UPPER WELLAND RIVER WATERSHED PLAN

DRAFT

MARCH 2011

NIAGARA PENINSULA CONSERVATION AUTHORITY
250 THOROLD ROAD WEST, 3RD FLOOR
WELLAND, ONTARIO L3C 3W2
(905) 788-3135
www.npca.ca

Executive Summary

The Welland River watershed is the largest watershed within the Niagara Peninsula Conservation Authority's jurisdiction and encompasses over 80 percent of the Canadian Niagara River Area of Concern (AOC). The Welland River has been the focus of much rehabilitation with over 200 restoration projects being completed by the NPCA and partnering agencies. The Upper Welland River Watershed Plan study area is comprised of 40 percent of the total Canadian Niagara River AOC and includes the upper region of the Welland River; upstream of Wellandport with its respective tributaries. This study area supports a unique environmental character and subsequent set of watershed issues. Contributing to the distinctiveness of this watershed are, for example, the Binbrook reservoir, the unique development pressures, such as for example, the Airport Employment Growth District in the upper watershed, and the predominantly rural nature of the watershed.

The Upper Welland River watershed is also rich in ecological diversity with one Carolinian Canada signature site; the Caistor-Canborough Slough Forest, and several provincially and locally significant Areas of Natural and Scientific Interest. The study area also boasts 18 federally listed Species at Risk by the Committee on the Status of Endangered Wildlife in Canada, 12 provincially rare species, and numerous provincially significant wetlands and natural areas which can be found throughout the watershed.
The Upper Welland River Watershed Plan study area encompasses approximately 480 square kilometres of land and includes nearly 3000 kilometres of watercourse. The study area includes Local Management Areas 2.1, 2.2, 2.3, 2.4, and 2.5 as identified in the *NWS* (RMN 2006a) and falls within the municipal boundaries of the Township of Wainfleet and Township of West Lincoln and extends into the boundaries of the City of Hamilton and Haldimand County (Figure 1). The subwatersheds that form the Upper Welland River Watershed Plan study area include Welland River West, West Wolf Creek, Little Wolf Creek, Wolf Creek, Buckhorn Creek, Elsie Creek, Oswego Creek, Mill Creek, Moores Creek, Wilson Creek, Sugar Creek Drain, James Drain, Michner Drain, Chick Hartner Drain, and Unamed Creek. Individual restoration strategies have been prepared for each of the main subwatersheds to protect the unique characteristics of each system.

Land use in the Upper Welland River watershed is characterized mainly by agriculture with a focus on poultry and egg production, and grain and oilseed. There is one major concentration of urban land uses (residential, commercial, industrial) within the Airport Economic Growth District in the City of Hamilton. Smaller urban areas include Mount Hope and Binbrook, also within the City of Hamilton.

The Upper Welland River watershed offers numerous recreational opportunities throughout the watershed with 7 conservation areas that offer passive recreational opportunities; Binbrook Conservation Area, Canborough Conservation Area, Chippawa Conservation Area, Hedley Forest Conservation Area, Port Davidson Conservation Area, Oswego Creek Conservation Area and Ruigrok Tract Conservation Area. The Welland River also offers ample of recreational opportunities for fishing, boating and nature observation.

In addition, there are 3 golf courses in the watershed; Southern Pines Golf and Country Club in Mt. Hope, Southbrook Golf and Country Club in Binbrook, and Caistorville Golf Club.

Upland forest covers 15 percent of the watershed, wetlands another 22 percent and approximately 55 percent of the watercourses have some riparian habitat. Guidelines set by Environment Canada (2004) suggest minimum upland forest cover in a watershed should be 30 percent, wetlands 10 percent *or to historic value*, and at least 75 percent of the watercourses in the watershed should have riparian habitat with a 30 meter buffer on both sides being ideal. Therefore, measures to create new upland areas and establish riparian habitat, as well as protect existing upland and wetland areas should be implemented to ensure adequate upland, wetland and riparian habitat to sustain minimum viable wildlife populations and maintain ecosystem functions and attributes.

As mentioned, 18 *Species at Risk* as designated by the *Committee on the Status of Endangered Wildlife in Canada* fall within the study area boundaries. Five of these species are *endangered*, meaning that they are facing imminent extinction or extirpation in Canada; 2 of these species are *threatened* species, which means they are at risk of becoming endangered; and 10 of the species are of *special concern* which simply means that they have characteristics that make them sensitive to human activities or natural events. In addition, there are 24 provincially rare flora and fauna found within the Upper Welland River watershed.

The unique environmental character of the subwatersheds has resulted in an assortment of issues related to water resources, fish and aquatic habitat, natural heritage resources, urban development, and communication. The watershed issues, which were derived from extensive public input and past studies, were used to form a set of watershed objectives that guided the development of subwatershed restoration strategies and an implementation plan.

The subwatershed strategies include sites for riparian, wetland and upland habitat restoration that have been derived from detailed restoration suitability mapping in conjunction with Regional Niagara's Core Natural Heritage Mapping and Carolinian Cores „Big Picture' mapping. In addition, project opportunities have been identified, in part through the NPCA Geomorphic Assessment, on private and public lands, such as erosion control, and shading to reduce water temperatures in the headwaters. Special studies including funding programs and urban water conservation programs have also been proposed. The implementation plan identifies responsible stakeholders for each recommended management action.

The recommended management actions and associated budget have been outlined and include riparian, wetland and upland restoration and creation to enhance water quality and fish habitat; specific policy tools including municipal and regional official plan amendments; outreach and communication for various aspects of water resources management; and research and monitoring programs to obtain additional data from which the Upper Welland River Watershed Plan can be updated and revised.

The implementation plan identifies responsible stakeholders for each recommended management action as well as a detailed breakdown of each watershed plan objective, recommended action and associated funding (existing and required) and time frame of implementation (e.g. long term, short term) has also been provided.

Acknowledgments

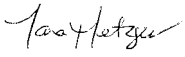
The Niagara Peninsula Conservation Authority would like to extend our sincere gratification to everyone that had an active role in the creation of the Upper Welland River Watershed Plan.

To the members of the public that attended the public open houses and workshops; your participation in these events and your input to the Watershed Plan has assisted the Conservation Authority in gaining a more intimate understanding of the study area and helped us to identify issues that we may not have been previously aware of.

A special thank-you also goes to the members of the Upper Welland River Steering Committee for your commitment and dedication to the creation of the Upper Welland River Watershed Plan. Your hard work and dedication to the project has resulted in the creation of a valuable and useful tool to be used as a resource for watershed managers and stakeholders that will aid in future planning decisions.

The Conservation Authority believes that stakeholder involvement in projects such as these are extremely important and we want you to know that the time you committed to the project is greatly appreciated.

Sincerely,



Tara Metzger
Watershed Planning Specialist

Upper Welland River Steering Committee

Tara Metzger: Niagara Peninsula Conservation Authority; Watershed Planning Specialist
Suzanne McInnes: Niagara Peninsula Conservation Authority; Watershed Planning Coordinator
Carmen D'Angelo: Chair of the Steering Committee; City of Hamilton
Valerie Cromie: Niagara River Remedial Action Plan Coordinator
Mike Dickman: Welland River Keepers
Tony Whelan: Welland River Keepers
Travis McBeth: Regional Municipality of Niagara
Cory Burant: Niagara Restoration Council
Kris Franklin: Haldimand County; Drainage Superintendent
Nick Huitema: Haldimand Federation of Agriculture
Nasir Mahmood: Haldimand County
Tim Robins: Niagara South Federation of Agriculture
David Deluce: Township of West Lincoln
Roy Schofield: Habitat Haldimand
Enzo Florio: City of Hamilton

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Introduction

The Regional Municipality of Niagara (RMN), Niagara Peninsula Conservation Authority (NPCA) and the Ministry of the Environment (MOE) formed a partnership to develop the foundation of a comprehensive water protection strategy for Niagara's watersheds. The result of this partnership was the *Niagara Water Quality Protection Strategy* (RMN 2003), now known as the *Niagara Water Strategy* (*NWS*) (2006a). The *NWS* is a multi-jurisdictional strategy based on 32 Local Management Areas (LMAs) with the intent of guiding respective stakeholders on best management and protection strategies for Niagara's water-dependant resources.

The strategy has identified the need to manage Niagara's watersheds in such a manner as to "*sustain healthy rural and urban communities in harmony with a natural environment, and rich in species diversity*". In 2005, the Regional Council of Niagara adopted new environmental policies for the Niagara planning area. These policies call for an integrated ecosystem approach to planning that includes the involvement of all respective stakeholders. An aspect of the framework for the environmental planning process under these policies is the preparation of watershed studies for Niagara's major watersheds. In Haldimand County's *Strategic Directions* (2004) the County recognizes that *"Environmental considerations require strategic input in terms of land use, management and protection"*. The County also recognizes that a watershed is the most effective unit for ecosystem planning and management of water resources, and that there may be a need to undertake subwatershed planning in areas experiencing development pressures and areas where significant environmental concerns are identified [Haldimand County 2006 (Section B2.2)]. Likewise, the City of Hamilton also recognizes in their *Rural* [Section F3 (2006)] and *Urban Official Plans* [Section F3 ((2009)] that "*In certain circumstances, more detailed plans, strategies and programs are required to guide decision making as the City implements the goals and objectives of this plan* [Official Plan]" (e.g. Watershed and subwatershed plans).

Watershed Planning and the Upper Welland River Watershed

A watershed, also referred to as a catchment basin, is an area of land from which surface runoff (water, sediments, nutrients and contaminants) drain into a common water body (e.g., Mill Creek, Elsie Creek and Welland River). Watersheds include all water and water-dependent features such as wetlands, forests, urban areas, and agriculture (Pollution Probe 2004).

A watershed management plan is a proactive document created cooperatively by government agencies and the community to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed to protect the health of the ecosystem as land uses change (Ontario Ministry of Environment and Energy and Ontario Ministry of Natural Resources 1993). The Upper Welland River Watershed Plan provides a systematic strategy to guide development, identify and recommend alternative and preferred restoration programs, and strengthen stewardship and partnerships in the watershed. Completed in 2 phases, the Watershed Plan consists of:

- background data collection in the form of a watershed characterization;
- a summary of the key issues in the watershed;
- completion of any additional studies to fill in data gaps in the study area;

- identification and suitability of restoration sites, landowner incentive programs, and land acquisition based on key issues in the watershed; and
- creation of an implementation plan including a monitoring component.

Completed over a 36 month period, the watershed planning process follows several steps including numerous opportunities for public involvement through open houses, workshops, public commenting and an agricultural land use survey (Figure 1). The Phase 1 watershed characterization contains a detailed background report including a description of the watershed's physiography, soils, land use, ecological, cultural and natural heritage, as well as a description of surface and groundwater resources. Phase 2 of the watershed planning process provides a set of watershed objectives that are linked to a comprehensive list of watershed issues derived from the *NWS* (RMN 2006a), and public events. Issues specific to agriculture were gathered through the *Land Management Issues and Agricultural Best Management Practices* survey (NPCA 2006a) (Appendix A), which was distributed to Ontario Federation of Agriculture members through a partnership with the Niagara Peninsula Conservation Authority. Any issues derived from these documents and public venues form the foundation of the watershed strategy and subsequent action plan, which are the focus of Phase 2 of the watershed planning process.

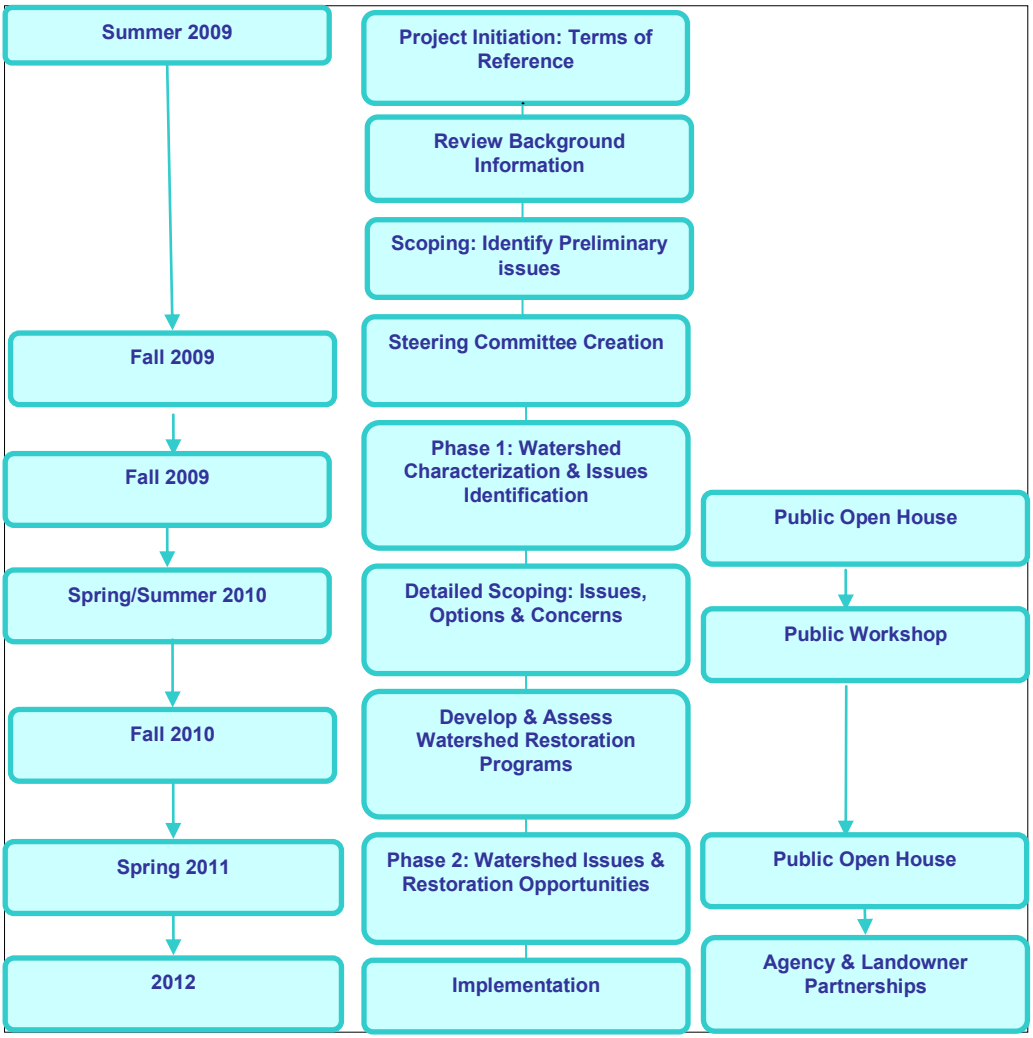

Figure 1: Watershed Planning Framework

The Welland River watershed is the largest watershed within the Niagara Peninsula Conservation Authority's jurisdiction and encompasses over 80 percent of the Canadian Niagara River Area of Concern (AOC). The Welland River has been the focus of much rehabilitation with over 200 restoration projects being completed by the NPCA and partnering agencies. The Upper Welland River Watershed Plan study area is comprised of 40 percent of the total Canadian Niagara River AOC and includes the upper region of the Welland River; upstream of Wellandport with its respective tributaries. This study area supports a unique environmental character and subsequent set of watershed issues. Contributing to the distinctiveness of this watershed is the Binbrook reservoir, the unique development pressures, such as for example, the Airport Employment Growth District in the upper watershed, and the predominantly rural nature of the watershed.

The Upper Welland River watershed (Figure 2) is also rich in ecological diversity with one Carolinian Canada signature site; the Caistor-Canborough Slough Forest, and several provincially and locally significant Areas of Natural and Scientific Interest. The study area also boasts 18 federally listed Species at Risk by the Committee on the Status of Endangered Wildlife in Canada, 12 provincially rare species, and numerous provincially significant wetlands and natural areas which can be found throughout the watershed.

A watershed management plan for the Upper Welland River watershed will aid in protecting and enhancing these distinctive resources in the watershed.

Watershed Vision

Under the Conservation Authorities Act (R.S.O. 1990, c.C27), the mandate of the Niagara Peninsula Conservation Authority is to establish and undertake programs designed to further the conservation, restoration, development and management of natural resources. In keeping with the mandate of the NPCA, *NWS* (RMN 2006a), and the watershed challenges and issues, residents of the Upper Welland River watershed envision the following:

The Upper Welland River watershed will continue to foster a viable agricultural industry and healthy, strong communities while balancing environmentally sustainable and compatible land uses. The Upper Welland River watershed will offer passive recreational opportunities for everyone while supporting a healthy diversity of natural features and flora and fauna within a healthy environment that is no longer listed an Area of Concern.

Watershed Objectives

Each watershed in the Niagara Peninsula Conservation Authority's jurisdiction is unique, having its own set of watershed planning objectives. The watershed objectives for the Upper Welland River watershed have been categorized based on the watershed's resource components, including the social and built environment. In accordance with the *Provincial Policy Statement* [Ontario Ministry of Municipal Affairs and Housing (MMAH) 2005a], *Greenbelt Plan* (MMAH 2005), *Growth Plan for the Greater Golden Horseshoe* [Ontario Ministry of Public Infrastructure Renewal (MPIR) 2006], *Regional Policy Plan* (RMN 2007a), Haldimand County's *Strategic Directions* (2004), City of Hamilton's

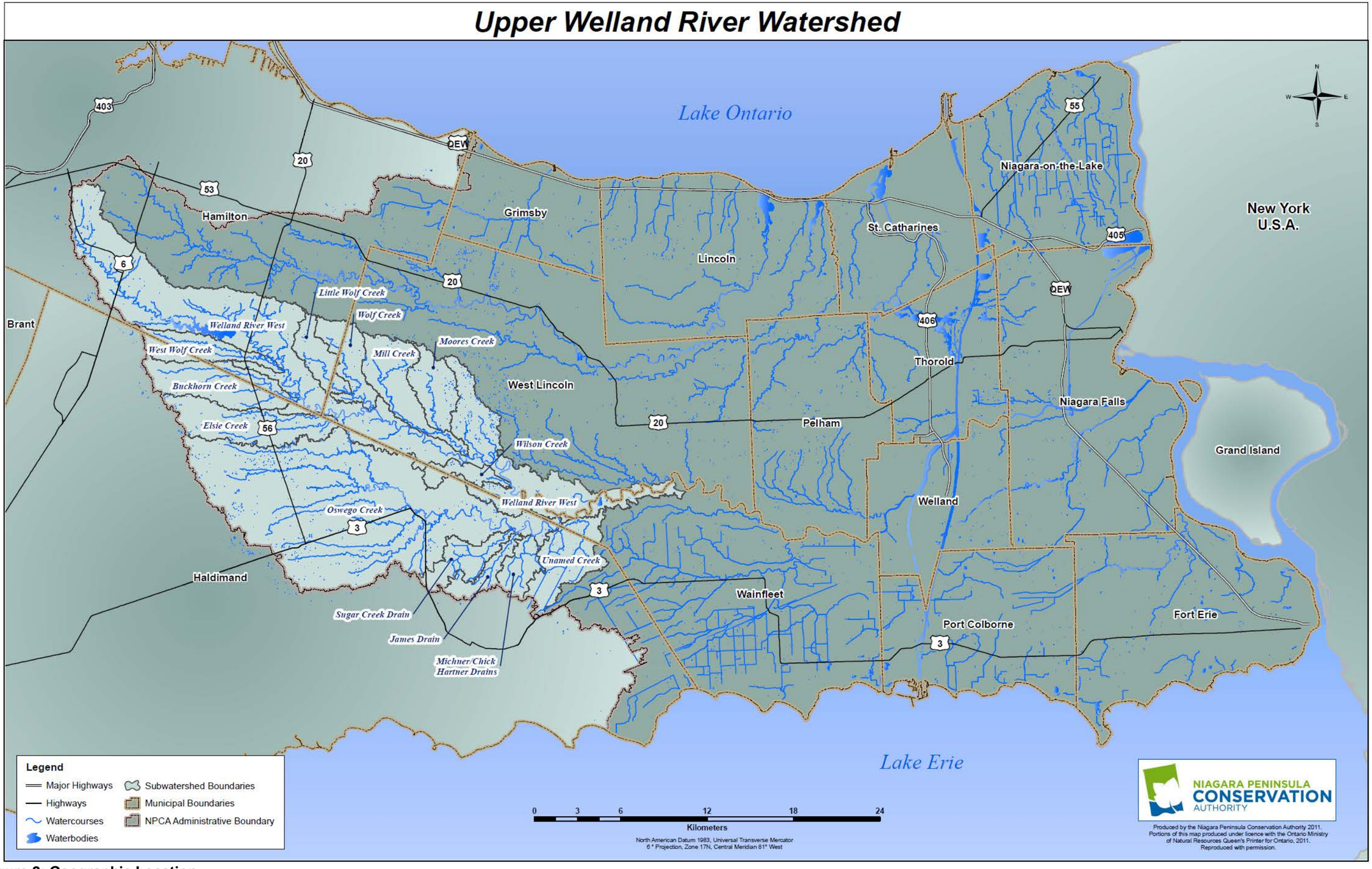

Figure 2: Geographic Location

Official Plans (2006, 2009), and public input, natural resources will be managed on a watershed scale in the Upper Welland River watershed to:

Water Resources

- improve, enhance, maintain and/or protect water quality and/or natural stream processes to support human uses, agricultural needs and ecological functions in accordance with Provincial Water Quality Objectives;
- ensure that urban and rural storm water management practices minimize storm water volumes, sediment, nutrient and contaminant loads;
- manage and mitigate flooding risks to human life and property within acceptable limits;
- protect, improve and/or restore hydrologically sensitive areas (surface and groundwater features); and
- find an ecologically compatible balance between drain maintenance and function

Fish and Aquatic Habitat

- protect, enhance, create, and/or maintain native fish populations and aquatic habitat;
- incorporate Species at Risk management plans into Restoration Strategy;
- investigate exotic and invasive fish and plant populations and their impacts; and
- complete evaluation of watercourses for importance to fish habitat

Natural Heritage and Resources

- protect, enhance and restore the health, diversity and integrity of the natural heritage systems in the watershed;
- create, maintain, protect and enhance natural heritage system cores and connections, including riparian in adjoining watersheds;
- maintain, restore and improve the linkages among surface water features, groundwater features, hydrologic functions, natural heritage features and areas, and their ecological functions;
- reach targets set by Environment Canada's recommended habitat targets (riparian, wetland and upland features);
- complete wetland evaluations; and
- identify significant and sensitive areas that need to be protected.

Communication, Education and Recreation

- foster educational programs and awareness pertaining to urban and rural best management practices (e.g. water conservation practices, alternate farming practices, septic maintenance, buffers, native species);
- increase awareness of current incentive programs available to the public;
- encourage and establish partnerships with respective watershed stakeholders (e.g. landowners, agencies, community groups); and
- encourage the continuation of children's education programs.

Development

- encourage intensification of built-up boundaries;
- promote environmentally-sound land use decisions for current and future urban development and rural/agricultural land use;
- incorporate natural heritage and greenspace into land use management and zoning decisions;
- identify significant and sensitive areas that need to be protected; and
- find an ecologically compatible balance between drain maintenance and function.

Watershed Characterization

Location and General Description of the Upper Welland River Watershed

The Upper Welland River Watershed Plan study area encompasses approximately 480 square kilometres of land and includes nearly 3000 kilometres of watercourse. The study area includes Local Management Areas 2.1, 2.2, 2.3, 2.4, and 2.5 as identified in the *NWS* (RMN 2006a) and falls within the municipal boundaries of the Township of Wainfleet and Township of West Lincoln and extends into the boundaries of the City of Hamilton and Haldimand County (Figure 3). The subwatersheds that form the Upper Welland River Watershed Plan study area include Welland River West, West Wolf Creek, Little Wolf Creek, Wolf Creek, Buckhorn Creek, Elsie Creek, Oswego Creek, Mill Creek, Moores Creek, Wilson Creek, Sugar Creek Drain, James Drain, Michner Drain, Chick Hartner Drain, and Unamed Creek (Figure 2).

Local Management Area 2.1

Local Management Area 2.1 includes the entire headwaters region of the Welland River, Lake Niapenco, and downstream to the confluence of Elsie Creek and the Welland River. LMA 2.1 predominantly falls within the City of Hamilton; only a small portion of the downstream section falls within the Township of West Lincoln. The lower reach of the Welland River in LMA 2.1 has been classified as critical fish habitat and one tributary in this region has been classified as important fish habitat; the remainder of the watercourses in LMA 2.1 have not been evaluated in terms of importance for fish habitat.
There are two municipal drains in this portion of the study area; Whitechurch Road Drain and Puhringer Drain. Both drains are Class F drains.

The topography of the western portion of LMA 2.1 is very steep as the headwaters descend off Fort Erie Moraine. As the elevation gradually declines eastward, the topography is relatively flat with a gentle slope towards the Welland River. Land use is characterized by a mix of urban and agriculture. Urban areas include a portion of the City of Hamilton in the headwaters, the area around John C. Munro Hamilton International Airport, and Binbrook further downstream. Agriculture in this area is predominately general field crops and livestock production (RMN 2006a).

Natural heritage features in LMA 2.1 include nearly 200 hectares of provincially significant wetland, fifteen hectares of locally significant wetland, and numerous wooded areas.

Binbrook Conservation Area and Lake Niapenco are located in this area, offering numerous recreational opportunities including for example fishing, boating, camping and a splash pad for children.

Local Management Area 2.2

Local Management Area 2.2 falls within Haldimand County and the City of Hamilton and encompasses the following subwatersheds: West Wolf Creek, Buckhorn Creek and Elsie Creek. The watercourses in this portion of the study area have not been evaluated in terms of importance for fish habitat and there are no watercourses in this area that are designated municipal drains.

The topography of the area is relatively flat with a gentle slope towards the Welland River. The land use is predominately agriculture with a focus on grain and oilseed production and general field crops. There are no urban areas in LMA 2.2; however there are rural residential areas such as Empire Corners and Blackheath.

Natural heritage features in LMA 2.2 include over 80 hectares of provincially significant wetland, and nearly another 150 hectares of wetland which are awaiting evaluations. In addition, Sinclair Meander Basin Life Science ANSI and numerous wooded areas are present throughout the area.

Local Management Area 2.3

Local Management Area 2.3 falls predominantly in Haldimand County with a small portion straddling the border of the Township of West Lincoln and Township of Wainfleet. The subwatersheds in this portion of the study area include Oswego Creek, Sugar Creek Drain, James Drain, Michner/Chick Hartner Drains, Unamed Creek, and a small portion of the Welland River and respective tributaries.

The Welland River and the lower main branches of Oswego Creek and Unamed Creek have been classified as critical fish habitat and the tributaries of these branches are classified as important fish habitat. There are over 60 kilometers of municipal drain in LMA 2.3. The drains in this portion of the study area include; Allen Drain, Babiy Drain, Baker Drain, Barry Drain, Black Creek Drain, Bouch and Moyer Drain, Brown Drain, Carter Drain, Charles Angel Drain, Chick-Harnett Drain, Corbett Drain, Holtrop Drain, James Drain, Michner Drain, North Forks Drain, Siddal Drain, Sugar Creek Drain, and Waines Drain. All the drains are F Class drains except for Carter Drain; it is in part a C Class drain.

The topography in this portion of the Upper Welland River Watershed Plan is relatively flat with a mild gradient towards the Welland River. Land use is characterized by a mix of rural residential and agriculture with a focus on grain and oilseed production (RMN 2006a)

Natural heritage features in LMA 2.3 include Attercliffe Station Slough Forest Life Science ANSI and a portion of Caistor-Canborough Slough Forest Life Science ANSI. There are also over 1500 hectares of provincially significant wetland, 1600 hectares of wetland that are awaiting evaluations by the Ministry of Natural Resources, and numerous wooded areas in this portion of the study area.

In addition, there are five Conservation Areas in LMA 2.3; Ruigrok Tract, Hedley Forest, Canborough, Oswego Creek and Chippawa Creek. These conservation areas offer ample of recreational opportunities including for example, fishing, swimming, camping, hiking and boating.

Local Management Area 2.4

Local Management Area 2.4 falls predominantly in the Township of West Lincoln with very small portions extending into Haldimand County and Township of Wainfleet. This portion of the study area includes Wilson Creek subwatershed and a portion of the Welland River subwatershed. The main channels of both watercourses have been classified as important fish habitat and their tributaries have been classified as important fish habitat. There are no municipal drains in this portion of the study area.

The topography of LMA 2.4 is relatively flat throughout the Welland River floodplain. Land use in this area is characterized mainly by rural residential and agriculture with a focus on livestock and grain and oilseed production (RMN 2006a).

Natural heritage features in this portion of the study area include East Caistor Centre Slough Forest Life Science ANSI, a portion of Caistor-Canborough Slough Forest, nearly 350 hectares

of provincially significant wetland, and over 1200 hectares of wetlands that are awaiting evaluations by the Ministry of Natural Resources.

Local Management Area 2.5

Local Management Area 2.5 falls predominantly in the Township of West Lincoln with the remainder of the study area within the City of Hamilton. Subwatersheds in this portion of the study area include Little Wolf Creek, Wolf Creek, Mill Creek and Moores Creek. The main channels of Little Wolf Creek, Wolf Creek, and Moores Creek are classified as critical fish habitat; the remaining watercourses in the study area that fall within the Region of Niagara have been classified as important fish habitat. There are no municipal drains in LMA 2.5.

The topography is relatively flat with a mild gradient towards the Welland River. Land use is characterized by a mix of rural residential and agriculture with a focus on grain and oilseed production (RMN 2006a).

Natural heritage features in the area include North Caistor Centre Slough Forest Life Science ANSI, nearly 200 hectares of provincially significant wetland, approximately 1200 hectares of wetland awaiting evaluation by the Ministry of Natural Resources, and numerous wooded areas.

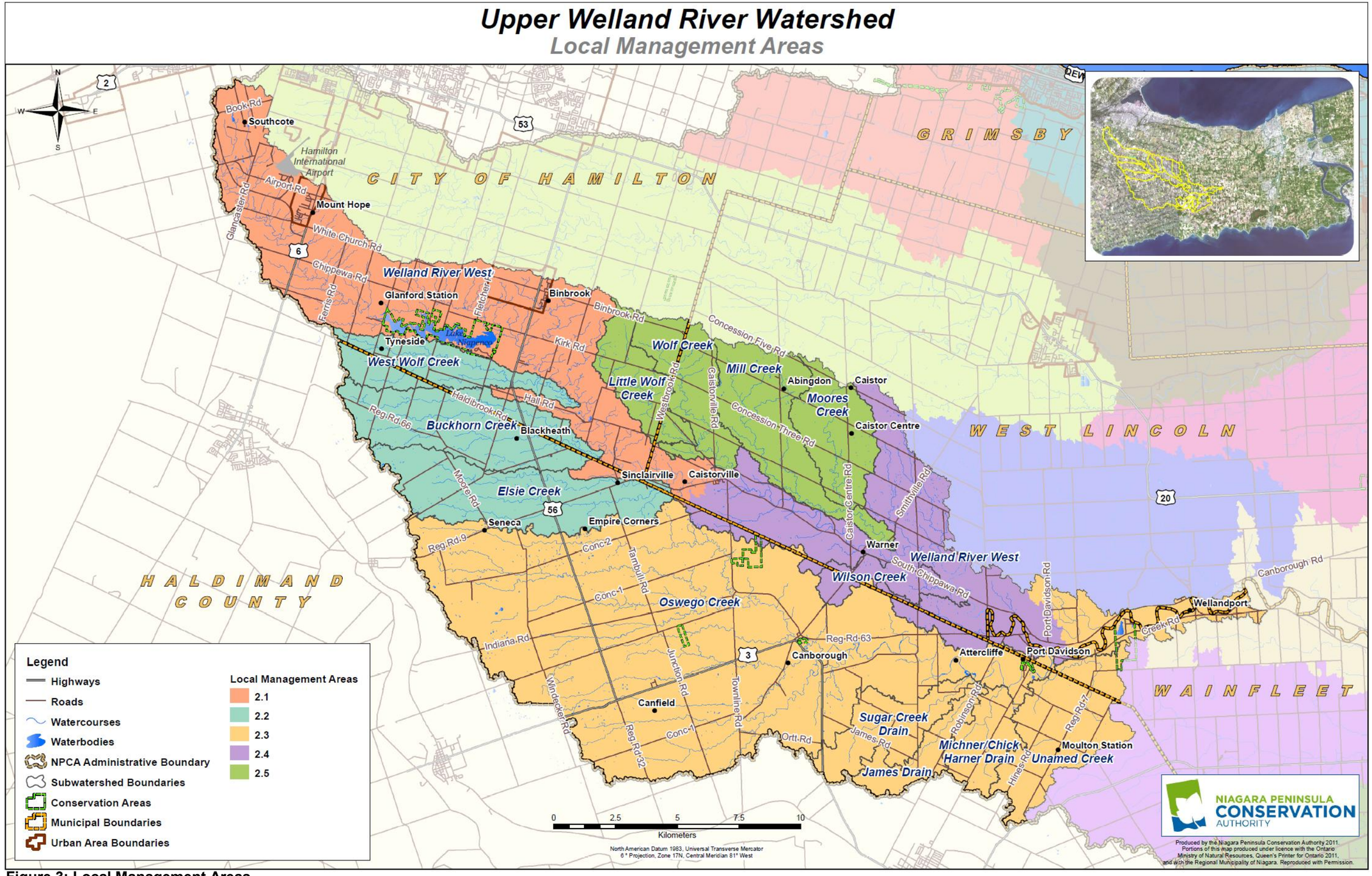

Figure 3: Local Management Areas

Topography

Bordered by the Fort Erie moraine on the north, the Welland River flows east from Ancaster, meandering through the central portion of the Niagara Peninsula towards its historic outlet, the Niagara River. The headwaters of the Welland River originate on the sandy moraine near Ancaster at an elevation approximately 240 m.a.s.l. The Welland River falls approximately 82 metres (270 feet) in elevation over its entire course. The most significant vertical drop is a 78 metres drop which occurs over the first 55 kilometres (34 miles) with only a 4 metre (15 foot) drop on the lower 80 kilometers (50 miles) of the River. This slight gradient results in a meandering, sluggish river from Port Davidson in the Township of West Lincoln downstream (NPCA 1999). The mild gradient of the Welland River can be attributed to isostatic rebound, which is the rise of land masses that were depressed by the huge weight of ice sheets during the last ice age. The eastern half of the peninsula rose relative to the western end, resulting in a near flat gradient.

The topography of the Upper Welland River watershed is illustrated on Figure 4.

Geology

The Upper Welland River study area is underlain with bedrock from the middle to upper Silurian period of roughly 425 to 410 million years ago; Guelph Formation and Salina Formation (Figure 5).

During the middle Silurian period the tropical sea that covered the Niagara Peninsula deepened and the Guelph formation was deposited. The Guelph Formation consists of reef and interreef deposits, characterized by tan, sugary, fossiliferous dolostone (Ministry of Northern Development and Mines No Date).

During the upper Silurian period, the seas became shallower resulting in land surfaces becoming more arid, and deposition of shale and fine grained dolostone occurred (Lewis1991). Restricted circulation and increased evaporation of the sea resulted in deposition of evaporites (halite, gypsum, and anhydrite), evaporitic carbonates and shales of the Salina Formation (Ministry of Northern Development and Mines No Date).

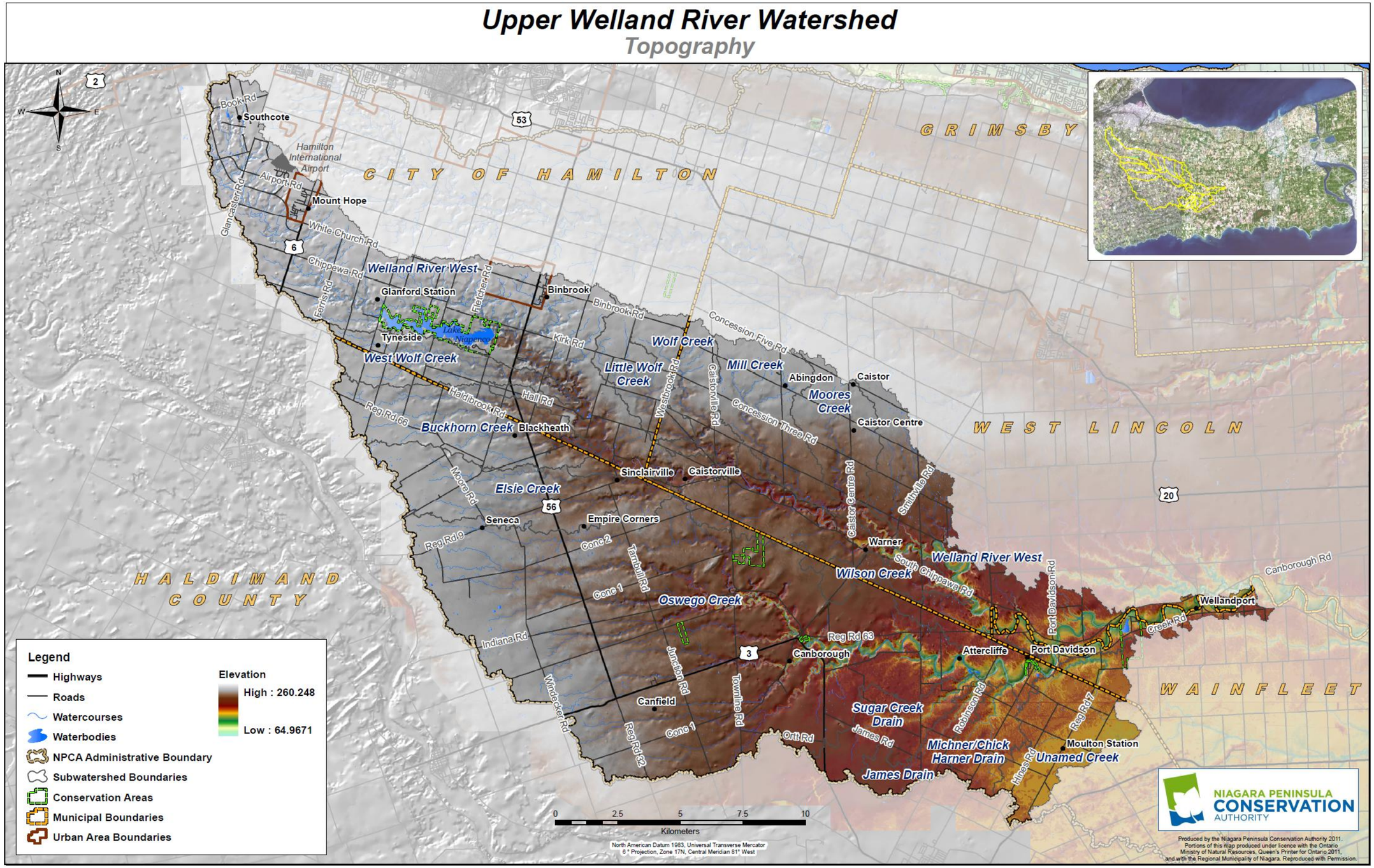

Figure 4: Topography

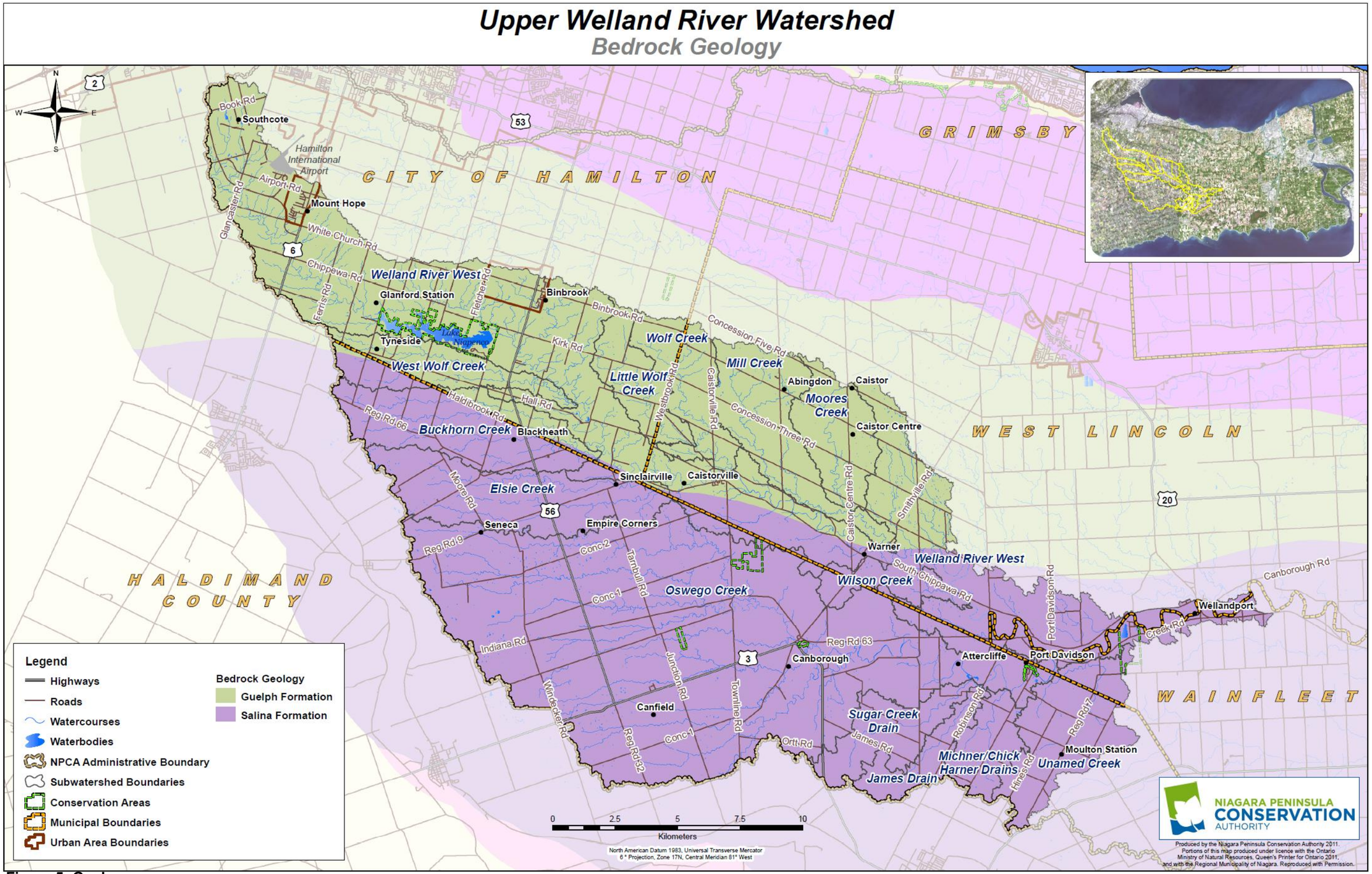

Figure 5: Geology

Physiography

The predominant physiographic region of the Upper Welland River watershed is the Haldimand Clay Plain which extends from the Niagara Escarpment to Lake Erie (Figure 6). The Haldimand Clay Plain was submerged by glacial Lake Warren and much of it is covered by lacustrine clay deposits.

Post-Lake Warren, following the last glacial retreat, the lake levels rose dramatically in Lakes Ontario and Erie. It was at this time that the lake levels in the Lake Erie basin were much higher than present day, and the shoreline of this ancient lake was near Lowbanks. The Grand River carried sediment from the heart of southern Ontario, and formed a delta of silt, sand and gravel covering the Dunnville area (Feenstra 1981, Chapman and Putnam 1984). This delta overlays the Haldimand Clay Plain and is known as the Dunnville Sand Plain which extends into the most south-eastern portion of the Upper Welland River study area. The northern portion of the Upper Welland River study includes a low, sinuous ridge of till that was developed during the halt or stall of Wisconsin glacier; the Fort Erie Moraine. The sublacustrine Fort Erie Moraine on the northern cusp of the headwaters serves as a drainage divide between the Welland River and Twenty Mile Creek**.**

Soils

The soils in the Niagara Region were resurveyed and documented in a report entitled *The Soils of Regional Niagara* (Kingston and Presant 1989) by the Ontario Ministry of Agriculture and Food and Agriculture Canada. This study included geological and physiological features; soil groups and types; soil moisture characteristics; drainage and variability; common properties of soil groups; as well as information related to agricultural soil use and classification. The following soil descriptions are derived primarily from this document and the mapping is a result of the consolidation of existing digital soil data mapped on a county basis onto a digitally stitched and standardized product by the Ontario Ministry of Agriculture, Food and Rural Affairs and Agriculture and Agri-Food Canada, in cooperation with the Ministry of Natural Resources (Table 1 and Figure 7).

Several soil groups characterize the Upper Welland River watershed; however, it is dominated by lacustrine clay soil groups. Lacustrine heavy clays of the Smithville, Haldimand and Lincoln soil groups and lacustrine silty clays of the Beverly, Toledo and Brantford soil groups dominate.

Smithville soils are moderately well-drained, slowly permeable but can be moderately permeable during dry periods when cracks develop in the surface horizons. They have a medium to high water-holding capacity but are often droughty during dry periods because of slow water release by the clays. Inclusions of Haldimand soils are fairly common where Smithville soils are mapped and Lincoln soils may also occur in depressions and channels.

Haldimand soils are imperfectly drained, slowly permeable with a medium to high capacity to hold water. Like Smithville soils, Haldimand soils can be droughty during dry periods. Typically, there is some temporary perching of groundwater during seasonal high groundwater levels. They are commonly associated with Lincoln soils. Lincoln soils

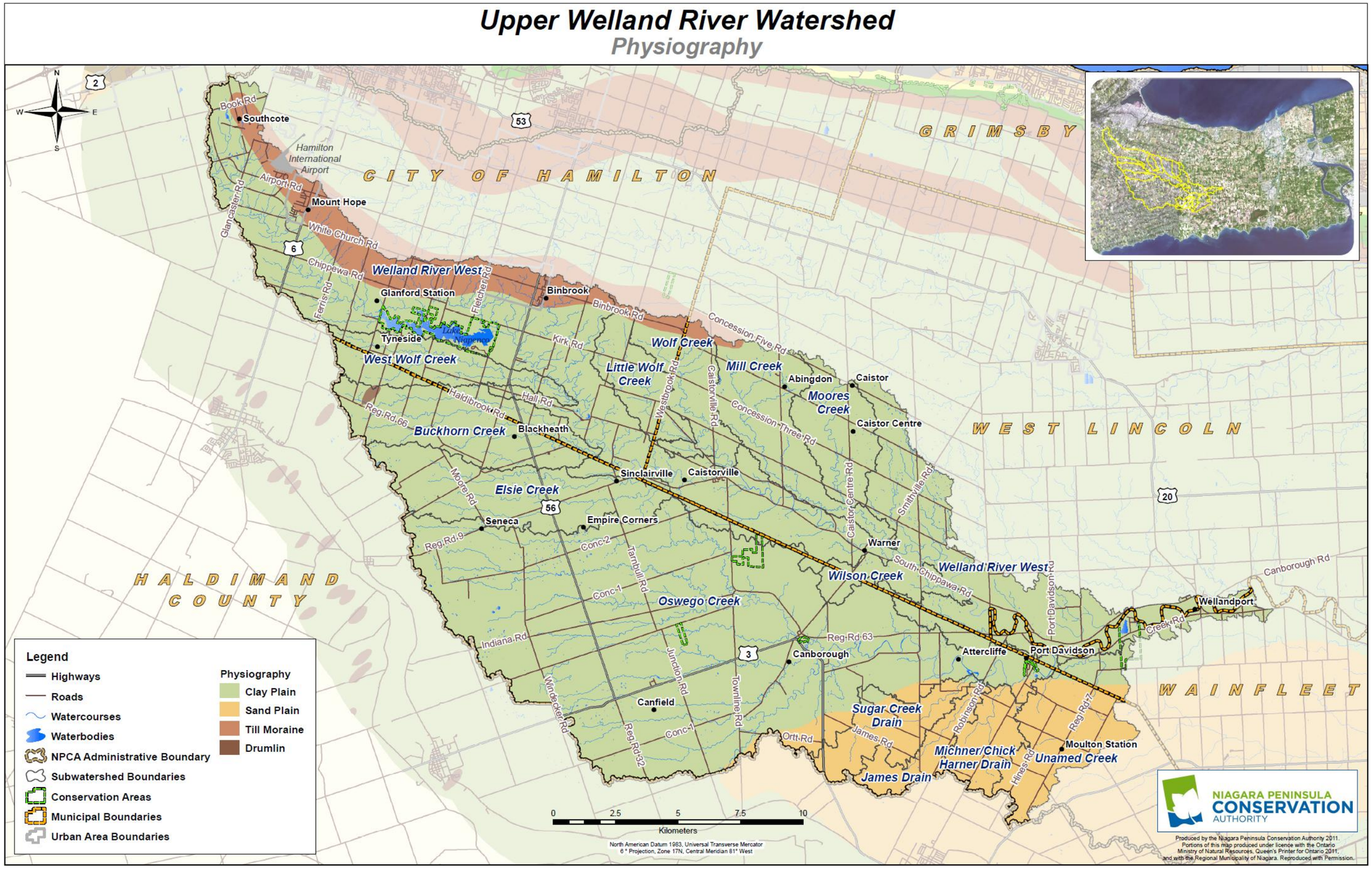

Figure 6: Physiography

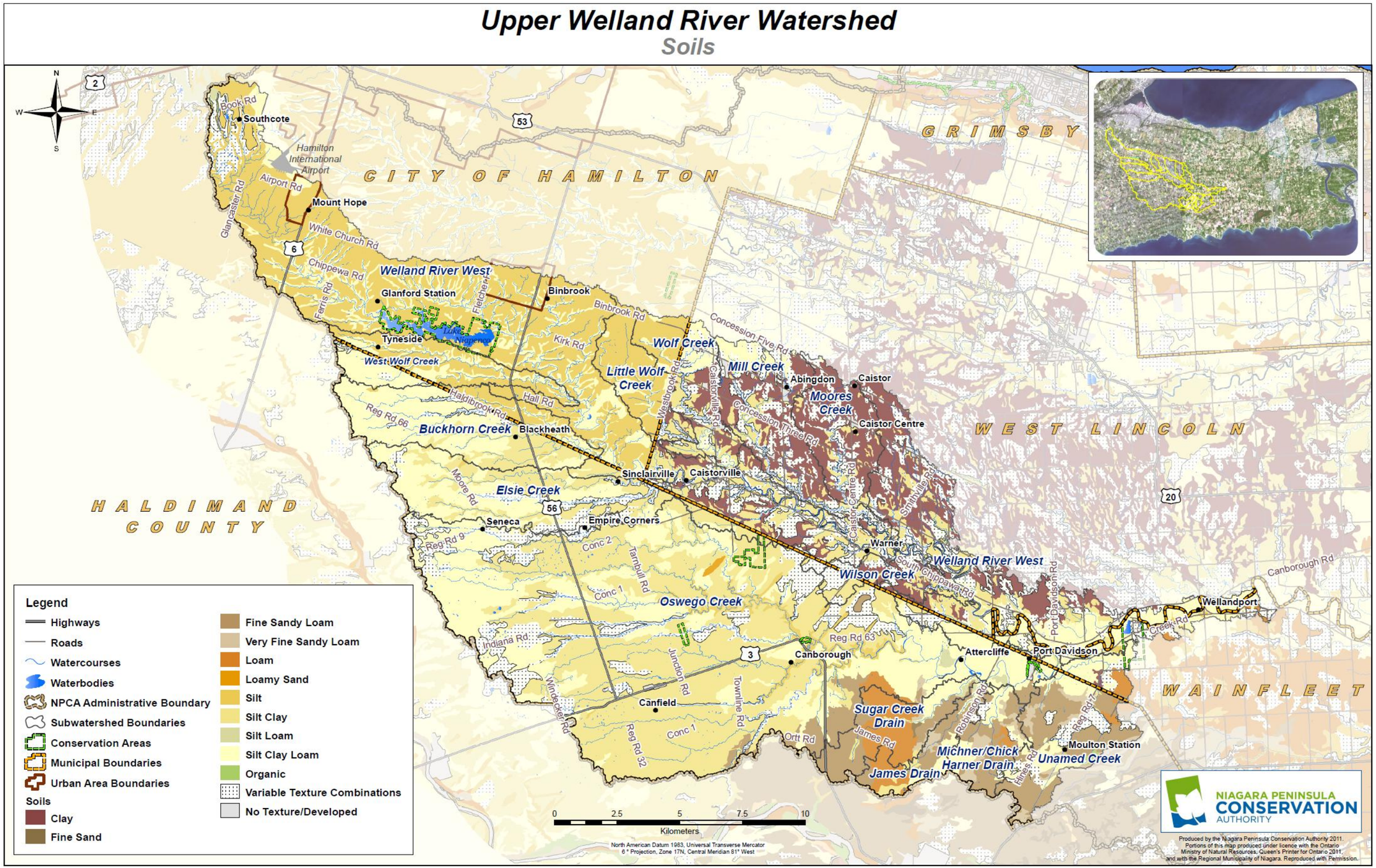

Figure 7: Soils

are poorly drained and like Haldimand and Smithville soils, are slowly permeable, have a high water holding capacity and also can be droughty during dry season due to insufficient moisture release for plants. Care must be taken when using heavy equipment to avoid compaction. These soils groups are commonly used for field crops.

Beverly soils, like Haldimand soils are imperfectly drained. Their permeability is moderate to slow, and they have a medium to high water holding capacity. For a period each year, groundwater occupies the surface horizons. Saturation periods tend to be prolonged in cultivated fields where the subsoil has been overcompacted from use of heavy equipment. This soil group is commonly used for small grains, corn and forage crops. Commonly associated with Beverly soils are Toledo and Brantford soils.

Toledo soils are poorly drained and typically slowly permeable with a high capacity to hold water. Like Beverly soils, groundwater levels tend to stay near the surface much of the year. Due to the high degree of subsoil compaction with these soil groups, tile drainage and continued maintenance may be required.

Brantford soils are moderately well-drained and moderately to slowly permeable depending on amount of subsoil compaction that has taken place. Like Toledo soils, Brantford soils have a high water-holding capacity. In Niagara, these soils are commonly used for field crops. The greatest limitation of Brantford soils is overcompaction by use of heavy equipment creating structural degradation.

Table 1: Soils of the Upper Welland River Watershed Plan Study Area

Soil Series	Geologic Deposits	Natural Drainage	Water Holding Capacity	Permeability	Surface Runoff	Class	Land use Comments
Mineral Soils							
Smithville (SHV)	Deep water lacustrine heavy clay	Moderately - well	Medium to High	Moderate to Slow	Rapid	3D	Suitability for soybeans and white beans is considered fair to good. Poor to fair suitability for some vegetable crops.
Haldimand Soils (HIM)	Deep water lacustrine heavy clay	Imperfect	Medium to High	Slow	Rapid	3D	Capable of producing acceptable yields if certain precautions are taken (e.g. tile drainage)
Lincoln Soils (LIC)	Deep water lacustrine heavy clay	Poor	High	Slow	Slow to Rapid	3WD	Unsuitable for most horticultural crops
Brantford Soils (BFO)	Deep water lacustrine silty clay and clay	Moderately - well	Relatively High	Moderate to Slow	Rapid	2D	Mainly used for field crops. Corn, soybeans, winter wheat and spring grains are most common crops grown on these soils.
Beverly Soils (BVY)	Deep water lacustrine silty clay and clay	Imperfect	Medium to High	Moderate to Slow	Moderate to High	2D	Used mainly for corn, small grains and forage crops.
Toledo Soils (TLD)	Deep water lacustrine silty clay and clay	Poor	Relatively High	Slow	Moderate to High	3W	Require artificial drainage to be useful for agriculture

Current Land Use

The Upper Welland River watershed study area falls within Niagara Region's municipal boundaries of Township of Wainfleet (2%) and Township of West Lincoln (22%) and extends into the boundaries of the City of Hamilton (22%), and Haldimand County (54%). Land use in the study area is characterized primarily by agriculture with a mix of rural residential (Figure 8).

Agriculture

The location of the Niagara Peninsula between the moderating influences of the Great Lakes and the Niagara Escarpment creates a unique microclimate that supports a viable agricultural community (Planscape 2003). The agricultural lands throughout the Upper Welland River Watershed Plan study are designated as „Good General Agriculture' and support numerous prosperous commodity sectors. In 2001, the Region of Niagara commissioned a study to assess the nature of agriculture in Niagara; *Regional Agricultural Economic Impact Study 2003.* The study confirmed that "*agriculture is of tremendous importance to the Niagara economy both directly and indirectly"* (Planscape 2003). According to the study, in 2001 the agricultural industry generated over $511 million in gross farm receipts in Niagara.

As described earlier, the mineral soils in the area are rated as Class 2 and Class 3 according to the Canada Land Inventory (CLI) Classification System for Agricultural. These soil classes have limitations that restrict the range of crops and/ or require moderate or special conservation practices. The limitations with Class 2 soils are moderate, and the soils can be managed and cropped with little difficulty. The limitations with Class 3 soils are more severe than Class 2 and can affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation (Kingston and Presant 1989).

According to Statistics Canada 2006 Agricultural Profile, the main agricultural commodity groups for each district (including outside of study area) based on the North American Industry Classification System farm-typing categories are:

- Township of West Lincoln: cattle ranching and farming, poultry and egg production, and oilseed and grain;
- Township of Wainfleet: oilseed and grain, animal production, and greenhouse and nursery production;
- Haldimand County: oilseed and grain farming, cattle ranching and farming, and other crop farming;
- City of Hamilton: greenhouse and nursery production, animal production, and oilseed and grain farming.

Urban/ Rural Residential

Aside from Hamilton International Airport there are no major concentrations of urban land uses (residential, commercial, industrial) within the study area, however smaller concentrations are located in Binbrook and Mount Hope. In addition, numerous small areas of rural residential such as Caistorville, Empire Corners and Blackheath are present throughout the study area.

