 for point particles, with cobbles and boulders representing the majority of substrate. Cobbles represented the maximum substrates throughout the site. The maximum particle size was observed at 860 mm. The mean max particle was 167.42 mm.	Banks were more stable throughout this reach, with less downcutting and less undercutting. Three transects fell on undercuts on the left bank (165 – 240 mm) and 2 on the right bank (100 – 105 mm). Bank angles were typical of coldwater headwaters within cedar-swamp forests.	Instream vegetation was non-existent at the time of investigation, likely due to substrate composition. Riparian vegetation consisted entirely of thick cedars, which provided the site with ample canopy cover. No understory existed.	The site was surrounded by upstream and adjacent landuse development buffered by thick cedar forest that likely mitigated any potential nutrient or pollutant loading. Upstream residential areas and lawns, along with a large residential development likely contribute to loading. A number of golf courses also existed upstream. The site fell immediately upstream of a CSP culvert servicing Liberty St N which acted as barrier to fish movement. Despite being upstream of a fish barrier, this site observed a higher species diversity and abundance compared to the downstream SOP7A site, including a warmwater YOY cyprinid which likely entered the system from upstream golf course irrigation ponds.



Clarington

Legend

- Study Area
- Aquatic Monitoring Stations
- Watercourse

KEY MAP

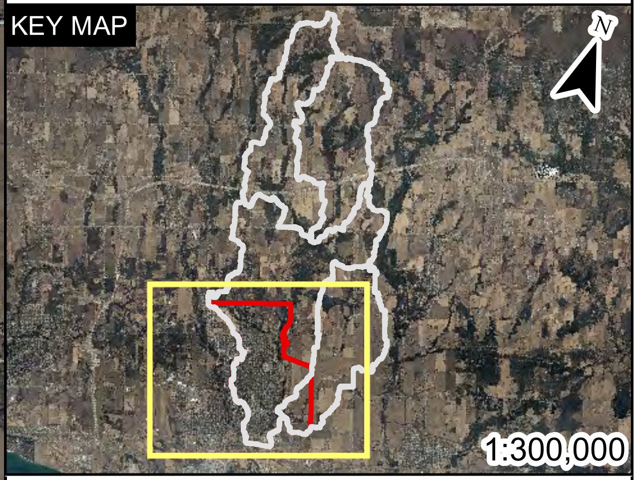


Figure 3.48

Aquatic Monitoring Stations

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.375 0.75 1.5
Kilometers

N

Aquafor Beech Limited

3.3.3.1.2 Conclusions

Within the study area, Soper Creek and its contributing tributaries exhibited a variety of aquatic habitat, varying in functionality throughout the reaches. The highest quality habitat was observed in the upstream sections (SOP4A through SOP8A); however, aquatic habitat throughout the entire system demonstrated conditions that provided integral habitat to a number of sensitive fish communities. As discussed in detail within **Section 3.3.3.3**, upstream sections of the Soper Creek subwatershed supported the greatest abundance of sensitive, coldwater species such as Rainbow trout (*Oncohynchus mykiss*) with aquatic habitat representative of these observations. SOP7A and SOP8A demonstrated characteristics of a coldwater stream contributing to the headwaters of Soper Creek, with abundant cover provided by coarse substrate and overhanging dense cedar forest. A number of groundwater influences were also observed throughout the year which contribute to high quality coldwater habitat.

The main branch of Soper as observed at sites SOP1A, 2A, 4A, 5A and 6A provided valuable habitat to migratory and resident salmonids such as Chinook Salmon, Brown Trout and Rainbow Trout that are typically more tolerant of disturbance. Along with migratory salmonids, downstream stretches provided habitat to a more diverse fish community with species that are generally more tolerant of disturbance and are characteristic of warmer thermal regimes, indicating impacted habitat within the downstream sections. In general, aquatic habitat demonstrated more impacts as the system progressed towards the mouth of the river which is likely attributed to adjacent and upstream land use development and other anthropogenic disturbances associated with the Town of Bowmanville. Downcutting of the creek bed worsened near the mouth with evidence of erosion on the banks and aggradation within the creek itself.

As the subwatershed progressed towards Lake Ontario, contributing features and tributaries increased in abundance, including Bowman Creek where SOP3A fell. SOP3A, which was selected to represent a contributing tributary of Soper Creek demonstrated the greatest amount of disturbance among the sampling sites, with aggradation and sedimentation observed throughout, as well as little instream vegetation, and little fish diversity. Furthermore, as detailed in **Section 3.3.3.2**, benthic macroinvertebrates within SOP3A were characteristic of an impaired watercourse. This supports that as the drainage area of Soper Creek increases, so to do the contributing features and the associated disturbances, leading to downstream aquatic habitat with characteristics suggestive of greater impacts.

A number of fish barriers were observed throughout the system. However, upstream reaches demonstrated comprehensive function as aquatic habitat, despite these fish barriers. The first barrier encountered within the system was observed upstream of Concession Street East, where a historic dam spanned the width of the stream and reached approximately 1 m of jumping height. Upstream of this barrier, diversity decreased with fish communities dominated by salmonids, such as Rainbow trout which are able to navigate barriers of greater jumping height. Chinook Salmon were also observed upstream of this barrier though were not sampled during electrofishing. A number of online and offline ponds were also observed throughout Soper Creek which could also provide to habitat. Barriers, ponds and crossings are discussed in **Section 3.3.3.4**.

In general, aquatic habitat was observed throughout the study area as both direct and contributing fish habitat. This is further supported in the following sections. Soper Creek and its contributing tributaries should be regarded as key features within the NHS and protected under the municipal OP.

3.3.3.2 Benthic Macroinvertebrate Communities

Benthic macroinvertebrates are commonly used to assess water quality, health, and integrity of aquatic ecosystems and are generally dependent on the quantity and quality of available aquatic habitat. While the municipal OP does not define fish habitat, Fisheries and Oceans Canada see fish habitat as “the spawning grounds and nursery, rearing and food supply, and migration areas” on which fish depend directly or indirectly in order to carry out their life processes (Department of Fisheries and Oceans, 2019). Benthic macroinvertebrates also represent important food sources for fish which helps identify fish habitat as defined above, a key feature within the NHS. They are suitable for study for many reasons, including:

a) Benthic invertebrates are highly sensitive to environmental changes which make them excellent indicators of water quality;
b) Benthic invertebrates are abundant in nearly all watercourses, living on or in the substrate;
c) Benthic invertebrates can be easily and inexpensively collected and easily quantified;
d) Benthic invertebrates are easily identified; and
e) They have restricted mobility and specific habitat preferences, and therefore cannot simply move away from environmental stresses occurring at a site. (Griffiths, 1999)

3.3.3.2.1 Methodology

Sites were set up using Section 1: Modules 1-3 (Site Identification and Site Features) of the OSAP. Sampling was conducted in accordance with OSAP, using the transect traveling kick and sweep method (Section 2: Module 3). This method involves walking from one bank to the other for three minutes while kicking the stream bed and holding a 500 µm D-net downstream to collect dislodged organisms. After three minutes the organisms are emptied from the net, placed in a jar and preserved in the field using isopropyl alcohol. This collection is completed at three sampling locations within a sampling reach (riffle-pool-riffle).

Samples were subsampled using the teaspoon method until at least 100 specimens were found. Specimens from each sample were identified to Family level. The OSAP field sheets are presented in **Appendix F.**

To analyze samples, water quality can be assessed using multiple indices, or metrics, which are easy to calculate. Multiple indices could relate to specific impacts, making it necessary to use many metrics to detect impacts.

In addition to species richness (e.g., the total number of taxa) and composition metrics (e.g., % Diptera), macroinvertebrates can also be classified according to:

- functional feeding groups (e.g., % Collector-Filterers, % Scrapers, % Shredders)

- habit/behavior characteristics (e.g., % Clingers)

Functional feeding groups provide an indication of food web relationships. Habitat and behavior characteristics indicate the functionality of the organism (e.g., the way it moves or searches for food) (Barbour et al, 1999).

The samples collected as part of this study were analyzed and compared qualitatively using a multimetric approach to summarize the condition of the watercourse, using the following indices:

Taxa Richness: Indicates diversity of taxa. The number of taxa increases with habitat quality and water quality.

% EPT: Percent composition of Ephemeroptera, Plecoptera and Trichoptera (EPT). Reflects the composition of the benthic community within Families that are considered to be sensitive to water quality.

% Oligochaeta: Percent composition by aquatic worms (tolerant organisms).

% Diptera: The percent composition by larvae of true flies.

% Chironomidae: The percent composition by larval midges.

% Collector-filterer: The percent composition by detrivores (feed on decomposing fine particulate organic matter) which filter feed or are suspension feeders.

% Collector-Gatherer: The percent composition by detrivores which gather food or are deposit feeders.

% Predator: The percent composition of organisms that feed on living animal tissue (not including parasitic organisms) by engulfing or piercing (Merritt et al, 2008).

% Scraper: The percent composition by organisms that feed on periphyton by grazing and scraping mineral and organic surfaces (Merritt et al, 2008).

% Shredder: The percent composition by organisms that feed on living vascular aquatic plant tissue by chewing, detrivores that feed on decomposing vascular plant tissue (coarse particulate organic matter) by chewing, and/or organisms that feed on wood by gouging and excavating (Merritt et al, 2008).

% Clinger: The percent composition by organisms having fixed retreats or adaptations for attachment to surfaces in flowing water (Barbour et al, 1999).

Shannon's Diversity Index:

The Shannon Weiner Diversity Index (H') is used to measure diversity in categorical data. This index takes into account the number of species and the evenness of the species.

Shannon's Diversity Index is calculated using the following formula:

$$H' = -\sum(p_i)(Lnp_i)$$

Where p_i is the proportion of individuals in the "ith" taxon of the community. H' increases as the number and distribution of taxa (diversity) in a sample increase.

Hilsenhoff's Family Biotic Index:

The Hilsenhoff's Family Biotic Index (FBI) uses the pollution tolerances of organisms to determine the level of stream impairment. Each organism is assigned a tolerance value of 0 to 10, with a value of 0 indicating that the organism has a very low tolerance to pollution and a value of 10 indicating that the organism has a very high tolerance to pollution. The index is calculated using the following formula:

$$FBI = \sum(x_i)(t_i)\ /n$$

Where x_i is the number of organisms in the i^{th} taxon, t_i is the tolerance value of the i^{th} taxon, and n is the total number of organisms in the sample.

Interpretation of the FBI Value is shown in **Table 3.15.**

Table 3.15: FBI Value Interpretation

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very Good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probably
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly Poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very Poor	Severe organic pollution likely

3.3.3.2.2 Results

The following are the results of the habitat assessment, benthic invertebrate community, and associated metrics. **Table 3.16** provides a summary of the aquatic habitat conditions of the sites that were sampled, including the sampling date, average wetted width, average wetted depth, average hydraulic head, average bankfull width, channel substrate, and descriptions or instream and riparian habitats. Sample locations are displayed in **Figure 3.48**.

Table 3.16: Benthic Invertebrate Habitat Summary

Site	Date Sampled	Average Wetted Width (m)	Maximum Depth (mm)	Average Hydraulic Head (mm)	Substrate	Instream Habitat	Riparian Habitat	Other Site Features
SOP1A	July 11, 2018	7.41	935	7.67	Consolidated clay, sand, gravel, cobble and some boulders	Very little emergent and submergent vegetation was present throughout the site. Very little detritus or woody material was present. No algae was observed. Moderate canopy cover was provided from overhanging trees.	Left bank riparian vegetation consisted of forest up to 10 m with no vegetation beyond. Right bank consisted of forest.	A number of road crossings and a CP Rail crossing existed upstream of the site, along with multiple residential areas and residential developments. A well-used park existed on the left bank with maintain lawn and sports fields. An industrial area existed beyond the 30 m riparian zone on the right bank.
SOP2A	June 22, 2018	8.37	580	5.48	Sand, gravel and cobble	Very little emergent and submergent vegetation was present throughout the site. Very little detritus or woody material was present. No algae was observed. Moderate canopy cover was provided from overhanging trees.	Left bank riparian vegetation consisted of forest up to 30 m with meadow beyond. Right bank consisted of forest.	The site was immediately downstream of King St E which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely adjacent lawns, as well as upstream residential areas, residential developments and agricultural lands.
SOP3A	June 22, 2018	1.49	255	0.25	Sand, silt, and gravel	Very limited instream vegetation consists of emergent vegetation. Attached algae was present in the runs near the downstream reach. Detritus and woody material were present throughout. Canopy cover provided by overhanging trees was moderate.	Both right and left banks consisted of forest up to 100 m.	The site was immediately downstream of King St E which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely adjacent park lawns, as well as upstream residential areas.
SOP4A	June 22, 2018	8.11	640	7.02	Sand, gravel and cobble	Instream cover was limited, provided entirely by cobbles and gravel. Very little vegetation was present in the form of submergent macrophytes. Canopy cover was limited to select areas provided by large trees. Woody material was present throughout, concentrated in large jams.	Left bank riparian vegetation consisted of forest up to 10 m with meadow beyond. Right bank consisted of forest.	The site was immediately downstream of Concession St E which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely the adjacent land use development on the right bank beyond the ~80 m riparian zone on the right bank and the residential area to the left. Upstream residential areas were also likely contributors as well as upstream agricultural land.
SOP5A	June 22, 2018	6.84	390	10.68	Sand, gravel and cobble	Aquatic vegetation was very limited throughout the site, provided entirely by submergent vegetation. Woody material and detritus were absent. Canopy cover was very limited.	Left bank consisted of cropland up to 30 m with forest beyond. Right bank consisted of meadow up to 30 m and forest beyond.	The site was immediately downstream of the CP Rail crossing which likely contributed to nutrients and pollutant loading within the site and system. Other contributions were likely the agricultural land. A contributing tributary was observed on the left bank which ran dry later in the year.
SOP6A	June 22, 2018	5.40	985	15.62	Sand, gravel, cobble and some boulders	Aquatic vegetation consisted of submergent macrophytes and attached algae in runs. Canopy cover provided by well-established, large trees cedars on the right bank and a large willow on the left. Woody debris present in select areas.	Both right and left banks consisted of forest up to 100 m.	The nearest crossing (Concession Road 3) was approximately 1.15 km upstream. A small residential area existed on the left bank buffered by ~ 120 m of meadow. Evidence of ATV and other motorized vehicles using the meadow existed, with trails extending down to the watercourse. Two offline ponds existed upstream of Concession Road 3 which may contribute to thermal impacts. Other contributions to nutrients and pollutant loading include adjacent and upstream agricultural lands.

Site	Date Sampled	Average Wetted Width (m)	Maximum Depth (mm)	Average Hydraulic Head (mm)	Substrate	Instream Habitat	Riparian Habitat	Other Site Features
SOP7A	June 22, 2018	2.59	270	0.78	Sand, gravel, cobble and boulders	Aquatic vegetation was very limited consisting entirely of emergent and submergent macrophytes. Detritus was not present, and woody material limited at the time of assessment. Canopy cover provided the reach with 100% cover.	Both right and left banks consisted of well-established cedar swamp forest up to 100 m.	The site was approximately 900 m downstream of Liberty St N, buffered by thick cedar forest that likely mitigated any potential nutrient or pollutant loading. Upstream residential areas and lawns, along with a large residential development (upstream of Liberty St N) likely contribute to loading. Other contributions include adjacent and upstream agricultural lands.
SOP8A	June 22, 2018	1.79	205	0.00	Sand, gravel and cobble	Aquatic vegetation was very limited consisting entirely of emergent and submergent macrophytes. Detritus and woody material was present but limited at the time of assessment. Canopy cover provided the reach with 100% cover.	Both right and left banks consisted of well-established cedar swamp forest up to 100 m.	The site was surrounded by upstream and adjacent landuse development buffered by thick cedar forest that likely mitigated any potential nutrient or pollutant loading. Upstream residential areas and lawns, along with a large residential development likely contribute to loading. A number of golf courses also existed upstream.

Benthic Invertebrate Communities

The metrics calculated for the organisms collected at each site are summarized in **Table 3.17**, below; detailed information about each sampling site follows. Given that it is difficult to determine specific thresholds for the number, or percentage, of organisms for each metric that should be found in an unimpaired stream sample, sampled sites were compared to each other as well as average values for the entire study area.

There are known differences in the way the indices respond to human disturbance/habitat degradation (Jones, 2007). For Taxa Richness, % EPT, % Scraper, % Shredder, % Clinger, % Omnivore and the Shannon Index, a larger value implies a healthy biological community and low values imply reduced health (Jones, 2007; Barbour et al, 2009). For % Oligochaeta, % Chironomidae, % Isopoda and FBI, a lower value implies a healthier community (Jones, 2007; Barbour et al, 2009). However, there is no "target value" since there are no reference sites in this study. We can only determine which sites have higher or lower values.

In the case of % Collector-Filterer, % Collector-Gatherer, % Predator and % Diptera, critical values lie at both extremes (Jones, Somers, Craig, & Reynoldson, 2007) (Barbour et al, 2009). Therefore, these metrics were not used as an indication of better water quality between sites. However, they are useful to note habitat differences and changes in habitat quality over time, which suggests a change in water quality.

Table 3.17: Benthic Invertebrate Monitoring Results

	SOP1A	SOP2A	SOP3A	SOP4A	SOP5A	SOP6A	SOP7A	SOP8A
Total Number of Organisms	384	433	385	402	366	388	246	349
Taxa Richness	17	14	9	17	12	21	19	10
% Oligochaeta	2.34	6.47	7.01	8.71	3.55	8.76	2.03	2.01
% Diptera	36.98	69.28	15.58	46.02	50.27	34.02	48.78	77.36
% Chironomidae	33.59	69.05	15.06	42.04	47.81	27.06	42.28	76.79
% Isopoda	5.47	1.39	67.53	0.25	0.00	0.00	0.00	0.29
% EPT	22.40	3.23	1.30	30.60	23.77	39.18	26.42	0.00
% F-C	17.71	2.77	1.04	18.66	4.92	9.79	14.63	0.29
% G-C	77.86	96.07	98.96	78.11	93.99	82.73	79.67	98.85
% Pred	37.76	70.21	15.06	45.27	48.91	33.51	43.90	77.08
% Scr	9.11	1.85	0.52	0.75	1.37	3.35	3.66	1.43
% Shr	12.24	2.08	0.52	1.24	3.01	6.19	5.69	1.15
% Omni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Clinger	31.77	6.47	1.82	35.07	25.96	44.59	34.15	1.72
Shannon-Weiner Diversity	1.98	1.16	1.07	1.84	1.52	2.10	1.92	0.75
FBI	5.07	5.82	7.75	5.32	5.04	5.05	4.98	5.71

Indicates best water quality
Indicates second best water quality
Indicates worst water quality

3.3.3.2.3 Conclusions

Overall, the benthic invertebrate sites in Soper Creek indicated Fair to Good water quality. Communities that indicated the highest water quality and highest integrity of aquatic habitat were observed in the upstream sites of SOP6A, which was the furthest-most upstream site in the main branch of Soper Creek, and SOP7A, which fell in a contributing headwater stream upstream of Concession Road 3 and any major development.

SOP6A, within the main branch of Soper but upstream of the CN Rail line and the majority of existing landuse development, observed the highest taxa richness, as well as the highest Shannon-Weiner Diversity Index indicating this site had the most diverse benthic community. This site also had the highest abundance of sensitive Ephemeroptera, Plecoptera and Tricoptera (EPT). Zero Isopoda which are highly tolerable to disturbance were observed here, along with the downstream site of SOP5A. These observations indicate that the upstream sites of the main Soper Creek branch had the best water quality and the highest integrity of aquatic habitat.

SOP7A, which fell approximately 520 m upstream of the confluence with the main branch of Soper Creek in a contributing headwater stream, observed the second highest taxa richness in the system along with the lowest Hilsenhoff Family Biotic Index (FBI) of 4.98, or “Good” water quality with “Some organic pollution probable”. Zero Isopoda were also observed here. Aquatic habitat within this feature, observed at SOP7A and SOP8A, were vastly different from the habitat observed in the main branch of Soper Creek. The feature fell within thick cedar swamp forest which provided ample canopy cover and stream shading. This, along with a number of groundwater indicators, likely contribute to the health of the benthic community and the overall health of the headwater stream, creating a valuable coldwater contribution to Soper Creek. These observations indicate that the headwater streams outside of the major development areas contribute to the overall health of the main Soper Creek branch and the Soper Creek Subwatershed as a whole and should be protected. Areas adjacent to these features that differ from the habitat characteristics listed above, such as the area downstream of Mearns Ave and upstream of the Soper Creek confluence, should be considered for restoration where riparian plantings would benefit the stream by providing additional canopy cover where historic agriculture has removed all cedar cover.

Contrary to the generally high water aquatic habitat quality observed within the upstream of Soper Creek and its headwater streams, site SOP3A, which is located within Bowman Creek immediately downstream of King Street East and approximately 425 m upstream of Soper Creek, observed a benthic community that indicated “Very Poor” water quality with “Severe organic pollution likely”. This site indicated the worst water quality throughout the subwatershed, indicating that downstream contributing features may negatively influence the water quality and habitat of the Soper Creek system. The majority of the organisms sampled at SOP3A are pollution tolerant and are expected to be found in highly disturbed areas. However, the presence of EPT in small numbers indicates the potential for improved habitat if selected for restoration efforts.

Despite falling downstream of contributing features such as Bowman Creek and other potential sources of contaminants and nutrient loading, sites SOP1A and SOP2A observed similar benthic communities as the upstream sites. SOP2A results showed an FBI of 5.82, indicating “Fair” water quality with “Fairly substantial pollution likely”. The furthest, most downstream site (SOP1A) had an

FBI of 5.07 and the second highest Shannon-Weiner Diversity Index score (1.98). These observations suggest that despite aquatic habitat seemed to decrease in integrity as the subwatershed progressed downstream towards Lake Ontario, benthic communities were still demonstrative of generally fair water and aquatic habitat quality. This is supported by a diverse fish community at SOP1A with sensitive salmonids, including the only Brown Trout (*Salmo trutta*) observations within the Soper Creek system.

Measures of biodiversity can be influenced by factors outside of water quality. For a better understanding of water quality using benthic invertebrates as indicators, sampling would need to be conducted each spring over multiple years to allow comparison between sites, over time. Establishing a reference site for the study area would also be beneficial for future monitoring.

As discussed above, benthic macroinvertebrates play an important role in the overall health of a subwatershed. They are a valuable aquatic resource for many reasons, including the representation of an important food source for fish. This helps determine both direct and contributing fish habitat, a key feature in the NHS as defined by the municipal OP. Soper Creek displayed benthic macroinvertebrate communities that provide an important food source for fish and can therefore support fish directly or indirectly. These habitats should therefore be considered important fish habitat within the NHS. It is recommended that fish habitat be evaluated through site-specific studies in order to determine if habitat directly supports fish.

3.3.3.3 Fish Communities

Fish are effective biological indicators. They occur in a wide variety of habitats which are widely studied. Ontario fishes exhibit a wide range of tolerances to many disturbances and are easy to identify to species level. The following section focuses on the fish communities found within the Soper Creek subwatershed.

Conditions within the Soper Creek subwatershed allowed for fish community assessments at all sites discussed within **Section 3.3.3.1** and **Section 3.3.3.2**. Fish sampling was conducted in accordance with OSAP Version 10, Section 3: Module 1: Fish Community Sampling using Screening, Standard, and Multiple Pass Electrofishing Techniques (Stanfield, 2017). Screening surveys were conducted throughout June 2018 by qualified Aquafor Beech Limited biologists.

3.3.3.3.1 Methodology

Fish communities within the Soper Creek subwatershed were surveyed in accordance with the OSAP fish community sampling procedures (Section 3: Module 1). Surveys were conducted using a Halltech HT2000 Backpack Electrofisher and involved a standard single pass sampling technique with one netter. Sites were standardized following appropriate OSAP procedure in that each reach is represented by at least 40 m between one crossover and another. OSAP field sheets are presented in **Appendix F**.

3.3.3.3.2 Results

Fish community surveys were conducted at all eight sites, as shown in **Figure 3.48**, with five in the main branch of Soper Creek, one in a contributing tributary (Bowman Creek) and two in the headwater streams of Soper Creek.

A summary of the species found at each site is provided in **Table 3.18**. A diagram showing the species community composition is provided in **Figure 3.49**.

Table 3.18: Fish Community Survey Results

Scientific Name	Common Name	Count								
		SOP1A	SOP2A	SOP3A	SOP4A	SOP5A	SOP6A	SOP7A	SOP8A	Total
Oncorhynchus mykiss (YOY)	Rainbow Trout	16	11		39	54	30	12	24	**186**
Oncorhynchus mykiss (Adult)	Rainbow Trout	1	8		7	7	6		6	**35**
Salmo trutta (YOY)	Brown Trout	1								**1**
Salmo trutta (Adult)	Brown Trout	2								**2**
Semotilus atromaculatus	Creek Chub	2		5						**7**
Rhinichthys atratulus	Blacknose Dace	10		2	1	3			2	**18**
Rhinichthys cataractae	Longnose Dace	8	3	2	1					**14**
Neogobius melanostomus	Round Goby	2	1							**3**
Catostomus commersoni	White Sucker	3	7	2						**12**
Perca flavescens	Yellow Perch	1								**1**
Cottus bairdii	Mottled Sculpin		2		1	9	5			**17**
Etheostoma nigrum	Johnny Darter		3	1	2					**6**
Micropterus salmoides	Largemouth Bass				1					**1**
Lepomis sp.	Lepomis sp.								1	**1**
Total		**46**	**35**	**12**	**52**	**73**	**41**	**12**	**33**	**304**

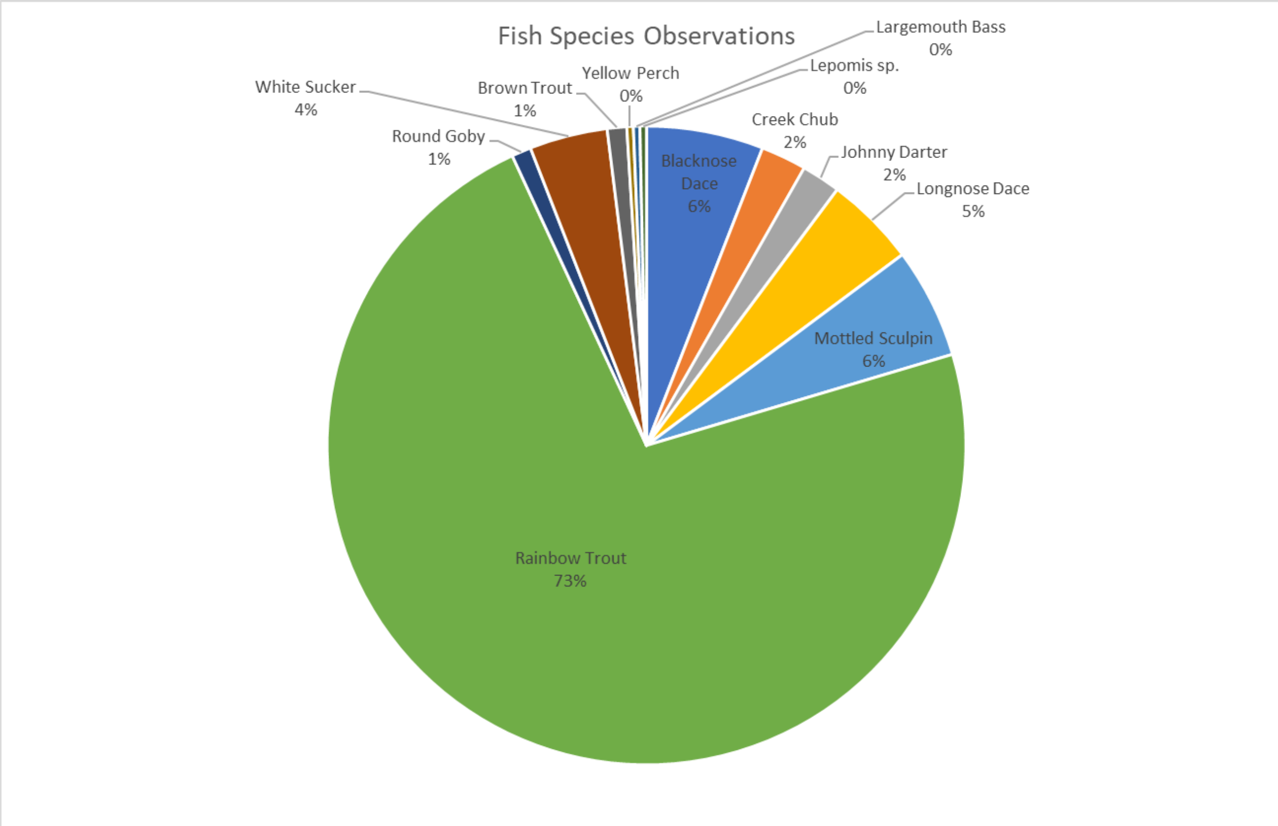


Figure 3.49: Soper Creek Subwatershed Fish Community Composition

3.3.3.3.3 Conclusions

A total of 12 fish species were recorded in Soper Creek and its contributing tributaries. Species communities differed throughout the system and were representative of the aquatic habitat discussed above. Sites downstream of the first barrier (shown in **Figure** 3.50) encountered in Soper Creek observed the greatest diversity, with SOP1A observing eight different species and SOP3A and 4A observing six species. Upstream of the aforementioned fish barrier, diversity declined. Despite a lesser degree of diversity, the communities observed at SOP5A, 6A, 7A and 8A were comprised of sensitive, coldwater fish species with a vast majority contributed by Rainbow Trout. While these coldwater indicator species were observed downstream of Barrier 1, they were less abundant, with the rest of the community comprised of species that are generally more tolerant to disturbance and thermal impacts. Juvenile rainbow trout represented the vast majority throughout the subwatershed, representing the most widely distributed species, suggesting that the Soper Creek subwatershed presents valuable spawning and rearing habitat for the sensitive species. Moreover, adult Rainbow Trout were observed throughout the system late into the year, suggesting that the creek maintains a coldwater thermal regime well into the summer which could provide over-summer habitat for fish that traditionally seek out thermal refuge in Lake Ontario during the summer months.

The only site at which Rainbow Trout were not sampled was with SOP3A (Bowman Creek). As Rainbow trout are generally indicative of coldwater habitat with limited disturbances, this observation supports that SOP3A demonstrated the poorest water and aquatic habitat quality amongst the sample sites. Furthermore, SOP3A had the lowest abundance of fish observations with fish species that demonstrate intermediate to high tolerance of disturbance. Only two species indicative of warmwater thermal regimes were observed throughout the sites. A single Largemouth bass (*Micropterus salmoides*) was observed at SOP4A below Barrier 1. A single *Lepomis* species (juvenile) was also sampled within the most upstream site in the system (SOP8A), which was above a number of fish barriers. This fish likely entered the headwater stream from upstream golf course irrigation ponds.

Overall, all species observed are common within Ontario. No aquatic Species at Risk (SAR) were observed throughout the sites. Furthermore, Fisheries and Oceans Canada records indicate that no critical habitat for these species is found within the study area. Photographs of sampling sites can be seen in **Appendix H**. Fish were observed throughout the study area, indicating that the subwatershed provides fish habitat as defined by Fisheries and Oceans Canada. It is recommended that fish habitat be evaluated through site-specific studies in order to determine if habitat directly supports fish.

3.3.3.4 Fish Barriers, Crossings and Online Ponds

Fish barriers, watercourse crossings and online ponds can have a number of impacts on watercourses. Fish barriers, such as dams or perched culverts, can affect the ability of fish to migrate through the study area. Watercourse crossings typically are associated with a structure, be that a bridge or a culvert, and can alter the morphology of the watercourse through narrowing or hydrologic jumping. Online ponds can influence the thermal regime of watercourses by increasing the temperatures downstream of the pond while decreasing the dissolved oxygen within the stream (CVC, 2011). Ponds fed by headwater streams, such as those within the study area, are generally cooler than those found further downstream in the system (Ebel & Lowe, 2013). Knowing where these features occur can help inform management decisions in regards to watercourses.

3.3.3.4.1 Methodology

An inventory of fish barriers and online ponds was compiled based on observations made during field work and through an analysis of aerial photographs of the study area.

