LOWER WELLAND RIVER CHARACTERIZATION REPORT

MAY 2011

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Introduction

Background and Objectives

For nearly two centuries, the Lower Welland River has endured several anthropogenic (man-made) modifications relating to the Welland Canal, hydro operations, and flow modifications.

In 1829, the Lower Welland River from Port Robinson to Chippawa acted as an extension of the first Welland Canal. The Canal terminated at Port Robinson and from here ships would travel east along the Welland River to Chippawa where the ships would travel upstream along the Niagara River to Lake Erie. In 1833 the First Welland Canal was extended southwards to Gravelly Bay in Port Colborne (St. Lawrence Seaway Management Corporation 2003).

In 1917, the construction of the Queenston-Chippawa Power Development was initiated. The project involved the construction of a canal to convey water from the upper Niagara River, via the lower Welland River, to Queenston where at the time the largest power plant in the world was to be constructed. The diversion permitted the use of the full available head of water between Lakes Erie and Ontario; twice the available head of the other power plants in Niagara Falls therefore delivering twice the amount of power from the same diversion of water [Hydro-Electric Power Commission of Ontario (HEPC) No Date]. Construction of the canal resulted in the excavation of 8.4 million cubic meters of earth, and 3 million cubic meters of rock (HEPC No Date).

In 1921 the Queenston-Chippawa Power Canal opened. The conveyance of the Niagara River water resulted in the flow reversal of the Welland River westward from the Niagara River to the mouth of the power canal. Dredging of the Welland River as far west as Montrose Road was completed to result in the necessary down grade for the flow reversal (Biggar 1920).

Again dredging occurred on the lower Welland River in 1953 when the last 7 kilometers of the Welland River was widened and channelized to accommodate Niagara River flows towards the Queenston-Chippawa Power Canal (Phillips Eng. Ltd. 1999) to facilitate hydro operations. "*The diversion of water in the lower Welland River creates a pattern of regular diurnal fluctuations that extends approximately 60 km upstream of the diversion*" (Phillips Eng. Ltd. 2001). It is estimated that approximately 90 hectares of littoral zone are affected by the water fluctuations (NPCA 1999).

The intent of this report is to present a complete watershed characterization of the Lower Welland River that provides a comprehensive description and inventory of the watershed and its resources. This document can be used by Niagara Peninsula Conservation Authority (NPCA) staff and respective stakeholders to assist in land use management and planning decisions in the study area. The study also outlines areas for potential restoration projects that can be implemented through the NPCA Water Quality Improvement Program as outlined in the Restoration Strategy portion of this document.

Lower Welland River Characterization Study Area

The Welland River is the largest watershed in the Niagara Peninsula Conservation Authority's jurisdiction. The watershed drains roughly 800 square kilometers of land stretching from Ancaster to Niagara Falls where it historically outletted. In 1987 the Niagara River and its tributaries were designated as an Area of Concern by the International Joint Commission due to its degraded water quality impairing complete use of its resources. The Welland River watershed accounts for approximately 80% of the Canadian Niagara River Area of Concern.

The Lower Welland River stretches from the lower siphon of the Welland Canal to the Niagara River. The Lower Welland River study area includes the Lower Welland River and Thompsons Creek (Figure 1). The study area falls primarily within the municipal boundary of the City of Niagara Falls, with small portions extending into the City of Thorold and the City of Welland. Together Thompsons Creek and the Lower Welland River drain 35 square kilometers of land with nearly 69 km of watercourse.

The study area includes 5.6 square kilometers of wetland, 7.6 square kilometers of upland habitat and approximately 19 kilometers of watercourse has riparian habitat. The study area is home to 13 listed Species at Risk; listed both nationally and provincially. Five of these species are endangered, another 5 are threatened species, and the remaining 3 are listed as species of special concern.

Additionally, old growth trees have been identified in along the South Queen Victoria Park bluff, and the Niagara River is an internationally designated Important Bird Area.

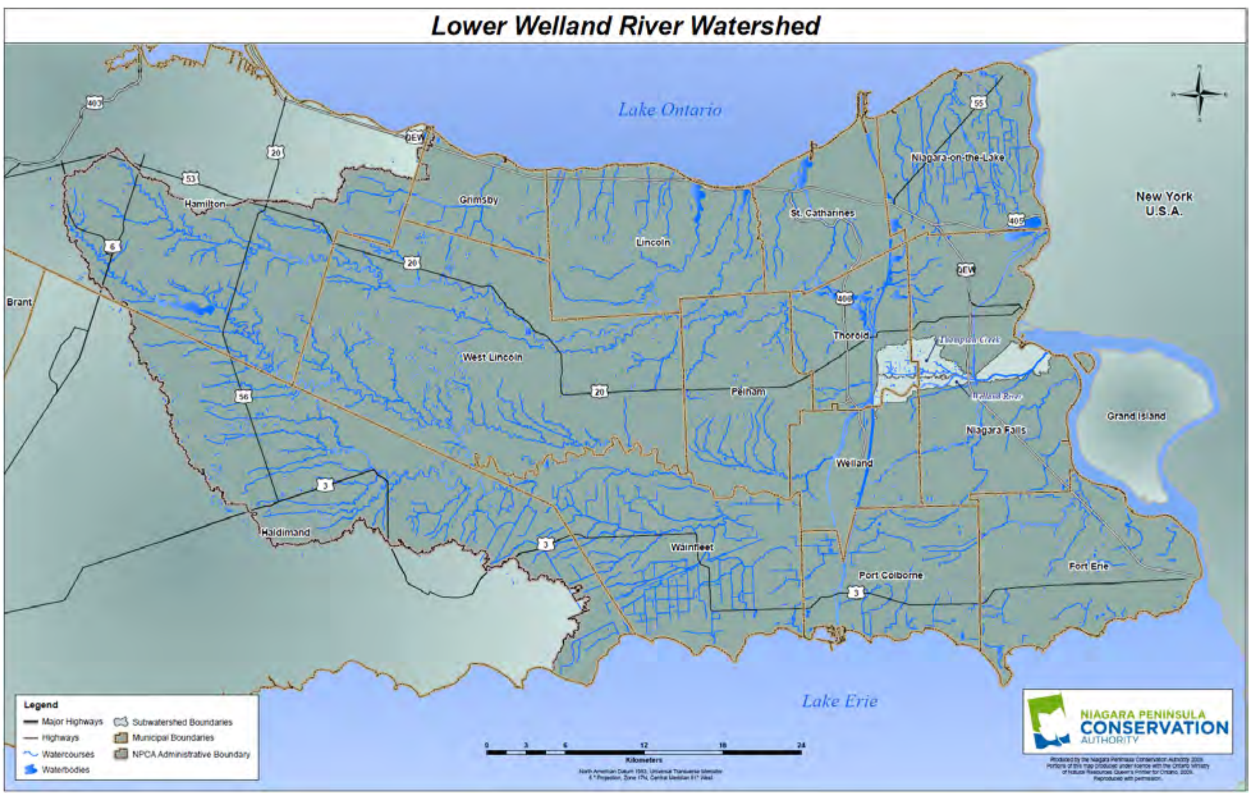

Figure 1: Geographic Location

Study Area Characterization

Topography

Bordered by the Niagara Falls 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 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. Over the course of its length of roughly 135 kilometers, the Welland River only drops approximately 82 meters in elevation. The most significant vertical drop is 78 meters which occurs over the first 55 kilometers; the lower 80 kilometers of the river only drop 4 meters (NPCA 1999). This slight gradient results in a meandering sluggish river from Port Davidson downstream.

Originally, the Welland River drained directly into the Niagara River; however its flow in its entirety has now been diverted into the Queenston-Chippawa Power Canal. In 1953, the last 7 km of the Welland River was widened and channelized to accommodate Niagara River flows toward the Queenston-Chippawa Power Canal (Phillips Engineering Ltd., 1999). As a result, the lower portion from the Niagara River now flows in reverse, drawing Niagara River water to the Power Canal. The topography of the Lower Welland River study area is illustrated in Figure 2.

Physiography

The predominant physiographic region of the Lower Welland River Watershed is the Haldimand Clay Plain which extends from the Niagara Escarpment to Lake Erie (Figure 3). The Haldimand Clay Plain was submerged by glacial Lake Warren and much of it is covered by lacustrine clay deposits. At its highest ground where the Haldimand Clay Plain meets the Niagara Escarpment, recessional moraines were built by the ice lobe that occupied the Lake Ontario basin. Aside from the gravel hills of Fonthill, the moraines consist of heavy boulder clay and have a much subdued relief due to having been built under water (Chapman and Putnam 1984). One of these moraines, the Niagara Falls moraine, falls within the Lower Welland River study area.

The headwaters of Thompsons Creek originate on the Niagara Falls moraine, which is a mere swell in the Haldimand Clay Plan which lies on the northern cusp of the study area. The Niagara Falls moraine, although discontinuous throughout Niagara, seems to be an extension of the Tonawanda Moraine in New York State (Chapman and Putnam 1984).

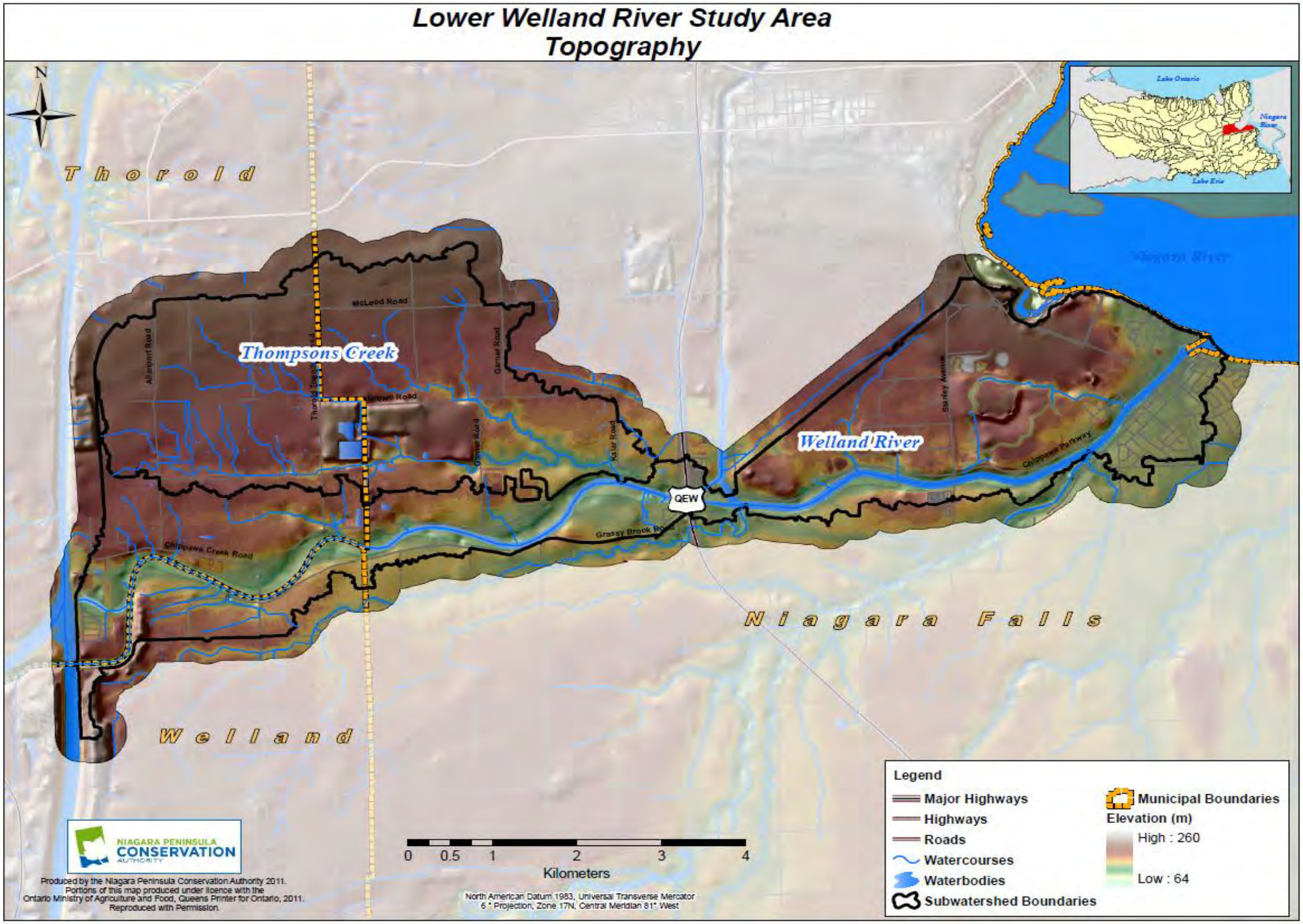

Figure 2: Topography

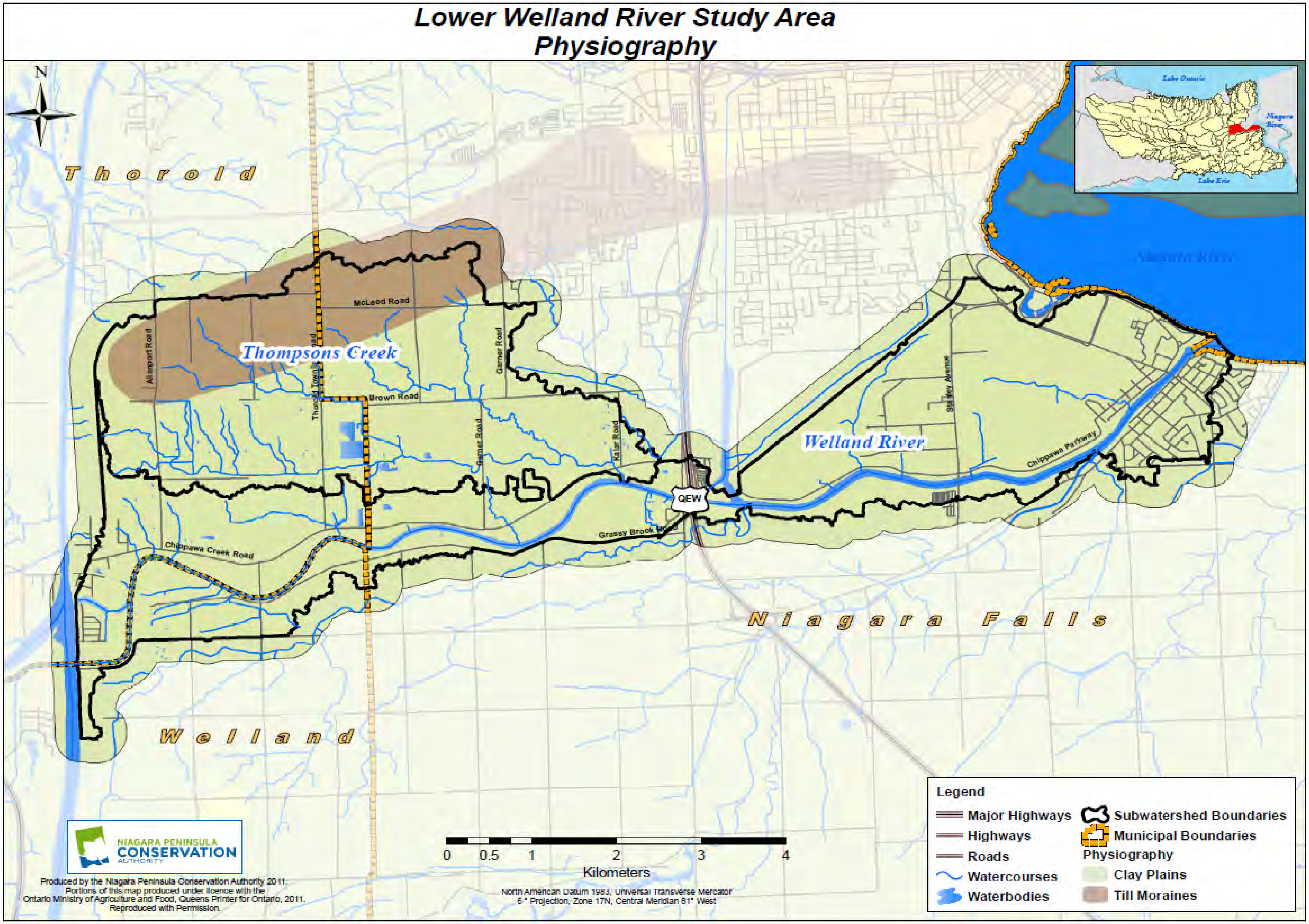

Figure 3: Physiography

Bedrock Geology

The Lower Welland River and Thompsons Creek subwatershed are predominately underlain with bedrock from the middle to upper Silurian period of roughly 425 to 410 million years ago; Guelph Formation and the Salina Formation along the southern cusp of the study area (Figure 4).

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 become shallower resulting in land surfaces becoming more arid, and deposition of shale and fine grained dolostone occurred (Lewis 1991). 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).

Soils

The soils in the Niagara Region were resurveyed and documented in a report entitled The Soils of Regional Niagara (Kingston and Present 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 and associated chart and map (Table 1 and Figure 5) are derived primarily from this document.

The Lower Welland River and Thompsons Creek are generally dominated by the lacustrine silty clays of Beverly and Toledo soils and the lacustrine heavy clays of the Niagara and Welland soils.

The western portion of the study area, including the headwaters of Thompsons Creek, is primarily Beverly and Toledo soils. Beverly 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 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.

The central portion of the study area is predominately Niagara and Welland soils with areas of Ontario and Alluvial soils along the Welland River. Like Beverly soils, Niagara soils are also imperfectly drained and also have a moderate to slow permeability. They have a moderate to high water holding capacity and their groundwater levels are usually close to the surface until late spring. Their suitability is poor for most horticultural crops and drainage is required before fair suitabilities are attained for special field crops, such as soybeans or canola. Welland soils are poorly drained, have a relatively high capacity to hold water and a slow to moderate rate of permeability, however, surface cracking increases the permeability of Welland soils during the summer months. Except for the drier period during the summer months, the groundwater level remains close to the surface in Welland soils, and although they have a high capacity to hold water, moisture availability for plants is limited at this time due to the soils high clay content. The combined problems associated with high clay contents and high water tables limit the use of this soil group for most agricultural crops.