Recreation

The Upper Welland River watershed offers numerous recreational opportunities throughout the watershed with 7 conservation areas that offer passive recreational opportunities; Binbrook Conservation Area, Canborough Conservation Area, Chippawa Conservation Area, Hedley Forest Conservation Area, Port Davidson Conservation Area, Oswego Creek Conservation Area and Ruigrok Tract Conservation Area. The Welland River also offers ample of recreational opportunities for fishing, boating and nature observation.

In addition, there are 3 golf courses in the watershed; Southern Pines Golf and Country Club in Mt. Hope, Southbrook Golf and Country Club in Binbrook, and Caistorville Golf Club.

Future Land Use

In Ontario planning decisions are influenced by all levels of government: federal, provincial, regional and local (e.g. municipal). Although each tier has an appropriate role in planning decisions, co-ordination between tiers is necessary for effective planning and management of respective jurisdictions. For example, in Niagara the federal government would be responsible for regulating railroads, the Welland Canal, and the defense of our international boundary; whereas the provincial government's major responsibilities are primarily concerned with matters of provincial interest, for example, provincial transport routes, utilities, property assessment, land use planning, and protection of the environment, as well as numerous aspects of municipal development. Regional governments are responsible for planning, waste management, regional roads, treatment and distribution of water, and community services (e.g. police, health and welfare). Municipalities are primarily responsible for their respective jurisdictions in areas of physical, economic and social development while adhering to provincial and regional policies. However, some of the aforementioned regional responsibilities are shared with respective municipalities with some direction from the provincial government; areas such as treatment and distribution of water, waste management, planning and land use regulation.

Therefore, implementation of the Upper Welland River Watershed Plan should be integrated into planning initiatives and roles of regulation by all levels of government. Land use changes in the Upper Welland River watershed should also consider recommendations put forth by the Watershed Plan and supporting studies and documents where appropriate.

Provincial Tier

In Ontario, the *Growth Plan for the Greater Golden Horseshoe* [(GGH) MPIR 2006] has been prepared under the *Places to Grow Act* (MPIR 2005), to help guide land-use planning decisions in the Greater Golden Horseshoe area. The Plan provides a framework for managing the projected future growth in the region by guiding decisions on a wide range of important planning aspects such as future transportation needs and infrastructure, natural heritage and resource protection, land use planning and housing requirements. The *GGH* promotes intensification of existing built-up areas and revitalization of urban growth centres while recognizing the vital economic and cultural importance of our rural communities. The *GGH* works with other government initiatives such as the *Greenbelt Plan* [Ontario Ministry of Municipal Affairs and Housing (MMAH) 2005b] which provides for the permanent protection of the agricultural land base and ecological features by identifying where urbanization should not occur, and the *Provincial Policy Statement* (PPS) (MMAH 2005a), which provides overall direction on matters

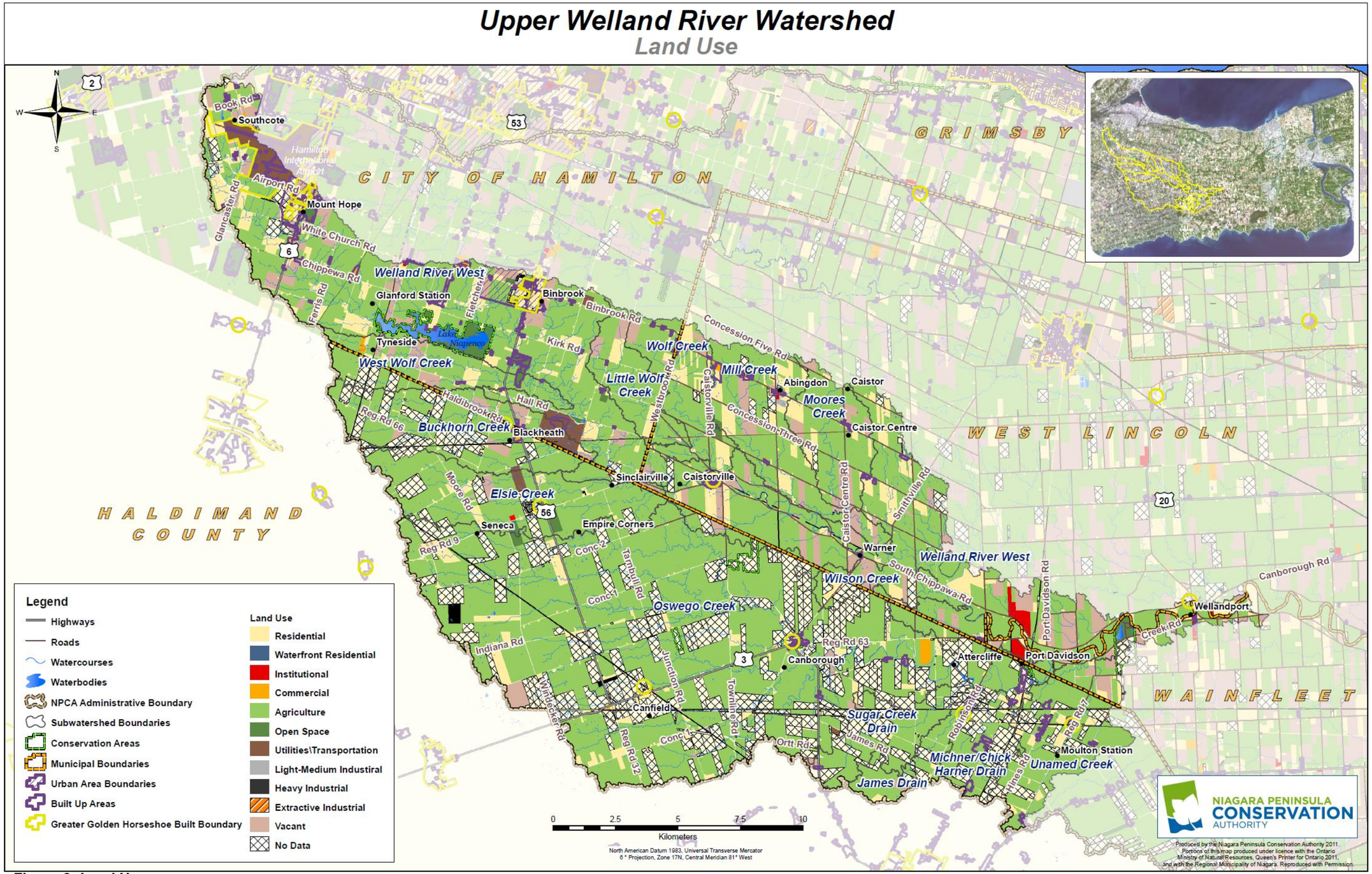

Figure 8: Land Use

related to land use and development in Ontario, and municipal official plans by providing growth management policy direction.

The *Greenbelt Plan* identifies Protected Countryside lands which are "*intended to enhance the spatial extent of agriculturally and environmentally protected lands currently covered by the NEP*[Niagara Escarpment Plan] *and the ORMCP* [Oak Ridges Moraine Conservation Plan-not in study area] *while at the same time improving linkages between these areas and the surrounding major lake systems and watersheds*"(Section 1.1). In the Upper Welland River Watershed Plan study area, the *Greenbelt Plan* applies to lands within the Protected Countryside designation within the City of Hamilton (Figure 9). The *Greenbelt Plan* outlines 3 key policy areas for lands within the Protected Countryside designation. The policy areas as described in the *Greenbelt Plan* are as follows:

- Agricultural System is comprised of specialty crop areas, prime agricultural areas and rural areas;
- Natural System is comprised of the Natural Heritage System, Water Resource System and key natural heritage features and key hydrologic features; and
- Settlement Areas are comprised of Towns/Villages and Hamlets (1.4.2 Section 3).

The *Greenbelt Plan* must be read in conjunction with all other applicable land use planning policy and regulations including but not limited to, the *GGH*, *PPS*, official plans (upper, lower and single), and zoning by-laws.

The *PPS* recognizes that sustainability of Ontario's natural and cultural heritage resources over the long term is of key provincial interest given that they provide significant social, economic and environmental benefits; "*Strong communities, a clean and healthy environment and a strong economy are inextricably linked"* (PPS 2005). Accordingly, while providing direction on appropriate development, the policies of the *PPS* provide protection for; resources of provincial interest, quality of the natural environment, and public health and safety by focusing growth within existing settled areas and away from sensitive or significant natural resources or areas that may pose as a threat to public health and safety.

The *PPS* calls for the wise use and management of resources by imposing stringent limitations on development and site alteration for numerous natural settings, including, but not limited to; significant and /or sensitive natural areas (terrestrial and aquatic), lands adjacent to significant and /or sensitive natural features, and areas of fish habitat. The *PPS* also calls upon planning authorities to "*protect, improve or restore the quality and quantity of water"*"(Section: 2.2.1) by means of for example, using the watershed as the ecological scale for planning activities; ensuring stormwater management practices have minimal negative impacts; and linkages and related functions between terrestrial/aquatic features are maintained.

In terms of agricultural areas, the *PPS* calls for the protection of prime agricultural areas for long-term agriculture and related usage, and for respective planning authorities to designate specialty crop areas in accordance with provincial evaluations. In regards to extraction of mineral aggregate resources, the *PPS* requires extraction to be *"undertaken in a manner which minimizes social and environmental impacts"* (Section: 2.5.2.2), and rehabilitation of the extraction area is required to "*accommodate subsequent land uses, promote land use compatibility, and to recognize the interim nature of extraction"* (Section 2.5.3.1).

In addition to requiring the wise use and management of resources, the *PPS* calls for promotion of healthy, active communities by for example, providing public accessibility to natural settings for recreation, including "*parklands, open space areas, trails and , where practical, water-based resources"* (Section: 1.5.1) including shorelines.

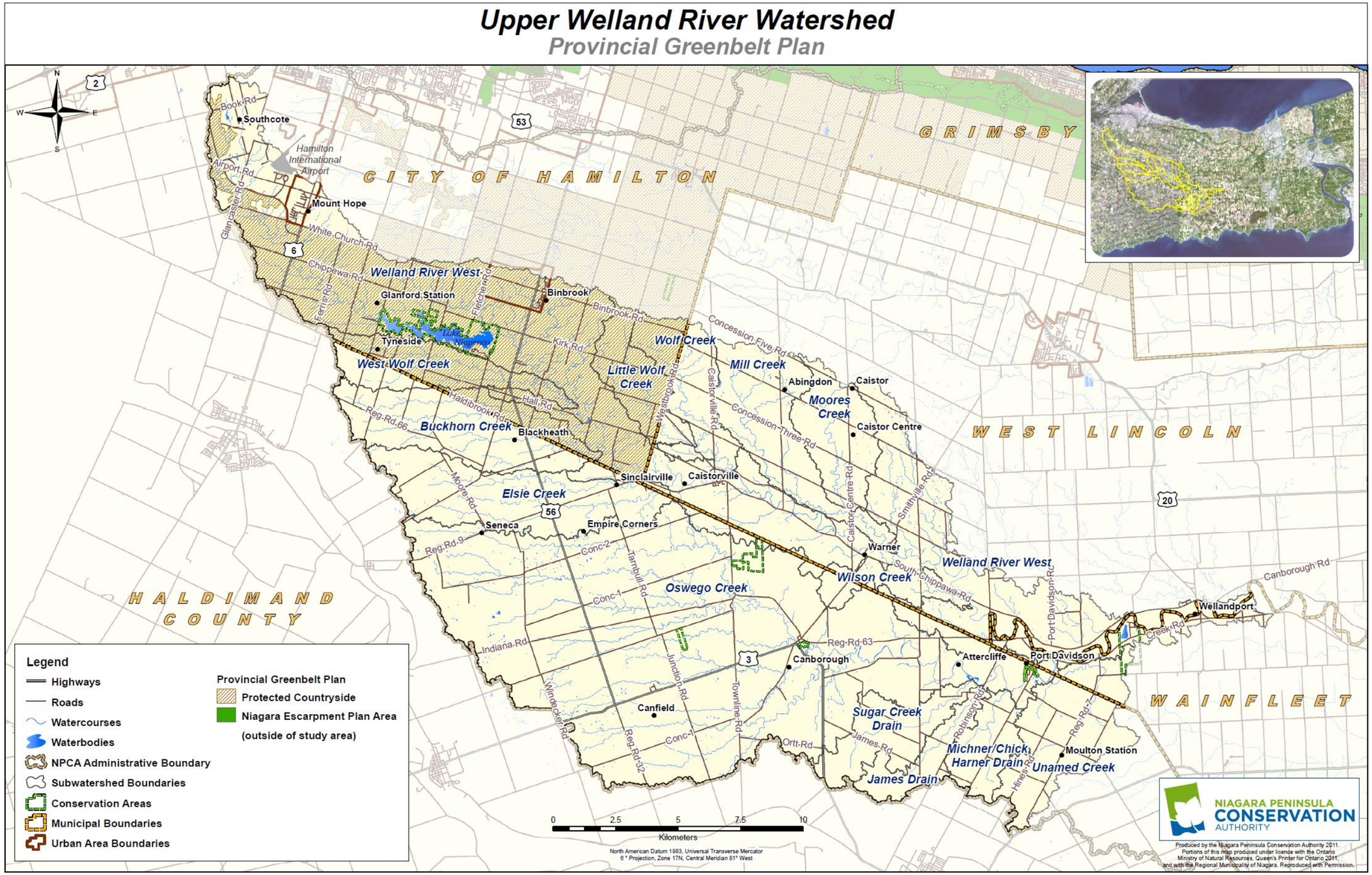

Figure 9: Provincial Greenbelt Plan Area

The *PPS* policies may be complemented by other provincial (e.g. *GGH*), regional (e.g. Regional *Policy Plan)*, and municipal policies (official plans) regarding matters of regional and municipal interest. Together, provincial plans, and regional and municipal official plans provide a "*framework for comprehensive, integrated and long-term planning that supports and integrates the principles of strong communities, a clean and healthy environment and economic growth, for the long term"* (PPS 2005).

In the Upper Welland River watershed, the *GGH* identifies areas as Built-Up Areas throughout West Lincoln, Haldimand and Hamilton. The Built Boundary is developed in consultation with the municipalities for settlement areas (urban and rural) where development is concentrated and has a mix of land uses, and where lands have been designated in respective official plans for long-term development planning prospects. Additionally, the *GGH* encourages municipalities to "*designate and preserve lands within settlement areas"* in the vicinity of existing major transportation routes (e.g. airports, highways, ports and railways) for manufacturing, warehousing and related activities. The *GGH* also identifies areas north of the John C. Munro Hamilton International Airport (HIA) as designated greenfields areas, making them the focus area of future intensification with an overall minimum density target of 50 jobs and residents per hectare.

Upper Tier

Region of Niagara

The *Planning Act* (MMAH 1990) designates the *Policy Plan: Regional Strategy for Development and Conservation* (RMN 2007a) as the paramount planning document for Niagara Region as stated in *Section 27.1* of the *Planning Act*: "*The council of a lower-tier municipality shall amend every official plan and every by-law passed under section 34* [addresses zoning by-laws]*, or a predecessor of it, to conform with a plan that comes into effect as the official plan of the upper-tier municipality."* Additionally, the *Planning and Conservation Land Statue Law Amendment Act, 2006 [(Bill 51)* MMAH 2007] provides direction for updating municipal official plans and zoning by-laws by requiring that municipalities assess the need for official plan updates every five years and update the respective zoning by-laws no later than three years after the official plan revisions are made as part of the five year review (Section 26.1; 9).

In accordance with the *GGH, PPS, Greenbelt Plan* and other provincial policies, the *Policy Plan* outlines numerous regional policies and strategies addressing local interests. For instance; land use and development, agriculture, cultural and natural heritage and aquatic resources, tourism and recreation are a few of the areas of interest addressed in the *Policy Plan*.

In 2009, Region of Niagara updated the Urban Areas policies in the *Policy Plan* (Amendment 2-2009) to implement strategic directions of an extensive 5-phase growth management strategy. It is the intent of the Region of Niagara to "*promote an integrated land use planning framework for decision making"* that involves all respective stakeholders, and it is the position of the amended policies to "*represent an opportunity for Niagara to affirm its commitment to building sustainable, complete communities"* [(Section 2) RMN 2009]. Accordingly, objectives of the Urban Policies include strategies that are intended to guide decisions related to "*land use planning, infrastructure development, natural and cultural resource management and fiscal planning"* (Section 2.2). Strategies in the *Policy Plan* for implementing this balance include policies related to for example, urban structure, intensification, Greenfield areas and transportation corridors.

Recognizing that Niagara supports a viable agricultural industry, the Region of Niagara commissioned a study to support the establishment of "*agricultural value added activities*" by considering "*how the land use planning process in Niagara can identify and encourage such*

value added activities" (Planscape 2009). The study makes a series of objective recommendations to be included with the existing agricultural policies of the *Policy Plan*. Recommendations include for example, "*To recognize the range of impacts that different types of value added activities may have on the farm and on surrounding farms, and provide for different regulatory provisions"* (Objective 6.10), and "*To recognize the role of the Region to establish flexible, performance based criteria for use by the local municipalities, and recognize variations in the range of diversification activities within individual municipalities*" (Objective 6.9).

The *Policy Plan* also outlines a number of objectives and strategies to maintain and foster a viable agricultural industry by preserving Niagara's agricultural lands and production through a multi-tier government coordinated effort by supporting the following policies; tariff/quota protection from imports (federal); adequate marketing and protection of unjustified taxes (provincial and local); and financial assistance and protection of unique and good agricultural lands are some of the local policies that the *Policy Plan* outlines.

The environmental policies apply an ecosystem approach to the environmental policy framework by employing proactive sustainable principles. Some of these principles include: stewardship plus regulation; environmental protection plus enhancement; and ecosystem health and sustainability. These principles are also applied to the mineral extraction sector to ensure that these resources are not only available for future use, but the extraction and "*management is compatible with the natural and human environment" (Section 7.E)*.

The *Policy Plan* also recognizes that successful planning and environmental conservation requires coordination and cooperation involving all levels of government and respective stakeholders (e.g. municipalities, landowners, environmental agencies and interest groups). Accordingly, the *Policy Plan*, which adheres to provincial policies, provides an overall framework for development and planning in Niagara Region that the respective municipalities are to adhere to with further detail at a municipal level.

Single Tier

City of Hamilton

Accordingly, the City of Hamilton initiated an *Airport Employment Growth District* study (AEGD) (Dillon 2008) to assess the full economic development potential of the employment lands surrounding the Hamilton International Airport and to adhere to City of Hamilton's and the province's identification of the John C. Munroe HIA as an economic development priority and economic driving force for Hamilton. Phase One of this study was completed in June 2008 and included documentation of existing conditions, confirmed land use requirements, and examined the infrastructure, economic and financial requirements to proceed with this project (Dillon 2008). Phase Two of the AEGD has resulted in numerous key outputs, including but not limited to, a *Financial/Economic Impact Report* (Dillon 2010a*), Draft Subwatershed Study and Draft Stormwater Management Plan* (Dillon 2010b), *Secondary Plan Report* (Dillon 2010c), an *Airport Market Analysis and Land Needs Analysis* (Dillon 2009), Zoning By-law recommendations, and an Archaeological/Cultural Heritage Assessment for the AEGD (Dillon 2008). A *Development Options Evaluation & Preferred Concept Plan* Report (Dillon 2010d) outlined 3 options for the lands around the HIA. The options include: a) Light Industrial Business Park; b) Prestige Business Park; and c) Hybrid Business Park. A preferred option with refinements has been identified which would include a Hybrid Business Park/Light Industrial Plan with the objectives of the preferred option to provide for a Prestige Business Park and Light Industrial designations for large portions of the AEGD study area (Florio 2009).

Like most municipalities, the City of Hamilton also has a growth strategy for a sustainable future for Hamilton; Vision 2020. Vision 2020 recognizes that all decisions must consider the effects they will have on the economic, social and environmental aspects of the City of Hamilton. Vision 2020 is based on four main principles; fulfillment of human needs, maintenance of ecological integrity, provision for self-determination, and achievement for equality (City of Hamilton 2003). These principles are broken down further into 14 key theme areas (e.g. natural areas and corridors, local economy, land use) and specific goals were set under these themes to guide the City of Hamilton towards integrating environmental, social, and economic well being (City of Hamilton 2003). In 2003, the City initiated a development strategy to serve Hamilton for the next 30 years; Growth Related Integrated Development Strategy (GRIDS). GRIDS focuses on the urban areas of the City and therefore only applies to the areas around the HIA, Mount Hope and Binbrook in the Upper Welland River watershed. A parallel process was undertaken for the rural areas through a new official plan. These processes recognize that rural and urban land use planning are not mutually exclusive, but rather both are interrelated (Dillon 2003).

The City of Hamilton's Official Plan occurs in two separate but integrated documents; a *Rural Hamilton Official Plan* (City of Hamilton 2006) for its rural lands and a draft *Urban Hamilton Official Plan* (City of Hamilton 2009) for its urban areas. It is the intent of both official plans to support the HIA by outlining various land use and zoning policies. It is also the intent of both official plans to protect the lands within the *Greenbelt Plan* area, as previously described, by outlining numerous restrictive policies for the lands within this designation.

In the Upper Welland River Watershed Plan study area, the draft *Urban Hamilton Official Plan* applies to the lands in the urban boundaries around Binbrook, Mount Hope and the HIA. GRIDS has identified areas for future urban boundary expansion to accommodate growth targets set for 2031. Included in these identified areas is the AEGD. However, the draft *Urban Official Plan* indicates that the "*exact limits of the lands to be included as part of the urban boundary expansion shall be determined as part of a municipally initiated comprehensive review and secondary plan"* (Section B.2.2.2), and no expansion shall take place until the aforementioned studies are complete (Section B2.2.3). It is the intent of the *Official Plan* to encourage intensification to ensure land, urban services and transportation networks are used efficiently (Section B2.4) by encouraging development throughout the Built-Up Areas, Urban Nodes and Corridors.

The remainder of City of Hamilton's jurisdiction that falls within its 22 percent of the Upper Welland River Watershed Plan study area consists of a mix of agriculture and rural residential. It is the intent of Hamilton's *Rural Hamilton Official Plan* to "*provide direction on a number of factors that are to be considered in municipal decision making; factors that when combined, work together to create exciting, diverse, effective and pleasing environments to live, work and play"* (Section B.3.0). Policies that will support a strong economy, provide for a range of housing opportunities, provide/maintain community facilities, protect/ enhance cultural resources, and ensure public safety through the protection of our air and water to create a quality community living experience will be amended to the *Rural Hamilton Official Plan*.

In terms of the lands designated as Agriculture. It is the intent of the *Rural Hamilton Official Plans* to protect the prime agricultural areas for agricultural use with policies that provide for a *"wide range of farm types while preventing further conflicts of use, and ensuring the sustainability of the Natural Heritage System"* (Section D2.0) by limiting land use in these designated lands to "*agricultural uses*, *agricultural-related commercial and agricultural-related industrial uses and on-farm secondary uses" (Section D2.1).*

Haldimand County

In consultation with the community, Haldimand County has also developed a series of strategic directions regarding the future of their municipality; *Haldimand County Strategic Directions 2004.* Similarly, the strategic directions process is based on 6 core themes (e.g. environment, economy, growth management) that are used to outline the main components of the Official Plan. These core themes will assist in preparing policy direction for achieving various components of the Vision Statement that was developed through community involvement (Haldimand County 2004).

Fifty-four percent of the Upper Welland River Watershed Plan study area falls within Haldimand County. The land use in this area consists primarily of agriculture and rural residential. Similar to other official plans, the *Haldimand County Official Plan* (Haldimand County Planning 2006) outlines various strategies for future development under the core themes developed through the Strategic Directions process as previously indicated. The *Official Plan* recognizes that with improvements to transportation facilities an increased pressure on hamlets exists as residential settlements and for development of these lands for commercial use rather than their traditional role as service centres for the surrounding agricultural community. It is the intent of the *Official Plan* to "*provide a hamlet environment conducive to rural residential living while permitting appropriately scaled and located commercial, industrial and institutional development in a manner that will minimize land conflicts" (Section E1).*

The *Official Plan* also recognizes the importance of Haldimand's productive agricultural lands as the "*prime economic basis for the rural community*" and it is in the "*County's interest to preserve that lifestyle and foster the agricultural industry"* (Section A1). The *Official Plan* outlines various policies that are intended to preserve and protect the agricultural land base for agricultural purposes by for example, limiting land use activities to agricultural and related activities and for land uses that are compatible with agriculture. In addition, the policies "*encourage the development of agricultural support services within urban areas and designated hamlets"* (Section 3A.3).

In 1987, an inventory of natural areas was completed for the Haldimand-Norfolk area; *The Natural Areas Inventory of the Regional Municipality of Haldimand-Norfolk* (Norfolk Field Naturalists). This study identified numerous significant natural areas and significant sites throughout the area. Accordingly, the *Official Plan* identifies the need to preserve and manage the County's natural environment features by stating that a "*high quality environment will be achieved and retained as human health is linked to environmental health. The County will strive to preserve essential* ***ecological functions*** *and protect natural biological diversity and* ***ecological integrity****"* (Section 2A.4). In order to accomplish this, the *Official Plan* outlines numerous policies with regard to but not limited to, provincially significant wetlands, habitats of „species at risk', development, and other natural environments such as water resources. The *Official Plan* also recognizes that cooperation and communication with other agencies is necessary to accomplish these objectives.

Lower Tier

Region of Niagara: Township of West Lincoln

Approximately 22 percent of the Upper Welland River watershed falls within the Township of West Lincoln. Land use in this portion of the study area is primarily agriculture dotted with small hamlet communities and rural clusters. It is the intent of the *Official Plan for the Township of*

West Lincoln (BLS Planning Associates 1998) to "*provide for sustained farming and related activities through the protection of prime agricultural lands and by preventing incompatible land uses"* (Section 2.4). Efforts to continue supporting the agricultural industry include limiting land use activities within areas designated agriculture. Land uses permitted include specialty farm uses such as greenhouses and mushroom farms, forestry and conservation lands (Section 4.4). Also permitted in this designation are farm-related residential and small-scale uses that are directly related to the agricultural industry and need to be located within proximity of the farm operations (Section 3.4). Any non-agricultural land uses are encouraged to occur within existing settled areas.

In terms of areas designated as a *Hamlet Community,* the predominant land use is for single-detached dwellings or other uses to serve the Hamlet Community and surrounding agricultural areas. Examples of permitted land uses include schools, churches, nursing homes, and government buildings (Section 4.6a). The general intent of the *Hamlet Community* designation is to "*recognize and encourage further development of those significant hamlets that provide both residential accommodation and a service function to the larger agricultural and rural community"* (Section 4.6.b.i).

In terms of areas designated as *Rural Cluster*, the predominant land use is also for single-detached dwellings. Other uses permitted in this designation include for example, home occupations, bed and breakfast establishments, and existing commercial and institutional uses (Section 4.7.a). The general intent of the *Rural Cluster* designation is to "*recognize certain existing clusters of rural residential development, and to permit infilling of clusters with additional similar development*" (Section4.7.b.i).

The *Official Plan* also intends to maintain the biological diversity and functionality of West Lincoln's important natural heritage ecosystems. Like the agricultural designation, the policies of the *Official Plan* limit activities within the lands designated as Significant Natural Heritage Areas. The predominant land use "*shall maintain and preserve the significant attributes and functions of these lands"* (Section 6.4a). Compatible land use activities permitted include "*passive recreation, research, education, wildlife management, maple syrup extraction and low intensity forestry"* (Section 6.4a).

Region of Niagara: Township of Wainfleet

Two percent of the Upper Welland River watershed falls within the municipal boundary of the Township of Wainfleet. The predominant land use within this area is agriculture. The municipally approved *Township of Wainfleet Official Plan Review* [Sorensen Gravely Lowes Planning Associates Inc. et al (SGL) 2010] recognizes that over the lifetime of the *Official Plan*, conflicts could occur between farm operations and non-farm uses (Section 3.1). Therefore, it is the intent of the *Official Plan* to "*preserve this area for agricultural uses, agriculture-related uses and rural uses that support the rural community"* (Section 3.1) through policies that aim to "*preserve prime agricultural land; promote, protect and maintain the farming industry for future generations; and avoid land use conflicts between agricultural and non-agricultural uses"* (Section 3.1).

Conservation Authorities

Conservation Authorities are the governing body responsible for hazard lands in Ontario. Hazardous land, as defined in the *Conservation Authorities Act* [Section 28 (25)], is *"land that could be unsafe for development because of naturally occurring processes associated with flooding, erosion, dynamic beaches or unstable soil or bedrock"*. Accordingly, under the

Planning Act (MMAH 1990), the Niagara Peninsula Conservation Authority is delegated provincial responsibility for reviewing natural hazard lands for respective municipalities on any proposed development within the NPCA jurisdiction. The NPCA has Memorandum of Understandings (MOU) with the City of Hamilton, Haldimand County, and the Region of Niagara whereby the NPCA provides comments on all natural hazards and natural heritage matters, and in the MOU with the Region of Niagara, the NPCA also provides the local municipalities with technical comments on Regional environmental policies. Comments provided by the NPCA outline implications of development proposals from a watershed perspective pertaining to natural hazard planning, natural heritage planning, or groundwater and surface water management [NPCA 2007 (Section 4.0)]. These comments not only reflect the goals and the objectives of the NPCA under the *Conservation Authorities Act* in terms of "*a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals"* (R.S.O. 1990, c. C.27, s. 20.), but also reflect the requirements of Niagara Region's environmental policies. The policies for NPCA's regulated areas are administered under the *Ontario Regulation 155/06: Development, Interference with Wetlands and Alteration to Watercourse Regulation.* The policies apply to all "*watercourses, floodplains, valleylands, hazardous lands, wetlands, the shoreline of Lake Ontario, Lake Erie and the Niagara River, and lands adjacent to each of these features/functions, within NPCA's jurisdiction"* (NPCA 2007).

Niagara River Area of Concern (AOC)

In 1987 the International Joint Commission (IJC) designated the Niagara River as one of 43 Areas of Concern (AOCs) around the Great Lakes Basin due to its degraded water quality impairing complete use of its resources. The AOC spans both the Canadian and American Niagara River watersheds. The Canadian Niagara River AOC includes the 58 kilometre long Niagara River to the international border and the Welland River drainage basin (Figure 10). The Welland River is the largest tributary of the Niagara River and its drainage basin accounts for approximately 80 percent of the AOC (Canada).

Water quality issues in this AOC stem from sedimentation and toxic contaminants from industry, municipal sources of heavy metals, nutrients and other toxic pollutants, urban and rural runoff, and combined sewer overflows (NPCA 2002). As a result of the poor water quality many Beneficial Use Impairments (BUIs), as outlined in the Great Lakes Water Quality Agreement (1987), have been identified.

In response to concerns over the health of the entire Niagara River watershed and its ecosystem, a Remedial Action Plan (RAP) was created with representation from various stakeholders including the federal and provincial governments, resource agencies and the public (NPCA 2000). The Remedial Action Plan uses an ecosystem approach to environmental decision-making that involves three stages. The first stage, completed in 1993 (*Environmental Conditions and Problem Definition*), included a detailed assessment of environmental problems and their sources in the AOC and the extent of the impairments. In the Stage 2 report, (*The Cleanup Connection 1995*), the representatives of the RAP identified goals and objectives; made recommendations to achieve the goals; and proposed an implementation strategy to address the recommendations (Niagara River RAP 1995). In 2000, *Implementation Annex* (NPCA) was published and along with *The Cleanup Connection (*Niagara River RAP 1995) completed Stage 2 of the RAP. The *Implementation Annex* identified responsible stakeholders for the implementation of the recommendations; provided a schedule of activities, timelines and project costs (NPCA 2000).

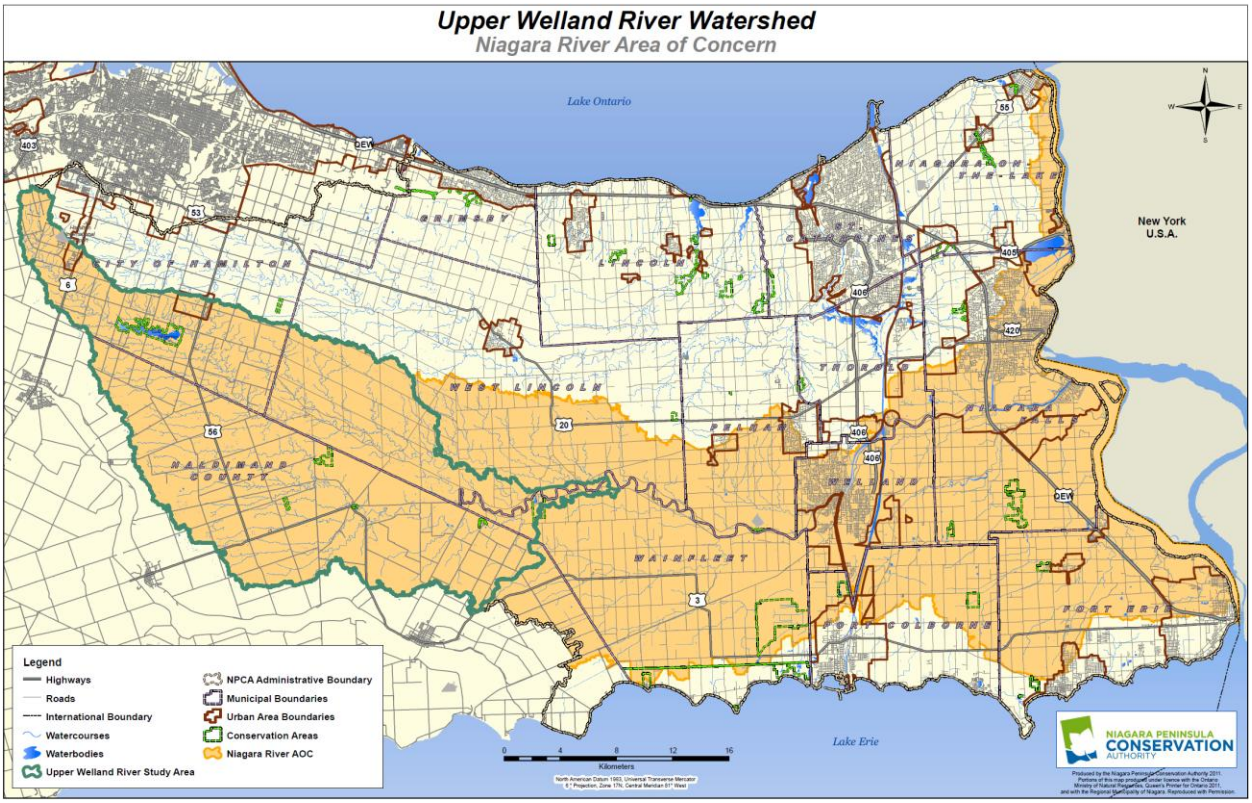

Figure 10: Area of Concern

Since the release of the 1995 Stage 2 report, and with various implementation activities completed or ongoing within the AOC, the outstanding questions that need to be addressed now are: "*What remains to be done in order to delist the Niagara River (Ontario) as a Great Lakes AOC?"* and *"How long will it take to achieve delisting?"* Many changes have occurred during that time with regard to environmental conditions within the AOC; remediation technologies; advances in analytical capabilities; advances in scientific understanding of environmental issues; and, the programs and priorities of RAP partners.

To answer these questions, government agencies and RAP partners felt it was necessary to review and update the RAP. With assistance from Technical Committees, a Steering Committee and a Public Advisory Committee, a full review of the Stage 2 report was initiated in 2004 to determine the status of implementation activities, identify any information gaps that require monitoring and assessment, and to focus all actions under the RAP towards delisting.

The Stage 2 Update report (2009) is a product of this review: it provides an update to the Stage 2 report and contains a summary of progress and several significant efforts which have taken place over the past nineteen years. It also contains the current status of impairments in the AOC and a new RAP work plan (2010-2015) that includes monitoring and assessment recommendations. It was clear from the Stage 2 review that there is still work to be done to address the remaining BUIs and achieve delisting of the AOC.

The *draft Stage 2 Update* report (2009) provides the following recommended status for the 14 BUIs:

No Longer "Impaired**":**

- Bird or animal deformities or reproduction problems
- Fish tumours & deformities
- Restrictions on fish and wildlife consumption (just the wildlife consumption component – the fish component continues to be impaired)
- Restrictions on dredging activities (this was originally incorrectly designated as impaired and has now been removed)

Continues To Be "Impaired":

- Restrictions on fish and wildlife consumption (just the fish consumption component)
- Degradation of benthos
- Beach closings
- Loss of fish & wildlife habitat
- Degradation of fish populations

From "Requires Further Assessment" To "Impaired":

- Degradation of fish & wildlife populations (just the degradation of wildlife populations component resulting in the entire BUI being listed as impaired)
- Eutrophication or undesirable algae (just the undesirable algae component resulting in the entire BUI being listed as impaired)

Continues To "Require Further Assessment":

- Degradation of Phytoplankton and Zooplankton populations

The Stage 2 Update report identifies priorities for remediation towards delisting the AOC (draft Stage 2 Update report 2009). These priorities include the following:

- Addressing sources of nutrients to eutrophication of the Welland River and its tributaries and develop a set of delisting criteria;
- Restoring and protecting fish and wildlife habitat, including unique habitats found rarely in other parts of the Great Lakes basin, and by mitigating the impacts of hydroelectric operations at the Sir Adam Beck Generating Station on the river upstream of the Chippawa Power Canal;
- Implementation of the monitored natural recovery strategy for PCB-contaminated sediment at Lyon's Creek East (e.g. administrative controls protocol);
- Complete assessments for Beneficial Use Impairment status for degradation of phytoplankton and zooplankton populations and implement appropriate actions for any other deemed impaired;
- Implementation of the updated monitoring plan which will help track progress of the Beneficial Use Impairments and ensuring that they don't backslide; and
- Complete assessment of Queens Royal Beach (not in study area) and implement required actions (Cromie 2010).

Initiatives to address these priorities are currently being coordinated by the lead RAP agencies through the new RAP implementation framework presented in the Stage 2 Update report. Implementation of the Niagara River RAP monitoring plan will allow comprehensive and defensible reports on the progress of ecosystem recovery, and will ultimately provide the evidence for delisting the Niagara River watershed as a Great Lakes Area of Concern (Cromie 2009).

Natural Heritage Resources

"One of the most fundamental principles of conservation is that there should be a system of natural corridors across the landscape, interspersed with large core natural areas" (Federation of Ontario Naturalists No Date). Not only does a natural heritage network provide a web of natural habitats that is crucial to the long-term survival and sustainability of biological diversity but this natural complex is critical in the maintenance of a healthy functioning ecosystem.

In southwestern Ontario, the Carolinian Life Zone is a rich and diverse network of cores and corridors that stretches from Toronto to Grand Bend extending southward to Lake Erie. Also known as the Eastern Deciduous Forest Region, this unique ecosystem boasts roughly one-third of Canada's rare and endangered species. Even though the Carolinian Life Zone makes up less than one percent of Canada's total land area, it contains a greater number of species than any other ecosystem in Canada and many of these species are not found anywhere else in the country (Johnson 2005). As part of its *Big Picture* project, Carolinian Canada identified considerable lands within the Upper Welland River watershed as a "Carolinian Core Natural Area" (Figure 11).

A core natural area is defined as: "*an intact natural area with larger habitat blocks; regions with a high overall percentage of natural vegetation cover; viable occurrences of globally rare species and vegetation community types, and concentrations of rare species and vegetation; should exceed 200 hectares where possible with smaller high-quality sites in areas with lower amounts of natural vegetation cover; as well as having minimum corridor widths of 200 metres plus any adjacent areas of natural cover"* (Riley et al 2003).

Corridors provide an increase in functionality of core areas, even smaller or fragmented areas, by not only facilitating in the movement of larger mammals between natural areas, but "*they are also essential for the movement and maintenance of genetic diversity for virtually all species regardless of size or species-pollen and seeds and other genetic material are passed along corridors*" (Pim No Date).

In Ontario the *PPS* (MMAH 2005) calls for the wise use and management of resources, accordingly Section 2.1.2 of the *PPS* states: "*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."*

The Upper Welland River Watershed Plan Restoration Strategy acknowledges and addresses linkages and potential corridors that extend outside of the study area. Large core areas that are present within and outside of the study area play an integral role in the formation or enhancement of corridors.

Upper Welland River Watershed Study Area Natural Heritage Resources

The percentages of upland forest cover, wetlands, and riparian habitat in Upper Welland River watershed are recorded in Table 2. These figures will be assessed based on the guidelines set by Environment Canada (2004c) as part of the restoration strategies in the watershed plan. These statistics were generated from the data produced through the NPCA Natural Areas Inventory project and from the MNR's Ontario Wetland Evaluation System wetland layer. All of

the natural heritage areas including wetlands, woodlots, and Areas of Natural and Scientific Interest are illustrated on Figure 12, and described below.

Table 2: Natural Heritage Resources		
Natural Heritage Resource	**Current %**	**Guideline (minimum) %**
Upland Forests	15	30 (of land cover)
Wetlands	22	10(of land cover in major watershed) 6 (of land cover in subwatershed) ***or to historic value***
Riparian Habitat	55	75 (of total stream length)

Carolinian Canada Signature Site

As part of the Carolinian Canada Coalition's early workings, 38 key sites in the Carolinian Life Zone were identified as being critically important. The **Caistor-Canborough Slough Forest**, located on the border of Haldimand County and the Region of Niagara, has been designated as one of the 38 sites in the Carolinian Life Zone. This natural heritage feature is one of the most extensive woodlots remaining in the region and is the source for more than 20 streams and tributaries (Johnson 2005). A portion of this slough forest is protected as the Ruigrok Tract Conservation Area.

Life Science and Earth Science Areas of Natural and Scientific Interest

An Area of Natural and Scientific Interest "*is an area of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education*" (MMAH 2005).The following natural areas are designated ANSIs in the Upper Welland River Watershed.

Sinclairville Meander Basin Swamp Life Science ANSI-provincial

The 86 hectare provincially significant ANSI and provincially significant wetland Sinclairville Meander Basin Swamp is comprised of 70 percent swamp and 30 percent marsh (Bergman et al. 1987). Located in Buckhorn Creek, this significant natural area presents a well developed series of incised meander stream landforms and associated young to subintermediate aged community patterns [Macdonald 1980]. According to Macdonald (1980) this area has the best developed complement of landforms associated with the incised meander stream riparian environment.

Attercliffe Station Slough Forest Life Science ANSI-provincial

This provincially significant wetland and ANSI is located in Oswego Creek subwatershed covers an area of approximately 90 hectares. Macdonald (1980) reports that this area presents an extensive example of very well developed slough pond patterned clay and sand plain landforms and associated forest and wetland communities. It occurs as three woodlot areas surrounded by extensive croplands. The upland deciduous forests range from young to submature in age and display an admirable degree of diversity and development, especially in the central and eastern woodlots. This ANSI is also designated in part as a provincially significant wetland. The expanse

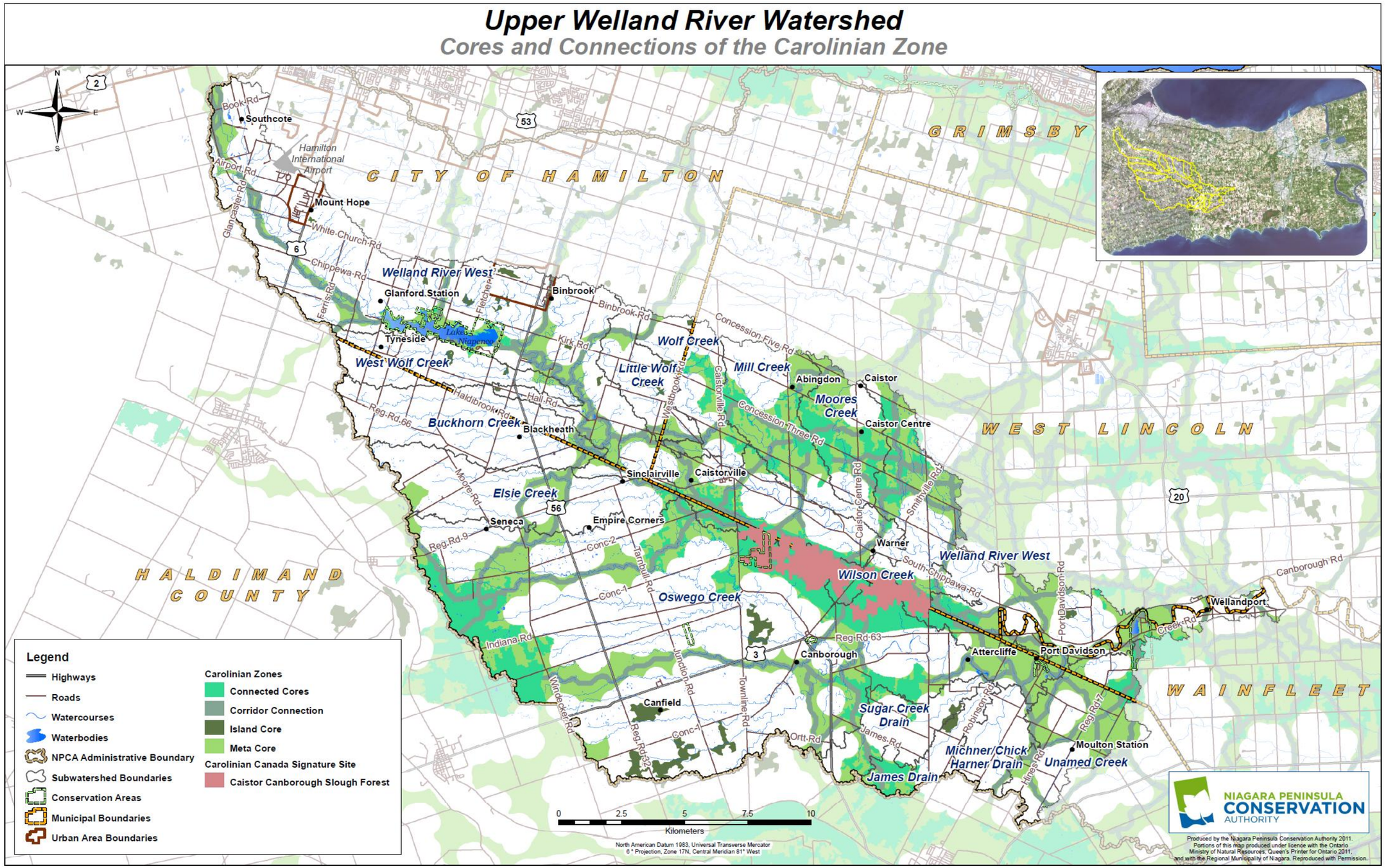

Figure 11: Carolinian Canada

of the Attercliffe Station Slough Forest PSW is over 125 hectares and is comprised of 131 individual wetlands composed of 73.5 percent swamp and 26.5 percent marsh (Chipman and Yarosh 1985).

Caistor-Canborough Slough Forest Life Science ANSI-provincial

This site is nearly 350 hectares in size and as previously described is also a designated Carolinian Canada Signature Site and a provincially significant wetland. In addition, this site is in part designated as provincially significant wetland. According to Eagles and Beechey (1985), this area presents one of the largest expanses of forested land on the slough/ridge patterned clay plain in the physiographic region. It includes a series of continuous to loosely joined woodlots, surrounded and separated by active croplands. In addition, this site is one of the most extensive woodlot complexes remaining in the region serving as habitat for wildlife and as a source for over 20 streams and tributaries. Ruigrok Conservation Area occupies a portion of the western section.

North Cayuga Slough Forest Life Science ANSI-provincial

Located on the border of the study area and on the boundary of the NPCA watershed in Oswego Creek, this provincially significant ANSI is nearly 700 hectares in size. This site is comprised of a complex of upland forests, sloughs and old fields characterized by alternating ridges and sloughs located on clay plain (Larson et al 1999). This site is drained partially eastward by headwaters of Oswego Creek and westward by tributaries of the Grand River and is also in part designated provincially significant wetland.

East Caistor Centre Slough Forest Life Science ANSI-regional

This regionally significant ANSI consists of two woodlots covering an area over 160 hectares in the upper Welland River West subwatershed. The site consists of moderately rolling clay plain with well developed slough pond and basin features; variously aged deciduous forest patterns on rises and diverse well developed swamp, scrub and marsh communities in the slough zones; local impact of hydro corridor and logging (Macdonald 1980). This site is also in part designated as provincially significant wetland.

North Caistor Centre Slough Forest Life Science ANSI-regional

This regionally significant ANSI consists of over 183 hectares of woodlot in 3 separate sections located in the headwaters region of Moores Creek and Mill Creek. These sites are also designated in part as provincially significant wetland. The topography of the sites consists of broadly rolling silt loam plain with linear and unpattered slough development (Macdonald 1980). This site is also in part designated as provincially significant wetland.

Wetlands

Wetlands are "*among the most productive and biologically diverse habitats on the planet*" (MNR No Date). Wetlands provide numerous beneficial water quality and ecological functions in a watershed, including naturally filtering water resources thereby improving water quality, act like sponges by slowing the flow of water which reduces the impact of flooding and allows for groundwater recharge, augments low flow by raising local water tables, which in turn contributes to base flows of the watercourses, and also provides valuable social and educational resources. In addition, "*a high proportion of Ontario's fish and wildlife species inhabit wetlands during part*

of their life cycle. Many of the species at risk of extinction in southern Ontario are highly dependent on wetlands" [Environment Canada (EC) 2004].

The Ontario Wetland Evaluation System (OWES) is a science-based ranking system used by the Ministry of Natural Resources to assess wetland functions and societal values. Wetlands are evaluated and assigned a status as "provincially significant" or "locally significant". With the assistance of the NPCA's Natural Heritage Areas Inventory program, the Ministry of Natural Resources is currently revising the boundaries of existing wetlands and identifying new wetlands in the Upper Welland River watershed. To date, over 104 square kilometres of wetland have been identified in the study area.

Conservation Areas

Binbrook Conservation Area

The Binbrook Conservation Area is home to Niagara's largest inland lake; Lake Niapenco reservoir. This fishing hot spot hosts a number of annual activities for the whole family including fishing derbies and controlled waterfowl hunts. Amenities at this conservation area include a swimming area, splash pad, picnic facilities, and nature trails.

Canborough Conservation Area

This 6 hectare conservation area is located in Dunnville along the Welland River. This floodplain property offers fishing and passive recreations opportunities.

Chippawa Creek Conservation Area

This conservation area offers rare public access to the Welland River. The resource management practices of the NPCA have established an ideal wildlife habitat that offers excellent wildlife viewing opportunities. A 10-hectare man-made reservoir, Dils Lake, offers numerous water related recreational opportunities for the whole family, including fishing, swimming and non-motorized boating. In addition, this conservation area includes 156 campsites that are available from the Victoria Day weekend in May through to the last weekend in September.

Hedley Forest Conservation Area

This 17 hectare conservation area was acquired by the NPCA in 1967 and offers passive recreational opportunities such as year-round hiking and snowshoeing and cross-country skiing in the winter. This forest is significant in providing wildlife habitat and helps to maintain soil and water quality.

Port Davidson Conservation Area

The Port Davidson Conservation Area is located along the Welland River in the Township of West Lincoln. This half acre natural area offers shoreline access for fishing and relaxing. There is no fee associated with this Conservation Area.

Oswego Creek Conservation Area

Located along Oswego Creek in Dunnville, this 6 hectare site is maintained for floodplain purposes. There is no public access at this conservation area.

Ruigrok Tract Conservation Area

The 75 hectare conservation area protects a large tract of interior forest; Caistor-Canborough Slough Forest. This land was acquired by the NPCA in 1963 and acts as a wildlife and forest management site. This conservation area offers year-round passive recreational opportunities such as hiking and wildlife viewing.

NPCA Natural Areas Inventory Study

In 2006, the NPCA initiated a comprehensive Natural Areas Inventory (NAI) that was completed in partnership with the RMN, local municipalities, Peninsula Field Naturalists and numerous other partners. The goal of the project was to use industry standard, scientifically-defensible protocols to inventory the natural areas in the NPCA watershed. The updated inventory provides a solid resource of information to aid in planning decisions, policy development, and the prioritization of restoration opportunities. Four major aspects comprise the Natural Areas Inventory project; these include a Community Series Ecological Land Classification (ELC) Mapping; field verifications of vegetative communities to Vegetation Type (ELC); faunal inventories of for example birds, lepidoptera and odonata, herpetofauna, and lichens; and education. In total, over 500 properties were visited for ELC vegetation type assessments; 25 of these sites fall within the Upper Welland River study area. Associated mapping (Figure 12) has been derived directly from the NPCA *Natural Areas Inventory* (2010d) report. For more information regarding the faunal inventories conducted during this study, please refer to the NPCA *NAI Inventory* report. Detailed site descriptions within the Upper Welland River Watershed Plan study area are located in Appendix F.

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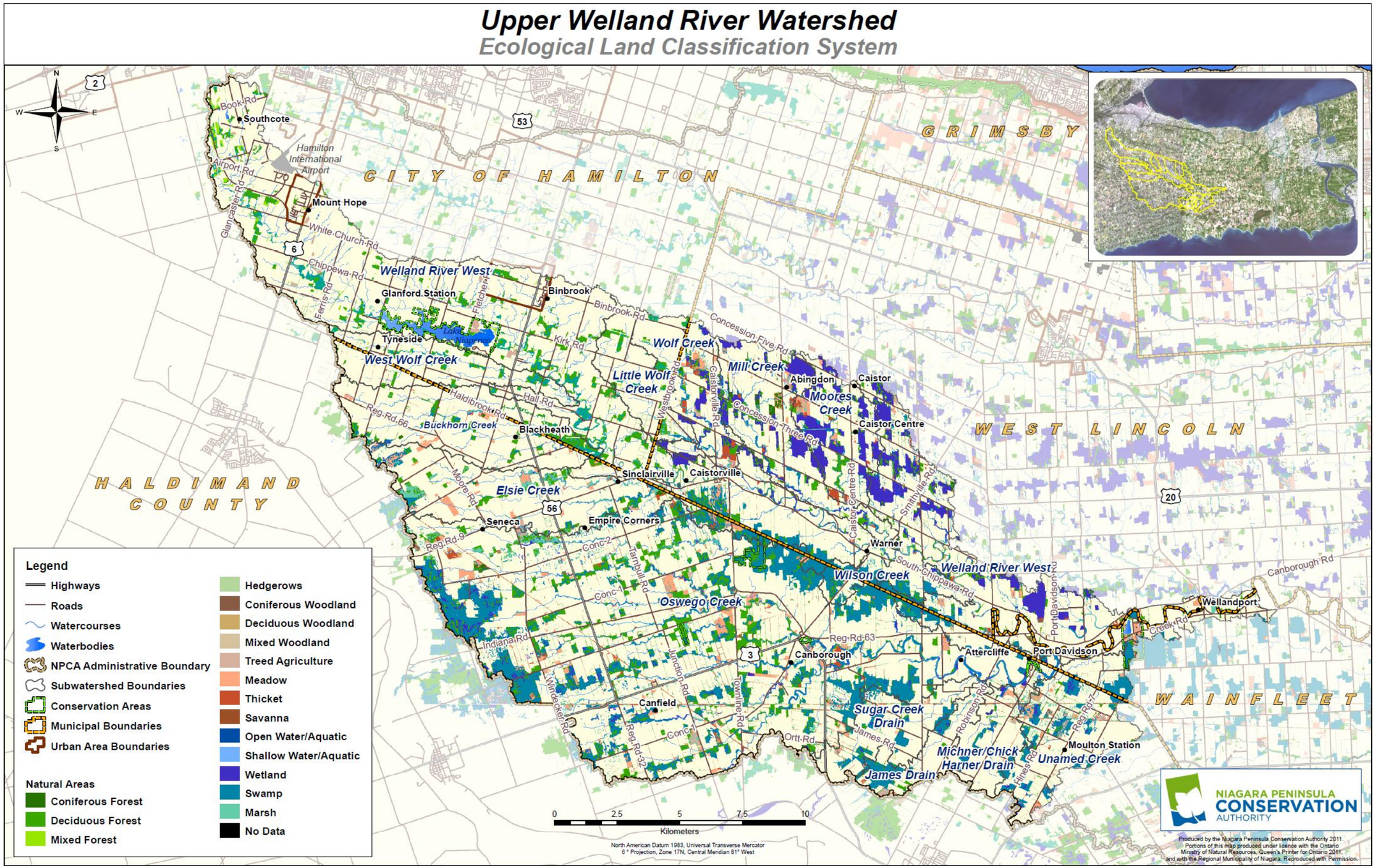

Figure 12: Ecological Land Classification System

Species at Risk

A Species at Risk is "*any plant or animal threatened by, or vulnerable to extinction* (Ontario Ministry of Natural Resources No Date). In Ontario, species at risk are governed by two bodies; *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) and the *Committee on the Status of Species at Risk in Ontario* (COSSARO).

COSEWIC is an independent body responsible for identifying species that are considered to be at risk in Canada. COSEWIC reports their findings to the federal government. The federal government then determines which at-risk species qualify for protection under the *Species At Risk Act* (EC 2003). COSSARO is an independent review body made up of up to 11 members from the public and private sectors; at least 5 of the members must be non-OMNR members. A species status designation may differ from COSEWIC and COSSARO because their vulnerability changes depending on the geographic scale. All species status designations given by COSEWIC will also be given an equal or greater status designation by COSSARO; a higher status indicates that there is a greater concern for a species province-wide than nation-wide. In addition, a species may have been given a status designation by COSSARO and not from COSEWIC because there may only be a province-wide vulnerability.