3.3.3.4.2 Results

A list of fish barriers and online ponds occurring within the study area is presented in **Table 3.19**. Their locations are shown in **Figure 3.50** and photographs, when available, are shown in **Appendix A.**

Table 3.19: Fish Barriers, Crossings and Online Ponds

Type	Location	Description
Fish Barrier 1	Main Soper Creek Pedestrian path behind "Camp 30" *17T 686966 m E, 4866439 m N*	Creek flows south over dam structure with stop logs creating top draw fish barrier (~1 m jumping height). Seems to have provided historic water level control. Chinook salmon observed up and downstream of structure.
Fish Barrier 2	Soper Creek Tributary Beaver dam, east of Lambs Road. *17T 688325 m E, 4865217 m N*	Creek flows south over large beaver dam creating fish barrier (~1.5 m jumping height).
Fish Barrier 3	Soper Creek Tributary Private dam, west of Lambs Road *17T 685916 m E, 4868007 m N*	Headwater feature (SOP3-8) flows east and is held behind private top draw dam structure. SOP3-8 demonstrated coldwater indicators throughout the year. Downstream tributary was observed dry.
Fish Barrier 4 *(Potential)*	Soper Creek Tributary Mearns Ave crossing, north of Concession Rd 3 *17T 686033 m E, 4867738 m N*	Creek flows east beneath Mearns Ave right-of-way, immediately downstream of monitoring station SOP7A. CSP culvert demonstrated elevated stream velocity during low flow, indicating the structure creates a barrier during times where water levels are low. Fish were observed upstream of barrier, suggesting the structure is navigable at times.
Fish Barrier 5 *(Potential)*	Soper Creek Tributary Liberty St N crossing, north of Concession Rd 3 *17T 685132 m E, 4867811 m N*	Creek flows east beneath Liberty St N right-of-way, immediately downstream of monitoring station SOP8A. CSP culvert demonstrated elevated stream velocity during low flow, indicating the structure creates a barrier during times where water levels are low. Fish were observed upstream of barrier, suggesting the structure is navigable at times.
Crossing 1	Main Soper Creek Wharf Street easement crossing *17T 686874 m E, 4863435 m N*	Historic easement for Wharf Street. No barrier observed.
Crossing 2	Main Soper Creek Private crossing, north of King St E *17T 687268 m E, 4864915 m N*	Private property: Crossing behind Bowmanville Zoo identified through ortho-imagery.
Crossing 3	Soper Creek Tributary Private crossing, north of King St E *17T 687443 m E, 4864905 m N*	Private property: Crossing behind Bowmanville Zoo identified through ortho-imagery. CLOCA has indicated this is a complete barrier to non-jumping fishes and likely restricts passage for jumping fishes as well.
Crossing 4	Soper Creek Tributary Private crossing, east of Lambs Rd *17T 688072 m E, 4864864 m N*	Private property: Pedestrian crossing behind church on corner of Lambs Rd and Highway 2. No barrier observed.

Type	Location	Description
Crossing 5	Soper Creek Tributary Private crossing, east of Lambs Rd *17T 688287 m E, 4864876 m N*	Private property: Pedestrian crossing. No barrier observed.
Crossing 6	Main Soper Creek Private crossing, west of Lambs Rd *17T 686537 m E, 4868480 m N*	Private Property: Pedestrian crossing servicing Offline Pond 2, north of Concession Road 3 and east of Lambs Rd. Identified through ortho-imagery.
Online Pond 1	Soper Creek Tributary Private pond, west of Lambs Road *17T 685889 m E, 4868007 m N*	HDF SOP3-7. Private pond created by Fish Barrier 3. Evidence of fish stocking within the pond. Water levels controlled by dam, limiting flow to downstream watercourse.
Offline Pond 1	Main Soper Creek Private pond, west of Lambs Rd *17T 686312 m E, 4867950 m N*	Private Property: Pond located downstream of Online Pond 1, north of Concession Road 3. Identified through ortho-imagery.
Offline Pond 2	Main Soper Creek Private pond, west of Lambs Rd *17T 686486 m E, 4868438 m N*	Private Property: Pond located downstream of Online Pond 1, north of Concession Road 3 and east of Lambs Rd. Identified through ortho-imagery.

Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Watercourse

Category:

- Barrier
- Crossing
- Offline Pond
- Online Pond

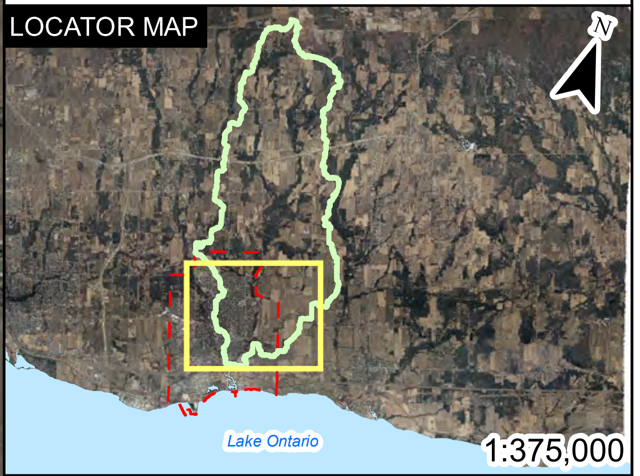


Figure 3.50

Fish Barriers, Crossings & Online Pond

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.25 0.5 1
Kilometers
N

Aquafor Beech Limited

3.3.3.4.3 Conclusions

Minimal fish barriers were observed within the study area; however, assessments were limited to visual inspections within the direct study area for physical barriers (i.e., perched culverts or dams). These inspections do not account for undersized culverts or barriers resulting from extreme gradients. Road crossings should be evaluated to better understand the impacts of non-perched, non-immediate fish barriers for culvert velocity under various storm return events.

The first barrier observed in Soper Creek (Barrier 1) evidently restricts fish movement throughout the corridor, as fish were recorded both upstream and downstream of the barrier, however observations were limited to salmonids with greater jumping capabilities. Fish that are limited in burst speed and jumping height were observed in much less abundance above the barrier compared to below. The beaver dam (Barrier 2) within the contributing tributary of Soper Creek to the east of the study area also likely contributes to fish passage disturbance. As recommended in **Section 3.2.1**, Barrier 3 servicing the private pond (Online Pond 1) and the HDF SOP3-8 should be considered for removal to reinstate fish passage within the Soper Creek tributary. By removing this dam and the associated online pond, thermal impacts will be mitigated by reintroducing the coldwater influence of SOP3-7 to the downstream watercourse. Two potential barriers were observed in the coldwater tributary where monitoring stations SOP7A and 8A were located. Both barriers were existing CSP culverts servicing rights-of-way north of Concession Road 3 (Mearns Ave and Liberty St N). At the time of assessment, water levels within the culverts were limited to sheet flow, creating turbulent and high velocity through the passage, which demonstrated potential challenges to fish migration. However, fish were observed upstream of both culverts (juvenile Rainbow trout) which suggests that the culverts are navigable at times by select species with greater burst speeds. These culverts were identified as potential restoration opportunities, discussed in later sections.

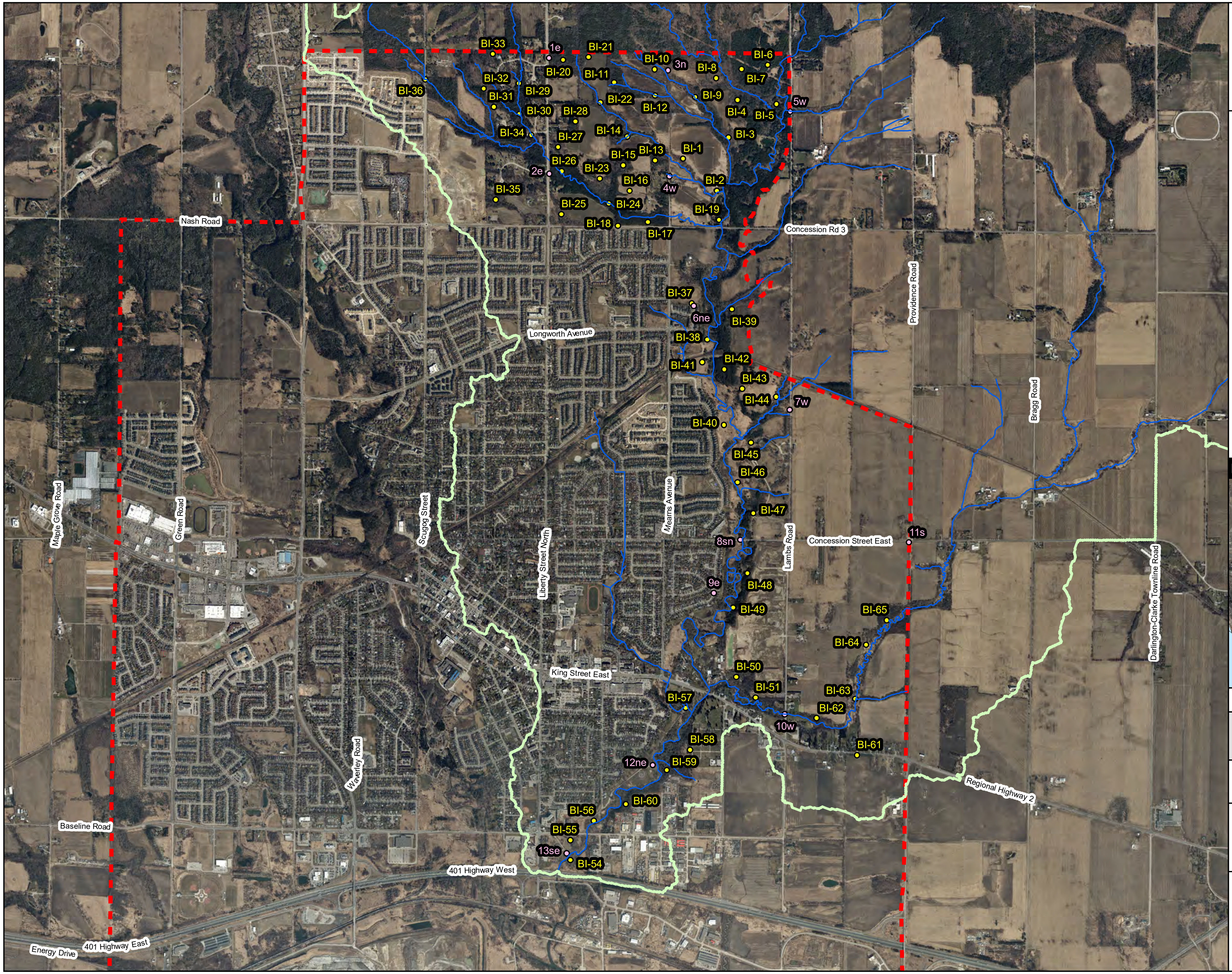
Crossings observed were limited to field observations within the HDF Assessment areas or to those obvious in ortho-imagery. A greater sampling effort is recommended to understand the significance of small-scale, private crossings throughout the subwatershed. It is also recommended that any future crossings, including pedestrian crossings, should consist of clear span bridges with terrestrial benches to allow for all types of events within bankfull conditions. If a clear span bridge is not appropriate, further geomorphic assessment is required to determine appropriate culvert sizing to allow for various return events without impeding on fish passage.

One online pond was noted as discussed above. Two offline ponds were observed in ortho-imagery and should be further assessed in-situ to understand potential impacts to the adjacent and downstream Soper Creek resources.

3.3.4 Terrestrial Resources

Terrestrial resources in the study area include the flora and fauna communities that are present as well as the habitats that support them. Habitat suitability for various species, including Species at Risk (SAR) is generally determined based on the vegetation communities that are present, as there can be specific correlations between certain community types (which often develop only under certain physiographic conditions) and the species that they are able to support. The surveys described in the following sections (vegetation community assessment, botanical inventory, breeding bird survey, and amphibian calling surveys) and their results aid in the delineation of the Natural Heritage Features to be protected by the Municipal NHS, as outlined in **Section 1.3.5**, and detailed further in **Section 3.3.7**.

Terrestrial and wetland vegetation characteristics, breeding bird survey results, amphibian calling survey results, and all other wildlife observations are outlined in the following sections. **Figure 3.51** provides an overview of the specific breeding bird and amphibian point survey locations that were used by this study.



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Watercourse
- Breeding Bird Survey Stations
- Amphibian Calling Stations

LOCATOR MAP

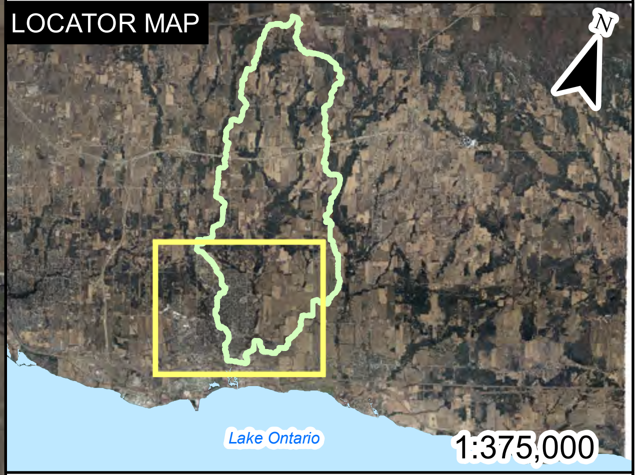


Figure 3.51

Terrestrial Ecology Survey Locations

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 300 600 1,200
Meters
N

Aquafor Beech Limited

3.3.4.1 Vegetation Community Classification

Vegetation community delineation and assessment focuses on identifying individual habitat features such as forests, wetlands, and meadows, and paints a picture of how these features fit together at the landscape level. Mapping of vegetation communities is an important preliminary step in the delineation of the NHS, as it informs our interpretation of habitat patches and mosaics that may be critical to the survival of particular plant or wildlife species in the local context.

The formation of vegetation communities is highly dependent on physical site characteristics such as level of moisture, soil texture, and slope, and so the community types present can also be used to draw conclusions about physical site aspects, such as flooding potential.

3.3.4.1.1 Methodology

Vegetation community assessments were conducted in 2019 on lands where access was permitted. Survey dates are provided above in **Table 3.13**. Vegetation communities were assessed according to Ecological Land Classification (ELC) for Southern Ontario (Lee, et al., 1998), a standardized methodology developed by the MNRF, and supplemented with community types from the Draft 2008 Southern Ontario ELC where no applicable community type was available to accurately represent the attributes of the feature. ELC polygons were evaluated to the community type level wherever possible, although there were sometimes missing or conflicting characteristics that necessitated the use of ecosite or series-level labels being applied instead. Although the smallest polygon size generally assessed under this methodology is 0.5 ha, Aquafor Beech Limited reviewed all distinct features on the landscape to determine their sensitivity/significance, and therefore the resulting ELC mapping produced for this report includes some polygons of less than 0.5 ha size. Soil sampling to ELC protocol standards was carried out in all natural (as opposed to cultural) community types.

Land access was a limiting factor to the locations where field surveys could be conducted. Full assessment per Ecological Land Classification methodology was completed on all lands where access was permitted. Where access was not permitted, limited site review was conducted from adjacent lands and through aerial photo interpretation. Where information on lands without site access permission was available through high level ELC data provided to Aquafor Beech by CLOCA (**Figure 3.52**), that information was incorporated into the current study and refined to the extent possible based on an understanding of the general habitats present elsewhere in the study area.

3.3.4.1.2 Results

A total of 385 ELC polygons were defined through the field work conducted by Aquafor Beech biologists in 2019. In-situ field surveys were completed throughout most of the lands within the Urban Boundary study area, although some locations were either inaccessible due to lack of land access granted and/or lacking in natural heritage features to be assessed. Where ELC mapping for these areas was provide by CLOCA (**Figure 3.52**), however, these polygons were incorporated into the current study and refined to the extent possible. A complete list of communities and a general description of each community type is provided in **Appendix I**.

All of the vegetation communities recorded within the study area are considered common and secure; none are rare at a global, national, or provincial level. Of the 385 ELC polygons delineated by Aquafor Beech, six were found to be ‘complex’ sites. Complexes occur “where site and vegetation conditions are variable, represented by two or more communities intermingled in a mosaic that is too complex to map” (Lee, et al., 1998).

The 385 polygons are composed of a total of 49 unique vegetation types, not including hedgerows and anthropogenic communities which are not recognized by ELC methodologies. Communities found most often within the study area include cultural types (meadows, thickets, and woodlands), Sugar Maple forest types, various meadow and shallow marsh types, and mixed or conifer forests (White Cedar or Plantations). Some communities also have ‘inclusions’, defined generally as areas where distinct communities are found within a larger polygon, but are too small to be individually mapped. As none of the inclusions observed within the study area demonstrated unique features or vegetation community types, they have been largely omitted from tables and maps for the purposes of this study.

In cases where the community codes in the 1998 ELC manual fell short of describing the communities present, updated codes provided by MNRF in 2008 (unpublished), were used (noted with an asterisk [*] in **Table 3.20**).

A list summarizing the vegetation types delineated in the field by Aquafor Beech in 2019 is presented in **Table 3.20**, and an overview of Aquafor Beech’s community delineations is provided in **Figure 3.52**. Communities assigned ELC classifications through aerial interpretation are described in detail in **Appendix I**. More detailed mapping is also provided in **Appendix I**, and the ELC field data sheets are provided in **Appendix K**.

3.3.4.1.3 Conclusions

A total of 385 ELC polygons were delineated by Aquafor Beech Limited biologists in 2019. These are composed of a total of 49 unique vegetation types, including forests, woodlands, wetlands, and culturally influenced community types, 45 of which were investigated with land access as part of field 2019 investigations (**Table 3.20**). All of the vegetation community types delineated are considered to be common and secure; none are rare at a global, national, or provincial level.

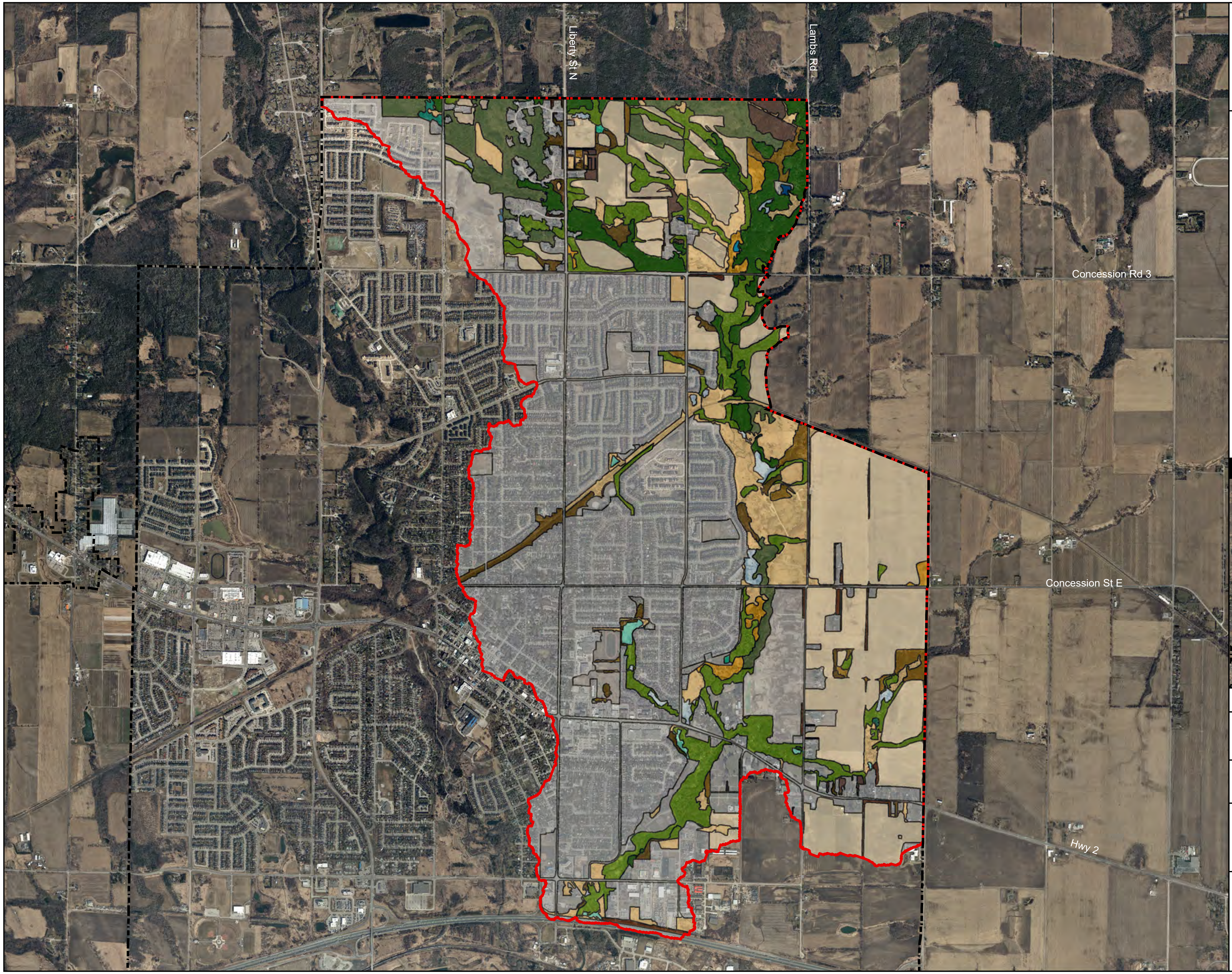
The ELC community types provide the basis for the SAR habitat assessment discussed in **Section 3.3.5**, and the Significant Wildlife Habitat assessment discussed in **Section 3.3.6**. In addition, the woodland communities (i.e., all forests, cultural woodlands, and plantations, per the OP definitions), and wetlands (i.e., all marshes and swamps) delineated through ELC are further assessed for their potential to act as ‘significant woodlands’ and/or ‘wetlands’ that are eligible for inclusion in the NHS in **Section 3.3.7**.

Table 3.20: Summary of Vegetation Communities Delineated in-situ During 2019.[1]

Code	Name	Polygon Numbers
CUM1-1	Dry - Moist Old Field Cultural Meadow	02.01 – 02.34, 34.03, 34.08, 42.05, 49.01, 68.02, 70.01, 70.07, 72.01, 78.06, 78.08, 86.02, 86.06, 86.08, 86.21, 90.06, 201.02, 337.01, 337.012, 373.02, 373.05, 377.01, 377.06, 377.07
CUP3	Coniferous Plantation	03.03 - 03.07
CUP3-3	Scots Pine Plantation	78.03, 78.07
CUP3-8	White Spruce Coniferous Plantation	72.02
CUS1	Mineral Cultural Savannah	04.01, 66.01, 86.03, 86.14, 90.07
CUW	Mineral Cultural Woodland	05.01 – 05.17, 70.03, 377.03
CUT1	Mineral Cultural Thicket	04.01 - 0.4.04, 42.04, 42.08, 70.15, 71.11, 72.04, 86.18, 377.05
CUT1-1	Sumac Cultural Thicket	22.03
FOC4	Fresh-Moist White Cedar Coniferous Forest	06.01 – 06.03
FOC4-1	Fresh-Moist White Cedar Coniferous Forest	06.04 – 06.11, 06.13, 70.05, 70.13, 72.05, 72.07, 78.04,78.05, 86.05, 86.10, 90.02, 90.14, 135.01
FOC4-2	Fresh-Moist White Cedar – Hemlock Coniferous Forest	72.06, 86.11
FOCM6-3	Dry-Fresh Scots Pine Naturalized Coniferous Plantation	72.03
FOD1-1	Dry-Fresh Red Oak Deciduous Forest	44.02
FOD3-1	Dry-Fresh Poplar Deciduous Forest	06.12, 78.09, 86.16, 129.02, 367.01
FODM4-11* (FOD4)	Dry-Fresh Black Locust Deciduous Forest	22.02
FOD5-1	Dry - Fresh Sugar Maple Deciduous Forest Type	06.14, 42.06, 66.02, 86.13, 86.20, 131.01
FOD5-6	Dry - Fresh Sugar Maple - Basswood Deciduous Forest	70.02
FOD5-7	Dry-Fresh Sugar Maple – Black Cherry Deciduous Forest	90.11
FOD5-10	Dry-Fresh Sugar Maple – White Birch - Poplar Deciduous Forest	129.01
FOD6	Fresh-Moist Sugar Maple Deciduous Forest	06.15
FOD7	Fresh-Moist Lowland Deciduous Forest	06.16 – 06.21, 86.12, 86.19, 192.01, 373.06
FOD7-3	Fresh - Moist Willow Lowland Deciduous Forest	44.01, 42.03, 70.04, 70.14, 78.02, 86.01, 86.07, 86.09, 90.01, 90.03, 90.05, 90.13, 134.01, 201.03, 337.04, 543.03
FODM7-7* (FOD7)	Fresh - Moist Manitoba Maple Lowland Deciduous Forest	34.02, 34.06, 42.07

[1] Note: An additional five community types were determined through aerial interpretation, not described here. See **Appendix I.**

Code	Name	Polygon Numbers
FODM7-9* (FOD7)	Fresh - Moist Exotic Lowland Deciduous Forest (Black Locust Dominated)	90.04
FOD8-1	Fresh-Moist Poplar Deciduous Forest	90.08
FOM2-2	Dry-Fresh White Pine – Sugar Maple Mixed Forest	134.02
FOM4	Dry-Fresh White Cedar Mixed Forest	06.22
FOM4-2	Dry-Fresh White Cedar – Poplar Mixed Forest	06.23, 70.12, 86.17
FOM6-1	Fresh - Moist Sugar Maple - Hemlock Mixed Forest	86.15
FOM7-1	Fresh - Moist White Cedar – Sugar Maple Mixed Forest	70.09, 135.02
MAM	Mineral Meadow Marsh	08.01, 08.02, 08.09
MAM2-2	Reed-canary Grass Mineral Meadow Marsh	08.04 – 08.08, 34.07, 70.08, 201.04
MAM2-10	Forb Mineral Meadow Marsh	373.03
MAS2	Mineral Shallow Marsh	09.01
MAS2-1	Cattail Mineral Shallow Marsh	09.02, 09.03, 34.04, 377.02
MAS2-3	Narrow-leaved Sedge Mineral Shallow Marsh	09.04, 09.05, 999.99
OAO	Open Aquatic	10.01 – 10.04
SAS1	Submerged Shallow Aquatic	86.04
SWD4-1	Willow Mineral Deciduous Swamp	34.09
SWM3-2	Poplar – Conifer Mixed Mineral Mixed Swamp	159.01
SWT2-2	Willow Mineral Thicket Swamp	90.12, 543.02
SVDM4-1* (CUS1)	Fresh-Moist Willow Deciduous Savanna	543.01
WODM4-4* (CUW1/ FOD7-4)	Dry – Fresh Black Walnut Deciduous Woodland	22.011, 22.0112, 22.012, 86.14, 70.10
WODM5-1* (CUW1)	Fresh – Moist Polar Deciduous Woodland	90.10, 90.101 373.04
WODM5-3* (CUW1)	Fresh – Moist Manitoba Maple Deciduous Woodland	0.06, 90.09, 367.02, 373.01
Anth	Anthropogenic	01.01 - 01.81, 159.02, 201.01, 201.05, 201.06
HR	Hedgerow	07.01 – 07.29, 22.0113, 34.01, 34.05, 42.01, 78.01, 78.10



Clarington

Legend

Urban Boundary		FOM	
Study Area		HR	
AGR		MAM	
ANTH		MAS	
CUM		OAO	
CUP		SAS	
CUS		SWD	
CUT		SWM	
CUW		SWT	
FOC			
FOD			

KEY MAP

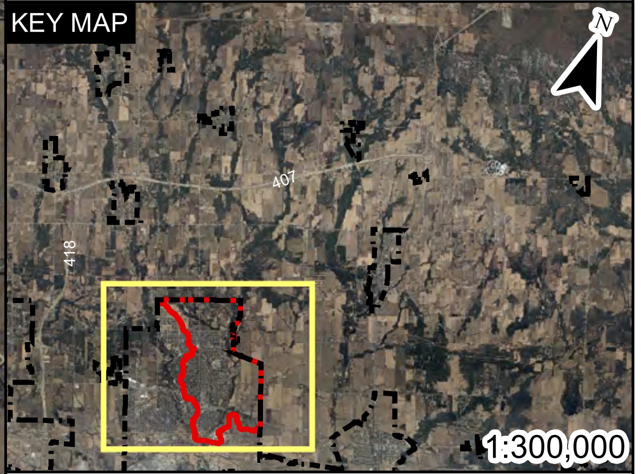


Figure: 3.52

Aquafor Beech 2019 ELC Overview
(refer also to Appendix I)

Date: April 2019
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.375 0.75 1.5
Kilometers
N

Aquafor Beech Limited

3.3.4.2 Botanical Inventory

Botanical inventories are a key component of terrestrial ecological investigations, as these support the classification of vegetation communities, as presented in **Section 3.3.4.1** (e.g., through identification of dominant species or wetland indicators) and identify occurrences of noteworthy plant species such as SAR or regionally significant species.

3.3.4.2.1 Methodology

Botanical inventories were undertaken concurrently with vegetation community studies during the early fall. The botanical inventory aimed to identify as many species as possible that were present within a given community (recognizing that the large study area of the SWS prohibited the completion of thorough, three-season inventories in any one community; additional inventory is likely to be required during future studies to create a comprehensive species list for a site or property). The inventory was compiled via wandering area searches, conducted by qualified biologists with botanical expertise.

3.3.4.2.2 Results

A total of 408 species of vascular plants were catalogued during the botanical inventories undertaken in the study area in 2019. Of these, 47 were identified to the genus level due to lack of floristic characteristics for identification at the time of survey. Of those identified to species level, 132 (37%) are native to Ontario and 222 (63%) are introduced species. An annotated list of flora recorded within the study area is contained within **Appendix J**.

Coefficient of Conservatism (CC) values, per the Floristic Quality Assessment System for Southern Ontario (Oldham, Bakowsky, & Sutherland, 1995), are an accepted criterion for assessing botanical quality. The majority of species inventoried have a high range of habitat tolerances, as evidenced by the high proportion of species with a low CC values. 26 species with narrow habitat tolerances (i.e., with CC values ≥7) were found in a wide variety of communities throughout the study area. The number of native plant taxa found within each category of CC values, as categorized by Oldham, Bakowsky, & Sutherland (1995) is presented in **Table 3.21**.

Table 3.21: Coefficient of Conservatism by Category

Coefficient of Conservatism Categories	# of Taxa
Wide variety of sites (CC 0-3)	82
Typically associated with a specific community, but tolerate moderate disturbance (CC 4-6)	112
Associated with a plant community in an advanced successional stage (CC 7-8)	23
High degree of fidelity to a narrow range of parameters (CC 9-10)	3

The majority of the species recorded during surveys are considered to be common and secure in Ontario (S4 or S5).

One species, Butternut (*Juglans cinerea*), is considered to be provincially imperiled (S2?; the '?' indicates that there may be some uncertainty about the ranking), and is also listed as an Endangered species under provincial and federal Species at Risk (SAR) legislation. Butternut was recorded in ELC polygons 03.02, 04.02, 05.15, 05.16, 06.22, 07.26, 07.27, 42.01, 66.01, 70.09, 70.10, 86.07, 86.09, 86.12, 86.15, 86.16, 86.17, 86.20, 90.03, 90.04, 90.05, 90.09, 90.10, 90.101, 90.11, 134.02, 543.01, and in the campground next to the old Bowmanville Zoo (201.01) (see **Figure 3.54** under **Section 3.3.5**). Full Butternut Health Assessments (i.e., per MECP protocols) were not carried out as a part of the current study. However, initial investigations suggest that both pure Butternut (protected under the ESA) and/or hybrid trees (not protected under the ESA) may be present throughout the study area. Further discussion about the protection of Butternut as a SAR can be found in **Section 3.3.5**.

Of the recorded species, 35 were found to have local significance based on the list for Durham Region contained in "Distribution and Status of the Rare Vascular Plants of the Greater Toronto Region" (Varga, et al., 2005). Of these 35 species, 17 are considered rare in Durham Region (annotated as "R#", where the number represents the number of sites where a species is known to occur), and 18 are considered uncommon (annotated as "U") in Durham Region.

Table 3.22: Regionally Rare and Uncommon Vascular Plants.