Ontario soils are moderately well-drained, also have a moderate to slow permeability, and have moderate to high water holding capability. Soil permeability decreases as compaction increases from heavy machinery and surface runoff is usually fairly rapid, increasing as slope increases. Water erosion is a significant problem on slopes greater than 3 percent.

As indicated earlier Alluvial soils with Ontario soils are found along the Welland River. Drainage conditions of Alluvial soils vary, but most are imperfectly or poorly drained because of the close proximity of the water table to the ground surface for long periods each year. Permeability, water holding capacity and surface runoff vary, depending on soil textures and horizon thicknesses. Flooding is the greatest limitation of alluvial soils for agricultural uses. In addition, these soils may be limited by high water tables that cannot be artificially drained.

Along the northern border of Thompsons Creek, Chinguacousy and Peel soils are present. Chinguacousy soils are mainly clay loam till, are imperfectly drained with a moderate to slow permeability, and have a relatively high capacity for holding water. Regional groundwater fluctuates in the lower horizons with temporary occupancy in the surface horizons for time periods each year. Chinguacousy soils have a moderate to rapid surface runoff and are also quite erodible; therefore as slope increases erosion control measures should be considered. These soils are used for growing common field crops, however tile drainage is necessary.

Like Chinguacousy soils, Peel soils also are imperfectly drained with a moderate to slow permeability and a medium to high water holding capacity. Surface runoff ranges from medium to high; increasing as slope increases. Perched groundwater tables are a common occurrence in the upper horizons of Peel soils because of tillage compaction and dense clay loam till subsoil. With artificial drainage they have fair to good suitability for fruit crops such as grapes, apples, pears, plums, currants and gooseberries. Similar suitabilities prevail for vegetable crops such as peppers, cucumbers, tomatoes, cole crops, sweet corn and squash. In addition to the need for artificial drainage, Peel soils are susceptible to soil compaction and erosion and should be managed to minimize these potential problems.

The eastern portion of the study area also includes areas of Lincoln soils. Lincoln soils are poorly drained, have a slow permeability, have a high water-holding capacity, and can be droughty during dry periods because of insufficient moisture release for plant use. Depending on the incidence of soil cracks, surface runoff can be slow to rapid. Although currently used for common field crops, they are unsuitable for most horticultural crops. Lincoln soils are usually considered as problem soils because of their poor drainage and high clay contents. It is important to avoid degradation of the soil structure as much as possible by not using heavy machinery on wet soils. Such degradation increases wetness problems and can increase summer droughtiness.

Table 1: Soils of the Lower Welland River Study Area							
Soil Series	**Geologic Deposits**	**Natural Drainage**	**Water Holding Capacity**	**Permeability**	**Surface Runoff**	**Class**	**Land use Comments**
Mineral Soils							
Toledo Soils (TLD)	Mainly lacustrine silty clay	Poor	Relatively High	Slow	Moderate to High	3W	Require artificial drainage to be useful for agriculture
Beverly Soils (BVY)	Mainly lacustrine silty clay	Imperfect	Medium to High	Moderate to Slow	Moderate to High	2D	Used mainly for corn, small grains and forage crops.
Welland Soils (WLL)	Mainly reddish-hued deep water lacustrine heavy clay	Poor	Relatively High	Slow	Slow to Moderate	3WD, 4W, 5W	Range from unsuitable to poorly suitable for most fruit & vegetable crops
Niagara Soils (NGR)	Mainly reddish-hued deep water lacustrine heavy clay	Imperfect	Moderate to High	Moderate to Slow	Slow to Rapid	3D	Their suitability is poor for most horticultural crops; artificial drainage usually necessary.
Ontario Soils (OTI)	Mainly reddish-hued deep water lacustrine heavy clay	Moderately well-drained	Moderate to High	Moderate to Slow	Fairly Rapid	3	Main limitation is high clay content. Fair to good suitability for canola, soybeans and white beans.
Alluvial Soils (ALU)	Variable alluvial deposits on floodplain	Various but most are imperfect or poor	Vary, depending on soil textures and horizons thickness	Vary, depending on soil textures and horizons thickness	Vary, depending on soil textures and horizons thickness	Vary	Flooding is the greatest limitation for agricultural uses
Chinguacousy Soils (CGU)	Clay loam till	Imperfect	Relatively High	Moderate to Slow	Moderate to Rapid	2D	Widely used for growing common field crops
Peel Soils (PEL)	40-100cm lacustrine silty clay over clay loam till	Imperfect	Medium to High	Moderate to Slow	Moderate to High	2D	With artificial drainage they have fair to good suitability for select fruit and vegetable crops. Susceptible to soil compaction and erosion should
Lincoln Soils (LIC)	Mainly lacustrine heavy clay	Poor	High	Slow	Slow to Rapid	3WD	Used for common field crops such as forages, small grains and corn. Usually considered problem soils because of poor drainage and high clay content.

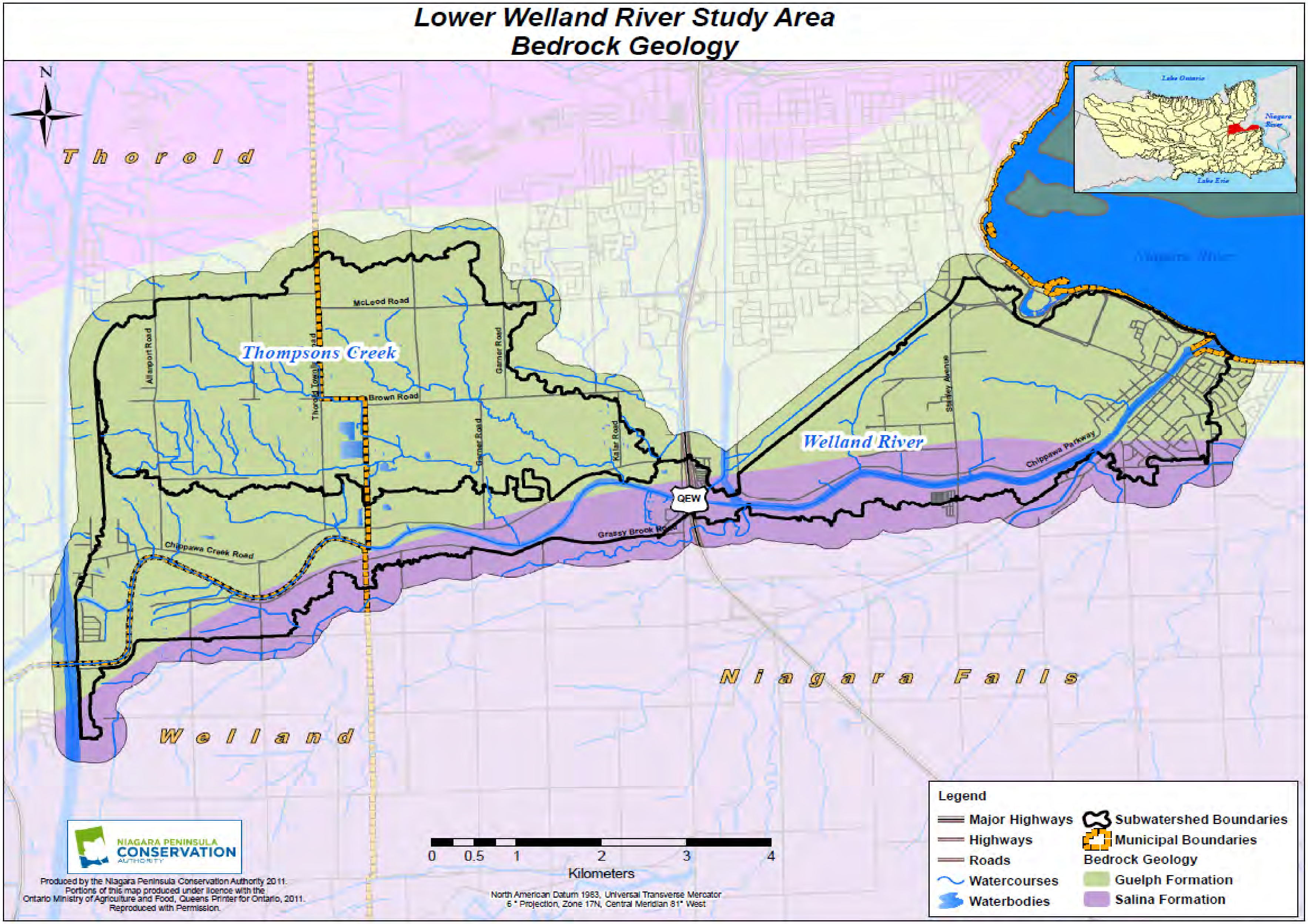

Figure 4: Bedrock Geology

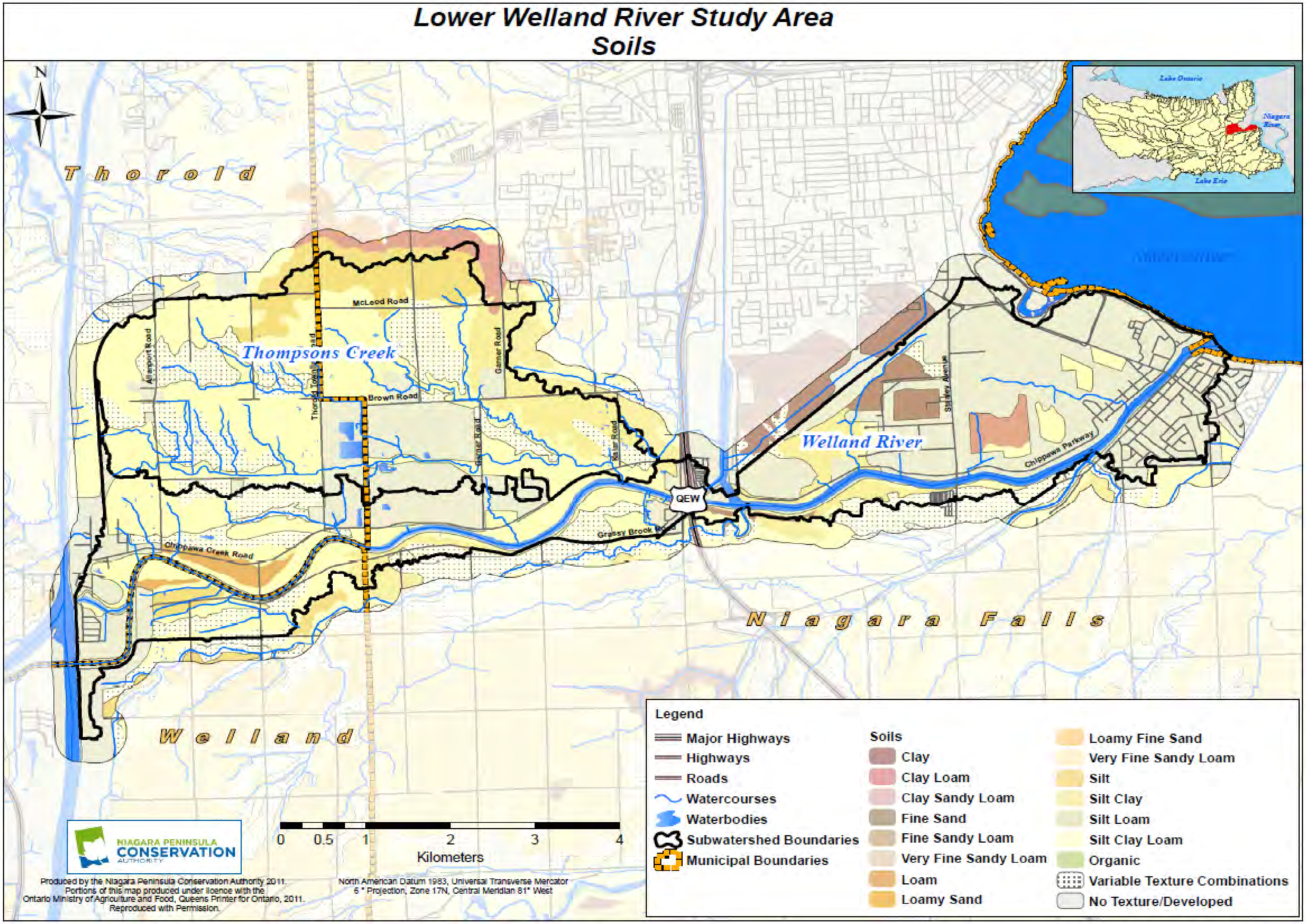

Figure 5: Soils

Local Climate

The climate of Southern Ontario is characterized as having warm summers, mild winters, and a long growing season, and usually reliable rainfall. The climate within southern Ontario differs somewhat from one location to another and from one year to the next. Spatial variations are generally caused by the topography and varying exposure to the prevailing winds in relation to the Great Lakes (Schroeter et al. 1998). In Niagara Region, although Lakes Ontario and Erie have a moderating influence, the regional climate is far from homogeneous. A number of microclimates exist and these result largely from the interaction of the Lakes and major topographic features with local circulation systems (Shaw 1994).

Several agencies operate climate monitoring stations in Niagara; these include Environment Canada, Ministry of the Environment, Ontario Weather Network, Region of Niagara, and local municipalities. Currently in the Lower Welland River and Thompsons Creek subwatersheds, climate is monitored at 5 stations. Three of these stations monitor precipitation and the remaining 2 monitor temperature, wind, and humidity. An aspect of the Source Water Protection program was to produce a water budget and stress assessment for Niagara's watersheds. To carry out these studies, an understanding of climate variations was necessary to accurately identify key hydrologic processes. Spatial variations in average annual precipitation (rain plus snow), and temperature were prepared for the Niagara Peninsula Source Protection Area using Meteorological Services of Canada (Environment Canada) data from 1991 to 2005. The following general observations were reported in the *Proposed Assessment Report: Niagara Peninsula Source Protection Area* (NPCA 2010c) using the 1991 to 2005 data.

- The driest and warmest calendar year was 1998 and had generally the lowest values for both precipitation and snow;
- The wettest calendar year was 1996;
- 14-17% of annual precipitation was generally snow;
- Lowest monthly precipitation was measured in February; and
- The wettest month was generally September.

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 Ministry of Natural Resources (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 2007).

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 2007). 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 2007). 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"* (2007).

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 2007). 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 2007). 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 A.

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 A.

Current Land Use

The Lower Welland River and Thompsons Creek study area falls primarily within the municipal boundaries of the City of Niagara Falls (63%) and the City of Thorold (31%), with a small portion extending into the City of Welland (6%).

Land use in the study area is a mix of agriculture, residential, industrial and commercial (Figure 6). According to statistics generated for the *Water Availability Study* (AquaResource 2009) through the

Source Water Protection program, land use coverage in the study area is dominated by monoculture, wetlands and built-up areas (Table 2).

Table 2: Land Use in the Lower Welland River Study Area	
Land Use	**% of Study Area**
Mixed Agriculture	3.7
Monoculture	29.4
Plantations	0.2
Forest	8.0
Hedge Rows	0.6
Idle Land	0.5
Marsh/Swamp	18.3
Open Water	4.4
Rural Land Use	13.8
Built-up Pervious and Impervious	16.2
Transportation	5.3

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 Lower 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 and in 2006 agriculture accounted for 52% of the land in the region.

As described earlier (Table1), the mineral soils in the area are predominantly 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 municipality (including outside of study area) based on the North American Industry Classification System farm-typing categories are:

- City of Niagara Falls: soybeans, alfalfa, and hay and other fodder crops;
- City of Thorold: soybeans, and corn for grain; and
- City of Welland: hay and other fodder crops.