In Ontario, over 185 native species have been given official status designations by the OMNR (OMNR No Date). Currently, several legislative and policy tools protect species at risk in Ontario. For instance, the *Provincial Policy Statement* (MMAH 2005a) under Ontario's *Planning Act* affords habitat protection by stating "*Development and site alteration shall not be permitted in: significant habitat of endangered species and threatened species* (Section 2.1.3)".

In May 2007, *Bill 184,* Ontario's new *Endangered Species Act,* (OMNR 2007a) made it to Royal Ascent in Ontario. It replaced Ontario's previous *Endangered Species Act* (1971) in June 2008. *Bill 184* states:

"*If a species is listed on the Species at Risk in Ontario List as an endangered or threatened species, the Bill prohibits damaging or destroying the habitat of the species. This prohibition also applies to an extirpated species if the species is prescribed by regulations. The regulations may specifically prescribe an area as the habitat of a species but, if no habitat regulation is in force with respect to a species, "habitat" is defined to mean an area on which the species depends, directly or indirectly, to carry on its life processes*"

The OMNR status definitions for species designations range from extinct (no longer exists anywhere) to data deficient (insufficient information for status recommendation). In the Upper Welland River Watershed Plan study area, endangered, threatened and species of special concern have been documented by the OMNR and the NPCA (Table 3). Due to the sensitive nature of this data, a map or any geographical information cannot be included in this report.

The definitions for these status designations by the OMNR are as follows:

- **Extirpated:** *A native species that no longer exists in the wild in Ontario, but still exists elsewhere*
- **Endangered (Regulated)**: *A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act*
- **Endangered (Not Regulated)**: *A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's Endangered Species Act*

- **Threatened:** *A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed*
- **Special Concern:** *A species with characteristics that make it sensitive to human activities or natural events*

Table 3: Listed Species at Risk in the Upper Welland River Watershed			
COSEWIC Status (Federal)	**COSSARO Status (Provincial)**	**Common Name**	**Scientific Name**
END	END-NR	American Chestnut	*Castanea dentata*
END	END	Butternut	*Juglans cinerea*
END	END	Flowering Dogwood	*Cornus florida*
END	END-R	Henslow's Sparrow	*Ammodramus henslowii*
END	SC	Five-lined Skink	*Eumeces fasciatus*
THR	THR	Blanding's Turtle	*Emydoidea blandingii*
THR	THR	Mapleleaf Mussel	*Quadrula quadrula*
SC	SC	Cerulean Warbler	*Dendroica cerulea*
SC	SC	Eastern Ribbonsnake	*Thamnophis sauritus*
SC	SC	Grass Pickerel	*Esox americanus*
SC	SC	Green Dragon	*Arisaema dracontium*
SC	SC	Milksnake	*Lampropeltis triangulum*
SC	SC	Northern Map Turtle	*Graptemys geographica*
SC	SC	Short-eared Owl	*Asio flammeus*
SC	SC	Woodland Vole	*Microtus pinetorum*
SC	SC	Yellow-breasted Chat	*Icteria virens*
NAR	SC	Southern Flying Squirrel	*Glaucomys volans*
SC	S3 (rare)	Snapping Turtle	*Chelydra serpentina serpentina*

As a result of Niagara's southern location and varied habitats (e.g. Great Lakes, escarpments, and physiography), Niagara is home to a diversity of flora that is considered nationally significant. To date, nearly 1700 taxa have been documented in Niagara Region, 1398 in Haldimand-Norfolk, and 1410 in Hamilton. In Niagara Region, over 170 of these taxa are considered a provincial conservation concern, 158 in Haldimand-Norfolk, and 83 in Hamilton (Oldham 2010).

A list of provincially rare species documented by the OMNR and NPCA in the Upper Welland River Watershed Plan study area can be reviewed in Table 4 and a list of regionally rare species can be reviewed in Table 5.

Table 4: Provincially Rare Species in the Upper Welland River Watershed	
Common Name	**Scientific Name**
Bee-balm	*Monarda didyma*
Blue-tipped Dancer	*Argia tibialis*
Blunt-lobe Grapefern	*Botrychium oneidense*
Branching Bur-reed	*Sparganium androcladum*
Button-bush Dodder	*Cuscuta cephalanthi*
Flaccid Sedge	*Carex flaccosperma var. glaucodea*
Flat-stemmed Danthonia	*Danthonia compressa*
Giant Swallowtail	*Papillio cresphontes*
Hairy Forked Chickweed	*Paronychia fastigiata*
Halberd-leaved Tear-thumb	*Persicaria arifolia*
Hickory Hairstreak	*Satyrium caryaevorus*
Hirsute Sedge	*Carex hirsutella*
Jefferson-Blue-spotted Salamander (hybrid)	*Ambystoma hydrid*
Lance-leaved Grapefern	*Botrychium lanceolatum*
Northern Ribbon	*Thamnophis sauritus septentrionalis*
Perfoliate Bellwort	*Uvularia perfoliata*
Slender Sedge	*Carex gracilescens*
Sharp-fruit Rush	*Juncus acuminatus*
Schreber's Wood Aster	*Eurybia schreberi*
Tufted Titmouse	*Baeolophus bicolor*
Wax-leaved Meadow-rue	*Thalictrum revolutum*
Weak Stellate Sedge	*Carex seorsa*
Willdennow's Sedge	*Carex willdenowii*

Table 5: Regionally Rare Species in the Upper Welland River Watershed	
Common Name	**Scientific Name**
Dotted Water Meal	*Wolffia borealis*
Downy Hawthorn	*Crataegus mollis*
Giant Ragweed	*Ambrosia trifida*
Halberd-leaved Tearthumb	*Polygonum arifolium*
Marsh Bellflower	*Campanula aparinoides*
Narrow-leaved Willow-herb	*Epilobium leptophyllum*
Pilewort	*Erechtites hieracifolia*
Purple-tinged Sedge	*Carex woodii*
Rattlesnake Manna Grass	*Glyceria canadensis*
Rough Hair Grass	*Agrostis scabra*
Sallow Sedge	*Carex lurida*
Small's Spike-rush	*Eleocharis smallii*
Small-flowered Agrimony	*Agrimonia parviflora*
Smooth Solomon's Seal	*Polygonatum biflorum*
Sweet Ox-eye	*Heliopsis helianthoides*
Sweetflag	*Acorus americanus*
Tall Swamp Beggar-ticks	*Bidens coronata*
Water Pimpernel	*Samolus valerandi ssp. parviflorus*
Yellow Mandarin	*Disporum lanuginosum*

As indicated earlier a comprehensive NAI study was completed for the NPCA jurisdiction using the provincial Ecological Land Classification (ELC). The ELC comprises six nested levels; from largest to smallest scale these are: Site Region, System, Community Class, Community Series, Ecosite, and Vegetation Type (Lee et al 1998). The NAI study typically collected data at the Community Series level, however, data was collected at a few sites to the Ecosite and Vegetation Type. Bakowsky (1996) defined Ecosite and Vegetation Type as follows:

"*Ecosite is a mappable landscape unit defined by a relatively uniform parent material, soil and hydrology, and consequently supports a consistently recurring formation of plant species which develop over time (vegetation chronosequence).The Vegetation Type is part of an ecosite, and represents a specific assemblage of species which generally occur in a site with a more uniform parent material, soil and hydrology, and a more specific chronosequence".* Additionally, Vegetation Type is the basic plant community unit that is ranked in Ontario for conservation purposes (Bakowsky 1996).

Within the Upper Welland River Watershed study area, 2 rare Ecosites, and 2 rare Vegetation Types were identified through the NAI study. The descriptions are taken directly from the *„Rare Vegetation Types (Goodban and Garofalo)*' section of the NAI Report:

- *Dry-Fresh Oak-Maple-Hickory Deciduous Forest Ecosite (FOD2):* This community typically occurs on upper to middle slopes on silty clays and silty very fine sands.
- *Fresh*-Moist *Lowland Deciduous Forest Ecosite (FOD7):* Sugar Maple-Black Maple Deciduous Forest and Black Maple Lowland Decidous Forest occur on moist, well drained sites.
- *Fresh-Moist Black Walnut Lowland Deciduous Forest Type* [(FOD7-4) Regionally Rare Vegetation Type]: This Vegetation Type occurs on alluvial silts and clays, and rarely on sands, along floodplains.
- *Swamp White Oak Mineral Deciduous Swamp Type* [(SWD1-1) Regionally Rare Vegetation Type]: Swamp White Oak dominated swamps occur on silty clays, clays and silts. These sites usually support semi-open stands of Swamp White Oak *(Quercus bicolour)* and Swamp White Oak-Bur Oak *(Quercus macrocarpo)* hybrids.

Aquatic Habitat

In Canada, the *Fisheries Act* (Department of Fisheries and Oceans R.S. 1985, c. F-14) was established to protect and manage Canada's fisheries resources. The Act applies to all fishing zones; territorial and inland waters. As federal legislation, should a conflict arise between the *Fisheries Act* and provincial legislation, the *Fisheries Act* takes precedence. Although management of fish habitat falls under the authority of the federal government, the federal government has *„essentially no control over the use of inland waters, beds of watercourses or shorelines which fall under provincial jurisdiction. Alternatively, the provinces cannot make regulatory decisions concerning fish habitat* (DFO No Date)*'*.

Section 35 of the Fisheries Act is the habitat provision of the *Fisheries Act*. This section is a *„general prohibition of harmful alteration, disruption or destruction (HADD) of fish habitat'*. Therefore, any project, work or undertaking that results in a HADD situation would result in a breach of this section of the Act and could result in a fine up to one million dollars, imprisonment or both.

Fish Habitat

Fish habitat falls into 1 of 3 categories in Niagara: Type 1, Type 2 or Type 3 (OMNR 2000). Habitat type is based on the sensitivity and significance of current or potential habitats in a water body. Type 1 habitat is the most sensitive habitat of the 3 types. As a result, it requires the highest level of protection. Examples of Type 1 habitat include critical spawning and rearing areas, migration routes, over-wintering areas, productive feeding areas and habitats occupied by sensitive species. Type 2 habitat is less sensitive and requires a moderate level of protection. These areas are considered "ideal for enhancement or restoration projects" and include feeding areas for adult fish and unspecialized spawning habitat. The third habitat type is considered marginal or highly degraded and does not contribute directly to fish productivity. Examples of Type 3 habitat include channelized streams and artificially created watercourses (OMNR 2000).

Fish habitat type in the Upper Welland River watershed has been delineated according to the Ministry of Natural Resources stream classification data. These areas are depicted on Figure 14

as critical habitat (Type 1), important habitat (Type 2) and marginal habitat (Type 3). As illustrated on Figure 13, the main channels of the Welland River, Little Wolf Creek and a portion of Wolf Creek have been classed as critical fish habitat. The remaining watercourses in the study area within Niagara Region have been delineated as important (Type 2) fish habitat. The remaining watercourses in the study area fall outside of the Region of Niagara's regional boundary and have not been assessed in terms of importance to fish habitat. The Upper Welland River Watershed Plan will recommend the completion of the fish habitat assessment for the Niagara Peninsula Conservation Authority's jurisdiction.

Fish Community Studies

During the spring when there is adequate flushing, flows are high, and temperatures are cool to moderate, fish species that are intolerant of high nutrients, high temperatures and low dissolved oxygen have a wider distribution throughout Welland River West (Yagi and Blott 2008). However, during the summer low flow, these intolerant species display a confined and disrupted distribution throughout the Welland River West and can be found in concentrated areas with the best habitat conditions and therefore more susceptible to predation and over harvest (Yagi and Blott 2008). The intolerant species are replaced by species that are more tolerant of high turbidity and temperature conditions.

The Ontario Ministry of Natural Resources conducted fish community surveys from 2003 to 2007 throughout the Niagara River watershed, of which the Welland River and its tributaries are a part of. In the Upper Welland River watershed study area a total of 42 species were recorded (Table 6).The purpose of the study was to characterize the resident fish community within the Niagara River and its tributaries. The Niagara River Watershed is divided into 10 Aquatic Resource Areas (ARA) as a result of natural and anthropogenic influences. Four ARA's fall within the Upper Welland River watershed; Welland River Headwaters, Binbrook Reservoir, Welland River above Port Davidson, and Welland River West.

The Welland River Headwaters ARA includes the main stem of the Welland River and its tributaries upstream of Binbrook Reservoir. When sampling was conducted in 2007, it was estimated that continuous habitat extended roughly 11 km upstream of Highway 6 (Yagi and Blott 2008).

Binbrook Reservoir is located in the headwaters of the Welland River. This artificial lake, Lake Niapenco, covers roughly 174 hectares and stretches 5.4 km. The reservoir was constructed in 1971 to augment base flow and for flood control downstream.

According to Yagi and Blott (2008) the fish community metrics for the reservoir show fairly poor results during sampling years 1997 and 2003; under species richness and relative abundance "*reservoir results are the lowest seen in the Welland River and probably a reflection of isolation and poor habitat*".

The next ARA extends roughly 70 km from above the Port Davidson weir to Binbrook Reservoir "*where the lake outflow structure is impassable to upstream fish migration at all times of the year*" (Yagi and Blott 2008). The fourth ARA within the Upper Welland River study area is the Welland River West ARA, and extends from the Fourth Welland Canal upstream to the Port Davidson weir.

The following descriptions of the sampling stations are derived from *the Niagara River Watershed Fish Community Assessment (2003-2007)* report completed by the Ministry of Natural Resources

Mill Creek

Sampling was conducted in Mill Creek at 3 stations during 2007. A total of 20 species including grass pickerel, a *Species at Risk*, were captured during sampling resulting in one of the highest diversities of fisheries in the Upper Welland River watershed study area. Unique to Mill Creek is Rock Bass and species unique to Mill Creek and Wolf Creek include bluegill, yellow perch and mimic shiner. Except for fathead minnow, all fish species historically recorded for Mill Creek were captured during the 2007 sampling (Table 6).

Moores Creek

During 2007 sampling was conducted at 2 stations in Moores Creek. 11 species were recorded including grass pickerel. The most abundant species recorded were green sunfish (Table 6).

Wolf Creek

Sampling was conducted at 3 stations during 2007; 2 of these sites were pools at road crossing culverts and the third was a 300 meter long pool. During sampling, 20 species were recorded including grass pickerel and 1 exotic, common carp (Table 6). All species that were captured in a 1976 survey were recaptured during 2007 sampling,

Little Wolf Creek

During 2007 sampling was conducted at one site in Little Wolf Creek. During sampling, 16 species were recorded including grass pickerel and 1 exotic, common carp. Unique to Little Wolf Creek is bigmouth buffalo while the most abundant species recorded was black bullhead (Table 6).

Elsie Creek

Sampling was conducted at 2 sites in Elsie Creek during 2007. During sampling, 13 species were identified including grass pickerel. All species that were historically recorded for this watercourse were recaptured during the 2007 surveys (Table 6).

Buckhorn Creek

During 2007, 6 sites were sampled in Buckhorn Creek upstream and downstream of a spring with permanent flow. The spring is adjacent to the creek channel and flow is routed through a 4 meter long rock lined channel to the creek. The sulphurous water quality of the spring inhibits fish survival to varying degrees depending on how much dilution there is with creek water. Only one top predator was found during sampling; northern pike which was found upstream of the spring (Table 6). Although grass pickerel can be found in the Welland River near Buckhorn Creek, they are absent from Buckhorn Creek, possibly due to the water quality associated with the sulphur spring water as the habitat requirement for grass pickerel seem otherwise suitable.

West Wolf Creek

Sampling was conducted at 3 sites during 2007. All 3 sites are pools under road culverts. One exotic species was identified during sampling; common carp (Table 6).

Welland River: Kirk Road tributary

This intermittent tributary was sampled at one station during 2007. Seven species were identified including white sucker which is found in the 3 upper tributaries of the Welland River (Table 6).

Welland River: Trinity Church Road tributary

This intermittent tributary discharges into the Welland River below Binbrook reservoir.
The sampling pool was very shallow with a soft silty muck substrate. Seven species were identified during sampling including the Iowa darter which was historically recorded in the Welland River in this vicinity (Table 6).

Welland River: headwaters

Sampling in 2007 was conducted at 5 stations from the reservoir to approximately 21 kilometres upstream. The sampling results indicate a fish community that resembles the fish community downstream of the reservoir as oppose to that in the Binbrook reservoir (Table 6).

Oswego Creek

Sampling was conducted above and below the Canborough weir in 1999, 2003, 2005 and 2007. In 2004 a more extensive survey of the lower and upper reaches of the creek was conducted. All species identified historically were recaptured during sampling, aside from grass pickerel which was captured in surveys from 2003 to 2007 (Table 6). A fish bypass was added to the Canborough weir in 2003. Sampling after the construction of the bypass channel indicates a doubling number of species to preceding sampling events.

Significant Fish Species

One of the fish species identified in the Upper Welland River watershed is considered “at risk”; grass pickerel. Grass pickerel has been designated as a species of *„special concern’* by the *Committee on the Status of Endangered Species in Canada* and *Committee on the Status of Species at Risk in Ontario*. The grass pickerel have specific habitat requirements, and in Niagara they can be found in wetland associated watercourses with organic soils.

Table 6: Fish Species Identified in the Upper Welland River Watershed													
	Mill Creek	**Moores Creek**	**Wolf Creek**	**Little Wolf Creek**	**Elsie Creek**	**Buckhorn Creek**	**Oswego Creek**	**West Wolf Creek**	**Welland River Kirk Rd trib**	**Welland River Trinity Church Road trib**	**Welland River Above Port Davidson**	**Binbrook Reservoir**	**Welland River Headwaters**
Bowfin							●						
Gizzard Shad							●						
White Sucker							●	●	●	●	●	●	●
Bigmouth Buffalo				●									
Shorthead Redhorse				●							●		
Grass Pickerel**	●	●	●	●	●		●				●		●
Central Mudminnow	●	●	●	●	●	●	●	●		●	●		●
Black Bullhead	●	●	●	●	●	●	●	●			●		●
Yellow Bullhead	●		●	●			●				●	●	●
Brown Bullhead	●	●	●	●	●	●	●	●			●	●	●
Tadpole Madtom	●	●	●	●	●	●	●	●			●		●
White Perch							●				●		
Johnny Darter	●		●	●	●	●	●	●	●		●		●
Blackside Darter	●		●		●		●				●		
Logperch							●				●		
Channel Catfish											●	●	
Brook Stickleback						●					●		
Iowa Darter										●			
Freshwater Drum											●		
Golden Shiner	●	●	●	●	●	●	●	●			●	●	●
Emerald Shiner							●					●	
Common Shiner											●	●	
Spottail Shiner												●	
Mimic Shiner	●		●								●		
Bluntnose Minnow	●		●	●	●	●	●	●	●	●	●	●	●
Brassy Minnow						●							
Fathead Minnow	●		●			●	●		●	●	●		
Creek Chub									●	●	●		
Rock Bass	●										●	●	
Green Sunfish	●	●	●	●	●	●	●	●	●	●	●	●	●
Pumpkinseed	●	●	●	●	●	●	●	●	●		●	●	●
Bluegill	●		●			●	●				●	●	
YOY Sunfish			●										
Sunfish							●				●		
Northern Pike	●	●		●	●	●	●	●			●	●	●
Smallmouth Bass												●	
Largemouth Bass											●	●	●
White Crappie	●	●	●	●		●	●	●			●	●	●
Black Crappie	●	●	●	●	●		●	●			●	●	●
Yellow Perch	●		●								●	●	●
Walleye											●	●	
Goldfish						●	●						
Common Carp	●		●	●		●	●	●			●	●	●
Total Species	**21**	**11**	**20**	**17**	**14**	**17**	**26**	**14**	**7**	**7**	**33**	**21**	**18**

Source: Niagara River Watershed Fish Community Assessment (2003 to 2007)

Native Minnow Family | Native Sportfish | Exotic Species, including exotic sportfish | Sunfish Family (Other than sportfish) | Sucker Family | ** Species at Risk

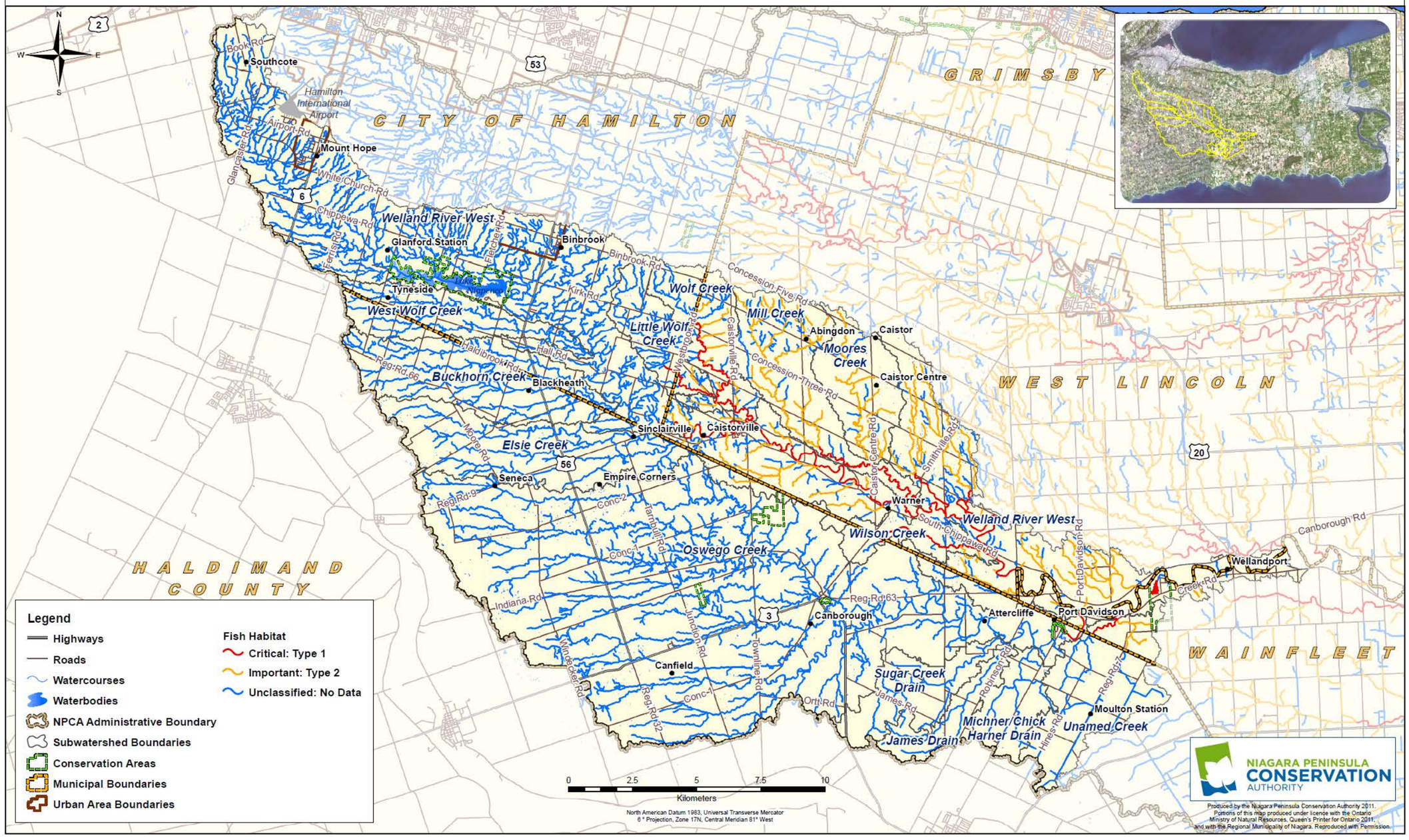

Figure 13: Fish Habitat

Municipal Drains

Under the Ontario Drainage Act (R.S.O. 1990, Chapter D.17) drainage works "*include a drain constructed by any means, including the improving of a natural watercourse, and includes works necessary to regulate the water table or water level within or on any lands or to regulate the level of the waters of a drain, reservoir, lake or pond, and includes a dam, embankment, wall, protective works or any combination thereof*."

Numerous municipal drains exist in the Upper Welland River watershed (Figure 14). Even though their purpose is to remove excess water from the land, municipal and agricultural drains do contain fish habitat. To better manage these drains, Fisheries and Oceans Canada has developed a classification system that identifies municipal drains as Types A through F using variables such as flow conditions, temperature, fish species present, and the length of time since the last clean out (Fisheries and Oceans Canada No Date). For example, a Class A drain has permanent flow with cold or cool water temperature and no presence of trout or salmon present. A Type C drain has a permanent flow with warm water temperatures and baitfish present in the drain. Type F drains are characterized by intermittent flow (Fisheries and Oceans Canada No Date). This classification system has been created for use by municipal drainage superintendents for the purpose of drain maintenance. Therefore, the classification assigned to a drain is subject to change frequently.

For a watercourses or pipe to become a municipal drain there must be a by-law adopting an engineer's report. Once the municipal drain has been constructed under the by-law, it becomes part of the infrastructure of the respective municipality. The local municipality is therefore responsible for repairing and maintaining the drain.

In the Upper Welland River watershed, almost 70 kilometres of watercourses have been classified as municipal drains. The drainage classifications are either a Class C or Class F; the majority have a Class F designation (Table 7).

Table 7: Municipal Drains in the Upper Welland River Watershed Plan Study Area

Class	Drain Name	Subwatershed
C	Carter Drain	Unamed Creek
F	Carter Drain	Unamed Creek
F	Brown Drain	Unamed Creek
F	Charles Angle Drain	Unamed Creek
F	Black Creek Drain	Unamed Creek
F	Corbett Drain	Unamed Creek
F	Bouch & Moyer	Unamed Creek
F	Whitechurch Road Drain	Welland River West
F	Puhringer Drain	Welland River West
F	Baker Drain	Oswego Creek
F	Sugar Creek Drain	Sugar Creek Drain
F	Siddal Drain	Sugar Creek Drain
F	Allen Drain	Sugar Creek Drain
F	Holtrop Drain	Sugar Creek Drain
F	Babiy Drain	Sugar Creek Drain
F	Barry Drain	Sugar Creek Drain
F	James Drain	James Drain
F	Waines Drain	James Drain
F	Chick-Harnett Drain	Chick Hartner Drain
F	Bouch & Moyer	Chick Hartner Drain
F	Michner Drain	Michner Drain

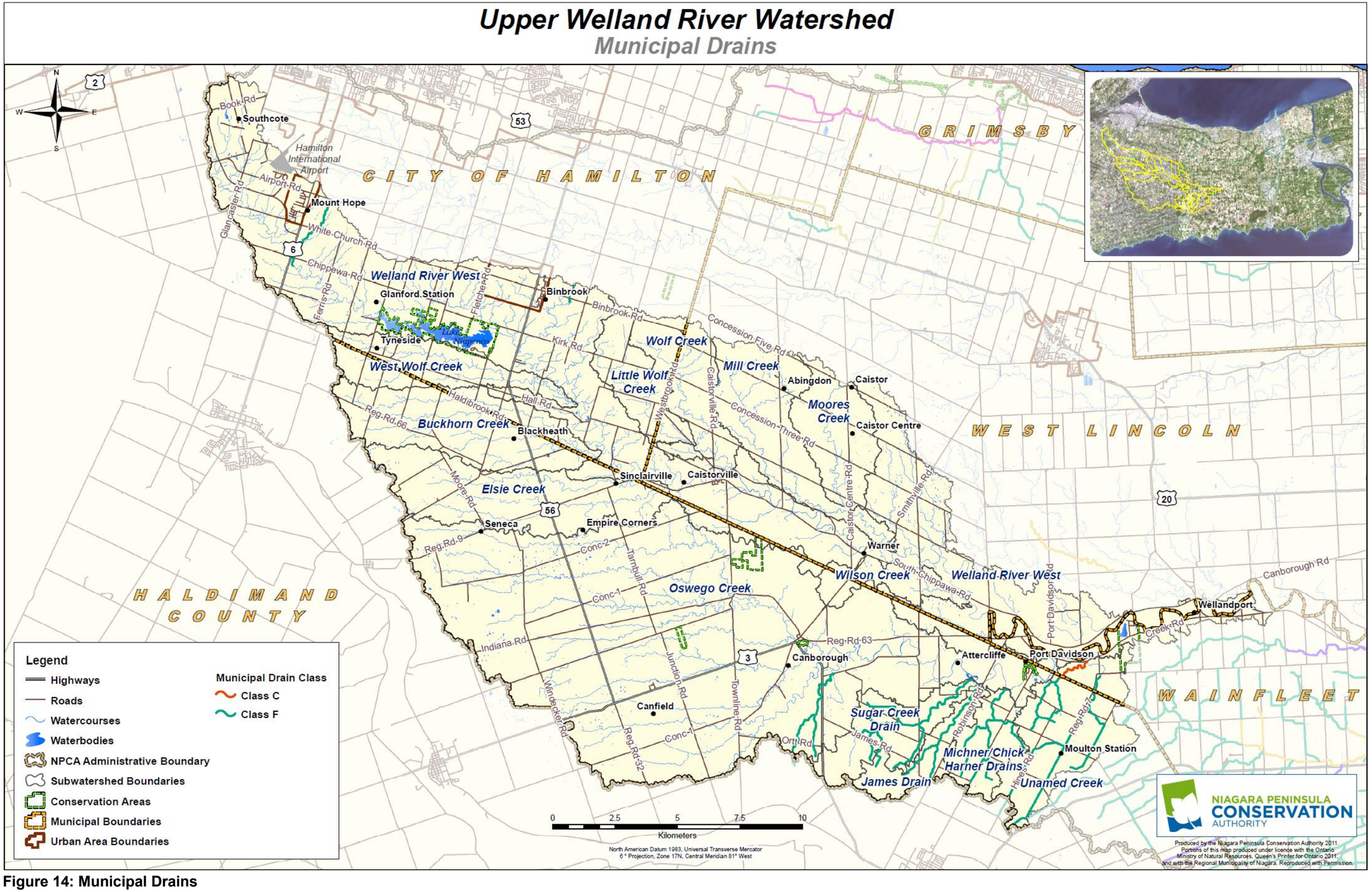

Figure 14: Municipal Drains

Water Quality

NPCA Water Quality Monitoring Program

The Ontario Ministry of Environment and Energy (MOEE) has established a set of *Provincial Water Quality Objectives* (PWQO) that are intended to be used to guide respective agencies when making water quality management decisions. The surface water quality management goal is "*To ensure that the surface waters of the province are of a quality which is satisfactory for aquatic life and recreation"* [MOEE 1994 (Section 3.1)]. Table 8 summarizes indicator parameters that are the most useful in assessing relative water quality. They include: total phosphorus, nitrate, copper, lead, zinc, *Escherichia coli*, chloride, suspended solids and benthic invertebrates (NPCA 2010a). The PWQO are useful indicators but other non-chemical factors such as for example, loss of habitat, sedimentation, and indigenous species must also be considered when assessing ecosystem health.

Table 8: Water Quality Parameters (NPCA 2010a)

Category	Indicator Parameter	Objective	Reference
Nutrients	Total Phosphorus	0.03 mg/L	PWQO (MOE 1994)
Nutrients	Nitrate	13 mg/L	CWQG (CCME 2007)
Metals	Copper	0.005 mg/L	PWQO (MOE 1994)
Metals	Lead	0.005 mg/L	PWQO (MOE 1994)
Metals	Zinc	0.02 mg/L	PWQO (MOE 1994)
Microbiological	*Escherichia coli*	100 counts/100mL	PWQO (MOE 1994)
Other	Chloride	100 mg/L	CWQG (CCME 2005)
Other	Suspended Solids	25 mg/L	BC MOE (2001)
Biological	Benthic Invertebrates	Unimpaired	BioMAP (Griffiths1999)

The Water Quality Index (WQI) is used by the NPCA to summarize water quality data collected from NPCA surface water quality monitoring stations for reporting and communication purposes. The WQI was developed by a sub-committee established under the Canadian Council for Ministers of the Environment (CCME) Water Quality Guidelines Task Group to provide a convenient means of summarizing complex water quality information and communicating it to the public (CCME 2001). The WQI incorporates the number of parameters where water quality objectives have been exceeded, the frequency of exceedances within each parameter, and the amplitude of each exceedance (NPCA 2010a). The index produces a number between 0 and 100 which represents the worst and best water quality, respectively. These numbers are divided into five descriptive categories that range from *poor* to *excellent* (Table 9).

Surface water quality is monitored at 14 stations by the NPCA in the Upper Welland River watershed through the collection of grab samples on a monthly basis during the ice-free season. (Figure 15) Water quality sampling was initiated between 2002 and 2007 and samples are analyzed for several parameters including nutrients, metals, bacteria, suspended solids and general chemistry (Table 8). The sampling sites are as follows: 2 stations are located in Buckhorn Creek, 2 stations in Oswego Creek, 1 station in Elsie Creek, 1 station in Mill Creek, and 8 stations in Welland River West. Three of the Welland River monitoring

stations (WR000, WR001 and WR002) have been established to monitor water quality impacts of the Hamilton International Airport. Both Buckhorn Creek stations BU000 and BU001 monitor potential impacts of the Glanbrook Landfill.

The summarized water quality data collected between 2002 and 2009 indicates that all stations for the Welland River and its tributaries in the study area have a water quality index rating of poor with mean total phosphorus at all stations greatly exceeding the provincial objective. Sources of total phosphorus include manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides (NPCA 2010a).

The headwater stations (WR00A, WR000) are impacted by elevated concentrations of *E. coli* and phosphorus (Table 11). Sources of phosphorus and bacteria include runoff from agricultural land use, animal waste, soil erosion and sewage discharge (NPCA 2010a). The baseflow at both stations is influenced by groundwater discharge and during summer months station WR00A is sustained entirely by groundwater discharge (NPCA 2010a). The poor water quality rating at headwater stations WR001 and WR002 is due to elevated concentrations of chloride, phosphorus, *E. coli*, copper and zinc. All samples collected were found to exceed the provincial objective for zinc (Table 11). A potential source of zinc could be leaching from galvanized roofing material from the Hamilton airport complex (NPCA 2010a). In addition, stormwater and glycol discharges from the airport are also sources of impairment at these stations (NPCA 2010a). The remainder of the Welland River water quality stations (WR003 to WR006) in the study area are most impacted by nutrient enrichment and elevated concentrations of suspended solids. As previously indicated, sources of nutrients and suspended solids include runoff from agricultural land use, soil erosion, sewage discharge and animal waste (NPCA 2010a).

Table 9: CCME Water Quality Index Categories (CCME 2001)

Category	Water Quality Index	Description
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The remaining water quality stations in the study area (Oswego Creek, Buckhorn Creek, Mill Creek, and Elsie Creek) report frequent exceedances of the provincial objective for *E. coli.* Sources of *E.coli*. in these tributaries include runoff from urban and agricultural land use, sewage discharges, and the presence of waterfowl (NPCA 2010a). Elsie Creek, Oswego Creek, and Buckhorn Creek stations also report frequent exceedances of chloride for the guideline for irrigation water. Likely sources of chloride in these tributaries include stormwater runoff, de-icing salt applied to roads, and sewage discharges (NPCA 2010a). In addition, the water quality in Oswego Creek is also being impacted by elevated concentrations of suspended solids as a result of soil erosion and agricultural land use.

Biological Monitoring and Assessment Program

Benthic macroinvertebrate sampling has been completed at surface water quality monitoring stations using the Biological Monitoring and Assessment Program (BioMAP) protocol. Benthic macroinvertebrates are defined as the larger organisms inhabiting the substrate of waterways for at least part of their life cycle. Benthic macroinvertebrate species that are commonly found in the Niagara Peninsula include clams, snails, leeches, worms, and the larval stages of dragonflies, stoneflies, caddisflies, mayflies and beetles. At sites where water quality is impaired, the organisms found are less sensitive and therefore more tolerant to environmental stresses than organisms that would have historically occurred. The benthic population at an impaired site would typically be dominated by these more tolerant species, and as a result, biodiversity at the site would be quite low.

Benthic invertebrate samples are collected during the spring and fall at 14 of the 14 stations in the Upper Welland River study area using the BioMAP protocol to assess water quality. Results from 13 of the 14 stations where BioMAP assessments were completed report impaired water quality (Table 11). Sediment loading, lack of in-stream habitat, and nutrient enrichment are the primary causes of impairment at all stations (NPCA 2010a). Stormwater and glycol discharges from Hamilton Airport are having a negative effect on benthic invertebrates at stations WR001 and WR002. Recent NPCA reports recommend that Hamilton International Airport review its stormwater and glycol management practices in order to improve the water quality in the Upper Welland River (NPCA 2010a). One station, WR004, falls within the *grey zone* BioMAP designation. This designation means that the animal community at this site does not indicate a clear impairment nor fully match unimpaired conditions (NPCA 2010a). Likely causes for a higher rating at this site include improved habitat and a continuous flow from the Binbrook Reservoir (NPCA 2010a).

Provincial Groundwater Monitoring Network (NPCA 2010a)

The Provincial Groundwater Monitoring Network (PGMN) is a province-wide groundwater monitoring initiative designed to collect long-term baseline data on groundwater quantity and quality in special areas of interest. Groundwater is monitored through a network of monitoring wells located throughout the NPCA watershed in locally significant hydrogeologic areas. The NPCA currently operates 15 monitoring wells in partnership with the MOE as part of the PGMN; 3 of these wells fall within the Upper Welland River Watershed study area.

Monitoring wells are instrumented with datalogging equipment which record hourly groundwater levels at all stations and groundwater quality samples are collected twice yearly from 13 of the 15 wells during the spring and fall.

The first round of groundwater quality samples were collected by the NPCA and MOE between 2002 and 2004 and analyzed by the MOE laboratory for a wide range of parameters including metals, nutrients, volatile organic compounds (VOCs), pesticides and general chemistry. Results from the first round of sampling generally indicate that water quality is good relative to natural bedrock conditions. VOCs and pesticides were not detected in any first round samples. Routine groundwater quality sampling was initiated in 2006, and samples are collected annually by the NPCA during the spring and fall seasons. Groundwater quality samples are analyzed for bacteria, nutrients, metals, and general chemistry.

Exceedances of the Ontario Drinking Water Standards (MOE 2003) are flagged by the MOE and are reported to the NPCA, Region of Niagara Public Health Department, and local

municipalities. Wells with reported exceedances are subsequently re-sampled by the MOE to confirm the initial exceedance. Confirmed exceedances of the Ontario Drinking Water Standards (MOE 2003) at NPCA PGMN wells sampled between 2002 and 2009 are summarized in Table 10 (NPCA 2010a).

Table 10:Summary of confirmed exceedances of Ontario Drinking Water Standards at NPCA PGMN wells (NPCA 2010a)

Station	Parameter Exceeded	Probable Source(s)
W0000080	Fluoride, Sodium	Natural groundwater conditions
W0000287	Sodium	Natural groundwater conditions
W0000288	Sodium	Natural groundwater conditions

Welland River Eutrophication Study

In 2008, the NPCA, MOE and EC initiated a 3 year study as part of the Niagara River Remedial Action Plan*; The Welland River Eutrophication Study.* The 3 years of field work are complete and the report is slated for completion in March 2011. The study was initiated in response to the technical review of Beneficial Use Impairments and delisting criteria identified in the *Niagara River RAP Stage 2 Update Report.* The primary objectives of this study are to:

- Characterize the biological response of the Welland River to high phosphorus inputs including the type, frequency, location, and timing of algal blooms, and whether oxygen depletion is occurring in relation to aquatic plant or algae overgrowth;
- Characterize concentrations of plant-available phosphorus versus sediment-bound phosphorus along the length of the Welland River;
- Develop delisting criteria for the Welland River upstream of the Old Welland Canal;
- Develop phosphorus loading targets for different subwatersheds of the Welland River upstream of the Old Welland Canal to meet delisting criteria; and
- Monitor success in meeting ambient targets for the Welland River through alterations to the existing AOC Tributary Monitoring Program (NPCA 2010b).

Monthly grab samples were collected by the NPCA at 23 monitoring stations throughout the Welland River watershed from April to November and sent to accredited labs for analysis. All grab samples were analyzed for nutrients, metals, bacteria, suspended solids, general chemistry, chlorophyll-a, and as a quality assurance/quality control measure additional samples were sent to the MOE lab for a phosphate analysis (NPCA 2010b).

In terms of total phosphorus (TP) and phosphate concentrations for samples collected during the 2008 and 2009 sampling seasons, *the Welland River Eutrophication Study Update Report: February 2010* reports a notable increase in both TP and phosphate in response to wet weather events. In regards to stations that fall within the Upper Welland River Watershed Plan study area, the *Update Report* indicates that the *"Upper Welland River stations WR00A – WR003 were found to have the lowest mean proportions of phosphate relative to TP in the order of 5-20%"* and that station *"WR004 located immediately downstream of the Binbrook Reservoir was found to have the lowest mean percentage of phosphate of all stations monitored in 2008-2009 with only 3% of the TP consisting of phosphate. The mean percentage of phosphate relative to TP at station WR003 located upstream of the Binbrook Reservoir is 20%, indicating that phosphate attenuation is occurring within the reservoir"* (NPCA 2010b).

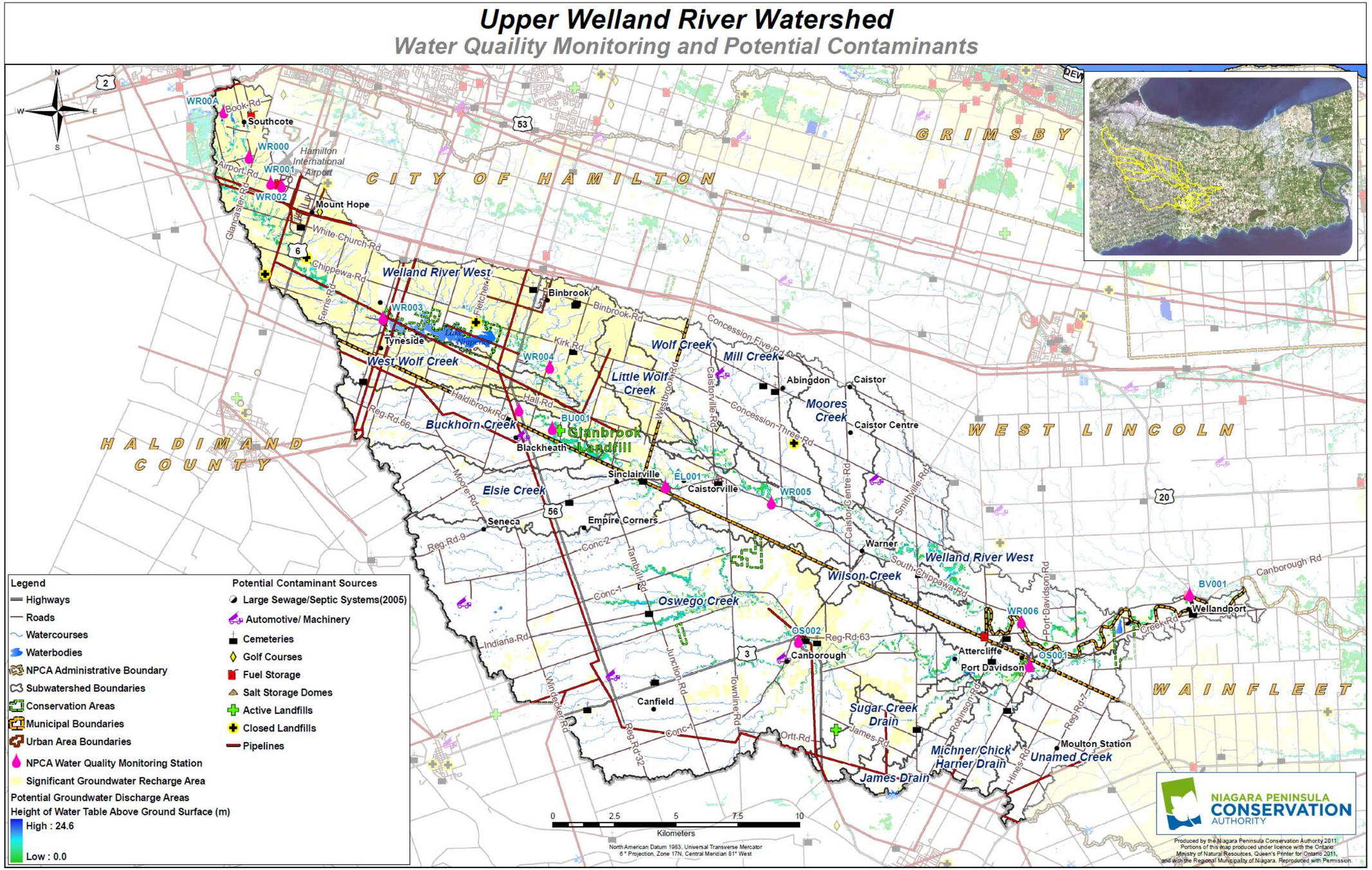

Figure 15: Water Quality and Potential Contaminants

In addition, "*phosphate concentrations are observed to increase sharply in the Welland River between WR004 and WR005. This increase in phosphate concentrations continues downstream and peaks at station WR007*(downstream of study area) *before decreasing at station WR010 due to mixing with the Niagara River*" (NPCA 2010b). In terms of Welland River tributaries, Oswego Creek stations OS001 was one of 3 stations with the highest mean TP concentrations; the other two are Beaver Creek BV001 and Tee Creek TE001 and do not fall within the Upper Welland River study area.

Four dissolved oxygen (DO) sensors were also positioned within the study area to assess the diurnal DO variations in the Welland River and Oswego Creek; in the Welland River at station WR005, downstream of station WR006 at Chippawa Creek Conservation Area, and at Colbeck Drive in the City of Welland (not in study area), and in Oswego Creek at station OS002. The logger data for all four stations show diurnal DO patterns; "*higher DO concentrations were observed during the day and lower DO concentrations were observed during the night"* (NPCA 2010b). The data also shows a decline in DO concentrations downstream of station WR005 which roughly coincides with the increased TP and phosphate concentrations at this location, as described above. Additionally, the Welland River from roughly WR005 to the siphon in the City of Welland (downstream of study area) has been delineated as a zone of walleye avoidance by the MNR (NPCA 2010b).

Table 11: Water Quality Data Monitored by the NPCA in 2010

Station	Water Quality Index	BioMAP Rating	Factors Affecting Water Quality
Buckhorn Creek BU000	Poor	Impaired	• Exceedances of *E. coli*, chloride and total phosphorus • High sediment loading evident from upstream erosion and runoff • Evidence of nutrient enrichment • Low baseflow conditions in summer • Adequate upstream forest and riparian buffer.
Buckhorn Creek BU001	Poor	Impaired	• Exceedances of *E. coli*, chloride, and total phosphorus • High sediment loading evident from upstream erosion and runoff • Evidence of nutrient enrichment • Low baseflow conditions in summer • Adequate upstream forest and riparian buffer
Elsie Creek EL001	Poor	Impaired	• Exceedances of chloride, *E. coli* and total phosphorus • High sediment loading evident from upstream erosion and runoff • Nutrient enrichment from upstream agricultural areas • Algae observed during summer months
Oswego Creek OS001	Poor	Impaired	• Exceedances of *E. coli*, total phosphorus and suspended solids
Oswego Creek OS002	Poor	Impaired	• Exceedances of chloride, *E. coli*, total phosphorus and suspended solids • Sediment loading evident from upstream erosion or runoff • Nutrient enrichment from upstream agricultural areas
Mill Creek MI001	Poor	Impaired	• Exceedances of total phosphorus and *E. coli*
Welland River WR00A	Poor	Impaired	• Exceedances of *E. coli* and total phosphorus • Site has continuous baseflow due to sustained groundwater discharge but hydrology has been altered upstream • Inadequate upstream forest and riparian buffer
Welland River WR000	Poor	Impaired	• Exceedances of *E. coli* and total phosphorus • Site is vulnerable to intermittent baseflow due to seasonal fluctuations in groundwater discharge • Adequate upstream forest and riparian buffer • This section of the watercourse supports some sensitive taxa such as stoneflies and mayflies
Welland River WR001	Poor	Impaired	• Exceedances of chloride, *E. coli*, total phosphorus and zinc • Watercourse is contaminated by runoff from airport property • Sedimentation caused by erosion and stormwater runoff
Welland River WR002	Poor	Impaired	• Exceedances of chloride, *E. coli*, total phosphorus and zinc • Watercourse is contaminated by runoff from airport property • Sedimentation caused by erosion and stormwater runoff
Welland River WR003	Poor	Impaired	• Exceedances of chloride, copper, total phosphorus, suspended solids and zinc • Inadequate upstream forest and riparian buffer • Sedimentation caused by upstream agricultural runoff • Evidence of nutrient enrichment
Welland River WR004	Poor	Grey Zone	• Exceedances of copper, *E. coli*, total phosphorus, suspended solids and zinc • Adequate upstream forest and riparian buffer • Site supports some sensitive taxa such as stoneflies and mayflies • Sedimentation caused by upstream agricultural runoff • Evidence of nutrient enrichment
Welland River WR005	Poor	Impaired	• Exceedances of nitrate, total phosphorus and suspended solids • Sedimentation caused by upstream agricultural runoff • Evidence of nutrient enrichment
Welland River WR006	Poor	Impaired	• Exceedances of nitrate, total phosphorus and suspended solids • Sedimentation caused by upstream agricultural runoff • Evidence of nutrient enrichment

Groundwater Resources

In 2005, a *Groundwater Study* [Waterloo Hydrogeologic Inc. (WHI) 2005] was completed for the land area within the jurisdiction of the NPCA. This study was a key component for planning and implementing measures to protect the sources of water for use by the residents of the Niagara Peninsula.

The *Groundwater Study* provides baseline data that outlines threats, potential threats and impacts to the areas groundwater resources. The study includes a series of maps illustrating recharge/discharge areas, well locations, overburden thickness, bedrock types, groundwater use, contaminant sources, and groundwater susceptibility to contamination.

In addition, the identification of vulnerable areas from possible threats is also critical to protecting our drinking water; accordingly this mapping exercise was also conducted through the Source Water Protection program. The delineation of vulnerable areas produced through the Source Water Protection program is comparable to the mapping produced through the 2005 Groundwater Study for the Upper Welland River watershed, aside from the addition of shallow bedrock vulnerability and transport pathways. Transport pathways that were considered to increase groundwater vulnerability include private water wells (including unused wells needing decommissioning), „unknown' status oil and gas wells, aggregate operations, and construction activities along the Welland Canal (outside of study area) (NPCA 2010c).

Potential Groundwater Discharge and Significant Groundwater Recharge areas (SGRA's) are illustrated on Figure 15 as identified through the Niagara Peninsula Source Protection Area *Assessment Report* (NPCA 2010c). Discharge areas are locations where groundwater leaves the aquifer and flows to the surface. Groundwater discharge occurs where the water table (or potentiometric surface) intersects the land surface. Potential discharge areas in the Upper Welland River include the Welland River valley below the Fort Erie Moraine and the Oswego Creek valley lands. The potential height of the water table ranges between 0 and 30 metres below the ground surface at these sites.

Groundwater recharge areas are locations where water is transmitted downward to an aquifer. The amount of water that infiltrates to the water table depends on, for example, vegetation cover, slope, soil composition, surficial geology, and depth to the water table. SGRA's are identified where the groundwater is recharged by a factor of 1.15 or more than the average recharge rate for the whole NPCA watershed. The average recharge rate for NPCA is 46 mm/year and the criterion 53 mm/year. The estimates of recharge were determined through HEC-HMS continuous surface water modelling. HEC-HMS catchment recharge results were distributed using infiltration factors that are a function of topography, land cover and soil texture (Campbell 2011).

In the Upper Welland River watershed, SGRA's have been identified along the Fort Erie Moraine and the Dunnville Sand Plain where the fine textured clay has been overlain with coarser material such as till and sand. Water that infiltrates to the water table may carry contaminants with it. Therefore, these areas are considered groundwater sensitive. Additionally, the *Clean Water Act (MOE 2006)* requires the delineation and protection of these vulnerable areas. Under *The Clean Water Act-Ontario Regulation 187/07* a SGRA is defined as "*an area within which it is desirable to regulate or monitor drinking water*

threats that may affect the recharge of an aquifer". As described earlier, recharge areas are classified as „significant' when they supply more water to an aquifer used as a drinking water source that the surrounding area. Once SGRA's are delineated, they are further subdivided by areas of groundwater vulnerability (NPCA 2010c).

Figure 16 illustrates areas with high, medium and low groundwater vulnerability. The Upper Welland River watershed has been delineated as having predominately low groundwater vulnerability due to the thick deposits of clay and silt of the Haldimand Clay Plain. This material restricts the downward movement of infiltrating surface water, making the underlying groundwater much less susceptible to associated contamination (WHI 2005). However, the Dunnville Sand Plain and areas along the Niagara Falls Moraine in the headwaters have been delineated as Highly Vulnerable Aquifers (HVA) through the NPCA *Groundwater Study* and the *Assessment Report* and therefore have a high groundwater vulnerability due to the high permeability of the overburden with little to no low conductivity layers overlying the aquifer. Under *The Clean Water Act-Ontario Regulation 187/07* an HVA is defined as *"an aquifer on which external sources have or are likely to have a significant adverse effect, and includes the land above the aquifer*". Highly Vulnerable Aquifers are illustrated in red on Figure 16.

Areas of medium groundwater vulnerability are found in the central portion of the study area. These areas typically coincide with areas where the overburden is less than 20 meters in thickness. These areas are illustrated in orange on Figure 16.

Upper Welland River Watershed
Groundwater Vulnerability

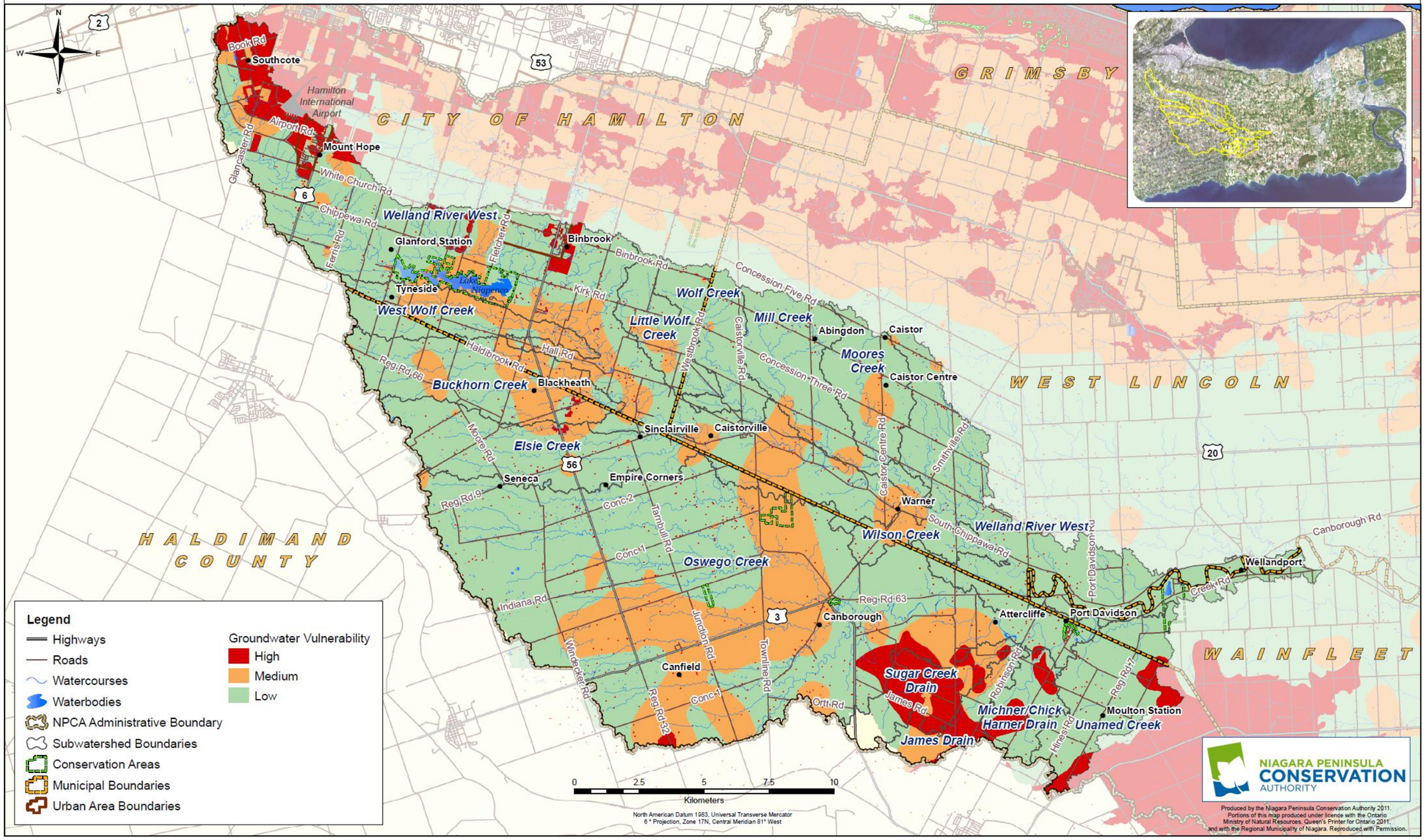

Figure 16: Groundwater Vulnerability

Intake Protection Zone Study

All Ontarians have the right to clean water, not only for recreational purposes but also for bathing, drinking and cooking. In Ontario over 80 percent of the population receives their drinking water from municipal sources (O'Connor 2002). In Ontario, the provincial government launched a *Source Water Protection* program to address the need for better protection of water resources from contamination or overuse. A facet of source water protection was the passage of the *Clean Water Act* (CWA) in 2006 by the provincial government. The purpose of the *CWA* (MOE 2006b) is to protect existing and future sources of drinking water supplies.