Scientific Name	Common Name	Durham Region Status (Varga et al. 2005)	Location (ELC Polygons)
Acer nigrum	Black Maple	R4	129.01
Agalinis tenuifolia	Slender False Foxglove	U	135.01
Anemone cylindrica	Long-headed Anemone	U	78.02, 78.04, 78.07, 86.14, 90.07, 159.01
Anemone quinquefolia	Wood Anemone	R4	78.09, 78.11
Carex blanda	Woodland sedge	U	86.11, 135.02
Carex rosea	Stellate Sedge	U	42.06, 86.15, 86.20
Chelone glabra	White Turtlehead	U	86.04
Cicuta maculata	Spotted Water-hemlock	U	C14, C16
Desmodium canadense	Showy Tick-trefoil	U	78.09
Epilobium coloratum	Purple-veined Willowherb	R5	86.06, 86.07, 86.08, 159.01
Epilobium strictum	Downy Willowherb	R6	90.08, 90.09, 201.05
Equisetum scirpoides	Dwarf Scouring-rush	U	78.05
Equisetum sylvaticum	Woodland Horsetail	R7	86.09, 86.10, 86.11
Galium aparine	Cleavers	U	66.02, 86.01, 90.08
Galium trifudum	Three-petaled Bedstraw	R7	68.02, 70.06, 70.15, 72.01, 86.13, 86.14
Helianthus giganteus	Tall Sunflower	R2	72.01
Heracleum maximum	American Cow Parsnip	R4	201.02
Hypericum punctatum	Spotted St. John's-wort	R2	86.02
Impatiens pallida	Pale Jewelweed	R	86.05, 159.01, 201.03, 201.05, 373.01
Juniperus communis	Common Juniper	U	78.05, 201.05

Scientific Name	Common Name	Durham Region Status (Varga et al. 2005)	Location (ELC Polygons)
Lespedeza capitata	Round-headed Bush Clover	R8	86.21
Lobelia siphilitica	Great Blue Lobelia	R8	78.05, 134.02, 201.03
Osmunda regalis	Royal Fern	U	90.08
Penstemon digitalis	Foxglove beardtongue	R6	78.08, 86.06, 86.08
Solidago caesia	Blue-stemmed Goldenrod	U	86.20, 367.02
Solidago juncea	Early Goldenrod	U	72.01, 78.09, 86.04, 90.01, 90.06, 159.01, 377.07
Sporobolus cryptandrus	Sand Dropseed		135.02
Symphyotrichum urophyllum	Arrow-leaved Aster	R8	A13, A16
Thelypteris noveboracensis	New York Fern	R8	86.11, 129
Vitis aestivalis	Summer Grape	R1	90.06

Five species listed as 'rare' or 'uncommon' locally by Varga et al. (2005) are not listed here, as they have since been found to be fairly common on the local landscape. The excluded species are: Gray Dogwood (*Cornus Racemosa*), Black Walnut (*Juglans nigra*), Highbush Cranberry (*Viburnum opulus ssp. trilobum*), Meadow Horsetail (*Equisetum pratense*) and Virginia Stickseed (*Hackelia virginiana)*. These species were found in 23, 56, 10, 34 and 23 polygons, respectively. Given their ubiquitous presence on the landscape, none of these species are further discussed in this report as limiting factors on the landscape.

A number of introduced species that are considered to be invasive were present throughout the study area. Two of the most prevalent and potentially problematic species are Common Buckthorn (*Rhamnus cathartica*) and European Swallow-wort, also known as Dog-strangling Vine (*Cynanchum rossicum*). Common Buckthorn was found in 79 polygons, while Dog-strangling Vine was found in 67 polygons. Other noted invasives include Scots Pine (*Pinus sylvestris*), Norway Maple (*Acer platanoides*), Garlic Mustard (*Alliaria petiolata*), Japanese Knotweed (*Reynoutria japonica*), Black Locust (Robinia pseudoacacia), Multiflora Rose (Rosa multiflora), Narrow-leaved Cattail (*Typha angustifolia*), Periwinkle (*Vinca minor*), Goutweed (*Aegopodium podagraria*), Japanese Barberry (*Berberis thunbergii*), Winged Euonymus (*Euonymus alatus*), Tatarian Honeysuckle (*Lonicera tatarica*), Purple Loosetrife (*Lythrum salicaria*), and European Reed (*Phragmites australis ssp. australis*).

Emerald Ash Borer (*Agrilus planipennis*) is prevalent in southern Ontario, and has caused severe decline of Ash (*Fraxinus spp.*) trees throughout the study area. As ash trees continue to decline, Common Buckthorn (among other invasive species) has become more common, taking advantage of the opening canopy in previously forested and treed swamp habitats.

3.3.4.2.3 Conclusions

A total of 408 plant species were inventoried by Aquafor Beech's biologists in 2019. Of these, the majority are considered to be common and secure. One SAR, Butternut, was recorded in several communities. This species and its habitat protections provided under the ESA are further detailed in **Section 3.3.5**; the implications of SAR habitat on the NHS are discussed under **Section 3.3.7**.

The Regionally rare and uncommon plant species listed in **Table 3.22** do not receive regulatory protection and do not constitute a constraint that is carried forward as part of the NHS presented in **Section 3.3.7**. However, these species and their habitat may be subject to further review and/or the application of impact mitigation and/or conservation measures during site-specific studies, at a later planning phase, per the discretion of the Municipality and/or CLOCA (i.e., as identified in an EIS Terms of Reference approved by the Municipality and CLOCA).

3.3.4.3 Hedgerows

Hedgerows are present across the study area, primarily along the edges of agricultural fields. Many of these features may have intentionally been planted as windbreaks, sound barriers, property markers, etc., or may have grown in naturally along unmanaged fences and property lines. Less often, hedgerows are remnants of historical woodlands that have otherwise been cleared. Owing to their purpose and growing conditions, individual trees within hedgerows may grow to a mature state and exhibit wide-spreading canopies and wildlife habitat features, such as well-developed cavities.

Hedgerows were defined as narrow features (generally 1-3 trees in width) either disconnected from adjacent woodlands or ecologically distinct from them (e.g., exhibiting a different species composition, or having different ground cover or understorey structure). Therefore, although some hedgerows are contiguous with woodlands, they were assessed as separate features due to their distinguishing features. Conversely, some linear features contiguous with woodlands were found to exhibit similar characteristics as the woodlands and were included in the boundary of those features.

Hedgerows often play an important role in natural heritage connectivity especially in an agriculture dominated landscapes. They are often some of the only remaining linkages connecting core areas. Hedgerows can be vastly different and therefore can provide a spectrum of levels of connectivity. Wide hedgerows with a greater diversity of habitat types (stream and riparian habitat, dense canopy cover, dense shrubs etc.) will provide more movement paths for a greater range of species.

3.3.4.3.1 Methodology

Hedgerows were reviewed through desktop aerial imagery. Those found to exhibit some level of connectivity between natural features were further examined concurrently with the ELC and botanical inventory surveys. Features surveyed in the field were assessed generally for their dimensions and continuity, linkage potential, habitat potential, vegetation health, species quality, and presence of specimen trees.

Linkages and potential linkages are intended to be subject to future study and confirmation/ refinement as appropriate. The classification of hedgerows provided in the following subsections and shown on the associated mapping shall be confirmed and may be modified if supported by the results of a site-specific EIS or similar study completed as part of a development application.

The spatial, aesthetic, and biophysical characteristics of each hedgerow assessed in the field are detailed in **Table 3.23**. Based on these characteristics, each individual hedgerow has been assigned one of the following categories:

- Category 1: Existing Linkage, also potentially contains SAR trees (Butternut) – to be retained; recommendations for enhancement provided.
- Category 2: Potential Linkage – may become a valuable NHS connection if recommendations for enhancement are implemented.
- Category 3: Feature Elements Present – does not provide linkage function to the NHS, but contains features (e.g., specimen trees) that could be valuable if integrated into the developing landscape (e.g., in a park setting), or is connected to NHS without providing linkage, but provides habitat for wildlife.
- Category 4: No Management Recommended – no linkage function or features found that are recommended for retention or enhancement. *Note that there are more Category 4 hedgerows on the landscape, which were ruled out based on aerial interpretation and are thus not included in the table below.*

These categories are the basis for guiding any constraints or restoration opportunities to each individual hedgerow in the future, discussed in **Section 4.2.3** and demonstrated on **Figure 4.4**.

3.3.4.3.2 Results

A total of 35 hedgerows deemed to have some linkage potential through aerial interpretation were visited during field surveys. These hedgerows are depicted on **Figure 3.52** and **Figure 4.4**: VPZs, Linkages, and Restoration/Enhancement Opportunities, and discussed in **Table 3.23**.

Table 3.23: Hedgerow Assessment

ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
07.01	**Moderate.** Single row of trees, approximately 17 m wide and 415 m long. Canopy is reasonably connected with three small gaps.	**Low.** Hedgerow is located approximately 55 m north of a forest patched with a building and a parking lot in between. There are no natural features within a kilometre north of this hedgerow.	**Moderate.** Ditch along hedgerow provides water source for wildlife.	**Moderate – high.** There were a few dead Ash trees present but trees are generally in good health.	**Low-Moderate.** Canopy consists of primarily Manitoba Maple with some Black Walnut and Ash. Riverbank Grape is abundant throughout the hedgerow. European Buckthorn is the dominant shrub species and the ground cover is typical of cultural meadows.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.02	**Moderate.** Thin, single layer of trees (10 m) and is approx. 400 m long, with occasional discontinuity throughout.	**Moderate.** Hedgerow is located at the corner of an intersection surrounded by agriculture, and is connected at the west extent to the Soper Creek Riparian Area (NHS). Does not provide linkage to any other features.	**Moderate.** Ditch along hedgerow provides water source for wildlife. Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife.	**High.** Trees generally in good health.	**Low.** Comprised almost exclusively of Manitoba Maple.	**Low.** No specimen trees present.	Category 3	Extends out from a forest and is easily replicable in the landscape.
07.03	**Low-Moderate.** Thin, single layer of trees (8 m) and is approx. 200 m long. Fairly continuous throughout.	**Low.** Isolated hedgerow abutting farm fields and residential. No natural connection.	**Moderate.** Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**Low.** Comprised almost exclusively of Manitoba Maple.	**Low.** No specimen trees present.	Category 4	Extends out from a valley and is easily replicable in the landscape.
07.04	**High.** Two to three trees (20 m) wide, approx. 860 m long, extending beyond the boundaries of the study area. Continuous mature treed hedgerow with few gaps.	**Moderate-High.** This hedgerow provides the only connection between non-NHS habitat patches to the east and northeast, but does not link any sections of the NHS.	**Moderate.** Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife. Ditch along hedgerow provides water source for wildlife	**High.** Trees generally in good health.	**Low.** Canopy primarily comprising non-native Austrian Pine, a few native deciduous trees throughout.	**Low.** No specimen trees present.	Category 3	Extends out from a valley and connects to another wooded feature outside of the study area.
07.05	**Low:** Thin, single layer (10 m) of trees, 420 m long. Discontinuous throughout.	**Low.** Isolated hedgerow abutting farm fields and residential. No natural connection.	**Low.** Large gaps between treed areas provides little cover for wildlife.	**High.** Trees generally in good health.	**Low-Moderate.** Canopy consists of primarily Manitoba Maple with some Black Walnut.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.06 + 07.07	**Low-Moderate.** Several maintained rows of trees side by side, total 35 m wide, 260 m long	**Low.** Isolated hedgerow abutting farm fields and residential, comprising fruit trees such as apple – likely maintained for agriculture. No natural connection.	**Low.** Large gaps between treed areas provides little cover for wildlife.	**High.** Trees generally in good health.	**Low.** Primarily introduced species such as Apple.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.

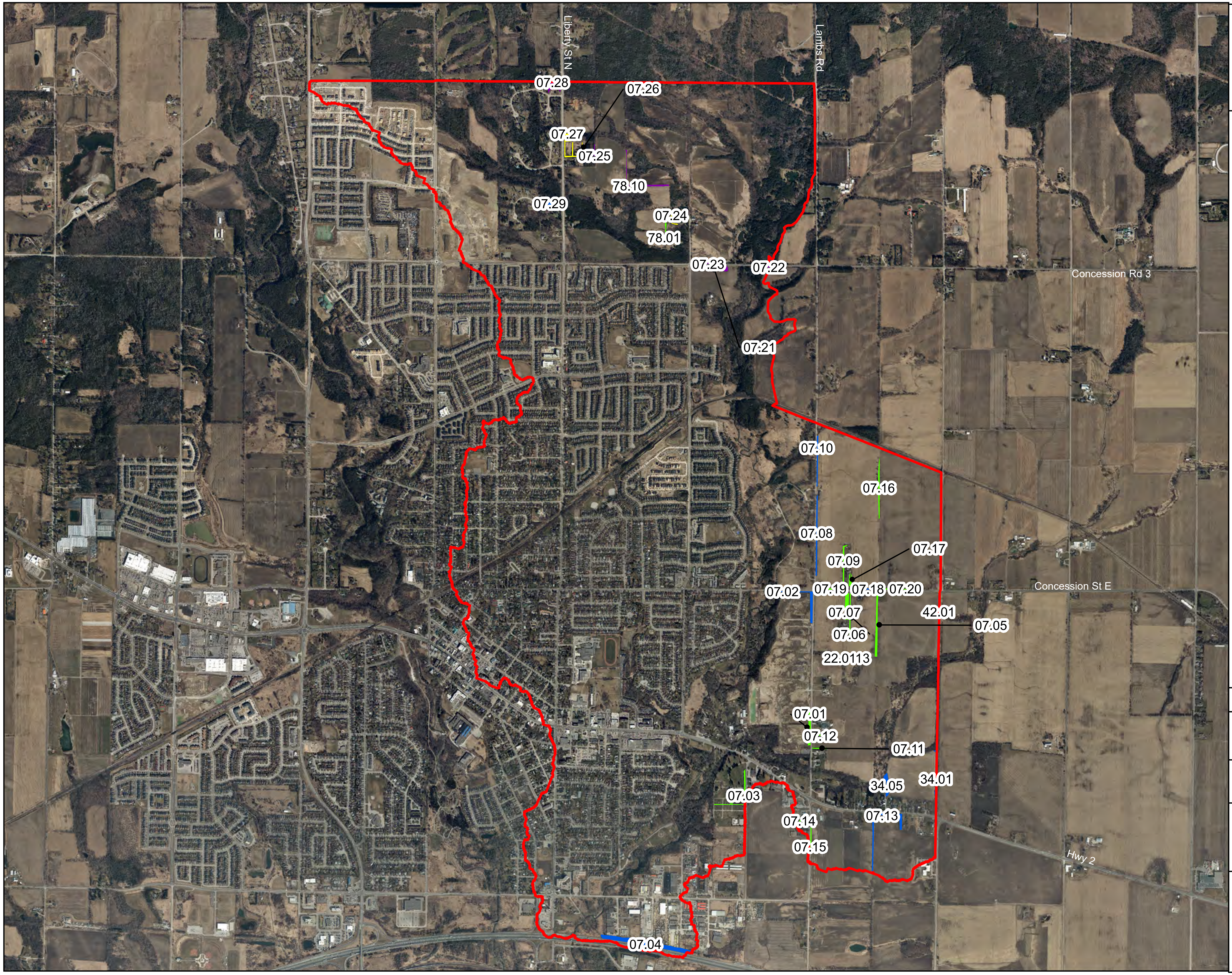
ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
07.08	**Moderate.** Thin, single layer of trees (7 m) and is approx. 490 m long. Fairly continuous throughout.	**Low-Moderate.** Isolated hedgerow abutting farm fields and residential. No natural connection. Large cultural meadow and wooded areas directly across the road.	**Moderate-High.** Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife. Butternut found in feature across the road. Ditch along hedgerow provides water source for wildlife.	**Moderate.** Trees generally in good health, although dead and dying Ash present in some sections of the canopy.	**Moderate.** Most canopy species appear to be native deciduous. Dead or dying Ash not sustainable, but only comprise a small portion of canopy.	**Moderate.** Several large Sugar Maples and other large deciduous trees noted.	Category 3	Contains specimen trees.
07.09	**Low.** Thin, single layer (10 m) of trees, 245 m long. Disconnected, particularly in the north.	**Low.** Isolated hedgerow abutting farm fields and residential. No natural connection.	**Low.** Large gaps between treed areas, many dead/dying Ash.	**Low.** Canopy dominantly dead/dying Ash trees.	**Low.** Ash trees not sustainable.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.10	**Low-Moderate.** Thin, single layer of trees (7 m) and is approx. 308 m long. Some gaps in the northern extent.	**Low-Moderate.** Closest connected natural feature is cultural meadow to the hedgerow at the north. Does not provide linkage to any other features, but is directly across the road from cultural meadow and wooded area.	**Moderate-High.** Large diameter Sugar Maples confirmed with well developed cavities suitable for bats or other wildlife.	**Moderate.** Trees generally in good health, although dead and dying Ash present in some sections of the canopy.	**Moderate.** Most canopy species appear to be native deciduous. Dead or dying Ash not sustainable, but only comprise a small portion of canopy.	**Moderate.** Several large Sugar Maples and other large deciduous trees noted.	Category 3	Contains specimen trees. Provides natural cover between ELC polygon 86.16 to the north and 78.09 to the south.
07.11	**Low-Moderate.** Thin, single layer of trees (7 m) and is approx. 95 m long. Very continuous.	**Low.** Isolated hedgerow abutting farm fields and residential. No natural connection.	**Low.** Dense, planted row of Spruce provides little cover for wildlife.	**High.** Trees generally in good health.	**Moderate.** Monoculture of native White Spruce with occasional deciduous trees.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.12	**Low.** One thin, short, maintained row of fruit trees. total 4 m wide, 55 m long	**Low.** Isolated hedgerow abutting farm fields and residential, comprising fruit trees such as apple – likely maintained for agriculture. No natural connection.	**Low.** Large gaps between treed areas provides little cover for wildlife.	**High.** Trees generally in good health.	**Low.** Primarily introduced species such as Apple.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.13	**Moderate.** Single row of trees, approx. 10 m wide and 360 m long, including a 90° bend. Canopy is continuous along the east – west stretch, but discontinuous in the north - south portion intersecting the agricultural field.	**Low.** Hedgerow is located directly south of a highway and extends south into an expanse of agricultural fields. The closest connected natural feature to this hedgerow is an isolated woodland south of the study area. Although the hedgerow is connected to a network of other hedgerow that eventually connect with the NHS, it does not provide linkages to any other features.	**Moderate-High.** Ditch along hedgerow provides water source for wildlife. Large diameter deciduous trees with cavities noted in the east – west may provide bat or other wildlife or habitat.	**High.** Trees observable from the road ROW are generally in good health.	**Low-Moderate.** Observable canopy consists of primarily Norway Spruce, Black Locust, Sugar Maple and Manitoba Maple. Riverbank Grape is abundant throughout the hedgerow. Buckthorn is the dominant shrub species and the ground cover is typical of cultural meadows.	**Moderate.** Several large Sugar Maples noted.	Category 3	Contains specimen trees.

ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
07.14	**Low-Moderate.** Thin, single layer of trees (6 m) and is approx. 45 m long. Very continuous.	**Low.** Isolated hedgerow abutting farm fields and residential. No natural connection.	**Low.** Dense, planted row of mature Spruce with little to no understory provides little cover for wildlife.	**High.** Trees generally in good health.	**Moderate.** Monoculture of native White Spruce with occasional deciduous trees.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.15	**Low.** Thin, short hedgerow (115 m long, 3 m wide) comprising a high content of tall shrubs or young trees.	**Low.** Isolated hedgerow abutting farm fields. No natural connection.	**Low.** Large gaps between treed areas provide little cover for wildlife.	**High.** Trees generally in good health.	**Low.** Young trees or shrubs.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.16	**Low.** Thin, single layer (10 m) of trees, 550 m long. Disconnected, particularly in the south.	**Low.** Isolated hedgerow abutting farm fields. No natural connection.	**Low.** Gaps between treed areas provide little cover for wildlife.	**High.** Trees generally in good health.	**Moderate.** Likely Manitoba Maple.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.17	**Low**. One to two trees (20 m) wide, approx. 80 m long.	**Low.** Isolated hedgerow abutting farm fields. No natural connection.	**Unknown.** No access granted for close visual inspection.	**Unknown.** No access granted for close visual inspection.	**Deciduous.** No access granted for close visual inspection.	**Unknown.** No access granted for close visual inspection.	Category 4	Does not provide any connections between existing features and is likely replicable in the landscape.
07.18	**Low**. Thin, single layer (7 m) of trees, 63 m long. Widely spaced trees.	**Low.** Isolated hedgerow abutting farm fields. In close proximity to HR 0.20, connected to a small woodland patch containing large DBH Maple.	**Moderate-High.** Ditch along hedgerow provides water source for wildlife. Large diameter Maple with cavities noted may provide bat or other wildlife or habitat.	**High.** Trees generally in good health.	**Moderate.** Large diameter Sugar Maples with cavities, non-native Black Locust interspersed.	**Moderate.** Several large Sugar Maples noted.	Category 3	Contains specimen trees.
07.19	**Low**. Thin, single layer (15 m) of trees, 150 m long. Widely spaced trees.	**Low.** Isolated hedgerow abutting farm fields. Connected to a small cultural meadow patch.	**Moderate.** Ditch along hedgerow provides water source for wildlife. Large diameter Maple may provide bat or other wildlife or habitat.	**High.** Trees generally in good health.	**Low.** Non-native Norway Maple dominant in canopy.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.20	**Low**. Thin, single layer (10 m) of trees, 180 m long. Widely spaced trees.	**Low.** Isolated hedgerow abutting farm fields. Connected to a small cultural savanna patch to the east, a small woodlot containing large DBH Maple to the north.	**Moderate.** Ditch along hedgerow provides water source for wildlife.	**Moderate.** Trees generally in good health, although dead and dying Ash present in some sections of the canopy.	**Low.** Non-native Norway Maple and dead/dying Ash.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.

ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
07.21	**Moderate-High.** Two to three trees (20 m) wide, approx. 245 m long, and highly continuous. Likely a remnant of old forest.	**Moderate.** This hedgerow is isolated from other features, but in close proximity to the Soper Creek Riparian Area (NHS), separated by approx. 50 m of farm field.	**Moderate-High.** Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife. Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**High.** Canopy primarily comprising large, native trees (e.g. Sugar Maple, Manitoba Maple, White Cedar, etc.).	**Low.** No specimen trees present.	Category 3	Remanent forest habitat with large native trees.
07.22	**Moderate.** Thin, single layer (7 m) of trees, 215 m long, extending beyond the study area boundary. Several gaps of approx. 20 m noted along the corridor.	**Moderate-High.** Connected to and provides secondary linkage between two branches the Soper Creek riparian area (NHS). Not the primary NHS linkage.	**Low-Moderate.** Large gaps in hedgerow trees, trees mostly young, non-native or native conifer**.** Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**Moderate.** White cedar may offer wildlife value as cover when mature. Non-native Scots pine is invasive.	**Low.** No specimen trees present	Category 2	Connects two branches of a valley.
07.23	**Low.** Thin, single layer (2 m) of trees, 120 m long, generally continuous but with shrubs intermittent throughout.	**High.** Isolated hedgerow connected to a cultural meadow field. Already exists within the NHS, is the only wooded connection between lower lobes of NHS forest tracts to the east and west, but separated by a road.	**Moderate.** Trees young. Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**High.** High content of Eastern White Cedar.	**Low.** No specimen trees present	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
07.24	**Low.** One to two trees (7 m) wide, 118 m long. A few small gaps noted, mowed between trees.	**High.** Provides one of the only solid connections between forested natural features to the north and south.	**Low.** Gaps between treed areas provide little cover for wildlife.	**High.** Trees generally in good health.	**Low.** Comprises primarily non-native Scots Pine with occasional Manitoba Maple.	**Low.** No specimen trees present	Category 1	Connects two natural features.
07.25	**Moderate-High.** Two or three trees wide, length of 77 m, width of 6 m. Continuous throughout. Previously connected to the NHS.	**Moderate-High.** Currently an isolated hedgerow connected to a cultural meadow field. Previously connected to the NHS prior to tree removals. In close proximity to other natural heritage features.	**Moderate-High:** Remnant plantation. 8 Butternut found in adjacent Polygon, likely additional Butternut in cleared area.	**High.** Trees generally in good health.	**Low.** Exclusively even aged Norway Spruce.	**Low.** No specimen trees present	Category 2	Feature was previously connected two woodlands which have been removed.
07.26	**Moderate.** One tree wide, length of 90 m, width of 7 m. Continuous throughout. Previously connected to the NHS.	**Moderate-High.** Currently an isolated hedgerow connected to a cultural meadow field. Previously connected to the NHS prior to tree removals. In close proximity to other natural heritage features.	**High.** 4 Butternuts confirmed in hedgerow at south end. Trees mature deciduous with potential wildlife value.	**Moderate.** Some Butternut show signs of advanced canker. Remaining trees in hedgerow appear healthy.	**High.** Native deciduous composition, confirmed Butternut.	**High.** Butternut Confirmed.	Category 1	Contains SAR and connects natural features. Assessment is based on the replacement of the removed natural features denoted with * in **Appendix** I.
07.27	**Moderate-High.** Multiple trees wide, several 90° angles. Length of 482 m, width of 9 m. Continuous throughout. Previously connected to the NHS.	**Moderate-High.** Currently an isolated hedgerow connected to a cultural meadow field. Previously connected to the NHS prior to tree removals. In close proximity to other natural heritage features.	**High.** 4 Butternuts confirmed in hedgerow in northwest corner**.** Trees mature deciduous with potential wildlife value.	**High.** Trees generally in good health.	**High.** Native deciduous composition, confirmed Butternut.	**High.** Butternut Confirmed.	Category 1	Connects cultural thicket, cultural woodland and plantations. Contains SAR species.

ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
07.28	**Moderate-High.** Variable. Two or three trees wide, several 90° angles. Length of 260 m, width of 14 m. Continuous throughout with the exception of one small break.	**Moderate-High.** Connected to the NHS, provides secondary linkage between branches. Not the primary linkage.	**Moderate-High.** Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife. Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**High.** Native deciduous composition.	**Low.** No specimen trees present	Category 2	Connects forest to the east to the forest to the north.
07.29	**Moderate.** One tree wide, continuous. Length of 119 m, width of 15 m.	**Moderate.** Connected to the NHS, does not provide linkage between features.	**Moderate-High.** Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife. Ditch along hedgerow provides water source for wildlife.	**High.** Trees generally in good health.	**High.** Native deciduous composition.	**Low.** No specimen trees present	Category 3	Connected to NHS but does not link features. Contains large native trees with noted knot holes.
22.0113	**Low-Moderate.** One tree wide with gaps and meadow between.	**Moderate-High.** Connects two woodlands to the east and west.	**Low.** Gaps between treed areas provide little cover for wildlife.	**High.** Trees generally in good health.	**High.** Native deciduous composition.	**Low.** No specimen trees present	Category 3	Provides linkage between two small woodlands that are not connected to the NHS.
34.01	**Moderate-High.** One to two trees (15 m) wide, 420 m long with one notable canopy gap approx. 50 m long.	**Moderate.** Connected to the Soper Creek riparian area (NHS) through a FOD forest corridor to the northwest. Does not provide linkage to any other features.	**Moderate-High.** Wide hedgerow that intersects with FOD community. Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife.	**High.** Trees generally in good health.	**Low-Moderate.** High content of non-native deciduous or “weedy” tree species – e.g., Manitoba Maple, Crack Willow, Norway Maple, European Mountain Ash. Buckthorn is the dominant shrub species and the ground cover is typical of cultural meadows.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
34.05	**Moderate.** One to two trees (15 m) wide, 136 m long, well connected.	**Moderate.** Connected to the Soper Creek riparian area (NHS) through a FOD forest corridor to the northwest. Does not provide essential linkage to any other features.	**Moderate-High.** Wide hedgerow that intersects with FOD community. Potential for large trees with cavities, knot holes, etc. suitable for bats and other wildlife.	**High.** Trees generally in good health.	**Low-Moderate.** High content of non-native deciduous or “weedy” tree species – e.g., Manitoba Maple, Crack Willow, Norway Maple, European Mountain Ash. Buckthorn is the dominant shrub species and the ground cover is typical of cultural meadows.	**Low.** No specimen trees present.	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.

ELC Polygon ID	Dimensions & Continuity	Connectivity/Linkage	Habitat Potential	Vegetation Health	Species Quality	Specimen Trees and Aesthetic Features	Category	Rational
42.01	**Low-Moderate.** One to two trees (25 m) wide, 400 m long. Canopy notably sparser in the northern extent of the hedgerow.	**Moderate-High.** Directly connected to the Soper Creek riparian area (NHS). Provides some linkage to other branches of the NHS outside of the study area and is directly across the road from a small patch of cultural savanna (CUS1).	**High.** Butternut confirmed in hedgerow nearest the road at the north end. Trees mature deciduous with potential wildlife value.	**High.** Trees generally in good health.	**High.** Primarily deciduous composition with some non-natives. Ground cover is typical of cultural meadows. confirmed Butternut.	**High.** Butternut Confirmed.	Category 1	Connects two valley systems and contains SAR species.
78.01	**Low.** One to two trees (12 m) wide, 130 m long. A few small gaps noted, mowed between trees.	**Low-Moderate.** Weakly connected to other natural features through another hedgerow (07.24). Provides no additional linkage to other features.	**Low.** Gaps between treed areas provide little cover for wildlife.	**High.** Trees generally in good health.	**Low.** Comprises primarily non-native Scots Pine with occasional Manitoba Maple.	**Low.** No specimen trees present	Category 4	Does not provide any connections between existing features and is easily replicable in the landscape.
78.10	**Low.** Single row of trees, approximately 8 m wide and 509 m long, including a 90° bend. Canopy largely discontinuous, particularly in the north-south stretch.	**Moderate.** Connected to the NHS and offers non-essential secondary linkage between east and west sections of the feature.	**Low.** Gaps between treed areas provide little cover for wildlife.	**Moderate.** Trees generally in good health with the exception of Ash.	**Low.** Dominated by Apple trees with occasional native species such as dying Ash and Black Cherry. High quantity of non-native invasive shrubs.	**Low.** No specimen trees present.	Category 2	Narrow hedgerow that connects to the NHS at both ends.



Legend

- Study Area
- Category 1
- Category 2
- Category 3
- Category 4

Figure: 3.53

Hedgerow Assessment Results

Date: September 2021
Author: KB
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.35 0.7 1.4
Kilometers

N

3.3.4.4 Breeding Birds

Breeding bird surveys are a standard component of terrestrial ecological investigations since the bird species that breed in an area will reflect the type, quality, and extent of habitat that is present. Certain species of birds will only breed in particular habitat types (e.g., successional thicket, forest interior) or in a minimum habitat patch size (i.e., area-sensitive species). Breeding bird surveys are also completed to support the identification of SAR occurrences (see also **Section 3.3.5**) and Significant Wildlife Habitat (see also **Section 3.3.6**).

3.3.4.4.1 Methodology

Sixty-five breeding bird point count survey station locations were established throughout the study area, distributed such that all habitat types were represented to the extent possible (given that some properties could not be accessed). Point count surveys were conducted on two dates during the typical bird breeding period, following the Ontario Breeding Bird Atlas (OBBA) protocol (Ontario Breeding Bird Atlas, 2001); surveys were completed during appropriate weather conditions, between dawn and approximately five hours after dawn.

Background information sources (such as eBird records and the OBBA) were used to supplement the results of the 2018 breeding bird surveys. Due to the frequently imprecise nature of these data, such observation records are only mentioned in the subsequent sections if the information from these sources indicated significant species or other constraints relevant to the study area and the current subwatershed study.

3.3.4.4.2 Results

Breeding bird survey results, combined with incidental observations where available, are summarized in **Table 3.24**, below. A total of 82 bird species were recorded during the course of this project, of which 79 exhibited evidence of breeding such as males singing on territory, displays of agitated or defensive behavior, and/or the presence of fledged young. The remaining eight species were observed only as flyovers or otherwise did not exhibit evidence of breeding.

The majority of bird species recorded are provincially common and typical of the habitat types present. However, seven SAR birds were recorded in the study area during breeding bird surveys: Bank Swallow (*Riparia riparia*), Barn Swallow (*Hirundo rustica*), Bobolink (*Dolichonyx oryzivorus*), Chimney Swift (*Chaetura pelagica*), Eastern Meadowlark (*Sturnella magna*), Eastern Wood-pewee (*Contopus virens*), and Wood Thrush (*Hylocichla mustelina*). Two other SAR, Golden-winged Warbler (*Vermivora chrysoptera*) and Common Nighthawk (*Chordeiles minor*), were observed incidentally in the study area (i.e., during the course of other surveys rather than during dedicated breeding bird surveys) but were observed during the typical nesting season for birds and in appropriate habitat, so both species have been included here as possible breeders. Detailed discussion relating to these birds and other SAR is provided in **Section 3.3.5**.

Multiple other species as indicated in **Table 3.24** have been identified as being of Regional Concern according to the Ontario Landbird Conservation Plan for the Lower Great Lakes/St. Lawrence region (Ontario Partners in Flight, 2008). For the majority of these, the designation indicates that they may be vulnerable due to various factors. Conversely, the designation of

Canada Goose (*Branta canadensis*) suggests that it may require ongoing management due to a population above the desired level.

Finally, 16 of the observed species (15 with breeding evidence) are considered area sensitive (Ontario Ministry of Natural Resources, 2000), meaning that they have a minimum habitat size threshold that must be met in order to establish a successful territory. These species typically do not thrive when habitat becomes fragmented by development or road networks.