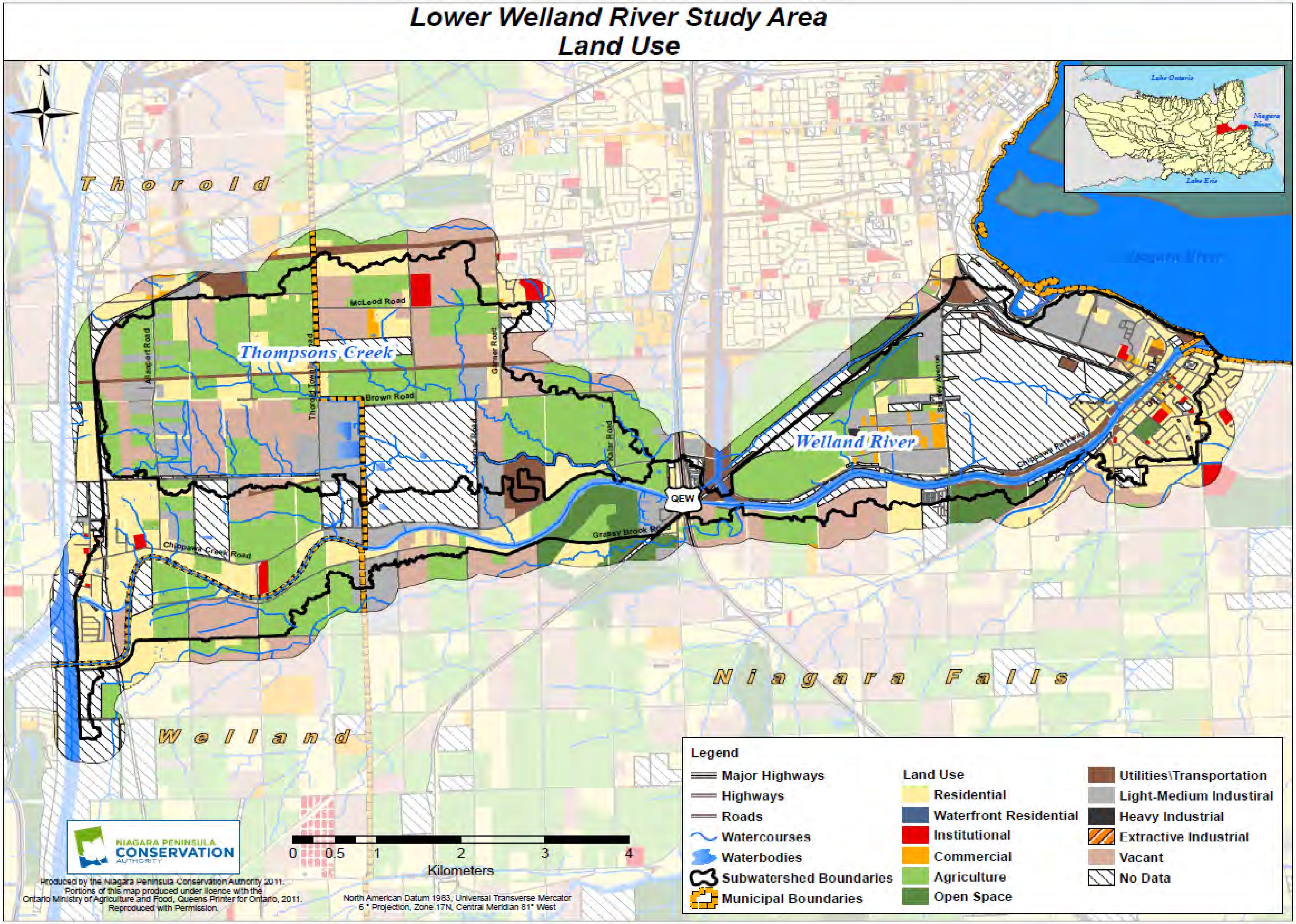

Figure 6: Land Use

Recreation

Four golf courses fall within the study area, all within Niagara Falls: Oak Hall Par 3 Golf Course, Thundering Waters, Oaklands Golf Course, and Grand Niagara Golf Course. Campgrounds include Yogi Bear's Jellystone Park and King Waldorf's Tent and Trailer Park. In addition Dufferin Islands and Marineland Amusement Park are also located in this study area. The Welland River also offers ample opportunities for fishing, boating, and nature observation.

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 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.

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 *Provincial Policy Statement* [(PPS) MMAH 2005a], which provides overall direction on matters related to land use and development in Ontario, and municipal official plans by providing growth management policy direction.

The *PPS* recognizes that sustainability of Ontario's natural and cultural heritage resources over the long term is of key provincial interest given that 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 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.

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).

Region of Niagara: Upper Tier

The *Planning Act* (MMAH 1990) designates the *Policy Plan: Regional Strategy for Development and Conservation* (RMN 2007) 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* 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.)*

Extensive trail systems such as the Trans Canada Trail, Welland Canal Trail and The Greater Niagara Circle Route not only provide an abundance of recreational opportunities for residents and tourists, but these trail systems link Niagara Regions history and cultural heritage with its natural heritage. It is the intent of the *Policy Plan* to promote and coordinate further development of recreational trails in Niagara to promote recreational opportunities and encourage healthy lifestyles while fostering the expansion of the tourism industry.

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.

In the Lower Welland River Characterization study area, the *GGH* identifies the lands adjacent to the Niagara River extending from the Greenbelt south to Fort Erie as a Gateway Economic Zone in recognition of the importance of cross-border trade with the United States. The GGH states that "*Planning and economic development in these areas will support economic diversity and promote increased opportunities for cross-border trade, movement of goods and tourism*" (MPIR 2006). Accordingly, in the *Policy Plan* (Amendment 2-2009) it is the intent of the Region of Niagara to work with the local municipalities to encourage land uses within this zone that promotes the flow of cross border trade and tourism; infrastructure for tourism; creation of attractive downtowns; and opportunities to create economic diversity and add value through production activity related to its proximity to the border (Section 8.3). In the study area, the *GGH* also identifies the lands surrounding the built-up areas of western Niagara Falls 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. The remainder of the Lower Welland River study area consists of Built-up Areas and Good General Agricultural Areas (RMN 2007).

Municipalities: Lower Tier

City of Niagara Falls

As indicated earlier, roughly 63 percent of the Lower Welland River Characterization study area falls within Niagara Falls. Land use consists of a mix of Residential, Commercial, Industrial, and Good General Agriculture.

The *City of Niagara Falls Official Plan* (2009) outlines various strategies to guide development and redevelopment of lands zoned as residential. Strategies include numerous policies to for example, accommodate anticipated population, various demands for housing types and densities, as well as ensuring compatible development with surrounding neighbourhoods.

In terms of commercial lands, it is the intent of the *Official Plan* to foster a healthy business climate and promote a balanced retail and office structure through numerous policies that establish a hierarchy of commercial districts, promote the strengthening of existing commercial areas, direct new commercial growth and provide for the recapture of retail dollars leaving the City (Section 3). In addition, market studies will be used to demonstrate any needs or changes in market conditions to guide development (Section 3). Marineland is a large scale theme park in the eastern portion of the study area that serves as a major tourist attraction and tourism generator. The *Official Plan* recognizes the value of Marineland to the tourism industry in Niagara Falls and accordingly outlines several policies that compliment the operation with other visitor services in the area, for example, the creation of a separate land use designation that recognizes the lower intensity land use and the planning and development of a transportation system linking the tourism districts (Section 6).

The *Official Plan* recognizes the contribution of industry to employment and economic growth. Accordingly, it is the intent of the *Official Plan* to provide for the expansion of existing industry and stimulation of new industrial growth by pursuing programmes which provide for the enhancement of industrial districts and the attraction of new firms in order to maintain a strong and competitive industrial resource base (Section 9).

The lands within the Good General Agriculture designation are a blend of agricultural and agricultural related uses, limited non-agricultural and recreational uses, and natural areas such as wetlands, woodlots and watercourses. It is the intent of the *Official Plan* "*to protect the continuation of farming operations, restrict the establishment of non-farm uses and minimize land use conflicts in favour of agriculture wherever possible, while protecting the natural environment consistent with the Provincial Policy Statement and the Regional Policy Plan*" (Section 7).

City of Thorold

Thirty-one percent of the study area falls within the City of Thorold. Land use in this area consists of a mix of Agriculture, Rural, and Dry Industrial. It is the intent of the *Official Plan of the City of Thorold Planning Area* (City of Thorold; Office Consolidation 2010) to preserve the lands within the Agriculture zone for existing and future farming operations, as well as for forestry and conservation of plant and wildlife, and to permit those uses that support or are directly related (Section 4.6.1). Like the areas zoned Agriculture, areas zoned as Rural Areas shall have the predominant land use of agriculture including livestock farming, and for forestry and the conservation of plant and wildlife. However, other types of development are permitted in these areas, such as for example, veterinary establishments, public utility, and schools, churches, and cemeteries (Section 4.7.1).

The City of Thorold has two designations under areas zoned Industrial; Serviced Industrial and Dry Industrial. Serviced Industrial lands receive full municipal services whereas Dry Industrial lands are "*those areas where industrial uses are permitted, but where there is no municipal commitment to provide piped water supply and piped sanitary sewerage*" (Section 4.3.3). The Lower Welland River study area contains lands designated as Dry Industrial. Uses permitted in these areas include industrial activities which do not require large amounts of water and wastes generated shall be of a clean and low discharge nature (Section 4.3.3).

City of Welland

The remaining 6 percent of the study area falls within the City of Welland boundary. Land use in this area is Agriculture. The *City of Welland Official Plan* (Dillon 2010) recognizes that agriculture is an important economic activity and therefore outlines several strategies to provide land for farming and agricultural related activities and help protect the City's agricultural lands from urbanization (Section 5.1.2.1). Some of the strategies include limiting activities permitted in this designation, limitations on lot creation, and the support of value added activities for the agricultural industry (Section 5.1.3.2 to 5.1.3.6).

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 a network of cores and corridors across much of central and southern Ontario, illustrating at a general level where important natural cores and corridors are located.

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 meters 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* <u>*ecological function*</u> *and biodiversity of* <u>*natural heritage systems*</u>*, 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."*

As previously indicated, Regional Niagara's *Policy Plan: Regional Strategy for Development and Conservation* (RMN 2007), includes objectives for a healthy landscape in the environmental policies. For example, Policy 7.A.1b calls upon planning authorities to employ an ecosystem approach that address "*The health and integrity of the broader landscape, including impacts on the natural environment in neighboring jurisdictions"* when making decisions regarding planning and development or conservation.

The cores and corridors within the Lower Welland River study area, as identified by the *Big Picture* project are illustrated on Figure 7.

NPCA Natural Areas Inventory Sites

In 2006, the NPCA initiated a comprehensive Natural Areas Inventory (NAI) that was completed in partnership with the Regional Municipality of Niagara, 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.

Detailed descriptions of natural areas can be found in Appendix B and the associated mapping (Figure 8) has been derived directly from the NPCA Natural Areas Inventory Report. For more information regarding the faunal inventories conducted during this study, please refer to the NPCA NAI Report.

Identified Old Growth

The Ministry of Natural Resources characterizes an old growth ecosystem "*by the presence of old trees and their associated plants, animals, and ecological processes. They show little or no evidence of human disturbance"* (MNR 1994). During an old growth forest survey conducted by the Bert Miller Nature Club during 2002 and 2003, the definition of an old growth forest used for purposes of their field work was "*a natural community that has been continuously forested since before European Settlement, and that forest's canopy must be dominated by trees with ages of 150 years or older. Most old-growth forests have 8 or more trees per acre that are 150 years old or greater"* (Bert Miller Nature Club 2004).

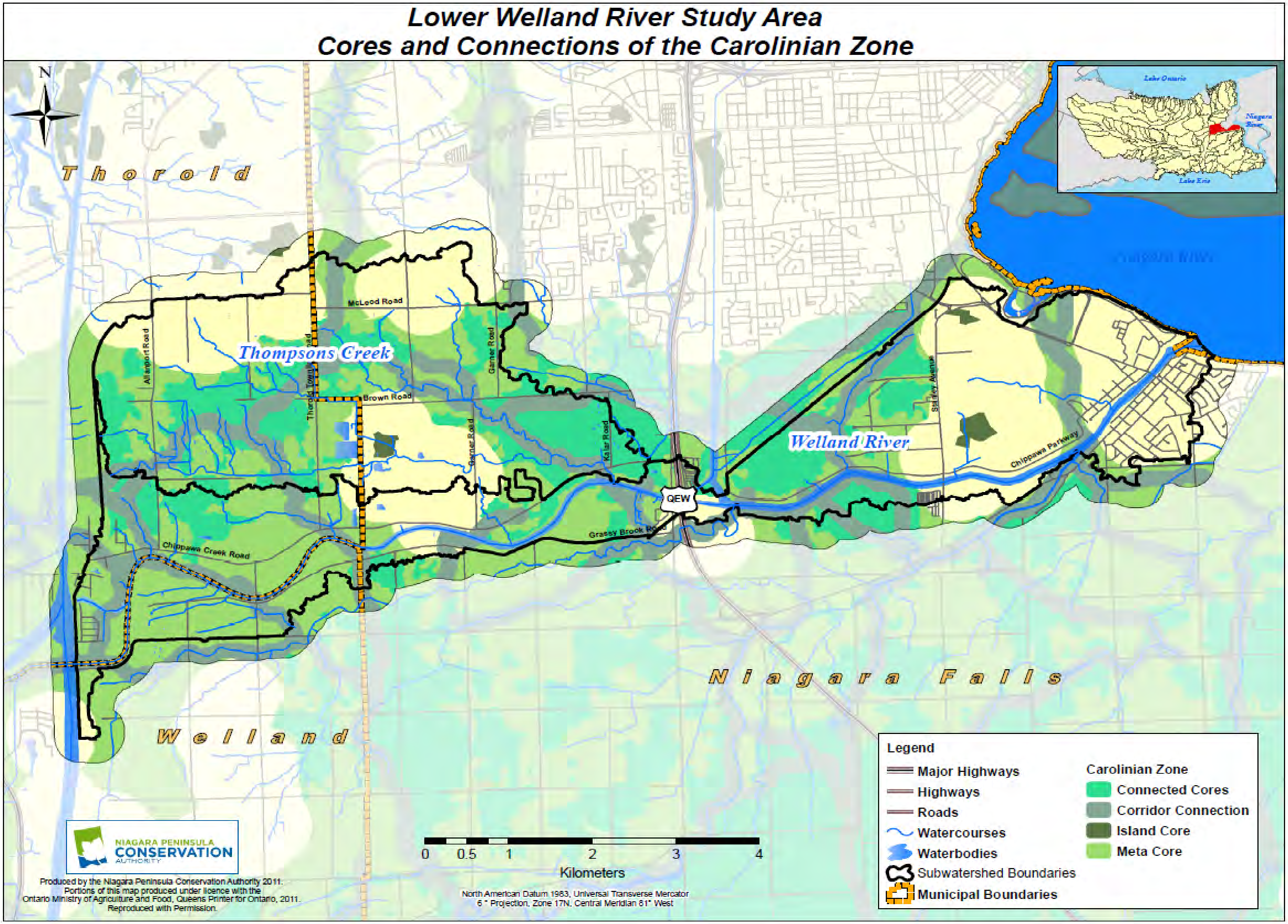

Figure 7: Cores and Connections of the Carolinian Zone

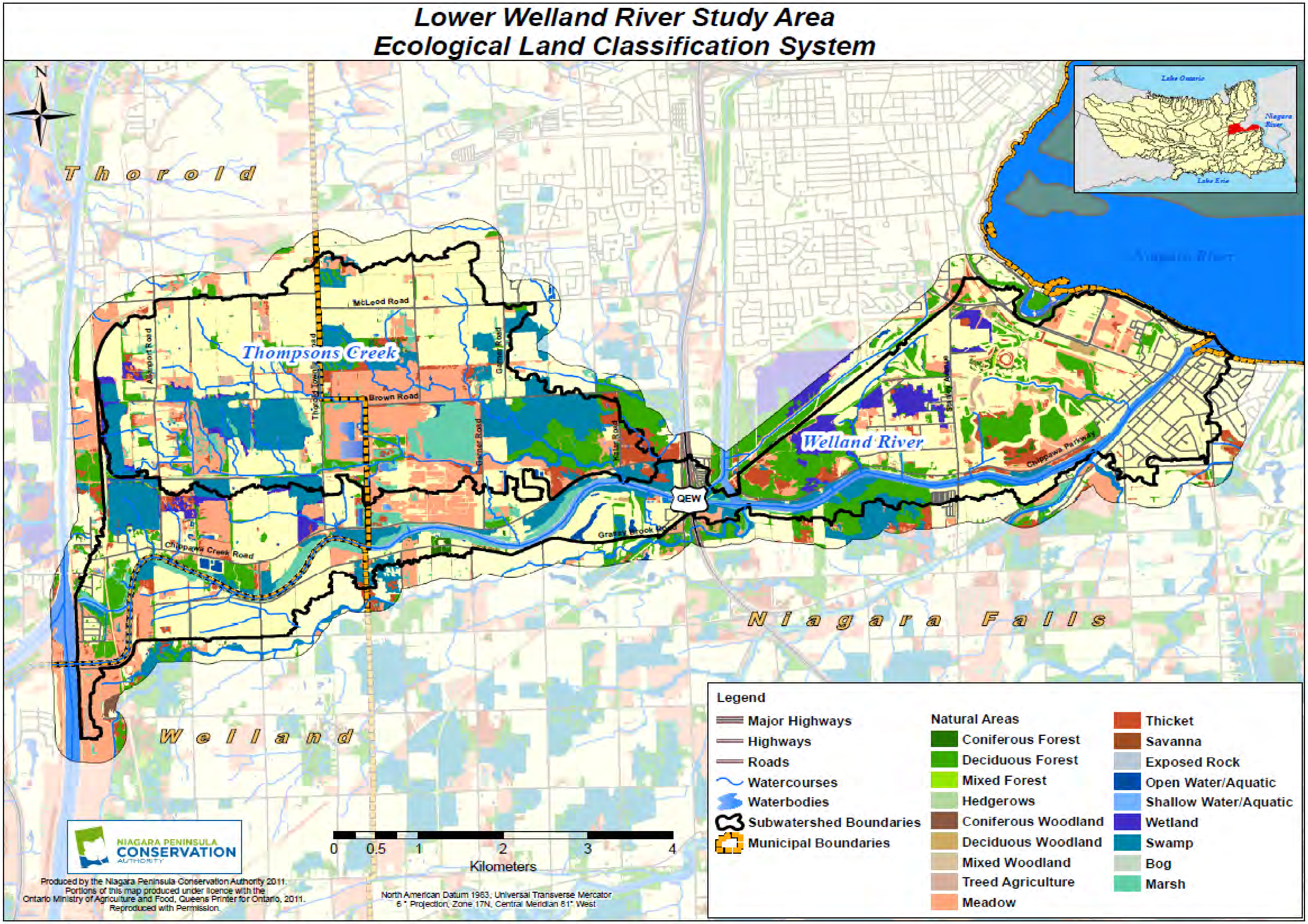

Figure 8: Ecological Land Classification System

South Queen Victoria Park Bluff Old Growth extends from the Murray Hill Road cut, south along the Niagara River Parkway to and including the Dufferin Islands Park. This bluff is also known as the Queen Victoria Park Glacial Moraine Hill. According to the survey conducted by the Bert Miller Nature Club, this bluff is not covered entirely by Original Old-growth Forest, but has the following categories:

- Secondary Old-growth Forest
- Original Old Growth mixed with Secondary Old Growth
- Second-Growth Mature Forest (sometimes with a scattering of Old-Growth individuals)
- Second-Growth Young Forests, and
- Non-native, scrubby invasive vegetation (Bert Miller Nature Club 2004).