Accordingly, the RMN and the City of Hamilton have completed a *Surface Water Vulnerability Study* for each of their Water Treatment Plant (WTP) intakes. There are no areas in the Upper Welland River watershed that receive services from Regional Niagara's WTPs; however Mt. Hope and Binbrook receive services from the Woodward Water Treatment Plant in Hamilton. The Woodward WTP is located along the southern shore of Lake Ontario, east of Hamilton Harbour. The Woodward WTP obtains its source water directly from Lake Ontario.

The main focus of the *Surface Water Vulnerability Study* was to characterize the aquatic and upland features of the area surrounding the WTP intake, delineate the Intake Protection Zone (IPZ) around the intake, and assess the vulnerability of this intake to drinking water threats that are located within the IPZ.

The *CWA* (2006b) required the Conservation Authorities across Ontario to establish source protection committees under the guidance of the provincial government with the Chairman of the committee being appointed directly by the province. There are 19 Source Protection Regions/Areas established in Ontario, each with a respective Source Protection Committee. The work of the committee includes mapping vulnerable areas around municipal drinking water sources, identifying and assessing risks to municipal drinking water, and ultimately developing and implementing plans for safeguarding rivers, creeks and other sources of surface and ground water for municipal drinking water supplies within their geographic jurisdictions. Therefore, the *Surface Water Vulnerability Study[s]* are being used by the Niagara Peninsula Source Protection Committee and Halton-Hamilton Source Protection Team to prepare an *Assessment Reports (AR)* and a *Source Protection Plans (SPP)* for their respective jurisdictions which are required under the *CWA* (MOE 2006).

The purpose of the *AR* (NPCA 2010c) is to assess the quality and quantity of municipal drinking water supplies across the source protection area. The *AR* identifies significant threats including potential future threats that could impact our drinking water sources (NPCA 2010c). Based on the analysis for the Welland IPZ area, there are no significant threats in the IPZ zone immediate surrounding the intake. This intake does not have an IPZ-2 zone.

Upon approval of the *Proposed Assessment Report* by the MOE, the report will be used to prepare a *Source Protection Plan*. The purpose of the *SPP* is to eliminate or reduce significant threats to municipal drinking water sources that are identified in the *AR* (NPCA 2010c). The *SPP,* which should be completed by 2012, may require municipalities to restrict future land use activities within the area of the Intake Protection Zone, in order to protect the municipal drinking water source (Wright 2007). The *SPP*

"*could use various types of policies ranging from outreach and education to incentive plans to risk management plans or even prohibition of certain activities"* (NPCA 2010c).

The *CWA* (MOE 2006) also requires that decisions made under the *Planning Act* or the *Condominium Act* (MMAH 1990,1998) shall conform to the significant threat policies and designated Great Lakes policies set out in the SPP's; the *Source Protection Plan* „prevails' in the case of a conflict with official plans and zoning by-laws, although subject to "*the provision that provides the greatest protection to the quality and quantity of any water that is or may be used as a source of drinking water prevails"* (MOE 2006, CWA Section 39). Therefore, while no policies are in place yet, once the *SPP* is approved, it could restrict future land use activities within the areas of the Intake Protection Zones. However, no IPZ areas fall within the Upper Welland River Watershed Plan study area.

Water Quantity

Water Budget

Under the *Clean Water Act* (MOE 2006), one of requirements of the Assessment Report Technical Rules is that each Source Protection Region/Area must complete a Tier 1 Water Budget. The purpose of the Tier 1 Water Budget in Niagara Peninsula is to:

- Estimate the hydrologic stress of each watershed planning area in order to screen out areas that are unstressed with respect to water quantity
- Highlight areas where the reliability of water supplies is questionable
- Delineate significant groundwater recharge areas

The Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment (NPCA 2010d) contains an analysis of the water inflows and outflows within each watershed planning area, for example, the Upper Welland River Watershed Plan study area. The inflows include precipitation, lateral groundwater inflows, surface water inflows from upstream catchments, and water diversions. Outflows include evapotranspiration, surface water discharges (e.g. Oswego Creek into Welland River), water takings by industry, residences and agriculture, and lateral groundwater outflow.

A *Water Availability Study* (WAS) (AquaResource Inc 2009) was completed for each watershed planning area by analyzing the inflows and outflows using computer models. The purpose of the *WAS* was to determine the water available for surface water flow, groundwater recharge and evapotranspiration on a monthly basis for the time period 1991 to 2005. This time period was chosen to best suit available datasets and meet the minimum World Meteorological Organization climate normal criterion of fifteen years.

Once the *WAS* were completed, the Tier 1 Water Budget focused on anthropogenic water takings and water consumption, to determine if the watershed planning area was stressed hydrologically. *The Tier 1 Water Budget and Water Quantity Stress Assessment* (NPCA 2010d) ties in the *Water Availability Study* and a Stress Assessment. The report includes a watershed characterization (climate, topography, geology, physiology, land cover, soils, streamflow), watershed modelling (model set-up, calibration, verification, sensitivity, results, and uncertainty), water taking analysis and stress assessment, as well as conclusions and recommendations. The Stress Assessment was completed for both surface water systems and groundwater systems;

these assessments were conducted separately. A system is considered moderately or significantly stressed if the demand exceeds a provincial benchmark threshold value Table 12 (NPCA 2010d).

Table 12: Provincial Benchmark Threshold Values		
Potential for Surface Water Stress Thresholds		
Stress Level Assignment	**Maximum Monthly % Water Demand**	
Significant	> 50%	
Moderate	20% to 50%	
Low	< 20%	
Potential for Groundwater Stress Thresholds		
Stress Level Assignment	**Average Annual**	**Monthly Maximum**
Significant	> 25%	> 50%
Moderate	> 10%	> 25%
Low	0 to 10%	0 to 25%

The Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment (NPCA 2010d) identified the Upper Welland River watershed as having a moderate surface water stress level based on provincial benchmark threshold values (Table 12). A moderate stress level is assigned to surface water systems where the maximum monthly water demand consists of 20% to 50% of the surface water supply. The Upper Welland River was also identified as having a low groundwater stress level. A low stress level is assigned to groundwater systems where the demand for monthly maximum ranges between 0 to 25% or the average annual is between 0 to 10% of the groundwater supply

Additional benefits that will result from the completion of the *Tier 1 Water Budget* include; this project will satisfy one of the Niagara Water Strategy objectives which is to prepare water budgets for watersheds within Niagara Region; and the project will aid the NPCA when commenting on Permit-To-Take-Water (PTTW) applications (Wright 2009).

In Ontario, water takings (both surface and ground) are governed under the *Ontario Water Resources Act* (MOE 1990) and the *Water Taking and Transfer Regulation*. Under the *Ontario Water Resources Act* "*a person shall not take more than 50,000 litres of water on any day by any means except in accordance with a permit issued by the Director"* (Section 34.3).

Currently in the Upper Welland River Watershed Plan study area there are 33 PTTW. Two of these permits are in the Township of Wainfleet, 4 in West Lincoln, 8 in the City of Hamilton, and 19 in Haldimand County. Fifteen of these permits are for surface water intakes, 11 are groundwater intakes and the remaining 7 permits are for a combined surface water and ground water intake. The purposes for these permits are as follows: 8 are for agricultural purposes, 7 commercial, 2 for water supply, 3 are recreational, and the remaining 13 are for miscellaneous purposes such as wildlife conservation, dams and reservoirs (MOE 2009).

Identification of Challenges in the Upper Welland River Watershed

The *NWS* (RMN 2006a) summarized a list of key water protection issues in the Upper Welland River watershed. Additional issues will be identified by residents living in the watershed via public open houses and workshops in the fall of 2009 and spring of 2010. A *Land Management and Agricultural Best Management Practice* survey (NPCA 2006a) (Appendix A) helped to identify land and water management issues in rural areas of the watershed. A description of the challenges facing the Upper Welland River watershed are reported here.

Landfill Sites

Three known closed dump/fill sites in the Upper Welland River watershed were identified in the *Groundwater Study* (WHI Ltd. 2005). Landfill sites labelled as "old dump/fill sites" are areas that were once used as a dump or landfill. The subwatersheds where these sites are located are as follows; one in Mill Creek and 2 in Welland River West. The *NWS* (RMN 2006a) has identified concern that potential leachate could be discharging from these old dump/fill sites. There are also 2 active landfills in the study area; Canborough landfill on James Road in the Oswego Creek subwatershed in Haldimand County and Glanbrook landfill in the Welland River West subwatershed in Hamilton.

In 2008 the NPCA conducted water quality assessments at six sites upstream and downstream of the Glanbrook Landfill to determine if landfill activities are having a negative impact on water quality in the Welland River and Buckhorn Creek. The assessments consisted of the collection of benthic macroinvertebrates using the BioMAP protocol and chemical sampling following the Provincial Water Quality Objectives. The sampling sites were selected based on previous NPCA assessments that have been carried out intermittently since 1996. The sampling results indicate impaired water quality at all sites; however the level of impairment at sites located downstream closely match the level of impairment at upstream stations. Based on these results, it is concluded that the landfill activities are not causing additional water quality impairment to Buckhorn Creek and the Welland River (NPCA 2009a).

PFOS Compounds at Binbrook Reservoir

In 2009, Environment Canada discovered higher than expected amounts of perfluorooctanesulfonic acid (PFOS), a persistent organic pollutant (POP), in plasma from turtles in the Binbrook Reservoir. The study findings were communicated to the NPCA, EC and the MOE in early 2010. Researchers recommended additional studies on sport fish to determine if humans were at risk for exposure to PFOS. Fish were harvested from the reservoir in early 2010. In addition, samples of fish collected in 2009 were re-analyzed for PFOS. In late 2010, the MOE confirmed that some of the samples taken from the reservoir exceeded the fish consumption advisory levels. Based on this new information, the MOE and the MNR revised the sport fish consumption advisory for Binbrook Reservoir in the *2011-2012 Guideline to Eating Ontario Sport Fish*. Since the NPCA operates a popular ice fishing program at Binbrook, starting in January, NPCA staff produced an information sheet for distribution to park visitors.

The MOE is conducting a sampling survey of sediment upstream and downstream of the Binbrook Reservoir to potentially identify the source of the contamination and any remedial action that may need to be taken. Part of this study will also include additional fish samples and wildlife to be analyzed for PFOS contamination, which may result in other changes to the consumption guidelines if adverse results are found. The NPCA will be advised of the findings along with other agencies/landowners impacted by the contamination (NPCA 2011).

Hamilton International Airport

Runoff from Hamilton International Airport (HIA) has been identified as a key issue in the *NWS* (RMN 2006a).

Since 1998 the NPCA has carried out annual biological assessments of water quality for Hamilton International Airport to determine if stormwater runoff and de-icing fluids such as propylene glycol are impacting surface water quality in two headwater tributaries of the Welland River (NPCA 2009b). Samples are collected at three separate locations; one reference site on a neighbouring tributary (not affected by airport operations), and two downstream from the airport.

Monitoring results from 2008 and previous years continue to demonstrate that propylene glycol and stormwater management practices implemented by HIA are not meeting water quality improvement objectives and water quality has shown marginal to no improvement in both East and West Creek since annual biomonitoring was initiated in 1998 (NPCA 2009b).

As previously mentioned this area is undergoing an Airport Employment Growth District Study (AEGD). This area presents unique challenges in terms of protecting stream corridors and natural heritage features due to the "*myriad of small headwater features, combined with restrictions on open water/wetland features imposed by the airport*" (Dillon et al 2009). Accordingly, an aspect of the AEGD is a Stormwater Management and Subwatershed Plan which is currently in draft stage. This study will provide detailed information regarding existing watercourses and related ecosystems, requirements for management of stormwater and of natural areas, as well as storm drainage opportunities and constraints (Dillon 2008).

Septic Systems

The basic design of a septic system includes a septic tank and a drainage field. Wastewater from toilets, bathtubs, sinks and other drains flows into the tank where bacteria that is naturally found in the wastewater breaks down any solid material. The liquid effluent travels through the perforated distribution pipes to the leaching bed. The water is then absorbed and filtered by the ground in the drainage field. Problems with septic tanks often stem from improper use and maintenance. Faulty septic systems can create serious local contamination problems with the potential to contaminate groundwater wells (Pollution Probe 2004).

Faulty or improperly maintained septic systems have been reported as a concern by participants in the *Land Management Issues and Agricultural Best Management Practices* survey (NPCA 2006a). A septic system maintenance and education program

could improve local septic system operation and well water quality for groundwater users in the watershed. The watershed strategy will put forth a set of recommendations for this type of watershed initiative.

Storm Water Management

A lack of stormwater management facilities to treat runoff in the study area has been identified as a key issue in the *NWS* (RMN 2006a). During a rain event, stormwater remains on the surface collecting contaminants instead of seeping into the ground as it would in a natural system. As a result, stormwater accumulates and runs off in great amounts, creating the potential for flooding and erosion (Pollution Probe 2004).

Several strategies can be implemented to achieve stormwater management that aims to reduce stormwater runoff. One method involves storing excess water on or near the site, and releasing it slowly over a long period of time. Detention basins are used to slow the rate of delivery of stormwater by discharging the captured water at a specified rate to receiving water bodies. Another method involves returning the excess water to the ground where it would have gone prior to development. Additional stormwater management methods will be identified as part of the watershed strategy.

The major urban land use in the Upper Welland River watershed is the area surrounding the airport. Currently much of this area does not have water and wastewater services, however, as previously indicated, a Stormwater Management and Subwatershed Plan is being completed as part of the AEGD; this document is currently in draft stage. Included in the scope of this study is a detailed analysis of the existing storm drain infrastructure and the identification of areas that are at or above capacity based on existing land use, as well as any changes in storm flows that will result from any proposed land use changes (Dillon 2008). While it is not currently serviced, the purpose of the AEGD Secondary Plan is to include the lands around the airport within the urban area which is fully serviced with water and wastewater.

In addition, City of Hamilton has developed a city-wide *Stormwater Master Plan* (Aquafor Beech Limited 2007) that provides a framework for the City to develop and implement appropriate stormwater strategies that will protect, enhance and restore the natural resources of the Watersheds that are situated within the City boundary under existing and future land use scenarios. The guiding principle of the Stormwater Master Plan is to treat rainwater as a resource to be protected and managed rather than as a waste product that needs to be quickly moved from is point of contact (Florio 2009). Examples of stormwater best management practices are listed in Appendix B.

Road Salt

Originating from salt storage and snow disposal sites as well as from runoff, road salts are an environmental concern because they are known to have an adverse effect on freshwater ecosystems, soil, vegetation and wildlife (EC 2004a). In April 2004, Environment Canada produced a *Code of Practice for the Environmental Management of Road Salts*. The *Code of Practice* recommends that all road authorities prepare and implement salt management plans that incorporate the implementation of best management practices (BMP) for salt application, salt storage and handling, and snow disposal. The benefits of improved salt management include:

- a reduction in corrosive damage to salt application equipment, vehicles, and infrastructure such as concrete sidewalks and steps;
- a reduction in salt damage to vegetation and surrounding roads and walkways;
- reduced salt releases to surrounding waterways; and
- an overall, more efficient and effective service resulting in safer roads and sidewalks for users (EC 2004b).

With over 3000 centreline kilometres of roads in the City of Hamilton that people rely on for safe transport, user safety remains the most important priority for winter maintenance operations (Ecoplans Ltd 2003). Accordingly, the City of Hamilton's *Salt Management Plan* (Ecoplans Ltd. 2003) ensures that roads are properly maintained in a safe condition while addressing concerns about the impact that road salt is having on the natural environment. A summary of their management goals in terms of environmentally sensitive areas include; to monitor Environment Canada's approach to addressing ESA's, identify salt sensitive areas within the City, develop strategies for reducing salt use affecting ESA's, establish criteria and indicators for determining impact, and develop a monitoring program in accordance with guidelines being developed by Environment Canada (Ecoplans Ltd 2003).

In 2005, the Regional Municipality of Niagara undertook a *Salt Vulnerability Study* (Ecoplans Ltd), which identified vulnerable areas from road salt for land use, surface water, groundwater, and natural areas.

Land use vulnerability in the Upper Welland River watershed that falls within the Region of Niagara has been ranked as having a moderate to low vulnerability to road salt. This low vulnerability is associated with the impermeable soil groups of the area, the tolerance level of the crops to salt that are typically grown in this area, and the traditional agricultural practices that are exercised.

Surface water runoff vulnerability in the study area is predominately high due to the relatively flat topography and the low infiltration capacity of the Haldimand Clay Plain. The Dunnville Sand Plain however, has a low vulnerability to salt runoff due to the high infiltration rate of the sand deposits resulting in less water being available for surface runoff, thereby representing a reduced risk of surface water contamination. Therefore, the higher the runoff potential, the higher the vulnerability of surface water features to road salt contamination. Similarly, majority of the wetland and fish habitat features in the Upper Welland River watershed have been ranked as having a high and moderately high vulnerability to road salt.

On the contrary, the situation is reverse in terms of groundwater vulnerability, whereas groundwater vulnerability has been ranked as high to moderately high around the Dunnville Sand Plain due to the high infiltration rate of the sand deposits; the remainder of the study area has a relatively low groundwater vulnerability to road salt.

It is important to note that the Regional Niagara salt vulnerability study only assessed risk for Regional roads. Municipal roads should also be assessed to better identify salt vulnerable areas in the watershed.

In the 2009-2010 winter season Niagara Region initiated a pilot study whereby a liquid organic de-icing/anti-icing product was used as an alternative winter control product. The regional roads within the lower portion of the Welland River West subwatershed were

included in the pilot study; these roads were identified as having a high salt vulnerability ranking in the RMN *Salt Vulnerability Study* (Ecoplans Ltd 2005). The organic product is a sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent. The organic product was found to outperform the standard salt brine mixture requiring fewer applications. Not only does this provide financial benefits, but fewer applications results in less salt being released into the environment. Based on the "*reported 2009/2010 winter season salt usage of 17,937 tonnes, between 4,220 to 6,833 tonnes less salt would be released into the environment resulting in a potential net savings in material costs of $200,000*" (RMN 2010).

In 2010, Haldimand County Council approved the County's Salt Management Plan. The Plan "includes references stating that the County will undertake to conduct a Salt Vulnerability Study within 1 to 5 years (Nasir Mahmood Personal Communication).

Nutrient Management

Concerns over nutrient management were also identified in the *NWS* (RMN 2006a) and in the *Land Management and Agricultural Best Management Practices* (NPCA 2006a) *survey* distributed to agricultural land owners. Nutrients derived from manure and chemical fertilizers are necessary for farm production.

However, the improper use of nutrients can result in soil-nutrient imbalances and it can impair water quality locally and downstream of a farm. In order to maintain soil and water quality, in 2002 the Ontario government introduced the *Nutrient Management Act* [Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA). As of September 2003, new livestock farms that are over 5 Nutrient Units (NU) and existing livestock farms expanding to 300 NU or more are required to complete a nutrient management strategy (NMS) that includes information on its operation, how much nutrient is produced, how it will be stored, an analysis of its nutrient content, and where it will be used. In Niagara, only roughly a handful of farming operations currently have NMS in place.

A Nutrient Management Plan (NMP) must be completed for agricultural operations that apply nutrients to the land. The NMP includes information about the farm and its fields, an analysis of the nutrients to be applied, how much will be applied and at what rate, and how the nutrients will be stored (OMAFRA and OMOE 2003). The purpose of proper nutrient management is to protect surface and ground water from contamination.

Water Quality

The *NWS* has identified the water quality impairment of the Welland River as a concern. The Welland River has been the focus of much study and restoration over the years. As indicated earlier the Welland River watershed is part of the Niagara River Area of Concern as designated by the International Joint Commission in 1987 due to its degraded water quality impairing complete use of its resources. Several initiatives, as previously mentioned, have been completed through the *Niagara River Remedial Action Plan* to help address concerns over the health of the entire Niagara River watershed and its ecosystem, including for example the Welland River Eutrophication Study.

The NPCA's Water Quality Improvement Program was established to work with landowners and implement projects geared towards the improvement of local water

quality and habitat diversity. Since 1991 the NPCA in collaboration with partnering agencies have completed nearly 250 restoration projects with over 300 components in the Niagara River AOC. Over 120 of these projects with 160 components were implemented in the Upper Welland River Watershed Plan area (Figure 17). A complete list of projects types and their components that were completed in the Upper Welland River Watershed Plan area can be found in Appendix B.

In 2008, the NPCA, Ministry of the Environment and Environment Canada initiated the *Welland River Eutrophication Study*. The purpose of this study is to determine loadings of key nutrient parameters (e.g. phosphorus and nitrogen); characterize the biological response of the Welland River to nutrients by assessing algal blooms; and to determine if oxygen depletion is occurring in relation to aquatic plant growth (NPCA 2010b). The outcome of this study will assist in the development of delisting criteria for key nutrient parameters in the river, and set targets for tributary nutrient loads to meet the delisting criteria. The *Welland River Eutrophication Study* is slated for completion in 2011.

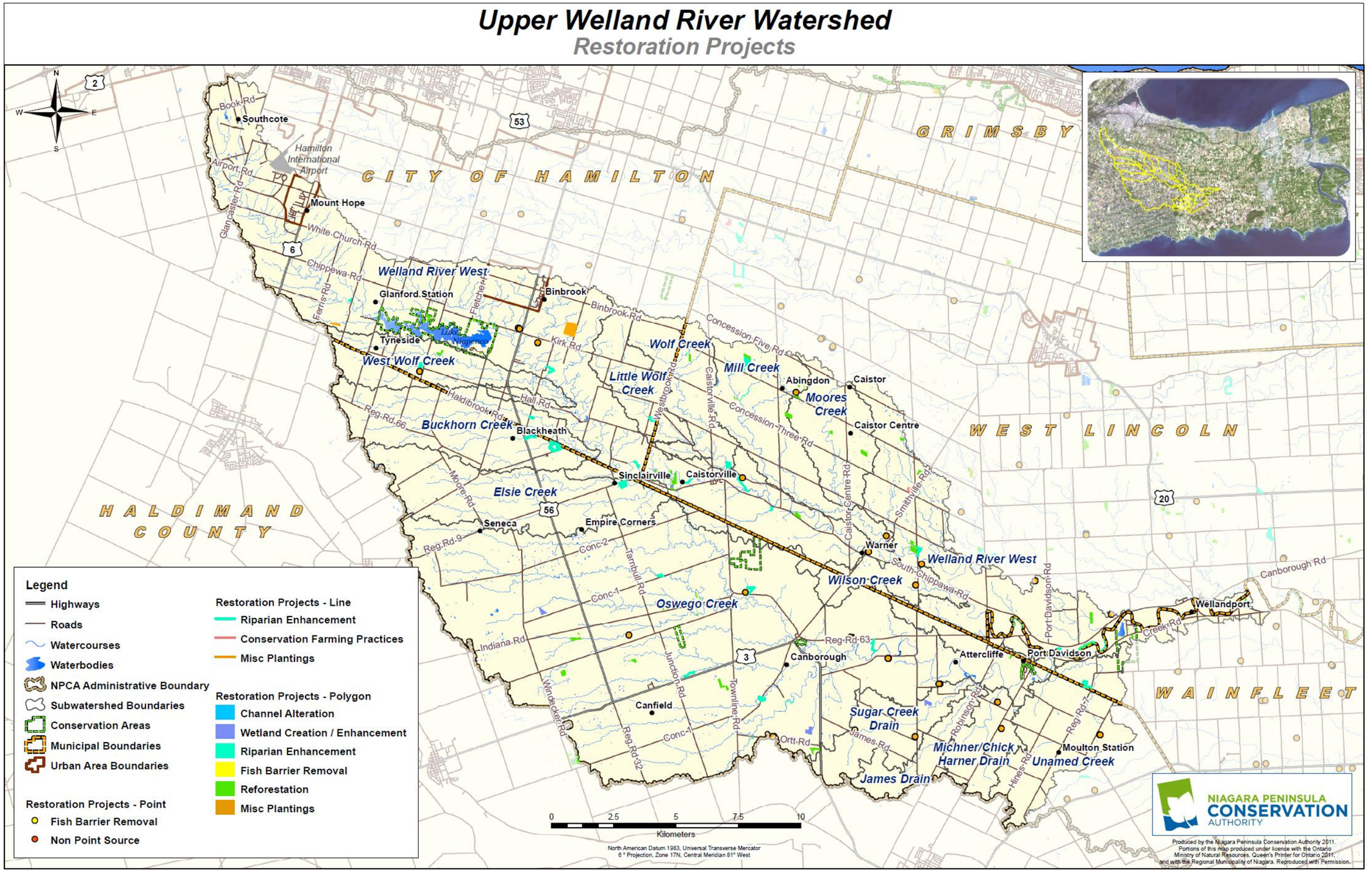

Figure 17: Restoration Projects Completed in Upper Welland River Watershed

Groundwater Vulnerability

Only a small percentage of the Upper Welland River Watershed Plan area receives municipal water and wastewater services, therefore protection of groundwater resources is very important to those communities that depend on these resources. The *NWS* (RMN 2006a), *Groundwater Study* (WHI 2005), and the Source Water Protection *Assessment Report* (NPCA 2010c) have identified areas in the Upper Welland River study area as highly susceptible to groundwater contamination; Highly Vulnerable Aquifers and Significant Groundwater Recharge Areas as described earlier. The *Clean Water Act* (MOE 2006a) requires the *Assessment Report (NPCA 2010c)* to identify and delineate these vulnerable areas within each respective Source Water Protection Area. As previously indicated and illustrated, the Dunnville Sand Plain and areas along the Niagara Falls Moraine in the headwaters have been delineated as HVA's and SGRA's due to the high permeability of the overburden with little to no low conductivity layers overlying the aquifer.

Areas of medium groundwater vulnerability are found in the central portion of the study area. These areas typically coincide with areas where the overburden is less than 20 meters in thickness. The thin overburden is unable to effectively provide the groundwater with sufficient protection from bacteria, sediment and other insoluble forms of contaminants that in a thick overburden would become trapped and filtered within the soil pores.

The *PPS* in section 2.2.1(MMAH 2005a) requires planning authorities to protect, improve or restore vulnerable and sensitive surface and ground water features, and their hydrologic functions. Likewise, it is the intent of *Haldimand County's Official Plan* to work with agencies "w*ith a role in water resource protection, to [will] protect both groundwater and surface water systems including wetlands, ponds, lakes, streams, rivers and underground aquifers from development that could adversely affect ground and surface water resources* (Section B.3.j)".

It is the intent of *Hamilton's Urban Official Plan* (2009) to restrict development and site alteration in and near sensitive surface and ground water features and tributaries; accordingly "*Mitigative measures and/or alternative development approaches may be required in order to protect, improve or restore sensitive surface water features, sensitive ground water features, and their hydrologic function"* (Chapter C Section 2.13.3).

Like the other jurisdictions, the Region of Niagara's Environmental Policies also outline objectives to protect, improve or restore ground and surface water resources by for example, outlining a number of restrictions for development and site alteration in the vicinity of vulnerable surface and ground water features (7.A.2.1).

Municipal Drain Maintenance

In addition to having a negative impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly. Naturalizing drains, especially through natural areas, is a recommendation that was made in the *NWS* (RMN 2006a). Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering the watercourse. Implementing Best Management Practices such as vegetating bare banks and maintaining a buffer strip; restricting cattle access; and allowing a slight meander to reduce bank erosion and flooding are a few measures that could potentially reduce the amount of sediment loading in the watercourse. In addition, when maintenance does occur several measures can be taken such as leaving the banks alone, working from one side of the drain and remove the vegetation at intervals. If a complete cleanout is necessary then ensure

that the banks are not cut too steep as this will just make the banks more vulnerable to erosion. However, for a watercourse or pipe to become a municipal drain there must be a by-law adopting an engineer's report. Once the municipal drain has been constructed under the by-law, it becomes part of the infrastructure of the respective municipality. The local municipality is therefore responsible for repairing and maintaining the drain. Therefore, in order to implement alternative maintenance practices, the engineers report for the respective drain will need to be re-visited. To review examples of current BMP mitigation measures, refer to Appendix I.

Nearly 70 kilometres of watercourse in the Upper Welland River watershed has been classified as municipal drain. Haldimand County began a 10 year drain maintenance cycle program; a full cleanout is not necessarily conducted every time. The drains included in this cycle are those that fall in the following subwatersheds; Black Creek Drain, Oswego Creek, Sugar Creek Drain, James Drain, and Michner/Chick Hartner Drain.

In 2010, White Church Road Drain in Glanbrook could potentially be cleaned out. Information regarding the maintenance activities on the other drains in the study area is still pending and this section will be updated upon its receipt.

Niagara to GTA Corridor

By 2031, the Greater Golden Horseshoe is expected to grow by almost 4 million people (MTO 2010). From a transportation perspective, this level of growth poses significant challenges as during peak periods many of the transportation networks are already functioning at or near capacity, therefore unable to support the predicted level of growth associated with the increase in commuter, tourist and goods movement.

To address these issues the Ontario government initiated the Niagara to GTA Corridor Planning and Environmental Assessment Study. This study was initiated to "*explore all modes of transportation, including transit, freight rail, marine, air, freight inter-modal, and roads and highways*" (MTO 2010) and to address existing and future anticipated transportation capacity deficiencies, for instance problems and opportunities, within the Niagara to GTA corridor by providing additional capacity for a 30 year planning horizon and beyond.

Since the initiation of Phase One in January 2007, several studies have been completed and released including: *Overview of Environmental Conditions and Constraints Report* and *Overview of Transportation and Socio-Economic Conditions* (MTO 2007a; 2007b); *Factors Influencing Transportation Demand in the NGTA Corridor: Discussion Paper* and *Study Vision, Purpose, Goals and Objectives: Discussion Paper* (MTO 2008a; 2008b); *Draft Area Transportation System Problems and Opportunities Report* (MTO 2009); and *Area Transportation System Alternatives Report* (MTO 2010).

The latest report, *Area Transportation System Alternatives Report* (MTO 2010) serves as a "*critical stage in the study providing a foundation for further assessment, evaluation, and selection of Preliminary Planning Alternatives that will be incorporated in the ultimate Transportation Development Strategy for this phase of the NGTA Study*" (MTO 2010). One of the key findings of this study was that "*no single mode of transportation is capable of fully addressing all of the transportation problems and opportunities*". The report outlines four transportation group alternatives made up of a number of individual alternatives. Group #1 focuses on optimizing existing networks, Group #2 focuses on new/expanded non-road

infrastructure and enhancements of Group #1, Group #3 focuses on widening and improving roads and improvements of Group #2, and Group #4 builds upon improvements provided in aforementioned 3 Groups plus new transportation corridors (MTO 2010).

Of the numerous transportation alternatives outlined in the four Groups, through Niagara and Hamilton widening of existing QEW is preferred and the monitoring of growth needs for the long term. The Upper Welland River watershed is not affected by the preferred option. The Niagara to GTA study area does not extend into the jurisdiction of Haldimand County.

Urban Expansion and the Protected Countryside

Future expansion of Binbrook has been identified as a concern in the *NWS* (RMN 2006a), in terms of affecting natural areas. In addition, this issue was also identified as a serious concern by participants of a *Land Management and Agricultural Best Management Practices* survey (NPCA 2006a). Survey participants were very concerned about the loss of agricultural land and the loss of natural areas to urban development. As indicated earlier, before an urban boundary expansion can be executed, a municipally initiated comprehensive review and secondary plan must be completed (City of Hamilton 2009).

Binbrook also falls within the designated Greenbelt area. The *Provincial Greenbelt Plan* (MMAH 2005b) has been created to provide permanent protection to the agricultural land base and the ecological features and functions by designating areas where urbanization should be limited. In the Upper Welland River watershed, Provincial Greenbelt areas include the Protected Countryside lands in the north-west portion of the study area. The Protected Countryside lands are intended to enhance the spatial extent of agriculturally and environmentally protected lands within the Niagara Escarpment Plan area as well as enhance linkages with surrounding major lake systems and watersheds.

Natural Heritage and Resources

Although municipal and regional official plans include the protection of environmentally significant areas, the loss of natural features still occurs with development. Natural features include, for example, wetlands, forests, and riparian stream cover, and they provide many ecological functions in the Upper Welland River watershed in terms of protecting water quality, moderating water quantity and providing habitat. In natural areas stormwater is more or less infiltrated where it falls, allowing most of the pollutants to be filtered through soils. When these areas are lost, and their functions not replaced with infiltration, detention or restoration measures, receiving watercourses are negatively affected with increased flows and pollutant loads.

The *NWS* has identified a severe lack of riparian buffers and a low extent of forest cover in the headwaters region of the Welland River. Recommendations and areas for potential restoration based on the guidelines set by Environment Canada (2004c) have been identified in the Restoration Strategies of the Watershed Plan.

The following is a brief summary of the benefits of each feature and its contribution to maintaining a healthy watershed.

Wetland Habitat

Wetlands can provide benefits anywhere in a watershed, but particular wetland functions can be achieved by rehabilitating and/or establishing wetlands in key locations. For example, wetlands on floodplains are ideal for flood attenuation, headwater areas for groundwater recharge and discharge, and coastal areas for fish production. Special attention should be paid to historic locations and site and soil conditions (EC 2004).

Currently, the percent of wetland cover (22%) in the Upper Welland River watershed meets Environment Canada's targets as recommendations state *10% or to historic value,* therefore, means to maintain the numbers and /or size of wetlands are included in the watershed strategy because wetlands:

- naturally filter water resources thereby improving water quality,
- act like sponges, slowing the flow of water which reduces the impact of flooding and allows for groundwater recharge,
- help to prevent soil erosion, and
- augments low-flow by raising local water tables, which helps to maintain base flows.

Riparian Cover

The area of land adjacent to a watercourse is the riparian or buffer zone. Environment Canada recommends that 75 percent of a streams length be naturally vegetated with a minimum of a 30 meter width naturally vegetated riparian zone on both sides of the watercourse. Headwater streams are highly dependent on vegetative cover for stream temperature moderation and the input of organic matter from adjacent vegetation for production.

Riparian cover in the watershed is low with roughly 55% of the watercourses having some vegetation along the watercourse. Therefore a means to improve the riparian habitat is addressed in the Restoration Strategy of the Upper Welland River Watershed Plan. Riparian buffers, like wetlands, provide many benefits to a watershed, including improving water quality. The benefits of riparian buffers include the following:

- remove sediment and pollution such as chemicals, fertilizers, pesticides, bacteria and road salt before they reach surface water,
- reduce the impacts of flooding,
- prevent erosion,
- improve water clarity, and
- provide shade and cooler water temperatures for fish and other aquatic organisms (NPCA 2003).

Upland Habitat: Woodland and Grasslands (Prairies and Meadows)

Environment Canada recommends that at least 30 percent of a watershed be in forest cover in order to support viable fish and wildlife populations. The forest habitat guidelines are designed to address habitat loss and fragmentation as two of the key factors in the decline of wildlife species, given that the amount of forest cover in a watershed determines its ability to support species diversity. The Upper Welland River watershed is below adequate levels with

15 percent of the watershed in forest cover. However, forest cover not only directly results in habitat, but forest cover is beneficial because it:

- reduces flooding and high flow events by intercepting runoff thereby encouraging infiltration,
- improves water quality by slowing the rate of runoff to watercourses, and trapping, using or breaking down some of the pollutants and nutrients found in runoff water,
- improves water quality by lowering water temperatures and shading water courses,
- improves groundwater quality by increasing the amount of rainfall that percolates to the groundwater table,
- reduces soil erosion, and
- preserves and increases flora and fauna diversity.

In addition, meadows also play an important role in creating habitat diversity and foraging areas for wildlife. Therefore, they should be given consideration in habitat creation and restoration actions in the Upper Welland River watershed.

Percent of an Urbanizing Watershed that is Impervious

Environment Canada's *How Much Habitat is Enough?* (2004) outlines numerous studies that have been conducted in regards to stream health and the amount of imperviousness to runoff in a watershed. Although not every watershed will respond uniformly as a result of varying characteristics (e.g. soil type, slope, location and amount of built-up areas) "*the most commonly chosen threshold for impervious surface is 10 percent of the land cover within a watershed*" (EC 2004) to preserve the health of the aquatic systems. For urban watersheds that have exceeded the proposed 10 percent, a "*second threshold of 30 percent or less impervious surfaces*" in addition to "*implementing and defending stormwater best-management practices*". It was reported that the "*impairment of stream quality is first noted at 10 to 12 percent impervious cover and becomes severely impaired at 30 percent watershed imperviousness*" (EC 2004). Within urbanized and/or urbanizing watersheds as such, careful planning to mitigate the impacts of impervious surfaces is necessary, for example through storm water management practices. In addition, as land uses change in the watershed, efforts should be made to decrease the amount of impervious cover by changing the land use of given properties as parcels become available.

However, none of the subwatersheds in the Upper Welland River watershed have 10 percent or more impervious cover. The subwatersheds that have the highest value are Chick Hartner Drain with 6.7 percent cover and Welland River with 6.1 percent impervious cover.

Fish and Aquatic Habitat

The need for protection and improvement of critical and important fish habitat was identified as a concern in the *NWS* (RMN 2006a). Fish habitat consists of areas that fish need, whether directly or indirectly in order to carry out their life processes including spawning grounds, nursery, rearing, food supply, and migration areas. Broadly defined, wetlands, groundwater recharge areas, aquifers, and the quantity and quality of groundwater and surface water are all important factors for maintaining the quality and quantity of fish habitat. Development activities, structures, changes in land use, and alteration to hydrology can all impact fish and fish habitat. Fish habitat can be damaged in numerous ways including:

- dredging and filling near spawning and nursery habitat,
- loss of riparian vegetation,
- stream alterations including fish barriers,
- poorly managed stormwater runoff,
- impaired water quality (e.g., sediment and nutrient loadings, increased temperature), and
- loss of groundwater recharge capability (*Fisheries Act, Section 34*).

The watershed strategy will focus on preserving Type 1 fish habitat in the watershed, and it will suggest restoration alternatives to maintain and improve Type 2 fish habitat. However, only watercourses within the Region of Niagara have been assessed in terms of importance for fish habitat. It is therefore recommended that the remaining watercourses in the Upper Welland River that have not been evaluated are assessed to assist in proper decisions regarding management of the watercourses.

Flow Augmentation of Lake Niapenco

During low periods in winter and summer when melt water, groundwater and precipitation contributions are at their lowest, the natural flow of the Welland River's low-grade, precipitation driven system is inadequate to offset reverse flow dynamics caused by the Welland Canal water introduction and water level fluctuation associated with hydro generation (Yagi and Blott 2008).

In 1971 the Binbrook dam and reservoir, also known as Lake Niapenco, was completed. The dam and reservoir serve four primary purposes which include:

- conservation of wildlife and habitat,
- flood control,
- augment low water flows downstream of the dam in the Welland River, and
- for recreational purposes (NPCA 2006b).

In 1997 the operational procedures of the dam were revised due to significant concern regarding ecosystem degradation in and around the reservoir as a result of the current fall draw down practice. It was concluded that operations which stabilize the water level would vastly improve aquatic habitat in the reservoir and enhance shoreline vegetation growth thus reducing erosion of the reservoir banks and reduce sediment loading (NPCA 2006b). In addition, landowners downstream of the reservoir preferred a reduced operating level which would allow for the capture of high runoff events and provide some degree of flood control (NPCA 2006b).

However, the effect of the flow augmentation from Lake Niapenco on downstream aquatic habitats has been identified as a concern in the *NWS.* Similarly, in the study entitled *Niagara River Watershed Fish Community Assessment (2003-2007)*, Yagi and Blott suggest "*Ongoing flow monitoring is needed to determine the amount of low flow augmentation needed to maintain fish habitat in the Welland River downstream of the reservoir*".

Climate Change

Most climatologists agree that climate change and warming of the Earth's atmosphere is occurring. In addition, there is also broad agreement that human activities are primarily responsible for the changes to global climate that have been observed during the last half of

the twentieth century (de Loë and Berg 2006). In 2007, the MNR released a report on climate projections for Ontario and how Ontario's climate could change during the 21st century. Climate models predict the effect of higher greenhouse gases based on increasing amounts of heat trapped in the atmosphere. Each modelled scenario has a different set of assumptions about future social and economic conditions "*since the amount of greenhouse gas in the future depends on highly variable factors such as global population, human behaviour, technological development and the carbon sink/source behaviour of land and water ecosystems"* (MNR 2007b).

For the Niagara region and westward to Windsor and Sarnia, the modeled projections calculate an increase in summer (April to September) average temperatures of 5 to 6 degrees Celsius and a 10% decrease in precipitation by 2071 (MNR 2007b). The winter climate for most of southern Ontario is projected to increase 1 to 2 degrees Celsius between 2011 and 2040, and could increase by 3 to 4 degrees by mid-century. In addition, most of southern Ontario could receive 10% less precipitation during the cold season (MNR 2007b). Although the projections for Ontario's future climate are not certain, it is reported by the MNR in this study that the projections are likely "*closer to future reality than assuming that the future climate will be similar to that of the past 30, 60, or 100 years"* (2007b).

The report also outlines possible impacts that climate change could have on Ontario's ecosystems, societal values and infrastructure. For example, impacts to the agricultural sector could include a possible change in crops grown, longer growing season and a reduced productivity where an increase of temperature without a compensatory increase in precipitation occurs (MNR 2007b). Examples of potential impacts to the environment include changes in biodiversity of species and ecosystems, and new species becoming „at risk' because of disequilibrium with climate (MNR 2007b). For the complete list of examples of key possible impacts that climate change could have on Ontario's ecosystems, societal values and infrastructure taken from this report refer to Appendix C.

In *Mainstreaming Climate Change in Drinking Water Source Protection Planning In Ontario*, de Loë and Berg (2006) report some of the predicted impacts climate change could have on the hydrologic cycle and water resources in the Great Lakes Basin. The hydrologic cycle is sensitive to changes in temperature, precipitation and evaporation which accordingly could result in significant changes to streamflows, lake levels, water quality, groundwater infiltration, and patterns of groundwater recharge and discharge (de Loë and Berg 2006). The following are examples of potential impacts that the predicted changes to the hydrologic cycle could have on water resources in the Great Lakes Basin as reported by de Loë and Berg (2006):

- Winter runoff is expected to increase, but total runoff is expected to decrease, thus summer and fall low flows are expected to be lower and longer lasting;
- Groundwater recharge is expected to decrease due to a greater frequency of droughts and extreme precipitation events. As a result, shallow aquifers will be more sensitive to these changes than deeper wells; and
- Water temperature in rivers and streams is expected to rise as air temperatures rise, and as summer baseflow is reduced.

These modeled or predicted impacts to water resources will affect society as well as ecosystems. Societal water use issues may arise because decreased runoff may lead to reduced water quality, resulting in increased water treatment costs and greater competition and conflict for water resources during low water or drought conditions. Ecologically, changes to wetland form and function may also experience change due to the impacts of climate

change. For example, a reduction in groundwater discharge and an increase in surface water temperature will stress fish and fish habitat (de Loë and Berg 2006).

For the summary table of identified hydrological changes expected in the Great Lakes Basin identified in this report, refer to Appendix C.

Ecological Restoration and Environmental Planning Tools

Communication and Education

Watersheds often span numerous political boundaries. Therefore, agency, non-governmental partnerships, and citizen involvement is essential to the successful implementation of the Upper Welland River watershed strategy. To facilitate communication between citizens and agencies in the watershed, a list of the major legislation and agencies governing land management in Ontario is provided in Appendix D. In addition to partnering on public and private lands, policy tools can be employed to foster environmentally responsible land and water management in the watershed.

Policy Tools and Incentive Programs

Policy tools addressing land use planning, significant natural heritage features and water quality and quantity protection can be implemented at the local or regional levels of government in the watershed. Designed to allow for continued development, and/or revitalization and intensification of developed areas, these tools ensure that issues pertaining to the protection, improvement, and enhancement of our natural resources are taken into consideration throughout the development process. Policy tools might include municipal policies, incentive-based tools as well as other water conservation related tools.

Specific examples of these policy tools are presented here. The following list is not exhaustive as new programs are frequently being implemented. For up to date information on incentive programs available in your area, please contact the respective municipality.

- **Stormwater Management Policies** require the control and treatment of stormwater discharges to prevent flooding, minimize downstream channel erosion, and protect water quality. Examples of stormwater best management practices are listed in Appendix E.
- **Riparian Buffer Policies** protect watercourses and maintain aquatic habitat. Riparian buffer guidelines should take into account the amount of natural vegetation adjacent to a stream, the width of the vegetated buffer, total suspended solid concentrations, percent imperviousness in urbanizing watersheds, and fish communities (EC 2004c).
- **Sustainable Subdivision Design** encourage the development of subdivisions whereby houses are clustered and open space is protected. Conventional subdivisions spread development evenly throughout a parcel of land. However, conservation subdivisions are considered “density neutral”, which means that the same number of lots can fit on a parcel of land, but the arrangement of the houses are clustered. Natural areas and special features such as watercourses, forest cover, sensitive areas, and heritage sites are incorporated into design.
- **Incentive-based Tools** such as **Water Conservation Programs** aid in the protection of water quality, quantity and aquatic habitat by maintaining instream flows. Thus, the natural hydrology of streams is protected during peak water demand.

- **Alternative Land Use Services (ALUS)** is a program whereby agricultural producers offer Canadians an environmental partnership opportunity by contributing the use of a portion of their land, plus labour, equipment, fuel, and money to produce environmental benefits, while encouraging investments from the rest of society to manage these benefits.
- **Land Securement Programs:** securing land into public ownership can help to protect water quality and natural heritage features. For example, maintaining the natural condition of land around watercourses is an ideal approach to enhance water quality protection. Land securement programs help protect greenspace, conserve biodiversity and promote stewardship and community involvement, e.g. **NPCA, Niagara Land Trust.**
- **Conservation Easements:** are agreements made between a landowner and conservation groups whereby the landowner still owns the property but has agreed to restrict or prevent certain land uses in order to protect the natural features on the property.
- **Heritage Properties Tax Reduction Program:** this program is designed to help property owners defer the higher maintenance and repair costs of heritage properties (RMN 2007b).
- **Heritage Restoration and Improvement Incentive Programs:** these programs are designed to provide financial incentives to encourage restoration and improvement of heritage properties in the Region of Niagara. These programs include the **Heritage Grant/Loan Program, Professional Design Study Grant Program,** and **Heritage Development Charge Incentive Program** (RMN 2007b).
- **Special Multi-Residential Tax Rate:** encourages the construction of new medium and high density rental housing by providing a special property tax rate (RMN 2007b).

Funding Sources for Environmental Projects

Several funding sources and land management tax incentive programs are available for landowners and non-profit organizations for creating, enhancing and preserving natural heritage. Examples of some of these programs follows:

Water Quality Improvement Program

The NPCA provides landowners with up to 75 percent cost-share funding (depending on the eligible project) through its Water Quality Improvement Program. Participating landowners are responsible for any remaining costs through cash and in-kind contributions. To qualify for funding the following criteria must be met:

- projects must be within the NPCA's jurisdiction;
- projects must demonstrate an improvement to local surface and/or groundwater quality;
- the landowner must demonstrate good land stewardship practices;
- the landowner must contribute financially to the project in some capacity; and
- the landowner must complete a water quality improvement application and sign a project agreement form (NPCA 2003).

Eligible projects are related to woodland, wetland and riparian habitat restoration; manure and nutrient management; milkhouse washwater treatment and disposal; livestock restriction, alternate watering systems and crossings; and conservation farm practices.

Conservation Land Tax Incentive Program

The Conservation Land Tax Incentive Program (CLTIP), offered by the MNR, was established by the province in 1998 to recognize, encourage and support the long-term private stewardship of Ontario's provincially significant conservation lands. This program provides property tax relief (100 percent for the eligible portion of the property) to landowners and non-profit organizations who agree to protect the natural heritage values of their property. Eligible lands consist of provincially significant areas identified by the MNR, and include: PSW's; provincially significant ANSI's; endangered species habitats; lands designated as escarpment natural areas in the Niagara Escarpment Plan; and community conservation lands, which are natural areas of significance owned by non-profit charitable conservation organizations and conservation authorities. Landowners whose land is eligible and who are enrolled in this program are automatically notified by the MNR during the summer before each new tax year (MNR 2004).

The Managed Forest Tax Incentive Program

The Managed Forest Tax Incentive Program (MFTIP), offered by the MNR, was established in 1998 to recognize the social and ecological benefits of forest lands. Privately owned forest land is eligible to be taxed at 25 percent of the municipal tax rate set for residential properties provided the property has at least 4 hectares of forest, is owned by a Canadian citizen, and has a Managed Forest Plan approved by a consultant designated by the MNR (Ontario Woodlot Association 2005).

Farm Property Class Tax Rate

Under the Farm Property Class tax rate, farm properties that satisfy the eligibility requirements will be taxed at 25 percent of the municipal residential rate. However, the farm residence and 1 acre of land surrounding the residence will be taxed as part of the residential class. In order to be eligible for the Farm Property Class tax rate all of the following criteria must be satisfied:

- the property must be assessed as farmland;
- the property must be used as part of a farming operation generating Gross Farm Income of at least $7,000 as reported to the Canada Revenue Agency for income tax purposes;
- a valid Farm Business Registration number is required for the business operating on the land; and
- the property must be owned by a Canadian citizen or a permanent resident of Canada (OMAFRA 2004).

Species at Risk Farm Incentive Program

The Species at Risk Farm Incentive Program (SARFIP) was launched in 2008 by the MNR to encourage greater protection and conservation of species at risk and their habitats on privately owned agricultural lands across Ontario. The program provides "*enhanced cost share opportunities for farmers who take action on selected environmental Beneficial Management Practices that play a key role in contributing to a healthy and diverse environment as well as helping sustain production and profitability on the farm*" (MNR No

Date-b). Ontario farmers may be eligible for up to 100 percent of the cost to establish a BMP project from the list of approved projects. Projects include, but are not limited to:

- riparian area management
- erosion control structures in riparian area
- improved pest management
- shelterbelt establishment, and
- enhancement of wildlife habitat and biodiversity.

Water Well Decommissioning Program

The NPCA has launched a water well decommissioning granting program for qualifying landowners with lands located within the NPCA jurisdiction. To qualify for funding the following criteria must be met:

- grants are available for the decommissioning of unused water wells only. Oil wells, gas wells and cisterns are not eligible under this program;
- the proposed work must be completed by a water well contractor licensed by the MOE as set out in Ontario Regulation 903;
- the proposed work must comply with MOE procedures for plugging or abandoning unused water wells according to Ontario Regulation 903. Details of the procedure must be documented on the water well record and submitted to the MOE by the hired water well contractor upon completion;
- a copy of the water well record must also be submitted to the NPCA by the landowner or the hired water well contractor upon completion;
- priority will be given to:
    - hydrogeologically sensitive areas (based on NPCA Groundwater Study or other studies as endorsed by NPCA),
    - projects located in areas with a high density of domestic water wells, and
    - areas where watershed plans have been completed or are on-going; and
- all proposals are subject to review and approval by NPCA staff.

Under this grant program, applicants must apply and be approved prior to initiating their project. Projects already underway or completed without NPCA approval are not eligible**.** Eligible costs include those incurred by a licensed contractor and/or licensed technician fees for water well decommissioning (as approved by the NPCA). The Grant will cover 90 percent of well decommissioning costs to a maximum of $2,000 per well (limit of two wells per property). This is a reimbursement program; the landowner will pay the full cost to the contractor, and will be reimbursed for 90 percent of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.

Abandoned Works Program

Through the MNR's Abandoned Works Program, any gas or oil well drilled before 1963 and not being used is potentially eligible for a grant that pays for the plugging of the well in full by the MNR. To be eligible for the grant, a well must be verified as an oil or gas well and have no current operator other than the landowner responsible for the well. The Petroleum Resources Centre of the Ministry of Natural Resources will investigate each well to determine if it qualifies for the Abandoned Works Program. The Province of Ontario law requires oil and gas well

operators to plug wells which are no longer used for the purpose for which they were drilled or that did not produce oil or gas. Where no operator exists, the landowner is responsible for plugging the well. If no operator or well record is found, the Ministry will evaluate the well and assign a priority ranking for consideration under the Abandoned Works Program (MNR No Date b).

EcoAction Community Funding Program

Environment Canada's EcoAction Community Funding Program provides financial support to community groups for projects that have measureable, positive impacts on the environment. Funded projects promote the participation of local communities to address clean air, climate change, clean water, and nature to protect, rehabilitate or enhance the natural environment (EC No Data). A maximum of $100,000 is available per project and the project duration may be up to 3 years. The following is a list of those that can apply for funding through the EcoAction Community Funding Program:

- Non-profit non-government groups and organizations and community groups
- Environmental groups
- Aboriginal groups and First Nation Councils
- Service Clubs
- Associations, and
- Youth and Senior Organizations

Watershed Best Management Practices

A best management practice (BMP) is a land management practice implemented to control sources or causes of pollution. The 3 types of BMPs that treat, prevent, or reduce water pollution include:

- Structural BMPs are practices that require construction activities such as stormwater basins, grade stabilization structures, and crib walls.
- Vegetative BMPs use plants, including grasses, trees and shrubs to stabilize erosion sites.
- Managerial BMPs involve policy changes or operating procedures at a site (Brown, *et. al.* 2000).

It is important to note that BMPs are available for both urban and rural areas. A brief description of urban and rural BMPs follow and a more complete list of structural, vegetative and managerial BMPs are provided in Appendix B.

Urban Best Management Practices

Urban BMPs are designed to redirect water from impervious surfaces to infiltration areas such as lawns, gardens, or forested areas. Residential landowners can minimize outdoor water consumption; plant drought-tolerant vegetation; capture rainwater for outdoor watering; avoid clearing vegetation around streams, riparian zones or floodplains; avoid channelizing streams or channels that connect to streams; avoid filling in floodplain or riparian zone areas; and discontinue the use of chemical fertilizers on their lawns and gardens. In addition to landowner BMPs in urban areas, BMPs can also be employed by local and regional governments to

reduce the impacts to water quality and quantity from stormwater. Examples of Urban BMP's can be reviewed in Appendix B.

Stormwater Best Management Practices

Stormwater BMPs are techniques, measures, or structural controls that are used to manage the quantity and improve the quality of stormwater runoff in a cost effective manner. Measures for controlling storm water include at source and lot-level controls, conveyance controls and end-of-pipe controls. Examples of Stormwater BMP's can be reviewed in Appendix B.

At Source and Lot-Level Quantity Controls

Typically *At Source and Lot-Level* controls are the most effective in providing water quality protection because they prevent pollutants from entering the drainage system and provide for flow retention at source. Most practices can assist in addressing the four criteria; quantity, quality, stream erosion, and hydrologic cycle, but they are more often associated with quality and quantity control (National Guide to Sustainable Municipal Infrastructure 2003; AECOM 2010). At Source and Lot-Level controls consist of non-structural source controls, housekeeping practices, control of construction activities, and structural at-source controls (AECOM 2010).

Conveyance Controls

Conveyance controls provide quality and/or quality control within the conveyance system between the source and outlet, to help mitigate the impacts of urbanization. They transport runoff from developed areas through storm sewers, roadside ditches, or vegetated swales (AECOM 2010).

End-of-Pipe Controls

End-of-pipe controls allow for flow attenuation, major flow conveyance, and water quality enhancement of storm water before outletting to receiving body of water. Examples include wetlands, dry ponds and wet ponds. End-of-pipe controls allow for storm water quality and quantity mitigation at or near the downstream end of the conveyance control (AECOM 2010).

Managerial Best Management Practices

Managerial BMPs can also be achieved through municipalities. Municipalities can encourage and/or regulate land use planning and management by developing ordinances to manage stormwater impacts by limiting pavement, preserving open space, and delineating areas in the watershed for more on-site stormwater management facilities. Examples of Managerial BMP's can be reviewed in Appendix B.

Agricultural Best Management Practices

BMPs can improve rural non-point source pollution problems. For example, a lack of tributary buffers, and nutrient management have been identified in the watershed (RMN 2006). Sediment control BMPs, water quality BMPs and nutrient management BMPs can be employed to mitigate the impacts of these activities on watercourses and wetlands. Examples

of agricultural BMPs are provided below and a more thorough list of agricultural BMPs can be found in Appendix B.

Sediment Control Best Management Practices

Conservation tillage results in minimum soil disturbance by leaving at least 30 percent of the soil surface covered with crop residue immediately after planting. It is estimated that conservation tillage reduces soil loss by 50-95 percent and is effective in improving water quality. Windbreaks also control sediment and simply consist of rows of trees planted around the edge of fields to reduce soil erosion by wind.

Water Quality Best Management Practices

Tailwater recovery ponds are located at the base of a drainage area. They are designed to intercept runoff before it enters a stream to treat and remove sediment and nutrients from the water. These ponds can also be used as a source of irrigation water. Contour farming involves ploughing furrows perpendicular to the contour of the land, which allows water to be captured between the furrows to prevent the formation of erosion rills down the slope. This method also helps minimize the volume of water that is applied to the field thereby reducing sediment washoff. Buffer strips represent a third example of agricultural BMPs to protect water quality. Vegetation planted along a watercourse ensures bank stability and provides shade to the stream. Buffer strips also act to trap sediment and filter nutrients out of runoff from agricultural fields.

Nutrient Management Practices

The objective of nutrient management in Ontario is to use nutrients wisely for optimum economic benefit, while minimizing the impact on the environment (OMAF 1996). A nutrient management plan provides direction on how nutrients are to be applied to a given land base to optimize the use of nutrients by crops in order to minimize environmental impacts. In addition to nutrient management plans, fertilizer storage BMPs can also be implemented on a farm to ensure storage facilities are placed in appropriate areas (e.g., impermeable areas, away from wells).

Watershed Habitat Restoration

Environment Canada (2004c) in its *How Much Habitat is Enough?* document puts forth restoration guidelines for wetland, riparian, and forest habitat. This framework provides "*science-based information and general guidelines to assist government and non-government restoration practitioners, planners and others involved in natural heritage conservation and preservation by ensuring there is adequate riparian, wetland and forest habitat to sustain minimum viable wildlife populations and help maintain selected ecosystem functions and attributes*". Given the breadth of science used to generate this framework, its guidelines will serve as the basis for the Upper Welland River watershed strategy. A summary of the riparian, wetland and forest habitat restoration guidelines have been reproduced in Appendix G.