Detailed breeding bird survey field data, including a breakdown of observations per location, are provided in **Appendix M.**

Table 3.24: Bird Species Documented in the Soper Creek Subwatershed

Common Name	Scientific Name	S RANK	ESA Status	SARA Status	Regional Concern	MNRF Area Sensitive	Highest Breeding Evidence Observed	Point Count Stations[2] at which Species was Observed (BI-#)
Alder Flycatcher	*Empidonax alnorum*	S5B					Possible	36, 45, 46
American Crow	*Corvus brachyrhnchos*	S5B					Observed	1, 2, 3, 4, 5, 6, 11, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24 25, 26, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 40, 43, 44, 46, 47, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64; IN
American Goldfinch	*Spinus tristis*	S5B					Probable	2, 5, 6, 7, 9, 10, 11, 12, 15, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 41, 42, 43, 44, 45, 46, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, IN
American Kestrel	*Falco sparverius*	S4			Y		Observed	19; IN (roadside, Polygon 90.01 – flyover)
American Redstart	*Setophaga ruticilla*	S5B				Y	Probable	13, 15, 19, 23, 24, 42, 44, 48, 49, 50, 51, 53, 56, 57, 58, 59, 60, 62, 64, 64, 65
American Robin	*Turdus migratorius*	S5B					Confirmed	1, 2, 4, 6, 7, 8, 9, 11, 14, 16, 17, 18, 19, 20, 21, 22, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 40, 41, 42, 43, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56, 57, 60, 61, 62, 63, 64; IN
Baltimore Oriole	*Icterus galbula*	S5B			Y		Probable	2, 3, 9, 19, 38, 40, 41, 42, 43, 44, 45, 46, 49, 57, 59, 62, 63, 65
Bank Swallow	*Riparia riparia*	S4B	THR	THR			Possible	16, 40
Barn Swallow	*Hirundo rustica*	S4B	THR	THR	Y		Confirmed	1, 16, 40, 41, 43, 61, 63
Belted Kingfisher	*Megaceryle alcyon*	S4B			Y		Possible	40, 41, 56, 58, 64; IN
Black-and-white Warbler	*Mniotilta varia*	S5B				Y	Possible	3, 21
Black-billed Cuckoo	*Coccyzus erythropthalmus*	S5B			Y		Possible	42, 43, 44
Black-capped Chickadee	*Poecile atricapillus*	S5B					Probable	2, 5, 6, 7, 8, 9, 10, 11, 12, 8, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, 39, 41, 42, 44, 45, 47, 48, 51, 52, 53, 54, 55, 58, 60, 61, 62; IN
Black-throated Green Warbler	*Setophaga virens*	S5B				Y	Possible	5, 7, 8, 42, 43, 58
Blue Jay	*Cyanocitta cristata*	S5B					Probable	1, 2, 3, 4, 5, 6, 8, 10, 11, 14, 15, 16, 17, 19, 20, 22, 23, 24, 26, 27, 28, 29, 30, 31, 33, 38, 41, 42, 46, 48, 49, 55, 57, 58, 61, 63; IN
Blue-gray Gnatcatcher	*Polioptila caerulea*	S4B				Y	Possible	59, 62
Blue-winged Teal	*Anas discors*	S4					Observed (migration only)	IN
Bobolink	*Dolichonyx oryzivorus*	S4B	THR	THR	Y	Y	Probable	12, 16, 62
Brown Thrasher	*Toxostoma rufum*	S4B			Y		Probable	63, 64, 65
Brown-headed Cowbird	*Molothurs ater*	S5B					Probable	25, 28, 30, 34, 37, 38, 40, 41, 42, 43, 44, 47, 48, 49, 51, 56, 57, 58, 59, 60, 61, 63, 64, 65
Canada Goose	*Branta canadensis*	S5			Y		Possible	28, 39, 47, 48, 55, 62; IN
Cedar Waxwing	*Bombycilla cedrorum*	S5B					Probable	1, 2, 9, 10, 11, 13, 14, 15, 17, 19, 20, 21, 24, 25, 26, 27, 28, 34, 35, 37, 38, 41, 44, 45, 46, 49, 51, 52, 54, 58, 61, 63, 65; IN
Chimney Swift	*Chaetura pelagica*	S4B	THR	THR			Observed	46
Chipping Sparrow	*Spizella passerina*	S5B					Possible	7, 29, 30, 31, 34, 40, 57
Cliff Swallow	*Petrochelidon pyrrhonota*	S4B					Probable	16
Common Grackle	*Quiscalus quiscula*	S5B					Confirmed	7, 11, 12, 14, 16, 17, 18, 24, 25, 26, 28, 29, 33, 34, 36, 37, 38, 40, 41, 42, 43, 44, 46, 48, 50, 52, 53, 54, 55, 56, 57, 59, 62, 65
Common Merganser	*Mergus merganser*	S5B				Y	Observed (migration only)	IN
Common Nighthawk	*Chordeiles minor*	S4B	SC	THR			Possible	IN (east of station 44)
Common Raven	*Corvus corax*	S5					Observed (migration only)	IN

[2] See Figure 3.51 for point count locations. Observations made outside of point count surveys (e.g., flyovers noted while en route between stations, incidental observations from other dates) are all denoted as incidental, "IN".

Common Name	Scientific Name	S RANK	ESA Status	SARA Status	Regional Concern	MNRF Area Sensitive	Highest Breeding Evidence Observed	Point Count Stations[2] at which Species was Observed (BI-#)
Common Yellowthroat	*Geothlypis trichas*	S5B					Probable	1, 2, 3, 4, 5, 6, 9, 10, 12, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 39, 40, 41, 42, 43, 44, 45, 46, 53, 58, 59, 63, 64
Downy Woodpecker	*Picoides pubescens*	S5					Confirmed	3, 9, 31, 32, 38, 45, 47, 48, 54, 55, 56, 57, 60, 64; IN
Eastern Kingbird	*Tyrannus tyrannus*	S4B			Y		Probable	2, 3, 19, 40, 43, 45, 46, 61, 62
Eastern Meadowlark	*Sturnella magna*	S4B	THR	THR	Y	Y	Probable	2, 13, 16, 22
Eastern Phoebe	*Sayornis phoebe*	S5B					Probable	36, 38, 46, 52, 54; IN
Eastern Wood-Pewee	*Contopus virens*	S5B	SC	SC	Y		Probable	3, 4, 7, 8, 9, 10, 14, 32, 35, 37, 47, 51, 58, 60
European Starling	*Sturnus vulgaris*	SE					Confirmed	1, 16, 17, 27, 39, 40, 43, 44, 45, 50, 55, 56, 57, 58, 61; IN
Golden-winged Warbler	*Vermivora chrysoptera*	S4B	SC	THR	Y		Possible	IN (closest to station #45)
Gray Catbird	*Dumetella carolinensis*	S5B					Probable	1, 2, 3, 12, 15, 17, 18, 22, 23, 25, 27, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 56, 57, 58, 60, 62, 63, 64, 65; IN
Great Blue Heron	*Ardea herodias*	S4			Y		Observed	36, 38, 56; IN
Great Crested Flycatcher	*Myiarchus crinitus*	S4B					Probable	1, 2, 3, 4, 6, 7, 8, 10, 12, 15, 16, 18, 21, 22, 27, 34, 39, 46, 47, 57, 58, 59, 62
Green Heron	*Butorides virescens*	S4B			Y		Possible	42, 47
Hairy Woodpecker	*Leucontopicus villosus*	S5				Y	Possible	20, 22, 27, 32, 43, 45, 51; IN
Herring Gull	*Larus argentatus*	S5B					Observed	40, 61
House Finch	*Haemorhous mexicanus*	SNA					Possible	27
House Sparrow	*Passer domesticus*	SNA					Probable	IN
House Wren	*Troglodytes aedon*	S5B					Probable	1, 2, 3, 6, 13, 18, 19, 25, 28, 29, 30, 37, 39, 43, 44, 45, 46, 47, 48, 49, 50, 51, 53, 59, 61, 62; IN
Indigo Bunting	*Passerina cyanea*	S4B					Probable	4, 5, 6, 8, 9, 10, 11, 12, 16, 18, 19, 21, 22, 23, 25, 27, 28, 31, 34, 44, 46, 47, 48, 50, 51, 58, 62, 64, 65
Killdeer	*Charadrius vociferus*	S5B			Y		Possible	41, 50, 51; IN
Mallard	*Anas platyrhynchos*	S5			Y		Possible	52; IN
Mourning Dove	*Zenaida macroura*	S5B					Probable	1, 6, 9, 13, 15, 16, 18, 19, 20, 21, 30, 32, 33, 34, 35, 37, 40, 41, 42, 45, 46, 47, 48, 61, 65; IN
Mourning Warbler	*Geothlypis philadelphia*	S4B					Probable	1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15, 19, 21, 22, 23, 27, 37, 38, 39, 43, 44, 47, 48, 5057, 58, 60
Northern Cardinal	*Cardinalis cardinalis*	S5B					Confirmed	2, 4, 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 28, 30, 31, 34, 35, 36, 37, 38, 39, 40, 42, 44, 45, 47, 49, 50, 53, 56, 57, 58, 59, 60, 63; IN
Northern Flicker	*Colaptes auratus*	S5B			Y		Probable	4, 12, 16, 17, 21, 25, 26, 30, 31, 32, 33, 34, 38, 44, 45, 46, 47, 57, 61, 64; IN
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	S4B			Y		Possible	2; IN
Northern Waterthrush	*Parkesia noveboracensis*	S5B					Probable	20
Ovenbird	*Seiurus aurocapilla*	S4B				Y	Probable	8, 9, 10, 21, 32, 33
Pileated Woodpecker	*Hylatomus pileatus*	S5				Y	Possible	32
Pine Warbler	*Setophaga pinus*	S5B				Y	Probable	6, 7, 9, 27, 28, 32, 47
Red-bellied Woodpecker	*Melanerpes carolinus*	S4					Possible	7, 8, 9, 12, 21, 57, 59; IN
Red-breasted Nuthatch	*Sitta canadensis*	S5				Y	Possible	6, 7, 13, 17, 27, 30, 31, 47
Red-eyed Vireo	*Vireo olivaceus*	S5B					Probable	7, 8, 9, 13, 14, 19, 21, 22, 24, 27, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 47, 48, 49, 50, 51, 53, 58, 59, 60
Red-tailed Hawk	*Buteo jamaicensis*	S5B					Confirmed	47, 64; IN
Red-winged Blackbird	*Agelaius phoneniceus*	S5B					Confirmed	1, 2, 5, 13, 16, 17, 20, 28, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 64, 65; IN
Ring-billed Gull	*Larus delawarensis*	S5B					Observed	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 21, 23, 25, 26, 27, 30, 31, 32, 35, 36, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 48, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65

Common Name	Scientific Name	S RANK	ESA Status	SARA Status	Regional Concern	MNRF Area Sensitive	Highest Breeding Evidence Observed	Point Count Stations[2] at which Species was Observed (BI-#)
Rock Pigeon	*Columba livia*	SNA					Possible	41; IN
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	S4B					Probable	2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 16, 17, 18, 19, 21, 23, 29, 36, 41, 42, 48, 49
Ruffed Grouse	*Bonasa umbellus*	S4					Possible	5
Savannah Sparrow	*Passerculus sandwichensis*	S5B			Y	Y	Probable	1, 2, 16, 21, 37, 62, 63, 64
Song Sparrow	*Melospiza melodia*	S5B					Confirmed	1, 2, 3, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 27, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65; IN
Spotted Sandpiper	*Actitis macularius*	S5					Probable	50
Swamp Sparrow	*Melospiza georgiana*	S5B					Probable	52, 53
Tree Swallow	*Tachycineta bicolor*	S5B					Probable	40, 41, 43, 45
Turkey Vulture	*Cathartes aura*	S5B					Possible	44, 46; IN
Veery	*Catharus fuscescens*	S4B				Y	Probable	4, 10, 14, 23, 36
Vesper Sparrow	*Pooecetes gramineus*	S5B			Y		Possible	39
Warbling Vireo	*Vireo gilvus*	S5B					Possible	47, 49, 52, 57, 63
White-breasted Nuthatch	*Sitta carolinensis*	S5				Y	Possible	31, 47, 49, 50, 57, 63, 64; IN
Willow Flycatcher	*Empidonax traillii*	S5B					Probable	40, 43, 52, 61
Winter Wren	*Troglodytes hiemalis*	S5B				Y	Observed	IN (Polygon 72.04 – moist thicket, fall)
Wood Duck	*Aix sponsa*	S5					Possible	52; IN
Wood Thrush	*Hylocichla mustelina*	S4B	SC	THR	Y		Probable	2, 3, 8, 12, 16, 18, 20, 22, 24, 36; IN (closest to station #7)
Yellow Warbler	*Dendroica petechia*	S5B					Probable	1, 40, 41, 43, 44, 45, 46, 50, 51, 52, 53, 54, 56, 61, 62, 63, 64, 65

3.3.4.4.3 Conclusions

Eighty-two bird species were recorded during the breeding bird field surveys and other field investigations completed as part of this SWS, of which 79 exhibited some evidence of breeding. The majority of bird species recorded are common and widespread, but nine SAR birds were determined to be at least possibly breeding in suitable habitat within the study area. These SAR are discussed further in **Section 3.3.5**. Some of the observed species are also considered to be of concern regionally and/or are area-sensitive.

3.3.4.5 Amphibians

Amphibians (frogs, toads, and salamanders) are highly sensitive to environmental stresses such as air and water pollution. Populations of many amphibian species have been in decline over recent decades, particularly in heavily populated and industrialized areas, due to anthropogenic impacts. Amphibian surveys may therefore be used as an indicator of overall ecosystem health. Locations with high numbers and/or a high diversity of breeding amphibians are considered significant habitats on the provincial level (MNRF, 2015).

3.3.4.5.1 Methodology

Frog and toad species are readily identifiable during their breeding periods, when they migrate to breeding ponds and give audible calls that can be identified to species (often from a great distance). Initially, 14 roadside survey stations for frogs and toads were chosen throughout the study area based on aerial interpretation of potentially suitable habitat characteristics and land access. One of these stations (Station 3) was later excluded as the area was found to be inaccessible during the first field visit. Thus, a total of 13 stations were ultimately surveyed as part of this SWS. These thirteen locations are illustrated on **Figure 3.51**.

Calling surveys for frogs and toads were conducted using the methods of the Marsh Monitoring Protocol (MMP) (Bird Studies Canada, 2009). Three calling surveys were undertaken at all stations. Date selection and methodology followed the MMP. Nighttime air temperatures were a minimum of 5˚C for the first visit, 10˚C for the second visit, and 17˚C for the third visit, and survey dates were separated by at least 15 days. Surveys were conducted on still nights, preferably during or immediately after rain. Parameters recorded during each survey include date, time, air temperature, wind speed, the degree of cloud cover, and level of precipitation.

At each call survey station, the intensity and number of calling amphibians were measured and recorded using call level and abundance codes, as outlined in the MMP. Codes are as follows:

- <u>Level 1</u>: Calls are not simultaneous and calling individuals can be counted;
- <u>Level 2</u>: Some calls are simultaneous but individual calls are distinguishable and number of individuals can be estimated; and
- <u>Level 3</u>: Calls are continuous and overlapping, individuals cannot be distinguished.

In addition to the above, accessible portions of the study area were reviewed for the presence of vernal pools in early spring of 2019. These features are typically fish-free, temporary ponds in woodlands that provide breeding habitat not only for certain frog species but also ambystomatid salamanders which are not detectable using calling surveys. Correspondence with the MNRF in

January, 2019 indicated that the study area is outside of the range for Jefferson Salamander (*Ambystoma jeffersonianum*), an Endangered species in Ontario, and therefore no specific studies would be needed related to that species. However, the identification of significant habitat features is a target for this study, and ponds used by high numbers of other salamander species are considered significant. The intention was therefore to complete spring visual egg mass surveys in suitable habitat, following the protocol provided by MNRF with their correspondence, in order to identify significant salamander breeding habitat in the study area. However, the initial site reconnaissance did not identify any candidate vernal pools that required further assessment. Salamanders and their habitat will therefore not be specifically discussed in the following sections.

3.3.4.5.2 Results

Four individuals of two species were recorded during amphibian calling surveys: Gray Treefrog (*Hyla versicolor*) and American Toad (*Anaxyrus americanus*). The site conditions and results of the amphibian calling surveys are contained in **Table 3.25** and **Table 3.26**, respectively. Field data sheets are provided in **Appendix L**.

Table 3.25: Conditions During Amphibian Calling Surveys

Survey	Date	Time (24hr)	Beaufort Wind Scale	Cloud Cover (%)	Air Temp (°C)	Precip.
1	2018-04-30	20:47 – 22:24	2	0	9-16	Dry
2	2018-05-16	21:08 – 22:32	1	0	13-14	Dry
3	2018-06-26	21:33 – 22:44	2	40	18	Dry

Table 3.26: Anuran Calling Survey Results

Station	Survey 1			Survey 2			Survey 3		
	Species	Call Level	Count	Species	Call Level	Count	Species	Call Level	Count
1	No Calls	-	-	No Calls	-	-	No Calls	-	-
2	No Calls	-	-	No Calls	-	-	No Calls	-	-
4	No Calls	-	-	No Calls	-	-	No Calls	-	-
5	No Calls	-	-	No Calls	-	-	Gray Treefrog	1	3
6	American Toad	1	1	No Calls	-	-	No Calls	-	-
7	No Calls	-	-	No Calls	-	-	No Calls	-	-
8	No Calls	-	-	No Calls	-	-	No Calls	-	-
9	No Calls	-	-	No Calls	-	-	No Calls	-	-
10	No Calls	-	-	No Calls	-	-	No Calls	-	-
11	No Calls	-	-	No Calls	-	-	No Calls	-	-
12	No Calls	-	-	No Calls	-	-	No Calls	-	-
13	No Calls	-	-	No Calls	-	-	No Calls	-	-
14	No Calls	-	-	No Calls	-	-	No Calls	-	-

In addition to the amphibian calling survey results, Green Frog (*Lithobates clamitans*) and Spring Peeper (*Pseudacris crucifer*) were observed incidentally at multiple locations in the study area. Green Frog is a common species that is able to thrive in ditches, ponds, and other marginal water features that sustain wetted conditions through the summer. By contrast, Spring Peeper is generally more habitat sensitive and utilizes woodlands and wetlands such as marshes, ponds and swamps, but is still relatively common in these habitats.

Based on the low number of amphibians observed, the surveyed study area was not confirmed to contain significant amphibian breeding habitat. This is not an entirely unexpected result, as the majority of the potential habitat within the Bowmanville Urban Boundary consists of small creek valleys without extensive riparian wetlands or ponds. These types of features do not always provide high-quality amphibian habitat for a variety of reasons, such as insufficient water depth or the presence of predatory fish that eat the frog eggs and larvae. However, the large scale of this SWS required scoping of amphibian surveys to a relatively small number of survey stations throughout the study area, which were selected as being the most likely locations to provide habitat based on existing mapping. It is possible that additional habitat areas are present elsewhere in the subwatershed (particularly at more remote locations without road access) which were not surveyed as part of this study. Such habitat areas would need to be surveyed as part of site-specific studies associated with development proposals on those properties. Existing areas identified in this study or other sources may also be confirmed and/or refined through that process.

3.3.4.5.3 Conclusions

Two species of breeding amphibians were documented during calling surveys completed in 2018, in low numbers. Neither species is considered rare or at risk in Ontario, and none of the survey stations were documented to have high numbers of calling amphibians.

3.3.4.6 Other Wildlife

Other wildlife groups were not directly surveyed during this study, although incidental wildlife observations were recorded during all terrestrial and aquatic ecology field surveys in order to make the characterization of the watersheds as comprehensive as possible. Incidental bird and amphibian observations have been incorporated into their respective sections, above. Other wildlife, including insects, mammals, and reptiles are discussed below.

3.3.4.6.1 Results

Insects

Nineteen insect species were positively identified during field surveys:

- Monarch (*Danaus plexippus*);
- Viceroy (*Limenitis archippus*);
- Mourning Cloak (*Nymphalis antiopa*);
- Red Admiral (*Vanessa atalanta*);
- Cabbage White (*Pieris rapae*);
- Sulphur species (*Colias* sp.);

- Isabella Tiger Moth (*Pyrrharctia isabella*);
- Hickory Tussock Moth (*Lophocampa caryae);*
- Laurel Sphinx Moth (*Sphinx kalmiae*);
- Common Green Darner (*Anax junius*);
- Black Saddlebags (*Tramea lacerata*);
- European Mantis (*Mantis religiosa*);
- Grasshopper (*Melanoplus sp.);*
- Common Eastern Bumble Bee (*Bombus impatiens*);
- Japanese Beetle (*Popillia japonica*);
- Ladybird Beetle (*Coccinellidae sp.);*
- Oil Beetle (*Meloe sp.*);
- Organ Pipe Mud Dauber (*Trypoxylon politum*)*;* and
- Paper Wasp (*Polistes* sp.).

It is expected that a wide range of other insects are present within the study area; dedicated insect surveys were not completed as part of this study. Larger patches of meadows and meadow marshes containing wildflowers, in particular, are likely to support high numbers and diversity of pollinating insects and other arthropods.

One of the observed species, Monarch, is a SAR. Monarch has the potential to occur in any area containing flowers as a food source, including suburban yards and parks, so observation of an individual does not necessarily indicate the presence of important habitat. Within the study area, Polygon 201.02 (CUM1-1) was identified as having a large concentration of milkweed. This Polygon is discussed further in **Section 3.3.6** as having potential as Significant Wildlife Habitat. Further information regarding this species is also provided in **Section 3.3.5**.

Mammals

Mammals observed in the study area (via direct sighting or other evidence such as tracks, dens, or browse) include:

- White-tailed Deer (*Odocoileus virginianus*);
- Raccoon (*Procyon lotor*);
- Red Squirrel (*Sciurus vulgaris);*
- Grey Squirrel (*Sciurus carolinensis*);
- American Mink (*Neovison vison*);
- Muskrat (*Ondatra zibethicus*);
- American Beaver (*Castor canadensis*); and
- Eastern Chipmunk (*Tamias striatus*).

Coyote (*Canis latrans*) dens were observed at two locations in the northern part of the Urban Boundary study area, and a suspected Red Fox (*Vulpes vulpes*) den was observed in a Sugar Maple forest in the northern headwater area, although it was unknown whether any were active at the time of observation. Other mammal species which are common in southern Ontario such as

Eastern Cottontail (*Sylvilagus floridanus*) and Striped Skunk (*Mephitis mephitis*) are also likely to be present in the study area.

Reptiles

Two reptile species were observed during field investigations: Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) and Snapping Turtle (*Chelydra serpentina*). Given the size of the study area, other common snake species are undoubtedly present. Permanent ponds and watercourses in the subwatershed are also thought likely to support Midland Painted Turtle (*Chrysemys picta marginata*), particularly in the lower reaches of Soper Creek where there is direct connectivity to the lakeshore and associated wetlands.

3.3.5 Species at Risk

For the purpose of this study, Species at Risk (SAR) are defined as species listed as Endangered (END), Threatened (THR), or Special Concern (SC) under the provincial *Endangered Species Act* (ESA) and/or the federal *Species at Risk Act* (SARA). Species that have been designated in these risk categories by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) but are not yet provincially or federally listed have also been considered SAR in this document for the purpose of discussion.

Species listed provincially as Endangered and Threatened receive regulatory protection for themselves and their general or specific habitat under the ESA:

- **General Habitat**: an area on which a species depends directly or indirectly to carry out its life processes (under clause 2(1)(b) of the ESA) or,

- **Regulated Habitat**: the area prescribed for a species in a habitat regulation (under clause 2(1)(a) of the ESA). A habitat regulation may prescribe an area as the habitat of a species by describing the boundaries of the area, the features of the area, or by describing the area in any other manner. Regulated habitat may be smaller or larger than general habitat. As well, unlike the general habitat of a species, regulated habitat may include areas currently unoccupied by the species, such as areas where the species formerly occurred or areas where there is the potential for the species to become re-established. These areas are commonly referred to as “recovery habitat”.

The habitat of Special Concern species does not receive regulatory protection under the ESA but may be considered significant wildlife habitat (SWH) and thus be protected under municipal policy and the PPS (see **Section 3.3.6** for further discussion).

3.3.5.1 Methodology

In addition to the results of field surveys conducted for this study, a number of primary and secondary information sources were consulted to assess the presence of SAR within the study area, as described in **Section 3.3.1**.

Information from all background sources was combined to create a comprehensive list of potential SAR associations which was then screened by comparing the habitat needs of each species with the habitat conditions present within the subject property and adjacent lands. The full results of this assessment are provided in **Appendix N**. The following sections provide a more comprehensive discussion of species that were either confirmed or determined likely to occur within the study area in the present day based on the availability of suitable habitat.

3.3.5.2 Bank Swallow - Threatened

Bank Swallow is a colonial nester that excavates nest burrows in eroding vertical banks (e.g., riverbanks, lake bluffs, road cuts, aggregate pits) situated near suitable grasslands, pastures, and other open terrestrial sites that provide adequate foraging habitat. Substrate is an important factor in nest site selection, with silty fine sands often preferred. Like many other aerial insectivores, Bank Swallow populations have experienced significant, long-term declines that are thought to result from multiple factors such as habitat loss (e.g., due to erosion control projects), reduction in prey abundance, and changing aggregate management practices.

General Habitat for Bank Swallow includes an area up to 500 m from the outer edge of a breeding colony to account for foraging habitat (MNRF, 2015).

This species was documented foraging within the study area, although breeding habitat was not confirmed during field investigations. Nesting habitat may be present in the area but, if extant, is expected to occur along Soper Creek, its tributaries, and/or the Lake Ontario shoreline where vertical eroding banks are present.

3.3.5.3 Barn Swallow – Threatened

Barn Swallow is a Threatened bird species of open-country habitats, although it has been recommended for downlisting to Special Concern by COSEWIC. It is commonly found in close proximity to humans as it forages over agricultural fields and builds its cup-shaped mud nests inside barns, on the underside of bridges, and in drainage culverts. Although it is the most widespread and abundant swallow in the world, it has been listed as a SAR due to population declines over the northern part of its North American breeding range (Heagy, et al., 2014).

Barn Swallows were observed in multiple locations during breeding bird surveys, mostly while foraging in open areas. The three main locations associated with this species, as determined via the breeding bird surveys, are as follows:

1) **Mearns Avenue north of Concession 3**: Several Barn Swallows were noted foraging in this area on multiple dates. Individuals were observed flying into a barn on the east side of Mearns Avenue which is highly suggestive of breeding at this location.

2) **Soper Creek valleyland east of Sprucewood Crescent**: Several Barn Swallow were noted foraging in the valleyland and over Soper Creek to the east of Sprucewood Crescent. An active Barn Swallow nest was observed beneath an awning on the front porch of a residence on Sprucewood Crescent. The individuals documented to be foraging in the valley may be associated with this nest.

3) **Regional Highway 2 near the eastern margin of the Urban Boundary**: Several Barn Swallows were noted foraging above a wheat field south of Regional Highway 2 (station BI-61) and were also documented to the north (BI-63). While no Barn Swallow nests (or activities suggestive of nesting) were noted at these stations, the large number of individuals recorded at BI-61 suggests that a breeding site may be located nearby (possibly within buildings or barns on the south side of Regional Highway 2).

The General Habitat definition for Barn Swallow in Ontario includes nest sites and the associated foraging habitat up to 200 m from a nest (MNRF, 2013). This includes nest sites which are found on artificial structures. The foraging habitat up to 200 m from the confirmed nest site on Sprucewood Crescent and the likely nest site off Mearns Avenue is therefore considered General Habitat for this species (see **Figure 3.54**; note that the existing Sprucewood Crescent subdivision is within this 200 m radius although it does not have characteristics typical of foraging habitat). General habitat is also likely present in the vicinity of Highway 2 at the location noted above, but this would require further studies to confirm the presence and exact location of nesting habitat. The general foraging habitat area around confirmed nest sites will be included in subsequent mapping and discussion in this document, to ensure that it is appropriately considered in future studies and development applications. However, as an anthropogenically-based feature, it is unlikely to be included in Natural Heritage System designations.

In general, barns, sheds, and other similar structures throughout the subwatershed could potentially support this species, and any work that would affect such structures (i.e., demolition) should be preceded by additional studies to confirm the presence/absence of nests. Removal of buildings or structures supporting nest sites may occur subject to conditions laid out in O.Reg. 242/08 under the ESA, but the impacts to the species associated with such an action would need to be addressed in site-specific impact assessment studies, and appropriate mitigation would need to be applied, as discussed in **Section 5.3**.

3.3.5.4 Bobolink – Threatened

Bobolink is an open-habitat bird species that nests on the ground in grasslands, meadows, hayfields, and similar habitats, although they are not typically found in row-cropped agricultural fields or areas with bare soil patches. They prefer grass-dominated fields and may prefer or at least tolerate wetter conditions. They will occupy fields having scattered shrubs or fence posts for perches, but tend to avoid fields where woody cover (i.e., trees and shrubs) is more than 25% of the area. Bobolink is considered an area sensitive species, generally preferring larger grassland patches of >10 ha, although other factors can contribute to site selection and smaller fields may be used if habitat is limited (McCracken, et al., 2013).

As a Threatened species, Bobolink's General Habitat is automatically protected under the ESA. General Habitat for Bobolink includes the area of continuous suitable habitat up to 300 m from a nest or the approximate center of a defended territory (MNRF, 2013).

Based on the results of breeding bird surveys and Aquafor Beech's discussion with a landowner in the study area, Bobolink breeding habitat is confirmed at a location north of Concession 3 and west of Mearns Road, as indicated on **Figure 3.54**. Modified farming practices (i.e., avoiding activities such as mowing during the nesting season) are in place at this location to protect the nesting birds.

Bobolink was also documented at other locations in the study area; however, breeding was not confirmed. The majority of open habitats are actively managed as row crops or hayfields and therefore do not currently provide optimal habitat for this species. However, any fields that are left fallow in future may be colonized by nesting Bobolinks.

The primary threats to the survival and recovery of Bobolink in Ontario are habitat loss and degradation (e.g., pastures and hay fields converted to row crops or developed for urban expansion, natural grasslands become grown in with woody vegetation). Since Bobolink is area sensitive, fragmentation of suitable open habitat can make the remaining habitat areas unsuitable for nesting. Protecting and enhancing existing habitat is therefore an important conservation goal for this species.

3.3.5.5 Chimney Swift – Threatened

The Chimney Swift is an agile, swallow-like bird that feeds on small insects while on the wing. Historically, this species is thought to have used hollow trees for nesting but now primarily nests inside chimneys and similar structures. They are therefore regularly encountered in urban areas. Chimney Swift has been designated Threatened due to a long-term decline; the primary threats include residential and commercial development that removes suitable nesting chimneys and/or reduces the available foraging habitat, as well as activities that reduce the abundance of prey (insects).

As a Threatened species, Chimney Swift's General Habitat is automatically protected under the ESA. General Habitat for this species includes artificial roost/nest sites but no associated or adjacent foraging habitat to those sites (MNRF, 2017).

One Chimney Swift was observed during breeding bird surveys, in general association with the Camp 30 property north of Concession Street and west of Lambs Road; an eBird record from 2017 also noted this species in association with that property. One chimney that could provide suitable nesting/roosting habitat conditions for this species was documented on one of the buildings on the Camp 30 site, although the use of this structure by birds was not confirmed as part of this study.

There is also a known Chimney Swift colony in Bowmanville, associated with the Central Public School. Some or all of the observed individuals could be foraging birds associated with this colony.

3.3.5.6 Common Nighthawk – Special Concern (ESA), Threatened (SARA)

Requirements for Common Nighthawk breeding include both open areas for foraging and bare ground for nesting; breeding habitat is known to occur in open forests (especially those interrupted by cuts or rock outcrops), short prairies, gravel pits, quarries, railways, orchards, and even gravel roofs. Key microhabitat factors include dry, well-drained substrate, and the presence of shade. Threats to this species are, to date, poorly understood but may be related to the general decline that is affecting all aerial insectivores due to declining prey insect populations (COSEWIC, 2018).

One male Common Nighthawk was incidentally observed during the third amphibian calling survey on June 26, 2018, east of Anuran Station #7; it was heard displaying in an agricultural field adjacent to a woodlot. Given the time of year and the habitat this individual was observed in, it is believed the site could have provided suitable breeding habitat and therefore it was considered a possible breeder. Nine Common Nighthawks were also reported via eBird in Sept. 2019 along the creek channel near Bowmanville Cemetery; given the time of year, however, these could have been south-bound migrants and not local breeders.

Common Nighthawk is designated Special Concern under the Ontario ESA, and it is therefore not afforded habitat protection under that Act. However, it is also designated Threatened under the federal SARA and therefore, as a species also listed under the federal *Migratory Birds Convention Act*, SARA prohibitions for Threatened species apply regardless of whether the land on which the species occurs is federally-owned. Under the SARA, it is prohibited to kill, harm, harass, capture or take an individual of a Threatened species, or to damage or destroy their residence. Critical habitat, per the 2016 Recovery Strategy for this species (Environment Canada, 2016), has not yet been designated.