According to the Old Growth Survey Report (2004), the forest categories alternate randomly with no pattern as to what forest category will come next. This random pattern is partly due to the way that invasive species may take hold and spread, or which large trees may topple and open up the forest to invasion from non-native species. Highlights of the site survey include 2 Black Walnut trees that are among the largest trees found during all the site surveys; the Dufferin Park Giant is approximately 250 years old with a diameter of 61 inches, and another one with a diameter of 58 inches. In addition, several trees were identified at this site that were over 200 years old.

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*" (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 of „provincially significant' or „non-provincially significant'. In the Lower Welland River study area, approximately 15 percent of the study area is covered in 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).

Upland Habitat: Woodland and Grasslands (Prairies and Meadows)

Environment Canada recommends that at least 30 percent of a watershed should be in forest cover in order to support viable fish and wildlife populations. In the Lower Welland River study area, approximately 21 percent of the study area is covered in upland habitat. The upland 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. 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, prairies and meadows also play an important role in creating habitat diversity and foraging areas for wildlife. Many species rely on expanses of prairie and the loss of habitat has contributed to their decline. According to Environment Canada in *A Guide to Establishing Prairie and Meadow Communities in Southern Ontario*, more than 150 plant species occurring in Ontario prairies are considered provincially or nationally rare.

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 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.

Currently in the Lower Welland River watershed, approximately 27 percent of the watercourses have some riparian habitat. The density and width of the buffer varies throughout the study area.

Important Bird Area

The Niagara River Corridor, between Lakes Erie and Ontario, was dedicated as a globally significant Important Bird Area in December 1996. The Niagara River annually supports one of the largest and most diverse concentrations of gulls in the world. During fall and winter, over 100,000 individuals can be observed foraging along the river, and a total of 19 species have been recorded. During the fall and winter, water fowl concentrations also can regularly exceed 20,000 individuals of more than 20 species. In addition, due to the regional geography, large numbers of migrating raptors and landbirds cross the river during migration (Bird Studies Canada No Date). Table 3 is a summary of bird records available for the Niagara River Corridor from Bird Studies Canada.

Table 3: Birds of Niagara River Corridor	
Species	**Season**
Black-crowned Night heron	Breeding, Spring Migration
Bonaparte's Gull	Fall Migration
Canvasback	Wintering
Colonial Waterbirds/Seabirds	Breeding
Common Goldeneye	Wintering
Common Merganser	Wintering
Common Tern	Breeding
Greater Scaup	Wintering
Herring Gull	Wintering
Little Gull	Spring Migration
Long-tailed Duck	Wintering
Ring-billed Gull	Breeding, Fall Migration
Wading Birds (Herons, Cranes ect.)	Breeding
Waterfowl	Fall Migration

In 2001 and 2002 Bird Studies Canada also conducted surveys in the area. Table 4 lists the bird species that were identified during these surveys in the Thompsons Creek and Lower Welland River subwatersheds.

Table 4: Birds Identified in Thompsons Creek and Lower Welland River Subwatersheds	
Common Name	**Scientific Name**
American Goldfinch	*Carduelis tristis*
American Robin	*Turdus migratorius*
Barn Swallow	*Hirundo rustica*
Cedar Waxwing	*Bombycilla cedrorum*
Chipping Sparrow	*Spizella passerina*
Common Grackle	*Quiscalus quiscula*
Eastern Kingbird	*Tyrannus tyrannus*
European Starling	*Sturnus vulgaris*
House Sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Mourning Dove	*Zenaida macroura*
Northern Mockingbird	*Mimus polyglottos*
Red-winged Blackbird	*Agelaius phoeniceus*
Savannah Sparrow	*Passerculus sandwichensis*
Song Sparrow	*Melospiza melodia*
Yellow Warbler	*Dendroica petechia*

Species at Risk

A Species at Risk is "*any plant or animal threatened by, or vulnerable to extinction"* (MNR 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 2005) 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, (*MNR 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 Lower Welland River study area, 13 endangered, threatened and species of special concern have been documented by the OMNR and the NPCA (Table 5).
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 5: Listed Species at Risk Identified in Lower Welland River Study Area			
COSEWIC Status (Federal)	**COSSARO Status (Provincial)**	**Common Name**	**Scientific Name**
Endangered	Endangered	Butternut	*Juglans cinerea*
Endangered	Endangered	Eastern Flowering Dogwood	*Cornus florida*
Endangered	Endangered	Northern Bobwhite	*Colinus virginianus*
Endangered	Under consideration	Eastern Pondmussel	*Ligumia nasuta*
Endangered	No Status	Four-leaved Milkweed	*Asclepias quadrifolia*
Threatened	Threatened	American Waterwillow	*Justicia americana*
Threatened	Threatened	Eastern Hognose Snake	*Heterodon platirhinos*
Threatened	Threatened	Red-headed Woodpecker	*Melanerpes erythrocephalus*
Threatened	Threatened	Round-leaved Greenbrier	*Smilax rotundifolia*
Threatened	Threatened	Grey Fox	*Urocyon cinereoargenteus*
Special Concern	Special Concern	Shumard Oak	*Quercus shumardii*
Special Concern	Special Concern	Swamp Rose-mallow	*Hibiscus moscheutos*
Special Concern	Special Concern	Yellow-breasted Chat	*Icteria virens virens*

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 Lower Welland River Watershed Plan study area can be reviewed in Table 6 and a list of regionally rare species can be reviewed in Table 7.

Table 6: Provincially Rare Species in the Lower Welland River Watershed	
Common Name	**Scientific Name**
Biennial Gaura	*Oenothera gaura*
Black Gum	*Nyssa sylvatica*
Greater Redhorse	*Moxostoma valenciennesi*
Halberd-leaved Tear-thumb	*Polygonum arifolium*
Round-leaved Yellow Violet	*Viola rotundifolia*
Shiny Wedge Grass	*Sphenopholis nitida*
Unicorn Clubtail	*Arigomphus villosipes*
Violet Bush-clover	*Lespedeza frutescens*
Weak Stellate Sedge	*Carex seorsa*
White Crappie	*Pomoxis annularis*

Table 7: Regionally Rare Species in the Lower Welland River Watershed	
Common Name	**Scientific Name**
Black Gum	*Nyssa sylvatica*
Butterfly Weed	*Asclepias tuberosa*
Giant Ragweed	*Ambrosia trifida*
Pink Spring Cress	*Cardamine douglassii*
Purple-stem Angelica	*Angelica atropurpurea*
Small Beggar-ticks	*Bidens discoidea*
Sweetflag	*Acorus americanus*

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 Lower Welland River Watershed study area, one rare Ecosite, and one rare Vegetation Type were identified through the NAI study and are described below. The descriptions are taken directly from the „*ELC Ecosystem Table'* and *Rare Vegetation Types (Goodban and Garofalo)*' section of the NAI Report:

- *Fresh-Moist Lowland Deciduous Forest Ecosite (FOD7):* Vegetation types within this Ecosite category includes white elm, willows, black walnut, black maple, basswood, green ash and black ash dominate separately or in variable mixtures (MNR 1999).
- *Pin Oak Mineral Deciduous Swamp Type (SWD1*-3): Pin Oak swamps are common to locally abundant in the eastern half of the Niagara Peninsula. This swamp type covers or often encircles seasonally inundated slough ponds, usually within larger stands of maple swamps. Pin Oak dominates the canopy almost exclusively, with Green Ash and White Elm as rare canopy associates or occasionally in the subcanopy (Goodban and Garofalo 2010).

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 prime focus 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).

The main channel of the Welland River from the siphon to the confluence of the hydro canal and Welland River has been classified as critical (Type 1) fish habitat according to the Ministry of Natural Resources stream classification data (Figure 9). The remainder of the Welland River to the Niagara River and Thompsons Creek have been delineated as important (Type 2) fish habitat. No watercourses in the study area have been classified as marginal (Type 3) habitat. The remaining watercourses in the study area have not been evaluated in terms of importance for fish habitat.

Lower Welland River Fish Community

The Niagara River Watershed is divided into 10 Aquatic Resource Areas (ARA) as a result of natural and anthropogenic influences. Within the Lower Welland River study area there are two ARA’s; the Chippawa Channel ARA and the Welland River East ARA. The Chippawa Channel ARA includes the lower Welland (Chippawa) River from the Power Canal to the Niagara River. Historically the Welland River entered into the Upper Niagara River, however, to accommodate hydroelectric operations the Welland River is diverted into the Chippawa-Queenston Power Canal and the water from the Upper Niagara River now enters the Welland River channel and meets Welland River flow at the Power Canal.

In 2004 the MNR sampled 4 stations in the Welland River within this ARA by means of boat electrofishing; marking the first community study conducted in this ARA. Each station covered approximately 500 meters of shore length over the duration of 1000 electrofishing seconds (Yagi and Blott 2008). A total of 30 species have been identified in this area including River Redhorse, a Species at Risk, and 2 exotic species; Round Goby and Rainbow Smelt. In addition, one of these species includes the Northern Brook Lamprey which was not identified during these surveys but from a scuba diver which later was confirmed by the MNR biologist. This find is significant because the Northern Brook Lamprey is also a Species at Risk and it burrows in the substrate so is not likely to be caught with electrofishing techniques and adult samples are rare to collect because they are small and die soon after spawning (Scott and Crossman 1973).

The Welland River East ARA extends from the Welland Canal, (includes a small section of the original channel in Port Robinson), to the Chippawa-Queenston Power Canal. The MNR differentiates this area because of the presence of the river diversion structure and the channelization created by the realignment of the river to accommodate the new canal in 1973(Yagi and Blott 2008). In October 1997 the MNR sampled 4 stations from the canal to Moyer Road and 8 stations in September 2004, including those sampled in 1994 with an additional 4 stations between Moyer Road and the Power Canal. According to the MNR, the fish community metrics for 1997 and 2004 were very similar for this ARA, despite an increase in sampling effort, indicating very little difference in habitat throughout this section of river (Yagi and Blott 2008).

The fish species identified in the Lower Welland River Study Area can be reviewed in Table 8.

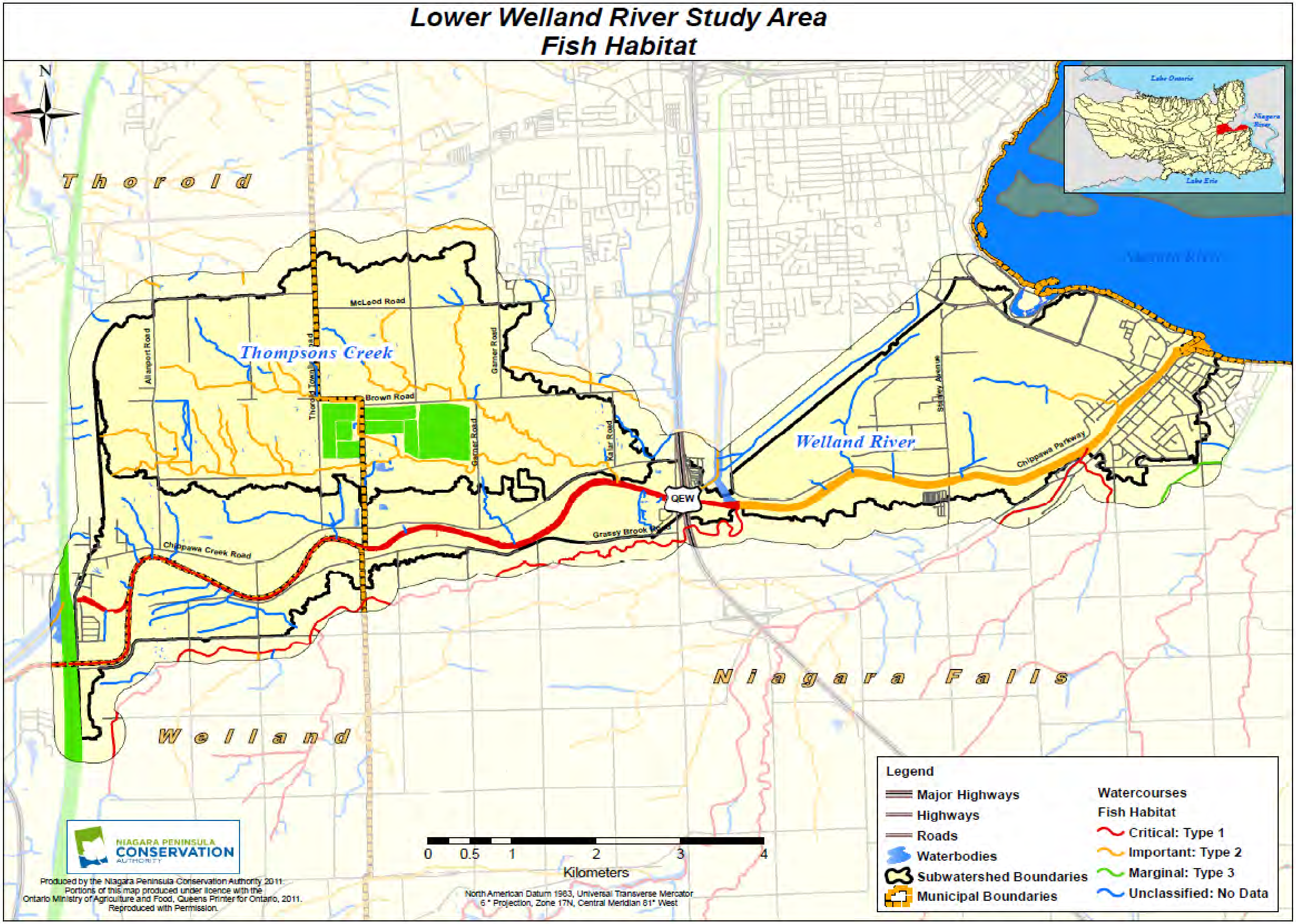

Figure 9: Fish Habitat

Table 8: Fish Species Identified in the Lower Welland River Study Area			
	Chippawa Channel	**Welland River East**	
	2004	**2004**	**1997**
Bowfin	√	√	√
Northern Brook Lamprey**SC	√ (scuba dive sample verified by biologist)		
Gizzard Shad	√	√	
White Sucker	√	√	√
Shorthead Redhorse		√	√
Greater Redhorse			√
River Redhorse **SC	√	√	
Redhorse sp.	√		
Central Mudminnow			√
Banded Killfish		√	√
Brown Bullhead		√	√
Channel Catfish		v	√
Trout-perch	√		
Rainbow Darter	√		
Johnny Darter	√	√	√
Logperch	√	√	
Brook Silverside	√		√
Mottled Sculpin	√		
Golden Shiner	√	√	√
Emerald Shiner	√	√	√
Common Shiner	√		
Spottail Shiner	√	√	√
Mimic Shiner			√
Bluntnose Shiner	√	√	√
Striped Shiner			√
Fathead Minnow	√		
Creek Chub	√		
Minnow sp.	√	√	
Rock Bass	√	√	√
Green Sunfish	√	√	√
Pumpkinseed	√	√	√
Bluegill		√	√
Northern Pike	√	√	√
Smallmouth Bass	√	√	
Largemouth Bass	√	√	√
White Crappie		√	√
Black Crappie	√	√	√
Yellow Perch	√	√	√
Muskellunge		√	
Round Goby	√	√	
Rainbow Smelt	√		
Goldfish		√	√
Common Carp		√	√
Rudd		√	
Total	**30**	**30**	**27**

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

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*."

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). This classification system has been created for use by municipal drainage superintendents for the purpose of drain maintenance.

There is roughly 7 kilometers of municipal drain present in the Lower Welland River study area; Allanport Drain in Thompsons Creek subwatershed (Figure 10). Approximately 4 kilometers is Class C and the remaining 3 kilometers is Class F. Class C drains have a permanent flow but with warm water temperatures and baitfish present in the drain. Class F drains are characterized by intermittent flow (Fisheries and Oceans Canada No Date).

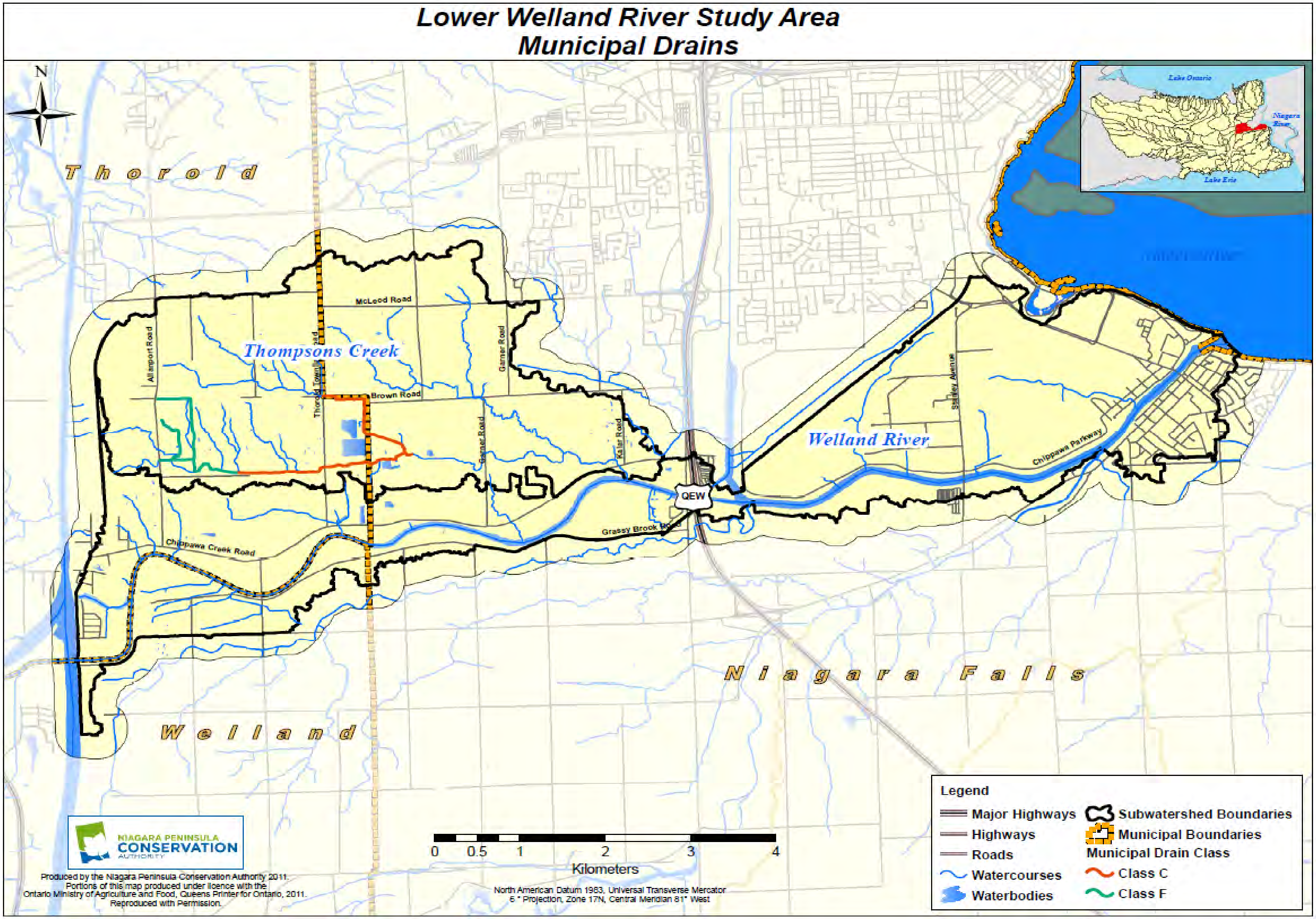

Figure 10: Municipal Drains

Water Quality

Niagara River Area of Concern

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).