Watershed Restoration Guidelines

EC's (2004c) guidelines for wetland, riparian and forest habitat restoration identify targets for each habitat type in a watershed (Appendix G). The guidelines recommend the following:

- Wetlands: Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
- Forest: At least 30 percent of the watershed should be in forest cover.
- Riparian: 75 percent of stream length should be naturally vegetated with a minimum 30m wide naturally vegetated adjacent-land on both sides, greater depending on site-specific conditions (e.g. urban areas)

As previously indicated, the guidelines are intended as minimum ecological requirements and are meant to provide guidance in setting local habitat restoration and protection targets.

The Upper Welland River watershed currently contains approximately 22 percent wetland cover and approximately 15 percent forest cover. Based on the above guidelines, an additional 15 percent of forest cover is required to create minimum desirable habitat proportions in the Upper Welland River watershed. Therefore, measures to create new upland areas, as well as protect and enhance existing forest cover should be implemented to ensure no net loss of forest cover. Riparian cover in the watershed is approximately 55 percent in the watershed. Based on this percentage approximately 20 percent of the watershed requires a vegetative buffer. The guidelines represent minimum desirable habitat proportions for riparian, wetland and upland forest habitat. Additional restoration above the minimum target is encouraged once these targets have been met. Existing natural heritage features and areas in the watershed should be preserved and enhanced whenever possible to improve water quality, ecological uses and human uses of the natural features. In addition, whenever possible projects should benefit species which are designated federally under the *Species At Risk Act* or provincially under the *Endangered Species Act* (EC 2004c).

Watershed Strategy

For convenience, and to make restoration recommendations more manageable and easier to implement, the watershed planning strategy has been divided into separate restoration plans for the following subwatersheds: Welland River West, West Wolf Creek, Buckhorn Creek, Elsie Creek, Oswego Creek, Little Wolf Creek, Wolf Creek, Mill Creek, Moores Creek, and Wilson Creek (Tables 11 -20).

Restoration priority areas have been identified using riparian, wetland and upland restoration suitability mapping produced by the NPCA (Figures 18 to 20); Carolinian Canada's „Big Picture' corridors; Regional Niagara's Core Natural Heritage System mapping, in conjunction with all natural heritage mapping layers including MNR's wetland mapping, wooded areas, NPCA ELC data, and ANSI's.

Carolinian Canada's „Big Picture' identifies existing natural cores, corridors and potential linkages in Canada's Carolinian life zone while Regional Niagara's Core Natural Heritage System consists of core natural areas to Niagara Region and potential linkages to areas identified as core areas. These layers and all subsequent layers were used in the analysis and identification of potential restoration areas in the Upper Welland River Watershed.

The criteria for each restoration category (riparian, wetland and upland) were derived from several sources including EC's (2004c) framework for guiding habitat rehabilitation (Appendix G).

Each type of habitat restoration (riparian, wetland, upland) has been prioritized as most suitable, moderately suitable or least suitable. Areas suitable for riparian, wetland and upland habitat restoration may overlap on the following watershed restoration strategy maps due to the methodology from which they were derived. When this occurs, the most suitable restoration project should be implemented based on field verification, available project funding, landowner partnerships as well as the opportunity to enhance ecological linkages.

Restoration Suitability Mapping

The criteria used to create the restoration suitability mapping were derived from several sources (Appendix H). The criteria for each restoration category (riparian, wetland and upland) vary and have been weighted differently based on the suitability of the land for habitat creation. A complete list, including the rationale, methodology and reference for each criterion used in the suitability analysis are presented in Appendix H, and the top three criteria for each restoration category are presented below.

Riparian Habitat Restoration Suitability

The criteria used to identify riparian habitat restoration suitability include, for example, stream bank erosion rates. This criterion is used because riparian areas identified as having high erosion rates resulting from an upslope contributing area and slope gradient analysis are most suitable to restoration with bioengineering. The proximity to a watercourse or waterbody identified riparian suitability because these areas contribute to both riparian buffers and floodplains, and restoration in these areas will improve the hydrological, habitat and water quality functions in the watershed. Land use type is ranked third in terms of identifying suitable areas for riparian restoration. Areas classified as scrub, low intensity agriculture, or natural areas are much more suitable to restoration than areas classified as industrial or urban.

Wetland Habitat Restoration Suitability

The criteria used to identify wetland habitat restoration suitability include, for example, soil drainage because the drainage class of an underlying soil determines the amount of water the soil can receive and store before runoff. The more poorly drained the underlying soil, the more suitable the area is for wetland restoration. The wetness index predicts zones of water saturation where steady-state conditions and uniform soil properties are assumed. Similar to riparian restoration, land use type plays a role in determining areas suitable for wetland restoration.

Upland Habitat Restoration Suitability

Upland habitat restoration suitability is also evaluated based on land use type. Wetland buffer habitat thresholds (0-240m) are also used, which include areas within the 0-240 metre span of a wetland because they contribute to a range of habitat functions when vegetated. Vegetation within the closest proximity to a wetland provides the greatest benefit to that wetland; this area is known as the Critical Function Zone. The third criterion for determining upland suitability is the proximity of an area to a significant patch. Areas within the closest proximity to existing forest patches with the highest Natural Heritage Score, or core size, are considered the most suitable for upland restoration because these sites will increase interior habitat. Additional criteria and the weighting scheme are presented in Appendix H. A series of habitat restoration suitability maps are provided (Figures 18 - 20).

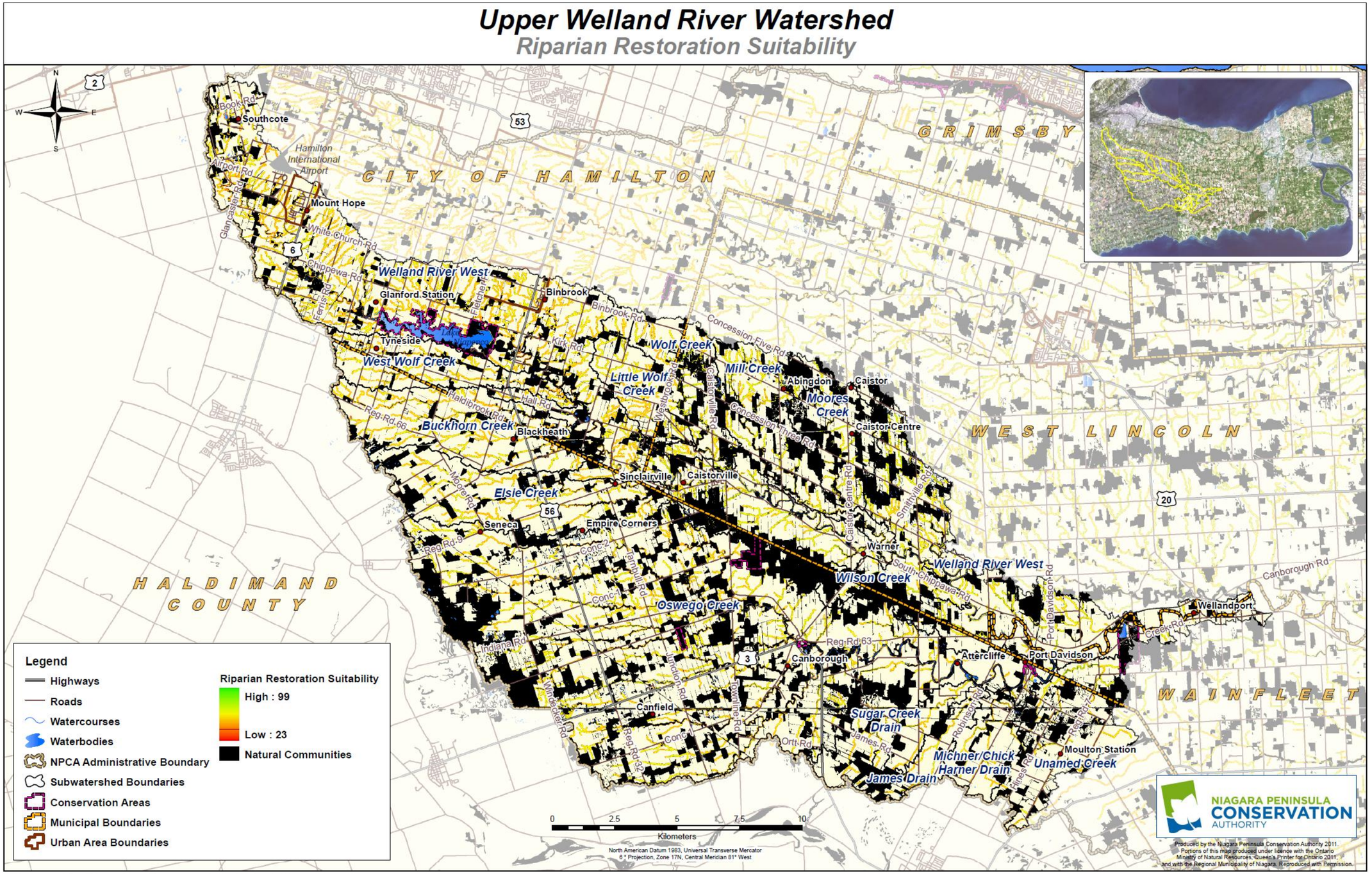

Figure 18: Riparian Restoration Suitability

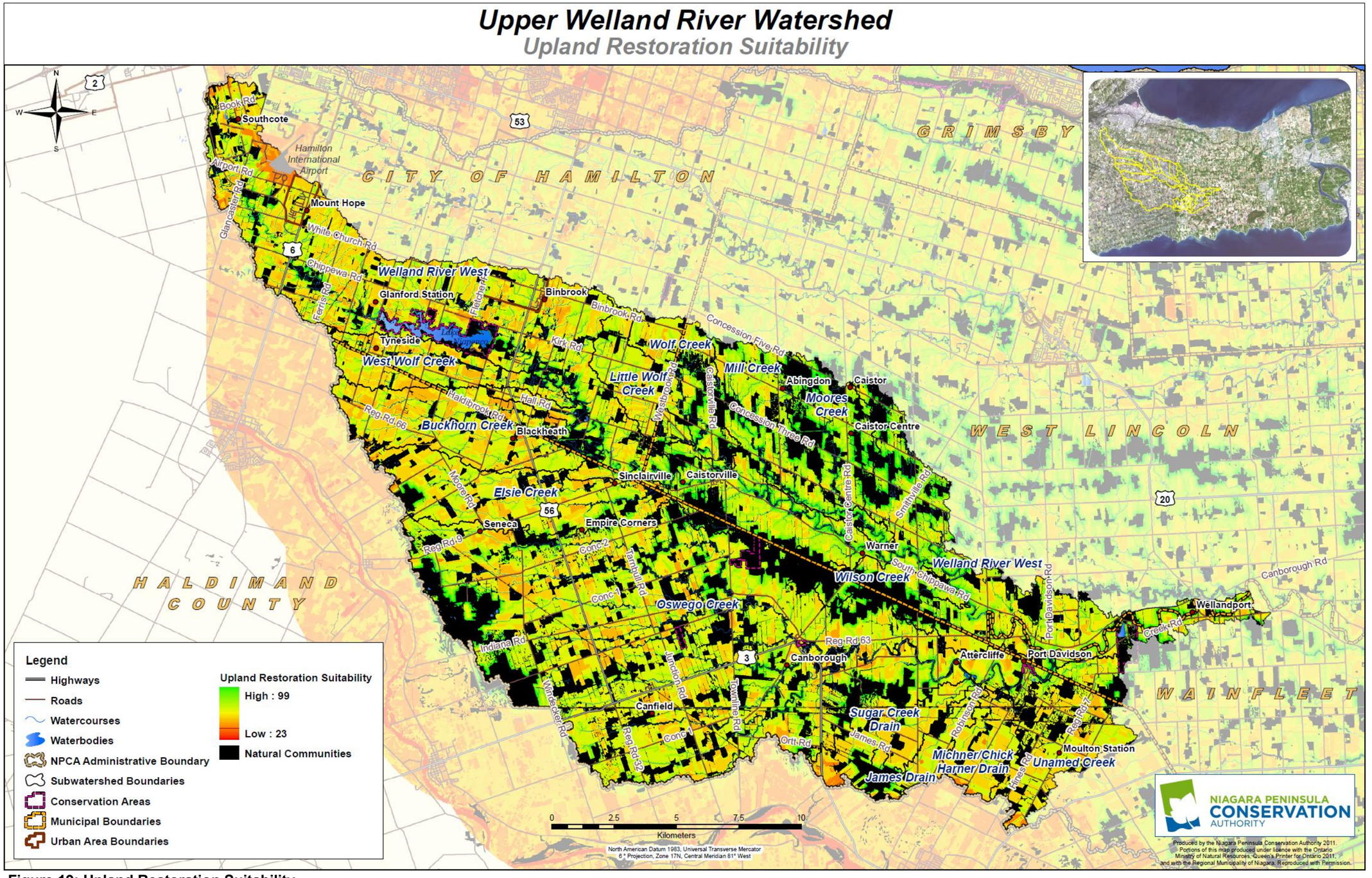

Figure 19: Upland Restoration Suitability

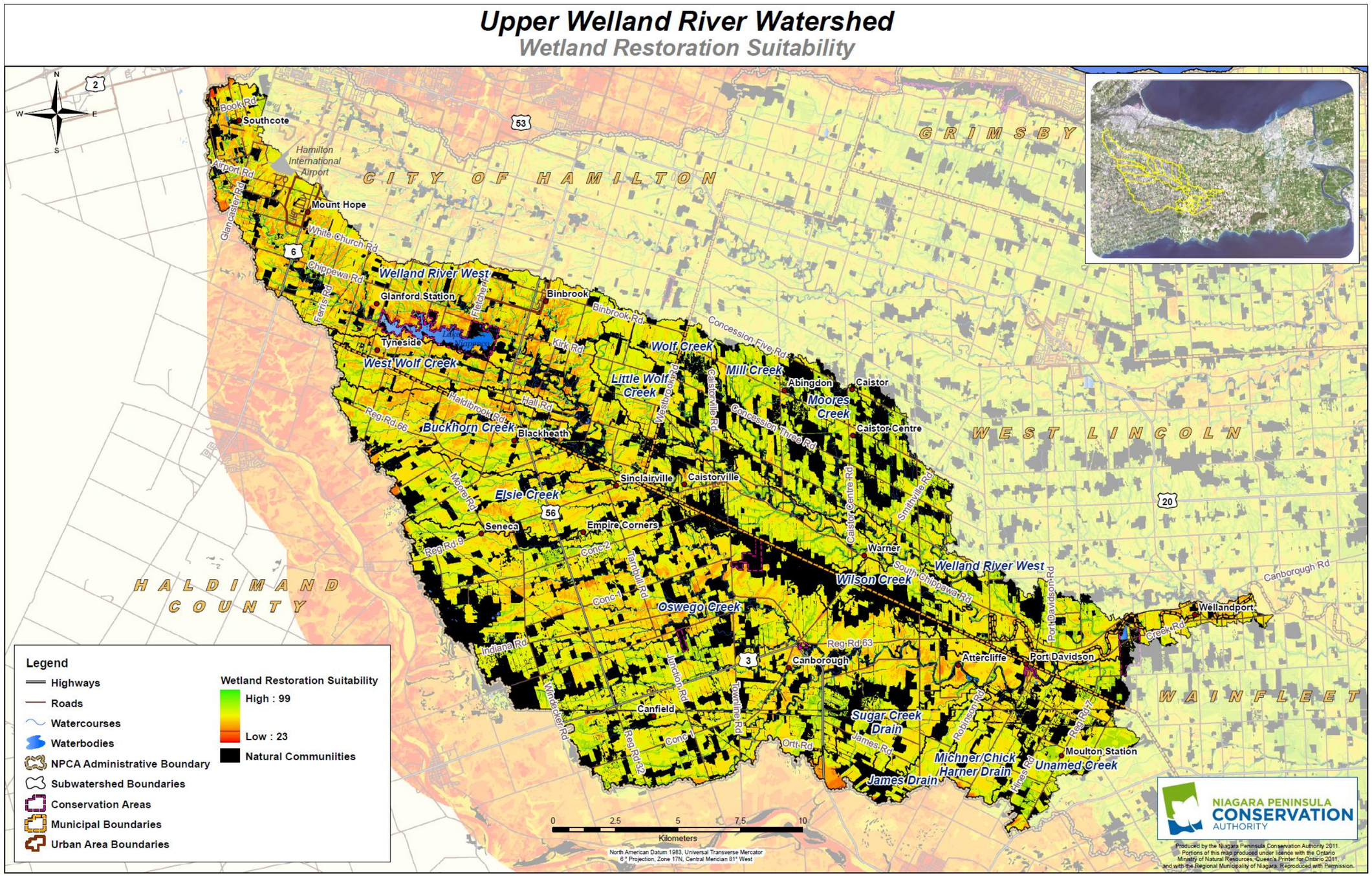

Figure 20: Wetland Restoration Suitability

Welland River West Subwatershed

Table 13: Welland River West Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	145.8 km^2	
Land Use	Mix of Urban and Rural Residential and Agriculture	Portions of Binbrook and Mount Hope; Southcote, Glanford Station, Caistorville, Warner, and Wellandport
Municipal Water and Sewer Services	Partial servicing	Urban areas of Mount Hope and Binbrook receive water and wastewater services from Woodward Treatment Plant in Hamilton
Aquatic Resources		
Length of Watercourse	510.6km	
Fish Habitat	Critical: Main Channel Important: Most tributaries	Some of the smaller tributaries and the watercourses within City of Hamilton have not been evaluated in terms of importance for fish habitat.
Municipal Drains	Puhringer Drain and Whitechurch Road Drain	Both Drains have been evaluated as Class F Drains
Water Quality	8 Stations Stations:WR00A, WR001, WR002, WR003, WR005, WR006 Water Quality Index: Poor BioMAP Rating: Impaired Station: WR004 Water Quality Index: Poor BioMAP Rating: Grey Zone	All stations report exceedances of total phosphorus. Elevated concentrations of total phosphorus are a widespread cause of water quality impairment in the Welland River. 100% exceedance is observed at stations WR003 though WR007, with total phosphorus concentrations up to 20 times greater than the provincial objective(NPCA2010). Station WR004 falls into the grey zone BioMAP category. The continuous flow from the Binbrook Reservoir and improved habitat are likely causes for the higher BioMAP rating at this station (NPCA 2010)
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability with areas of medium vulnerability. The headwaters have been identified as having a mix of high and medium vulnerability. In addition, pockets of high vulnerability to groundwater contamination are present	Land use in the high vulnerability area includes the urban areas of Binbrook and Mount Hope as well as Hamilton International Airport. In addition, transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	42.3	EC recommends 75% with 30m buffer
Upland Habitat	14.0	EC recommends 30% to support viable wildlife population
Wetland Habitat	15.0	EC recommends 10% or to historic value
ANSI, Conservation Areas	Sinclairville Meander Basin Swamp ANSI, Caistor-Canborough Slough Forest ANSI,	2 Life Science ANSI's and 3 Conservation Areas

	Binbrook CA, Ruigrok Tract CA,	
Restoration Projects Completed to date		
Riparian Enhancement	24 projects:1996 (2), 1997(3),1998, 1999, 2000(2), 2001, 2002(2), 2003(4), 2004(5), 2005, 2008(2)	In total 16,810 ft of fencing was installed with 2 alternate water supplies; planting of 15,565 trees, 2155 shrubs, 700 wildflowers, 2 bags of winter wheat & annual ryegrass, 3 bags cover crops, and 2kg tree seed
Reforestation	19 projects:1999, 2000, 2001(4), 2002 (2), 2003(2), 2004, 2005(2), 2007, 2008(2), 2009 (3)	In total 104,415 bareroot trees and shrubs were planted.
Wetland Creation/Enhancement	4 projects:2001(2), 2002, 2007	In total 438 trees, 600 lowland shrub plugs, 159 herbaceous terrestrial, and 3.1 kg of aquatics planted
Fish Barrier Removal	1 project in 2003	Farmer Crossing, planting. Infill of existing woodlot
Windbreak	1 project in 2008	3850 bareroot and 75 largestock planted
Clean Water Diversion	1 project in 2004	Channel improvement for water quality and wetland habitat
Nutrient Management	12 projects:1996 (6),1997,2000(2), 2005, 2006,2008	5 manure storages; concrete tank with grinder pump transfer sump; 2 concrete runoff pits with transfer pipes; 1100L milkhouse washwater; 2, 1000 gallon pits with transfer pipe to manure sump; and 100'x80'x12' earthen run off pit
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•riparian habitat is currently lower than EC recommendations (42.3%). •large number of watercourses commence in and flow through agricultural fields with little to no riparian buffer; primarily headwaters and tributaries throughout entire subwatershed •large extents of watercourse that have been evaluated as important and critical fish habitat flow through agricultural lands that have been identified as areas of medium groundwater vulnerability with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. • investigate possibility of building on previous NPCA Water Quality Improvement projects	
Upland and Ecological Linkages	•currently amount of upland habitat is lower than EC recommendations (14%) •suitability mapping indicates very high suitability in lower watershed for upland restoration and enhancement of existing wetland areas particularly adjacent to Chippawa CA. Creating an upland buffer surrounding a wetland is called a Critical Function Zone (CFZ): a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary (e.g. nesting habitat). • ample opportunity throughout subwatershed for creation and enhancement of corridor connections and for filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna • investigate possibility of building on previous NPCA Water Quality Improvement projects	
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations (15%)	

	• high suitability for riparian-wetland restoration along watercourse which would provide linkages between fragmented wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within the City of Hamilton have not been evaluated in terms of importance for fish habitat. It

	is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix E.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for the City of Hamilton Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that the City of Hamilton also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Organic Deicing Material Pilot Program included Canborough, Creek, and Wellandport Roads in the Upper Welland River study area. The pilot program anticipated a reduction in salt usage and overall cost savings to regional winter maintenance activities as a result of fewer salt applications being required. A reduction in salt usage results in less salt being introduced into the environment. Therefore, expansion of the Organic Deicing Material Program is recommended to include all regional roads, primarily those adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Enhanced Water Quality Sampling	Through the NPCA Water Quality Monitoring Program, elevated concentrations of zinc have been detected at station WR001 and WR002. The zinc concentrations were found to exceed the provincial objectives in nearly all samples (NPCA 2010a). A possible source of the zinc could be the galvanized roofing of the Hamilton International Airport (HIA). Additionally, storm water and glycol discharges from the HIA have been identified as

	sources of impairment at these stations (NPCA 2010a). Enhanced sampling for zinc and propylene glycol should be conducted at these stations to determine the source of zinc and to ensure that the airport glycol containment system is functioning and that no glycol is discharged to the receiving tributaries.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Welland River West subwatershed numerous areas were identified; 4 fuel storages, 3 closed landfills, 9 pipelines, 10 cemeteries, 2 golf courses, 1 salt storage, 1 automotive machinery/wreckers, and sewage/septic systems. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Environmentally Responsible Maintenance Practices for Golf Courses	By integrating golf course management practices with wildlife management, such as incorporating enhanced natural areas into the landscaping, golf courses have the potential to offer a wide range of habitat for wildlife. In addition, encouragement of environmentally responsible maintenance practices, if not already adopted, will be beneficial to water quality and the aquatic habitat. Investigation into the Audubon Cooperative Sanctuary Program for Golf Courses should be explored for golf courses if such a program has not already been adopted. In addition, environmentally friendly practices should be encouraged (e.g. chemical free practices).
Binbrook Reservoir Riparian Restoration Site Assessment	The Niagara Water Strategy identified severe erosion of the riparian habitat in Binbrook Reservoir resulting from the water fluctuations as part of the dam operations. Since the initial operation procedures, the NPCA has revised operations in an effort to improve aquatic habitat by stabilizing the water level and allowing for seasonal variations as in a natural system. However, a geomorphic assessment of the reservoir is recommended to identify existing erosion prone areas, rate of erosion, and prioritize areas for riparian restoration/stabilization.
Binbrook Reservoir Fish Community Monitoring	Regular monitoring of the Binbrook Reservoir fish community is recommended to assess temporal changes in fish community and abundance. Based on monitoring results, work with respective stakeholders to create and implement recommendations in an effort to improve fishery resources within the reservoir.
Binbrook Reservoir Aquatic Habitat Assessment and Improvement Projects	Annual monitoring of existing aquatic habitat should be conducted to assess temporal changes in aquatic habitat within the reservoir. Habitat improvement projects should be implemented based on assessment results.
Monitoring and Enforcing Water Extractions from Binbrook Reservoir	To assist in maximizing water flow downstream of the Binbrook Reservoir, the NPCA recommends better monitoring of water extraction activities within the reservoir. All water extraction activities should comply with Ontario Water Resources Act, Permit To Take Water.
Removal of Canborough Weir	A fish by-pass was constructed at the Canborough weir as a temporary remediation solution to the barrier to fish migration. However, it is recommended to remove the weir as originally planned in an effort to improve the state of the Welland River fishery resources as identified in the Welland River Watershed Strategy (NPCA 1999).
Removal of Fish Barriers	Dams, weirs, floodgates, road crossings, and even debris jams can act as barriers to fish passage. They block the channel and can make areas of habitat inaccessible to all aquatic organisms, thereby reducing breeding opportunities for many native species, and they can cause an increase in competition and predation. Several barriers to fish migration have been identified throughout the Welland River watershed through various initiatives. These sites should be reviewed and where possible, the barrier should be removed to optimize the passage of

	fish.
Blue Flag Beaches	Work with partnering agencies to mitigate water quality issues and work towards Blue Flag Beach status at the Binbrook and Chippawa Conservation Area beaches. Blue Flag status meets high standards with respect to water quality, environmental management, environmental education and safety and services (Blueflag.ca) and is known globally. Blue Flag beaches have the potential to increase tourism in the area.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

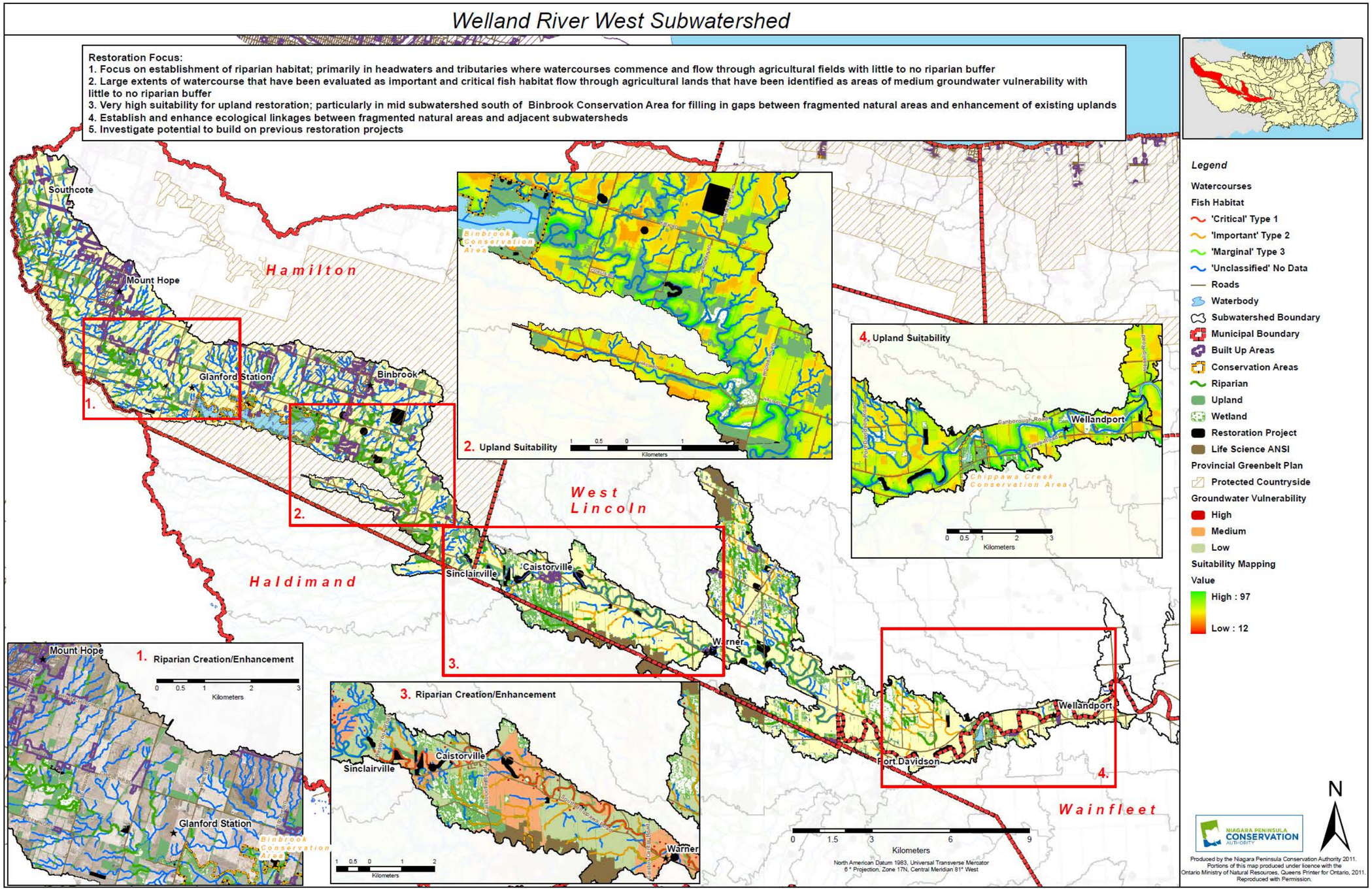

Figure 21: Welland River West Subwatershed

West Wolf Creek Subwatershed

Table 14: West Wolf Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	13.8 km^2	
Land Use	Agriculture	Tyneside
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	45.9km	Outlets to Welland River
Fish Habitat	Unevaluated	The watercourses within Haldimand County and the City of Hamilton have not been evaluated in terms of importance for fish habitat
Municipal Drains	N/A	
Water Quality	N/A	
Groundwater Vulnerability	Mix of Low and Medium Groundwater Vulnerability with pockets of high vulnerability to groundwater contamination present	Land use in areas with medium vulnerability to groundwater contamination is agriculture. Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	28.7%	EC recommends 75% with 30m buffer
Upland Habitat	11.5%	EC recommends 30% to support viable wildlife population
Wetland Habitat	2.2%	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date		
Riparian Enhancement	1 project in 2000	Planted 1800 Bare Root Trees and 1000 ft of fencing
Reforestation	1 project in 2007	Planted 4705 Bare Root Trees covering an area roughly 7 acres
Nutrient Management	1 project in 2005	Manure Pad ; Compost Yard for Manure
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (28.7%) •very little vegetative cover in headwater region •large extents of watercourse flow through agricultural fields identified as having a medium vulnerability to groundwater contamination with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •potential opportunity to build on previous NPCA Water Quality Improvement project	
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (11.5%) •potential opportunity to establish and enhance ecological linkages between fragmented natural areas within	

	subwatershed and extending into adjacent subwatersheds. Corridor connections will facilitate in the movement of flora and fauna between natural areas. •suitability mapping indicates very high suitability in upper watershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area. A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat	•currently amount of wetland coverage is below EC recommendations (2.2%) •very high suitability for wetland creation in upper subwatershed • very high suitability for riparian-wetland restoration along watercourse which would provide linkages between natural areas and extending into adjacent subwatershed(e.g. Binbrook Conservation Area) • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single

area	storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within Haldimand County and the City of Hamilton have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for Haldimand County and City of Hamilton Road Networks	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that Haldimand County and the City of Hamilton also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the West Wolf Creek subwatershed 6 of these areas were identified; 1 cemetery and 5 pipelines. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

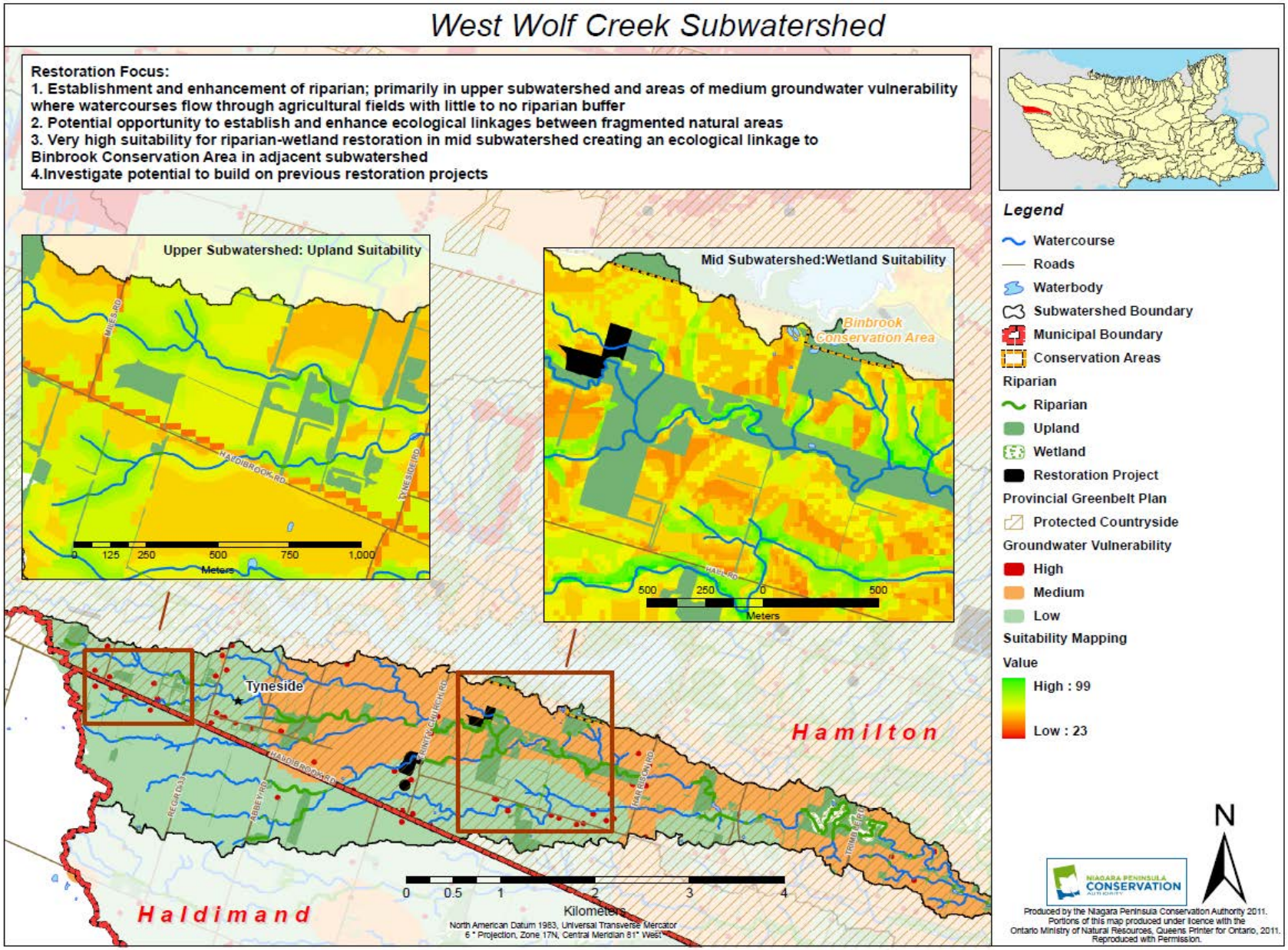

Figure 22: West Wolf Creek Subwatershed

Buckhorn Creek Subwatershed

Table 15: Buckhorn Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	24.3 km^2	
Land Use	Agriculture	Hamlet of Blackheath
Municipal Water and Sewer Services		
Aquatic Resources		
Length of Watercourse	75.4km	Outlets to Welland River
Fish Habitat	Not evaluated	The watercourses within Haldimand County have not been evaluated in terms of importance for fish habitat
Municipal Drains	N/A	
Water Quality	2 Stations: Station:BU000 Water Quality Index: Poor BioMAP Rating: Impaired Station:BU001 Water Quality Index: Poor BioMAP Rating: Impaired	Factors affecting water quality include exceedances of *E.coli,* chloride and total phosphorus. *E.coli* and chloride concentrations frequently exceed the guideline for irrigation water. Sources of *E.coli* include runoff from urban and agricultural land use, sewage discharges, and the presence of waterfowl. Sources of chloride include storm water runoff, de-icing salt applied to roads, and sewage discharges (NPCA 2010)
Groundwater Vulnerability	Mix of Low and Medium Groundwater Vulnerability with pockets of high vulnerability to groundwater contamination present	The area around Blackheath has been identified with a medium vulnerability to groundwater contamination. In addition, several pockets have been identified with a high vulnerability to groundwater contamination. These areas include transport pathways such as private wells (active and inactive), unknown status oil and gas wells and have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	35.3%	EC recommends 75% with 30m buffer
Upland Habitat	12.0%	EC recommends 30% to support viable wildlife population
Wetland Habitat	5.4%	EC recommends 10% or to historic value
ANSI, Conservation Areas	Sinclairville Meander Basin Swamp ANSI	Life Science ANSI along outlet of subwatershed
Restoration Projects Completed to date		
Riparian Enhancement	3 projects:1998 (2), 2000	Planted 3400 Bare root trees, installed 11 180 ft of streamside fencing, and retired 5 acres of riparian buffer; 4500 Bare root trees planted, 500 ft of fencing and an alternate water supply; Installation of 8900 ft of streamside fencing, retired 6 acres of riparian buffer, and planted 4500 bare root trees
Wetland Creation/Enhancement	1 project in 2000	Lowland shrubs planted

Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (35.3%). •little to no riparian habitat in headwaters region •large extents of watercourse flow through agricultural fields identified as having a medium vulnerability to groundwater contamination with little to no riparian buffer •factors affecting water quality include high sediment loading from upstream erosion and runoff •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. • investigate possibility of building on previous NPCA Water Quality Improvement projects	
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (12%) •suitability mapping indicates a very high suitability for enhancement of and filling in gaps within the Sinclair Meander Basin Swamp ANSI in the lower subwatershed •suitability mapping indicates moderate to high suitability for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna •investigate possibility of building on previous NPCA Water Quality Improvement projects	
Wetland Habitat	•currently level of wetland coverage is below EC recommendations (5.4%) • high suitability for riparian-wetland restoration along watercourse which would provide linkages between fragmented natural areas • suitability mapping indicates a very high suitability for wetland creation in upper portion of the subwatershed • suitability mapping indicates a very high suitability for wetland establishment between and surrounding upland features in lower subwatershed providing for a diversity of habitat • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).	
NPCA Education and Incentive Programs		
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.	
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.	
Abandoned Well	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater	

Decommissioning Program	resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within Haldimand County and the City of Hamilton have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for Haldimand County and City of Hamilton Road Networks	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that Haldimand County and the City of Hamilton also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Buckhorn Creek subwatershed 7 of these areas

	were identified; 1 cemetery, an active landfill, 1 automotive machinery/wrecker, and 4 pipelines. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

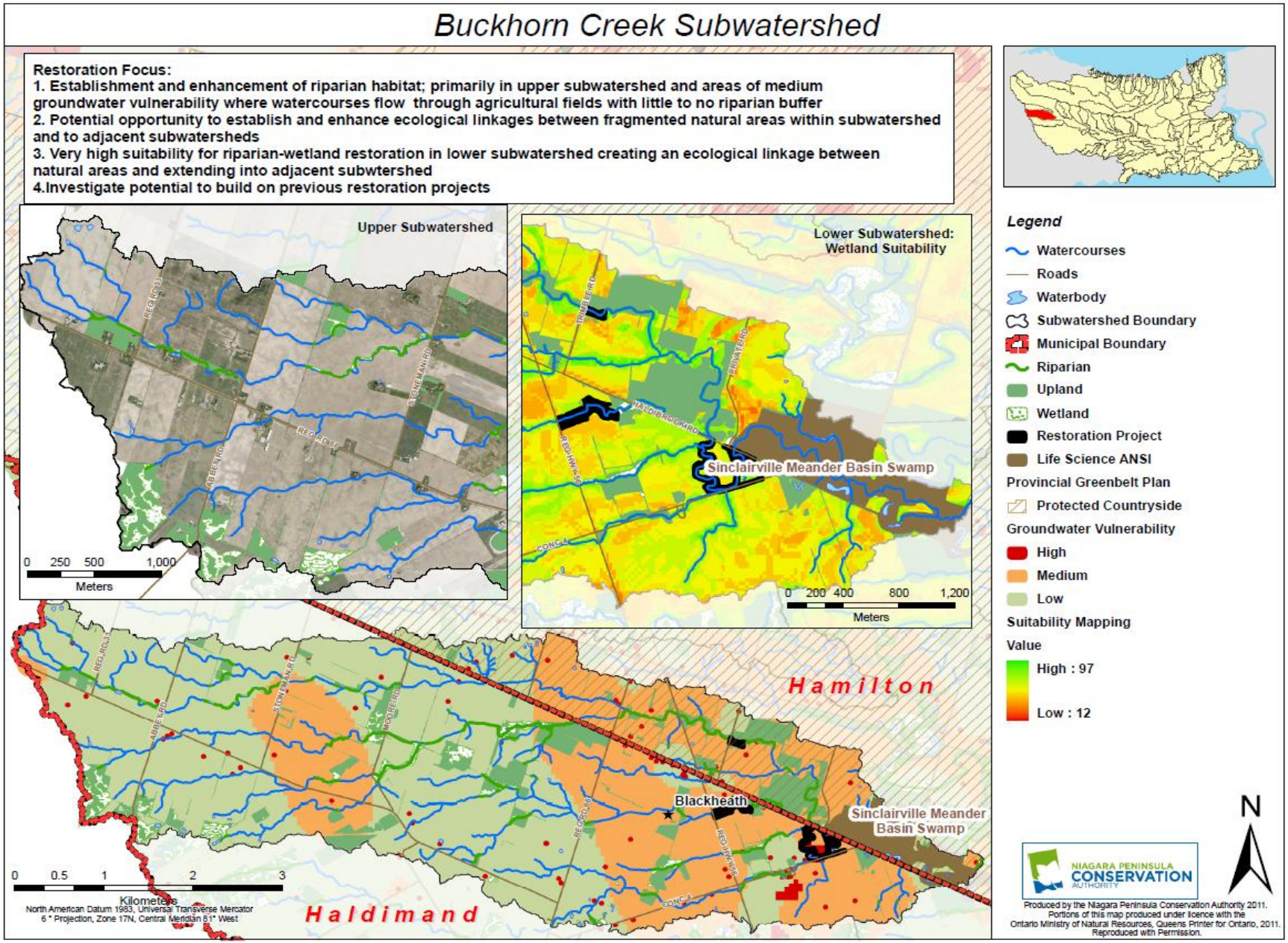

Figure 23: Buckhorn Creek Subwatershed

Elsie Creek Subwatershed

Table 16: Elsie Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	25.5 km^2	
Land Use	Agriculture	Sinclaireville
Municipal Water and Sewer Services	N/A	
Aquatic Resources		
Length of Watercourse	65.7 km	
Fish Habitat	Last reach of outlet has been evaluated as important fish habitat.The remaining watercourses are unevaluated	The watercourses within Haldimand County and the City of Hamilton have not been evaluated in terms of importance for fish habitat
Municipal Drains	N/A	
Water Quality	Station:EL001 Water Quality Index: Poor BioMAP Rating: Impaired	Factors affecting water quality include exceedances of chloride, *E.coli* and total phosphorus. High sediment loading is evident from upstream erosion and runoff. Nutrient enrichment from upstream agricultural areas.
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability with small areas of medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	58.4%	EC recommends 75% with 30m buffer
Upland Habitat	13.2%	EC recommends 30% to support viable wildlife population
Wetland Habitat	15.5%	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date		
Riparian Enhancement	2 projects: 2004, 1999	352 trees/shrubs, and 648 flower plugs planted; installed 1800 ft of stream fencing and retired 5 acres of riparian buffer zone
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (58.4%). •large extents of watercourse flow through agricultural fields with little to no riparian buffer •factors affecting water quality include high sediment loading from upstream erosion and runoff, and nutrient enrichment from agricultural areas •riparian habitat will provide linkages between fragmented natural areas facilitating in the movement of flora and fauna	

	•riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat • investigate possibility of building on previous NPCA Water Quality Improvement projects
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (13.2%) •suitability mapping indicates very high suitability in upper and southern edge of subwatershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna •ample opportunity for corridor creation linking fragmented natural areas within subwatershed and extending into adjacent subwatershed
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations, however ample of opportunity is present for infilling and enhancement of existing wetlands • very high suitability for riparian-wetland restoration along watercourse which would provide linkages between fragmented natural areas • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on

	their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within Haldimand County and the City of Hamilton have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for Haldimand County Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that Haldimand County also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In Elsie Creek subwatershed 3 of these areas were identified; 2 cemeteries and a pipeline. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.

Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

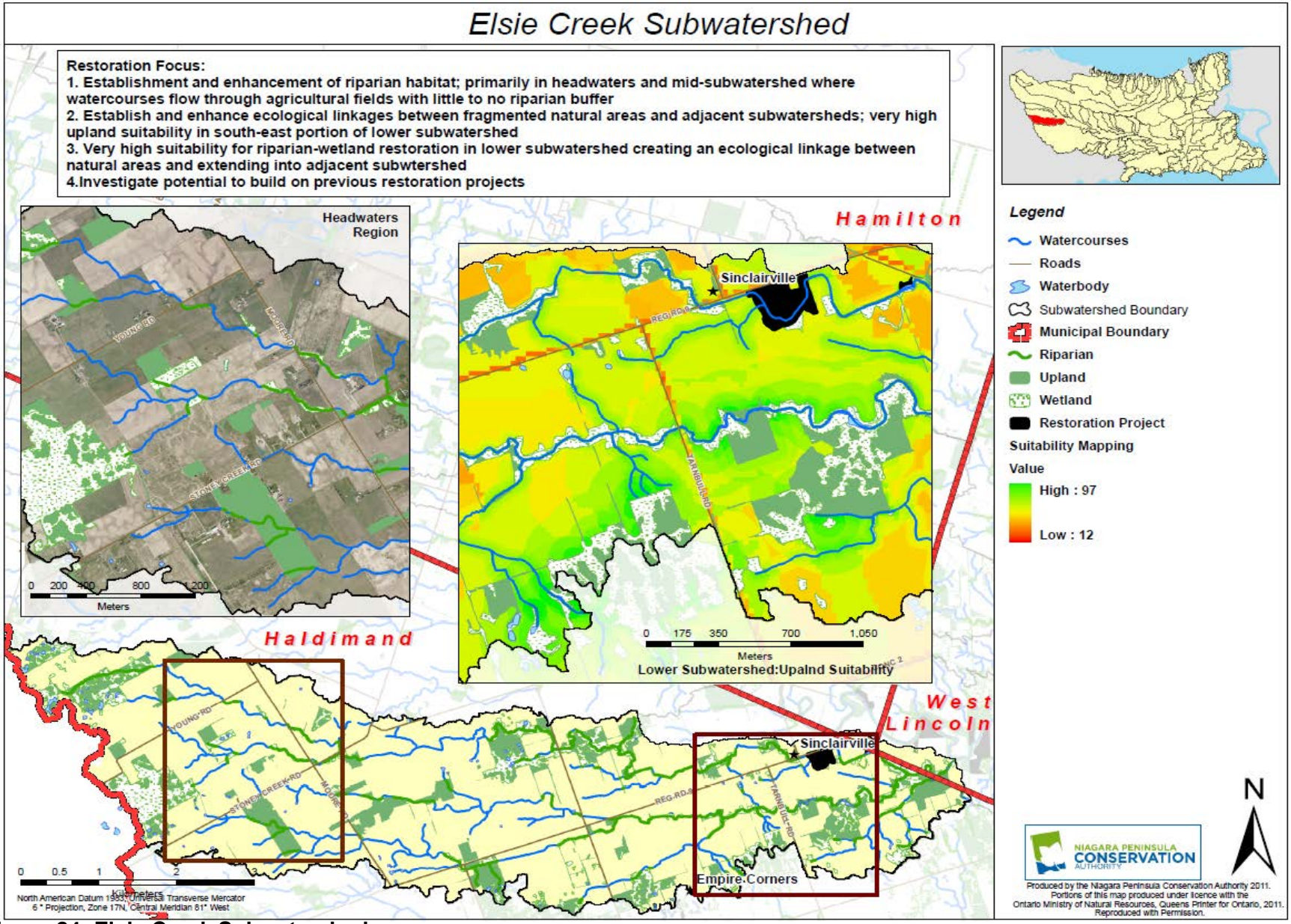

Figure 24: Elsie Creek Subwatershed

Oswego Creek Subwatershed

Table 17: Oswego Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	156.9 km^2	
Land Use	Agriculture	Hamlets of Canfield, Canborough, and Attercliffe, Port Davidson
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	385.2km	
Fish Habitat	Unevaluated	The watercourses within Haldimand County have not been evaluated in terms of importance for fish habitat
Municipal Drains	Baker Drain	Class F
Water Quality	2 Stations Station:OS001 Water Quality Index: Poor BioMAP Rating: Impaired Station:OS002 Water Quality Index: Poor BioMAP Rating: Impaired	Factors affecting water quality include exceedances of *E.coli* , total phosphorus and suspended solids. Sources of *E. coli* include runoff from urban and agricultural land uses, sewage discharges, and the presence of waterfowl. Elevated concentrations of total phosphorus is a wide spread issue throughout the tributaries of the Welland River with concentrations that greatly exceeding provincial objectives, particularly at stations OS001 and BV001, BF001 [(not in study area) NPCA 2010].
Groundwater Vulnerability	Mix of Low and Medium Groundwater Vulnerability; one small area and numerous pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	84.0%	EC recommends 75% with 30m buffer
Upland Habitat	17.2%	EC recommends 30% to support viable wildlife population
Wetland Habitat	31.6%	EC recommends 10% or to historic value
ANSI, Conservation Areas	North Cayuga Slough Forest ANSI, Caistor-Canborough Slough Forest ANSI, Attercliffe Station Slough Forest ANSI, Hedley Forest CA, Oswego Creek CA, Ruigrok Tract CA, and Canborough CA	3 Life Science ANSI's and 4 Conservation Areas throughout subwatershed
Restoration Projects Completed to date		
Riparian Enhancement	8 projects:1995, 1997, 1998, 2003(3), 2004 (2)	In total 3400 trees, 200 shrubs, and 675 wetland plants planted; installed 3700 ft of streamside fencing; 55 livestock fenced off; 3 acres of riparian

		buffer retired
Reforestation	15 projects: 2000, 2004(4), 2005(5), 2008(3), 2009(2)	In total 58,940 trees and 40 shrubs planted
Wetland Creation/Enhancement	7 projects: 2004, 2007(3), 2008, 2009(2)	5235 trees, 550 lowland shrubs, 3600 seedlings, 1760 plugs, and 9 kg of seed planted
Nutrient Management	8 Manure Storage: 1996(4), 1999 2004,2005,2008	150'x100'x10' gravity flow manure storage; 2- 1000 gallons pits with transfer pipe to manure sump; 150' eavestrough to divert water away from manure sump; manure management; manure storage & milkhouse washwater; turkey storage; covered manure storage
Fish Barrier Removal	1 project in 2003	Farmer crossing
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat meets EC recommendations (84.0%) for length of watercourse with riparian buffer, however the watercourses in this subwatershed do not meet the recommended width of a 30m buffer. The buffer width varies throughout the subwatershed •Agricultural Non-Point Source (AGNPS) GIS model has identified a number of nutrient loading „hot spots' in the headwaters region; watercourses in these areas start in agricultural fields with no riparian buffer •focus should be towards riparian establishment/enhancement in upper subwatershed and areas of medium groundwater vulnerability •water quality has been identified as an issue in the NPCA Water Quality Report with mean total phosphorus concentrations greatly exceeding provincial objectives •large extents of watercourse flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. • investigate possibility of building on previous NPCA Water Quality Improvement projects	
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (17.2%) •suitability mapping indicates very high suitability in upper subwatershed and east of Tarnbull Road and North of Indiana Road for enhancement of existing upland areas, corridor creation/enhancement and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna and corridors facilitate in the movement of flora and fauna between natural areas •ample opportunity to create linkages to large core natural areas such as Conservation Areas, Caistor-Canborough Slough Forest and North Cayuga Slough Forest and to natural heritage features in adjacent subwatershed •investigate possibility of building on previous NPCA Water Quality Improvement projects	
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations (31.6%), however ample opportunity is present for enhancement of existing wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).	

NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Re-run the Agricultural Non-Point Source (AGNPS) Model in this subwatershed	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality. In 2005 the AGNPS model was applied in the Oswego Creek subwatershed for the area upstream of the Canborough weir. It is recommended that the model be re-applied and the results compared to identify persistent hot-spots to target for restoration initiatives.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within Haldimand County have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.