3.3.5.7 Eastern Meadowlark - Threatened

Similar to the Bobolink, above, Eastern Meadowlark is a bird species of open habitats that nests on the ground in anthropogenic grasslands such as hayfields, pastures, and old-field meadows. It has also been known to occur in orchards, golf courses, and other marginal grassland habitats, although it rarely nests in row crop fields. Optimal conditions typically include a high density of tall grasses, a low proportion of woody vegetation, and a low percent cover of bare ground. They use scattered trees, shrubs, fenceposts, and similar features as singing perches, which may be an additional habitat requirement. Eastern Meadowlark is considered to be moderately area sensitive, generally preferring larger tracts of grassland; the minimum territory size is about 5 ha (McCracken, et al., 2013).

As a Threatened species, Eastern Meadowlark's General Habitat is automatically protected under the ESA. General Habitat for this species includes the area of continuous suitable habitat up to 300 m from a nest or the approximate center of a defended territory (MNRF, 2013).

Eastern Meadowlark was documented at three general locations during breeding bird surveys. Of these locations, two were associated with "probable" breeding evidence and the extent of suitable habitat is shown on **Figure 3.54**; note that one of the two locations overlaps with the noted Bobolink habitat described in the section above. The majority of open habitats within the study area are actively managed as row crops or hayfields and therefore do not currently provide optimal habitat for this species. However, any fields that are left fallow in future may be colonized by nesting Eastern Meadowlarks.

3.3.5.8 Eastern Wood-pewee – Special Concern

The Eastern Wood-pewee occurs throughout southern Ontario, breeding most often in deciduous forests with an open understory, with a preference for nest sites near clearings and forest edges. In general, the size of forest fragments does not appear to be an important factor in habitat selection for this species, though the presence of residential developments surrounding woodlots does appear to decrease the likelihood that Eastern Wood-pewee will be present. The presence of dead branches that are used as hunting perches may be an additional habitat need (COSEWIC, 2012).

Eastern Wood-pewee was documented at 14 of the point count locations established for the breeding bird surveys completed in 2018; it was considered a probable breeder at eight of those locations. Woodlot edges without adjacent developments are fairly common in the study area, particularly in the northern part of the Urban Lands where wooded watercourse corridors and agricultural fields form a complex mosaic. Any such habitat could potentially support this species. As a Special Concern species, Eastern Wood-pewee does not receive habitat protection under the ESA; however, its habitat could be considered Significant Wildlife Habitat (see **Section 3.3.6**).

Threats contributing to the decline of this species are not fully understood. Forest fragmentation of itself does not appear to be a major factor since the size of forest fragments has not been found to significantly affect nest site selection. However, the overall amount of forest cover on the landscape and the proximity of human development to remaining woodlots may both influence habitat suitability. As noted above, Eastern Wood-pewees are less likely to be found in urban woodlots surrounding by residential developments as opposed to forests in natural or rural settings. Reductions in flying insect populations, which are the main food source for Eastern Wood-pewee, are also a likely factor (COSEWIC, 2012).

3.3.5.9 Golden-winged Warbler – Special Concern (ESA), Threatened (SARA)

This species nests and forages in a variety of early successional habitats adjacent to a forested edge. The transitional area between forest and open/shrub habitat is considered especially important for Golden-winged Warbler, as nests most often occur within 200 m of that transition (Environment and Climate Change Canada, 2016). Primary threats to this species include hybridization with the closely-related Blue-winged Warbler and habitat destruction or degradation (e.g., due to invasive *Phragmites* colonization of wetland sites).

One observation of Golden-winged Warbler was made along a woodlot edge just north of the Camp 30 buildings, west of Lambs Road; it was considered a “possible” breeder given the suitability of habitat in the vicinity.

Golden-winged Warbler is designated Special Concern under the Ontario ESA, and it is therefore not afforded habitat protection under that Act. However, it is also designated Threatened under the federal SARA and therefore, as a species also listed under the federal *Migratory Birds Convention Act*, SARA prohibitions for Threatened species apply regardless of whether the land on which the species occurs is federally-owned. Under the SARA, it is prohibited to kill, harm, harass, capture or take an individual of a Threatened species, or to damage or destroy their residence.

Critical habitat for this species, per the federal Recovery Strategy (Environment and Climate Change Canada, 2016), includes the transitional corridor between forest and open habitat, plus a 50-200 m setback (depending on the characteristics of adjacent lands), where certain occupancy criteria are met (i.e., where one or more records of confirmed or probable breeding have been observed since 2001, or where both the first and second Ontario Breeding Bird Atlases found Golden-winged Warbler within that survey square). Within the study area, Golden-winged Warbler was only found as a possible breeder, and only the first atlas reported it within the study area, so the occupancy criteria for critical habitat are not currently met.

3.3.5.10 Wood Thrush – Special Concern (ESA), Threatened (SARA)

In Ontario, the Wood Thrush mainly nests in moist mature and second-growth deciduous and mixed forests with dense undergrowth, preferring large forest mosaics but also occurring in smaller fragments. Forest structure may be an important factor in habitat for this species; they have been noted to prefer nest sites with a closed canopy, high diversity of deciduous tree species, a fairly open forest floor, and moderate shrub density. Habitat degradation and fragmentation due to development are among the primary threats to this species (COSEWIC, 2012).

Within the study area, Wood Thrush was documented as a possible or probable breeder at ten survey stations, all of which are associated with wooded habitat located in the northern part of the Urban Lands (north of Concession Road 3).

Wood Thrush is designated Special Concern under the Ontario ESA, and it is therefore not afforded habitat protection under that Act. However, it is also designated Threatened under the federal SARA and therefore, as a species also listed under the federal Migratory Birds Convention Act, SARA prohibitions for Threatened species apply regardless of whether the land on which the species occurs is federally-owned. Under the SARA, it is prohibited to kill, harm, harass, capture or take an individual of a Threatened species, or to damage or destroy their residence. A Recovery Strategy has not yet been developed for this species and therefore protected critical habitat has not been determined.

3.3.5.11 Monarch – Special Concern

The well-known Monarch butterfly is currently listed as Special Concern both provincially and federally and therefore receives no regulatory protection. However, COSEWIC reassessed the Monarch as Endangered in 2016, citing declines of greater than 50% in the last decade. The primary threats facing the Eastern North American Monarch population include the degradation and loss of overwintering habitat in Mexico, the widespread use of pesticides and herbicides throughout their breeding grounds, climate change, severe weather events, succession and/or conversion of breeding and nectaring habitat, and the impacts of bark beetles on overwintering habitat (COSEWIC, 2016).

Adult Monarchs were observed in multiple locations throughout the study area, feeding on wildflowers; it is anticipated that adult Monarchs will occur at additional locations throughout the study area, wherever flowers are present as a food source. Larvae were observed incidentally on Common Milkweed (*Asclepias syriaca*) plants in Polygons 42.05 and 135 (CUM1-1) and are likely to exist elsewhere, as detailed surveys for these were not conducted for this species. Of the vegetation communities assessed in 2019, Common Milkweed was found primarily in dry communities that had at least some degree of openness (e.g. CUM1-1, CUS1, CUT1, CUW1, ANTH, HR), but forested communities also frequently contained Milkweed along edges or where gaps in the canopy occurred. In most communities, Milkweed was listed occurring with 'rare' to 'occasional' frequency. One community was found to have an abundance of milkweed: 201.02 (CUM1-1), and this polygon is discussed as Candidate Significant Wildlife Habitat in **Section 3.3.6**. Milkweed is likely present in additional areas not surveyed, such as agricultural field edges, roadsides, and rail rights-of-way.

The federal Management Plan for the Monarch (Commission for Environmental Cooperation, 2009) recommends the conservation and enhancement of Monarch breeding and nectaring habitat in Ontario - i.e., open grasslands, meadows, wetlands, etc. which contain wildflowers, particularly milkweeds which are the required larval host plants. The Management Plan also encourages landscaping with native species and the creation of butterfly gardens in residential developments, which is a measure that could be carried forward to future development proposals. Recommendations for future work are discussed in **Section 5.3**.

3.3.5.12 Butternut – Endangered

Butternut is a short-lived (<75 years), mast-bearing tree in the walnut family (Juglandaceae). It is frequently found along floodplains, streambanks, and ravine slopes, but can occur in a wide variety of other conditions; it is more common in areas with underlying limestone and is generally absent from regions with acidic soil such as the granite-dominated areas of the Canadian Shield. Butternut is intolerant of shade and tends to be found either as a mature canopy tree or in or in openings and edges (COSEWIC, 2017).

Butternut is currently designated as Endangered and receives general habitat protection under the ESA. The primary threat to Butternut is an introduced exotic fungal pathogen, *Sirococcus clavigignenti-juglandacearum* ("butternut canker"). Infection generally occurs through wounds, broken branches or leaf scars, causing twig dieback and eventual tree mortality. The most obvious sign of infection is a black, oozing canker on the stem or twigs. Potential habitat for butternut occurs throughout the subwatershed study area.

The provincial Butternut Recovery Strategy (Poisson & Ursic, 2013) recommends that a minimum radius of 25 m from the base of the stem of all Butternuts be considered protected habitat. However, it also recommends that this protection only be applied to healthy trees (i.e., trees which are not affected by the canker to the degree they are classed as "non-retainable" by a Butternut health assessment). The MNRF's interim guidance on general habitat for Butternut under the ESA (2015) confirms that a 25 m radius from each tree should be considered Category 1 habitat which protects the critical root zone and other functions that support the life of that individual, but further adds that suitable areas from 25-50 m of a tree should be considered Category 2 habitat necessary for nut dispersal and seedling establishment. Aquafor Beech therefore recommends a 50 m radius around each retainable Butternut be protected as habitat.

Butternut was recorded in ELC polygons 66.01, 70.09, 70.10, 86.09, 86.12, 86.15, 86.16, 90.03, 90.04, 90.05, 90.09, 90.11, 134.02, 201.01, and 07.26 (**Figure 3.54**). These communities were generally deciduous or mixed forests, and trees frequently occurred along the edges of the polygons, or in interior areas with increased light penetration. In particular, Polygons 66.01 (CUS1) and 90.04 (FODM4-11) contained multiple Butternut throughout, several of which were mature and on initial inspection did not appear to be exhibiting signs of severe butternut canker infection. These polygons and surrounding polygons with similar deciduous composition likely serve as very productive regeneration zones for this species.

Due to the size of the study area it was not possible to inventory every tree in the Soper Creek subwatershed, therefore there are potentially more Butternut present in the study area than were recording during field investigations. Full Butternut Health Assessments (per MNRF protocols) were not carried out as a part of the current study as this is typically completed during site-level assessment closer to the time of potential disturbance (i.e., development). However, initial review revealed that both pure Butternut (protected under the ESA) and hybrid trees (not protected under the ESA) may be present throughout the study area. The presence/absence of Butternut (and the genetic purity of identified trees, as needed) should be confirmed by future site-level studies and a Butternut health assessment by a qualified Butternut Health Expert (as defined under provincial legislation) would be required for proposed removal of or disturbance within the recommended 50 m habitat radius surrounding a pure Butternut, as discussed in **Section 5.3**.

3.3.5.13 Snapping Turtle – Special Concern

Snapping Turtles prefer shallow waters where they can hide under soft mud and leaf litter. Nesting sites occur on open gravely or sandy areas along streams; Snapping Turtles also frequently take advantage of man-made structures for nest sites, including roads (especially gravel shoulders), dams and aggregate pits.

Aquafor staff observed a Snapping Turtle incidentally at the southern end of the study area, near where Soper Creek and Bowmanville Creek converge. Additional observation records of this species have been submitted to the iNaturalist website for the watercourse corridor just north of the Urban Lands. However, the entire main branch of the Soper Creek corridor, particularly in the southern parts of the study area where the watercourse channel is wider and deeper, may be suitable habitat for Snapping Turtles.

3.3.5.14 Other Species with Potential Presence

An additional five provincial SAR, listed below, are considered to have the potential to occur within the study area based on the known range of these species and suitability of habitat in the study area (see **Appendix N** for details). None of the species listed below were observed in the study area during field investigations for the current study, but could potentially find suitable habitat in the study area based on observed conditions.

- **Midland Painted Turtle (*Chrysemys picta marginata*; SC [SARA only])** – Midland Painted Turtles inhabit ponds, marshes, lakes, and slow-moving creeks, preferring sites with soft substrate and abundant basking sites and aquatic vegetation. They hibernate at the bottom of waterbodies. Potential habitat for this species is generally consistent with the potential habitat for Snapping Turtle, discussed above.

- **SAR bats (END)** – Summer (i.e., maternity/roosting) habitat for the four SAR bat species found in Ontario could potentially be present in woodlots of any condition in the study area. Woodland habitat in the study area may potentially provide the necessary features (i.e., tree snags with cracks, crevices, cavities, loose bark, dead branch clusters, etc.) for bats; as woodlands, the majority of these features are expected to be protected in the Natural Heritage System. Further assessment may be required prior to development if tree removal is proposed, as discussed in **Section 5.3**. Any coniferous, deciduous, or mixed wooded ecosite with trees at least 10 cm diameter at breast height should be considered candidate suitable maternity roost habitat.

3.3.5.15 Conclusions

SAR associated with the study area were screened based on background information and the availability of habitat. Twelve SAR were confirmed to occur within the study area through either dedicated surveys (breeding bird surveys), background records, or incidental observations: Bank Swallow, Barn Swallow, Bobolink, Butternut, Chimney Swift, Common Nighthawk, Eastern Meadowlark, Eastern Wood-pewee, Golden-winged Warbler, Monarch, Snapping Turtle, and Wood Thrush. Additional SAR with the potential to occur in the study area based on past occurrence records and/or the presence of suitable habitat are: Midland Painted Turtle and the four SAR bats found in Ontario.

The habitat of SAR identified in this SWS has been included in the discussion of constraints in **Section 4.2**, in the context of requiring additional study or consultation to determine or confirm the associated requirements. Site-specific studies completed as part of development proposals in the study area shall include an updated SAR screening and assessment based on the most up-to-date listings and available knowledge at that time. Those studies shall confirm the presence/absence of the species listed above and/or potential habitat opportunities, plus any additional species as appropriate under current SAR legislation at that time, and identify the requirements for each under both applicable SAR legislation and municipal policy.

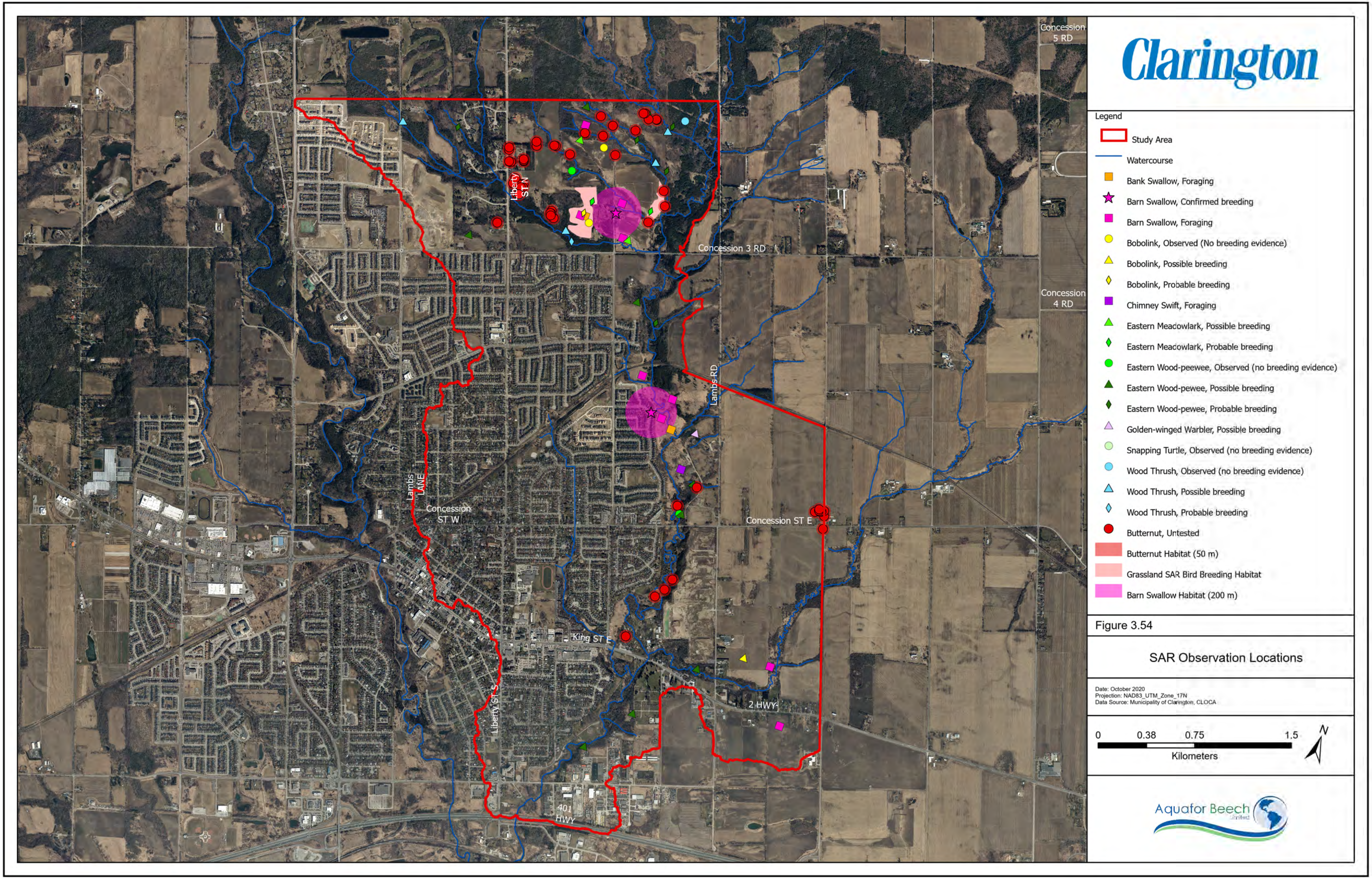


Figure 3.54

SAR Observation Locations

3.3.6 Significant Wildlife Habitat

Wildlife habitat is considered to be significant when it is "ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity" of wildlife habitat (MMAH 2020). Specifically, when habitat provides features and functions critical to the survival of an individual, species, or group, it may be considered Significant Wildlife Habitat (SWH); for example, specialized vegetation communities, nest/den sites, overwintering sites, and migratory stopovers with particular characteristics may be limited on the landscape and/or provide habitat function during key life stages of the organism, and would therefore be considered significant.

3.3.6.1 Methodology

The *Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E* (MNRF, 2015) document was used to define the presence of Significant Wildlife Habitat (SWH) within the study area. The corresponding analysis and assessment of all SWH types are detailed in **Appendix O**. This analysis and assessment was based largely on data collected through studies described in **Section 3.3.3.1**.

Confirmed and Candidate SWH types identified through this screening process are described below and illustrated, as appropriate, in **Figure 3.55**. Please note that for properties where access permission was not granted, a conservative approach to identifying candidate habitat was used (e.g., ponds identified through air photo interpretation were assumed to provide candidate turtle overwintering habitat, lacking evidence to suggest otherwise). SWH shall be subject to additional assessment as part of site-specific studies (e.g., EIS) in order to confirm up-to-date habitat conditions at that time, and the assessment provided below may be amended or refined based on the results of those future studies.

3.3.6.2 Results

Waterfowl Stopover and Staging Areas (Aquatic) – Candidate
Large aggregations of 100 or more listed waterfowl species in ponds, marshes, lakes, bays, coastal inlets and watercourses for more than 700 waterfowl use days during migration qualifies aquatic habitat as Candidate Stopover and/or Staging Areas. Although no formal surveys were completed over the seven day period to Confirmed SWH, Aquafor staff incidentally observed a concentration of 100+ waterfowl (including Mallard, Wood Duck, Blue-winged Teal, and Common Merganser) in suitable flooded riparian habitat along the watercourse corridor south of Concession St. E., just east of the Urban Boundary (i.e., just outside of the current study area) in March 2019. Regardless, the candidate SWH (which includes the combined area of riparian wetland habitat plus a buffer of 100 m) has been indicated for future information on **Figure 3.55**.

Bat Maternity Colonies – Candidate
Mature forests fitting the requirement for candidate maternity habitat are present in the study area. Therefore, all woodlands (e.g., forests, treed swamps, cultural woodlands, and plantations) with trees exhibiting suitable habitat characteristics are considered to be candidate bat maternity habitat; these areas are not depicted on **Figure 3.55**, as mapping all woodlots in the study area would render the figure largely illegible for other SWH types. Further studies at subsequent

planning stages may be required to confirm the presence of this SWH type in specific woodlands, if impacts to those woodlands are proposed.

Turtle Wintering Areas – Candidate

The primary feature within the study area most likely to provide candidate turtle wintering areas is the main channel of Soper Creek, particularly in the lower reaches, as it is a deep, permanent waterbody surrounded by a variety of connected wooded, wetland, and open habitat types with sandy soils. Notwithstanding, any aquatic feature of sufficient depth, substrate types and adequate levels of dissolved oxygen has potential to provide overwintering habitat. Based on habitat criteria, several ponds and wetland features within the study area have been identified as candidate turtle wintering areas, as shown on **Figure 3.55.** These features were not field-verified for their potential suitability as overwintering habitat for turtles, and turtle basking surveys were not undertaken in support of this study. Further studies at subsequent planning stages are recommended to confirm this SWH type in specific ponds and wetlands.

Reptile Hibernaculum – Candidate

Potentially suitable habitat that was observed within the study area during 2019 field investigations includes old farm foundations, abandoned buildings or rock piles in several locations throughout the subwatershed, particularly in Polygons 22.01 (WODM4-4 [CUW1]), 66.02 (FOD5-1), 70.01/70.07 (CUM1-1), 70.10 (WODM4-4 [CUW1]), 90.04 (FODM7-9 [FOD7]), 90.09 (WODM5-3 [CUW1]), 90.14 (FOC4-1), 201.05 (CUM1-1), as shown on **Figure 3.55**. It is likely that additional sites may be located on properties where access was not provided. Natural rock fissures are generally not present in this area, due to the lack of surface bedrock. Further studies at subsequent planning stages are recommended to confirm the presence of this SWH type in areas that may contain anthropogenic habitats that go below the frost line, such as old stone fences and abandoned crumbling foundations.

Migratory Butterfly Stopover Areas – Candidate

Significant butterfly stopover habitat includes areas located within 5 km of Lake Ontario (a distance which includes a significant portion of the study area) with a mosaic of open habitat and forest. Fields and forests adjacent to each other are found throughout the study area. One candidate site has been identified based on the presence of old field habitat with abundant Milkweed and adult Monarchs observed. This site is located in Polygon 201.02, and is shown on **Figure 3.55**. Numerous other locations contained Milkweed (rare to occasional in individual ELC polygons), and observations of Monarch (low numbers observed), most often associated with open to semi-open habitats (CUM1-1, CUS1, CUT1, CUW1) or forested habitats with breaks in the canopy. Therefore, the location depicted on **Figure 3.55** is not the only location where Monarch was observed in the study area, but rather represents the most suitable location where conditions were identified for candidate Migratory Butterfly Stopover SWH.

Landbird Migratory Stopover Areas - Candidate

Approximately 75% of the urban area is found within 5 km of Lake Ontario (i.e., south of Longworth Ave.) and all woodlots in this area >10 ha in size therefore qualify as candidate SWH; these features are shown on **Figure 3.55**. The habitat matrix associated with this SWH type (i.e., forests, grasslands, and wetlands) are predominantly contained in the Soper Creek valley and other established NHS features. Migratory bird surveys were not completed as part of the field survey program in 2018 or 2019, and therefore further studies during subsequent planning stages may be completed during the migration period to confirm the presence of this SWH type, as required.

Woodland Raptor Nesting Habitat – Candidate

Large unbroken tracts of deciduous and mixed forest within the most northern extent of the study area and extending north beyond the boundaries contains over 30 ha of interior forest, exceeding the criteria for Candidate Woodland Raptor Nesting Habitat. Although none of the qualifying species were observed during field investigations, background sources (e.g., Ontario Breeding Bird Atlas) reveal Red-shouldered Hawk has been confirmed breeding in the vicinity, and Cooper's, Sharp-shinned and Broad-winged Hawks as well as Barred Owl have been historically identified as a probable or possible breeders within the general area. Identified candidate habitat based on the habitat size criterion has been shown on **Figure 3.56**. Further studies including nest searches from mid-March to end of May may be completed to confirm the presence of this SWH type, as required.

In addition, one empty stick nest was confirmed in Polygon 34.06 (FOD7), located in the southeastern extent of the study area within a riparian corridor. The observation was made outside of the breeding window for most raptors, therefore no evidence of nest usage was observed and the species was unable to be verified. As many species of raptor reuse old nests or construct new nests in the same general vicinity, nest surveys within this polygon during the active breeding period may be used to confirm whether it is used by one of the target species.

Turtle Nesting Areas – Confirmed and Candidate

Suitable candidate areas of coarse sandy/gravelly soil in open, exposed sites near ponds, wetlands, large watercourses or other potential turtle habitats were common across the study area. Turtle eggs were confirmed in a recently tilled agricultural field adjacent to Polygon 90.01, which contained a watercourse connected to nearby swamp thicket (Polygon 90.12) and meadow marsh (Polygon 08.02) habitats. Although the species of turtle could not be identified, records indicate that both Midland Painted and Snapping Turtles have been historically observed within the study area. As Snapping Turtle is a Special Concern species, even one nesting Snapping Turtle would confirm this site as SWH per the provincial criteria (note that Midland Painted Turtle has also been designated by COSEWIC as Special Concern although it is not yet listed in SAR legislation, so this consideration should, by that criterion, also qualify a single Midland Painted Turtle nest site as SWH).

Additional notable candidate areas include Polygons 68.02 (CUM1-1/MAS2-4 incl), 86.04 (SAS1), 90.07 (CUS1) and 70.03 (CUW1), which all featured bare sandy substrates in nearby proximity to an aquatic feature. Given the confirmation of turtle nesting in at least one location, and the suitable core habitat for turtles present (i.e., wetlands and watercourses), it can be assumed with a high degree of confidence that turtle nesting is occurring in similar habitat closely situated to water features across the study area. Areas considered to have high nesting potential have been shown on **Figure 3.56.** Further studies at subsequent planning stages are recommended to confirm additional presence of this SWH type.

Seeps and Springs – Confirmed

Multiple seeps were observed within ELC polygons 78.05, 86.09, 86.10, 90.01, 90.11, and 135.01, which were a combination of FOC4-1 (Cedar), FOD5-7 (Sugar Maple-Cherry) and FOD7-3 (Willow lowland) forest communities, generally containing sandy soil. Confirmed seeps were all located in headwater areas of the subwatershed, and a high likelihood exists for additional seeps, particularly in the northeastern extent of the study area. There was evidence of turkey, deer, and other wildlife using them as well as plant species like watercress which are known to occur in seeps. Hydrogeological studies would be helpful to further define the extent of seepage and the significance of these features from a hydrogeological standpoint, but sufficient biological evidence was observed to confirm the presence of these features with regards to habitat. Confirmed seeps are shown on **Figure 3.56.**

Woodland Area Sensitive Bird Breeding Habitat – Confirmed

Area-sensitive forest interior birds were documented during breeding bird surveys, particularly at stations along the northern edge and in the northeast corner of the study area (i.e., BI-4, BI-5, BI-6 BI-7, BI-8, BI-10 – associated with the large woodlot to the north containing forest interior habitat). Indicator species recorded include Veery, Black-throated Green Warbler, Ovenbird, and Red-breasted Nuthatch, all of which were recorded as possible or probable breeders. Winter Wren, another indicator species, was also documented incidentally in this area, but outside of the breeding season.

Forested areas that were identified for this SWH category include those areas with continuous connectivity with the large interior forest patch found generally north of the Urban Boundary, illustrated on **Figure 3.56**. While some of the indicator bird species were observed elsewhere in the study area, the indicated habitat patch is the only location where the required number of species with breeding evidence was observed to confirm the presence of SWH.

Open Country Bird Breeding Habitat – Candidate

Large expanses of open, fallow meadow habitat (CUM1-1) were found at the old Bowmanville POW Camp (Camp 30), in Polygon series 70, shown on **Figure 3.56.** In total, open meadow habitat exceeds 30 ha, fulfilling the criteria for Candidate Open Country Breeding Bird Habitat. Open country indicator birds such Vesper Sparrow and Savannah Sparrow were observed elsewhere in the study area, with the potential for additional species not easily captured in breeding bird surveys (e.g. Short-eared Owl). Further studies at subsequent planning stages are recommended to confirm presence of this SWH type.

Special Concern and Rare Wildlife Species

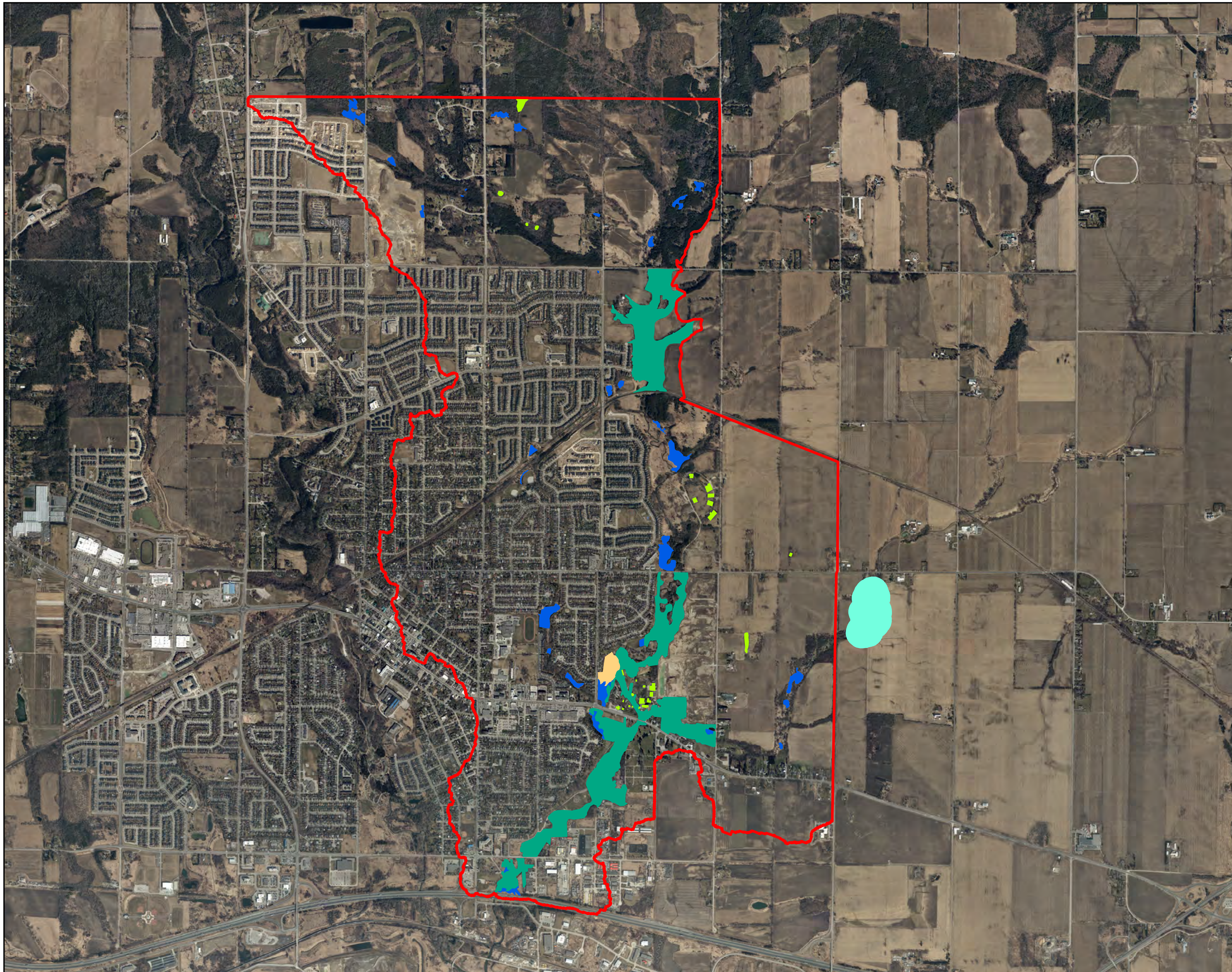
Six species designated Special Concern were documented within the study area: Eastern Wood-pewee, Wood Thrush, Common Nighthawk, Golden-winged Warbler, Monarch, and Snapping Turtle. Midland Painted Turtle, which was assessed Special Concern by COSEWIC, is also expected to occur. These species were previously discussed in detail in **Section 3.3.5**.The observed locations of these species were previously illustrated on **Figure 3.54** and are therefore not repeated on **Figure 3.56**. For the most part, an observation of the species does not necessarily indicate the presence of important or critical habitat; also considered here is the fact that observed locations correlate with woodlands, watercourses, other SWH categories, and/or other features which will be ultimately protected as part of the municipal NHS. Therefore, habitat for Special Concern and Rare Wildlife Species has not been illustrated as a separate layer on **Figure 3.56** and will only be further discussed in this report if critical features occur as isolated or separate features on the landscape.