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 (1995) 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.

The report provides the following recommended status for the applicable 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

It was clear from the Stage 2 review that while a lot of positive work has been completed there is still work to be done to deal with the impairments listed above. Some of the remaining key actions include:

- Assessing and addressing sources of nutrients leading to eutrophication of the Welland River and its tributaries;
- Restoring and protecting fish and wildlife habitat, including unique habitats found rarely in other parts of the Great Lakes basin, and reducing 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);
- Completing assessments for the Beneficial Use Impairment status degradation of phytoplankton and zooplankton populations and implementing appropriate actions for any other beneficial uses deemed impaired;
- Implementing the updated monitoring plan to help track progress of the Beneficial Use Impairments and ensure that they don’t backslide; and
- Completing assessment of Queens Royal Beach (not in LWR study area) and implementing any required actions to reduce *E.coli* at this beach (Niagara River RAP Update 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).

NPCA Water Quality Monitoring Program

The Ontario Ministry of Environment (MOE) 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"* [MOE 1994 (Section 3.1)]. Table 8 summarizes indicator parameters that are the most useful in assessing relative stream water quality. They include: total phosphorus, nitrate, copper, lead, zinc, *Escherichia coli*, chloride, suspended solids and benthic invertebrates (NPCA 2010a). These parameters 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 (as modified from 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 (Griffiths 1999)

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).

Water quality is monitored at two stations in the Lower Welland River study area; station WR010 and station TC001 (Figure 11). Station WR010 is located where the Welland River exits the second siphon under the Welland Canal. Station WR010 has a Water Quality Index (WQI) rating of Marginal, which is the highest WQI rating achieved in the Welland River watershed in 2009. Water quality is improved at this site by direct mixing with backflow from the Niagara River as it is redirected up the Welland River as part of the hydroelectric operations and from flow-through at the Welland Water Treatment Plant where water from the Old Welland Canal flows into the

Welland River. Factors affecting water quality at this site include exceedances of total phosphorus and *E. Coli*. (NPCA 2010a). Currently benthic invertebrate sampling is not conducted at station WR010 due to access restrictions. The second site, TC001, was added April 2010 and is located at the outlet of Thompsons Creek. There is not enough data collected for this site to determine a Water Quality Index rating.

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.

Biological Monitoring and Assessment Program

Benthic macroinvertebrate sampling has been completed at surface water quality monitoring stations using the BioMAP (Biological Monitoring and Assessment Program) protocol (Griffiths 1999). 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.

For the analysis, the number and assortment of animals found at each site are used to calculate the biological metrics and indices for the biological assessment. These indices and metrics are used to convert biological data into a measure of water quality. This allows for the determination of water quality at a sample site and for cross comparison against other equivalent watercourses. Water quality results can then be classified as *impaired* or *unimpaired*. *Unimpaired* sites consist of animals that are susceptible to environmental pressures; in turn finding these animals in a water system implies the system has limited environmental stresses. *Impaired* sites consist mainly of organisms that are more tolerant to environmental stressors and typically do not include animals that are historically found. A *grey-zone* designation is for those sites which cannot be clearly defined as *impaired* or *unimpaired*

BioMAP sampling was initiated at station TC001 in April 2010 and as indicated earlier a sufficient amount of data has not yet been collected to determine water quality. Due to high water depth and channel morphology BioMAP samples are not collected from station WR010.

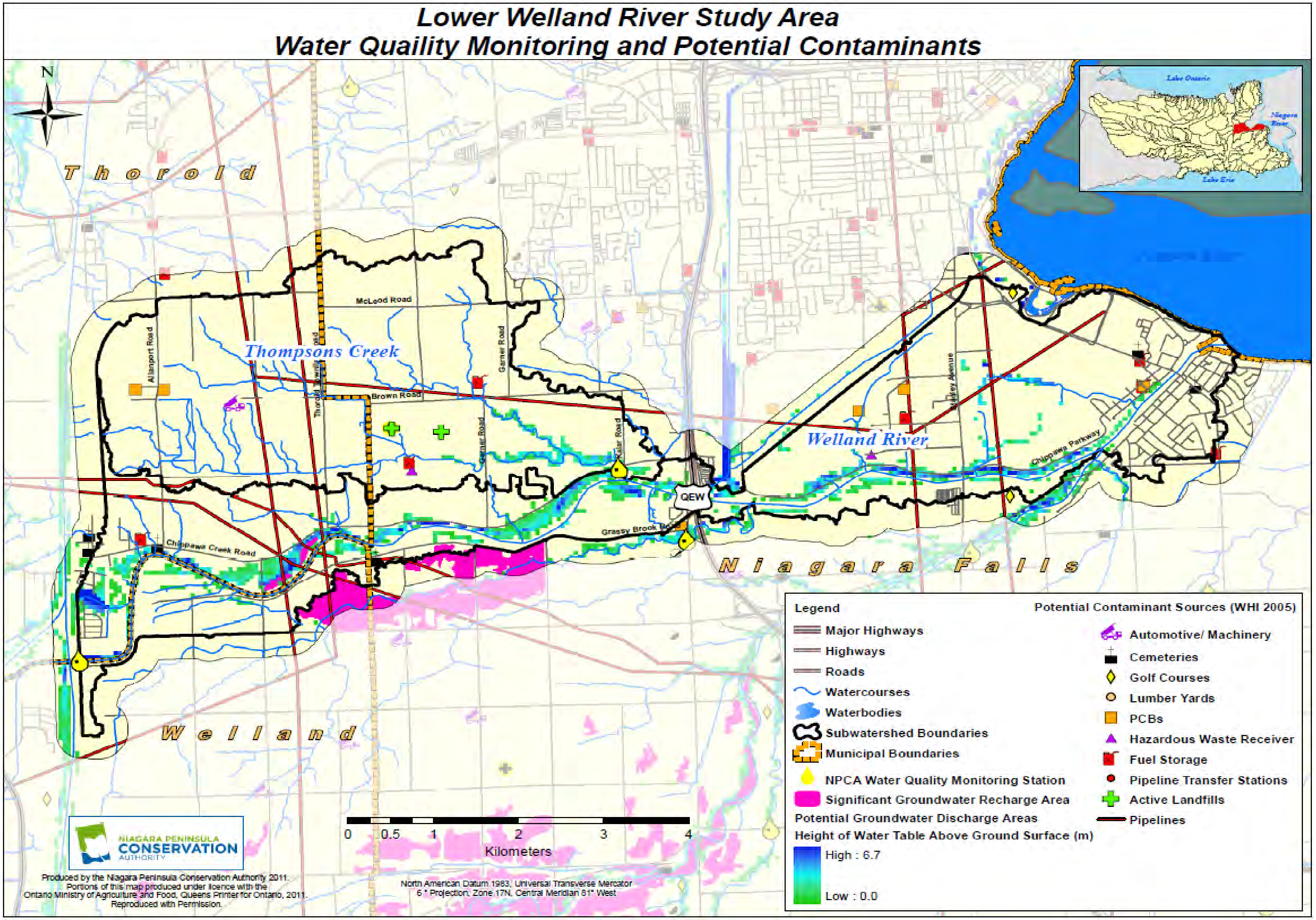

Figure 11: Water Quality and Potential Contaminants

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 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 "*elevated phosphate concentrations (with respect to TP) peak in the mid to lower portions of the Welland River between stations WR005 and WR010";* the latter station is within the Lower Welland River study area. The decrease in TP concentrations at WR010 is due to the Welland River mixing with the Niagara River and from the flow-through at the Welland Water Treatment Plant where water from the Old Welland Canal flows into the Welland River.

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, 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 groundwater vulnerability studies through the Source Water Protection Program focused on 2 areas; Significant Groundwater Recharge Areas (SGRA) and Highly Vulnerable Aquifers (HVA).

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 Lower 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 are illustrated on Figure 11 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 Lower Welland River include portions of the Welland River floodplain, lower Thompsons Creek, and the Chippawa Power Canal. The potential height of the water table ranges between 0 and 4 meters 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).

The *Clean Water Act (MOE 2006)* requires the delineation and protection of vulnerable groundwater areas for quantity protection (i.e. SGRAs) as well as for quality protection (i.e. HVAs) as mentioned above. 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.

There are no SGRA's in the Lower Welland River study area; however an area south of the study area in the Grassy Brook subwatershed has been identified as an SGRA.

Figure 12 illustrates areas with high, medium and low groundwater vulnerability. The Lower 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). Areas of medium groundwater vulnerability are found in the eastern 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 12.

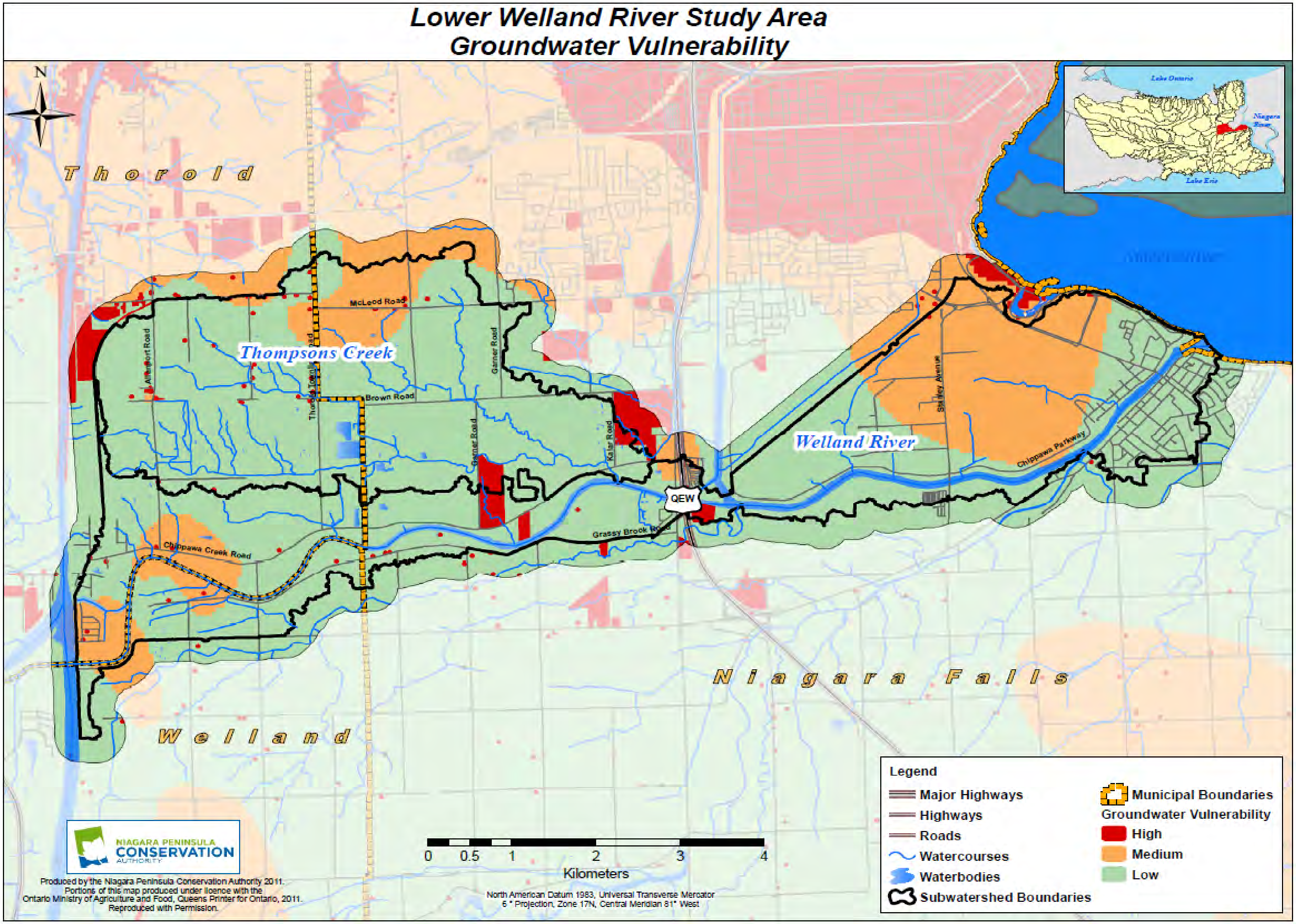

Figure 12: Groundwater Vulnerability

There are limited pockets delineated as Highly Vulnerable Aquifers (HVA) through the *Assessment Report* that are associated with transport pathways where water well records have been identified within municipally serviced areas. 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 12.

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 2006) is to protect existing and future sources of drinking water supplies.

Accordingly, the Regional Municipality of Niagara has completed a *Surface Water Vulnerability Study* for each of its 6 municipal Water Treatment Plant (WTP) intakes. 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 Niagara Falls WTP and its intake are located along the north shore of the lower Welland River near its confluence with the Niagara River. Although the intake is in the Welland River it actually receives raw water from the Niagara River as a result of the flow reversals of the Welland River. This treatment plant supplies water to the City of Niagara Falls, the community of Port Robinson in the City of Thorold, and the community of Bevan Heights in the Town of Niagara-on-the-Lake; approximately a population of 80,000 (Stantec 2008).

The *Clean Water Act (2006)* 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, all 6 *Surface Water Vulnerability Study[s]* are being used by the Niagara Peninsula Source Protection Committee (NPSPC) to prepare an *Assessment Report* and a *Source Protection Plan* which are required under the *Clean Water Act* (MOE 2006).

The purpose of the *Assessment Report* (NPCA 2010c) is to assess the quality and quantity of municipal drinking water supplies across the source protection area. The *Assessment Report* identifies significant threats including potential future threats that could impact our drinking water sources (NPCA 2010c). Based on the analysis for the Niagara Falls IPZ areas, there are no significant threats in the IPZ zone immediately surrounding the intake, or within the outer IPZ zone; this outer zone was delineated based on a 2-hour time of travel to the intake. Twenty-seven moderate threat activities were identified within the combined IPZ areas. The activity threats fall within the following threat categories: application of pesticide to land; application of road salt; handling and storage of fuel; application of agricultural source material to land; application of pesticide to land; and the use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard (NPCA 2010c).

Upon approval of the *Proposed Assessment Report* by the MOE, the report will be used to prepare a Source Protection Plan (SPP). The purpose of the *Source Protection Plan* is to eliminate or reduce significant threats to municipal drinking water sources that are identified in the Assessment Report (NPCA 2010c). The *Source Protection Plan,* 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 *Clean Water Act* (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 Source Protection Plans; 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 *Source Protection Plan* is approved, it could restrict future land use activities within the areas of the Intake Protection Zones.

Water Quantity

Water Budget

Under the *Clean Water Act* (MOE 2006), one of the 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 Lower Welland River study area. The inflows include precipitation, lateral groundwater inflows, surface water inflows from upstream catchments, and water diversions (such as those from Welland Canal). Outflows include evapotranspiration, surface water discharges (e.g. Thompsons Creek), 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 *Water Availability Studies* were completed, the Tier 1 Water Budget focused on anthropogenic water takings and water consumption, to determine if the watershed planning area is stressed hydrologically. *The Tier 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 10 (NPCA 2010d).

The Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment (NPCA 2010d) identified the Lower Welland River study area as having a moderate surface water stress level based on provincial benchmark threshold values (Table 10). 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 Lower Welland River study area 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.

Table 10: 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%

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 Lower Welland River and Thompsons Creek subwatershed there are 31 PTTW. Four of these permits are in the City of Thorold and the remaining 27 are in the City of Niagara Falls. Eleven of the PTTW are for surface water takings, 6 are for groundwater takings, and the remaining 14 are for both surface and groundwater. The purposes of these permits are as follows; fifteen are for commercial uses, 11 industrial, 2 de-watering, 1 for groundwater remediation, 1 for water supply, and the remaining permit is for agriculture (MOE 2009).

Due to the moderate surface water stress assignments determined by the *Water Budget and Water Quantity Stress Assessment* (NPCA 2010d) study and an ongoing fluctuation of water demand it is recommended that this study be improved further by undergoing development of subwatershed scale hydrogeologic characterizations and the inclusion of precise actual takings in the demand calculations for large permitted takers (NPCA 2010d). Increased precision in the water budgets and modelling would provide better information to make informed decisions in regard to PTTW applications and for use in planning decisions and policy development.