Naturalizing Drains and Drain Best Management Practices	In addition to having an impact on aquatic and riparian habitat, drain maintenance has the potential to become quite costly through repeated maintenance activities. Naturalizing drains can potentially lengthen the time between maintenance events by reducing the amount of sediment entering and remaining in the drain. Best Management Practices for drain maintenance should be developed in consultation with, but not limited to, the following agencies; OMAFRA, DFO, MNR, Conservation Ontario, OFA, DSAO, CFFO, and the agricultural community to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain. Any future maintenance of this watercourse should be done in accordance with Best Management Practices for drains. To review examples of current BMP mitigation measures, refer to Appendix E.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for Haldimand County Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that Haldimand County also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Oswego Creek subwatershed 15 of these areas were identified; 7 cemeteries, 3 automotive wreckers/machinery, an active landfill and 4 pipelines. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

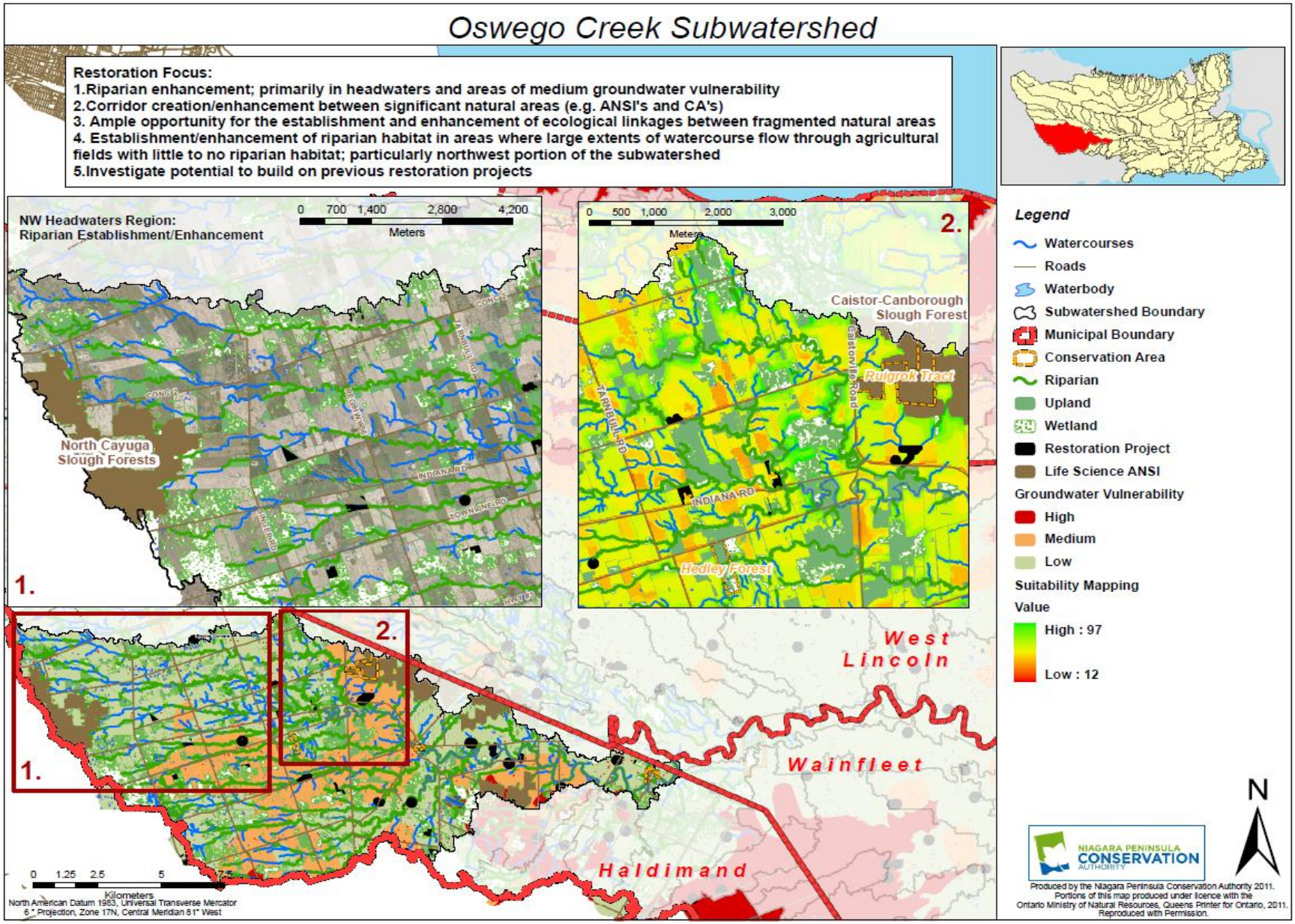

Figure 25: Oswego Creek Subwatershed

Little Wolf Creek Subwatershed

Table 18: Little Wolf Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	10.1 km^2	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	34.6km	Outlets to Wolf Creek
Fish Habitat	Main channel: Critical Tributaries: Important	The watercourses that fall within the City of Hamilton have not been evaluated in terms of importance for fish habitat
Municipal Drains	N/A	
Water Quality	N/A	
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability; one small area has a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	10.3	EC recommends 75% with 30m buffer
Upland Habitat	11.0	EC recommends 30% to support viable wildlife population
Wetland Habitat	2.2	EC recommends 10% or to historic value
ANSI, Conservation Areas	N/A	
Restoration Projects Completed to date		
Riparian Enhancement	1 project in 1997	Installed 750ft of stream fencing and retired riparian buffer
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (10.3%). •large extents of watercourse flow through agricultural fields with little to no riparian buffer •little to no riparian buffers in areas of medium groundwater vulnerability •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. •riparian habitat can also act as corridors to facilitate in the movement of flora and fauna between fragmented natural areas • investigate possibility of building on previous NPCA Water Quality Improvement projects	
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (11%) •natural areas are fragmented across landscape with few corridors to facilitate the movement of flora and fauna between areas; therefore focus should be the establishment and enhancement of connections between natural	

	areas •suitability mapping indicates very high suitability in upper watershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat	•currently level of wetland coverage is below EC recommendations (2%) •very high suitability for riparian-wetland restoration along watercourses in upper mid and lower mid reaches providing a riparian buffer as well as linkages between fragmented natural areas • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The

	model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within the City of Hamilton have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for the City of Hamilton Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that the City of Hamilton also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Little Wolf Creek subwatershed one of these areas was identified; a pipeline. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed

	stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

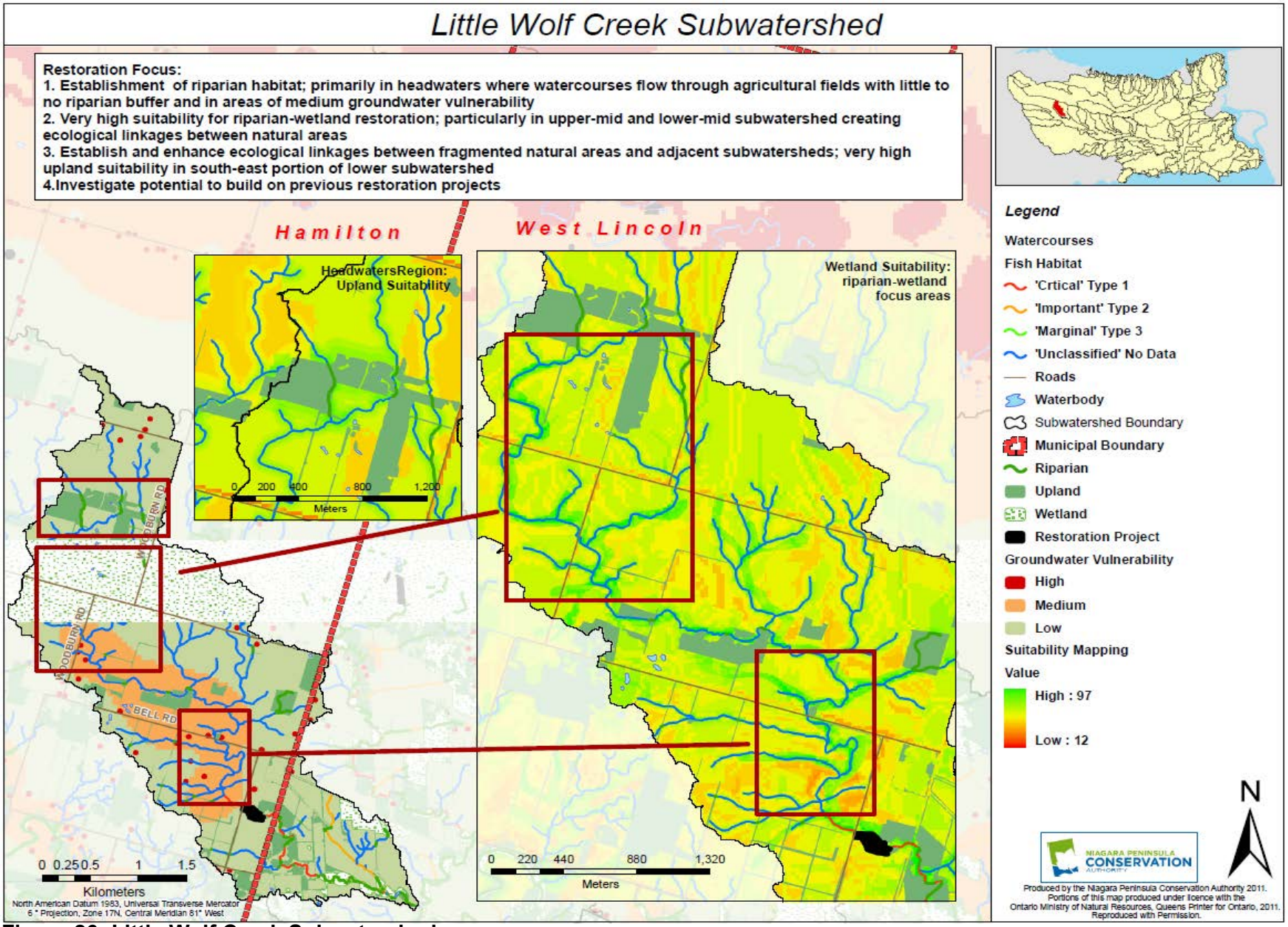

Figure 26: Little Wolf Creek Subwatershed

Wolf Creek Subwatershed

Table 19: Wolf Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	13.3 km^2	
Land Use	Agriculture	
Municipal Water and Sewer Services	N/A	
Aquatic Resources		
Length of Watercourse	44.2 km	Outlets to Welland River
Fish Habitat	Main Channel: Critical Tributaries: Important	The watercourses within the City of Hamilton have not been evaluated in terms of importance for fish habitat Lower tributaries have been evaluated as important fish habitat; the headwaters have not yet been evaluated in terms of importance for fish habitat.
Municipal Drains	N/A	
Water Quality	N/A	
Groundwater Vulnerability	Low Groundwater Vulnerability; one very small area has a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	35.2%	EC recommends 75% with 30m buffer
Upland Habitat	18.3%	EC recommends 30% to support viable wildlife population
Wetland Habitat	12.3%	EC recommends 10% or to historic value
ANSI, Conservation Areas		
Restoration Projects Completed to date		
Riparian Enhancement	2 projects:1998, 2007	In total 12,685 bareroot trees and 225 upland shrubs planted, and retired 15 acres of riparian buffer
Reforestation	1 project in 2008	2940 bareroot trees planted covering 4.2 acres
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (35.2%). •priority should be the establishment of riparian buffers in the headwaters region which currently has little to no riparian vegetation •large extents of watercourse evaluated as important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.	

	•potential opportunity to build on previous NPCA Water Quality Improvement project
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (18.3%) •suitability mapping indicates very high suitability throughout the subwatershed for enhancement of existing upland areas and filling in gaps of natural areas, particularly in the mid-subwatershed. Filling in gaps will reduce forest edge –interior ratio and create a larger continuous natural area. A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations, however ample opportunity is present for infilling and enhancement of existing wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The

	model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within the City of Hamilton have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for the City of Hamilton Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that the City of Hamilton also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Wolf Creek subwatershed one of these areas was identified; a golf course. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Environmentally Responsible Maintenance Practices for Golf Courses	By integrating golf course management practices with wildlife management, such as incorporating enhanced natural areas into the landscaping, golf courses have the potential to offer a wide range of habitat for wildlife. In addition, encouragement of environmentally responsible maintenance practices, if not already adopted, will be beneficial to water quality and the aquatic habitat. Investigation into the Audubon Cooperative Sanctuary Program for Golf Courses should be explored for golf courses if such a program has not already been adopted. In addition, environmentally friendly practices should be encouraged (e.g. chemical free practices).
Multi-Stakeholder Incentive	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging

Programs Information Flyers/Advertisements/Workshops	in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

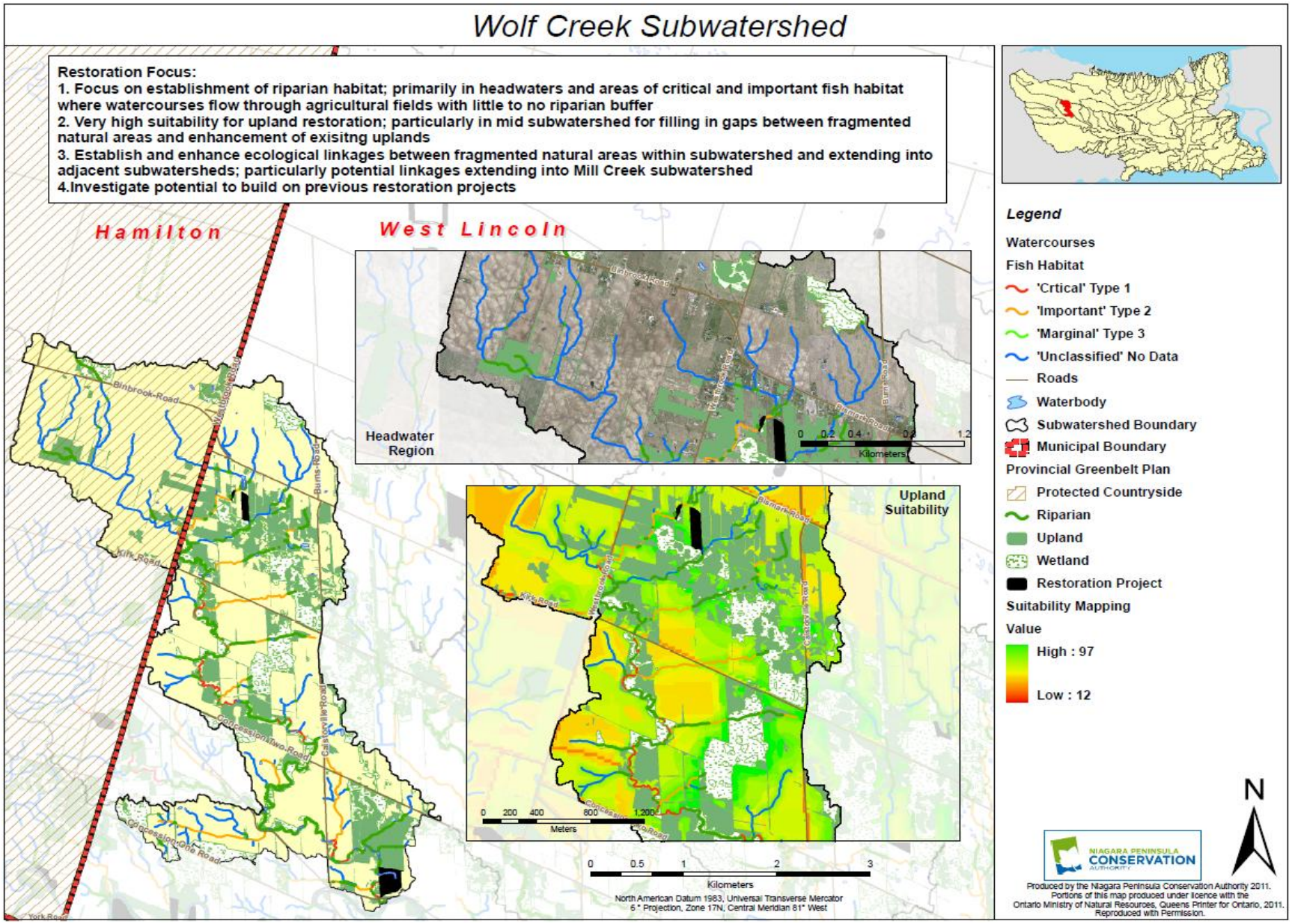

Figure 27: Wolf Creek Subwatershed

Mill Creek Subwatershed

Table 20: Mill Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	20 km^2	
Land Use	Agriculture	Rural Cluster of Abingdon
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	57.6km	
Fish Habitat	Critical and Important	Lower half of main channel has been designated as critical fish habitat. The remainder of the main channel and the larger tributaries have all been designated as important fish habitat. Some smaller tributaries are present that have not yet been evaluated.
Municipal Drains	N/A	
Water Quality	Station:MI001 Water Quality Index: Poor BioMAP Rating: Impaired	This station measures the cumulative land use impacts of Moores Creek and Mill Creek subwatersheds. Factors affecting water quality include exceedances of *E.coli* and total phosphorus.
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability; 3 small areas have a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	60.3	EC recommends 75% with 30m buffer
Upland Habitat	16.5	EC recommends 30% to support viable wildlife population
Wetland Habitat	21.2	EC recommends 10% or to historic value
ANSI, Conservation Areas	North Caistor Centre Slough Centre ANSI	Life Science ANSI extends into upper portion of the subwatershed.
Restoration Projects Completed to date		
Riparian Enhancement	2 projects:2000, 2005	In total 3425 trees and shrubs planted
Reforestation	4 projects: 1999, 2005, 2009(2)	In total 27335 trees planted
Nutrient Management	1 projects:2003	Manure storage: 617.5 m^3 /yr
Conservation Farm Practices	1 project: 2009	Conservation tillage project: no till drill
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian	•currently amount of riparian habitat is below EC recommendations (60.3%).	

Establishment/Enhancement	•water quality has been identified as an issue in the NPCA Water Quality Report with sources of *E.coli* including runoff from agricultural land use, sewage discharges and the presence of waterfowl •large extents of watercourse evaluated as important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat. • investigate possibility of building on previous NPCA Water Quality Improvement projects
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (16.5%) •suitability mapping indicates very high suitability in mid-subwatershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna •suitability mapping also indicates very high suitability for upland enhancement of riparian wetlands along watercourse in lower subwatershed creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat). • investigate possibility of building on previous NPCA Water Quality Improvement projects
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations •very high suitability for riparian-wetland enhancement along watercourse, primarily along lower reach of critical fish habitat which currently has little to riparian habitat • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be

	reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Organic Deicing Material Pilot Program included Canborough, Creek, and Wellandport Roads in the Upper Welland River study area. The pilot program anticipated a reduction in salt usage and overall cost savings to regional winter maintenance activities as a result of fewer salt applications being required. A reduction in salt usage results in less salt being introduced into the environment. Therefore, expansion of the Organic Deicing Material Program is recommended to include all regional roads, primarily those adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Mill Creek subwatershed 5 of these areas were identified; 3 cemeteries, 1 automotive machinery/wreckers, and a closed landfill. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the

	possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

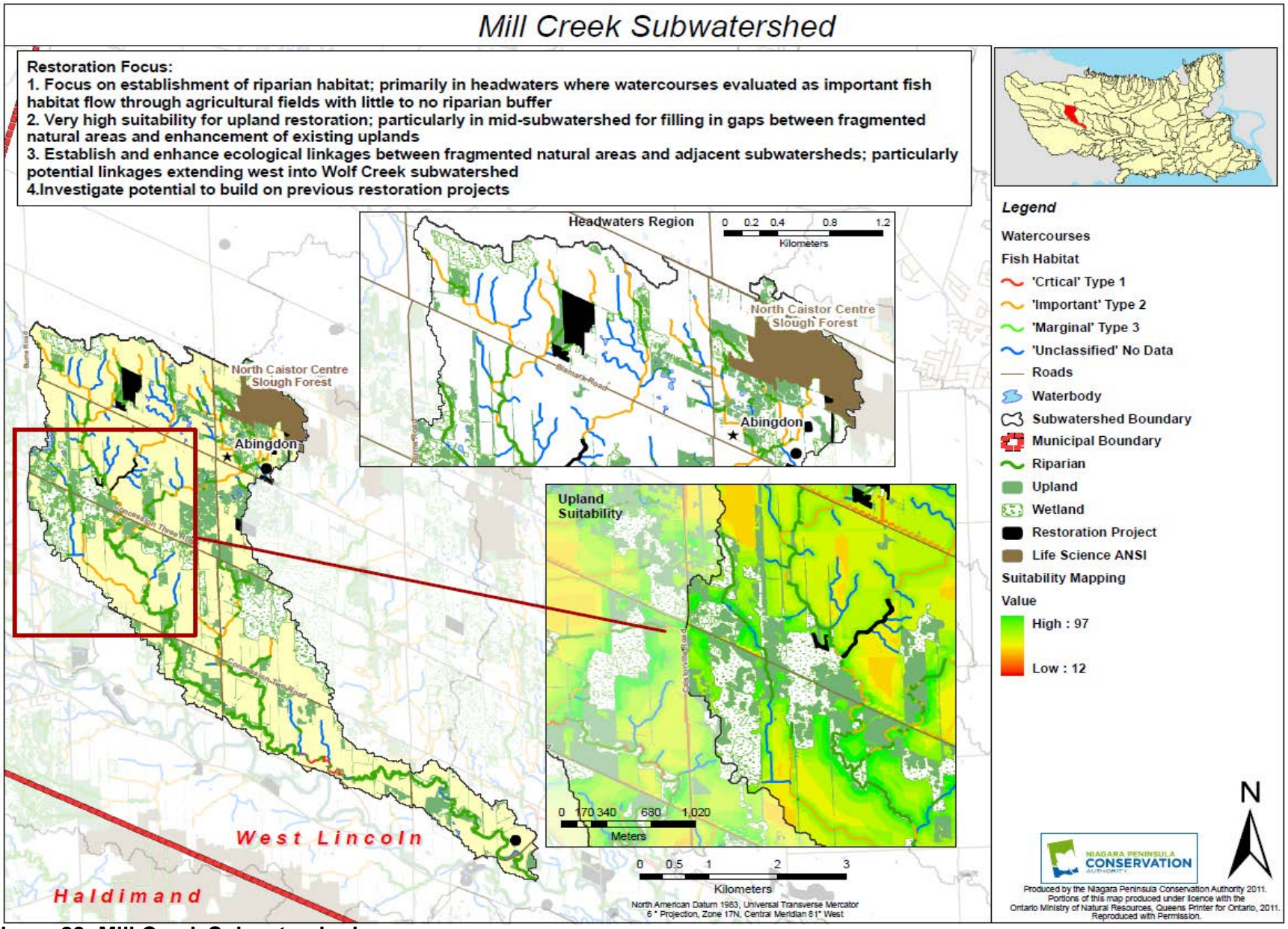

Figure 28: Mill Creek Subwatershed

Moores Creek Subwatershed

Table 21: Moores Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	13.2 km^2	
Land Use	Agriculture	Caistor and Rural Cluster of Caistor Centre
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	23.9km	Outlets to Mill Creek
Fish Habitat	Important	Main channel and most tributaries have been evaluated as important fish habitat. Some of the smaller tributaries have not been evaluated in terms of importance for fish habitat.
Municipal Drains	N/A	
Water Quality	Station:MI001 Water Quality Index: Poor BioMAP Rating: Impaired	This station measures the cumulative land use impacts of Moores Creek and Mill Creek subwatersheds. Factors affecting water quality include exceedances of *E.coli* and total phosphorus.
Groundwater Vulnerability	Low Groundwater Vulnerability; one small area has a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	28.5	EC recommends 75% with 30m buffer
Upland Habitat	14.9	EC recommends 30% to support viable wildlife population
Wetland Habitat	29.7	EC recommends 10% or to historic value
ANSI, Conservation Areas	North Caistor Centre Slough Forest	Life Science ANSI in upper portion of the subwatershed
Restoration Projects Completed to date		
Reforestation	5 projects: 2004, 2008(2), 2009(2)	In total 11,415 trees and shrubs, and 16515 bareroot trees
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is below EC recommendations (28.5%). •water quality has been identified as an issue in the NPCA Water Quality Report with exceedances of *E.coli* and total phosphorus. •large extents of watercourse evaluated as important fish habitat flow through agricultural fields and through agricultural fields identified as having a medium vulnerability to groundwater contamination with little to no riparian buffer	

	•riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.
Upland and Ecological Linkages	•currently amount of upland habitat is below EC recommendations (14.9%) •suitability mapping indicates very high suitability throughout subwatershed for enhancement of existing upland areas and filling in gaps of natural areas reducing forest edge –interior ratio and creating a larger continuous natural area extending into adjacent subwatershed. A larger natural block could support a larger diversity of flora and fauna • investigate possibility of building on previous NPCA Water Quality Improvement projects
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations (29.7%) • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single

area	storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Expansion of Niagara Region's Organic Deicing Material Program	Niagara Region's Organic Deicing Material Pilot Program included Canborough, Creek, and Wellandport Roads in the Upper Welland River study area. The pilot program anticipated a reduction in salt usage and overall cost savings to regional winter maintenance activities as a result of fewer salt applications being required. A reduction in salt usage results in less salt being introduced into the environment. Therefore, expansion of the Organic Deicing Material Program is recommended to include all regional roads, primarily those adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of Welland River Eutrophication Study	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete, work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

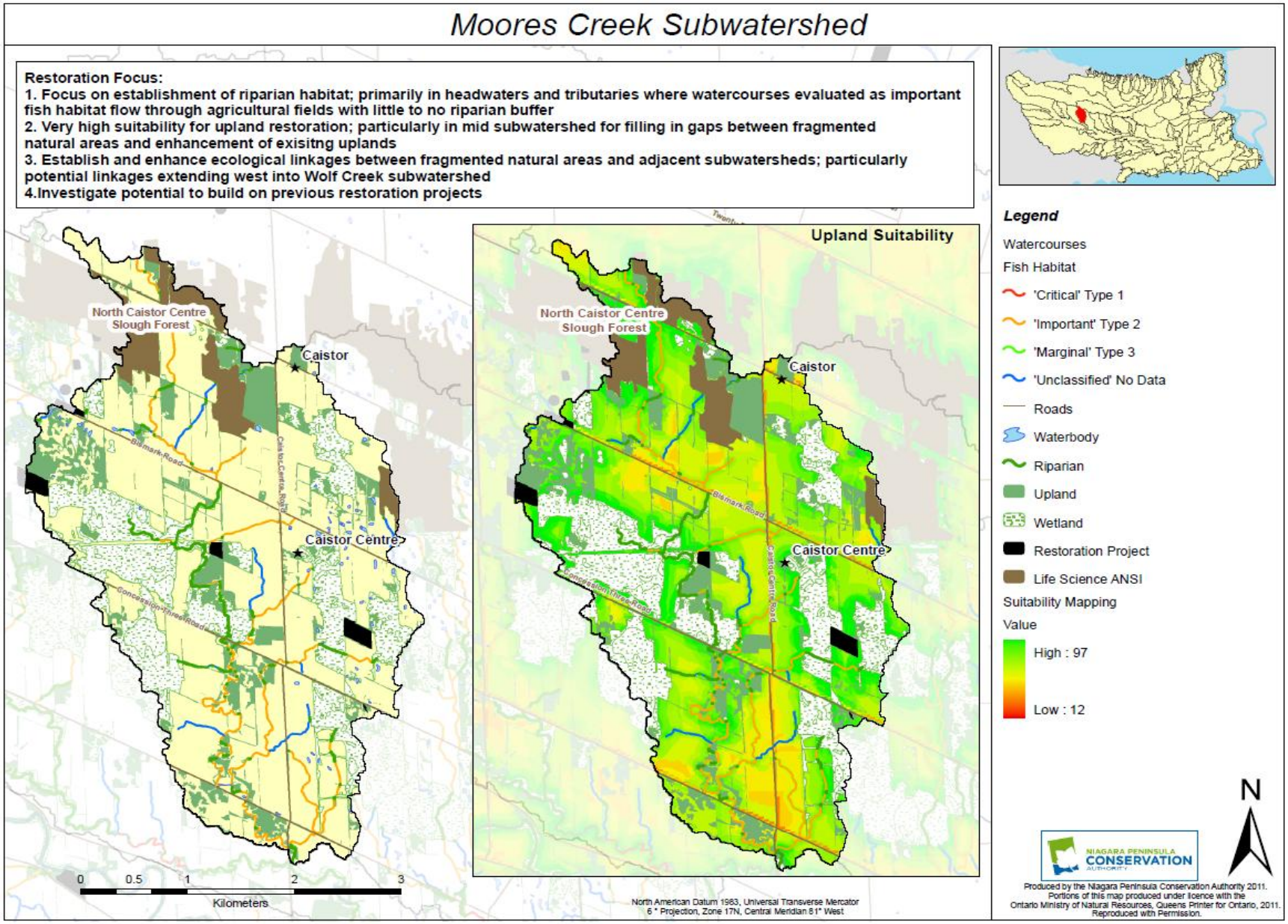

Figure 29: Moores Creek Subwatershed

Wilson Creek Subwatershed

Table 22: Wilson Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	6.4 km^2	
Land Use	Agriculture	
Municipal Water and Sewer Services	No	
Aquatic Resources		
Length of Watercourse	11.7km	
Fish Habitat	Main channel is critical fish habitat and the tributaries are important; some of the tributaries have not been evaluated in terms of importance for fish habitat	Main channel originates in an agricultural field and flows intermittently through wetland and agricultural fields. Lower 3rd of watercourse flows through agricultural fields with little to no riparian habitat. All tributaries originate in and flow through agricultural fields with little to no riparian buffers.
Municipal Drains	N/A	
Water Quality	N/A	
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability; one small area has a medium vulnerability, and pockets of high vulnerability to groundwater contamination are present	Land use in medium groundwater vulnerability is agricultural. Transport pathways such as private wells (active and inactive), unknown status oil and gas wells have been identified as posing a high vulnerability to groundwater through SWP Program
Natural Heritage Resources		
Riparian Cover	49.4%	EC recommends 75% with 30m buffer
Upland Habitat	11.5%	EC recommends 30% to support viable wildlife population
Wetland Habitat	46.8%	EC recommends 10% or to historic value
ANSI, Conservation Areas	Caistor-Canborough Slough Forest ANSI	Life Science ANSI in upper portion of the subwatershed
Restoration Projects Completed to date		
Nutrient Management	1 project in 2002	Manure storage: 3931 m^3/yr
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian Establishment/Enhancement	•currently amount of riparian habitat is lower than EC recommendations (49.4%). •large extents of watercourse evaluated as critical and important fish habitat flow through agricultural fields with little to no riparian buffer •riparian buffers will help to reduce sediment and contaminant loads from adjacent land uses, and cool the water to enhance water quality and fish habitat.	

Upland and Ecological Linkages	•currently amount of upland habitat is lower than EC recommendations (11.5%) •suitability mapping indicates very high suitability for enhancement of Caistor-Canborough Slough Forest ANSI A larger natural block could support a larger diversity of flora and fauna
Wetland Habitat	•currently level of wetland coverage exceeds EC recommendations, however ample of opportunity is present for infilling and enhancement of existing wetlands • high suitability for riparian-wetland restoration along watercourse which would provide linkages between wetlands • protect existing wetlands by creating a buffer called a Critical Function Zone (CFZ) surrounding the wetland: a CFZ is a functional extension of the wetland into upland habitat providing for a variety of critical functions for wetland-associated fauna that extend outside the wetland boundary(e.g. nesting habitat).
NPCA Education and Incentive Programs	
Riparian Buffer Education Program	Many landowners keep their properties manicured or plant crops to the edge of the creek. The NPCA's program aimed at educating landowners about the benefits of buffer zones along watercourses should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum of 75% of the cost of a project with caps between $2,000 and $10,000.
Agricultural Best Management Practices Program	The NPCA's program aimed at educating landowners about the benefits of rural and agricultural best management practices should be extensively promoted. In addition, landowners should be made aware of and encouraged to participate in the Conservation Authority's Water Quality Improvement Program. This program provides grants to a maximum 75% of the cost of a project with caps between $5,000 and $12,000 depending on the project.
Abandoned Well Decommissioning Program	Abandoned wells that are not properly decommissioned (capped and sealed) pose a threat to groundwater resources by providing a direct route to groundwater. The NPCA has a well decommissioning program in place for its jurisdiction. Grants are available for the decommissioning of unused water wells only. Priority is given to hydrogeologically sensitive areas, projects located in areas with a high density of domestic water wells, and areas where watershed plans have been completed or are ongoing (NPCA 2007). Approved grants will cover 90% of well decommissioning costs to a maximum of $2,000 per well (limit of 2 wells per property). This is a reimbursement program, which means that the landowner will pay the full cost to the contractor, and will be reimbursed for 90% of the total project cost after all receipts, invoices, and water well decommissioning records are submitted to the NPCA.
Wetlands are Worth It Program	Wetlands provide important water quality and ecological functions in a watershed by augmenting low flow, acting as natural filtration systems and helping to reduce flooding by acting like giant sponges and absorbing excess water. The Wetlands are Worth It Program through NPCA's Water Quality Improvement Program aims to assist landowners that are interested in restoring, protecting, rehabilitating and creating wetland habitat on their property by providing grants to a maximum of 75% of the cost of a project with a grant ceiling of $10,000.
Special Studies	
Execute the Agricultural Non-Point Source (AGNPS) Model in the Upper Welland River study area	The AGNPS modelling exercise is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land

	management practices, precipitation, drainage sediments inputs, erosion and existing water quality.
Riparian Buffer Tax Incentive Program	Partial exemption on property taxes for the establishment and maintenance of effective riparian and conservation buffers on property. Buffers provide a wide range of functions and benefits depending on their location (e.g. adjacent to watercourse or separating land uses).
Fish Habitat Classification	The watercourses within Haldimand County have not been evaluated in terms of importance for fish habitat. It is recommended that this assessment be completed so this information can be used for proper resource management and land use planning decisions.
Septic System Re-Inspection Program	Areas that do not receive municipal water and sewer services and that have medium and high groundwater vulnerability should be considered priority for such a program. "*Municipal councils could approve and endorse the allocation of funds from property taxes or general revenue to fund the program. This approach may be facilitated with council knowledge that a percentage of inspected septic systems will also require remedial action on the part of some property owners, including the installation of new septic systems. Owners may also pro-actively undertake action if they are aware that a program is underway. Both will affect the number of permits issued in a municipality, and may generate revenue as a result"* (MMAH 2001).
Adoption of an Organic Deicing Material Program for Haldimand County Road Network	The organic sugar beet derivative that is mixed with salt brine and used as a pre-wetting or anti-icing agent was found to outperform the standard salt brine mixture by requiring fewer applications when tested on Niagara Region's pilot study road network. Benefits not only include financial incentives as fewer applications are required, but this also results in less salt being introduced into the environment. It is recommended that Haldimand County also considered implementing an organic de-icing program; primarily for roads that are adjacent to environmentally sensitive areas such as wetlands and waterways.
Municipal Road Salt Impact Study and Initiation of an Organic Deicing Material Program for sensitive areas	Through RMN's *Salt Vulnerability Study* (2005) the Upper Welland River watershed has been ranked as having a predominantly high and moderately high vulnerability to road salt from regional roads for surface water, wetland and fish habitat features. However this study was not conducted on municipal roads; therefore it is recommended that a similar study be completed by the respective municipalities to determine the impact of road salt applications on municipal roads to surrounding features. Once complete, it is recommended that an organic deicing material program be initiated, such as Regional Niagara's, for areas that have been identified as vulnerable to road salt from municipal roads.
Potential Contaminant Sources of Point Source Pollution	An inventory of potential contaminant sources and threats to water quality was identified as part of the objectives for the NPCA's *Groundwater Study* (2005). In the Wilson Creek subwatershed one of these areas was identified; 1 cemetery. An updated inventory to confirm potential contaminant sources and locations is recommended as well as further investigation into the possible effects these potential contaminants may have on surface and/or ground water quality and aquatic habitat, and whether or not a contaminant management plan is needed.
Multi-Stakeholder Incentive Programs Information Flyers/Advertisements/Workshops	Numerous watershed stakeholders offer incentive programs and educational materials for landowners ranging in a number of areas, including for example, non point source pollution projects, backyard naturalization, species at risk, best management practices, green alternatives for your home, green energy, restoration projects, and so forth; the list is endless. However, many people are not aware of the many programs and information available to them. Educational open houses, flyers, advertisements, and/or workshops would be beneficial to the community to become knowledgeable and aware of the roles of the various watershed stakeholders and the numerous programs that are offered.
Implement Recommendations of	Data for the Welland River Eutrophication Study is compiled and the report is in its final stages. Once complete,

Welland River Eutrophication Study	work with respective watershed stakeholders to implement the recommendations of the study in an effort to reduce nutrient loadings to the Welland River and work towards meeting AOC delisting criteria.

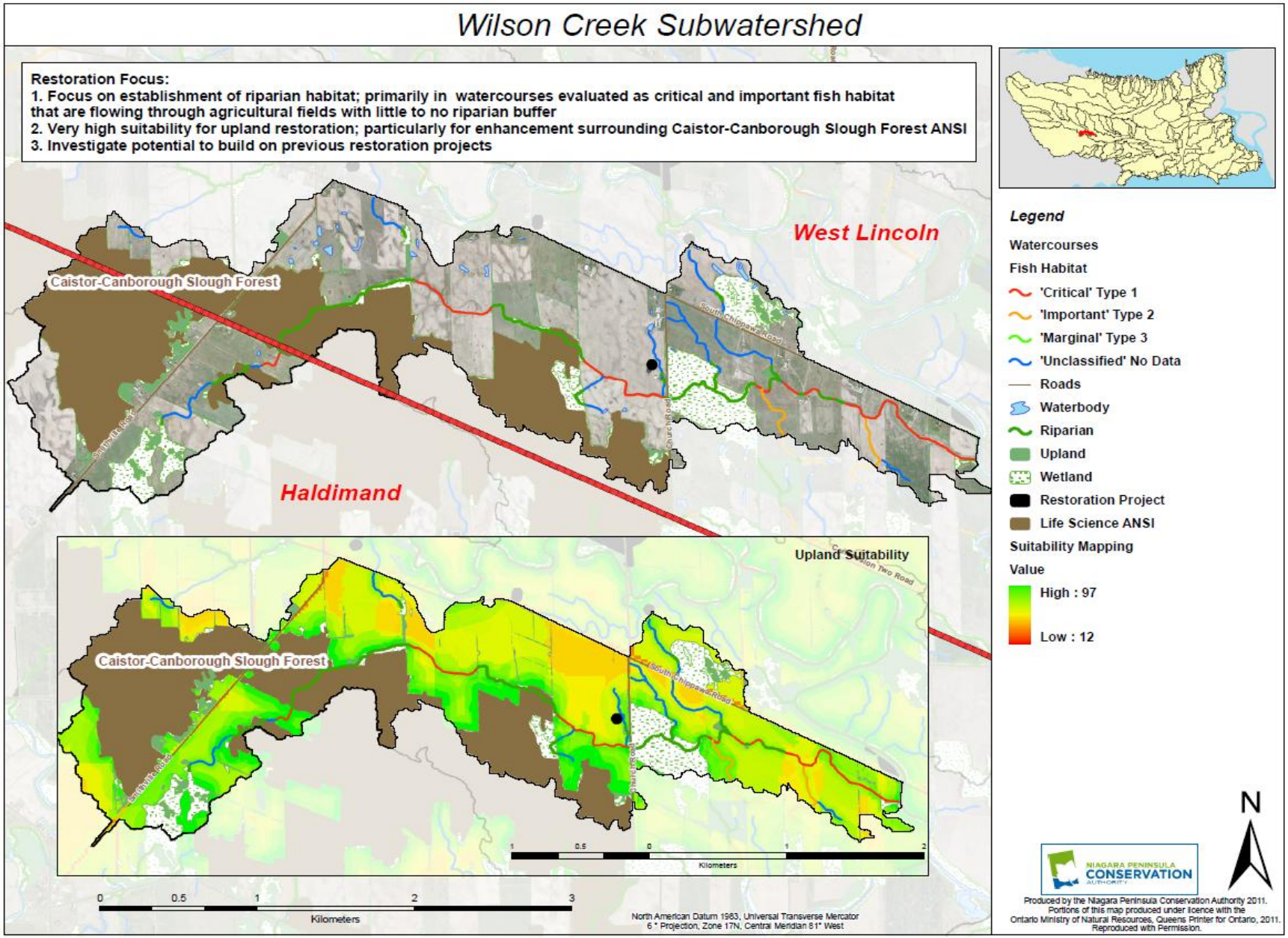

Figure 30: Wilson Creek Subwatershed

Overview of Restoration Strategy

The Welland River watershed has been the focus of restoration for several decades due to its degraded water quality, and its restoration requires a collaboration of all stakeholders with a vested interest in the watershed. As indicated earlier, the IJC designated the Niagara River as one of 43 Areas of Concern in 1987. The Welland River is the largest tributary of the Niagara River and its drainage basin accounts for approximately 80 percent of the Canadian portion of the AOC. The Upper Welland River watershed study area is comprised of 40 percent of the total Canadian Niagara River AOC and includes the upper region of the Welland River; upstream of Wellandport with its respective tributaries.

The predominantly agricultural nature of the land use, the physiography and the topography within the Welland River watershed poses a challenging set of issues regarding water quality. Some have described the Welland River as *„too thick to drink, and too thin to plow!*.' One of the primary challenges in this watershed is nutrient management "*with elevated concentrations of total phosphorus being a widespread cause of water quality impairment*" (NPCA 2010a). It is reported in the *NPCA Water Quality Monitoring Program 2009 Annual Report* that stations WR003 through to WR007 (downstream of UWR) are "*most impacted by nutrient enrichment and elevated concentrations of suspended solids. Sources of nutrients and suspended solids include runoff from agricultural land use, soil erosion, sewage discharges, and animal waste*" (NPCA 2010a). Additionally at these stations, 100% exceedance of total phosphorus is observed with "*total phosphorus concentrations up to 20 times greater than the provincial objective*" (NPCA 2010a). In the Welland River tributaries where water quality is monitored, high concentrations of phosphorus have also been identified with "*100% exceedance [is] observed at most stations with total phosphorus concentrations up to three orders of magnitude higher that the provincial objective"* (NPCA 2010a).

As outlined in the Restoration Strategy, many of the watercourses in the subwatersheds do not have a sufficient riparian buffer (Tables 13-22) and the establishment and/or enhancement of a number of riparian buffers has been recommended (e.g. riparian habitat, buffering land uses). It is important to note that the role of a buffer and its function is directly related to its location. For a list of objectives and functions for conservation buffers, please refer to the chart in Appendix G. This chart was taken directly from *Conservation Buffers; Design Guidelines for Buffers, Corridors, and Greenways* (Bentrup 2008) and can be a useful tool when planning such a restoration project.

The primary objective for the establishment of riparian buffers in this study area is to reduce erosion and runoff of sediments, nutrients and other potential pollutants. Buffers with the function of water quality enhancement will be more effective when combined with best management practices being implemented on land; together these strategies will work towards improving water quality issues.

As mentioned earlier and as identified through the NPCA Water Quality Monitoring Program and the *Welland River Eutrophication Study* (NPCA 2010b), total phosphorus is a major water quality issue in this watershed. Phosphorus in runoff either occurs as particulate phosphorus (sediment bound) or dissolved phosphorus. Sediment bound phosphorus can be moderately well trapped by deposition in buffers whereas dissolved phosphorus must infiltrate with runoff water and be trapped in the soil. Therefore key considerations when designing a buffer to help trap phosphorus are to a) avoid trapping in riparian zones which can be remobilized by flood waters (upland buffer may be required); and b) unlike nitrogen (which can be released to the atmosphere through denitrification) phosphorus will accumulate in the buffer; once saturated it can then turn into a source of phosphorus (Bentrup 2008). However, "*buffers consisting of unfertilized crops or hayfields can trap and utilize phosphorus.*

Removing this vegetation through harvest may help export phosphorus, as well as nitrogen, out of the watershed" (Bentrup 2008).

Restoration should initially be focused in the upper subwatersheds of Little Wolf Creek, West Wolf Creek, Buckhorn Creek and Oswego Creek. Land use in all these subwatersheds is predominantly agriculture and aside from Oswego Creek, the amount of natural heritage cover in these subwatersheds is roughly less than one-third of Environment Canada's recommendation of 30% forest cover, 10% wetland cover, and 75% of a streams length be vegetated, as discussed earlier. Despite Oswego Creek's level of natural cover, it has been identified as one of 3 Welland River tributaries with the highest mean total phosphorus concentration. In addition, although 84% of the watercourses in the Oswego Creek subwatershed have some riparian cover, the width throughout the subwatershed does not meet EC's recommendations of a 15m buffer on either side of the watercourse.

In 2005, an Agricultural Non-Point Source (AGNPS) pollution modelling pilot project was conducted on the watercourses in the Oswego Creek upstream of Canborough weir. The AGNPS model is intended to provide watershed managers with a tool to enable them to design BMP's and to target priority areas where projects would improve water quality conditions. The AGNPS model simulates surface runoff, sediment, and nutrient (nitrogen and phosphorus) transport using a single storm event based model that considers the impact of water quality and quantity from non-point sources. The model also considers all variables affecting water quality including for example, soil, slope, nutrient inputs, land management practices, precipitation, drainage sediments inputs, erosion and existing water quality.

The AGNPS model identified nutrient loading hot spots throughout the Oswego Creek subwatershed. Many of the hot spots identified are watercourses that flow through the agricultural areas with no riparian buffer. Many of these areas are also located in the headwaters region of the subwatershed. In terms of restoration works in this subwatershed, priority should be directed towards the establishment and enhancement of riparian buffers.

It is recommended that the AGNPS model be executed for the Upper Welland River Watershed Plan, starting in these subwatersheds, to assist the Implementation Committee in identifying „hot spots' in the watershed and therefore priority areas for remediation or restoration in an effort to improve water quality. In addition, the AGNPS model can be used to evaluate the success of restoration measures in subsequent years after the Watershed Plan has been implemented by re-evaluating pollutant loadings in the watershed.

Numerous projects have already been implemented in these subwatersheds through the NPCA Water Quality Improvement Program, including several non-point source pollution projects such as manure storages and milkhouse washwater. Investigation into other potential non-point source pollution project opportunities should be undertaken, as well as inquiry into expanding upon existing reforestation and riparian projects that have already been successfully implemented.

The Restoration Strategy also identifies numerous potential opportunities for enhancement of existing natural areas; bulking them up to increase patch size. Larger patches tend to have a greater "*diversity of habitat niches and therefore are more likely to support a greater richness and/or diversity of wildlife species"* (EC 2004c). Currently, the percent of wetland cover is high and should be maintained. Accordingly, the Restoration Strategy identifies opportunities for the establishment of Critical Functions Zones. A Critical Function Zone "*describes non-wetland areas within which biophysical functions or attributes directly related to the wetland [of interest] occur*" (EC 2004c). These areas are functional extensions of the wetland into the upland area and provide a number of functions for

wetland-associated fauna that extend beyond the wetland boundary (e.g. nesting habitats, foraging areas). These areas can also act as buffers, protecting the wetland and its functionality.

When the planning process is initiated to implement a restoration project in the study area, prairies and meadows should be given consideration and incorporated in habitat creation as they play an important role in creating habitat diversity and foraging areas for wildlife.

Opportunities for the establishment of corridor connections between fragmented areas are also identified. Such linkages not only provide shelter to facilitate in the movement of wildlife between natural areas, but they also promote seed dispersal and biodiversity in the watershed. The Restoration Strategy identifies core natural areas that should act as building blocks in which to connect and restore gaps in the surrounding landscape.

As indicated earlier, the Upper Welland River watershed currently contains approximately 22 percent wetland cover, 15 percent forest cover, and approximately 55 percent of the watercourses in the watershed have riparian cover. Once again, Environment Canada recommends at least 30 percent of the watershed should be in forest cover, 10 percent wetland cover *or to historic value*, and at least 75 percent of the watercourses should have a recommended 30 meter riparian buffer. The guidelines are intended as minimum ecological requirements and are meant to provide guidance in setting local habitat restoration and protection targets. Additionally landscapes "*that contain higher amounts of habitat* [than outlined in EC guidelines] *should maintain or improve that habitat*" (EC 2004c).

The following chart (Table 23) specifies the upland, wetland and riparian habitat percentages for each subwatershed in the study area generated from the NPCA Natural Areas Inventory data and the MNR Ontario Wetland Evaluation Systems wetland layer (April 2010). The percent impervious data comes from the *Water Availability Study* (AquaResource Inc 2009) that was done through the Source Water Protection Program.

Table 23:Subwatershed Natural Heritage/Habitat Statistics

Subwatershed Name	Area (sq.km)	% Upland	% Wetlands	% Riparian	% Impervious
Welland River	145.8	14.0	15.0	42.3	6.1
Little Wolf Creek	10.1	11.0	2.2	10.3	3.4
Wolf Creek	13.3	18.3	12.3	35.2	4.3
Mill Creek	20.0	16.5	21.2	60.3	3.3
Moores Creek	13.2	14.9	29.7	28.5	2.8
Wilson Creek	6.4	7.8	46.8	49.4	2.0
West Wolf Creek	13.8	11.5	2.2	28.7	3.6
Buckhorn Creek	24.3	12.0	5.4	35.3	3.5
Elsie Creek	25.5	13.2	15.5	58.4	2.3
Oswego Creek	156.9	17.2	31.6	84.0	2.4
Unamed Creek	20.5	9.5	41.8	51.7	3.5

This chart should be used in conjunction with the Restoration Strategy and AGNPS model to prioritize the implementation of riparian, upland and wetland restoration projects. In addition, as earlier indicated, opportunity to enhance earlier projects that have been implemented through the NPCA Water Quality Improvement Program should be investigated.

Estimating Ecosystem Services

Ecosystem services "*are the benefits that people obtain, either directly or indirectly, from our ecological systems. These services can be understood in ecological terms and they can also be*

translated into economic terms through valuation studies" (MNR 2009c). The MNR commissioned a study intended to understand the socio-economic value of our ecological systems and how this information could be used as a tool to support policy and planning decisions as well as to develop a defensible economic rationale for the conservation of southern Ontario's natural heritage systems. Although ecosystem services form the "*foundation of human well-being and they also represent a significant part of the total economic value of our landscape and economy" (*MNR 2009c), their value is often not considered.

The pilot study methodology was approached by assigning a value to each respective ecosystem category based on an average derived from research for similar research sites. This method is known as „value transfer' or „benefits transfer' and was used because it is not feasible to conduct valuation studies on the entire study area due to significant time and financial constraints. The project generated estimates for southern Ontario for the yearly value of ecosystem services. However, one of the key findings of the study was that due to the number of gaps in existing valuation study data, the results present a greatly under-estimated value of the natural systems. The science of Ecosystem Services Valuation is still relatively young and has not yet "*progressed to the point of matching changes in landscape configuration and ecosystem processes to levels of the provision and the values of the corresponding services. These processes affect ecological indicators like net primary productivity, biodiversity, soil quality, runoff, sedimentation rates, nutrient cycling, and natural disturbance processes, which in turn underlie the provision of most ecosystem services"* (MNR 2009c).

Although still a relatively new science, it is hopeful that as the science improves and data gaps are filled that Ecosystem Services will be considered in future provincial and local policy decision making. This tool would enhance the ability of decision makers to make informed decisions in areas such as cost-benefit analysis and to compare outcomes of various scenarios of different policy criteria (MNR 2009c).

Implementation Responsibilities and Recommended Management Actions

The Upper Welland River Watershed Restoration Strategy is guided by an implementation framework (Table 24). The implementation framework has been designed to account for the watershed plan objectives which were derived from key issues in the watershed and extensive public input. The implementation framework identifies project stakeholders (e.g., provincial agencies, regional government watershed municipalities, public interest groups and landowners), and recommended management actions for each watershed plan objective.

Implementing the Recommended Actions

Lead project stakeholders and those who should be involved in the project have been identified in the following framework. The recommended management actions for the Upper Welland River Watershed include planning and regulatory actions (e.g., septic system re-inspection program), project opportunities on private and public lands (e.g., riparian buffer planting, corridor creation), and areas requiring additional research and monitoring (e.g., salt studies, geomorphic assessments) in the watershed. The budget for NPCA restoration projects through the NPCA Water Quality Improvement Program is identified in the table. If the project is identified as ongoing then it is likely an action that requires continual updating such as the five year review process for regional and municipal Official Plans, which is not allocated a dollar amount. If an existing program already has funding, and the project and funding have a termination date, then these projects have a specific

dollar amount attached to them. In addition, funds allocated as part of annual budgeting have also been assigned dollar amounts.

The recommended actions have also been identified in terms of their implementation. Green denotes short term implementation, yellow represents medium term implementation and red is used to indicate long term implementation. For example, projects that are ongoing are almost always implemented over the long term and are therefore, represented in red. Projects that have specific funding requirements or require approvals, for example, are often represented in green and yellow, thereby indicating short term or medium term implementation respectively.

Welland River Watershed Strategy Update

In 1998, the Welland River Restoration Committee was established to facilitate in the restoration of the Welland River watershed and its resources. As a result, in 1999 together with various stakeholders in the watershed, the *Welland River Watershed Strategy* (NPCA 1999) was initiated. The goal of the strategy was to "*restore the ecological health of the Welland River and its watershed"* (NPCA 1999). The strategy identified numerous management issues and options in the Welland River watershed and 10 year action plan listing the responsible agency for each project. Since the initiation of the *Welland River Watershed Strategy*, several of the project recommendations have been completed or addressed, including for example:

- Agricultural Stewardship and Monitoring Program: The NPCA continues to work with landowners through cost-sharing programs that demonstrate and encourage the use of Best Management Practices
- In addition to the restoration projects completed through the RAP program, nearly 250 projects have been completed in the Welland River since 1999 through the NPCA Water Quality Improvement Program; 122 of these fall within the Upper Welland River watershed study area. Projects include, for example, reforestation, stream fencing, manure storage and buffer strips.
- Fish bypass channels have been constructed at the Port Davidson and Oswego Creek weirs to eliminate the barrier to fish migration
- The Regional Municipality of Niagara and the Niagara Peninsula Conservation Authority have developed policies that address sediment and stormwater management within Niagara Region. Water Quality Monitoring Program: The NPCA has established an extensive network of monitoring stations throughout the watershed to gather long term surface and ground water quality data. Included in this program is the area upstream and downstream of the Glanbrook landfill in addition to site specific targets such as the stormwater ponds.

Table 24: Implementation Framework

WATERSHED PLAN OBJECTIVE	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	HALDIMAND COUNTY	CITY OF HAMILTON	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULTURAL COMMUNITY	PRIVATE LANDOWNERS	ENVIRONMENT CANADA	RECOMMENDED MANAGEMENT OPTION	IMPLEMENTATION	COST ($)
														▲ Lead Stakeholder • Involved Stakeholder ● Short Term ● Medium Term ● Long Term		
Water Resources																
Improve, enhance, maintain or protect water quality and/or natural stream processes to support human uses and ecological functions in accordance with Provincial Water Quality Objectives		▲	▲	▲	▲									**1.** Include water quality protection in regional and municipal planning documents		Ongoing
	▲	•	•	•	•	•			•					**2.** Continue to restrict no new on-line pond construction		Ongoing
	▲						•						•	**3.** Continue to monitor water quality to achieve Provincial Water Quality Objectives		10,000/yr
	•						▲						▲	**4**. Work with EC and MOE to implement recommendations from the Welland River Eutrophication Study once complete		Existing Program
	▲									•	•	•		**5**. Work with agricultural community to implement non-point source nutrient management projects		50,000/yr
Protect, improve and/or restore hydrologically sensitive areas (surface and groundwater features)	▲	•	•	•	•	•	▲							6. Develop and implement a specific Groundwater and Management Protection Strategy for high susceptibility areas identified in the *Groundwater Study* (WHI 2005)		Existing Program
	▲	•	•	•	•		•					•		**7.** Continue to implement the water well decommissioning program in the Upper Welland River watershed through NPCA Decommissioning Program		Existing Program
	▲	•	▲	▲	▲		•							**8.** Continue to identify and map surface and groundwater "hot spots" to determine areas with poor water quality including salt vulnerable areas through Water Quality Program and Annual Report		Existing Program
	▲									•	•	•		**9.** Continue to promote the NPCA's Water Quality Improvement Program		160,000/yr*
	•	▲	▲	▲	▲		•							**10.** Incorporate surface and groundwater protection policies into regional and municipal planning documents		Ongoing
Find an ecologically compatible balance between drain maintenance and function	▲	▲	•	•	•	▲			▲		▲	•		**11.** Best Management Practices for drain maintenance should be developed to reduce ecological impacts to aquatic systems and to prevent sediment from returning to the drain		BMP Report in Progress
Ensure that storm water management practices minimize storm water volumes, sediment, nutrient, and contaminant loads, Recognize the role of natural features and pervious features in minimizing the impacts of flooding	▲	▲	▲	▲	▲									**12.** Continue to implement NPCA Stormwater Policies and BMPs into regional and municipal planning documents		Ongoing
					▲							▲		**13**. Re-instate the rain barrel subsidy program for urban areas in watershed (Binbrook and Mount Hope)		Existing Program
		▲	▲	▲	▲									**14**.Continue to incorporate natural features into planning initiatives		Ongoing
Manage and mitigate flooding risks to human life and property within acceptable limits	▲	•	•	•	•									**15.** Maintain NPCA flood warning system		Ongoing
	▲	•	•	•	•						•	•		**16.** Continue to implement regulations adopted under Section 28 of the Conservation Authorities Act		Ongoing
	▲	•	•	•	•						•	•		**17.** Continue to permit no new development in the 1 in 100 year floodplain		Ongoing
Fish and Aquatic Habitat																
Protect, enhance and restore populations of native species and their habitats in the watershed	▲					•								**18.** Conduct bi-annual fisheries studies in Binbrook Reservoir		$2000/year
	▲	•	•	•	•	▲		•	▲	•	•	•		**19.** Identify and remove human created barriers to fish movement		Ongoing
Complete evaluation of watercourses for importance to fish habitat	▲					▲						•		**20.** Identify and evaluate online ponds to determine value to fish habitat and function in watershed		Ongoing
Incorporate Species at Risk management plans into Restoration Strategy	▲	▲	▲	▲	▲			•	•	•	•	•		**21.** In-stream restoration of fish/aquatic habitat (e.g. spawning bed restoration), and the establishment and/or enhancement of riparian buffer strips around watercourses, wetlands, and highly vulnerable groundwater areas		27,500/yr 5000/250m
	•					▲			▲					**22.** Develop recovery strategies for critical habitat (e.g. spawning areas)		Ongoing
Investigate exotic and invasive fish and plant populations and their impacts	•	•	•	•	•	▲		•	▲				▲	**23.** Review SAR management plans and work with partnering agencies to incorporate recommendations into restoration projects to benefit SAR where possible		Existing Program

Includes project costs, materials and salaries; ** Based on grant ceiling under NPCA's Water Quality Improvement Program for landownersWater Quality Improvement Program Annual Project Budget only; **** Based on Student Wage**

WATERSHED PLAN OBJECTIVE	RESPONSIBLE STAKEHOLDER													RECOMMENDED MANAGEMENT OPTION		COST
	▲ Lead Stakeholder • Involved Stakeholder Short Term Medium Term Long Term														IMPLEMENTATION	($)
	NPCA	MUNICIPALITIES	REGIONAL NIAGARA	HALDIMAND COUNTY	CITY OF HAMILTON	MNR	MOE	OMAFRA	DFO	CONSERVATION GROUPS	AGRICULTURAL COMMUNITY	PRIVATE LANDOWNERS	ENVIRONMENT CANADA			
Natural Heritage and Resources																
Protect, enhance and restore the health, diversity and integrity of the natural heritage systems in the watershed	▲									▲	▲	▲		**24.** Implement the upland reforestation program based on upland suitability mapping targeting interior forest expansion, and ecological linkage opportunities		16,500/yr (1500/acre)
Create, maintain, protect and enhance natural heritage system cores and connections to natural heritage systems, including riparian, in adjoining watersheds	▲	•	•	•	•	▲				•		•		**25.** Continue comprehensive biological inventory and map of natural heritage areas including wetlands		45,000/yr ****
	▲	▲	▲	▲	▲					•	•	•		**26**. Utilize conservation easements, land dedication and acquisition to secure critical linkages as desired lands become available for purchase		Existing Program
Maintain, restore and improve the linkages among surface water features, groundwater features, hydrologic functions, and natural heritage features and areas, and their ecological functions	▲	▲	▲	▲	▲	▲	▲	▲		▲	▲			**27.** Continue partnership building with public interest groups to access funding for reforestation programs (e.g., NRC, Haldimand Stewardship Council)		Ongoing
	▲	▲	▲	▲	▲									**28.** Continue review of new developments and building permits; ensure compliance with PPS and NPCA Regulations		Ongoing
Reach goals set by Environment Canada's recommended habitat targets for riparian, wetland , and upland features	▲	•	•	•	•	▲			▲	•	•	•		**29.** Create new wetlands or enhance existing wetlands based on wetland suitability mapping		1,000/yr 10,000/project **
Identify significant and sensitive areas that need to be protected	▲					▲						▲	▲	**30.** Review SAR management plans and work with partnering agencies to incorporate recommendations into restoration projects to benefit SAR where possible		Existing Program
	•	•	•	•	•	▲			•	•	•	•		**31.** Work with landowners and conservation groups to foster partnerships pertaining to Species at Risk and inform interested parties of funding programs such as Habitat Stewardship Fund, Species at Risk Farm Incentive Program		Existing Program
Communication, Education and Recreation																
Encourage and establish partnerships with respective watershed stakeholders (e.g. landowners, agencies, community groups)	▲									•	•	•		**32**. Continue the NPCA's Water Quality Improvement Program whereby landowners are provided with incentives to carry out projects on their lands		110,000/yr***
	▲	•	•	•	•					•	•	•		**33.** Continue to recognize groups and individuals for their environmental efforts in the Upper Welland River watershed		Ongoing
	▲	•	•	•	•									**34.** Present Watershed Plan findings and successes to regional and municipal government officials and policy makers		Ongoing
Foster educational programs and awareness pertaining to urban and rural best management practices (e.g. water conservation practices, alternate farming practices, septic maintenance, buffers, value of local resources)	▲	•	•	•	•	•	•	•	•	•	•	•	•	**35.** Assemble and meet with a Watershed Plan Implementation Committee made up of local representation (government agencies, organizations, landowners) to annually re-evaluate the UWR Watershed Plan's components, and provide input on new or revised restoration initiatives in the watershed		Ongoing
	•	•	▲	▲	▲		▲				•	•		**36.** Implement a septic system awareness and educational program		10,000/yr**
Increase awareness of current incentive programs available to the public	▲											▲		**37**. Continue creating demonstration sites to educate landowners about the water quality benefits of riparian buffers, wetlands and upland restoration (if possible include map of demonstration sites on NPCA website)		Existing Program
	▲													**38**. Create and disseminate a Watershed Report Card to inform residents on the state of water resources and encourage public stewardship initiatives		Existing Program
Encourage the continuation of children's education programs	▲	▲	▲	▲	▲					▲				**39.** Seek partnerships with public interest groups to improve natural heritage features and recreational opportunities (e.g., conservation groups)		Ongoing
Development																
Incorporate natural heritage and greenspace into land use management and zoning decisions	•	▲	▲	▲	▲									**40.** Identify and incorporate significant natural areas and ecological linkages into planning documents and policies to ensure they are buffered from development		Ongoing
Promote environmentally-sound land use decisions for current and future urban development and rural/agricultural land use	▲	•	•	•	•									**41**. Continue to implement NPCA Policies, Procedures and Guidelines for the Administration of Ontario Regulation 155/06 and Land Use Planning Policy Document (NPCA 2010)		Ongoing
Identify significant and sensitive areas that need to be protected	▲	•	•	•	•									**42.** Continue to implement NPCA Stormwater Management Policies and Guidelines (NPCA 2010)		Ongoing
Encourage intensification of built-up boundaries Find an ecologically compatible balance between drain maintenance and function		▲	▲	▲	▲									**43.** Discourage urban sprawl and focus new growth in existing urban areas through Official Plans		Ongoing

Monitoring

Monitoring serves two purposes in watershed planning. Monitoring is required to update the watershed plan as land uses change and new issues are identified, and monitoring serves to measure the success of restoration projects in terms of enhancing and protecting water quality for all users in a watershed. Monitoring the achievement of a watershed plan's objectives involves continually reviewing the Upper Welland River Watershed Plan. The Plan will be reviewed by the NPCA Restoration Team and the Upper Welland River Watershed Plan Implementation Committee (comprised of public interest groups, watershed municipalities, agency, and citizen representatives) annually. As part of the review process, the plan will be amended whenever necessary to reflect the changing environmental, economic, technical, or social trends within the jurisdiction of the NPCA, and more specifically within the Upper Welland River watershed. A complete review and necessary revisions is slated to occur every 5 years.