3.3.6.3 Conclusions

Using the MNRF criteria for identifying SWH, four confirmed categories of SWH were identified in the study area: Seeps and Springs; Turtle Nesting Habitat; Woodland Area Sensitive Bird Breeding Habitat, and Habitat of Special Concern and Rare Wildlife Species.

Additional candidate SWH as discussed above will be subject to further study or confirmation during site-level environmental assessments if confirming the presence/absence of habitat is required at future planning stages. Habitat areas or features that are associated with other developmental constraints (to be discussed in **Section 4.0**) might be assumed to provide SWH with no further confirmation needed.

Nine SWH categories are thought to have a strong possibility of being confirmed by those future studies based on existing conditions and past data records: Open Bird Breeding Habitat, Woodland Raptor Nesting Habitat, Migratory Butterfly Stopover Areas, Reptile Hibernaculum, Turtle Overwintering Areas, Landbird Migratory Stopover Habitat, Bat Maternity Colonies, Raptor Wintering Areas and Waterfowl Stopover and Staging Areas.



Clarington

Legend

- Study Area
- Reptile Hibernaculum - Candidate
- Waterfowl Stopover and Staging Areas (Aquatic) - Candidate
- Landbird Migratory Stopover Areas - Candidate
- Migratory Butterfly Stopover Areas - Candidate
- Turtle Wintering Areas - Candidate

Candidate Bat Maternity Colonies were not mapped but include all woodlands (e.g. forest, treed swamps, cultural woodlands, and plantations) with trees exhibiting suitable habitat characteristics are considered to be candidate bat maternity habitat.

Figure 3.55

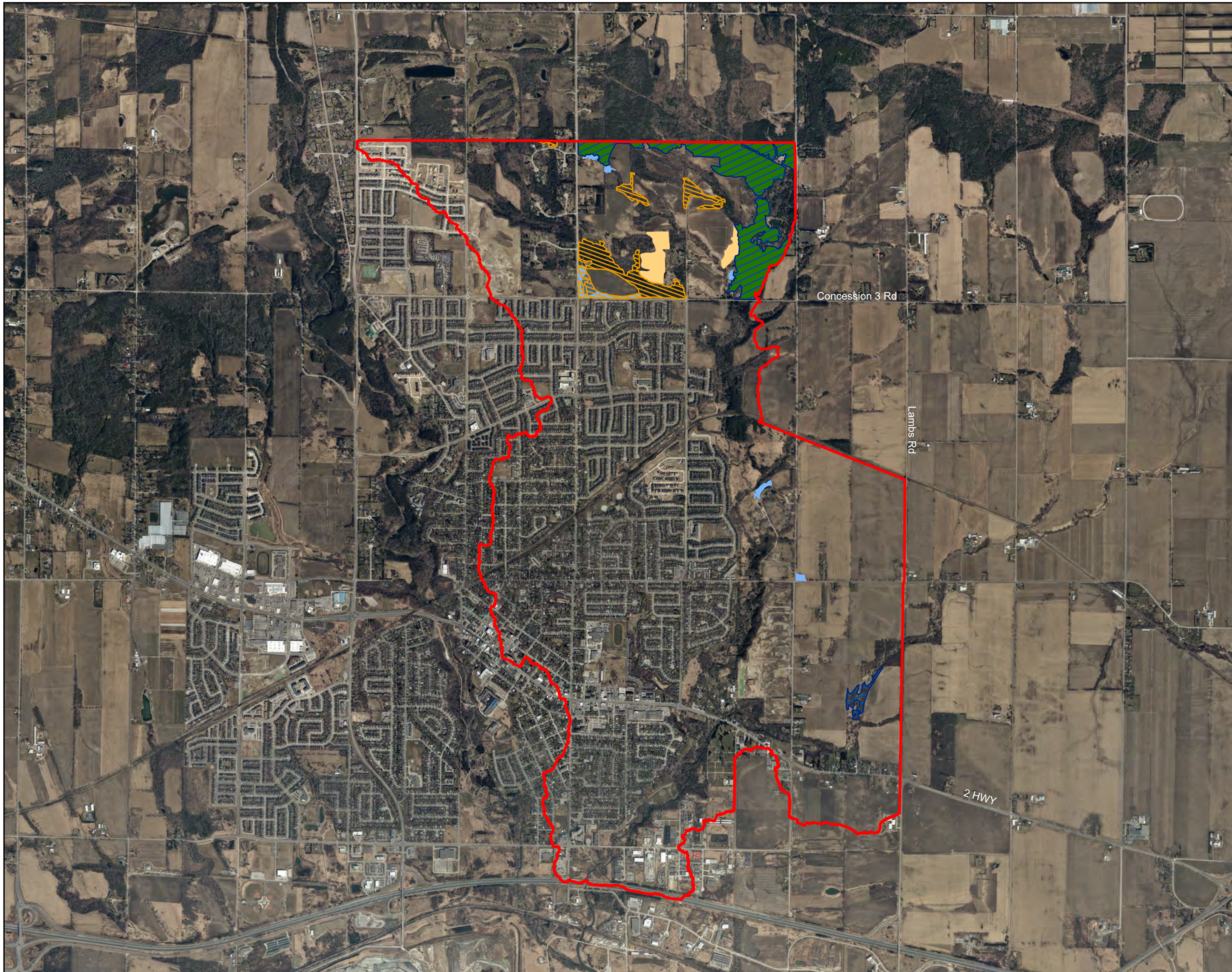
Significant Wildlife Habitat:
Seasonal Concentration Areas of Animals

Date: March 2022
Projection: UTM_Zone_17N
Source: Municipality of Clarington, LIO

0 700 1,400
Metres

N

Aquafor Beech Limited



Clarington

Legend

- Study Area
- Woodland Raptor Nesting Habitat - Candidate
- Woodland Area-Sensitive Bird Breeding Habitat
- Seeps and Springs - Confirmed
- Turtle Nesting Areas -
- Turtle Nesting Areas -
- Open Country Bird Breeding Habitat – Candidate
- Landbird Migratory Stopover Areas - Candidate

Figure 3.56

Significant Wildlife Habitat:
Specialized Habitats for Wildlife &
Habitats of Species of Conservation Concern

Date: March 2022
Projection: UTM_Zone_17N
Source: Municipality of Clarington, LIO

0 750 1,500
Metres

N

Aquafor Beech Limited

3.3.7 Summary of Ecological Resources

The ecological resources within the study area were characterized through a combination of field investigations and background information review.

Soper Creek and its contributing tributaries exhibited a variety of aquatic habitat, with the highest quality habitat observed in the upstream sections. However, aquatic habitat throughout the entire system demonstrated conditions that provided integral habitat to a number of sensitive fish communities (e.g., Rainbow Trout). A number of fish barriers were observed throughout the system; however, upstream reaches demonstrated comprehensive function as aquatic habitat, despite these fish barriers. In general, aquatic habitat was observed throughout the study area as both direct and contributing fish habitat. A total of 12 fish species were recorded in Soper Creek and its contributing tributaries; none of these are Species at Risk.

Overall, the benthic invertebrate sites in Soper Creek indicated Fair to Good water quality. Communities that indicated the highest water quality and highest integrity of aquatic habitat were observed in the furthest upstream site in the main branch of Soper Creek, and a site which fell in a contributing headwater stream upstream of Concession Road 3. Conversely, the site located within Bowman Creek immediately downstream of King Street East observed a benthic community that indicated “Very Poor” water quality with “severe organic pollution likely”. This site indicated the worst water quality throughout the subwatershed. However, the downstream sampling sites generally observed similar benthic communities as the upstream sites, with “Fair” water quality and “fairly substantial pollution likely”.

A total of 385 ELC vegetation communities consisting of a total of 49 unique community types (not including hedgerows and anthropogenic land) were identified in the study area. Within these communities, 408 species of vascular plants were catalogued during the botanical inventories, 37% of which were native to Ontario and 63% of which were non-native. Key observations include one Endangered tree species (Butternut) and 35 plant species with local significance in Durham Region (Varga, et al., 2005). Invasive species including Common Buckthorn and European Swallow-wort (Dog-strangling Vine) were observed throughout the study area, and evidence of Emerald Ash Borer infestation was observed to have caused severe decline of ash trees throughout the study area. Hedgerows in the study area were identified with respect to potential connectivity that they may provide within the NHS, but were not considered as vegetation communities on their own.

Eighty-two bird species were recorded during breeding bird field surveys, of which 79 exhibited signs of breeding. The majority of bird species recorded are common and widespread, but SAR birds were identified during field surveys.

SAR with potential to occur in the broader region were screened for their potential to occur or use habitat within the study area. Twelve SAR were identified within the study area via targeted surveys (breeding birds), incidental observations, or background resources: Bank Swallow, Barn Swallow, Bobolink, Butternut, Chimney Swift, Common Nighthawk, Eastern Meadowlark, Golden-winged Warbler, Monarch, Eastern Wood-pewee, Snapping Turtle, and Wood Thrush. Additional SAR with the potential to occur in the study area based on the presence of suitable habitat are: Midland Painted Turtle and the four SAR bats found in Ontario. Potential SAR may require additional studies to confirm the presence/absence of species at the time of any proposed development, if that proposed development will impact habitat.

Four categories of SWH were confirmed in the Urban Boundary study area: Seeps and Springs; Turtle Nesting Habitat; Woodland Area Sensitive Bird Breeding Habitat, and Habitat of Special Concern Species. Additional Candidate SWH types were also identified: Open Bird Breeding Habitat, Woodland Raptor Nesting Habitat, Migratory Butterfly Stopover Areas, Reptile Hibernaculum, Turtle Overwintering Areas, Landbird Migratory Stopover Habitat, Bat Maternity Colonies, Raptor Wintering Areas, and Waterfowl Stopover and Staging Areas.

Based on the above findings, ecological resources that will be carried forward in this document as part of the analysis of future developmental constraints and opportunities include the following:

- Watercourses and their associated floodplains and valleylands. In addition to the ecological and hydrologic functions these features provide (e.g., fish habitat, flood attenuation), these areas are typically regulated by the Conservation Authority.

- Woodlots and wetlands of various sizes, which are largely concentrated around watercourses and/or found in the northern extents of the Urban Boundary. Given the high degree of agricultural and developed lands across the local landscape, these areas are considered valuable for maintaining subwatershed and ecosystem health. Wetlands are also regulated by the Conservation Authority.

- Hedgerows currently or potentially providing linkages between areas of natural habitat at key locations (to be further analyzed in **Section 4.2.3**).

- Confirmed habitat supporting SAR, such as ELC polygons containing Butternut, General Habitat associated with Barn Swallow nesting, and known nesting locations of Bobolink.

- Candidate and confirmed Significant Wildlife Habitat as identified in **Section 3.3.6.**

Opportunities and constraints are analyzed in greater detail (with respect to their implications for future land use changes) in **Section 4.0**.

4.0 Opportunities and Constraints

The term *constraints* is used here to indicate features or areas which will be subject to some limitation regarding future development (this includes natural heritage features which will be protected as part of the Municipality's NHS and natural hazard policy as outlined in the Official Plan) or which are recommended for further investigation to determine the potential impacts of development before any action is approved.

Opportunities for restoration and enhancement of existing natural heritage resources were identified based on the results of site investigations and a landscape-level review. It is recognized, however, that the opportunities identified do not represent the only opportunities for improvement that exist within the study area, and that future site-specific studies may refine or revise the noted locations with support from a suitable impact assessment or similar study.

4.1 Natural Hazards

The Municipality of Clarington Official Plan (June 2018) outlines the definition of natural hazards and specific policies related to Natural Hazards in Sections 3.7.2 through 3.7.5. These are presented as reference below:

i. *Natural hazard lands are those lands which exhibit one or more hazards such as poor drainage, organic soils, flood susceptibility, susceptibility to erosion, steep slopes, or any other physical condition on which development could cause loss of life, personal injury, property damage, or could lead to the deterioration or degradation of the natural environment.*

ii. *All lands, including lands that are covered in water, and the furthest landward limit of the flooding hazard, erosion hazard or dynamic beach hazard, are considered natural hazard lands.*

iii. *To protect people, infrastructure, buildings, and properties and promote a healthy and resilient Municipality in the preparation of Secondary Plans, the Municipality shall consider the potential impacts of climate change that may increase the risk associated with natural hazards.*

iv. *No new buildings or structures shall be permitted on lands identified as natural hazard lands, save and except for those buildings or structures required for flood and/or erosion control which are approved by the Conservation Authority and the Municipality.*

Along with the policy in Clarington's Official Plan, relevant natural hazards policy includes Ontario Regulation 42/06 Regulation of Development, Interference with Wetlands and Alteration to Shorelines and Watercourses (O.Reg. 42/06) which is administered and enforced by the Central Lake Ontario Conservation Authority (CLOCA). This regulation was created for the following reasons;

- To minimize the risk to loss of life and property damage as a result of flooding
- To direct development away from natural hazard prone land (e.g. flooding, erosion)
- To determine whether or not in the opinion of the Authority, the development proposal will affect the control of flooding, erosion, pollution, or the conservation of land

Though O.Reg. 42/06 is administered at the development approval-level as opposed to the planning-level, it is prudent to consider these restrictions at present to avoid additional effort at a later time.

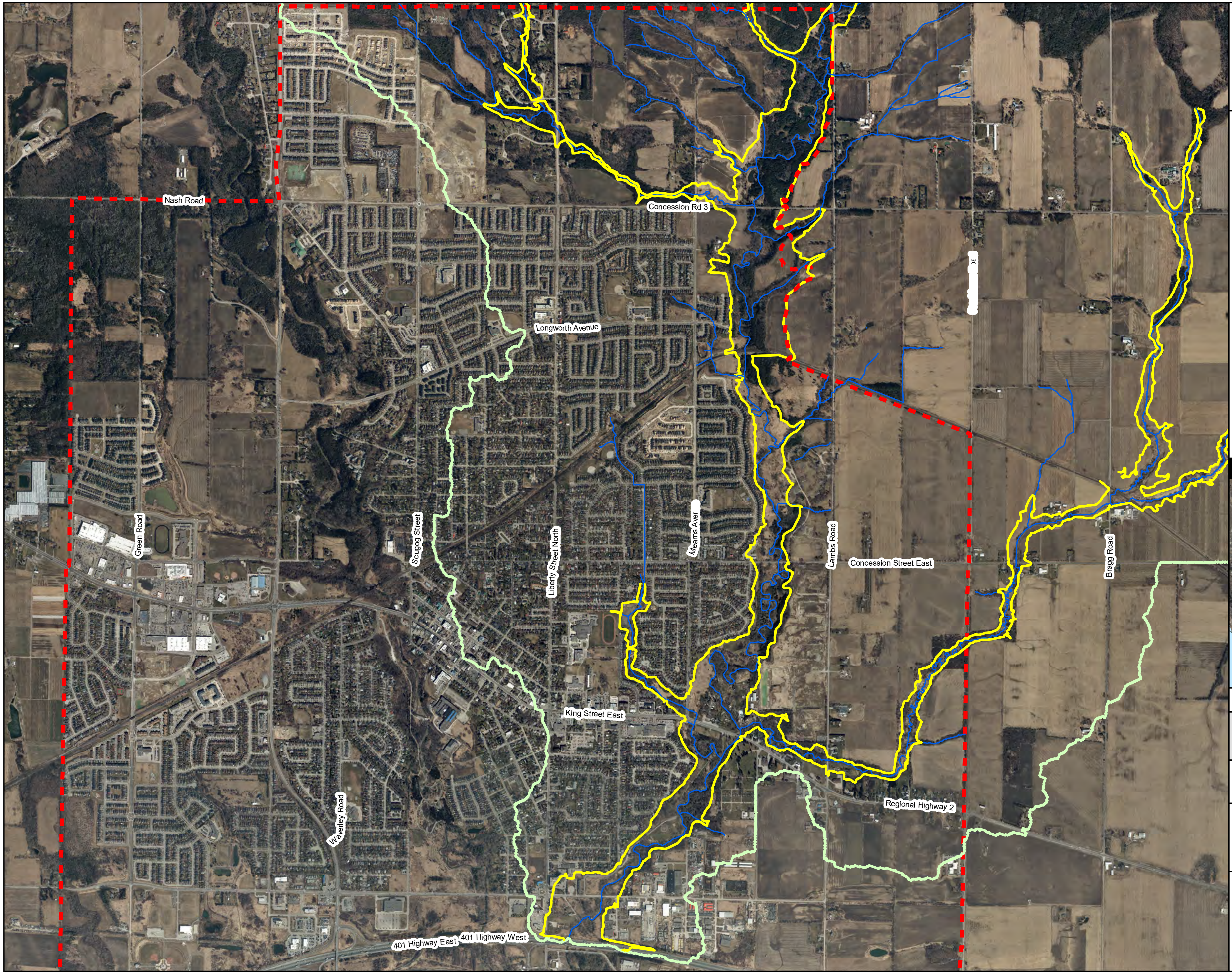
4.1.1 Flood Hazards

Although development is generally prohibited from the flood hazard through O.Reg 42/06, the following exceptions outlined in Section 5.4.1-Policies for One-zone Floodplain-River or Stream

Valleys of CLOCA's Policy and Procedural Document for Regulation and Plan Review (CLOCA, 2014) may be relevant to new development proposed within the Soper Creek Subwatershed:

> **Exception 3)** Stormwater management facilities shall be encouraged to locate outside of the flood hazard. However, quantity control facilities may be permitted within the flood hazard provided they are outside of the 1:100-year floodplain. Quality treatment facilities may be permitted provided they are outside of the 1:25-year floodplain. Both quantity and quality facilities must:
>
> a. ensure outlets are outside of the 2-year floodplain; and
> b. demonstrate there is no impact on flood hydraulics and flood storage; and
> c. be located outside of the natural heritage system as defined in the Watershed Plan.
>
> **Exception 4)** Public infrastructure (e.g. roads, sewers, flood and erosion control works) and various utilities (e.g. pipelines) may be permitted if it has been demonstrated to the satisfaction of CLOCA that there is a demonstrated need to locate in the flood hazard.
>
> **Exception 5)** Low intensity recreation areas (e.g. passive or low intensity outdoor recreation and education, trail systems) may be permitted if it has been demonstrated to the satisfaction of CLOCA that there is no alternative location outside of the flood hazard. Per the Municipality of Clarington Official Plan Policy 3.7.5, no new buildings or structures shall be permitted on lands identified as natural hazard lands.

Figure 4.1 presents the existing flood hazard, which consists of the current CLOCA floodplain mapping.



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Regulatory Floodline
- Watercourse

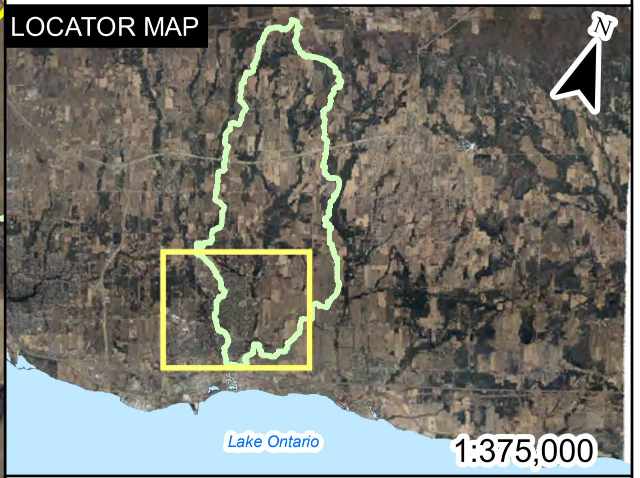


Figure: 4.1

Regulatory Floodline

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

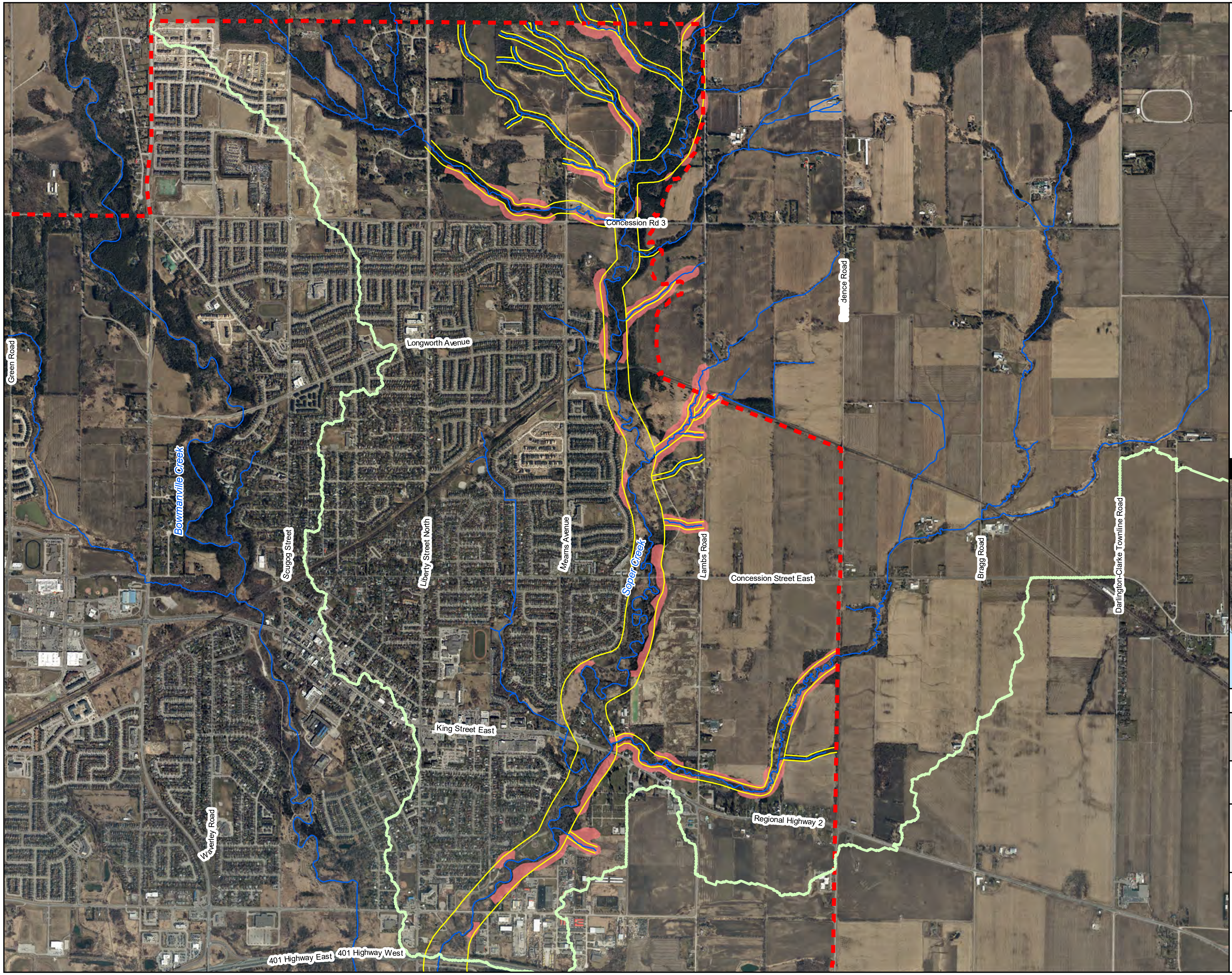
0 0.25 0.5 1
Kilometers
N

Aquafor Beech Limited

4.1.2 Erosion Hazards

The Soper Creek subwatershed contains a mix of confined, partially-confined, and unconfined reaches that requires the erosion hazard corridor be delineated through a combination of meander belt assessment and geotechnical stable slope hazard assessment. Meander belt delineation identifies an erodible corridor in which natural fluvial processes may occur over a 100-year period. Under future development conditions, these erodible corridors are to remain as low-lying floodplain areas adjacent to the watercourse.

In addition to meander belt delineation, the long-term stable slope crest (LTSSC) is a component of the erosion hazards assessment required to determine development setbacks and constraints, specifically around confined and partially confined valley systems (MNR, 2002). Priority stable slope hazard areas have been identified as provisional assessments of the LTSSC hazards for confined and partially confined reaches. Ultimately, detailed geotechnical studies for each development application are necessary to delineate the final erosion hazard limit around confined valley systems where the LTSSC component is required. For constraint mapping developed for this Subwatershed Study, the erosion hazard limit is the greater of the meander belt and priority stable slope hazard lines (**Figure 4.2**), and the limits of valleylands have been based on existing LTSSC information. These mapped constraint boundaries may be modified based on the results of site-specific studies.



Clarington

Legend

- Bowmanville / Newcastle Urban Boundary
- Soper Subwatershed Boundary
- Priority Slope Hazard Areas (for LTSSC geotechincal assessment)
- Meander Belt Width (including partially confined reaches)
- Watercourse

LOCATOR MAP

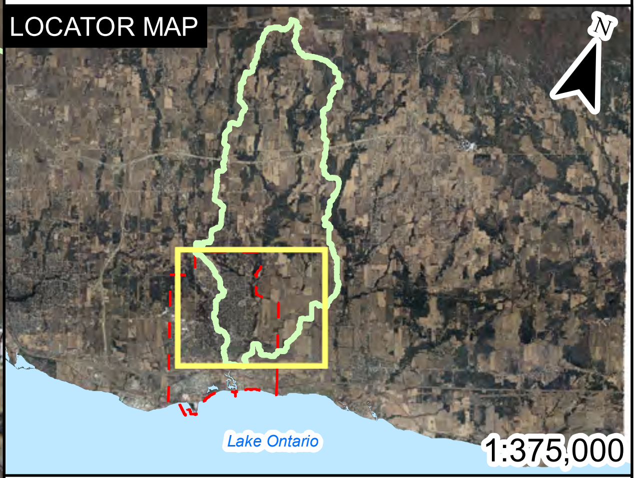


Figure 4.2

Erosion Hazards

Date: February 2020
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 250 500 1,000
Meters
N

Aquafor Beech Limited

4.1.3 In-Stream Geomorphic Restoration Opportunities

Within the Soper Creek subwatershed, the completed geomorphic assessments have identified a number of opportunities to mitigate erosion hazards, and/or restore stream functions from both geomorphological and ecological perspectives (Figure 3.45):

- Local bank protection works;
- Repair of perched culverts;
- Removal of non-essential structures from channels; and,
- Reestablishment of adequate riparian corridors and removal of invasive species within riparian corridors.

The opportunities are discussed in greater detail below.

Local Bank Protection Works

Localized channel bank and/or bed work has been recommended to address erosion issues at a number of erosion sites. While it is understood that local erosion protection works may require ongoing maintenance, occasional repairs, or eventual replacement, this alternative is often still preferred to limit the economic cost and the environmental damage of large-scale channel engineering and stream restoration works. Examples of possible restoration works include:

- Armourstone wall protection
- Vegetated rock buttress
- Live crib wall
- Live staking

Repair of Perched Culverts

A number of perched culverts were identified throughout the watercourse, which may act as barriers to fish passage. These culverts have been recommended for repair or replacement. When crossings are replaced on Soper Creek, consideration should be given to natural geomorphic processes in addition to hydraulic capacity and associated erosive forces. Increasing the width of undersized culverts and bridges will allow more room for natural meandering and channel processes, in addition to increasing potential for aquatic and terrestrial passage helping to support the recommendations in CLOCA’s Instream Barrier Action Plan (2017a). Culvert capacity and associated erosive forces should be reassessed prior to replacement to prevent scour downstream of the culvert, and culvert alignment should be designed to accommodate fish passage.

Opportunity to Remove Structures from Channel

Non-essential and/or damaged structures including bridges, culverts, weirs and grade control structures were documented in the field, and opportunities for structure removals have been identified. Removal of non-essential structures can reduce erosion potential in some locations and improve aquatic habitat through removal of channel and corridor constrictions, removal of fish passage barriers, and naturalization of the channel corridor, helping to support the recommendations in CLOCA’s Instream Barrier Action Plan (2017a). Bank and/or bed regrading works may be required following structure removal to remediate abrupt changes in grade, and repair areas of outflanking or bank erosion.

Revegetation of Riparian Corridor

CLOCA's Riparian Corridors Restoration Plan (2017b) recommends that adequate riparian corridors (a minimum of 30m on both sides of a stream) be maintained along 75% of a subwatershed's stream length as a fundamental subwatershed health target. However, only 45% of the Soper Creek stream length has adequate riparian corridors. Riparian vegetation decreases the erodibility of soil, contributing to bank stability. One private property (see ES15, Figure 3.45) was noted with minimal vegetation in the overbank and floodplain area. It is recommended that riparian vegetation should be reestablished through this property using native species to increase bank stability, and existing riparian corridors throughout the watershed should be maintained or widened during the planning of future developments. Invasive species should be removed from channel corridors and riparian areas where possible.

In-stream restoration opportunity recommendations for each erosion site (introduced in **Section 3.2.2.6**) are summarized in **Table 4.1** below.

Table 4.1: Soper Creek Erosion Sites and Associated In-Stream Restoration Opportunities. Higher Priority Public Erosion Sites are Highlighted.

Erosion Site	Channel Reach	Ownership	Description of Issue	In-Stream Restoration Opportunity
ES01	2A	Private	Bank is eroding towards private property.	Localized bank protection works.
ES02	2A	Public	Bridge imparts constriction on channel corridor.	Opportunity to remove bridge.
ES03	2B	Private	Embankment is eroding towards fence at top of slope.	Realignment of fence (may be offset from property line), or localized slope protection works.
ES04	2B	Public	Bank is eroding towards public park lands.	Localized bank protection works.
ES05	3B	Private	Undercut tree at risk of falling is posing risk to adjacent fence and building.	Localized bank protection works.
ES06	3B	Private	Fence running along eroding channel bank is falling towards the creek.	Removal of fence or localized bank protection works.
ES07	3B	Private	Bank is eroding towards fence. Outfall is becoming undercut.	Bank protection works. May be paired with bridge abutment maintenance works (M01).

Erosion Site	Channel Reach	Ownership	Description of Issue	In-Stream Restoration Opportunity
ES08	4A	Private	Outer channel bank is eroding towards fence.	Extend stone bank protection works further south along outer bank.
ES09	4B	Public	Weir at outlet of stormwater outfall channel is outflanked.	Remove weir. Regrade banks at outlet and apply localized bank protection works.
ES10	4C	Public & Private	Bank erosion poses long term risk to natural gas line and road. Runoff flows overland from roadside ditch to creek, causing eroding headcut.	Monitoring and bank protection works along the outer southern bank of the channel. Ditch maintenance works or design of an outfall channel from the ditch to the creek.
ES11	4D	Public & Private	Slope is failing and old abutment is outflanked.	Slope restoration works (may include removal of abutment).
ES12	4D	Private	Old dam poses potential passage barrier to small fish.	Regrading of bed to remove fish passage barrier. Potential to remove dam structure if no longer in use.
ES13	6A	Public	Bank erosion upstream of railway culvert poses long term risk to bank hardening at culvert.	Extend bank protection works further upstream through eroding section.
ES14	7	Private	Grade control structure is causing potential fish passage barrier.	Removal of grade control structure and regrading of bed.
ES15	SE-2	Private	Lack of vegetation along southern channel bank may increase rates of bank erosion.	Revegetation of riparian corridor.
ES16	SE-2	Private	Old weir structure imparts channel constriction.	Opportunity to remove structure.
ES17	SE-T1	Private	Channel crossing structure is perched and deteriorating.	Opportunity to remove structure and regrade channel.
ES18	T4	Public	Culvert is perched.	Regrade channel and include scour protection.
ES19	T4	Private	Concrete culvert under private drive crossing is damaged.	Restoration, removal, or replacement of culvert.
ES20	T5	Public	Ditch is eroding towards road on both sides of road.	Bank protection works along road.
ES21	T6B	Public	Culvert is perched and car tire is wedged into inlet. Channel approaches culvert at sharp angle.	Culvert maintenance. Channel realignment and regrading with scour protection.

Erosion Site	Channel Reach	Ownership	Description of Issue	In-Stream Restoration Opportunity
ES22	T7	Public	Channel crossing imparts constriction on channel corridor.	Opportunity to remove structure.
ES23	T10-1	Public	Bank erosion is posing risk to guardrail and road.	Localized bank protection works.
ES24	T10-2	Public	Road embankment is failing, culvert inlet is outflanked.	Slope restoration and protection works.
ES25	T11-1	Private	Channel is confined to small culvert.	Opportunity to remove culvert.
ES26	T14	Public	Culvert is perched.	Regrade channel and include scour protection.