Geomorphic Study

NPCA Geomorphic Study of Thompsons Creek

In 2010 NPCA staff conducted fluvial geomorphic assessments along 2 reaches of Thompsons Creek (Figure 13). The purpose of the assessments was to identify geomorphic processes occurring in the Thompson Creek watercourse; assessments were not conducted on the Lower Welland River. The following information is derived from this report: *Beaverdams and Shriners Creek Geomorphic Study, including Thompson Creek* (NPCA 2010e).

A geomorphic assessment provides historical and current conditions on the physical state of the stream in order to assess its stability and to prioritize restoration and protection. Three phases of assessment were conducted which began in the spring of 2010. The first phase of the assessment provides general physical information about specific reaches within the watershed. The second phase involves site specific geomorphic studies, which also includes the third phase of carrying out a stream visual assessment.

The format for the first two phases of the geomorphic assessment is closely based on the phases developed by the Vermont Agency of Natural Resources (2005). The Stream Visual Assessment Protocol has been taken from the National Water and Climate Center Technical Note 99-1 (1998) by the United States Department of Agriculture and the Natural Resources Conservation Service.

Methodology

Initially, the watershed was delineated using a drainage basin of 1.25km^2 or greater, which is the size of the drainage basin the NPCA uses for floodplain regulation. The stream was then broken down into smaller reaches based on physical characteristics of the stream and the surrounding landscape. The reaches were defined by stream confinement (or valley width), valley slope, geologic materials, and joining tributaries, which should result in the reaches having similar hydraulic properties and morphology. This criteria was taken from the Vermont Stream Geomorphic Assessment Phase 1 Handbook (2005) and was determined using various digital layers in the GIS program ArcMap. Once the reaches were identified they were given a unique code in order to distinguish it from the other reaches. The procedure used to collect information for the three phases of the assessment will be described in the preceding sections.

Phase One Data Collection

The first phase in this assessment determined the physical characteristics of the defined reaches for each of the sub-watersheds, and involved the collection of historical data. The types of data gathered for every reach within the Beaverdams & Shriners Creek study area, as well as Thompsons Creek watercourse are listed below. These characteristics were determined using various digital layers in ArcMap (Land-use, Soils, and Quaternary Geology), 2006 Ortho photography, as well as aerial photographs from 1934.

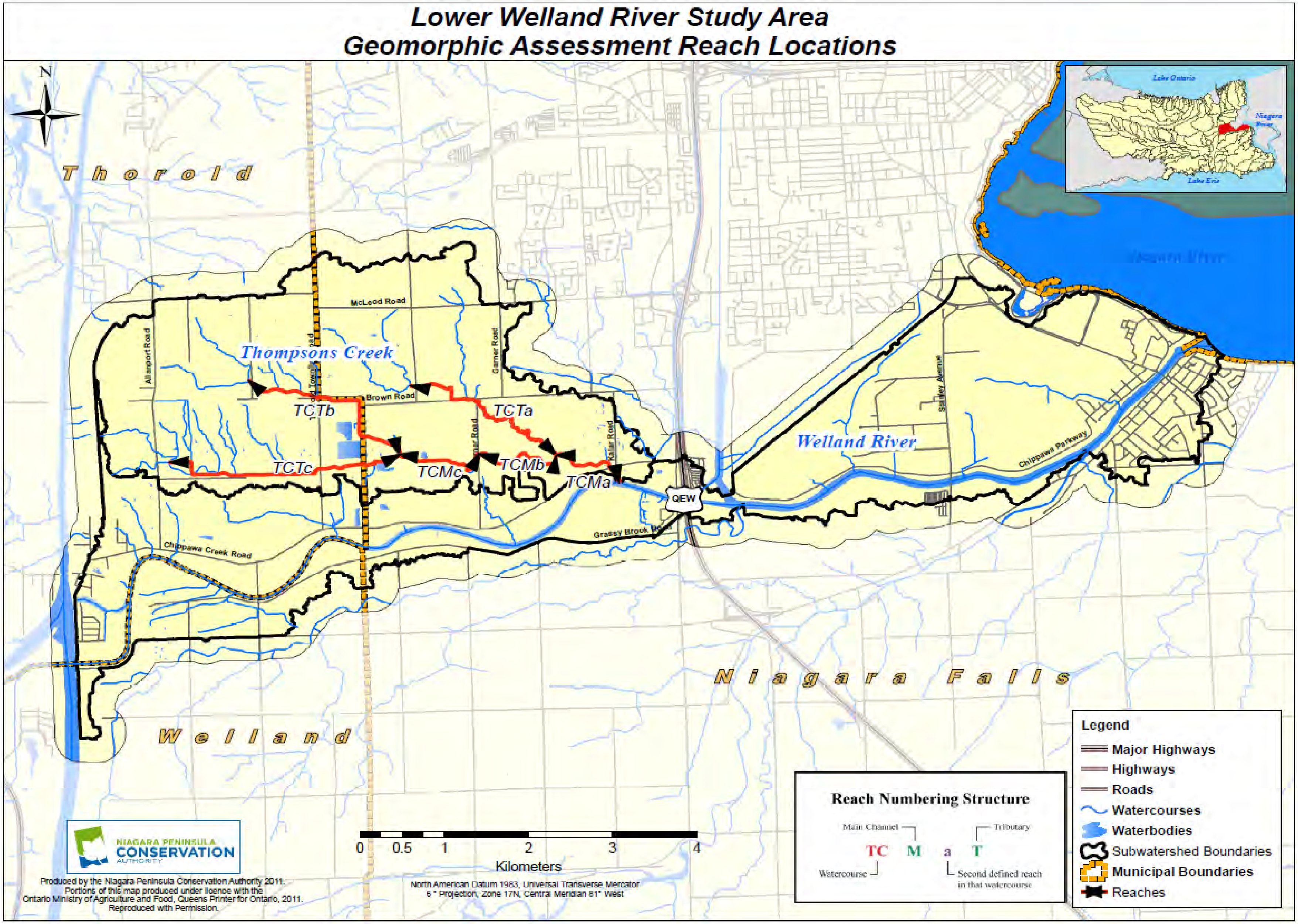

Figure 13: Geomorphic Assessment

Reach Characteristics:

- The valley and channel lengths were measured and used to determine the valley and channel slope, as well as channel sinuosity (the amount of bending in a stream).
- Surficial geology and soil properties were identified.
- Unstable valley side slopes were listed for those reaches that contained them.
- The length of bank that contains a treed riparian buffer was measured and is listed as a percentage of the total reach.

Historical Characteristics:

- The present and historical land uses were determined for the watershed and along the stream corridor. Any changes to the channel planform (the outline of an object when viewed from directly overhead) as based on the 1934 aerial photographs were also identified.

This data was collected for Thompsons Creek and the information can be found in the *Beaverdams and Shriners Creek Geomorphic Study, including Thompsons Creek report* (NPCA 2010e).

Phase Two Data Collection

The second phase of the investigation required site visits in order to gather physical and hydraulic information from site specific reaches within the watershed. The data collected during this phase was based on the Vermont Stream Geomorphic Assessment Phase 2 and Phase 3 Handbook (2005). Letters were mailed out to property owners living along the streams in the watershed and site locations were based on landowner permission. The site characteristics collected from the field were separated into five categories which are listed below.

Channel Bed and Planform Changes:

- Identify whether or not riffle and steps were present.
- The composition of the streambed and the average size of the largest particle were identified. Pebble counts were completed at field sites that consisted of a mixture of particle sizes and not just sand sized or smaller.
- Bar types found along the bed were also identified.
- The type and number of planform changes (i.e. flood chutes, neck cut-offs, channel avulsions, and braiding) within the field site were listed.
- Animal crossings along the field site were identified.

Valley and River Corridor:

- Encroachments parallel to the stream (berms, roads, or paths) which may not allow flood waters to overflow onto its floodplain were identified and measured.
- The gradient and texture of adjacent terraces or hills was recorded.
- It was noted whether or not the stream bank was continuous with the valley slope or greater than one bankfull width away.
- Grade controls were identified along the channel and their height was measured.

Flow Modifiers:

- Channel constrictions present within the stream were noted.

- Springs, seeps, small tributaries and adjacent wetlands were identified due to their influence on water storage and habitat.
- Debris jams present within the channel were recorded.
- Inputs from stormwater drains were identified and it was noted whether or not the flow is regulated upstream.
- The amount of water presently flowing within the channel was also recorded.

Stream Banks, Buffers, and Corridors:

- Bank slope and sediment type present within the bank were identified. Slope was identified as either shallow (<30%), moderate (30-50%), or steep (>50%).
- The presence of bank erosion and revetments were noted.
- Type of bank vegetation and approximate width was identified for the near bank, buffer, and riparian zones. The degree of canopy across the channel was also identified.

Channel Cross Sections:

- Measurements on bankfull width, bankfull maximum depth, floodprone width, and estimated present flow status were recorded.
- Calculations on mean bankfull depth, cross sectional area, wetted perimeter, entrenchment ratio, hydraulic radius, width/depth ratio, average water depth, and the estimated discharge and velocity for bankfull were also determined.

Phase Two data was collected for 2 sites visited in the Thompsons Creek watercourse. This data is presented in the *Beaverdams and Shriners Creek Geomorphic Study, including Thompsons Creek report* (NPCA 2010e).

Phase Three Data Collection

Each field site was analyzed using the “Stream Visual Assessment Protocol” taken from the National Water and Climate Center Technical Note 99-1 (1998) by the United States Department of Agriculture and the Natural Resources Conservation Service. Using visual indicators, this form helps to determine the stability of the watercourse. There are 15 possible categories that a score out of 10 is assigned to, but two of the categories were not used during this assessment. The macroinvertebrate category was not used because this information is captured as part of the water quality program, and the salinity category was not used because it is not applicable to any of the sites. The 13 categories and their descriptions used in this assessment are listed below.

Channel condition:

- A low score for this category would indicate that the channel has been structurally altered and is no longer in its natural form. A low score would also be assigned if the channel is incised and can no longer access the floodplain. Streams that have been channelized or straightened would result in a lower score as well.

Hydrologic Alteration:

- A low score for this category would indicate that flooding occurs rarely or never. This would be due to deep incision or structures that prevent floodplain access. Known water withdrawals from the area would also result in a low score.

Riparian Zone:

- If the bank vegetation adjacent to the stream is non-existent or barely present then a low score is assigned to this category. The lack of structural components from a variety of vegetative types (i.e. aquatic plants, sedges, grasses, shrubs, understory and overstory trees) will result in a lower score as well.

Bank Stability:

- A low score for this category would indicate that bank erosion is present throughout the majority of the site. Bank erosion includes areas where bare soil is extending up the bank, fallen vegetation is present, and slumped soil is found at the base of the bank.

Water Appearance:

- Contributors to a low score in this category would include the presence of cloudy or turbid water, visible pollutants within the water, or odours.

Nutrient Enrichment:

- Low scores indicate that an excessive amount of nutrients are present within the stream. Dense macrophyte beds and algal blooms can be sources of serious problems for the system.

Barrier to Fish Movement:

- A low score for this category means that there is a barrier to fish movement present. Natural barriers, such as waterfalls are also considered in this category.

Instream Fish Cover:

- The score in this category depends on the number of suitable habitat and cover types available. The cover types include: logs/large woody debris; deep pools; overhanging vegetation; boulders/cobble; riffles; undercut banks; thick root mats; dense macrophyte beds; isolated/backwater pools; and other cover types.

Pools:

- A low score for this category indicates that the majority of pools present are shallow or there are no pools present at all.

Insect/Invertebrate Habitat:

- The score in this category depends on the number of suitable habitat types present. The cover types include: fine woody debris; submerged logs; leaf packs; undercut banks; cobble; boulders; coarse gravel; and other habitat types.

Canopy Cover:

- Based on a warm water system a low score for this category means that less than 25% of the water surface is shaded in the reach.

Manure Presence (if applicable):

- A low score for this category indicates that livestock have access to the riparian zone and that manure is present.

Riffle Embeddedness (if applicable):

- If particles along the stream bed are completely or partially embedded then a low score is assigned to this category.

This information collected for the 2 field sites in the Thompsons Creek watercourse is presented in the *Beaverdams and Shriners Creek Geomorphic Study, including Thompsons Creek report* (NPCA 2010e).

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Site Characterizations

As indicated earlier, during the summer months of 2010 two field sites were assessed along Thompsons Creek. The results of the field work, as well as possible restoration alternatives are recorded for each site in the following section.

1. Heartland Forest (TCTa): This field site is within the Provincially Significant Wetland, Thompsons Creek Wetland. Bank instability is present in the form of undercutting and quite a few debris jams were noted. A large debris jam was identified on the upstream side of a footbridge which could indicate that the bridge is constricting the channel. The presence of algae was noted during a site visit in 2010. Recommendations for this site include monitoring bank erosion to ensure the banks are adequately stabilized. This can be done by the use of erosion pins inserted into the bank. Additional sediment may be entering the channel through bank erosion at the numerous debris jams present along this field site. If these debris jams are causing more sediment to enter the channel then they should be removed. This can be determined by monitoring the bank erosion adjacent to the debris jams with erosion pins. Excessive sediment deposition can cause problems in the watercourse, such as lateral channel adjustments, increased turbidity, filling in of pools, and impacting fish habitat. Measurements taken of the foot bridge will determine whether the bridge is constricting the channel. If this is the case then the bridge should be replaced and properly sized. Water quality should continue to be monitored due to the presence of algae.

2. Garner Road (TCTb/TCTc/TCMc): Two tributary channels at this field site are classified as municipal drains named Allanport Drain, class 3. Based on the 1934 aerial photograph the channel has been altered. The presence of algae, and duckweed were noted during a site visit in 2010. Turbid water was also noted after a storm event in 2010. The invasive species, phragmites was identified at this field site and further research should be conducted to determine whether the phragmites should be removed from this location. Water quality should continue to be monitored in this watershed.

Watershed Habitat Restoration

Environment Canada (2004) 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 habitat restoration recommendations to be implemented through the NPCA Water Quality Improvement Program. A summary of the riparian, wetland and forest habitat restoration guidelines have been reproduced in Appendix D.

Watershed Restoration Guidelines

EC's (2004) guidelines for wetland, riparian and forest habitat restoration identify targets for each habitat type in a watershed (Appendix D). 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; ***<u>or restore to original percentage of wetlands in the watershed.</u>***
- 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 Lower Welland River watershed currently contains approximately 15 percent wetland cover and approximately 21 percent forest cover. Based on the above guidelines, an additional 9 percent of forest cover is required to create minimum desirable habitat proportions in the Lower 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 27 percent in the watershed. Based on this percentage approximately 48 percent of the watershed requires a vegetative buffer. As indicated, 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 2004).

Restoration Suitability Mapping

Potential habitat improvement and enhancement restoration areas have been identified using riparian, wetland and upland restoration suitability mapping produced by the NPCA (Figures 14 to 16). The criteria used to create the restoration suitability mapping were derived from several sources (Appendix E. 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 E.

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.

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 E. A series of habitat restoration suitability maps are provided (Figures 14 - 16).

For convenience, and to make restoration recommendations more manageable and easier to implement, the suitability mapping recommendations have been divided into separate subwatersheds: Thompsons Creek and Lower Welland River (Tables 11 and 12, Figures 17 and 18).