In addition to monitoring the objectives or outcomes of the Watershed Plan, the monitoring process includes measuring the performance and success of the management actions used to achieve the objectives. In this regard, monitoring serves to collect and analyze aquatic, terrestrial and socio-economic data to identify changes in the watershed; both from restoration activities, and growth and development. This component of the monitoring program should include:

- Water quality sampling, benthic studies (BioMAP), and water temperature monitoring through the NPCA's Water Quality Monitoring Program. This data can be used as an indicator of whether or not the recommendations provided in the Watershed Plan have maintained and/or improved the physical and chemical characteristics of water quality in the watershed.
- On-going classification of vegetative communities using standardized protocols (Ecological Land Classification). These habitat areas are recorded as Geographic Information System layers and are updated bi-annually to evaluate changes in community composition, habitat size and fragmentation.
- Biological life assessments (qualitative and quantitative) such as insects/pollinators, fish and birds.
- A compilation of the number and location of BMPs implemented in the watershed. This will also include pollutant loading reduction measurements. This information will be housed in a restoration database and updated as projects are completed.
- Watershed landowners should also be surveyed (at least every 5 years prior to the Watershed Plan review) to help watershed planners and the restoration team identify new watershed issues, and evaluate changes in knowledge and behaviour.

The overall objectives of the Upper Welland River Watershed Plan monitoring program are to:

- continually evaluate and amend the watershed plan whenever necessary to reflect changing environmental, economic, technical, or social trends;
- continually assess the overall health and water quality of watercourses; and
- gauge the success of the restoration action plans in protecting and improving water quality and aquatic health.

Table 25: Watershed Monitoring Schedule	
Time Frame	**Action**
Monthly during ice free season(April-November)	Surface water quality sampling
Yearly	Project Monitoring: photos and notes of restoration projects are taken to document status of project(i.e., improvements, growth, change)
Typically every 3 years (spring and fall)	Biological Monitoring and Assessment Program (BioMAP) sampling
Continuous Monitoring	Landowners are given a monitoring journal to document any changes they observe occurring in the project area.
Continuous Monitoring	Update Natural Heritage Information Database and GIS layers to reflect Natural Heritage Areas Inventory field surveys and project findings.

Conclusion

Like many watersheds, the Upper Welland River watershed supports a unique environmental character. Contributing to the distinctiveness of this watershed are, for example, the Binbrook reservoir, the rural nature of its land use, diversity of natural heritages features, and the wealth of endangered and threatened species throughout the watershed.

The Welland River watershed is the largest watershed within the NPCA's jurisdiction and encompasses over 80 percent of the Canadian Niagara River Area of Concern (AOC). As indicated earlier, the predominantly agricultural nature of the land use, the physiography and the topography within the Welland River watershed poses a challenging set of issues regarding water quality. Nutrient management is the greatest challenge in the Upper Welland River watershed study area.

For the residents of the Upper Welland River, they envision the watershed as one that will:

"Continue to foster a viable agricultural industry and healthy, strong communities while balancing environmentally sustainable and compatible land uses. The Upper Welland River watershed will offer passive recreational opportunities for everyone while supporting a healthy diversity of natural features and flora and fauna within a healthy environment that is no longer listed an Area of Concern".

Through extensive public consultation during the watershed planning process, a wide-ranging set of watershed issues have been gathered resulting in a set of watershed objectives. The objectives have been divided under 5 main categories: water resources, fish and aquatic habitat, natural heritage and resources, urban development, and communication and education. These watershed objectives have formed the basis of restoration strategies at the watershed level for riparian, wetland and upland habitat that have been derived from detailed restoration suitability mapping. In addition, project opportunities on private and public lands have been identified such as nutrient management and upland forest restoration to create ecological linkages between existing forested areas. Special studies, including policy tools, education programs and tax incentive programs have also been proposed.

The implementation plan identifies responsible stakeholders for each recommended management action. The recommended management actions have been organized to include riparian, wetland and upland and ecological linkages; to enhance water quality, fish habitat and recreation; specific policy

tools including municipal and regional official plan amendments; outreach and communication for various aspects of water resources management; and research and monitoring programs to obtain additional data from which the Upper Welland River Watershed Plan can be updated and revised every 5 years.

The Niagara Peninsula Conservation Authority will oversee the implementation of the Upper Welland River watershed strategy and recommendations made in this report with the assistance of the Upper Welland River Watershed Plan Implementation Committee, which is comprised of public interest groups, watershed municipalities, agencies and landowners. Watershed plan progress will be communicated annually by means of a qualitative report card that details progress in the watershed.

As indicated earlier, implementation of the Upper Welland River Watershed Plan should be integrated into planning initiatives and roles of regulation by all levels of government. Land use changes in the Upper Welland River watershed should also consider recommendations put forth by the Watershed Plan and supporting studies and documents where appropriate. The NPCA and the Upper Welland River Implementation Committee will also work with local stakeholders to identify restoration actions that are supportive of the Remedial Action Plan and help work towards delisting this area as an Area of Concern. Implementation of such actions will benefit both the Welland River watershed and the Niagara River.

Together the watershed strategy and recommended management actions aim to contribute to supporting healthy natural areas, farms, watercourses, and habitat for a diversity of flora and fauna. Through this plan, the preservation, conservation and restoration of the watershed's ecosystem will protect society's resource needs by sustaining the ecological processes that naturally protect air, water and land resources. All of this will be achieved through environmental stewardship that fosters a collaborative approach to conservation that respects landowners while providing exciting opportunities for education and recreation for all citizens in the Upper Welland River watershed.

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Acronyms

ANSI: Area of Natural and Scientific Interest
BC MOE: British Columbia Ministry of Environment
BioMAP: Biological Monitoring and Assessment Program
BMP: Best Management Practice
CLTIP: Conservation Land Tax Incentive Program
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
CWQG: Canadian Water Quality Guidelines
DFO: Department of Fisheries and Oceans
E. coli: Escherichia coli
ELC: Ecological Land Classification
GTA: Greater Toronto Area
GGH: Growth Plan for the Greater Golden Horseshoe
GMS: Regional Growth Management Strategy
HADD: Harmful Alteration, Disruption or Destruction
IPZ: Intake Protection Zone
LMA: Local Management Area
MFTIP: Managed Forest Tax Incentive Program
MMAH: Ontario Ministry of Municipal Affairs
MNR: Ministry of Natural Resources
MOE: Ministry of the Environment
MOEE: Ontario Ministry of Environment and Energy
MPIR: Ontario Ministry of Public Infrastructure Renewal
NAI: Natural Areas Inventory
NMP: Nutrient Management Plan
NMS: Nutrient Management Strategy
NPCA: Niagara Peninsula Conservation Authority
NPSPC: Niagara Peninsula Source Protection Committee
NU: Nutrient Unit
NWS: Niagara Water Strategy
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
OMNR: Ontario Ministry of Natural Resources
OMOE: Ontario Ministry of the Environment
OWES: Ontario Wetland Evaluation System
PPS: Provincial Policy Statement
PSW: Provincially Significant Wetland
PTTW: Permit To Take Water
PWQO: Provincial Water Quality Objectives
RMN: Regional Municipality of Niagara
SAR: Species at Risk
WAS: Water Availability Study
WTP: Water Treatment Plant
WQI: Water Quality Index

Glossary

Area of Natural and Scientific Interest: Areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education (Provincial Policy Statement 2005).

Best Management Practice: A land management practice implemented to control sources or causes of pollution. The 3 types of Best Management Practices that treat, prevent, or reduce water pollution include: structural, vegetative and managerial.

Bioengineering: Combination of vegetative and structural practices to prevent erosion or stabilize slopes or streambanks

Biological Monitoring and Assessment Program: The use of benthic invertebrates as indicators of water quality.

Carolinian Life Zone: Also known as the Eastern Deciduous Forest Region, the Carolinian Life Zone stretches across southwestern Ontario from Toronto to Grand Bend. It is estimated that approximately one third of Canada's rare and endangered species are found within this zone.

Committee on the Status of Endangered Wildlife in Canada: Is an independent body responsible for identifying species that are considered to be at risk in Canada. Their findings are reported to the federal government who then determines which at-risk species qualify for protection under the Species At Risk Act (2003).

Committee on the Status of Species at Risk in Ontario: The provincial review body implemented by the Ontario Ministry of Natural Resources: also an independent body made up of non-OMNR members.

Ecological function: The natural processes, products, or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions (Provincial Policy Statement 2005).

Endangered Species: A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act (MNR No Date)

Entrenched Channel: A channel that has eroded downward or was constructed such that it no longer has access to its original floodplain during moderate flow events.

Fish Habitat: means spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes [Fisheries Act, Section 31 (5)].

Geomorphic: Relates to the physical properties of the rock, soil, and water in and around the stream.

Intake Protection Zone: Protected area (land and water) surrounding a surface water intake

Intrinsic Susceptibility: The vulnerability of the groundwater system to potential contamination from surface sources.

Local Management Area: As part of the Niagara Water Quality Protection Strategy, Niagara Peninsula Conservation Authority's district was divided into 32 Local Management Areas, each representing an ecologically valid and functioning water management unit derived from the over 140 subwatersheds in its jurisdiction.

Municipal Drain: Municipal drains can be either open watercourses or closed systems buried in the ground (i.e., tiles, pipes) designed and constructed to primarily improve drainage of agricultural lands, but also improve drainage of roads and rural lands.

Niagara Water Quality Protection Strategy: The strategy is part of a multi-stakeholder and multi-jurisdictional effort to work towards the common goal of management, restoration and protection of water resources across Niagara„s watershed.

Permeability: The measure of the ability of a material to transmit fluids through it.

Physiography: The natural configuration of the landscape.

Potentiometric Surface: The area where the ground surface intersects the water table

Provincial Significance: Important on a provincial scale; this may refer to a species; a habitat; or a natural area.

Provincially Significant Wetland: A Class I, II and III Wetland identified as provincially significant as defined in „An Evaluation System for Wetlands of Southern Ontario, South of the Precambrian Shield, Third Edition.'

Species of Special Concern: A species with characteristics that make it sensitive to human activities or natural events (MNR No Date).

Subwatershed: A subunit of a watershed; often defined as the drainage area of a tributary or watercourse (e.g. Wignell Drain).

Threatened Species: A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed (MNR No Date)

Topography: The relief of the land surface.

Watershed: An area of land from which surface runoff (water, sediments, nutrients and contaminants) drain into a common water body (e.g. Lake Erie).

Watershed Management Plan: A proactive document created cooperatively by government agencies and the community to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed to protect the health of the ecosystem as land uses change (Ministry of Environment and Energy and Ministry of Natural Resources 1993).

Wetlands: Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens (Provincial Policy Statement 2005).

Wildlife Habitat: Areas 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 concern may include areas where species concentrate at a vulnerable point in the annual or life cycle; and areas which are important to migratory or non-migratory species (Provincial Policy Statement 2005).

Woodlands: Treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products (Provincial Policy Statement 2005).

Appendix A:
Land Management Issues and Agricultural Best Management Practices Survey

(Sample Survey Form)

Land Management Issues and Agricultural Best Management Practices

Please complete the following survey and return in the self-addressed, stamped envelope.

"The Niagara Peninsula Conservation Authority collects and uses your personal information pursuant to Section 29(2) of the Municipal Freedom of Information Act 1991, and under the legal authority of the Conservation authorities Act R.S.O. 1990 as amended." Questions regarding the policy or its administration should be directed to: Niagara Peninsula Conservation Authority, 250 Thorold Rd. W., 3rd Floor, Welland, ON L3C 2W3, Attn. Privacy Officer.

Background Information

1. Please indicate the municipality in which you live.

O Fort Erie O Niagara Falls O Niagara-on-the-Lake O Thorold O Welland O_____

2. Please indicate, based on the map provided, the watershed in which you live?

O Fort Erie Creeks O Niagara-on-the-Lake O South Niagara Falls

3. Please indicate the title that best describes your situation.

- O Non-farm Landowner
- O Landowner / Farm Operator
- O Absentee Landowner
- O Tenant Farm Operator
- O Landowner / Farm Operator / Tenant Farm Operator
- O Other (specify): _____

4. How much agricultural land do you currently own in the watershed? _____

5. How much agricultural land do you currently rent in the watershed? _____

6. How much land do you have in production? _____
and/or how many livestock do you have? _____

7. What type of agricultural commodity(s) do you produce? _____

8. Are you a member of any agricultural associations?

O Yes O No

If yes, please specify the name of the organization(s):

_____

9. Do you make land management decisions for property that borders a stream or creek?

O Yes O No O Not Sure

10. What is the source of your drinking water (e.g., water well, cistern)? _____

11. Do you rely on a septic system for wastewater treatment?

O Yes O No

Land Management Issues and Concerns

12. Please rank your top three concerns related to your land.

A rank of 1 would represent your most important concern, a rank of 2 would represent your next most important concern, and a rank of 3 would represent the least of your top three most important concerns.

First Concern: _____
_____
_____

Second Concern: _____
_____
_____

Third Concern: _____
_____
_____

13. Please estimate how much of a problem you think each of the following issues will be in the next 5 to 10 years.

Issue	Not a Problem	Slight Problem	Moderate Problem	Serious Problem	Do Not Know
a. Nitrate, phosphate and bacteria levels in streams, rivers, and lakes	O	O	O	O	O
b. Nitrate, phosphate and bacteria levels in groundwater	O	O	O	O	O
c. Pesticide levels in streams, rivers and lakes	O	O	O	O	O
d. Pesticide levels in groundwater	O	O	O	O	O
e. Soil deposition in streams, rivers and lakes	O	O	O	O	O
f. Drinking water quality	O	O	O	O	O
g. Soil loss from agricultural fields	O	O	O	O	O
h. Rivers and streams with eroding banks	O	O	O	O	O
i. Smells, noise, or dust from livestock operations	O	O	O	O	O
j. Smells, noise, or dust from non-agricultural business	O	O	O	O	O
k. Seepage from septic tanks	O	O	O	O	O

Issue	Not a Problem	Slight Problem	Moderate Problem	Serious Problem	Do Not Know
l. Solid waste disposal	O	O	O	O	O
m. Frequency of flooding	O	O	O	O	O
n. Economic losses due to flooding	O	O	O	O	O
o. Economic costs of complying with land-use regulations	O	O	O	O	O
p. Loss of wetlands	O	O	O	O	O
q. Loss of forested or wooded areas	O	O	O	O	O
r. Loss of agricultural land to development	O	O	O	O	O
s. Loss of agricultural land to natural land	O	O	O	O	O
t. Loss of natural land to development	O	O	O	O	O
u. Loss of natural land to agricultural production	O	O	O	O	O
v. Wells drying up	O	O	O	O	O
w. Low surface water conditions (drought)	O	O	O	O	O
x. Other (please specify):_____	O	O	O	O	O

Best Management Practices and Restoration Resources

14. Which of the following Best Management Practices (BMPs) do you currently use? Please select all that apply and specify the specific BMP.

O Tillage and seeding practices: _____

O Erosion control: _____

O Crop rotations: _____

O Residue management: _____

O Nutrient management: _____

O Pest management and pesticides: _____

O Irrigation: _____

O Other (please specify): _____

15. In your opinion, how would you rate the availability of restoration/conservation resources in the watershed?

	Bad	Poor	Fair	Good	Excellent	Do Not Know
a. The availability of restoration/conservation funding programs	O	O	O	O	O	O
b. The availability of restoration/conservation technical assistance	O	O	O	O	O	O

16. List the restoration/conservation funding programs that you are aware of:

_____
_____
_____
_____

17. If funding was available, would you be interested in pursing a project on your property? If yes, please identify the type of project you would be interested in.

_____
_____
_____
_____

Communication

18. How do you prefer to obtain information about watershed planning in your watershed? Please select all that apply.

O Local newspaper (please indicate which newspaper) _____
O Direct mail newsletter
O Email
O Website
O Meetings of local groups and organizations
O Other (please specify): _____
O None

19. Please provide any additional comments:

_____
_____
_____
_____
_____
_____
_____

~ Thank you ~

Appendix B:
Restoration Projects Completed in the Upper Welland River Watershed Plan study area

The following tables summarize the water quality and habitat enhancement projects that have been completed in the Upper Welland River Watershed Plan study area by the NPCA in collaboration with partnering agencies.

Project Type	# Completed
Fish barrier removal	2
Non Point Source	32
Conservation Farm Practices	1
Riparian Enhancement	73
Misc. Plantings	2
Channel Alteration	1
Reforestation	36
Wetland Creation/Enhancement	12

Project Component Breakdown	# Completed
Clean water Diversion	2
Manure Storage	20
Milkhouse washwater	8
Fish barrier removal	2
Nutrient Management Plan	1
Stream Fencing	25
Windbreak	4
Bioengineering Material	4
Free to Grow/ Retire	12
Herbaceous (Aquatic)	6
Herbaceous (Terrestrial)	2
Infil over existing	1

Appendix C:
Examples of key Ontario ecological, infrastructure, and social values likely to be affected by climate change

The following chart lists examples of key Ontario ecological, infrastructure, and social values likely to be affected by climate change. This chart is taken directly from a report published by the Ontario Ministry of Natural Resources entitled *Climate Change Projections for Ontario: Practical Information for Policymakers and Planners (2007b)*

Area	Climate Change Impacts
Agriculture	• Reduced productivity where temperature rises without a compensatory increase in precipitation • Change in crops that can be grown • Less suitable climate to produce ice wine in southern Ontario • Longer growing season • Expansion of agriculture into new areas of northern Ontario where soils are productive
Environment	• Changes in the biodiversity of species and ecosystems • Increased difficulties for species currently at risk to survive or maintain their status • New species at risk because of disequilibrium with climate • Increased opportunity for natural migration of invasive species to Ontario • Loss of plants and animals for which some protected areas were established
Forestry	• Increased frequency and more area burned by forest fires, placing stress on firefighting infrastructure and increasing the number and length of shutdowns of bush operations • Regional changes in timber supply (some may increase while others decrease) • Less access for forestry operations due to late freeze-up and mid-winter thaws • Opportunities to plant faster-growing, less cold hardy tree species • Migration of mountain pine beetle from Alberta threatening old-growth pine forests
Human Health	• Fewer winter cold alerts but more summer heat alerts • More SMOG days • Appearance of new insect-borne diseases • Increased water quality issues due to less total precipitation but more extreme rainfall events
Northern Communities	• Threats to northern communities by forest fires will be more frequent • Soil instability and shifting of houses and other structures due to melting permafrost • Increased community isolation and higher cost of living due to shortened winter road season
Power Generation	• Higher maximum summer power requirements due to increased summer temperatures • Lower winter maximum power requirements due to warmer winters • Reduced hydroelectric power generation due to lower stream/river flow and lower lake levels • More risk to power transmission lines from ice storms
Tourism and Recreation	• Fewer winter outdoor recreation opportunities in southern Ontario (e.g., less reliable skiing, snowmobiling, ice fishing, and outdoor ice skating) • Longer warm weather outdoor recreation season (e.g., boating, camping, and golf)
Transportation	• Shorter road snow-clearing season • Greater risk of freezing rain and need for de-icing in southern Ontario • Longer Great Lakes shipping season • More shipping disruptions and channel/harbour dredging due to lower Great Lakes water levels

The following table summarizes commonly identified changes to the hydrological cycle that are expected in the Great Lakes Basin resulting from climate change. This chart is taken directly from *Mainstreaming Climate Change in Drinking Water Source Protection Planning (de Loe and Berg 2006).*

Hydrological Parameter	Expected Change in the 21st Century, Great Lakes Basin
Runoff	• Decreased annual runoff, but increased winter runoff • Earlier and lower spring freshet (the flow resulting from melting snow and ice) • Summer and fall flows are lower and last longer • Increased frequency of high flows due to extreme precipitation events
Lake Levels	• Lower net basin supplies and declining levels due to increased evaporation and timing of precipitation • Increased frequency of low water levels
Groundwater Recharge	• Decreased groundwater recharge, with shallow aquifers being especially sensitive
Groundwater Discharge	• Changes in amount and timing of baseflow to streams, lakes and wetlands
Ice Cover	• Ice cover season reduced, or eliminated completely
Snow Cover	• Reduced snow cover (depth, area, and duration)
Water Temperature	• Increased water temperature in surface and water bodies
Soil Moisture	• Soil moisture may increase by as much as 80% during winter in the basin, but decrease by as much as 30% in summer and autumn

Appendix D:
Summary of Legislation Governing Management in Ontario

The following is not an exhaustive list of legislation governing management in Ontario. The purpose of the following chart is to provide insight into some of the management tools used in the province of Ontario.

SUMMARY OF LEGISLATION GOVERNING MANAGEMENT IN ONTARIO		
MANAGEMENT TOOL	**DESCRIPTION**	**GOVERNMENT AGENCY**
FEDERAL LEGISLATION		
Fisheries Act	Established to manage and protect Canada's fisheries resources. It applies to all fishing zones, territorial seas and inland waters of Canada and is binding to federal, provincial and territorial governments	Fisheries and Oceans Canada
Environmental Contaminants Act	Prevents dangerous contaminants from entering the environment.	Environment Canada
Canada Shipping Act	Controls water pollution from ships by imposing penalties for dumping pollutants or failing to report a spill.	Transport Canada
Canada Water Act	Authorizes agreements with provinces for the designation of water quality and quantity management.	Environment Canada
Canadian Environmental Protection Act	An Act respecting pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. The Act is intended to protect the environment and human health from the risks posed by harmful pollutants and to prevent new ones from entering the Canadian environment.	Environment Canada
Canadian Environmental Assessment Act	Requires federal departments to conduct environmental assessments for prescribed projects and activities before providing federal approval or financial support.	Canadian Environmental Assessment Agency
Pest Control Products Act	Regulates products used to control pests through a registration process based on prescribed standards.	Agriculture Canada
Navigable Waters Protection Act	Prohibits construction in navigable waters.	Transport Canada
International Rivers Improvement Act	Prohibits damming or changing the flow of a river flowing out of Canada.	Foreign Affairs and Environment Canada
Canadian-Ontario Agreement	Federal-provincial agreement that supports the restoration and protection of the Great Lakes Basin Ecosystem. The Agreement between the governments of Canada and Ontario outlines how the two governments will cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes basin ecosystem.	Environment Canada & Ministry of the Environment
Agricultural & Rural Development Act	An Act to provide for federal-provincial agreements for the rehabilitation and development of rural areas in Canada	Ministry of Industry, Science and Technology
Migratory Birds Convention Act, 1994	The Act ensures the conservation of migratory bird populations by regulating potentially harmful human activities. A permit must be issued for all activities affecting migratory birds, with some exceptions detailed in the Regulations.	Environment Canada
Canada Wildlife Act	The Act allows for the creation, management and protection of wildlife areas for wildlife research activities, or for conservation or interpretation of wildlife.	Environment Canada
Species at Risk Act	To prevent wildlife species in Canada from disappearing and to provide for the recovery of wildlife	Environment Canada

	species that are extirpated (no longer exist in the wild in Canada), endangered, or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened.	
PROVINCIAL LEGISLATION		
Ontario Water Resources Act	Protects the quality and quantity of Ontario's surface and ground water resources (includes Permits to Take Water).	Ministry of the Environment
Clean Water Act	Protects the natural sources of drinking water. Sources of drinking water are to be mapped by municipalities and conservation authorities, especially vulnerable areas that require protections.	Ministry of the Environment
Environmental Protection Act	Protects Ontario's land, water, and air resources from pollution (includes Certificates of Approval for landfills, sewage treatment, etc.).	Ministry of the Environment
Environmental Assessment Act	Requires an environmental assessment of any major public or designated private undertaking.	Ministry of the Environment
Sustainable Water and Sewage Systems Act	To ensure clean, safe drinking water for Ontario residents by making it mandatory for municipalities to assess the costs of providing water and sewage services and to recover the amount of money needed to operate, maintain, and replace them.	Ministry of the Environment
Pesticides Act	Protects Ontario's land, and surface and ground water resources from damage due to improper use of pesticides.	Ministry of the Environment
Endangered Species Act	The purpose of the Act is to Identify species at risk based on the best available scientific information, protect species that are at risk and their habitats, and promote the recovery of species that are at risk, and promote stewardship activities to assist in the protection and recovery of species that are at risk	Ministry of Natural Resources
Fish and Wildlife Conservation Act,1997	This Act enables the Ministry of Natural Resources to provide sound management of the province's fish and wildlife game	Ministry of Natural Resources
Nutrient Management Act	The purpose of the Act is to provide for the management of materials, containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development.	Ministry of the Environment
Conservation Authorities Act	Ensures the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs (includes floodplains).	Conservation Authorities
Lakes and Rivers Improvement Act	Ensures flow and water level characteristics of lakes and rivers are not altered to the point of disadvantaging other water users.	Ministry of Natural Resources
Beds of Navigable Waters Protection Act	Declares the beds of navigable waters as the Crown's responsibility.	Ministry of Natural Resources
Planning Act	Provides for and governs land use planning including the provision of statements of provincial interest to be regarded in the planning process.	Ministry of Municipal Affairs and Housing
Ontario Planning and Development Act	Authorizes Minister to establish development planning areas for promotion of the economic and environmental condition of areas	Ministry of Municipal Affairs and Housing
Development Charges Act	Empowers municipalities to impose development charges against land to be developed where the development will increase the need for municipal services.	Ministry of Municipal Affairs and Housing
Greenbelt Plan (Act)	Identifies where urbanization should not occur in order to provide permanent protection to the agricultural land base and the ecological features and functions occurring on this landscape.	Ministry of Municipal Affairs and Housing

Provincial Policy Statement	Issued under the Planning Act, it provides direction on matters of provincial interest related to land use planning and development, and promotes the provincial "policy-led" planning system.	Ministry of Municipal Affairs and Housing
Places to Grow Act	Ontario government's program to manage growth and development in Ontario in a way that supports economic prosperity, protects the environment and helps communities achieve a high quality of life	Ministry of Energy and Infrastructure
Public Lands Act	Protects and perpetuate public lands and waters for the citizens of Ontario.	Ministry of Natural Resources
Public Utilities Act	Empowers municipalities to acquire and operate water works and divert a lake or river for their purposes.	Ministry of Municipal Affairs and Housing
Drainage Act	Facilitates the construction, operation and maintenance of rural drainage works.	Ministry of Agriculture, Food and Rural Affairs
Tile Drainage Act	Provides for low interest loans to farmers from municipalities for tile drainage on their property.	Ministry of Agriculture, Food and Rural Affairs
Building Code Act	The Building Code regulates standards for the construction and demolition of new buildings	Ministry of Municipal Affairs and Housing
UPPER AND LOWER TIER LEGISLATION		
Municipal Act	Provides for the structure of single, upper and lower tier municipalities, and sets out their basic powers including the ability to regulate (e.g. licensing), provision of services, finances and roads..	Ministry of Municipal Affairs and Housing
Regional Municipalities Act	This Act puts forth the structuring and governance of municipalities in support of the Municipal Act	Ministry of Municipal Affairs and Housing
Regional Municipality of Niagara Act	This Acts puts forth the structuring and governance of municipalities in support of the Municipal Act and Regional Municipalities Act.	Ministry of Municipal Affairs and Housing
Town of Haldimand Act	Establishes a new single tier Town of Haldimand effective January 1, 2001. Establishes the composition of the Town council and sets out certain financial and other powers and duties of the new Town.	Ministry of Municipal Affairs and Housing
City of Hamilton Act	Establishes a new single tier city of Hamilton effective January 1, 2001. Establishes the composition of the new City council and sets out certain financial and other powers and duties of the new city.	Ministry of Municipal Affairs and Housing
Municipal Affairs Act	Give municipalities the power to be responsible and accountable governments with respect to matters within their jurisdiction and each municipality is given powers and duties under this Act and many other Acts for the purpose of providing good government with respect to those matters	Ministry of Municipal Affairs and Housing
Official Plans and Policy Plans	An official plan and/or policy plan describes your upper, lower or single–tier municipal council's policies on how land in your community should be used. It is prepared with input from you and others in your community and helps to ensure that future planning and development will meet the specific needs of your community	Regional or Municipal respective jurisdiction upon approval by the Ministry of Municipal Affairs and Housing
CONSERVATION AUTHORITIES		
Conservation Authorities Act	Ensures the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs (includes floodplains).	Ministry of Natural Resources

Ontario Regulation 155/06- Development, Interference with Wetlands and Alterations to Shorelines and Watercourses	This regulation and associated policies are used by Conservation Authorities to regulate all watercourses, floodplains, valley lands, hazardous lands, wetlands, shorelines, and lands adjacent to these features/functions within their respective jurisdictions.	Ministry of Natural Resources

Appendix E:
Best Management Practices

The following includes potential best management practices for the Upper Welland River watershed derived in part from Niagara Region's and NPCA's policies regarding stormwater management; *Stormwater Management Policies and Guidelines, January 2010.* For detailed information regarding the policies please refer to directly to the document.

Management Alternative	Description
Stormwater Best Management Practices	
At Source and Lot-Level Quantity Controls	
Retrofit Existing Stormwater Basins	Modify older basins that were designed to control only the 100-year storm into multi-functional stormwater wetlands or conventional wet ponds.
Retrofit Existing Detention Devices	Modify to incorporate forebays. Sediment forebays allow polluted sediments to settle out before water is discharged into the detention pond, thereby increasing treatment time and capacity.
Retrofit Infiltration Devices	Where soil permeability and depth to groundwater are sufficient, infiltration measures such as permeable pavement and infiltration trenches should be considered for introduction.
Lot Control	Ensure proper foundation drainage and type of soil and long-term behaviour as far as compaction should be considered. Reduced lot grading can be implemented for soil types with a minimum infiltration rate of 15mm/hr or greater.
Off-line Infiltration Basin	In new development areas design drainage corridors to include an infiltration basin which is not part of the main channel to capture water and allow it to slowly infiltrate into the soil.
Extended Detention Dry Basin	Design new developments to include stormwater basins that capture water and detain it for 24-40 hours before releasing it.
Catch Basin Restrictors	Detain storm water on parking lots or divert flows onto road surfaces, delaying the entry of storm water into the conveyance system.
Green Parking Lots	Install new bioretention areas, infiltration areas, underground vaults, or other practices to detain and clean parking lot storm water before discharging. Encourage businesses to share parking space, require that vegetated spaces in parking lots be used to treat stormwater, encourage mass transit, and encourage permeable spillover parking.
Rain Gardens	Planted depressions designed to receive excess rainwater runoff from buildings and associated landscape. During a storm event the rain garden fills with water and slowly percolates into the ground rather than draining towards a storm drain.
Porous Paving for Low Traffic Roadways and Pathways	Parking areas, fire lanes, bicycle paths that consists of open-graded asphalt on a crushed stone base are capable of absorbing water reducing the amount of runoff entering the storm sewers.
Conveyance Controls	
"Daylighting" Storm Sewers	Eliminate a storm sewer or culvert and replace it with an open, vegetated channel.
Vegetated Swales vs. Curb and Gutter	Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff instead of curb and gutter systems.

Vegetated Swale	Compared to storm sewers, overland flow offers longer contact time with the soil and allows settling of pollutants, nutrient uptake by vegetation and complete infiltration of smaller events.
Road and highway runoff improvements	Construct stormwater wetlands, pond systems, grassed swales, natural vegetation in highway rights-of-way open space.
Pervious Pipe Systems	Convey runoff below ground level by allowing water to infiltrate through the pipe into adjacent soils, providing pollutant removal and reducing the amount of runoff in the storm sewer system
Pervious Catch Basins	These are normal catch basins with a large sump connected to an exfiltration storage area. The storage area may be located either directly below the catch basin floor through a series of holes or beside the catch basin where low flows discharge through the wall of the catch basin into the exfiltration storage area.
End-of-Pipe Controls	
Wet pond	In new development areas include wet ponds that use a permanent storage pool to capture or transform dissolved pollutants thereby holding water and releasing it slowly back to the environment. Wet ponds also reduce peak flows and assist in sedimentation control.
Dry Ponds	Dry ponds only contain water during runoff events and for the length of time it takes for draw down. Dry ponds also provide storage, reduce peak flows, and assist in sedimentation control and pollutant removal.
Constructed Wetlands	Offer peak flow reduction, storage, filtration, sedimentation, biological uptake, and absorption. Beneficial from a water quality perspective as they have the ability to trap and hold contaminants and pollutants.
Infiltration Trench or Dry Well	Design new developments to include an infiltration trench, which receives runoff in a shallow excavated trench that has been backfilled with stone to form a below-grade reservoir. Water can then slowly infiltrate into the soil.
Sand Filters	Sand filters can be used for smaller developments and urban areas with limited open space. This system uses sand in an underground catchment to filter stormwater.
Screening	Generally installed upstream of storage facilities or overflow structures to remove floatable material before water discharges into the receiving waters. Screening requires maintenance and can be prone to clogging.
Oil/Grit Separators	Located in the place of conventional manhole below the ground in a storm drain system. Sediment in the runoff entering the separator is settled out and oil is removed through skimming and trapping. The separator implements the use of a permanent pool storage in the removal of hydrocarbons and sediment from storm water runoff before discharging into receiving waters or storm sewers.
Rural/Urban Best Management Practices	
Conservation Tillage/Agricultural Filter Strips/Buffer and Filter Strips	Alter agricultural practices to encourage naturally vegetated buffers/filters around streams and rivers. Discourage landowners adjacent to watercourse from mowing to streambank.
Lawn Debris Management	Grass trimmings and leaf litter can be controlled by composting or by community curb side collection programs. Compost can be converted to mulch, which when applied in lieu of fertilizer, can reduce nutrient excess into

	watercourses.
Protect receiving waters from bank erosion	Stabilize existing steep slopes with bioengineering methods, and preserve and plant trees along streams to reduce bank erosion.
Stream Channel Restoration/Stabilization	Construct pipe outlets and bank stabilization measures to prevent streambank erosion due to excessive discharge velocities (usually bioengineered).
Constructed Wetland	Build wetlands to capture pollutants from runoff draining urban and agricultural areas. Wetlands differ from basins in that they are shallower, and are planted with wetland plants to filter the water.
Rain Barrels	Rain barrels can be used to catch rooftop runoff for later use (e.g. watering gardens and lawns)
Downspout Disconnection	Disconnecting downspouts from storm drains, or directing them away from paved surfaces that lead directly to the stormwater system allows water to infiltrate into unpaved soils. An education and incentive program should also be created for this alternative.
Native landscaping and/or tree planting	This measure includes planting street trees, and planting trees and plants in parking lot medians or in other landscapes. They can be designed so water flows into these areas before flowing into the stormwater system. Native plants do not need fertilizers, irrigation, or mowing, which can reduce phosphorus and possibly runoff.
Encourage diverse non-turf vegetation at stormwater basin edges	Educate landowners to allow long grasses and wetland plants to flourish in stormwater basins to filter the waste of, and discourage large populations of waterfowl.
Planning and Development	
Establish better enforcement, fines to ensure compliance	May include hiring more staff to inspect and enforce regulations.
Improve septic system maintenance	Require septic system inspection and compliance at point-of-sale; encourage regular maintenance through incentive and/or education programs; and identify any currently failing systems so they can be fixed.
New/Revised Zoning By-Laws	If necessary, a zoning by-law should be created or revised to meet water quality/quantity needs so that planning decisions based on that by-law are defensible.
Conduct Zoning By-Law review	Establish a committee to conduct a formal review of zoning by-laws from a planning perspective for open space and natural features protection/restoration.
Adopt stormwater policies for new developments	This policy tool can be used to control and treat stormwater discharges whereas stormwater management must be addressed before building permits are issued.
Encourage and/or regulate land use planning and management	Develop policies limiting pavement, preserving open space and define locations for more on-site storm water management facilities, and zone/sizing criteria for on-site facilities.
Integrate natural features into the planning process	Through overlay zoning and other methods, valuable natural features should be taken into account when zoning and making planning decisions where such policies are not present. Coordination with municipalities in this area is necessary to preserve systems of open space, and reduce fragmentation of the natural complex of woodlands, prairies and other natural water filtering systems.
Encourage open space site design	Reduction in lot size to preserve common open space of woodlands and wetlands; shared driveways, chipped paths, swales, reduction in road widths, and so forth.
New/Revised Master Plans	If substantial changes are made to implement stormwater

	quantity and quality measures, the master plan should be revisited so that it upholds the changes in natural features inventories, zoning priorities, and so forth to ensure that stormwater measures are not in conflict with the master plan.
Downzoning	Changes an established zone to a lower density level or less intense use. Can be used on strips of land adjacent to waterways to provide a buffer between industrial sites and the streambank or on a whole area surrounding a water body to reverse or prevent pollution.
Encourage and/or regulate land use planning and management	Develop policies limiting pavement, preserving open space and define locations for more on-site storm water management facilities, and zone/sizing criteria for on-site facilities.
Public Education and Participation	
Storm Drain Stencilling Program – Trout Unlimited "Yellow Fish" Program	Residents are frequently unaware that materials dumped down storm drains may be discharged to a local water body. Stencilling can create awareness and prevention.
Citizen Monitoring (Adopt-a-Stream Program)	Citizen groups can collect valuable information on basic parameters – they can monitor and identify problems, collect surface water samples, and measure turbidity.
Promotion of NPCAs Water Quality Improvement Program and Funding Opportunities for Landowners	This program guides restoration activities in the watershed, educates land-owners on how to do restoration and/or manage their land, organizes volunteers, and encourages stewardship.
Promote Incentive Programs for preservation of farmland, wooded areas and open space	Work with agencies, organizations and individuals to promote incentive programs such as Conservation Land Tax Incentive Program, Managed Forest Tax Incentive Program and Farm Property Tax Class Tax Rate.
Reduce excess fertilizer nutrients applied to lawns	Change excessive homeowner and golf course lawn fertilizer application habits by educating homeowners and managers about proper soil testing and lawn care practices.
Reduce/apply only appropriate level of fertilizer to farm fields	Educate farmers and/or offer incentives to have soils tested for the appropriate application of fertilizers.
Develop an education program to encourage proper septic system maintenance	Proper maintenance of septic systems is essential in preventing septic failure, which pollutes natural water systems. Landowners must refrain from inappropriate plantings and uses on the septic field, and periodically arrange for the removal of solids from the system.
Utilize parks and public land for hands-on educational projects	Public places, especially along a watercourse/wetland, provide opportunities for public involvement and education. Projects could include streambank stabilization, native planting, invasive plant removal, logjam removal, wetland creation and so forth.
Use recreational areas as demonstration/education opportunities	In park areas, develop educational signage (watershed awareness, natural vegetation and so forth) and/or create a demonstration/ interpretive area to illustrate natural landscaping, detention basin landscaping, and wetlands to teach about best management practices.
Watershed Signs/Project Signs	Signs can be used to mark watershed boundaries, identify critical areas, promote specific behaviours in specific places, identify co-operators in a project, explain a project and its BMPs, and provide interpretive natural resources information.
Newspaper Articles	Newspaper articles provide detail about local success stories; photos of citizen activities; and feature stories provide information about problems and solutions. They can also be used to announce meetings or public

	involvement opportunities.
Newsletters	Newsletters are a good way to provide key messages and contribute a series of watershed management articles. They can also be used to announce meeting times and dates, update information on actions already taken, and list issues to be discussed at upcoming meetings.
Meetings/Open Houses	Public gatherings, club meetings, special conferences, and workshops can be used to explain a program and receive input, share information, plan actions, and evaluate progress.
Events	Watershed displays should be set up at every opportunity – fairs, local Earth Day events, conferences, and school events.
Awards	Recognize good work, and gain a variety of advocates for your program though conservation awards for young people, public service awards, and participation and sponsorship awards.
Use a website to host information	Develop an Upper Welland River Watershed website to keep agencies, organizations, and others updated about restoration programs.
Training/workshops/presentations	Many times, people do not change their habits and behaviours because they do not know what to do instead (composting, native landscaping, no-phosphorus lawn care, and so forth).
Involve Schools	Make presentations to classes or conduct field trips. Find out what schools are already doing and see how water quality education can fit into the curriculum.
Form a committee/task force of citizens	Create a committee to work on specific aspects of the watershed program; try to include representatives from all interest groups.

Appendix F:
Natural Heritage Species Reference List
And
Site Descriptions

Species List

Common Name	***Scientific Name***
American Basswood	*Tilia americana*
American Beech	*Fagus grandifolia*
Arrow-leaved tearthumb	*Polygonum sagittatum*
Asters	*Aster sp.*
Basswood	*Tilia americana*
Beggar-ticks	*Bidens sp.*
Bitternut Hickory	*Carya cordiformis*
Bittersweet Nightshade	*Solanum dulcamara*
Black Cherry	*Prunus serotina*
Black Chokeberry	*Aronia melanocarpa*
Black Gum	*Nyssa sylvatica*
Black Raspberry	*Rubus occidentalis*
Black Walnut	*Juglans nigra*
Blue Beech	*Carpinus caroliniana*
Broad-leaved Cattail	*Typha latifolia*
Bulrushes	*Scirpus sp*
Bur Oak	*Quercus macrocarpa*
Buttonbush	*Cephalanthus occidentalis*
Canada Blue Grass	*Poa compressa*
Canada Blue-joint	*Calamagrostis canadensis*
Canada Enchanter's Nightshade	*Circaea lutetiana ssp. canadensis*
Canada Mayflower	*Maianthemum canadense*
Cattails	*Typha sp*
Choke Cherry	*Prunus virginiana ssp. virginiand*
Cinnamon Fern	*Osmunda cinnamomea*
Common Blackberry	*Rubus allegheniensis*
Common Boneset	*Eupatorium perfoliatum*
Common Cinquefoil	*Potentilla simplex*
Common Clearweed	*Pilea pumila*
Common Elderberry	*Sambucus canadensis*
Common Hop Sedge	*Carex lupulina*
Common Strawberry	*Fragaria virginiana ssp. virginiana*
Devil's Beggar-ticks	*Bidens frondosa*
Early Goldenrod	*Solidago juncea*
Eastern Bracken Fern	*Pteridium aquilinum var. latiusculum*
Eastern Manna Grass	*Glyceria septentrionalis*
Eastern White Pine	*Pinus strobus*
Enchanter's Night Shade	*Circaea lutetiana ssp. canadensis*
False Nettle	*Boehmeria cylindrica*
False Solomon's Seal	*Maianthemum racemosum ssp. racemosum*
Ferns	*Osmunda sp*
Fowl Manna Grass	*Glyceria striata*
Freeman's Maple	*Acer X freemanii*
Fringed Sedge	*Carex crinita*
Garlic Mustard	*Alliaria petiolata*
Goldenrod	*Solidago sp*
Grass-leaved Goldenrod	*Euthamia graminifolia*

Gray Dogwood	*Cornus foemina ssp. racemosa*
Green Ash	*Fraxinus pennsylvanica*
Hairy Aster	*Aster pilosis*
Hawkweed	*Hieracium sp*
Hawthorn	*Crataegus sp*
Herb Robert	*Geranium robertianum*
Highbush Blueberry	*Vaccinium corymbosum*
Hop Hornbeam	*Ostrya virginiana*
Jack-in-the-Pulpit	*Arisaema triphyllum ssp. triphyllum*
Kentucky Blue Grass	*Poa sp*
Lady's Thumb	*Polygonum persicaria*
Lakebank Sedge	*Carex lucustris*
Large-leaved Aster	*Aster macrophyllus*
Largetooth Aspen	*Populus grandidentata*
Lesser Duckweed	*Lemna minor*
Maple-leaved Viburnum	*Viburnum acerifolium*
Mayapple	*Podophyllum peltatum*
Meadowsweet	*Spirea alba*
Mosses	*Moss sp*
Narrow-leaved Cattails	*Typha angustifolia*
Narrow-leaved Meadowsweet	*Spirea alba*
Northern Water-horehound	*Lycopus uniflorus*
New England Aster	*Aster novae-anglais*
Norway Spruce	*Picea abies*
Oak species	*Quercus sp*
Pale Smartweed	*Polygonum lapathifolium*
Pennsylvania Sedge	*Carex pennsylvanica*
Pink Knotweed	*Polygonum pennsylvanicum*
Poison Sumac	*Rhus vernix*
Porcupine Sedge	*Carex hystericina*
Radiate Sedge	*Carex radiata*
Raspberries	*Rubus sp*
Red Maple	*Acer rubrum*
Red Oak	*Quercus rubra*
Red Osier Dogwood	*Cornus stolonifera*
Reed-canary Grass	*Phalaris arundinacea*
Rice Cut-Grass	*Leersia oryzoides*
Rough Goldenrod	*Solidago rugosa ssp. rugosa*
Royal fern	*Osmunda regalis var. spectabilis*
Sedges	*Carex sp.*
Sensitive Fern	*Onoclea sensibilis*
Serviceberry	*Amelanchier sp*
Shagbark Hickory	*Carya ovata*
Selfheal	*Prunella vulgaris ssp. vulgaris*
Silky Dogwood	*Cornus amomum ssp. obliqua*
Silver Maple	*Acer saccharinum*
Small's Spike-rush	*Eleocharis smallii)*
Smooth Serviceberry	*Amelanchier laevis*
Soft Rush	*Juncus effusus ssp. solutus*
Speckled Alder	*Alnus incana ssp. rugosa*
Spicebush	*Lindera benzoin*

Spotted Crane's-bill	*Geranium maculatum*
Spotted Touch-me-not	*Impatiens capensis*
Sugar Maple	*Acer saccharum*
Spicebush	*Lindera benzoin*
Spotted Water-hemlock	*Cicuta maculata*
Swamp Dewberry	*Rubus hispidus*
Swamp Maple	*Acer fremanii*
Swamp Rose	*Rosa palustris*
Swamp White Oak	*Quercus bicolour*
Tall Goldenrod	*Solidago altissima var. altissima*
Tartarian Honeysuckle	*Lonicera tatarica*
Thicket Creeper	*Parthenocissus inserta*
Three-lobed Beggar-ticks	*Bidens tripartita*
Trembling Aspen	*Populus tremuloides*
Western Poison-ivy	*Rhus radicans ssp. rydbergii*
Witch-hazel	*Hamamelis virginiana*
White Ash	*Fraxinus americana*
White Elm	*Ulmus americana*
White Grass	*Leersia oryzoides*
White Pine	*Pinus strobus*
White Oak	*Quercus alba*
Willow species	*Salix sp*
Winterberry	*Ilex verticillata*
Wool Grass	*Scirpus cyperinus*
Yellow Birch	*Betula alleghaniensis*

Site Descriptions

Site I.D.: HAL-10-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 426 hectares
Subwatershed: Drainage from this study site flows to Chick Hartner Drain in the west and an unnamed creek in the central portion. Small portions flow south west to Michner Drain, and north west to Oswego Creek.
General Summary: Study site located along the Haldimand - Wainfleet border and is bound by The east-west rail line in the north and bird Road to the south. It extends from Diltz Road in the west to Gore „A' Road in the east.
Summary: This study site is dominated by Swamp Maple, Red Maple, and Green Ash, with White Elm and Spicebush. The understory was a mix of Black Raspberry, Thicket Creeper, and Herb Robert. The more open water community was dominated by Broad-leaved Cattail, and Soft Rush. There are a total of 93 recorded taxa for this study site.

Site I.D.: HAL-11-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 107 Hectares
Subwatershed: This study site drains in a number of directions. It drains to Oswego Creek to the north, and moving from east to west, drains to a number of municipal drains. Michner Drain in the east, to Chick Hartner Drain to the east and central areas of the study site and, west to James Drain. This complicated drainage pattern may be partly responsible for the interesting micro topography and associated communities that characterize this study site.
General Summary: This study site is located between the east-west rail line in the north and Bird Road in the south. It extends from Regional Road 15 in the west to Diltz Road in the east.

Summary: This site had Deciduous Forest mixed with patches of Thicket Swamp communities. There was interesting microtopography alternating across the landscape. The Deciduous Forest communities contained Sugar Maple and American Beech as the dominants with associated White Ash and Red Oak.

The Thicket Swamps were largely Freeman's Maple, Swamp White Oak and Willow species. The lower layers contained Narrow-leaved Meadowsweet, Winterberry, Reed-canary Grass and Rice Cut-Grass. More uncommon for this study site were the Yellow Birch and Green Ash dominated or, Freeman's Maple and Willow dominated Meadow Marsh communities. Once again there was interesting topography that saw the drier knolls inhabited by Sugar Maple. There are a total of 96 recorded taxa for this study site.

Site I.D.: HAL-12-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 75 Hectares
Subwatershed: Sugar Creek Drain
General Summary: This site is bordered by Moote Road to the west and Regional Road 15 to the east, Swayze Road in the north and Stringer Road in the south.
Summary: The most dominant community noted for this study site was a Deciduous Swamp community largely made up of Green Ash, Red Maple, and Basswood. The understory was characterized by a mix of Spicebush, Gray Dogwood, and regenerating Trembling Aspen.
The ground layer was a mix of Canada Enchanter's Nightshade, Spotted Touch-me-not, and Spotted Crane's-bill. The drier knolls were mostly Red Oak and Sugar Maple, with a ground layer of Canada Mayflower, False Solomon's Seal, Sedges, and Mayapple. The Thicket Swamps noted were characterized by dense stands of Buttonbush, with Beggar-ticks and Lesser Duckweed. There are a total of 86 recorded taxa for this study site.

Site I.D: HAL-14-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 487 hectares
Subwatershed: Oswego Creek
General Summary: It is bound on the west by the watershed boundary of Oswego Creek and Windecker Road. The eastern boundary is the Dunnville Haldimand Townline Road. The study site is below Highway 3 and north of Concession One.
Summary: This study site is a complex of wet and dry areas. Overall, the area is dominated by Red Maple Swamp with associated Freeman's Maple, Swamp White Oak and White Elm.
The understory is largely Red Maple, Freeman's Maple and Shagbark Hickory with Narrow-leaved Meadowsweet, Grey Dogwood, Sedges and Swamp Dewberry. There are a total of 127 recorded taxa for this study site.

Site I.D.: HAL-22-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 289 hectares
Subwatershed: Elsie Creek and Oswego Creek
General Summary: Study site is bound on the north by Young Road and on the south by Regional Road 9. The western boundary is Sims Locks Drive and Moore Road is the eastern boundary.
Summary: The most common community noted for this study site was the Meadow Marsh dominated by Spotted Touch-me-not, Rice Cut-grass, Reed-canary Grass, and Sedges. Common Clearweed, Fowl Manna Grass, and Sensitive Fern were found as associates.

The Deciduous Forests noted were characterized by Sugar Maple, American Beech, Shagbark Hickory, and Basswood in the canopy. Understory species included regenerating canopy species with White

Ash, Black Raspberry, Canada Enchanter's Nightshade, and Western Poison-ivy. The ground layer was a mix of Spotted Crane's-bill, Large-leaved Aster, Canada Mayflower, and Common Strawberry.

The Deciduous Swamps were mostly Red Maple with Shagbark Hickory, and Swamp White Oak in the canopy and an understory of Sedges, Spotted Touch-me-not, Common Clearweed and Sensitive Fern.

The Shallow Aquatic community recorded for this study site was almost entirely covered with Lesser Duckweed. There are a total of 156 recorded taxa for this study site.

This site is also in part designated as **Nelles Tracts Provincially Significant Wetland**.

Site I.D.: HAL-23-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 371 hectares
Subwatershed: Elsie Creek and Oswego Creek subwatersheds.
General Summary: Study site HAL-23 is located south of Regional Road 9 and north of Concession 2. It extends from Indian line in the east to just west of the watershed boundary between the Welland River and the Grand River.
Summary: The most common communities noted for this study site were the Meadow Marshes dominated by Buttonbush, Reed-canary Grass, Narrow-leaved Meadowsweet, and Highbush Blueberry. Associates included Speckled Alder, Winterberry, Green Ash, and Sedges such as, Lakebank Sedge and Porcupine Sedge

The herbaceous layer was a mix of Rice Cut-grass, Devil's Beggar-ticks, Wool Grass, and Bittersweet Nightshade. In wetter areas Broad-leaved Cattails were prevalent. The Thicket Swamps were dominated by Gray Dogwood, with Narrow-leaved Meadowsweet, Hawthorn, Common Elderberry, Winterberry, Buttonbush, Poison Sumac, and Black Chokeberry.

The herbaceous layer was a mix of Early Goldenrod, Cinnamon Fern, Sedges, and Bittersweet Nightshade. The Deciduous Forest communities noted for this study site were largely Sugar Maple, American Beech, Red Oak, Shagbark Hickory, and White Ash, with Basswod and in some Mixed Forests, White Pine. Shallow Marshes documented were mostly Narrow-leaved Cattails, with Pale Smartweed, Common Boneset, Beggar-ticks, and Pink Knotweed. There are a total of 225 recorded taxa for this study site.

This site is also in part designated as **Fish Carrier Areas 1, 2, 3 and 4 Provincially Significant Wetland**

Name: North Cayuga Slough Forest
Formerly: North Cayuga Slough Forest (Norfolk Field Naturalists, 1987)
Site I.D: HAL-24-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 1,391 hectares
Subwatershed: Oswego Creek
General Summary: Study site HAL-24 is located within Haldimand County on the far west border between Regional Road 9 and Highway 3. It is bound by Regional Highway 54 to the west and Singer Road to the east.
Summary: The most common communities recorded for this study site were the Thicket Swamps characterized by Narrow-leaved Meadowsweet, Buttonbush, Winterberry or, Speckled Alder as the dominant with Red Maple, Gray Dogwood, Highbush Blueberry and, Willows as associates.

The herbaceous layer was generally a mix of Devil's Beggar-ticks, Goldenrod and, Spotted Touch-me-nots. Shallow Marsh communities were also found throughout this study site. They were dominated by

Rice Cut Gras, White Grass and, Cattails with Bulrushes or Winterberry, Meadowsweet and Devil's Beggar-ticks.

A community that is uncommon to the area but was present in this study site was the Poison Sumac Swamp community. Poison Sumac was growing dominant in very organic soils in a Deciduous Swamp on the edge of a large Buttonbush slough. There are a total of 238 recorded taxa (unique plant records) for this study site.

This site is also in part designated as **North Cayuga Slough Forest (Young Tract) Provincially Significant Wetland** and **North Cayuga Slough Forest Life Science Area of Natural and Scientific Interest.**

Name: Hedley Forest
Site I.D.: HAL-26-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 1,034 hectares
Subwatershed: This study site drains to the Oswego Creek subwatershed.
General Summary: This study site is one of the largest in Haldimand. It stretches from Caistorville Road/ Regional Road 2 in the east to the watershed boundary for the Niagara Peninsula Conservation Authority in the west (Oswego Creek). The northern boundary is just north of Concession One and the southern boundary is Highway 3.
Summary: Given the location of this study site and the drainage pattern of the landscape, it would be expected that slough forests would dominate. However, the properties visited by the field crews were dominated by naturalized conifer plantations and shallow marshes.

The naturalized plantations communities were largely Eastern White Pine and Norway Spruce with associated Shagbark Hickory and White Elm that had obviously seeded itself over the years. The Shallow Marsh community was found most often in the less successional areas. These open sedge marshes were saturated with water and had interspersed pockets of open water or open water aquatic communities. These communities were dominated by Fringed Sedge, Wool Grass and Narrow-leaved Meadowsweet.