Stream restoration approaches should consider a variety of "naturalized" channel design methods by a qualified stream restoration professional.

4.2 Natural Heritage

The Natural Heritage component of this Soper Creek Subwatershed Study builds upon the Municipality of Clarington's Natural Heritage System (as depicted on Map D of the Official Plan) using the existing conditions data contained in the preceding sections, and further applies concepts such as linkages and buffers to protect both ecological features and functions on the landscape in keeping with the goals and objectives identified for this study. The following sections provide details of the analysis that was completed to determine the natural heritage constraints and opportunities within the study area.

4.2.1 Municipal Natural Heritage System

The Municipality of Clarington's OP defines the Natural Heritage Features and Hydrologically Sensitive Features that may be included in the NHS, and the criteria those features must meet in order to qualify for inclusion. These criteria were applied to the study area's existing conditions (as determined through Aquafor Beech's investigations for this SWS and described in the preceding sections) to create the preliminary NHS mapping included in this document. This preliminary mapping, summarized on **Figure 4.3**, is intended to update and build upon the pre-existing NHS identified on Map D of the Municipality of Clarington's OP, and to be confirmed, refined and/or built upon in turn by site-specific assessments completed as part of Secondary Plans or other future studies.

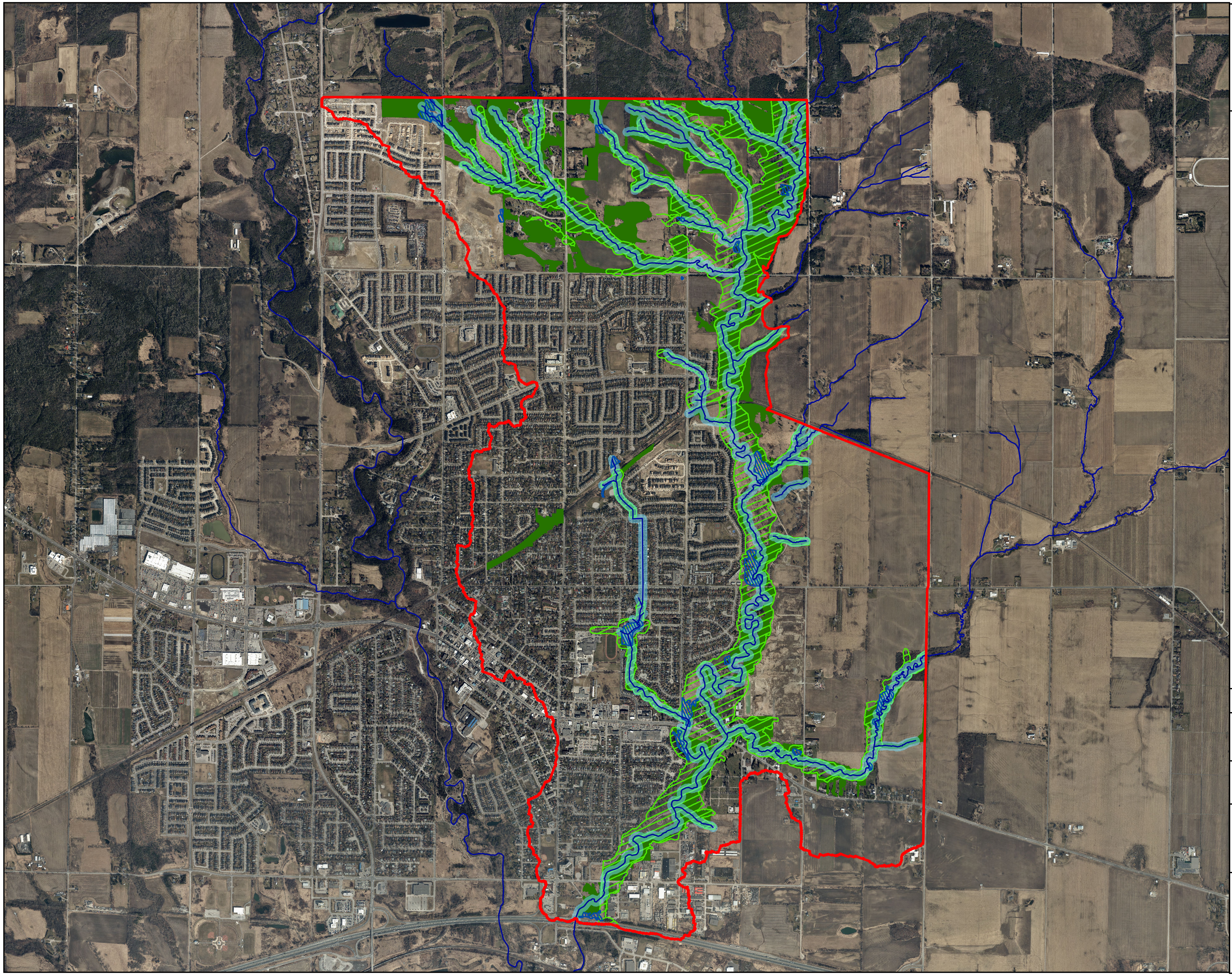
The following table (**Table 4.2**) provides an overview of NHS components (Natural Heritage Features and Hydrologically Sensitive Features) that were identified within and adjacent to the Soper Creek subwatershed study area. The full extent of these features is illustrated on **Figure 4.3**.

Table 4.2: NHS Components Documented Within the Soper Creek Subwatersheds

Natural Heritage Designations		Discussion
Natural Heritage Features	**Wetlands**	Wetlands were identified through field investigations and background data; all wetland communities greater than 0.5 ha in size were included in this category.
	Areas of Natural and Scientific Interest (ANSI)	No ANSIs are present within the Urban Boundary. The nearest ANSI within the Soper Creek subwatershed is the Stephen's Gulch Earth Science ANSI, located north of Concession Road 4.
	Significant Woodlands	Per the Municipality of Clarington's criteria, all treed vegetation communities (including swamps, plantations, and cultural woodlands) within the Urban Boundary that are >1 ha in size, and outside of the Urban Boundary that are >4 ha, were classified as Significant Woodlands.
	Valleylands	Much of the Soper Creek NHS meets the provincial definition of Valleylands.
	Fish habitat & riparian corridors	Within the study area, fish habitat and riparian corridors consists of a width of 30 m on either side of watercourses (i.e., for a total 60 m width), which contain fish at time during any given year, or are directly connected to watercourses that contain fish at any time during any given year thus contributing to fish habitat. These features are shown in on **Figure 3.48**.
	Rare vegetation communities	No rare vegetation communities (S1 to S3) were found in the study area.

	Habitat of endangered and threatened species	Habitat for Endangered or Threatened SAR was identified within the study area, as previously discussed in **Section 3.3.5** and illustrated on **Figure 3.54**. Specific habitat areas and features which have been included are: • Bobolink (THR) and Eastern Meadowlark – two patches of habitat were identified during breeding bird surveys for these species. • Barn Swallow (THR) – protected general habitat for this species includes foraging habitat up to 200 m from a confirmed nest. • Butternut (END) – **Figure 3.54** illustrates both individual observed trees (where individual coordinates are available) and vegetation community polygons which contained multiple Butternut. This species was locally abundant and additional trees may be found upon further study. A Butternut health assessment will be required prior to development to determine the retainability of individual trees, and will provide the basis for protection of trees and their habitat (i.e., up to recommended 50 m radius from trunk). Occurrences and habitat of SAR are subject to the requirements of the Endangered Species Act and, ultimately, designation of habitat in perpetuity is the responsibility of the MECP. Known habitat areas and features will be illustrated on **Figure 4.3** but these may not be treated as confirmed, permanent components of the NHS in subsequent sections since the habitat in question is derived from/maintained by anthropogenic activities. The list of species protected under the ESA is regularly updated; the current *Species at Risk in Ontario List* (O. Reg. 230/08) should be referenced during the EIS phase, prior to approval of any development, in order to ensure protection of listed species is addressed in accordance with MECP designations and requirements at the time of application.

Natural Heritage Designations		Discussion
	Wildlife habitat	The Significant Wildlife Habitat assessment completed for this SWS was previously detailed in **Section 3.3.6**, and the results were illustrated on **Figure 3.55**. The majority of identified areas are found in locations overlapping with other NHS features and are therefore expected to be protected under those designations. An updated review and assessment of SWH shall be completed as part of future site-specific assessments, to confirm/refine significant habitats in the study area based on up-to-date conditions.
Hydrologically Sensitive Features	**Wetlands**	See discussion under *Natural Heritage Features: Wetlands*, above.
	Watercourses	Permanent and intermittent watercourses are primarily considered under *Natural Heritage Features: Fish Habitat*, above. Watercourses within the study area include Soper Creek and its tributaries.
	Seepage areas and springs	Seepage area were observed within the study area and were previously identified as Significant Wildlife Habitat, which was discussed above.
	Groundwater features	Per the Official Plan, this designation applies to recharge/discharge areas, water tables, aquifers and unsaturated zones. These features are identified in **Section 3.1**, but are not shown in the NHS mapping for the subwatershed study.
	Lake Ontario and its littoral zones	As the southern extent of the study area occurs at the confluence of Soper Creek with Bowmanville Creek, approximately 700 m north of the lakeshore, Lake Ontario and its littoral zones are not present in the study area.
Linkages	**Linkage**	Linkages identified through field investigations include hedgerows that connect at least two natural heritage features (e.g. significant woodlands or wetlands), as well as drainage features. In developing the NHS, Aquafor Beech Limited also considered opportunities to create linkages in key locations where existing linkages may be lacking (see **Section 4.2.3**). The suitability of identified linkages for preservation will be subject to further study, and further opportunities to enhance or create connectivity within the NHS should also be considered, if warranted.”



Clarington

Legend

- Study Area
- Watercourse
- Wetlands greater than 0.5 ha
- Natural Heritage System
- Valleylands
- Significant Woodland

Habitat of Endangered and Threatened species and Significant Wildlife Habitat have not been shown pending further assessment at the site-level; refer to Section 3.3.5 and 3.3.6 as well as Figure 3.54 and 3.55 for further information.

Valleylands are defined using CLOCA's Hazard Stable Slope layer.

Figure 4.3

Features Meeting Criteria for the Natural Heritage System

Date: May 2023
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.375 0.75 1.5
Kilometers
N

Aquafor Beech Limited

4.2.2 Vegetation Protection Zones

Vegetation protection zones (VPZs), as defined in the Municipality of Clarington's OP, are vegetated buffer areas surrounding Natural Heritage Features or Hydrologically Sensitive Features, within which development and site alteration is generally prohibited save for:

- Forest, fish and wildlife management;
- Conservation and flood or erosion control projects, but only if they have been demonstrated to be necessary in the public interest after all alternatives have been considered;
- Transportation, infrastructure and utilities, but only if the need for the project has been demonstrated by an Environmental Assessment, there is no reasonable alternative, and it is supported by a project specific Environmental Impact Study;
- Low intensity recreation; and
- Low-impact development stormwater systems such as bioswales, infiltration trenches and vegetated filter strips, provided that the intent of the VPZ is maintained and it is supported by an Environmental Impact Study.

A VPZ *"is intended to be restored with native, self-sustaining vegetation and be of sufficient width to protect the feature and its functions from effects of the proposed change and associated activities before, during, and after, construction, and where possible, restore and enhance the feature and/or its function from effects of the proposed change and associated activities before, during, and after construction, and where possible, restore and enhance the feature and/or its function*" (Municipality of Clarington 2018). VPZs are to be imposed only where new development and/or site alteration is to occur but will not affect lands which are within the study area but not being proposed for development/site alteration or which have previously been developed.

The Municipality of Clarington's OP was used as the primary source of information to develop VPZs for the NHS, and the OP's outline of minimum VPZ requirements is provided in **Table 1.1** in **Section 1.3.4**, for reference. Other guidance documents such as CLOCA's NHS methodology (CLOCA, 2011a) were also reviewed and taken into consideration, where appropriate. A summary of the VPZs applied to the preliminary NHS (which was shown in **Figure 4.3**) as part of this study are outlined in **Table 4.3**.

As noted above, the Municipality of Clarington's OP states the intention for VPZs throughout the study area are intended to be restored with native vegetation so that eventually they may become an extension of the habitat area they were designated to protect. Passive naturalization of these areas may also be considered but this approach is likely to promote colonization by non-native species. VPZs based on the preliminary identified NHS are depicted on **Figure 4.4.**

Table 4.3: Summary of NHS Features and Minimum VPZs

NHS Features	Site-specific Requirements	Minimum VPZ Requirement*	
		Within the Urban Area	Outside of the Urban Area
Wetlands	Measured from the outermost extent of the feature.	30 m	30 m
Watercourses, Fish Habitat and Riparian Corridors	Measured from the outermost extent of the feature.	15 m	30 m
Valleylands	Measured from the stable top of bank.	15 m	30 m
Significant Woodlands	Measured from the dripline of the outermost tree.	15 m	30 m
Seepage and Springs	Measured from the outermost extent of the feature.	15 m	30 m
Habitat of Endangered and Threatened Species	Subject to confirmation by site-specific EIS or equivalent study	Appropriate VPZ may be specific to the species under discussion (e.g., degree of sensitivity to disturbance) and the configuration/ location of the habitat in question. As previously noted, Endangered and Threatened species habitat is the responsibility of the MECP and the protection of habitat is subject to the requirements and regulations of the *Endangered Species Act*. Establishing a VPZ around specific occurrence locations and general protected habitat may be reviewed during future planning stages and in consultation with the regulating agency.	
Significant Wildlife Habitat	Subject to confirmation by site-specific EIS or equivalent study	Similar to the above category, appropriate VPZ specific to SWH is dependent on the factors such as the sensitivity of habitat. This study has applied a 30 m VPZ around the Significant Woodlands confirmed as Area-Sensitive Forest Bird Habitat, as the habitat function is highly likely to be impacted by adjacent development. Other SWH types discussed in this document are associated with other components of the NHS and are considered to be adequately protected by the minimum VPZ applied per municipal policy.	

** Unless otherwise permitted under Official Plan Policies (e.g., Policy 3.4.17)*

The above values denote the <u>minimum</u> VPZ width that is considered acceptable around the various features. The presence of particularly sensitive features or functions may warrant an increase to the minimum recommended VPZ. Additional features which may warrant increased VPZs include forests providing wildlife habitat. Noise and light are known to negatively impact the behavior and breeding success of animals such as birds and amphibians (Longcore and Rich, 2004; Baker and Richardson, 2006; Bayne et al., 2008; Pidgeon, et al., 2007). Traffic noise, for example, decreases the occurrence, breeding density, and breeding success of bird species (Brotons and

Herrando, 2001; Reijnen, Foppen, & Veenbaas, 1997). Similarly, several studies have shown that anthropogenic noise negatively affects the foraging behaviour of bats, reducing their ability to detect prey and resulting in avoidance behaviours (Gillam and McCracken, 2007; Schaub et al., 2008). The 15 m VPZ specified for Significant Woodlands within the Urban Area is considered the absolute minimum that should be considered adjacent to habitats confirmed or suspected to support sensitive forest species such as Eastern Wood-pewee.

The VPZs outlined in this report may be revisited and refined as new information regarding the potential land use and updated information on the ecological function of natural heritage features becomes available; however, the minimum VPZ requirements applying to natural heritage features must be observed. VPZ boundaries may be adjusted to reflect updated feature boundaries (e.g., dripline of forests, wetland boundary, as determined through site-specific studies).

4.2.3 Linkages

Sections 3.5.8, 3.5.9, and 3.5.10 of the Municipality of Clarington's OP state:

> *Connections or linkages between natural heritage features and hydrologically sensitive features provide opportunities for wildlife movement, hydrological and nutrient cycling, and maintain ecological health and integrity of the overall Natural Heritage System. The Municipality recognizes the importance of sustaining linkages.*
>
> *The Municipality shall support the protection of connections between natural heritage features and hydrologically sensitive features and across the Natural Heritage System through the identification of linkages in watershed plans, subwatershed plans, Environmental Impact Studies and other studies where appropriate.*
>
> *Linkages shall be evaluated, identified and protected through the preparation of Secondary Plans.*

This SWS has therefore identified existing linkages within the study area which may be carried forward for further evaluation and eventual implementation by later planning stages. Future site-specific studies shall confirm functional linkages within the affected study area(s) and may refine, adjust, or relocate the linkages identified in this SWS so long as all linkage function (i.e., connectivity on the landscape) is maintained.

The primary linkages within the study area occur along Soper Creek and its tributaries, which create a largely contiguous and interconnected north-south corridor throughout. Linkages identified in this study have been largely based on drainage corridors; however, as drainage corridors are typically protected as part of the NHS, most of this section focuses instead on hedgerows which are not afforded the same protection. High value linkages provided by hedgerows are uncommon throughout the study area in general, but may provide linkage between otherwise disconnected features or act as additional corridors to other branches of the NHS. No hedgerows were identified as the sole connection between areas of the NHS. It should be noted that not all of the identified linkages are well developed in maturity, wildlife cover, or species composition and could benefit from enhancement. Locations where linkages do not currently exist but may be established in future have also been identified as restoration opportunities (see **Section 4.2.4** for further discussion) and future site-specific studies should further explore these opportunities.

4.2.4 Natural Heritage Restoration and Enhancement Opportunities

CLOCA has indicated a general goal of 30% natural cover per subwatershed as a "best practice" target on the landscape. Environment Canada's "How Much Habitat Is Enough?" document (2013) further recommends a minimum of 30% woodland cover and 10% wetland cover per subwatershed as a broad-scale goal to maintain ecosystem health. These values are not intended to be prescriptive but are provided as a threshold below which remnant natural areas may not be sustainable in the long-term with regards to ecological function. Currently, the Soper Creek watershed as a whole (according to existing mapping maintained by Land Information Ontario) contains approximately 23% woodland and 5.1% wetland cover.

It is recognized that the Soper Creek subwatershed includes both urban development lands and a larger area outside of the Urban Boundary. It is further acknowledged that extensive habitat restoration or similar measures are unlikely to be feasible within the Urban Boundary if the Municipality's future growth needs are to be met. However, an appropriate goal both for this SWS and related future development in the study area is to avoid a net loss of existing natural heritage resources and their important ecological functions. The policies in the Municipality of Clarington's OP support sustainable development and enhancement of the natural heritage system, requiring the identification of VPZs and linkages which may undergo restoration and ultimately contribute to higher overall natural cover within the subwatershed. The current planning stage for the study area offers a valuable opportunity to increase existing cover, maintain or increase connectivity across the landscape, and improve the condition of existing natural heritage features. The identification of restoration and enhancement opportunities in the study area was therefore considered an important objective of this SWS.

Opportunities to improve the existing NHS should be considered in keeping with the following factors:

- **Size**: Larger patches of habitat are generally more valuable than smaller. Opportunities to increase the size of existing patches of natural cover (e.g., by designating open space or establishing parks adjacent to existing natural areas) should therefore be considered.

- **Shape**: Habitat patches which are compact (i.e., those which have less 'edge' per area) are generally more valuable than those which are linear or elongated. Edges are often associated with effects such as greater establishment of introduced and invasive plant species, increased rates of predation, increased noise disturbance, and changes to microclimate. Opportunities to fill in gaps and reduce the edge to interior ratio of natural heritage patches should therefore be considered.

- **Complexity**: Natural areas with a high diversity of vegetation communities, microhabitats, and topographical features often support a wider variety of species (and a greater proportion of rare species) than those which are more uniform. Opportunities to increase the diversity of habitat across the landscape (e.g., by planting restoration areas with a variety of native species, by creating sloughs or pit/mound topography in restoration areas, or by conserving successional meadows and thickets in addition to forests) should therefore be considered.

- **Connectivity**: Fragmentation of natural areas by development can lead to the isolation of habitat patches and the wildlife they support, limiting dispersal of individuals and reducing genetic variability within the population. Opportunities to maintain and improve existing connections between natural areas (e.g., by completing riparian planting along ephemeral watercourses and HDFs, or by widening and enhancing canopy cover along hedgerows) and to create new connections where they are currently lacking should therefore be considered.

Restoration and/or enhancement of a site may be done either actively (i.e., by planting or seeding native vegetation, potentially accompanied by grading to create specific topography or features such as constructed wetlands) or passively (i.e., by ceasing management and allowing vegetation to colonize according to the in-situ seed bank). Active restoration is a more costly and labour-intensive approach, but it offers opportunities for community involvement (e.g., tree planting days) and can “kick-start” a site to a more advanced stage of succession (i.e., promote forest development through tree and shrub planting). It is also more likely to achieve a target vegetation community or species diversity target; passively allowing succession to occur is more likely to allow colonization of a site by non-native and/or invasive species. Active restoration is likely to be a component of an ecological offsetting plan or compensation strategy related to impacts of proposed development; the need for and scope of such an offsetting plan would be identified through the development application process (i.e., addressed as a component of a site-specific EIS or equivalent study), and would need to be developed in consultation with the approval authority. It should be noted that CLOCA’s stated preference is for any required offsetting/compensation to occur in the same watershed, or even the same landholdings if possible, and for necessary compensation to be provided on lands that are to be conveyed to a public authority.

The Municipality of Clarington’s OP, Section 3.5.7, states that “*restoration and/or regeneration areas identified in … subwatershed plans shall be addressed through the Secondary Plan process*”. In this context, it is acknowledged that the restoration opportunities identified in this SWS do not represent the only opportunities for restoration or enhancement in the study area, and that the indicated locations and/or boundaries shown on **Figure 4.4** may be subject to change following site-level assessment as part of the Secondary Plan process and/or land use design. Regardless of whether the suggested locations in this document are ultimately carried forward, it is strongly recommended that future assessments and site planning exercises look for opportunities to improve existing natural heritage features and functions, both within individual properties and within the landscape context. Where development proposals require ecological offsetting to address negative impacts, restoration considerations such as those discussed in this section should be carried forward to ensure no net negative impacts and no net loss of natural cover.

Opportunities for restoration and enhancement were generally identified in three categories: infill areas adjacent to or between existing NHS components, stream corridor restoration, and restoration of VPZs. These general categories are discussed further in the following subsections.

4.2.4.1 NHS Infill

The maps provided on **Figure 4.3** and **Figure 4.4** illustrate multiple locations where cleared land (mainly fields currently in use for agriculture) are surrounded on all sides by the identified NHS. These locations may be undevelopable due to a lack of access and are therefore ideal candidates for restoration in order to improve the size and shape of the existing NHS patches.

This ‘infill’-type restoration would be particularly valuable along the northern limit of the Urban Boundary study area, adjacent to the large woodlot containing interior forest habitat, and the main Soper Creek Corridor in that same vicinity. Minimizing or eliminating edge intrusions at the southern end of this feature would, in the long term, increase the interior habitat provided by the woodland as a whole. Similarly, filling in the edges along the creek corridor would greatly improve connectivity between the large patch of interior habitat to the north and the smaller patch that is present along Soper Creek within the study area.

4.2.4.2 Stream Corridor Restoration

Restoration and enhancement of riparian zones along watercourses and retained HDFs is also recommended; well-vegetated riparian zones provide shade, cover and food sources for in-stream wildlife, help control water temperature, and allow the filtration/settling of suspended sediment in runoff before it reaches a watercourse channel. Specifically, the area shown on the north east corner of Mearns Ave and Concession Road 3 and downstream of aquatic monitoring station SOP7A should be planted and restored to a condition similar of the upstream cedar swamp riparian area. This coldwater tributary has been identified through aquatic habitat, fish and benthic community assessments as a valuable contribution to the Soper Creek subwatershed.

Other restoration opportunities include the removal of Barrier 3 and restoration of Online Pond 1 shown in **Figure 3.50** to restore the connectivity and thermal mitigation of the headwater drainage features of SOP3-7 to the downstream watercourse. Barrier 1 should be considered for removal as discussed in **Section 3.3.3.1** to restore fish passage through the main Soper Creek branch. The CSP culverts servicing Mearns Ave and Liberty Street N north of Concession Road 3, shown as ES24 in **Figure 3.45,** should be considered for removal and replaced with open bottom culverts or clear span bridges to mitigate potential fish barriers within the valuable fish habitat observed at monitoring stations SOP7A and 8A. As identified by CLOCA, Crossing 3 (**Figure 3-50**) is a barrier to non-jumping fish species and should be evaluated for mitigation. Considerations should also be made for other crossings, including future pedestrian crossings. New crossings should be avoided where possible. Lastly, two watercourses observed on the “Camp 30” property along with the lower portion of Soper Creek (SOP3A) demonstrated impacts and should be considered for potential restoration. Specifically, the buried section of the watercourse on “Camp 30” as shown in **Figure 3.35** could be daylighted and restored.

4.2.4.3 VPZ Restoration

The Municipality of Clarington's OP indicates that VPZs "*intended to be restored with native, self-sustaining vegetation".* Restoration of the identified VPZs around eligible components of the NHS would provide a benefit to the NHS as a whole and increase the effectiveness of the buffering function the VPZs were established to provide. Restoration of VPZs is not, however, eligible for consideration as ecological offsetting, if such is required, since the naturalization of VPZs is a pre-existing requirement.

Compatible land uses or low-impact development (e.g., LIDs) may be allowed within VPZs as previously discussed in **Section 1.3.6**, but should not compromise the ability of the VPZ to provide the necessary buffering function to the NHS feature for which it was established.

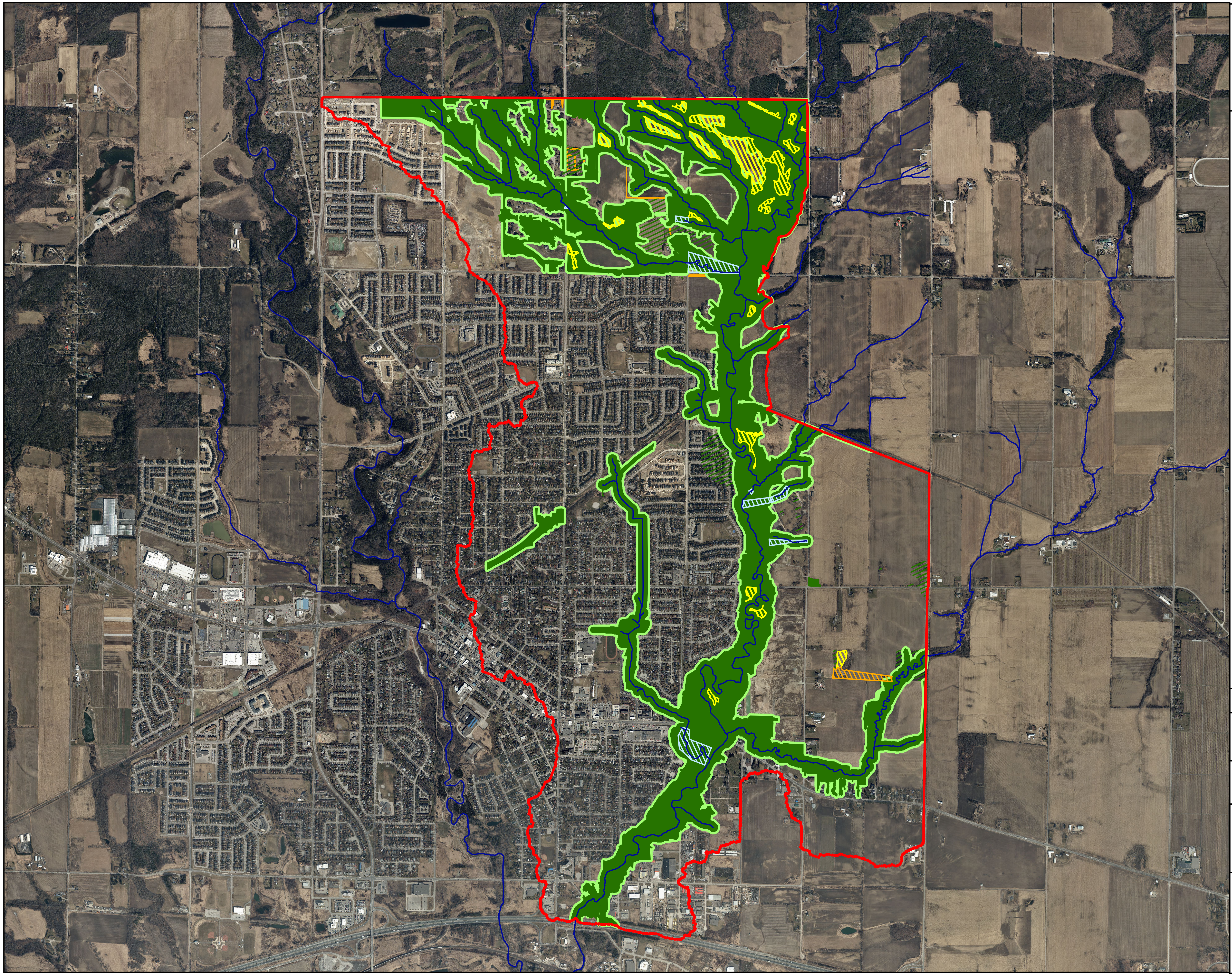
4.2.4.4 Hedgerow Management and Enhancement

Hedgerows can provide food and shelter for wildlife and can function as linkage between patches of habitat. In general, hedgerow continuity and width are positively correlated with ecological function. The presence of other habitat features, such as cover objects (e.g., rock piles, boulders, large woody debris, etc.) and water, also add to a hedgerow's function as direct habitat and as a corridor.

The spatial, aesthetic, and biophysical characteristics of each hedgerow within the study area was assessed in the field, as detailed in **Section 3.3.4.3** and **Table 3.23**. Hedgerows have not been identified as a major component of connectivity and linkage throughout the watershed, but a few hedgerows have been characterized as Category 1 or 2 (Polygons 07.21, 07.22, 07.23, 07.24, 07.25, 07.26, 34.05, 42.01, 78.01 and 78.10 – shown on **Figure 3.52** and **Figure 4.4**), indicating that they have, or potentially have, high value for connectivity in the subwatershed area, or contain protected SAR such as Butternut that warrant retention. Based on these characteristics, management recommendations or enhancement opportunities may exist to further increase their value as linkage corridors within the NHS. Hedgerows that are Category 3 (containing other valuable attributes unrelated to connectivity or linkage) may be also considered for integration based on the presence of mature or specimen trees or wildlife habitat, where adjacent land uses allow (e.g., where parklands can be integrated). These hedgerows are included in the ELC mapping on **Figure 3.52** but are not presented on **Figure 4.4**.

In general, management or linkage enhancement recommendations for high value hedgerows (e.g., Category 1 and 2) include the removal of invasive species and native species planting to widen existing corridors or bridge existing tree gaps. It is recommended that dead/dying ash also be replaced with native trees.

One opportunity has been identified in the Soper Hills area to link an isolated natural heritage feature (Polygon 22.02) with the main NHS system corridor. The isolated feature currently exists in an agricultural field to the west of an eastern branch of the Soper Creek, and a corridor could be established laterally between the two features through native species plantings. The location of the proposed linkage corridor shown on **Figure 4.4**.



Clarington

Legend

- Study Area
- Watercourse
- Natural Heritage System
- Vegetation Protection Zone
- Candidate Natural Heritage System
- Enhancements / Restoration Opportunities
- Riparian Habitat Enhancement / Restoration Opportunities
- Linkages (Category 1 and 2)
- Additional Linkage Opportunities

Figure 4.4

Vegetation Protection Zones, Linkages, and Enhancement/Restoration Opportunities

Date: May 2023
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.375 0.75 1.5
Kilometers
N

Aquafor Beech Limited

4.2.5 Summary of Natural Heritage Considerations

The preceding sections describe the natural heritage features and functions that were identified via this SWS and which form part of the overall developmental constraints for the study area, including features which meet the criteria for the municipal Natural Heritage System (NHS) and associated minimum required Vegetation Protection Zones (VPZs). Also identified are linkages (both existing and potential) and restoration/enhancement opportunities to provide a benefit to the NHS.

Natural heritage constraints and opportunities were assessed based on the results of a detailed field program executed in 2018 and 2019 with supplementary material provided by background resources, and the analysis of these data under current provincial and municipal policies as well as other agency guidance documents. Field studies completed include aquatic habitat assessments, aquatic community surveys (fish and benthics), vegetation community classification, botanical inventories, breeding bird surveys, and amphibian calling surveys, as well as assessment of SAR potential and SWH. The results of these surveys and the review of background resources are detailed in **Section 3.3**. Features which meet the criteria for inclusion in the NHS, based on the findings of this SWS, are depicted on **Figure 4.3**.

VPZs, linkages, and opportunities for restoration/enhancement are indicated on **Figure 4.4**, with detailed discussion regarding the identified features provided in the preceding sections. The establishment of VPZs and protection of linkages through the planning process (beginning with the SWS and continuing in subsequent stages) is a requirement of municipal policy per the OP; the OP also indicates that restoration opportunities are to be identified by the SWS and further evaluated and addressed during the Environmental Impact Study (EIS) and Secondary Plan process.