Lower Welland River Study Area
Riparian Restoration Suitability Mapping

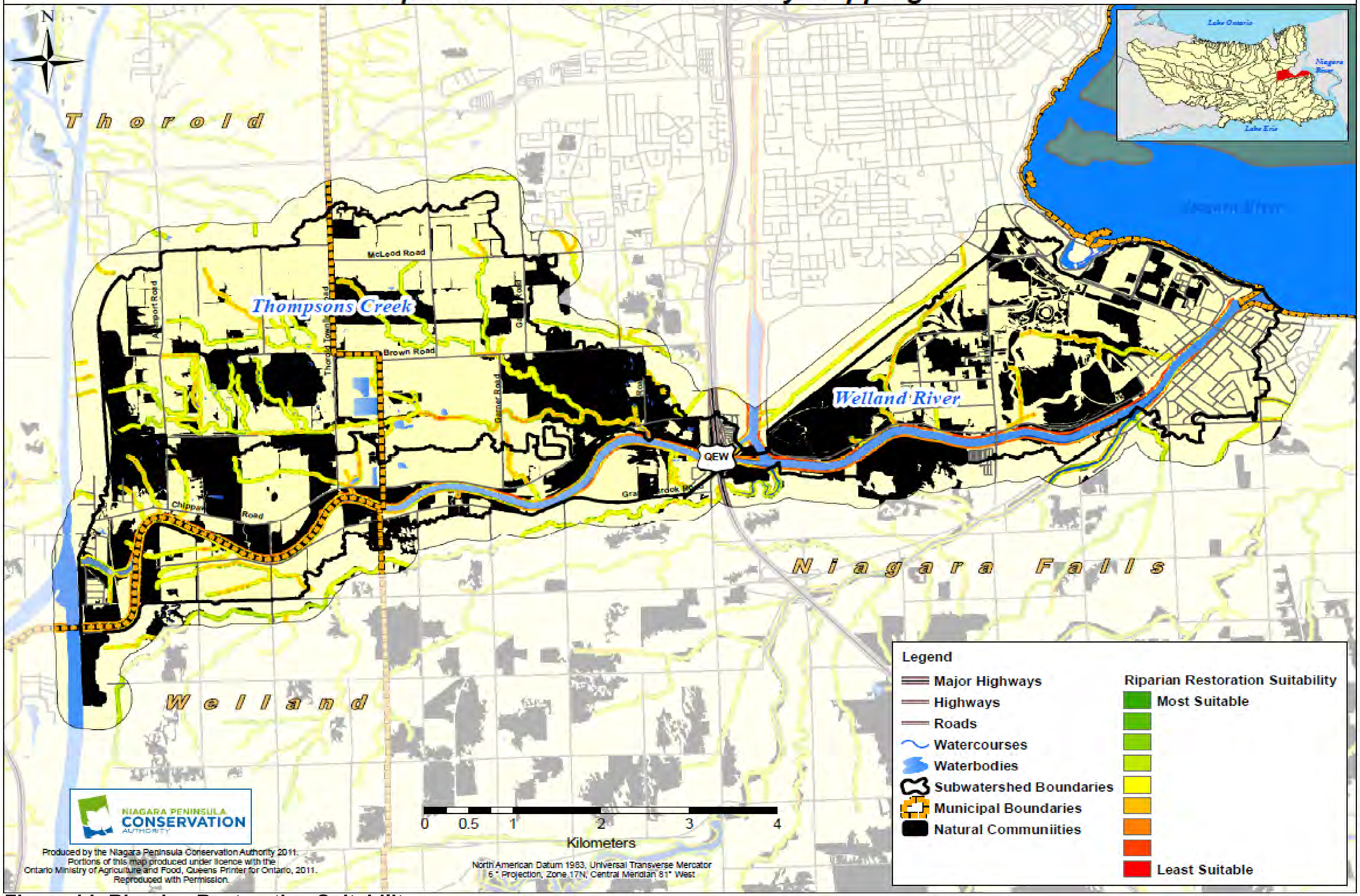

Figure 14: Riparian Restoration Suitability

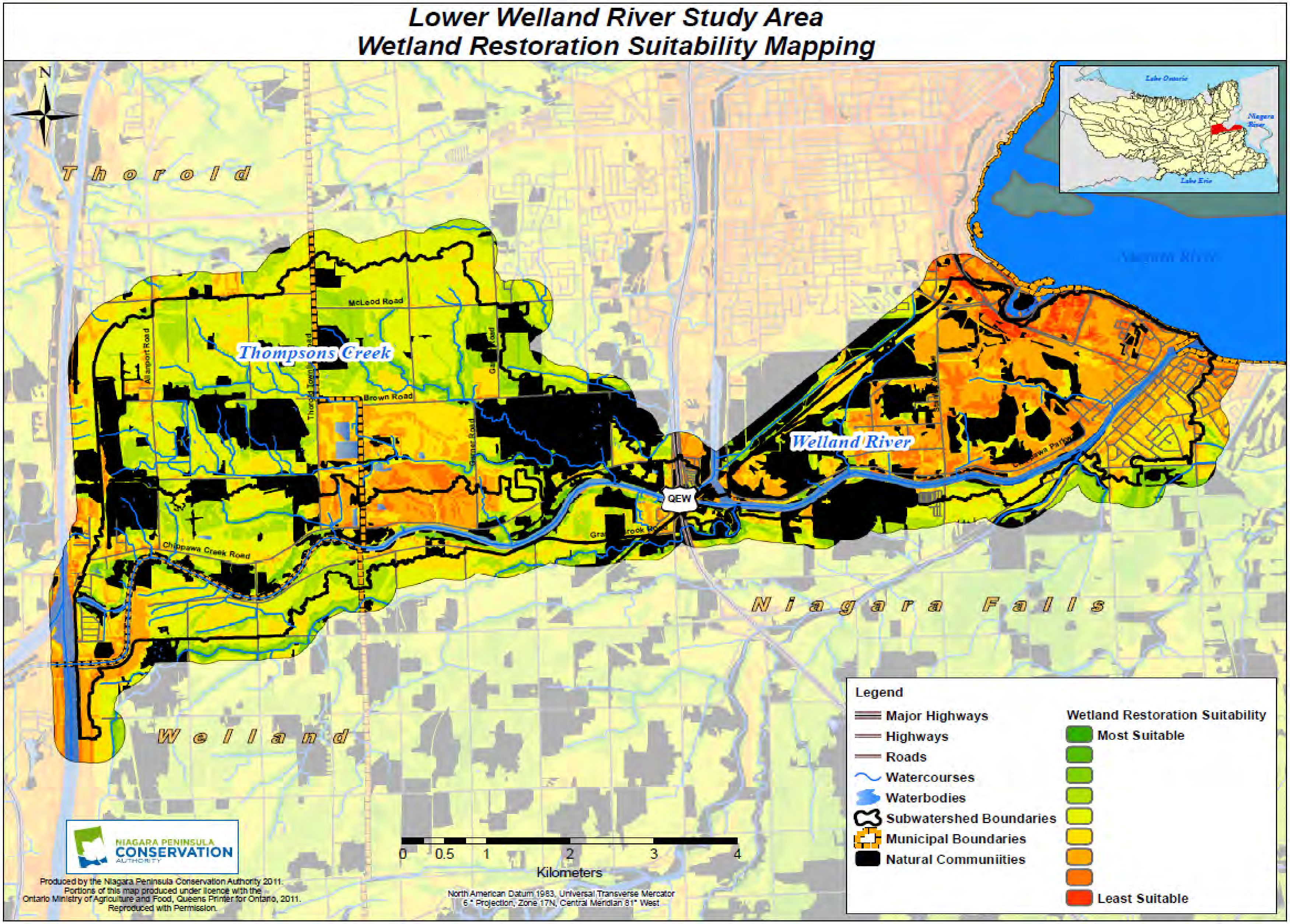

Figure 15: Wetland Restoration Suitability

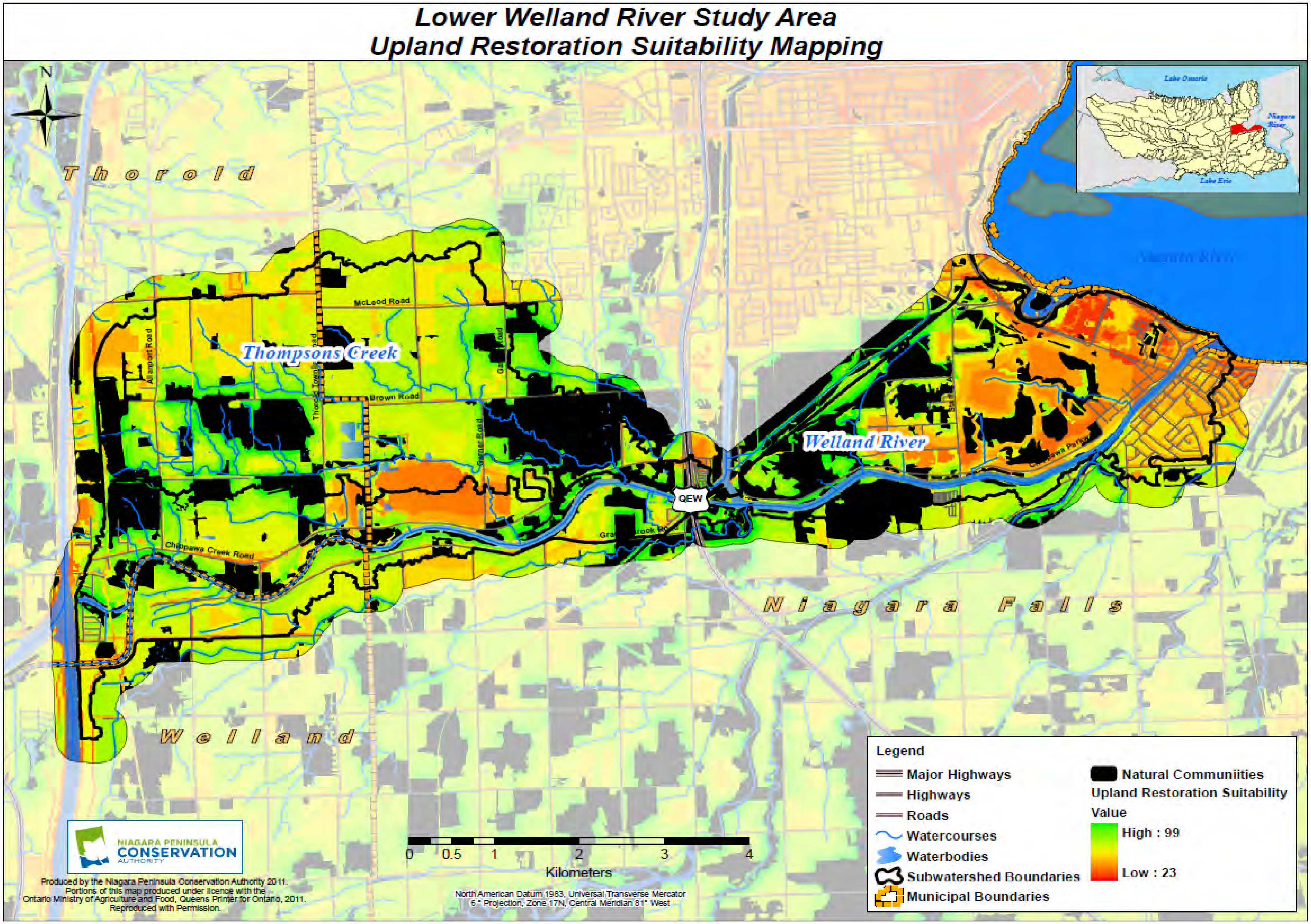

Figure 16: Upland Restoration Suitability

Table 11: Thompsons Creek Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	14.5 km^2	
Land Use	Mix of Residential, Rural Residential, Agriculture, Institutional, Light-medium Industrial, and Vacant lands	
Municipal Water and Sewer Services	Yes	Rural areas in headwaters without municipal servicing
Aquatic Resources		
Length of Watercourse	33.8 km	
Fish Habitat	Important Fish Habitat	Some of the smaller tributaries have not been evaluated in terms of importance for fish habitat.
Municipal Drains	Allanport Drain	Lower portion of drain is Class C and upper portion of drain is Class F.
Water Quality	Station: TC001	This site was added to the monitoring network in April 2010.
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability with areas of medium vulnerability. In addition, pockets of high vulnerability to groundwater contamination are present	The Source Water Protection Program has identified a few areas posing a high vulnerability to groundwater contamination; these areas include transport pathways such as private wells (active and inactive), unknown status oil and gas wells
Natural Heritage Resources		
Riparian Cover	37.8	EC recommends 75% with 30m buffer
Upland Habitat	13.3	EC recommends 30% to support viable wildlife population
Wetland Habitat	18.4	EC recommends 10% *or to historic value*
Restoration Projects Completed to date		
Fish Barrier Removal	3 major barriers removed	Pond embankment was causing a drop at creek input; instream debris was affecting flow; weir
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 (37.8%). •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 fish habitat flow through agricultural lands 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 while facilitating the movement of flora and fauna between natural areas.	
Upland and Ecological Linkages	•currently amount of upland habitat is lower than EC recommendations (13.3%) •suitability mapping indicates very high suitability for upland restoration and enhancement of existing wetland	

	areas creating an upland buffer surrounding the wetland 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). •suitability mapping indicates 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(e.g. north of Turner Road)
Wetland Habitat	•currently level of wetland coverage meets EC minimum recommendations (18.4%) • high suitability for riparian-wetland restoration along watercourses; particularly the headwater streams. Creating buffers along the watercourse would not only provide a function in water quality and fish habitat enhancement but also would provide linkages between fragmented wetlands to facilitate in the movement of flora and fauna between 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.

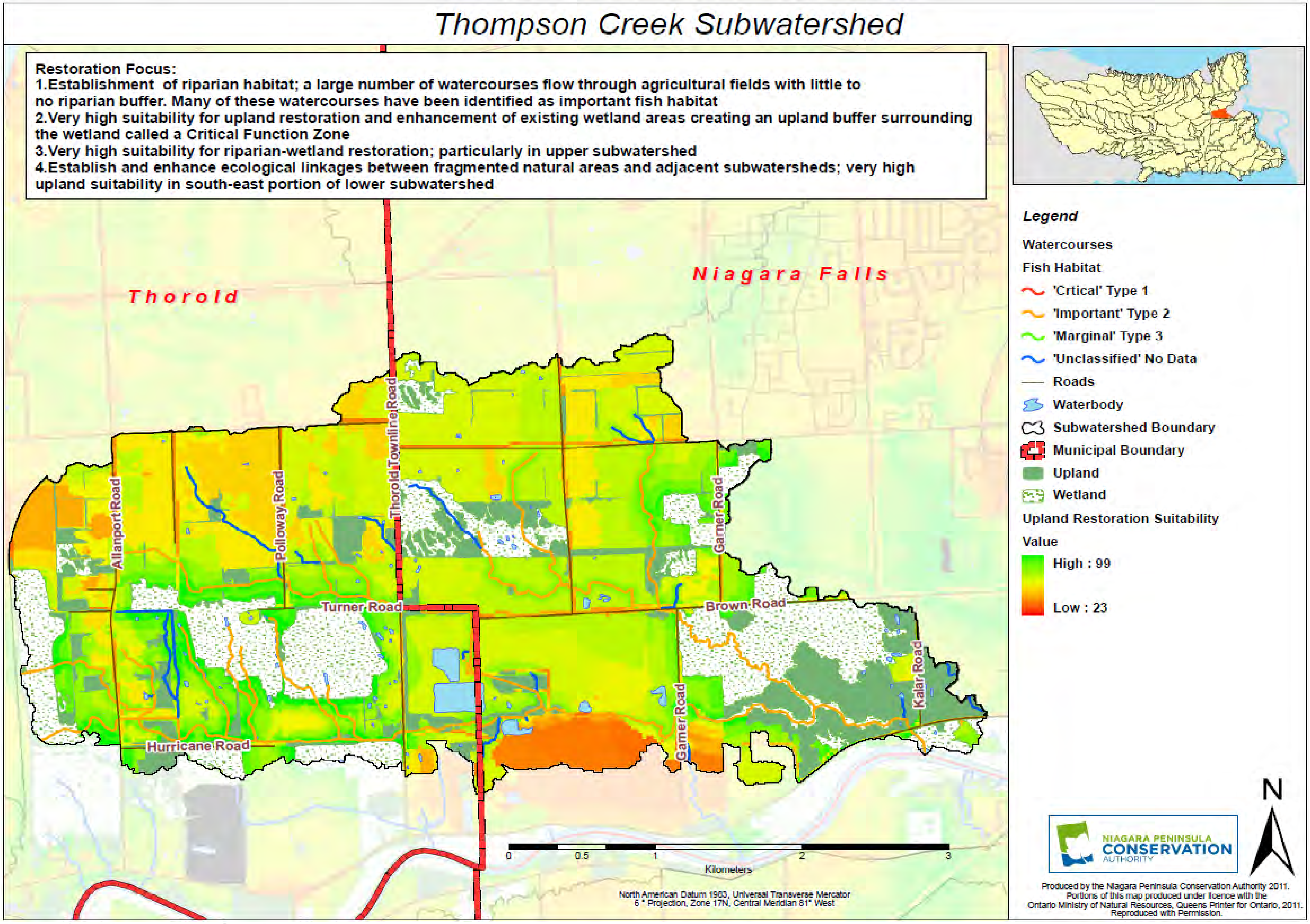

Figure 17: Thompsons Creek

Table 12: Lower Welland River Subwatershed Characteristics		
Attribute	**Description**	**Comments**
Area	20.7 km^2	
Land Use	Mix of Residential, Rural Residential, Agriculture, Institutional, Light-medium Industrial, and Vacant lands	
Municipal Water and Sewer Services	Yes	Some of the rural areas in tributaries without municipal servicing
Aquatic Resources		
Length of Watercourse	38.8 km	
Fish Habitat	Critical: Main Channel between Welland Canal and Power Canal Important: Between Power Canal and Niagara River	Most of the smaller tributaries have not been evaluated in terms of importance for fish habitat.
Municipal Drains	N/A	
Water Quality	Station: WR010 Water Quality Index: Marginal BioMAP Rating: Sampling not conducted due to access restrictions	Water quality is improved at this site by direct mixing with backflow from the Niagara River as it is redirected up the Welland River as part of the hydroelectric operations.
Groundwater Vulnerability	Predominantly Low Groundwater Vulnerability with areas of medium vulnerability. In addition, pockets of high vulnerability to groundwater contamination are present	The Source Water Protection Program has identified a few areas posing a high vulnerability to groundwater contamination; these areas include transport pathways such as private wells (active and inactive), unknown status oil and gas wells
Natural Heritage Resources		
Riparian Cover	19.1	EC recommends 75% with 30m buffer
Upland Habitat	27.6	EC recommends 30% to support viable wildlife population
Wetland Habitat	14.0	EC recommends 10% *or to historic value*
Restoration Projects Completed to date		
Riparian Enhancement	2 projects:2009	1.Bioengineering for bank stabilization/erosion control 2.Demostration Project: Bi-O-Blocks for shoreline protection & buffer plantings
Reforestation	1 project: 2002	In total 21,358 bareroot trees were planted.
Restoration Opportunities: Recommended Actions for Public and Private Lands		
NPCA Water Quality Improvement Program		
Riparian	•riparian habitat is currently significantly lower than EC recommendations (19.1%).	

Establishment/Enhancement	•a large number of watercourses commence in and flow through agricultural fields with little to no riparian buffer; most of the tributaries west of the QEW have little to no buffer strips •investigate possibility of additional bioengineering projects along riparian zone of Welland River to alleviate impacts of water fluctuations on littoral zone •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 while facilitating the movement of flora and fauna between natural areas • 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 (27.6%) •suitability mapping indicates very high suitability for enhancement of uplands and wetlands as well as filling in gaps and corridor creation in western portion of study area along Thompsons Creek and Welland River subwatershed boundaries. •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). •filling in gaps between and within natural areas reduces forest edge –interior ratio creating a larger continuous natural area. 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 the level of wetland coverage meets EC minimum recommendations (14%) •very high suitability for riparian-wetland restoration along Welland River; linking existing fragmented natural areas and creating a continuous buffer along the watercourse • 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.