In the areas where slough forest communities were present, they were largely found to have the typical suite of canopy species including Red Maple, Swamp Maple, and Green Ash. The understory contained regenerating canopy species with Buttonbush, Narrow-leaved Meadowsweet, and Silky Dogwood.The herbaceous layer was a mix of Asters and Sedges.

On the drier knolls between sloughs, Shagbark Hickory was the dominate canopy species with Hop Hornbeam and White Elm as the understory. Grey Dogwood and Hairy Aster were common in the lower forest layers. There are a total of 111 recorded taxa for this study site.

This study site encompasses **Hedley Forest Conservation Area.**

Site I.D.: HAL-28-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 245 hectares
Subwatershed: Oswego Creek.
General Summary: The northern boundary is just north of Concession Road and the southern limit is Townline Road. It is bound on the west by Singer Road and on the east by Turnbull Road.
Summary: The first community identified for this study site is dominated by Red Oak with Swamp White Oak and Sugar Maple as associates. The understory was largely characterized by American Beech, Sugar Maple, Bitternut Hickory, Hop Hornbeam and Basswood. The herbaceous layer was made up of Large-leaved Aster, Spotted Crane's-bill, Common Strawberry and others.

Commonly, the Thicket Swamps were dominated by Red Maple and White Elm. Gray Dogwood and Narrow-leaved Meadowsweet.

An interesting Thicket Swamp community identified had Poison Sumac as its dominant species with Willow and Red Maple. The understory was largely Black Chokeberry with Poison Sumac and Swamp Rose and, the ground layer was a mix of Ferns, Sedges and Spotted Touch-me-nots.

The Meadow Marsh communities noted were dominated by Willow species with Sedges, Willows, Swamp Rose and Narrow-leaved Meadowsweet in the upper layers. The lower layers were mostly White Grass, Small's Spike-rush and Devil's Beggar-ticks. Areas of Cattail Marsh and some Shallow Water communities were also identified.

The areas of Deciduous Forest identified were drier with Sugar Maple and Red Oak or Sugar Maple and American Beech as the dominants. The understory associates were largely Shagbark Hickory, Hop Hornbeam and White Ash. The herbaceous layer was commonly Canada Enchanter's Nightshade and Western Poison Ivy or, Large-leaved Aster, Spotted Touch-me-not, False Solomon's Seal and Common Cinquefoil.

There were of course the more common Deciduous Swamp communities that are characteristic of the slough forests in the area. These communities were dominated by Red Maple, Green Ash, White Elm and Bur Oak. Black Raspberry, Radiate Sedge, Common Hop Sedge, Spotted Touch-me-not are common associates. There are a total of 233 recorded taxa for this study site.

Site I.D.: HAL-32-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 153 hectares
Subwatershed: Oswego Creek
General Summary: This study site is located between Concession 1 to the south and Concession 2 to the north. The study site is bound on the east by Turnbull Road and on the west by Singer Road.
Summary: The Deciduous Forests of this Study Site are dominated by a canopy of Sugar Maple, Shagbark Hickory and Red Oak , and an understory of regenerating Sugar Maples and White Ash.

The understory is dominated by Green Ash with Common Blackberry, Enchanter's Night Shade, Large-leaved Aster and Spotted Crane's–bill. The Thicket Swamp areas are dominated by species of Hawthorn, Green Ash and White Elm. The understory in these communities is largely Meadowsweet, Grey Dogwood and Silky Dogwood with Goldenrod species.

The meadows of this study site contain Silky Dogwood, Grey Dogwood, Meadowsweet and Hawthorns with patches of Goldenrod and Aster species. The Meadow Marshes noted were dominated by Grey Dogwood and Meadowsweet with associated Broad-leaved Cattail and Wool Grass. The ground cover is largely Lakebank Sedge, Rice Cut Grass, Spotted Touch-me-nots and Common Clearweed. The one Shallow Marsh community documented was characterized by Winterberry and Highbush Blueberry with Broad-leaved Cattail and Rice Cut Grass. There are a total of 160 recorded taxa for this study site.

Site I.D:HAL-33-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 174 hectares
Subwatershed: A very small portion of this study site drain east to the Welland River West subwatershed while the larger area is part of the Elsie Creek subwatershed of the Welland River.
General Summary: This study site extends from just west of Moore Road to Haldibrook Road in the east. It is north of Regional Road 9 and south of Stoney Creek Road/ Concession 4.

Summary: The Deciduous Forest communities of this study site are dominated by Red Oak, Sugar Maple and White Ash, with an understory of Sugar Maple, American Beech, Hop Hornbeam and Basswood. The herbaceous layer was largely sedges and Canada Enchanter's Nightshade.

The Thicket Swamp communities were dominated by either Trembling Aspen or Hawthorns with Grey Dogwood, and Narrow-leaved Meadowsweet as associates. The herbaceous layer in these communities was a mix of Spotted Water-hemlock, Common Strawberry, Goldenrod Species, and Common Clearweed.

The Meadow Marshes of this study site are largely dominated by Reed Canary Grass, Rice Cut Grass and Pale Smartweed. There are a total of 116 recorded taxa (unique plant records) for this study site.

This site is also in part designated as **Sinclair Meander Basin Swamp Provincially Significant Wetland.**

Name: Dunnville Heronry Woods/Dunnville Northwest Forest
Formerly: Dunnville Heronry Woods/ Dunnville Northwest Woods (Norfolk Field Naturalists, 1987)
Site I.D.: HAL-37-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 526 hectares
Subwatershed: This study sites drains to Sugar Creek Drain in the west and James Drain in the east.
General Summary: Study site HAL-37 is situated in Haldimand County between Highway 3 in the west and Regional Road 15 in the east. It is north of Kentucky Hill Road and south of James Road.
Summary: Based on the location and information available for the area, study site HAL-37 was expected to be a slough forest. Much of the study site falls within the James Drain watershed and the drainage patterns on the landscape clearly show slough and ridge topography. The properties visited by the field crew, however, had altered hydrology due to the municipal drains and as a result had only small wet areas and thus were not supporting the typical slough forest communities.
The most common species recorded for the site was Sugar Maple with associates of Basswood, American Beech and White Ash more indicative of a drier Deciduous Forest community. The understory was largely regenerating canopy species with Red Oak and Thicket Creeper. In the Thicket Swamp communities noted, Buttonbush was the dominant species with Winterberry in the understory and Spotted Touch-me-not in the ground layer. There are a total of 73 recorded taxa for this study site.

This site is also in part designated as **Dunnville Woodlots Provincially Significant Wetland**.

Site I.D.: HAL-38-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 60 hectares
Subwatershed: Buckhorn Creek
General Summary: It is a small study site made up of several small woodlands. It is bound on the east by Regional Road 66/ Stoney Creek Road and on the west by Moore Road. It is located south of Haldibrook Road and north of Regional Road 66.
Summary: The communities recorded for this study site are mostly upland dominated by Sugar Maple, Basswood, and American Beech with associated Spotted Crane's Bill and Jack-in-the-Pulpit. The Shallow Marsh communities noted were small and scattered throughout the upland communities. They were dominated by stands of Spotted Touch-me-nots. There are a total of 82 recorded taxa for this study site.

Site I.D.: HAL-39-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 34 Hectares
Subwatershed: Buckhorn Creek

General Summary: This study site is small containing only a few small woodlands. It is located south of Haldibrook Road and north of Regional Road 66. It is bound on the west by Stoneman Road and reaches to just east of Moore Road.
Summary: This Shallow Marsh community is dominated by Reed Canary Grass with associated Rice Cut-Grass, and Goldenrod species. There are a total of 25 recorded taxa for this study site.

Name: Attercliffe Station Slough Forest
Formerly: Attercliffe Station Slough Forest (Norfolk Field Naturalists, 1987)
Site I.D.: HAL-40-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 454 hectares
Subwatershed: This study site is split nearly in half with the northern portion draining to Oswego Creek, and the southern portion flowing into Sugar Creek Drain.
General Summary: This study site extends from Lane Road in the north to just south of James Road. Highway 3 is the western boundary and Hart Road is the eastern boundary.
Summary: This study site is a good representation of a typical slough forest community with a complex of features having Thicket Swamp and Deciduous Swamps as dominant followed by Deciduous Forests (found on the higher, drier knolls), and other Deciduous Forest and Deciduous Swamp communities found in the troughs.
The Thicket Swamp communities were noted most often in the study site. Swamp Maple, Speckled Alder, Poison Sumac and, Winterberry were often found together. Willow species, White Elm, and Yellow Birch were also noted several times.

The understory in these communities is largely Dogwood with a mix of Buttonbush, Bittersweet Nightshade, and Highbush Blueberry.
The herbaceous layer was mostly Beggar Ticks, Ferns and Sedges. One particular area was characterized by the field crew as a “quaking mat of vegetation”.
The Deciduous Forests of this study site are characterized by stands of Swamp Maple and Red Oak, with Sugar Maple and White Ash; Trembling Aspen with Sugar Maple and Green Ash; or, American Beech with Sugar Maple and Green Ash.
The understory in these forests is largely made up of the same species as the canopy with Maple-leaved Viburnum and Raspberries. The herbaceous layer is a mix of Large-leaved Aster, Pennsylvania Sedge, and Goldenrod species. There are a total of 270 recorded taxa for this study site.

This site is also in part designated as **Attercliffe Station Slough Forest Provincially Significant Wetland** and **Attercliffe Station slough Forest Life Science Area of Natural and Scientific Interest.**

Site I.D: HAL-41-00-00-00-00
Municipality: County of Haldimand
Approx. Size: 79 hectares
Subwatershed: Elsie Creek
General Summary: County of Haldimand, along the Hamilton border.
Summary: Study site HAL-41 was a very wet area dominated by Thicket Swamps, Deciduous Swamps and Meadow / Shallow Marsh communities.
The Thicket Swamps was dominated by Meadowsweet with associated Reed-canary grass, and Spotted Touch-me-not. There were also Deciduous Forest and Woodland communities. The forest community was dominated by Red Maple, American Basswood and Oak species. There are a total of 107 recorded taxa for this study site.

Name: Chippewa Creek Wetlands
Formerly: Chippawa Creek Conservation and Wildlife Management Area (Brady, et al., 1980)
Site I.D. : WF-01-00-00-00-00

Municipality: Township of Wainfleet
Approx. Size: 500 hectares
Subwatershed: The drainage for this study site is split between Wolf Creek Drain, Welland River West and an unnamed Creek.
General Summary: This study site is located between Sideroad 42 in the east and Marshagan Rd/ Sideroad 50 in the west. It extends from the Welland River in the north to the Wainfleet/ Haldimand Townline in the south.
Summary: This is a typical slough forest with the deepest areas of the swamp supporting Deciduous Swamps and Shallow Marshes and the driest knolls supporting a complex of terrestrial forest communities.

The Deciduous Swamps were dominated by Red Maple, Green Ash, and White Elm.The drier knolls were slightly rolling with some microtopography. These were dominated by Sugar Maple, Red Oak and, Blue Beech. A few supported small stands of Largetooth Aspen.

The understory was a mix of Asters and Goldenrods. There were a few inclusions of Naturalized Conifer Plantations which were dominated by Norway Spruce .The Shallow Marsh communities noted were largely dominated by Broad-leaved Sedges and surrounded by Red Osier Dogwood, or Buttonbush. There are a total of 531 recorded taxa for this study site.

This site is also in part designated as **Chippawa Creek Slough Forest Provincially Significant Wetland** and also encompasses **Chippewa Creek Conservation Area.**

Name: Myer's Woods
Formerly: Myer's Woodlot (Brady et al., 1980)
Site ID: WF-02-00-00-00-00
Municipality: Wainfleet
Size: 255 hectares
Subwatershed: Little Forks Creek and Wolf Creek Drain East subwatersheds.
General Summary: This site is bound by Creek/River Road to the north, Gracey and Smith Roads to the east, Willford Road to the south, and Sideroad 42 to the west.
Summary: Study site WF-02 is highly variable with many complexes and inclusions noted. The dominant community type was Deciduous Swamp characterized by Silver Maple, with Red Maple and Green Ash. The understory was largely regenerating Silver Maple and Green Ash with Blue Beech, and Choke Cherry.The herbaceous layer was a mix of Goldenrod species and Mosses.The areas of deep organic deposits were classified as either Winterberry Thicket Swamps, or Willow Thicket Swamps. The areas with standing open water supported Cattail Shallow Marshes, or, Reed Canary Grass Shallow Marshes with Beggar-ticks as an associate. There are a total of 138 recorded taxa for this study site. This site is also in part designated as
South Welland Port Slough Forest and **Chippewa Creek Slough Forest.**

Name: Little Forks Creek
Formerly: Henderson Road Woodlots (Brady, et al., 1980)
Site ID: WF-03-00-00-00-00
Municipality: Township of Wainfleet
Size: 225 hectares
Subwatershed: Welland River West and to the south and east by Little Forks Creek to the Welland River.
General Summary: This study site is located between Gracey Road to the west and Vineland Townline Road in the east. The southern boundary is Concession 6 Road and Little Forks Creek and the Welland River is the northern boundary.
Summary: This study site exhibits gently undulating slough and ridge topography. The Deciduous Swamp communities were noted as being very wet. They were dominated by Freeman's Maple and

Green Ash with some Sugar Maple and Red Maple. The understory was a mix of Common Clearweed, Thicket Creeper, Cinnamon fern, and Royal fern. The drier areas of this study site were noted as Deciduous Forest with a dominance of Sugar Maple, Black Walnut, and Red Oak.

The understory in these areas was characterized by Spicebush, Maple-leaved Viburnum, and Witch-hazel with Large-leaved Aster. Also noted for this study site were several small swamps with sections of open marsh. These areas were largely dominated by Buttonbush, Winterberry and Highbush Blueberry and an herbaceous layer of Beggar-ticks and Spotted Touch-me-nots.
The associated tree species where they existed were Freeman's Maple, Yellow Birch, and some Black Gum.There are a total of 266 recorded taxa for this study site.

This site is also in part designated as **Little Forks Creek** and **Little Forks Creek Wetland Complex Provincially Significant Wetlands.**

Name: Welland River
Site ID: WF-29-00-00-00-00
Municipality: City of Hamilton, Township of West Lincoln, Township of Wainfleet, City of Welland
Size: 357 hectares
Subwatershed: Welland River West
General Summary: This study site includes the main channel of the Welland River, and its closely associated woodlands from the headwaters near Sinclairville Road in the City of Hamilton, to the Welland Canal in the City of Welland.
Summary: This study site is unique in that its boundaries are based on the floodplain of the Welland River and the closely associated woodlands. Most of the communities recorded were fresh-moist Deciduous Forests with some Thicket Swamps and Shallow or Meadow Marsh communities. The Deciduous Forests were dominated by Black Walnut, Red Oak, Silver Maple, and Green Ash. The associated understory contained Choke Cherry, Hawthorns, Basswood, and Gray Dogwood. The herbaceous layer was characterized by a mix of Grasses, Sedges, Asters, and in some cases, Garlic Mustard.

The Thicket Swamp communities were dominates by Red Maple, Poison Sumac, and Yellow Birch with Hawthorn, Winterberry, Highbush Cranberry, and Buttonbush. The herbaceous layer was commonly a mix of Ferns, Mosses and Sedges.

The Shallow Marsh communities were characterized by Reed Canary Grass and Broad-leaved Cattails with associated Rice Cut Grass, Devil's Beggar-ticks, and Sedges. The Meadow Marshes were largely Common Elderberry, Gray Dogwood, and Reed Canary Grass with scattered Green Ash and White Elm. The successional meadow areas were dominated by Kentucky Blue Gras, New England Aster, Tall Goldenrod, and Grass-leaved Goldenrod. There are a total of 373 recorded taxa for this study site.

This site is also in part designated as **Welland River West Provincially Significant Wetland**

Name: Mill Creek – Inverary Woods
Formerly: Inverary Woods (Brady, et al. 1980)
Site ID: WL-02-00-00-00-00
Municipality: Township of West Lincoln
Size: 363 hectares
Subwatershed: Mill Creek with a small portion in the south/east draining to Moores Creek.
General Summary: This study site is located near the boundary of the Niagara Region and the City of Hamilton. It is between Sixteen Road in the north and Bismark Road in the south. It extends from Westbrook Road in the west to Caistor Centre Road in the east.

Summary: A small portion of this study site was visited. The dominate community noted was Deciduous Swamp consisting of Red Maple, Bur Oak, White Swamp Oak, and Shagbark Hickory in the canopy.

The understory was largely regenerating canopy species with Blue Beech, Highbush Blueberry, Selfheal, and Winterberry. The ground layer was a mix of Spotted Touch-me-nots, Aster species, Fowl Manna Grass, and Rough Goldenrod.

A slightly drier community noted was dominated by Red Oak, Sugar Maple and White Ash. The understory was characterized by Hop Hornbeam, Black Cherry, and Serviceberry. The herbaceous layer was a mix of Large-leaved Aster, Canada Blue Grass, and Sedges. There are a total of 84 recorded taxa for this study site.

This site is also in part designated as **Abingdon NW Woodlots, Caistor Centre NW Woodlots, Lower Twenty Mill Creek Wetland Complex Provincially Significant Wetlands,** and as **North Caistor Centre Slough Forest Life Science ANSI.**

Name: McCready's Bush
Formerly: McCready's Bush (Brady, et al., 1980)
Site ID: WL-05-00-00-00-00
Municipality: Township of West Lincoln
Size: 358 hectares
Subwatershed: This study site is basically split in half with the western portion flowing into Moores creek and the eastern portion flowing into Welland River West.
General Summary: This study site is located between Caistor Centre Road to the west and Smithville Road to the east. It extends from Bismark Road to the north and Concession Two Road to the south.
Summary: The most common community noted for this study site was the Deciduous Swamp dominated by Red Maple with Swamp White Oak, Green Ash, and the occasional White Elm. The understory was a mix of Green Ash, Blue Beech, and Winterberry. The herbaceous layer was characterized by Common Cinquefoil, Spotted Touch-me-not, and Sedges.

The drier areas within the Deciduous Swamps and upland areas of the study site were classified as Deciduous Forests. These forests were dominated by Red Oak and White Oak with Sugar Maple, Serviceberry, Black Cherry, Witch-hazel, and Hop Hornbeam as understory associates.
The herbaceous layer was a mix of Pennsylvania Sedge, Black Raspberry, and Hawkweed.

The Thicket Swamp community noted was dominated by Narrow-leaved Meadowsweet and Three-lobed Beggar-ticks. There are a total of 190 recorded taxa for this study site.

Name: Ruigrok Tract – Caistor Canborough Slough Forest
Formerly: Ruigrok Tract (Brady, et al., 1980)
Site ID: WL-06-00-00-00-00
Municipality: Township of West Lincoln
Size: 1605 hectares
Subwatershed: The drainage for this study site is split almost in half with the northern drainage going to the Welland River West subwatershed and the south draining to Oswego creek.
General Summary: The study site is located along the boundary of the Region of Niagara and the County of Haldimand; about two thirds falls within Niagara and one third in Haldimand. The northern boundary is York Road/ South Chippawa Road and the southern boundary is Regional Road 2/ Regional Road 63. It extends from just east of Turnbull Road in the west to, Caistor-Gainsborough Townline Road in the east.

Summary: This study site is part of what could potentially be a globally rare community of slough forest. These Deciduous Swamps were dominated by Red Maple, Swamp Maple, and Swamp White Oak. Associates included White Elm, White Ash, Basswood, and Shagbark Hickory.

The understory was regenerating canopy species with Blue Beech, Black Raspberry, Highbush Blueberry, Royal Fern, Gray Dogwood, and Silky Dogwood. The ground layer was a mix of Asters, Sedges, Arrow-leaved Tearthumb, Common Boneset, False Nettle, and Rice Cut Grass.

The most common community documented by field teams was the Thicket Swamp. These communities were dominated by Swamp Maple, Swamp White Oak, Red Maple, with Winterberry, Buttonbush, Narrow-leaved Meadowsweet, or Poison Sumac. The understory was largely Black Chokeberry, Highbush Blueberry, Speckled Alder, and Gray Dogwood. The ground cover was a mix of Eastern Manna Grass, Canada Blue-joint, Cinnamon Fern, Swamp Rose, Arrow-leaved Tearthumb, Devil's Beggar-ticks, Spotted Touch-me-nots, and Sedges such as, Lakebank Sedge.

The Deciduous Forests were dominated by White Oak, Red Oak, Shagbark Hickory, White Ash, and Sugar Maple. Maple-leaved Viburnum, Choke Cherry, Gray Dogwood, Common Blackberry, and Narrow-leaved Meadowsweet were common in the understory. The herbaceous layer was characterized by Large-leaved Aster, Pennsylvania Sedge, Grass-leaved Goldenrod, New England Aster, and Eastern Bracken Fern.

Successional communities of Meadow Marshes and Forb Meadows were also documented for this site. The Meadow Marshes were largely Winterberry and Highbush Cranberry with the occasional White Swamp Oak or Swamp Maple. Very wet depressions supported small inclusions of Narrow-leaved Cattails. The Forb Meadows were mostly Asters and Goldenrods with a ground layer of Mosses and Common Strawberry. The Shallow Marsh communities noted were dominated by Lakebank Sedge and Common Hop Sedge with Three-lobed Beggar-ticks, Northern Water-horehound, Lady's Thumb, Rice Cut Grass, and Fowl Manna Grass. There are a total of 313 recorded taxa for this study site.

This site is in part designated as **Caistor – Canborough Slough Forest East, Centre and West Provincially Significant Wetlands, Caistor – Canborough Slough Forest Life Science Area of Natural and Scientific Interest** and also encompasses **Ruigrok Tract Conservation Area.**

Site ID: WL-26-00-00-00-00
Municipality: Township of West Lincoln
Size: 387 hectares
Subwatershed: Beaver Creek subwatershed; however a very small portion drains north to an unnamed creek, and south to Welland River West.
General Summary: This study site closely follows Beaver Creek between Vaughn Road in the north and Canborough Road in the south. It extends from Caistor/Canborough Townline Road in the west to Wellandport Road in the east.
Summary: This study site is characterized by Deciduous Swamps that are associated with the floodplain of Beaver Creek. These swamp communities were dominated by Swamp White Oak, Swamp Maple, and Green Ash with some White Elm.

The understory was a mix of Hawthorn, Gray Dogwood, Buttonbush, Winterberry, Narrow-leaved Meadowsweet, Blue Beec, and Willow. The herbaceous layer was mostly Spotted Touch-me-not, Aster, Avens , and Reed-canary Grass.

The transition zones between the swamp communities and the drier Deciduous Forests were classified as Meadow Marshes dominated by Reed-canary Grass. The Deciduous Forests were largely dominated by Green Ash and White Elm with the same basic understory of Gray Dogwood, Hawthorn

and Tartarian Honeysuckle. The ground cover was a mix of Avens and Goldenrod, with Garlic Mustard. There are a total of 74 recorded taxa for this study site.

This site is in part designated as **Beaver Creek Provincially Significant Wetland**
Name: Little Wolf Creek
Site ID: WL-32-00-00-00-00
Municipality: Township of West Lincoln
Size: 197 hectares
Subwatershed: The drainage for this study site is divided nearly in half with the western portion draining to Little Wolf Creek and the eastern portion draining to Wolf Creek.
General Summary: This study site is located along the Hamilton border between Westbrook Road to the west and Caistorville Road in the east. The northern boundary is Concession Three Road and the southern boundary is Concession one Road.
Summary: A very small portion of this study site was visited by NAI teams. The dominant community noted was a Deciduous Swamp characterized by Red Maple, Red Oak, Green Ash, with the occasional White Oak. The understory was a mix of Sugar Maple, American Beech, Blue Beech, and Smooth Serviceberry. The herbaceous layer was mostly Sedges, Asters, Beggar-ticks, and Spotted Touch-me-nots. The Shallow Aquatic community noted was dominated by Lesser Duckweed.

There are a total of 82 recorded taxa for this study site. This site is in part designated as **Wolf Creek Provincially Significant Wetland**

Appendix G:
Riparian, Wetland and Upland Habitat Restoration Guidelines

Restoration guidelines for riparian, wetland and forest habitat as recommended by Environment Canada (2005) in its *„How Much Habitat is Enough?'* document. This framework was used as a guideline in the Upper Welland River Restoration Strategy.

RIPARIAN HABITAT GUIDELINES	
Parameter	**Guideline**
Percent of stream naturally vegetated	75 percent of stream length should be naturally vegetated.
Amount of natural vegetation adjacent to streams	Steams should have a minimum 30 metre wide naturally vegetated adjacent-lands area on both sides, greater depending on site-specific conditions.
Total suspended sediments	Where and when possible suspended sediment concentrations should be below 25 milligrams/litre or be consistent with Canadian Council of Ministers of the Environment (1999) guidelines.
Percent of an urbanizing watershed that is impervious	Less than 10 percent imperviousness in an urbanizing watershed should maintain steam water quality and quantity, and preserve aquatic species density and biodiversity. An upper limit of 30 percent represents the threshold for degraded systems.
Fish communities	Watershed guidelines for fish communities can be established based on knowledge of underlying characteristics of a watershed (e.g., drainage area, surficial geology, flow regime), historic and current fish communities, and factors (and their relative magnitudes) that currently impact the system.

WETLAND HABITAT GUIDELINES	
Parameter	**Guideline**
Percent wetlands in watersheds and subwatersheds	Greater than 10 percent of each major watershed in wetland habitat; greater than 6 percent of each subwatershed in wetland habitat; or restore to original percentage of wetlands in the watershed.
Amount of natural vegetation adjacent to the wetland	For key wetland functions and attributes, the identification and maintenance of the Critical Function Zone and its protection, along with an appropriate Protection Zone is the primary concern. Where this is not derived from site-specific characteristics, the following are minimum guidelines: Bog – the total catchment area Marsh – 100 metres Fen – 100 metres or as determined by hydrogeological study Swamp – 100 metres
Wetland Type	The only 2 wetland types suitable for widespread rehabilitation are marshes and swamps.
Wetland Location	Wetlands can provide benefits anywhere in the watershed, but particular wetland functions can be achieved by rehabilitating wetlands in key locations, such as headwater areas for groundwater discharge and recharge, flood plains for flood attenuation, and coastal wetlands for fish production. Special attention should be paid to historic wetland locations or site and soil conditions.
Wetland Size	Wetlands of a variety of sizes, types, and hydroperiods should be maintained across a landscape. Swamps and marshes of sufficient size to support habitat heterogeneity are particularly important.
Wetland Shape	As with upland forests, in order to maximize habitat opportunities for edge-tolerant species, and where the surrounding matrix is not natural habitat, swamps should be regularly shaped with minimum edge and maximum interior habitat.

FOREST HABITAT GUIDELINES	
Parameter	**Guideline**
Percent forest cover	At least 30 percent of the watershed should be in forest cover.
Size of largest forest patch	A watershed or other land unit should have at least one 200 hectare forest patch that is a minimum 500 metres in width.
Percent of watershed that is forest cover 100 metres and 200 metres from forest edge	The proportion of the watershed that is forest cover 100 metres or further from the forest edge should be greater than 10 percent. The proportion of the watershed that is forest cover 200 metres further from the forest edge should be greater than 5 percent.
Forest shape	To be of maximum use to species such as forest-breeding birds that are intolerant of edge habitat, forest patches should be circular or square in shape.
Proximity to other forested patches	To be of maximum use to species such as forest-breeding birds, forest patches should be within 2 to 1 kilometre of one another or other supporting habitat features.
Fragmented landscapes and the role of corridors	Connectivity width will vary depending on the objectives of the project and the attributes of the nodes that will be connected. Corridors designed to facilitate species movement should be a minimum of 50 metres to 100 metres in width. Corridors designed to accommodate breeding habitat for specialist species need to be designed to meet the habitat requirements of those target species.
Forest quality – species composition and age structure	Watershed forest cover should be representative of the full diversity of forest types found at that latitude.

The following chart is taken directly from *Conservation Buffers; Design Guidelines for Buffers, Corridors, and Greenways* (Bentrup 2008).

Issue and Objectives	Buffer Functions
Water Quality	
Reduce erosion and runoff of sediment, nutrients, and other potential pollutants Remove pollutants from water runoff and wind	Slow water runoff and enhance infiltration Trap pollutants in surface runoff Trap pollutants in subsurface flow Stabilize soil Reduce bank erosion
Biodiversity	
Enhance terrestrial habitat Enhance aquatic habitat	Increase habitat area Protect sensitive habitats Restore connectivity Increase access to resources Shade stream to maintain temperature
Productive Soils	
Reduce soil erosion Increase soil productivity	Reduce water runoff energy Reduce wind energy Stabilize soil Improve soil quality Remove soil pollutants
Economic Opportunities	
Provide income sources Increase economic diversity Increase economic value	Produce marketable products Reduce energy consumption Increase property values Provide alternative energy sources Provide ecosystem services
Protection and Safety	
Protect from wind or snow Increase biological control of pests Protect from flood waters Create a safe enviroment	Reduce wind energy Modify microclimate Enhance habitat for predators of pests Reduce flood water levels and erosion Reduce hazards
Aesthetics and Visual Quality	
Enhance visual quality Control noise levels Control air pollutants and odor	Enhance visual interest Screen undesirable views Screen undesirable noise Filter air pollutants and odors Separate human activities
Outdoor Recreation	
Promote nature-based recreation Use buffers as recreational trails	Increase natural area Protect natural areas Protect soil and plant resources Provide a corridor for movement Enhance recreational experience

Appendix H:
Restoration Suitability Criteria and Weighting Scheme

RESTORATION SUITABILITY CRITERIA : RIPARIAN HABITAT			
HABITAT: RIPARIAN	**RATIONALE**	**METHODOLOGY**	**REFERENCE**
CRITERIA: Proximity to Watercourse/Waterbody			
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*	Niagara River AOC RAP
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*	Riparian Habitat Guidelines
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*	
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*	
CRITERIA: Land Use Type			
(lurwood)	*In terms of potential conflict, existing land use type is scaled in terms of*	*Generate Land Use surface on Land Use Type value. Reclassify*	Niagara Peninsula Conservation
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*suitability to restoration. Areas classified as scrub, low intensity*	*Land Use values where low conflict land use types have higher*	Authority
2 Recreational, Residential, High Intensity Agriculture	*agriculture, or natural area are much more suitable to restoration*	*suitability values than high conflict land use types.*	
1 Industrial, Built Up Urban	*than areas classified as industrial or built-up urban.*		
CRITERIA: Slope			
(slopedr)	*Considers the presence of vegetation in terms of hydrological and*	*Generate slope surface from DEM. Reclassify surface where*	Niagara Peninsula Conservation
3 ≥ 10 degrees	*mechanical contribution to bank stability and erosion control.*	*higher slope values have higher suitability values.*	Authority
2 < 10 degrees	*As slope increases, restoration suitability increases.*		
1 0 degrees			
CRITERIA: Fish Habitat Classification of Catchment			
(catchfhr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*	Niagara Peninsula Conservation
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*	Authority
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*	
1 Marginal			
CRITERIA: Stream Order of Catchment			
(catchsor)	*Catchments which drain to watercourses in headwater streams*	*Generate surface from catchment polygons on stream order*	Niagara River AOC RAP
3 intermittent flow (1st & 2nd order)	*are considered more suitable for restoration than those that drain to*	*value. Reclassify values according to restoration suitability.*	Riparian Habitat Guidelines
2 intermittent / permanent flow (3rd order)	*higher ordered streams in terms of water quality improvement.*		
1 permanent flow (> 3rd order)			
CRITERIA: Forest Cover			
(coverwor)	*It is more suitable to restore habitat where vegetation does not*	*Generate surface from natural vegetation polygons based on*	Niagara River AOC RAP
3 woodland not present	*presently exist, or where infilling may be necessary from a previous*	*vegetation type. Reclassify cells lacking forest cover as highest*	Riparian Habitat Guidelines
2 planting site	*restoration project.*	*suitability values.*	
1 woodland present			
CRITERIA: Streambank Erosion Rates (Wetness Index)			
(ripwir)	*Riparian areas identified as having high erosion rates resulting from*	*Generate wetness index surface from topographic analysis.*	Niagara Peninsula Conservation
3 High (10-21)	*upslope contributing area and slope gradient analysis are most*	*Reclassify surface where highest erosion rates have*	Authority
2 Mid (5-10)	*suitable to restoration with bioengineering.*	*highest suitability values.*	
1 Low (0-5)			
CRITERIA: Protected Area			
(careasdr)	*Areas within C.A. boundaries are protected from development*	*Generate straight line distance surface from Conservation Area*	Niagara Peninsula Conservation
3 within conservation area boundary	*pressure and destruction. Areas in close proximity to these*	*boundary polygons. Reclassify surface values according to*	Authority
2 ≤ 30m from conservation area boundary	*boundaries are good areas to restore in terms of establishing*	*restoration suitability.*	
1 > 30m from conservation area boundary	*connectivity.*		

RESTORATION SUITABILITY CRITERIA : WETLAND HABITAT

HABITAT: WETLAND	RATIONALE	METHODOLOGY	REFERENCE
CRITERIA: Proximity to Existing Significant Patch (Size)			
(wecoredr)	*Areas within closest proximity to existing wetland patches of highest*	*Select existing patches with highest size significance value.*	Niagara River AOC RAP
3 ≤ 50m	*Natural Heriage Score (core size) will be most suitable to restoration of*	*Generate distance surface from selected patches. Reclassify*	Wetland Extent Guidelines
2 > 50m & < 100m	*increased interior habitat.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Significant Existing Patch			
(wenndr)	*Areas within closest proximity to existing wetland patches of highest*	*Select existing patches with highest size significance value.*	Niagara River AOC RAP
3 ≤ 50m	*Natural Heritage score (nearest neighbor) will be most suitable to*	*Generate distance surface from selected patches. Reclassify*	Wetland Extent Guidelines
2 > 50m & < 100m	*restoration.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Watercourse / Waterbody			
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*	Niagara River AOC RAP
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*	Wetland Extent Guidelines
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*	
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*	
CRITERIA: Soil Drainage			
(sdrainr)	*The drainage class of the underlying soil determines the*	*Generate surface from OMAF soil polygons based on drainage*	North Carolina
3 Alluvial Soil	*amount of water the soil can receive and store before runoff.*	*class. Reclassify surface according to suitability values.*	Coastal Region Evaluation of
2 Very Poorly and Poorly Drained	*The more poorly drained the underlying soil, the more suitable the*		Wetland Significance
1 Imperfectly Drained	*area to wetland restoration.*		
CRITERIA: Land Use Type			
(lurwood)	*In terms of potential conflict, existing land use type is scaled in*	*Generate Land Use surface on Land Use Type value. Reclassify*	Niagara Peninsula Conservation
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*terms of suitability to restoration. Areas classified as scrub, low*	*Land Use values where low conflict land use types have higher*	Authority
2 Recreational, Residential, High Intensity Agriculture	*intensity agriculture, or natural area are much more suitable to*	*suitability values than high conflict land use types.*	
1 Industrial, Built Up Urban	*restoration than areas classified as industrial or built-up urban.*		
CRITERIA: Fish Habitat Classification of Catchment			
(catchfr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*	Niagara Peninsula Conservation
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*	Authority
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*	
1 Marginal			
CRITERIA: Stream Order of Catchment			
(catchsor)	*Catchments which drain to watercourses in headwater streams*	*Generate surface from catchment polygons on stream order*	Niagara River AOC RAP
3 intermittent flow (1st & 2nd order)	*are considered more suitable for restoration than those that drain to*	*value. Reclassify values according to restoration suitability.*	Wetland Extent Guidelines
2 intermittent / permanent flow (3rd order)	*higher ordered streams in terms of water quality improvement.*		
1 permanent flow (> 3rd order)			
CRITERIA: Wetness Index (Topographic Position/slope)			
(wetindr)	*The wetness index equation predicts zones of water saturation where*	*Generate wetness index surface from slope gradient and flow*	Niagara Peninsula Conservation
3 high (10-21)	*steady-state conditions and uniform soil properties are assumed.*	*accumulation. Reclassify surface where highest Wetness Index*	Authority
2 mid (5-10)	*It is a function of upslope contributing area and slope gradient. Areas*	*values have highest suitability values.*	
1 low (0-5)	*of highest W.I. values are most suitable to wetland restoration.*		

CRITERIA: Forest Cover		
(coverwer)	*Where forest cover is already present, restoration is more suitable*	*Generate surface from woodland polygons. Reclassify values*	Niagara Peninsula Conservation
3 Forest cover present	*particularly in terms of the establishment of swamp habitat.*	*according to suitability value.*	Authority
2 Planting site present			
1 Forest cover present			
CRITERIA: Protected Area			
(careasdr)	*Areas within C.A. boundaries are protected from development*	*Generate straight line distance surface from Conservation Area*	Niagara Peninsula Conservation
3 within conservation area boundary	*pressure and destruction. Areas in close proximity to these*	*boundary polygons. Reclassify surface values according to*	Authority
2 ≤ 30m from conservation area boundary	*boundaries are more suitable to restore in terms of establishing*	*restoration suitability.*	
1 > 30m from conservation area boundary	*connectivity.*		
RESTORATION SUITABILITY CRITERIA : UPLAND HABITAT			
HABITAT: UPLAND FOREST	**RATIONALE**	**METHODOLOGY**	**REFERENCE**
CRITERIA: Proximity to Significant Patch (CoreSize)			
(wocoredr)	*Areas within closest proximity to existing forest patches of highest*	*Select existing patches with highest size significance value.*	Niagara River AOC RAP
3 ≤ 50m	*of Natural Heriage Score (core size) will be most suitable to restoration*	*Generate distance surface from selected patches. Reclassify*	Evaluation of Upland Habitat
2 > 50m & < 100m	*increased interior habitat.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Significant Patch (Connectivity)			
(wonndr)	*Areas within closest proximity to existing forest patches of highest*	*Select existing patches with highest proximity significance value.*	Niagara River AOC RAP
3 ≤ 50m	*Natural Heritage score (nearest neighbor) will be most suitable to*	*Generate distance surface from selected patches. Reclassify*	Evaluation of Upland Habitat
2 > 50m & < 100m	*restoration of wildlife corridors.*	*surface values where lowest distances have highest suitability*	
1 ≥ 100m		*values.*	
CRITERIA: Proximity to Watercourse / Waterbody			
(edgedr)	*Areas within closest proximity to watercourses or waterbodies will*	*Generate straight line distance surface from watercourses and*	Niagara River AOC RAP
3 ≤ 30m	*be most suitable to restoration. These areas contribute to both*	*waterbodies. Reclassify surface values where lowest distances*	Riparian Habitat Guidelines
2 > 30m & < 50m	*riparian buffer and floodplain. Restoration in these areas will*	*have highest suitability values, reflecting riparian and floodplain*	
1 ≥ 50m	*improve hydrological, habitat and water quality functions.*	*location.*	
CRITERIA: Land Use Type			
(lurwood)	*In terms of potential conflict, existing land use type is scaled in terms*	*Generate surface from 1992 Landsat 7 Landuse Classification on*	Niagara Peninsula Conservation
3 Woodland, Wetland, Scrub, Low Intensity Agriculture	*of suitability to restoration. Areas classified as scrub, low intensity*	*Land Use Type value . Reclassify Land Use values where low*	Authority
2 Recreational, Residential, High Intensity Agriculture	*agriculture, or natural area are much more suitable to restoration*	*conflict land use types have higher suitability values than high*	
1 Industrial, Built Up Urban	*than areas classified as industrial or built-up urban.*	*conflict land use types.*	
CRITERIA: Fish Habitat Classification of Catchment			
(catchfhr)	*Catchments which drain to watercourses classified as Fish Habitat*	*Generate surface from catchment polygons on fish habitat*	Niagara Peninsula Conservation
3 Critical	*are considered more suitable, as restoration projects will contribute*	*classification value. Reclassify values according to restoration*	Authority
2 Important	*to food, shelter, temperature moderation and oxygen production.*	*suitability.*	
1 Marginal			
CRITERIA: Stream Order of Catchment			
(catchsor)	*Catchments which drain to watercourses in headwater streams*	*Generate surface from catchment polygons on stream order*	Niagara River AOC RAP
3 intermittent flow (1st & 2nd order)	*are considered more suitable for restoration than those that drain to*	*value. Reclassify values according to restoration suitability.*	Evaluation of Upland Habitat
2 intermittent / permanent flow (3rd order)	*higher ordered streams in terms of water quality improvement.*		
1 permanent flow (> 3rd order)			
CRITERIA: 0-240m Wetland Buffer Habitat Thresholds			
(sigwetdr)	*Areas within these buffer distances contribute to a range of habitat*	*Generate straight line distance surface from wetlands. Reclassify*	Niagara River AOC RAP

	3 < 50m	*functions when vegetated. Vegetation within closest proximity to the*	*surface values where habitat threshold distances have highest*	Wetland Extent Guidelines
	2 50m - 120m	*wetland provides the greatest benefit to that wetland. These areas*	*suitability value.*	
	1 120m - 240m	*are thus considered most suitable to restoration.*		
CRITERIA: Protected Area				
	(careasdr)	*Areas within C.A. boundaries are protected from development*	*Generate straight line distance surface from Conservation Area*	Niagara Peninsula Conservation
	3 within conservation area boundary	*pressure and destruction. Areas in close proximity to these*	*boundary polygons. Reclassify surface values according to*	Authority
	2 ≤ 30m from conservation area boundary	*boundaries are good areas to restore in terms of establishing*	*restoration suitability.*	
	1 > 30m from conservation area boundary	*connectivity.*		
CRITERIA: Slope				
	(slopedr)	*Considers the presence of forest cover in terms of hydrological and*	*Generate slope surface from DEM. Reclassify surface where*	North Carolina
	3 ≥ 10 degrees	*mechanical contribution to slope stability and erosion control.*	*higher slope values have higher suitability values.*	Coastal Region Evaluation of
	2 < 10 degrees	*As slope increases, restoration suitability increases.*		Wetland Significance
	1 0 degrees			
CRITERIA: Forest Cover				
	(coverwor)	*The amount of forest cover must be increased in order to meet habitat*	*Generate surface from natural vegetation polygons based on*	Niagara River AOC RAP
	3 woodland not present	*targets. It is obviously more suitable to restore forest habitat where it*	*vegetation type. Reclassify areas lacking forest cover as highest*	Evaluation of Upland Habitat
	2 planting site	*does not presently exist, or where infilling may be necessary from*	*suitability values.*	
	1 woodland present	*a previous restoration site.*		

Appendix I:
Mitigation Measures for Drain Maintenance

Mitigation Measures implemented in drains. This information was taken directly from Fisheries and Oceans Canada publication *The Drain Primer: A Guide to Maintaining and Conserving Agricultural Drains and Fish Habitat*

MITIGATION MEASURES

Timing

Digging should be done so as to avoid local fish spawning or nursing periods. If done at the wrong time, suspended sediments from the maintenance work might prevent spawning, smother eggs, or kill young fish.

Option: Do the Project in the Summer

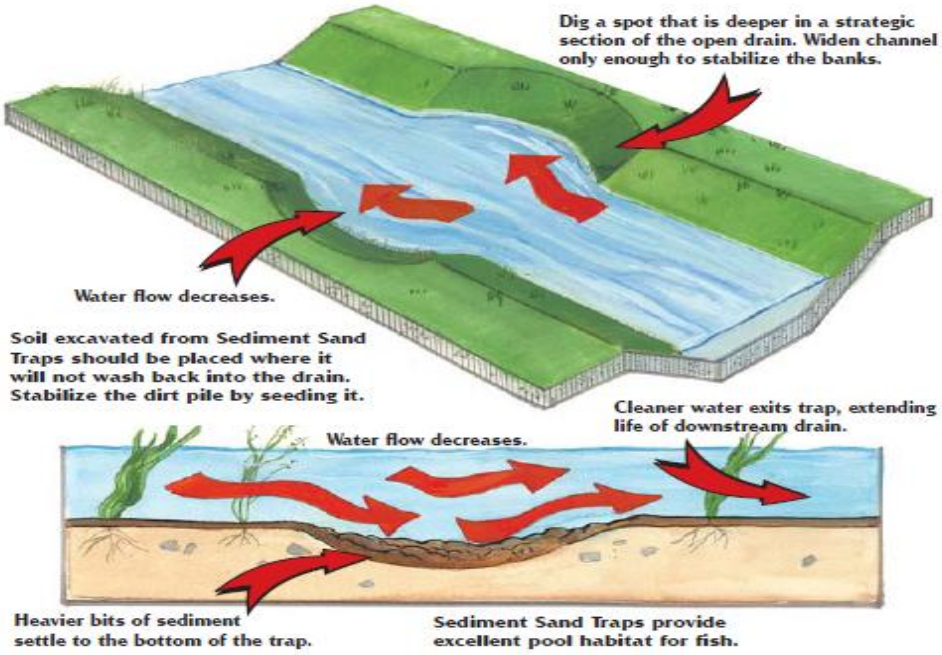
Summer may be a good time to do maintenance work when drains are dry or have little flow. This way the crane or backhoe operators can see exactly what needs to be cleaned out without the obstruction of clouded water. Doing the work when the ditch is relatively dry also ensures that little, if any, sediment will float downstream where it might impact fish. As well, maintenance should be done as quickly as possible in order to limit the amount of disruption to fish migration and habitat

Sediment Controls

If work is undertaken while water is still flowing in the drain, controls need to be put in place to prevent the flow of sediment downstream. The following options are essentially designed for areas with sandy or sandy loam soils.

Option: Sediment Sand Traps

Sediment sand traps are created by strategically digging a spot that is deeper in the open drain. Excessive widening of the channel should be avoided, however the channel should be widened enough to stabilize the banks. This larger hole acts as a settling pond, slowing down water as it drops into the deeper spot. As the water flow decreases, heavier sediments and debris settle to the bottom of the trap, somewhat improving the quality of the water leaving the trap and moving downstream.



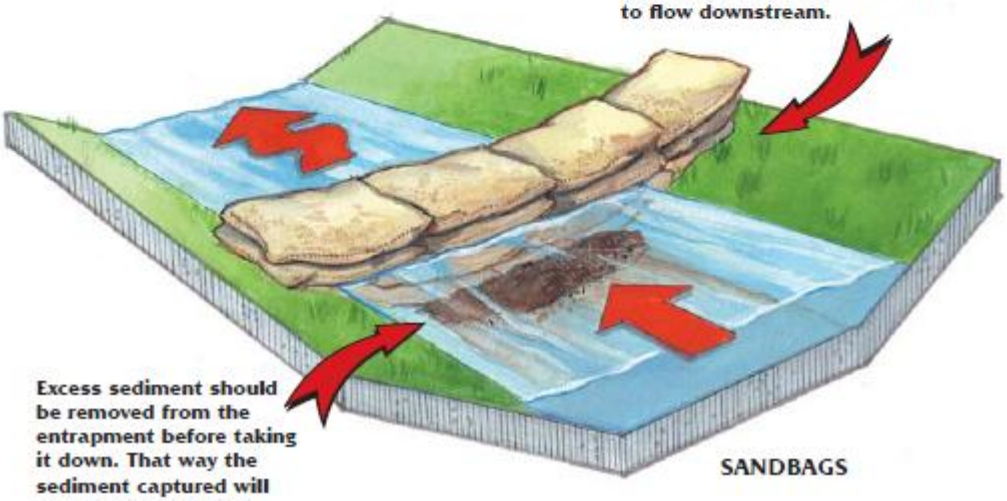
The sediment sand trap technique can be low cost when compared to other conventional methods. Farmers and municipalities need only worry about cleaning the trap out, which is a lot cheaper than paying for a full-scale clean out. Less of the drain is disturbed and clean out is quicker. Sand traps should be placed in spots easily accessible so as to avoid having to drive over planted crops in order to get maintenance equipment to the site.

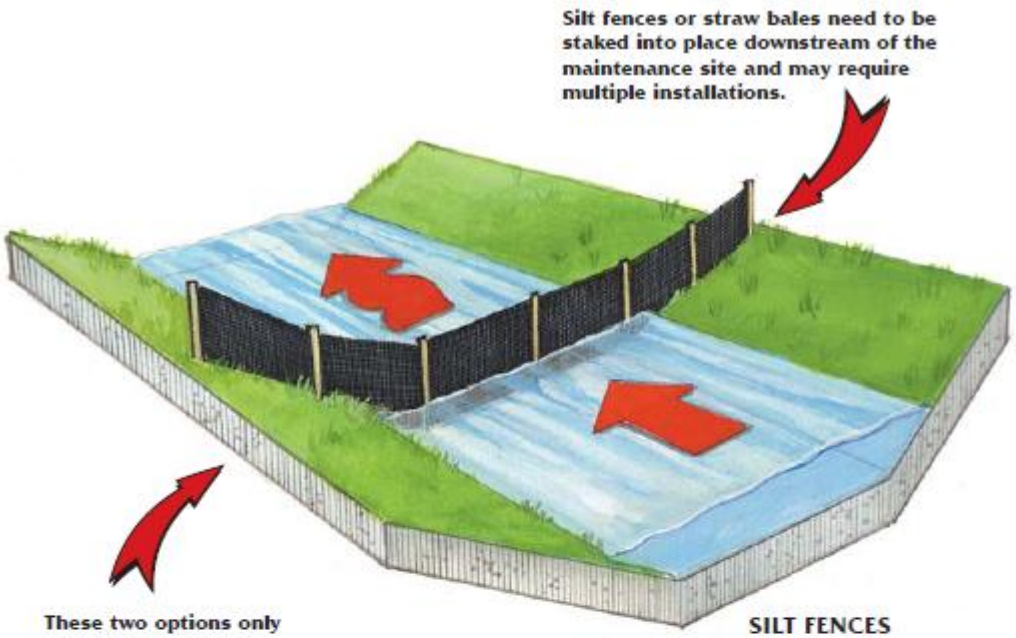
Option: Silt Fences /Straw Bales/Sandbags

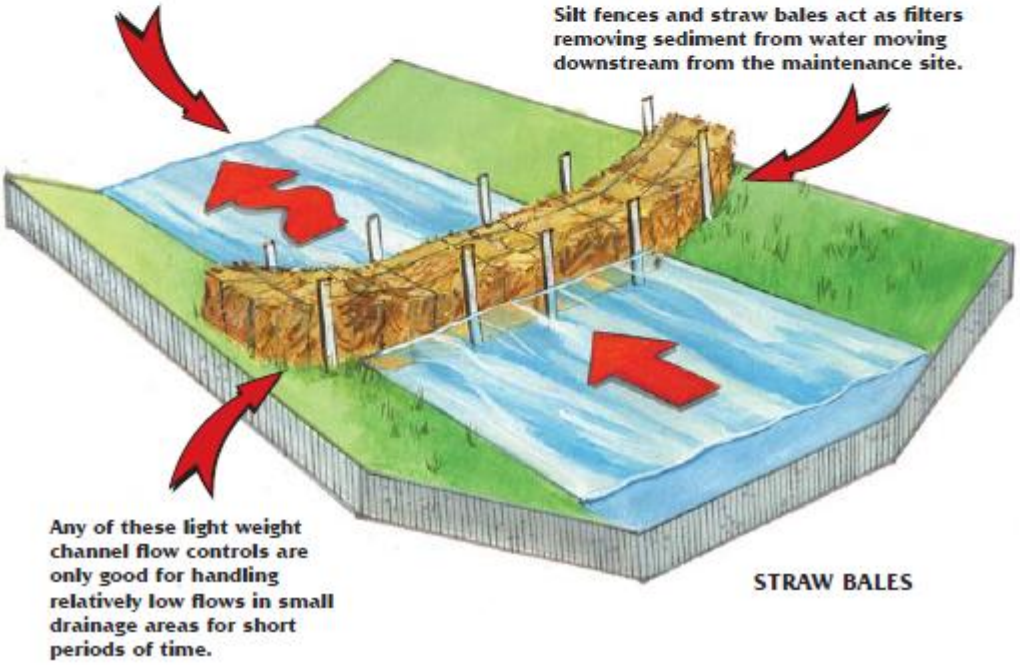
Silt fences (those little black curtains we see between construction sites and watercourses), straw bales, and sandbags are inexpensive ways to prevent the flow of sediments downstream. Silt fences or straw bales need to be staked into place downstream of the maintenance site. These two options act as filters removing sediment from water. More than one set of curtains or bales may be required.

Sandbags act much like sand traps. By sandbagging the water back, one creates a settling pond where heavier sediment can drop out, allowing relatively cleaner water to flow downstream.

Any of these light-weight channel flow controls are only good for handling relatively low flows in small drainage areas for short periods of time. These options only work when they are properly maintained. Care also needs to be taken when removing these controls. Excess sediment should be removed from the entrapment before taking down a sediment control structure. That way, the sediment captured will not be released back into the stream.




Silt fences or straw bales need to be staked into place downstream of the maintenance site and may require multiple installations.
These two options only work when they are properly maintained.
SILT FENCES


Silt fences and straw bales act as filters removing sediment from water moving downstream from the maintenance site.
Any of these light weight channel flow controls are only good for handling relatively low flows in small drainage areas for short periods of time.
STRAW BALES

To extend drain life, save money on routine maintenance and enhance fish and wildlife habitat, banks need to be protected from erosion.

Erosion Control and Bank Stabilization

Eroding drain banks can be costly to farmers, municipalities and the environment. The more soil collapses into a drain, the more that drain's flow is disrupted. The extra soil entering the system is unlikely to be carried very far in the water, resulting in an accumulation of sediment, which in turn fills the drain. Eroding banks may lead to trees and other vegetation falling into the watercourse, further diverting and slowing water flow and leading to more erosion. Eventually, the ability of the open ditch to drain surrounding land is hampered and further maintenance is required sooner than was originally planned. To extend the life of the drain, save money, and help the environment, a number of techniques can be used.

Option: Leave the Banks Alone

Bank erosion is best prevented by not disturbing the banks at all. Stable banks usually have grass, shrubs and trees growing along them. Vegetation adjacent to the bank helps slow down runoff from the fields, which in turn helps to minimize erosion of the bank. As well, the root systems of vegetation along the banks hold the sides together and stabilize the slopes. Environmentally, the stalks and leaves from the different types of plants slow down runoff and act as a filter by trapping sediment, pesticides and other pollutants – improving the quality of water entering the drain.

Option: Plant Bigger Buffers

Other means to prevent erosion, extend the life of the drain and improve habitat is to plant shrubs and trees and to increase the size of the vegetated buffer between the field and drain.

Conservation cropping, such as the soy beans planted to the left of the drain above, can help stabilize the bank, reduce future drain maintenance, and improve habitat for a wide variety of species.

Bigger buffers can help remove more of the sediment carried by field runoff into the open ditch, and thus minimize the need for drain maintenance. This option might involve taking productive land out of operation. The alternative may be to look at planting such crops as hay or alfalfa as buffers along the drain. Once these crops are planted, the land can go a number of years without the need for being plowed up, crops can be harvested annually, and the root systems remain undisturbed.

Option: Work from One Side of Drain

If vegetation needs to be removed from a ditch, it would be best to remove it from one side only. That way, one side of the ditch is better protected from erosion, less movement of equipment is needed, clean-out is quicker, and there is less disruption. Where applicable, it is best to leave the south side of the drainage bank alone as that will ensure shade, cover and food sources for fish.

Option: Remove Vegetation at Intervals

Depending on various circumstances, another option may be to remove vegetation at certain intervals. If an open drain has gone several years without maintenance – trees, shrubs and other brush may have grown to the point where removal of vegetation is required to allow a crane or backhoe access for proper drain clean out.

Mature or young trees should be left on either bank. These trees help stabilize the ditch, provide cover and insect food for fish, and shade the banks and the water. The shade from the trees also helps prevent the growth of vegetation that may create blockages to drain flow.

Rather than clearing out all the vegetation, one can remove for example, 20 metres of vegetation on one side of the bank, skip 20 metres, and then continue so on down the one side of the drain. Then to ensure total bottom clean out, do the same on the opposite bank. Later, when one needs to maintain the drain, vegetation removal and drain maintenance can be done from the spots that were originally left untouched. While this option may be a bit more costly and time-consuming, the landowner is always guaranteed that there will be mature vegetation along the drain to help stabilize it.

Option: Brushing

Brushing involves using large mowers to cut the vegetation along the bank. The trimming of the plants and shrubs should improve water flow and thus cause the drain to naturally deepen on its own, as faster water tends to scour a watercourse. As well, runoff from the surrounding land is less impeded by mature vegetation when entering the drain. Brushing can also be a helpful step in providing access spots for maintenance equipment to the drain bottom. Regardless of the reason for using the technique, the key to brushing is that it leaves the root system untouched. Thus the drain's banks are stabilized, the mulch from the mowing protects the surface from wind and rain erosion, and reseeding the slope is unnecessary. Care must be taken to make sure that the mulch from the brushing that ends up in the waterway is removed so that the drain does not get clogged downstream.

Gentle bank slopes help reduce erosion by reducing runoff speed.

Brushing leaves the root systems intact, stabilizing the banks from erosion. Debris from the brushing protects the banks from wind and rain erosion.

Option: Reseeding

As soon as the drain maintenance is done, one should consider leveling the spoils, or excavated material, created from clear-out and reseed the work area while the soil is still moist in order to reestablish vegetation and stabilize the bank. If immediate revegetation is not an option (maybe the growing season has passed) then using filter cloth, various mulches or erosion blankets made of natural material might help in protecting the banks from erosion.

Option: Sloping

When maintaining a drain, it is preferable to have gentle slopes on the banks rather than steep ones. The steeper the grade, the quicker the water enters the drain, the more unstable banks become, and the more likely erosion will take place.

Straw blankets, such as the one seen above, help protect the exposed area from wind and rain erosion, and incorporate natural materials to help vegetation get reestablished.

Natural channel design features can be incorporated into drains where appropriate. Natural channels are efficient at moving both water and sediment, as well as providing long-term stability for the drain and enhancing fish habitat.