4.3 Other Considerations

4.3.1 Groundwater Resource Opportunities

Within the study area, important groundwater-surface water interactions result from deep groundwater transport from the headwater areas of the watershed which are geologically set within the Oak Ridges Moraine. Modelling indicates that this groundwater complex maintains cool persistent discharge in the form of baseflow to Soper Creek and contributes to water quality maintenance and support of aquatic ecosystem function. Within the urban boundary, more recent surficial deposits of sand associated with the historic Lake Iroquois shoreline play a crucial role in supporting seasonally intermittent groundwater - surface water interaction which supports local wetland and watercourse hydrology during critical spring periods.

Supporting the preservation of infiltration is key to any development plan within the study area, especially in the Soper Springs Secondary Plan area where NHS systems are hydrologically supported by infiltration into the local sand plain. An opportunity exists within the study area to develop an urbanization strategy which preserves groundwater recharge via the use of strategically located source and conveyance controls which take advantage of local infiltration capacities.

Schedule E – Table E5 of the Regional Official Plan identifies High, Moderate and Low Risk Land Uses which should be consulted in developing Land Use Plans for areas within Highly Vulnerable Aquifer Areas (HAVAs).

4.3.2 Headwater Drainage Features

HDFs are important in maintaining primary and secondary inputs to surface water, groundwater, and fish habitat as applicable; HDFs within the study area were previously defined in **Section 3.2.1**. A summary of the HDF management recommendations, as related to the hydrologic and ecologic function of each feature, is presented below in **Table 4.4**. HDFs on lands not accessed during this study will have to be assessed as part of a future study.

Table 4.4: Summary of HDF Management Implications

Management Implications	HDF Classification			
	Protection	Conservation	Mitigation	No Management Required
Must remain open	Yes	Yes	n/a	n/a
Relocate using Natural Channel Design	Not permitted, enhancement only	May be considered, not preferred	Natural Channel Design not required[1]	n/a
Maintain or replicate groundwater or wetlands	Maintain or enhance	Maintain or replicate, restore if possible	n/a	n/a
Maintain hydroperiod	Yes	Yes	Yes	n/a
Direct connection to downstream	Yes	Yes	Yes	n/a
Replicate function through enhanced lot conveyance control	n/a	n/a	Replicate using bioswales, LID, vegetated swales or constructed wetlands	n/a

[1]*Unless the management recommendations call for the restoration of lost function or enhancement and creation of fish habitat.*

HDFs with a "Protection" management recommendation are to be retained and protected in situ. As these features within the study area were documented to provide indirect fish habitat, "Protection" HDFs will hereafter be treated as Fish Habitat and Riparian Corridors (defined above as a component of the NHS) with appropriate VPZs applied.

HDFs with a "Conservation" or "Mitigation" classification also provide indirect fish habitat within the study area and would, per Clarington's OP, qualify for protection as a component of the NHS. However, the Management Recommendations provided in the HDF Guidelines indicate that these features can be relocated or replicated within certain guidelines/requirements (detailed previously in **Table 3.4**). To rectify this apparent conflict between municipal policy regarding fish habitat and the management recommendations of the HDF Guidelines, this study recommends the following approach: proposed development or land-use change should consider HDFs first using the Management Recommendations, as these were developed specific to HDFs and account for the preservation of important features and functions associated with these features. Relocation or replication of “Conservation” or “Mitigation” HDFs may therefore be proposed in keeping with the Management Recommendations.

However, once any proposed relocation of a “Conservation” HDF is completed as part of a new development, the new channel would then need to have the Fish Habitat and Riparian Corridor designation applied and all associated setbacks and VPZs would need to be observed for the new alignment. For “Mitigation” HDFs where function is to be replication through LIDs or similar, NHS designation would not apply but an EIS or other appropriate study must be completed to ensure no net loss of function to downstream systems (i.e., maintenance of indirect fish habitat function would need to be demonstrated).

Please note that other considerations (e.g., flood hazard limits, wetland vegetation communities) may also apply to HDFs.

4.4 Consolidation of Constraints

The above sections detail the various constraints to development that are present in the study area. This study recognizes that not all constraints function at the same level. Thus, constraints have been categorized according to their implications towards future land management and development.

Figure 4.5 provides a visual summary of the preliminary constraints to development posed by Natural Hazards and Natural Heritage, and **Table 4.5**, below, details the various categories of constraint that are illustrated on that figure. Please note that the highest level of constraint that is applicable to a given area has been shown on **Figure 4.5** (i.e., if a particular location is High Constraint due to the location of the regulatory flood line but a Moderate or Low Constraint due to natural heritage considerations, the High Constraint will be shown as the overriding factor. The regulatory flood line is based on CLOCA’s current floodplain mapping.

It is the intention that future site-specific studies may refine/confirm the boundaries of the constraints illustrated on **Figure 4.5** based on updated information (e.g., staking and survey of wetland boundaries or forest driplines, updated geotechnical investigations, etc.). Further, it is acknowledged that future studies related to transportation and utilities/servicing may affect the constraints illustrated in this SWS; if the placement of essential infrastructure results in impacts to constraint areas, it is expected that the Environmental Assessment for that infrastructure will address those impacts and provide any necessary mitigation or compensation. Future Environmental Assessments should consider the constraints and their triggering sensitivity presented within this study to best plan mitigations and compensation actions.

Figure 4.5 also indicates locations where additional studies are required to confirm the presence or category of a constraint; this is primarily associated with areas that were identified as Candidate SWH.

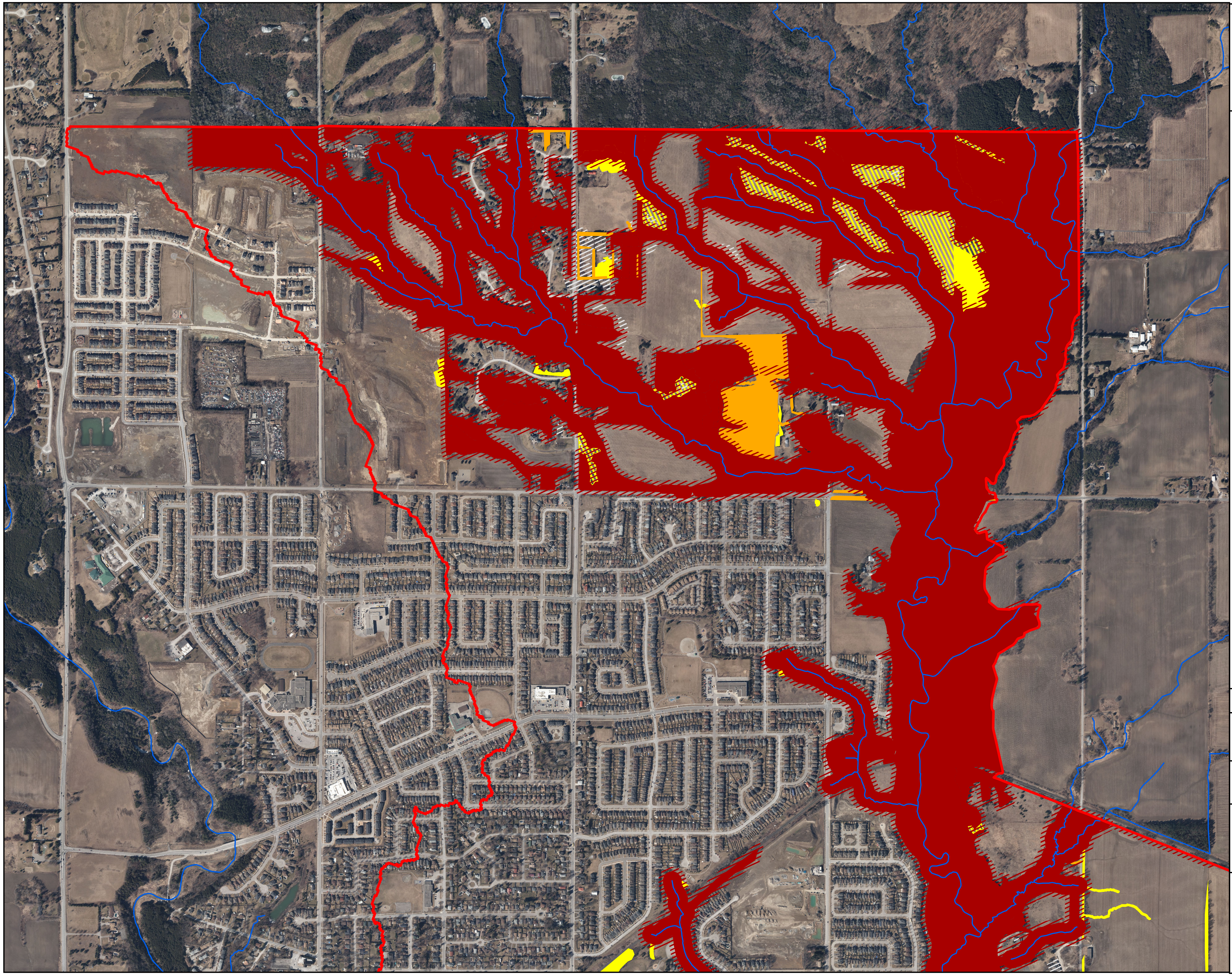
Table 4.5: Description of Constraints

Colour on Figure 4.5	Category	Management Recommendation	Included Features	Further Discussion
Red	High Constraint	Development intrusion is generally prohibited.	<u>Natural Hazards</u> • Meander Belt and CLOCA Regulatory Flood Line • Slope Hazard and Long-term Stable Slope Setback* <u>Natural Heritage System Features</u> • Significant Woodlands • Wetlands over 0.5 ha • Fish Habitat and Riparian Corridors <u>Other Constraints</u> • HDFs with a "Protection" classification (to be treated as Fish Habitat and Riparian Corridors under the NHS)	Generally, no development will be allowed in High Constraint areas. Feature boundaries may be refined through future study.
Red - Hatched	VPZs on High Constraint Features	Development and site alteration generally prohibited, save for certain exceptions as discussed in **Section 4.2.2**.	Minimum VPZ to be applied to features noted above in the High Constraint category, as previously described in this document.	Configuration of VPZs as depicted in this SWS may be adjusted where High Constraint features are refined through future study as noted above. However, minimum VPZs under policy, as previously discussed in this document, must be applied.
Orange	Moderate Constraint	Some development intrusion may be acceptable in Moderate Constraints, pending site-specific study and/or assessment to determine the impact(s) the proposed actions will have on Natural Heritage and determine appropriate mitigation/compensation.	<u>Natural Heritage System Features</u> • Locations of retainable Butternut (pending completion of Butternut health assessment) • Habitat of Threatened bird species <u>Other Constraints</u> • Category 1 and 2 Hedgerows • HDFs with a "Conservation" or "Mitigation" classification	Feature boundaries may be refined through future study. Development plans affecting Moderate Constraint features will be subject to site-specific study and completion of an EIS. The scope of this EIS will be reviewed and approved by the Municipality/CLOCA and shall include confirmation of the status/condition of natural heritage features under municipal policy and any other requirements (e.g., SAR legislation) as well as determination of whether the proposed development will have a significant negative impact on the identified features/functions. Mitigation and/or compensation requirements are anticipated to offset impacts to Moderate Constraint features. Occurrences and habitat of SAR are subject to the requirements of the Endangered Species Act. Some alteration or removal of habitat may be permitted following appropriate study (e.g., Butternut health assessment) and/or under conditions prescribed by the ESA, its regulations, and/or the MECP. "Conservation" HDFs are expected to be classified as Fish Habitat and Riparian Corridor (per NHS) following the completion of any proposed relocation, if relocation is approved.

Colour on Figure 4.5	Category	Management Recommendation	Included Features	Further Discussion
Yellow	Low Constraint	Development intrusion is not restricted by existing policies and regulations, but it is suggested that features be considered for incorporation into site-level plans where possible to avoid net loss of natural cover. Ecological offsetting may be required to ensure no net loss of natural cover where the removal of low constraint features is proposed.	Natural Features not Eligible for Inclusion in the NHS • Wetlands smaller than 0.5 ha • Woodlands that do not meet the criteria for Significant Woodlands per the Municipal Official Plan and do not exhibit other indicators of significance • Category 3 and 4 Hedgerows Other Constraints • HDFs with a "No Management Required" classification	Features may be considered for incorporation into site-level plans where possible (e.g., parks or SWM blocks, preservation of individual specimen trees, alignment with rear lot lines or trail routes, etc.).
Grey - Hatched	Status Pending Further Study	Complete additional study as required to confirm the presence/absence and sensitivity of features affected by future development applications.	All features requiring additional study, for example: • Areas providing candidate/unconfirmed SWH (presence/absence and extent of habitat to be confirmed through further studies)	To be addressed by future studies.

* The constraints mapping includes a 6 m erosion access allowance, as discussed in **Section 3.2.2.5.**

Clarington



Legend

- Study Area
- Watercourse
- High Constraint
- VPZs on High Constraint Features
- Moderate Constraint
- Low Constraint
- Status Pending Further Study
- Enhancements / Restoration Opportunities

Figure 4-5

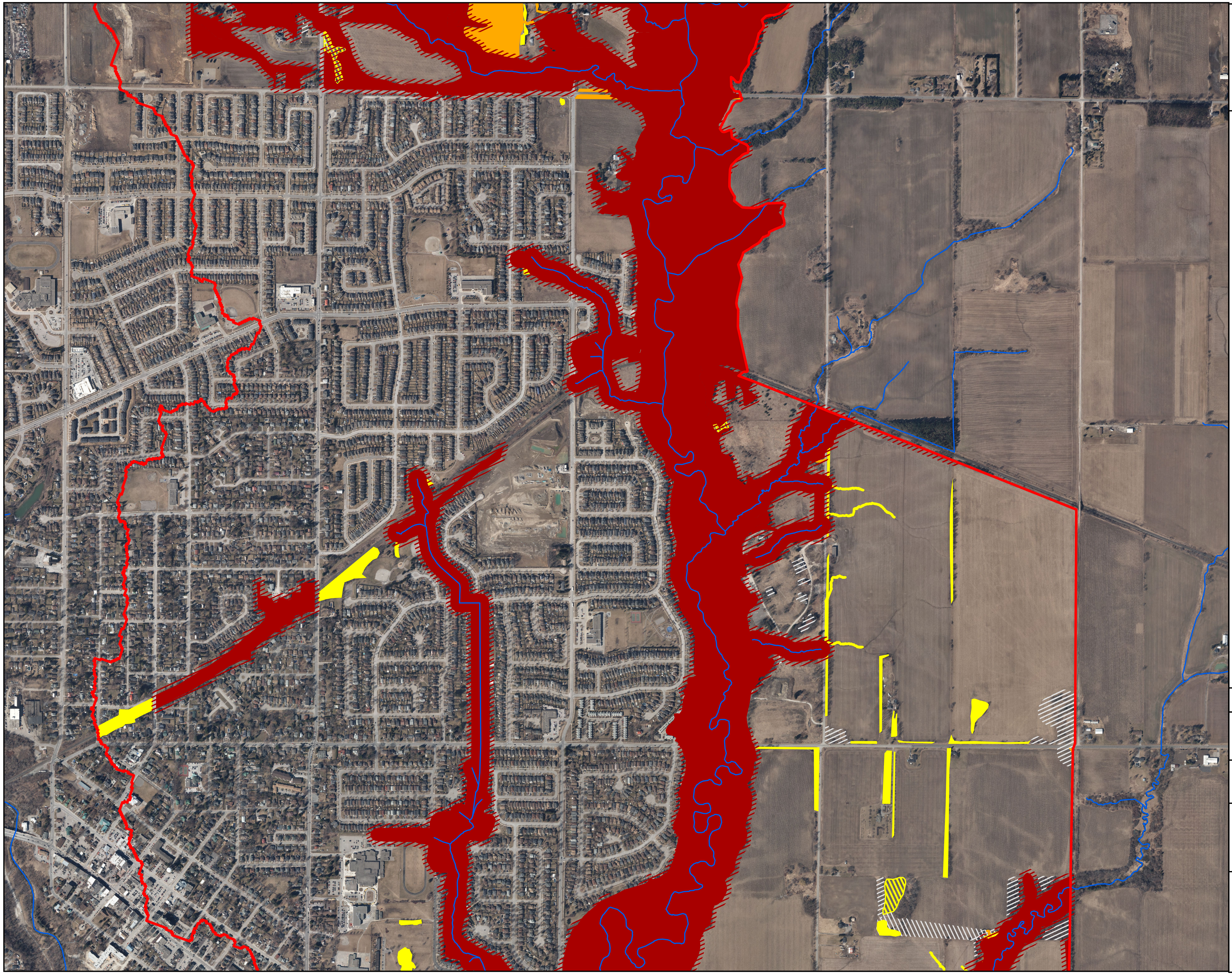
Constraints to Development

Date: May 2023
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.175 0.35 0.7
Kilometers

N

Aquafor Beech Limited



Clarington

Legend

- Study Area
- Watercourse
- High Constraint
- VPZs on High Constraint Features
- Moderate Constraint
- Low Constraint
- Status Pending Further Study
- Enhancements / Restoration Opportunities

Figure 4-5

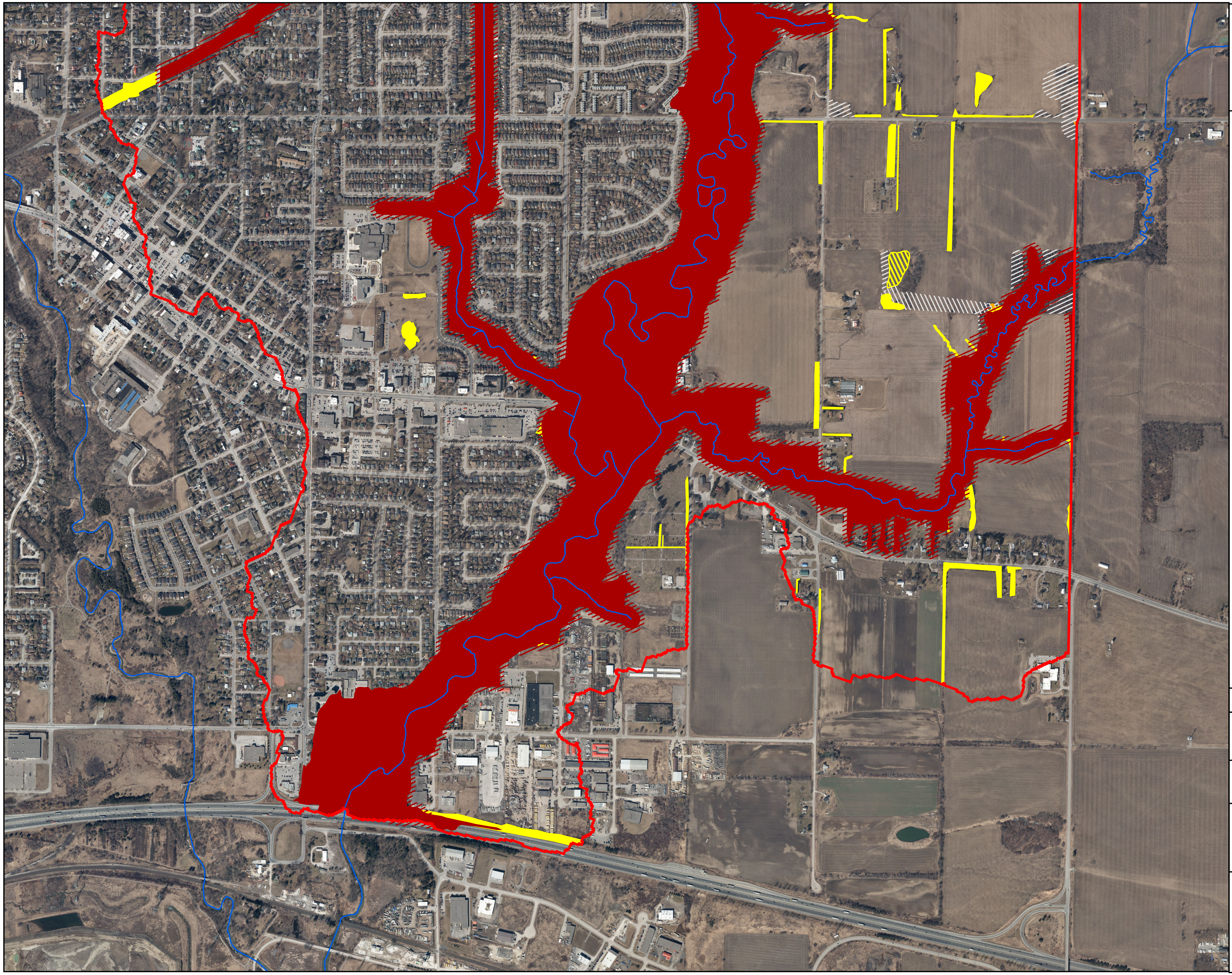
Constraints to Development

Date: May 2023
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.175 0.35 0.7
Kilometers

N

Aquafor Beech Limited



Clarington

Legend

- Study Area
- Watercourse
- High Constraint
- VPZs on High Constraint Features
- Moderate Constraint
- Low Constraint
- Status Pending Further Study
- Enhancements / Restoration Opportunities

Figure 4-5

Constraints to Development

Date: May 2023
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA, LIO

0 0.175 0.35 0.7
Kilometers

N

Aquafor Beech Limited

5.0 Recommendations for Further Study

The following section outlines recommendations for further study based on the findings of the work completed to date. Further recommendation(s) may be introduced following additional analysis during later phases of the SWS.

As previously mentioned, lands not accessed during this study were treated with a conservative approach that inferred significance to features where there was no evidence available to prove otherwise. Any constraints illustrated on lands not accessed as part of this study represent an assessment of the best available information at the time of this study. Where possible, features on inaccessible lands were evaluated from adjacent properties and/or roadsides plus a review of available background data. Future site-specific studies on unaccessed lands may require an enhanced level of assessment as compared to properties which were assessed during this SWS and therefore have a greater amount of baseline data available. Regardless, to ensure that detailed, current, site-specific data are available at the time of review, future development proposals will need to be accompanied by relevant studies to confirm whether features/functions are present and determine the appropriate level of protection/management that may apply.

5.1 Groundwater Recommendations

Increased urbanization in the Soper Creek Watershed, without preservation of groundwater recharge, will likely impact groundwater-surface water interactions which support local aquatic ecosystem function. The magnitude of the impact of these effects and potential measures to minimize the impact will be discussed during Phase 2 of the subwatershed study.

5.2 Surface Water Recommendations

5.2.1 Watercourses

To ensure the hydrologic and hydraulic impacts of urban development are fully quantified and development is planned in a manner to best mimic the natural hydrologic and hydraulic regime, the following is recommended.

A. That the Visual Otthymo hydrologic model be updated with revised land uses developed through the Soper Hills Secondary Plan and Soper Springs Secondary Plan and that these flows be used to evaluate the potential impact to the flood hazard via hydraulic analysis.

B. That the updated Visual Otthymo hydrologic model include the construction of Highway 407 and associated SWM facilities.

C. That climate change scenarios be incorporated into both single event and continuous hydrologic modelling for future scenarios in order to ensure community and infrastructure resiliency.

D. That the flood mapping assessment within the Secondary Plan Areas (Soper Hills and Soper Springs) be extended where technically feasible beyond the 125 ha threshold.

E. That during Phase 2 of the Soper Creek Subwatershed Study, Low Impact Development Stormwater Management Practices consisting of conveyance and source controls be considered along with end-of-pipe SWM facilities to ensure the runoff regime is not significantly altered, natural hazards are not exacerbated, and important ecological features associated with aquatic and riparian habitat are maintained. These practices should be modelled via a continuous hydrologic model simulating average, wet and dry years in order to complete a robust analysis of water balance within the subwatersheds.

F. That headwater protection be an ongoing consideration for any OP amendments as they contribute to the maintenance of baseflow and associated water quality, fisheries, ecological, and natural heritage benefits.

5.2.2 Erosion Hazard

In addition to meander belt delineation, the long-term stable slope crest (LTSSC) is a component of the erosion hazards assessment required to determine development setbacks and constraints, specifically around confined and partially confined valley systems (MNR, 2002). Priority stable slope hazard areas have been identified in **Section 3.2.2.5** as provisional assessments of the LTSSC hazards for confined and partially confined reaches. Ultimately, detailed geotechnical studies for each development application are necessary to delineate the final erosion hazard limit around confined valley systems where the LTSSC component is required. It is recommended that every site-specific investigation that needs slope stability assessment be required to complete the *Slope Inspection Record* and *Slope Stability Rating Chart* as provided in the MNR (2002) Technical Guide: River and Stream Systems as Tables 4.1 and 4.2 respectively. These forms serve to document baseline information on the slope conditions prior to development, and to determine the level of detailed investigation required based on slope stability rating.

Within the Soper Creek subwatershed, the completed geomorphic assessments have identified a number of opportunities to mitigate erosion hazards, and/or restore stream functions from both geomorphological and ecological perspectives (**Figure 3.45**):

- Local bank protection works;
- Repair of perched culverts;
- Removal of non-essential structures from channels; and,
- Reestablishment of adequate riparian corridors and removal of invasive species within riparian corridors.

The opportunities are discussed in greater detail in **Section 4.1.3**.

5.3 Ecological Resources Recommendations

The scope of work for this Soper Creek SWS (Phase 1) included a broad array of ecological field surveys within the Urban Boundary study area. However, due to limitations in property access and study scope, not all aspects of the natural environment that may pose constraints to development have been confirmed through this study. Further, as identified throughout this document, a site-specific EIS is anticipated to be required wherever development is proposed adjacent to natural heritage features, not only to confirm the existing conditions (per a scope of work to be determined at that time in consultation with the Municipality and applicable agencies), but to assess the potential impacts of the proposed development and to propose appropriate protection/mitigation/offsetting measures related to the potential impacts (e.g., confirmation of appropriate VPZ).

5.3.1 Site-Specific Studies to Confirm Constraints

The following field surveys may be warranted in certain locations during future planning phases to confirm and/or refine the existing constraints that were discussed in this document:

- **Headwater Drainage Feature Assessments** – should occur in areas where land access restricted surveys from occurring as part of this subwatershed study (HDF assessment was already completed for land with access permission during this SWS). Surveys should follow the same protocols that were used in the current study (CVC & TRCA, 2014).

- **Benthic Macroinvertebrate Monitoring** - Measures of biodiversity can be influenced by factors outside of water quality. For a better understanding of water quality using benthic invertebrates as indicators, sampling would need to be conducted each spring over multiple years to allow comparison between sites, over time. Establishing a reference site for the study area would also be beneficial for future monitoring.

- **Fish Community Sampling** - While the municipal OP does not define fish habitat, Fisheries and Oceans Canada see fish habitat as “the spawning grounds and nursery, rearing and food supply, and migration areas” on which fish depend directly or indirectly in order to carry out their life processes (Department of Fisheries and Oceans, 2019). As noted in **Section 3.3.3**, benthic macroinvertebrates represent important food sources for fish which helps identify fish habitat as defined by the DFO. It is recommended however that fish habitat be evaluated through site-specific fish sampling studies in order to determine if habitat directly supports fish.

- **Fish Passage Assessments** – Crossings and barriers identified in this study should be assessed using Ontario Stream Assessment Protocol (OSAP) Version 10 (Stanfield, 2017), Section 4 Module 9: Instream Crossing and Barrier Attribution to better understand the potential impacts of the crossings and barriers on fish passage through the subwatershed. Findings from these assessments can be cross-referenced between fish species presented in this study and resources such as Fisheries and Oceans Canada’s Swim Speed & Swim Time Tool to prioritize crossings and barriers for mitigation or removal.

- **Butternut Health Assessments** – should occur in areas where Butternut has been identified, if development is proposed within 50 m. Since Butternut was noted as locally abundant in some wooded areas, area searches of treed edges up to 50 m from potential development sites should also be completed to locate any additional Butternut that may not have been observed during the SWS or new saplings that might grow in the time between studies. Butternut health assessments are to be conducted by a qualified Butternut Health Expert according to current approved protocols, during the leaf-on period. Eligibility for Butternut removal and associated compensation requirements are under the jurisdiction of the MECP.

- **Turtle Basking and Nesting Surveys** – may be completed to confirm the presence/absence of turtles in the areas that have been identified as containing potential turtle habitat. Surveys would be most appropriate during the spring (basking) and/or summer (nesting) season. These surveys will help to confirm the presence/absence of SAR turtles (i.e., Snapping Turtle, Midland Painted Turtle) and confirm SWH associated with turtles (i.e., Turtle Wintering Areas and Turtle Nesting Areas).

- **Bat Maternity Roost Surveys** – cavity tree surveys may be warranted during the leaf-off season (i.e., late fall to early spring) in any treed areas that will be affected by proposed development; acoustic surveys may also be required prior to tree removals, pending advice from MECP. These surveys will help determine the presence of SAR bats and SWH associated with bat species (i.e., Bat Maternity Colonies).

- **Reptile Hibernaculum Surveys** – may be required prior to removal of features that could provide this habitat function. Candidate areas that were documented during Aquafor Beech Limited's field investigations were shown on **Figure 3.55** but these locations do not necessarily represent the only possible locations where hibernacula could occur. Monitoring of spring snake emergence may be required, pending advice from MNRF/MECP.

- **Additional Flora and Fauna Surveys** – due to the large size of the study area, it was often necessary to scope the ecological field surveys to a limited number of survey locations or site visit dates. Future site-specific studies may be required to complete additional floral inventories (particularly targeting spring and early summer species which were not identified by this study) and/or breeding bird or amphibian surveys (particularly where the site is located distant to the survey stations documented in this report).

The surveys noted above may not be applicable or required for all properties or development applications; the presence of habitat as well as the potential impact to that habitat will determine the need for related surveys (e.g., a proposed site plan that requires no tree removals will likely not require detailed surveys to confirm bat habitat). The terms of reference for work to be carried out as part of site-specific assessments should be scoped with the Municipality, CLOCA, MECP, and/or any other applicable agencies prior to beginning work.

If the above studies conclude that SWH or SAR habitat is present, then the applicability of these habitats under municipal legislation would need to be assessed (i.e., if they are appropriate to include in the NHS as "wildlife habitat" or "habitat of endangered species and threatened species") and any SAR legislative requirements addressed.. An Environmental Impact Study for any development proposed adjacent to natural heritage features would need to demonstrate that the proposed development would not cause a loss or impairment of habitat features or functions.

Any change in habitat between the time this SWS is completed and the submission of a development proposal may trigger a need for additional surveys. For example, if an agricultural field has been allowed to go fallow, it may become habitat for Threatened open-country bird species or be considered a candidate for certain categories of SWH.

Further, if any natural heritage features currently identified by this study are removed without due assessment, a forensic assessment of the features and their functions may be required and restoration/compensation measures may be assigned. Further, known locations where features have been removed without authorization are to be discussed specifically during Phase 2/3 of this study and may result in the establishment of a special study area to facilitate further discussion on restoration/compensation requirements.

5.3.2 Development of Opportunities

The following considerations are recommended during future planning stages:

- **Improve Connectivity of the NHS through Development of Linkages** – Category 1 and 2 Hedgerows and other opportunity areas identified as linkages on **Figure 4.4** are recommended to be enhanced to provide better connectivity across the NHS. Potential improvements include restoration of gaps between hedgerows and nearby natural heritage features, enhancing canopy cover through native tree planting, and removal of invasive species (e.g., Common Buckthorn) and dead ash trees. Consideration may also be given to improving wildlife passage at road crossings (e.g., through addition of terrestrial benches, increased openness ratios within culverts, etc.). Future planning studies and development proposals should demonstrate how linkages on the landscape will be improved and maintained.

- **Confirm Restoration/Enhancement Opportunities** – This SWS has suggested locations for restoration/enhancement that would provide a benefit to the existing NHS and landscape connectivity. Subsequent studies should further review and assess the opportunities present in the study area and confirm locations where enhancement or restoration will occur. Active restoration of priority areas may be completed as part of offsetting the impacts of proposed developments.

- **Plant Native Wildflowers to Support Native Insects –** Native wildflowers, especially species known to support Monarch (i.e., Milkweed species), should be included in seeding plans. Construction of 'Butterfly Gardens' in landscaped areas (e.g., neighborhood parks) should also be considered, and landowners in new developments could be encouraged to landscape with native wildflower species instead of maintaining a grassed lawn.

- **Integrate Existing Specimen Trees with Future Landscaping** – Existing mature trees, especially those of native species, are recommended to be retained where possible and integrated into planning of future parks and greenspaces.

- **Riparian planting along drainage channels –** Many HDFs occur on cropped agricultural properties with little to no natural vegetation currently present. These HDFs may be enhanced through riparian plantings, as may watercourses within the study area that currently do not have consistent riparian vegetation.

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