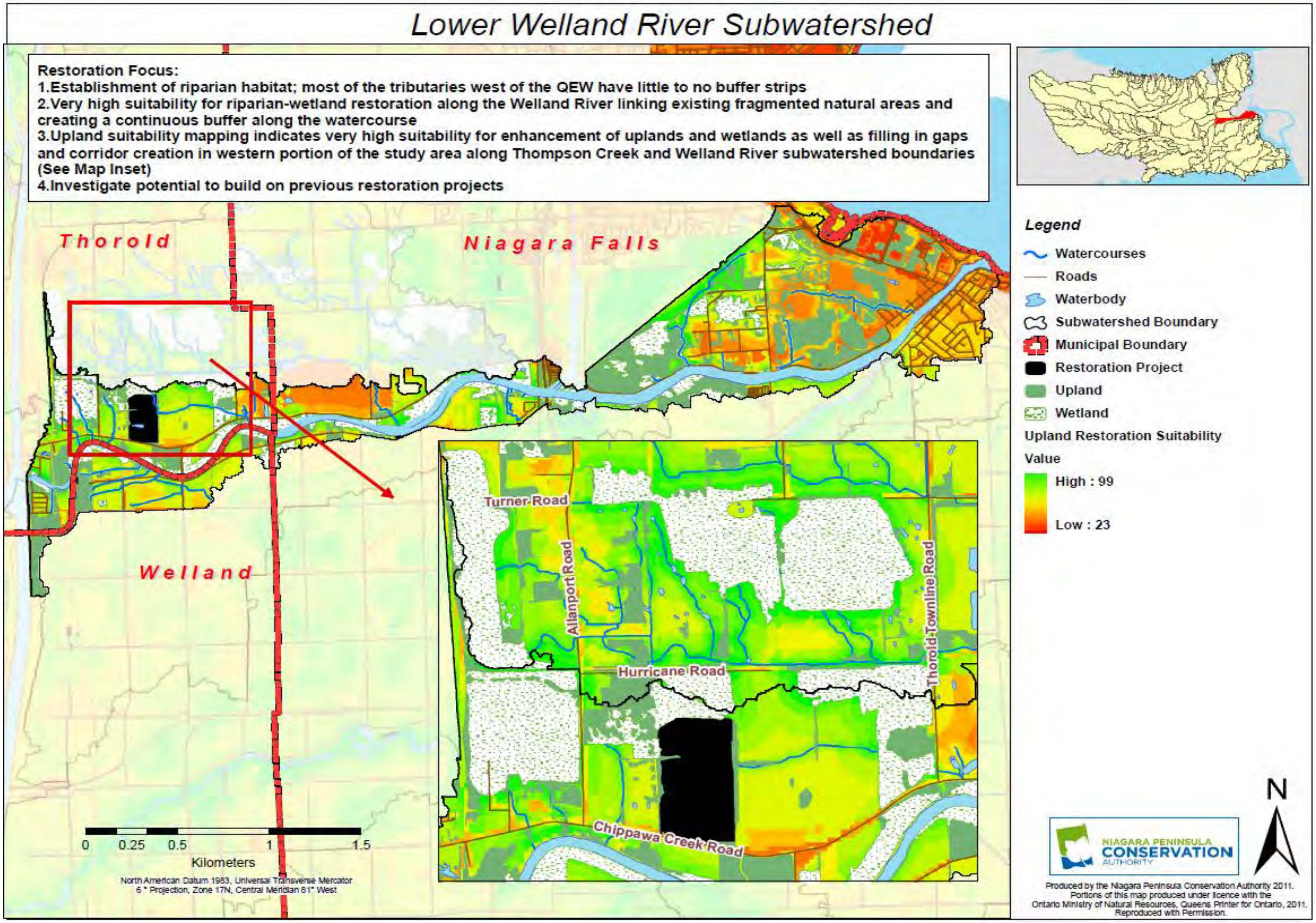

Figure 18: Lower Welland River

Overview of Recommendations

The previous recommendations addressed locations that have been identified as potential areas for riparian, upland, and wetland restoration through the NPCA Water Quality Improvement Program. As indicated earlier, the Lower Welland River currently contains approximately 15 percent wetland cover, 21 percent forest cover, and roughly 27 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 2004).

The recommendations identify numerous areas for potential riparian restoration measures. As outlined, only 27 percent of the watercourses in the study area have riparian habitat (width of this riparian varies throughout the study area), therefore measures should be implemented to increase this an additional 48 percent to meet EC minimum habitat recommendations.

Many of the watercourses in the study area flow through agricultural fields with little to no riparian cover, therefore 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 E. 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.

Additionally, the water reversals and water level fluctuations associated with the hydroelectric operations have been identified as having a negative impact on the littoral zone of the Welland River through studies such as the *Welland River Strategy* (NPCA 1999) and the *Draft Welland River Water Fluctuation Study* (Phillips 2001). The NPCA has implemented bioengineering projects in the zone of fluctuation in an effort to reduce the impacts of the water fluctuations and reversals on the littoral zone; addition projects are planned for 2011.

The Restoration Strategy also identifies numerous potential opportunities for enhancement of existing natural areas; bulking them up to increase the 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 2004). Currently, the percent of wetland cover meets EC minimum recommendations 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 2004). 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.

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.

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.

Conclusion

As indicted earlier, the primary intent of this report is to present a complete watershed characterization of the Lower Welland River that provides a comprehensive description and inventory of the watershed and its resources that can be used by NPCA staff and respective stakeholders to assist in land use management and planning decisions. Like many watersheds in the NPCA's jurisdiction, the Lower Welland River supports a unique environmental character. As the report outlines, the Lower Welland River is home to old growth forest; 13 provincially and nationally listed Species at Risk, 5 of which have been listed as endangered; and the Niagara River is an internationally designated Important Bird Area.

The nearly two centuries of anthropogenic modifications relating to the Welland Canal and hydro operations has resulted in unique environmental challenges with regards to flow reversals and flow modifications and efforts to reduce these impacts is ongoing. Since designation in 1987 as an Area of Concern by the International Joint Commission, a lot of positive work has been completed in the Welland River watershed, and respective partners and stakeholders continue to work towards the goal of delisting the Niagara River from the list of Areas of Concern in the Great Lakes basin. One of the 6 remaining key actions includes "*Restoring and protecting fish and wildlife habitat, including unique habitats rarely found in other parts of the Great Lakes basin, and reducing the impacts of hydroelectric operations at the Sir Adam Beck Generating Station on the river upstream of the Chippawa Power Canal*" (NPCA 2010f). Accordingly, a continued collaboration of all vested stakeholders is required to continue to address the unique challenges in the Lower Welland River watershed and to continue the work towards the preservation, conservation and restoration of the watershed's ecosystem.

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Acronyms

BC MOE: British Columbia Ministry of Environment
BioMAP: Biological Monitoring and Assessment 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
GGH: Growth Plan for the Greater Golden Horseshoe
HADD: Harmful Alteration, Disruption or Destruction
IPZ: Intake Protection Zone
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
NPCA: Niagara Peninsula Conservation Authority
NPSPC: Niagara Peninsula Source Protection Committee
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

Appendix A: 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 (2007)*

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 B:
Natural Heritage Species Reference List
And
Site Descriptions

Species List

Common Name	Scientific Name
American Beech	*Fagus grandifolia*
Arrow-leaved Tearthumb	*Polygonum sagittatum*
Asters	*Aster sp*
Avens	*Geum sp*
Basswood	*Tilia americana*
Black Cherry	*Prunus serotina*
Broad-leaved Cattail	*Typha angustifolia*
Bur-reed	*Sparganium sp*
Bur Oak	*Quercus macrocarpa*
Buttonbush	*Cephaanthus occidentalis*
Canada Blue-joint	*Calamagrostis canadensis*
Canada Enchanter's Nightshade	*Circaea lutetiana ssp. canadensis*
Choke Cherry	*Prunus virginiana ssp. virginiana*
Clearweed	*Pilea sp*
Climbing Poison-ivy	*Rhus radicans ssp. negundo*
Common Cinquefoil	*Potentilla simplex*
Common Buckthorn	*Rhamnus cathartica*
Common Reed	*Phragmites australis*
Common Strawberry	*Fragaria virginiana ssp. virginiana*
Dotted Smartweed	*Polygonum punctatum*
Downy Serviceberry	*Amelanchier arborea*
Duck-weed	*Lemna sp.*
Early Goldenrod	*Solidago juncea*
Eastern Hemlock	*Tsuga canadensis*
False Nettle	*Boehmeria cylindrica*
False Solomon’s Seal	*Maianthemum racemosa ssp. racemosa*
Fringed Loosestrife	*Lysimachia ciliata*
Garlic Mustard	*Allaria petiolata*
Grass-leaved Goldenrod	*Euthamia graminifolia*
Gray Dogwood	*Cornus foemina ssp. racemosa*
Green Ash	*Fraxinus pennsylvanica*
Hawthorn	*Craaugus sp*
Hop Hornbeam	*Ostrya virginiana*
Jack-in-the-pulpit	*Arisaema triphyllum ssp. triphyllum*
Lesser Duckweed	*Lemna minor*
Mayapple	*Podophyllum peltatum*
Moneywort	*Lysmachia nummularia*
Motherwort	*Leonurus cardiaca ssp. cardiaca*
Narrow-leaved Cattail	*Typha latifolia*
Pin Oak	*Quercus palustris*
Red Maple	*Acer rubrum*
Red Oak	*Quercus rubra*
Reed Canary Grass	*Phalaris arundinacea*
Rough Goldenrod	*Solidago rugosa ssp. rugosa*
Sedges	*Carex sp*
Sensitive Fern	*Onoclea sensibilis*
Shagbark Hickory	*Carya ovata*
Silky Dogwood	*Cornus amomum ssp. obliqua*
Silver Maple	*Acer saccharinum*
Skunk Cabbage	*Symplocarpus foetidus*
Spicebush	*Lindera benzoin*

Spotted Crane's-bill	*geranium maculatum*
Spotted Touch-me-not	*Impatiens capensis*
Star Duckweed	*Lemna trisulca*
Sugar Maple	*Acer saccharum ssp. saccharum*
Swamp Maple	*Acer fremanii*
Virginia Creeper	*Parthenocissus quinquefolia*
Western Poison Ivy	*Rhus radicans ssp. rydbergii*
White Ash	*Fraxinus americana*
White Elm	*Ulmus americana*
White Oak	*Quercus alba*
White Swamp Oak	*Quercus bicolor*
Wild Blue Phlox	*Phlox divaricata*
Willow	*Salix sp*

Site Descriptions

Name: Lyons Creek (only a very small portion of this site is within the LWR study area)
Formerly: Waverly Woodlot (Brady, et al., 1980)
Site I.D. : NF-01-00-00-00-00
Municipality: City of Niagara Falls
Approximate Size: 349 Hectares
Subwatershed: This study site drains to the Lyons Creek subwatershed.
General Summary: This study site follows Lyons Creek from the Welland Canal to the Welland River at Chippawa. It consists of the floodplain areas and closely associated woodlands.

This study site is unique in that it is basically limited to the floodplain communities and closely associated woodlands. Therefore, the majority of the communities noted were either, Shallow Marsh, Thicket Swamp, or Deciduous Swamp.

The Shallow Marsh communities were characterized by Narrow-leaved Cattail, Broad-leaved Cattail, Common Reed, and Dotted Smartweed, with floating communities of Lesser Duckweed, and Star Duckweed. The Bur-reed marshes were a frequent component in areas with slightly deeper water, typically just beyond the limits of cattails. Buttonbush and Silky Dogwood were common on the banks. The Thicket Swamp communities noted were dominated by Buttonbush and Dogwood with some Green Ash trees scattered around. The herbaceous layer was mostly Canada Blue-joint, Fringed Loosestrife, Arrow-leaved Tearthumb, and Clearweed.

The Deciduous Swamps were largely Dogwood and Willow with patches of Green Ash, Red Maple, Pin Oak, and White Swamp Oak. The understory was usually a mix of Buttonbush and Dogwood with a herbaceous layer of Sedges, Avens and Moneywort. In the more upland areas of the floodplain, there were Deciduous Forest communities dominated by Red Oak, Sugar Maple, Shagbark Hickory and Hop Hornbeam. There are a total of 418 recorded taxa for this study site.

This site is also in part designated as **Lyon's Creek Provincially Significant Wetland** and **Lyon's Creek Floodplain Wetland ANSI** (both are not in the LWR study area).

Name: Heartland Forest
Formerly Cyanamid Corners (Brady, et al. 1980)
Site I.D.: NF-02-00-00-00-00
Municipality: City of Niagara Falls

Approximate. Size: 490 Hectares
Subwatershed: The north/west section of this study site drains to Thompsons Creek, the north/east section drains to the Chippawa Power Canal, and a small portion in the south drains directly to the Welland River East.
General Summary: This study site is bound by McLeod Road to the north, Chippawa Creek Road/ Welland River to the south, Thorold Townline Road to the west, and Montrose Road/ QEW to the east.

A diversity of Deciduous Forests were recorded for this study site. These were generally associated with upland, or ridge areas within the larger forest patches. Drier sites include associations characterized by American Beech, Red Oak, Sugar Maple, White Ash, Hop Hornbeam, and Black Cherry. Fresh-moist sites include Basswood, Red Maple, Sugar Maple, White Elm, and Bur Oak.

Groundcover in the upland forest communities was varied according to the microtopography. Common species observed included Spotted Crane's-bill, Wild Blue Phlox, Jack-in-the-pulpit, Western Poison Ivy, Mayapple, Canada Enchanter's Nightshade, and Virginia Creeper.

The Deciduous Thicket Communities were dominated by Gray Dogwood in association with various species of Hawthorn. The Deciduous Swamp communities were characterized by mature Red Maple and Silver Maple co-dominates, or Pin Oak. Other canopy species included White Elm and Swamp White Oak. Understory species included Spicebush with Sensitive Fern, Skunk Cabbage, and Spotted Touch-me-not. Some sloughs supported Bur-reed Shallow Marsh communities while others favoured Duck-weed Floating Aquatic communities. One particular slough pond supported an organic Buttonbush Thicket Swamp. There are a total of 406 recorded taxa for this study site.

This site is also in part designated as **Thompsons Creek Wetland PSW and Warren Creek Wetland Complex PSW.**

Name: Dufferin Islands – Queen Victoria Park – Niagara Gorge
Formerly Dufferin Islands-Victoria Park-Niagara Gorge (Brady, et al., 1980)
Site I.D.:NF-03-00-00-00-00
Municipality: City of Niagara Falls
Approximate. Size: 59 Hectares
Subwatershed: This study site drains directly to the Niagara River.
General Summary: This Study Site follows the Niagara River on Niagara Parks Commission property from Upper Rapids Road in the south to the Whirlpool Bridge in the north. It is bound by the Niagara River to the east, Portage Road/Fallsview Boulevard/Victoria Avenue to the west and Niagara River Parkway to the south and north.

The Natural Areas Inventory field crews only visited the forested areas of Dufferin Islands. The Deciduous Forest communities of this study site are characterized by Sugar Maple*,* and Red Oak. Common understory associates are Eastern Hemlock, and Spicebush. There are a total of 137 recorded taxa for this study site.

Site I.D.: NF-20-00-00-00-00
Municipality: City of Niagara Falls
Approximate Size: 196 Hectares

Subwatershed: The majority of this study site drains to Lyons Creek but there is a portion of the site in the west that flows to Grassy Brook, and a small portion in the north that flows directly into the Welland River.
General Summary: This study site is bound by Lyons Creek Road to the south, Welland River to the north, QEW to the west and Stanley Avenue to the east.
Summary: A very small portion of this study site was visited during the Natural Areas Inventory.

The Deciduous Forest community noted was dominated by White Oak and Red Oak with Red Maple, and Swamp White Oak as associates. The understory was characterized by regenerating Red Maple, Hop Hornbeam, Black Cherry and White Elm, with Downy Serviceberry, Green Ash, and Choke Cherry. The herbaceous layer was a mix of Avens, Common Strawberry, Common Cinquefoil, and Asters.

A unique Deciduous Savanna community dominated by Hawthorn was also recorded for this study site. Associated species included Green Ash, White Elm, Gray Dogwood and Common Buckthorn. The understory was a mix of Grasses, and Goldenrods including, Rough Goldenrod, Early Goldenrod, and Grass-leaved Goldenrod. There are a total of 63 recorded taxa (for this study site.

Name: Garner Road Woods
Site I.D. – NF-22-00-00-00-00
Municipality: City of Niagara Falls
Approximate Size: 454 Hectares
Subwatershed: The majority of this study site flows to Beaver Dams Creek, however there is a very small portion in the south west that drains to Thompsons Creek.
General Summary: This study site includes a number of small urban forests fragmented throughout the area between Thorold Townline Road to the west and Dorchester Road, just east of the 420 interchange to the east. It extends from Beaverdams Road in the north to McLeod Road in the south.

A very small percentage of this study site was visited by the NAI teams during the course of this project.

The Deciduous Forests were mostly Red Oak and Red Maple with Green Ash, Sugar Maple, and American Beech. The understory was mostly regenerating canopy species with Spicebush and a ground cover of False Solomon's Seal, Climbing Poison-ivy, Canada Enchanter's Nightshade, and Garlic Mustard. The Deciduous Swamp communities were dominated by Red Maple and Swamp Maple, with associated Green Ash and White Elm. The ground cover in these areas was mostly Sensitive Fern and Canada Enchanter's Nightshade. A Meadow Marsh community was also noted for this site. It was characterized by Reed Canary Grass, False Nettle, and Motherwort. There are a total of 167 recorded taxa for this study site.

This site is also in part designated as **Thompsons Creek Wetland Complex.**

Appendix C: 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 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.	Environment Canada
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
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 D: Riparian, Wetland and Upland Habitat Restoration Guidelines

And

Conservation Buffers; Design Guidelines for Buffers, Corridors, and Greenways

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 Lower 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 E:
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.*		