NIAGARA-ON-THE-LAKE WATERSHED STUDY

Final Report

Report prepared for:

Niagara Peninsula Conservation Authority

Prepared by:

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Aquafor Reference No. 64512

INTRODUCTION

The Niagara-On-The-Lake (NOTL) watersheds study is unique to some degree, compared to studies in other parts of the province for a number of reasons:

- It has a significant rural component, with unique (within Canada) agricultural commodities, including grapes, tender fruits and greenhouse operations, which are the most significant and rapidly growing;
- The management of irrigation systems and municipal drains and the associated conflicts with aquatic habitat objectives is a major issue;
- The Greenbelt Plan and strong legislative protection of farmland has placed significant constraints to urban growth and further emphasized the Ontario government's long term commitment to agriculture, though economic incentives for farmers are still lacking;
- The area is home to an unusually high density of "special status" flora and fauna, because of an abundance of Carolinian plant and animal communities;
- Farmers continue to operate within stringent economic margins, need to be recognized for their past stewardship efforts and encouraged to continue to improve their Environmental Best Management Practices;
- While there are some urbanizing areas that will need guidance in terms of stormwater management, protection of environmental features and protection of groundwater resources, a substantial aspect of the watershed plan and implementation needs to be directed at addressing water quality and quantity issues in existing agricultural and existing urban areas to ensure the long term sustainability of agriculture and natural resources.

The watershed includes all of the lands drained by watercourses and municipal drains discharging into the Welland Canal, Lake Ontario and the Niagara River, draining north of the Niagara Escarpment between the Niagara River and the Welland Canal (see the attached figure "Study Area" and photos). The study area includes the municipalities of Niagara-on-the-Lake, St. Catharines and Niagara Falls, with the majority of the lands falling within Niagara-on-the-Lake.

ORGANIZATION AND STRUCTURE

The watershed plan was coordinated by NPCA and developed in consultation with a steering committee consisting of representatives of the following organizations / departments:

- Niagara-on-the-Lake Council
- Niagara Peninsula Conservation Authority (NPCA)
- Niagara-on-the-Lake Staff
- Region of Niagara
- Niagara-on-the-Lake Irrigation / Drainage Committee

Three public meetings were held to solicit public input on the watershed issues, watershed goals and objectives, the long list of management actions and evaluation criteria for prioritizing the long list of actions to develop a recommended watershed plan.

It is important to recognize that the successful implementation of the watershed plan depends upon the willingness of landowners to implement a variety of environmental stewardship measures on their properties, rather than implementing measures using regulatory or policy measures.

While NPCA has a mandate to foster the enhancement and sustainability of the watershed's natural resources, it is also recognize that the remedial projects and programs must take into account the importance of the Town and its residents and the economic viability of farming operations. The watershed goal is to develop a plan that balances the needs of the agricultural community with those of the watershed's natural resources and sets out a multi-year plan that respects and achieves this balance by working with the agricultural community to establish programs that both meet the needs of the agricultural industry and support a healthy and sustainable environment for the benefit of all.

EXISTING CONDITIONS

The major landform in the Niagara-on-the-Lake watershed is the Iroquois Plain, extending north of the Niagara Escarpment to Lake Ontario. The topography is very flat. The overburden materials are sandy in the northern and eastern portions of the study area, with the middle part of the study area comprised of silty and clayey till materials. This distribution of materials is also reflected in soils which tend to be sandy loams in the north and silty to clayey loams in the central part of the watershed. The soils tend to be easily eroded by stream channels, while the middle of the watershed is generally poorly drained.

In order to farm these lands, an extensive network of field tile drains, municipal drains and irrigation canals has been constructed. This network of drainage features connects the headwater areas on the Escarpment with the watercourses in the northern part of the watersheds. The extensive network of municipal drains and field tile drains provides two important functions:

- the efficient conveyance of runoff from the flat topography of the middle portions of these watersheds, downstream of the Escarpment,
- the conveyance of irrigation water to the agricultural operations located throughout the watershed

As a result of this efficient drainage network, the hydrology of the watershed is flashy (i.e. storm runoff is delivered rapidly to drainage features), in some respects more typical of an urban than a rural watershed, and the stream channels (shown in red in Figure 7.1) are enlarging in response to this change. Urban development also contributes to this effect but to a relatively small extent, proportional to the urbanized portion of the watershed (see Urban Areas in Figure 7.1). Erosion and sedimentation of municipal drains and watercourses is also extensive, requiring regular drain maintenance and leading to significant gullying in the watercourses, as they have widened and deepened to

accommodate flows. Examples of gullying can be found in the lower portions of Two, Four and Six Mile Creeks (shown in red in Figure 7.1).

The irrigation system, with proposed expansion, is capable of providing about 17,850 US gal./min of irrigation water that is pumped from the Welland Canal, the Niagara River and Ontario Power Generation (OPG) facilities (the Reservoir and Tunnel), into the main system of municipal drains and watercourses. Landowners pay for the right to access this water and for the upkeep of the irrigation and drainage system. Irrigation water has also enhanced base flows in many streams and municipal drains providing habitat for warmwater fish and even some coldwater migratory species.

Water quality conditions in the municipal drains and watercourses are impaired as a result of nutrient enrichment, bacterial contamination, high suspended sediments levels and high chloride levels. In particular, concentrations of Total Phosphorus and ***E.coli*** bacteria were orders of magnitude above the Provincial Water Quality Guidelines throughout the watershed. While levels of these contaminants are within federal irrigation water guidelines, they occur at levels that are stressful to aquatic life and degrade the quality of irrigation water. Sources of these contaminants include agricultural fertilizers, faulty septic systems, road runoff, point discharges such as field tile drains, storm sewers, and urban land uses. These pollutants enter surface drainage features primarily through runoff, groundwater discharge and tile drainage systems. While irrigation water entering the drains is relatively clean, it rapidly becomes contaminated with these pollutants.

Regular municipal drain maintenance, including brushing, debris removal, dredging and erosion controls are necessary to facilitate water conveyance and land drainage, however these activities impair fish habitat and cause erosion and sedimentation in watercourses downstream. The lack of streamside vegetation along many watercourses and drains allows runoff carrying the above noted contaminants to enter these features unimpeded causing further water quality degradation. While revegetating these areas would help reduce erosion, sedimentation and water quality degradation effects, vegetated riparian areas may harbour pests that affect crop productivity and may take productive lands out of agricultural uses.

The remaining natural features within the study area are primarily limited to areas along the Escarpment and some woodlots and riparian lands. Though small and few in numbers, these areas sustain a high diversity of flora and fauna and provide habitat for many Carolinian species that are rare in Ontario. While these areas persist as a result of the good stewardship efforts of landowners, they continue to be under threat as urban and rural land use activities intensify. As areas urbanize, it is difficult to protect the form and function of existing natural areas such as woodlots and wetlands. Many agricultural landowners also noted that these features are sometimes considered a threat to agriculture because they harbour wildlife and pests, and also could be developed for agriculture. In the public meetings, it was identified that incentives are needed to encourage landowners to protect these features. Although there are few opportunities to develop quality

naturally vegetated wildlife corridors along the watercourses and drainage features, there exist a number of large natural areas distributed in an east-west direction along the Escarpment that offer potential as a corridor and core natural habitat for the region's flora and fauna.

PUBLIC CONSULTATION

In the words of one landowner: "Sustainable agriculture should be a primary driver in any plan. Balancing sustainable agriculture with the natural environment is a doable long-term goal that is and must be a priority of any NPCA study." Landowners dominated the public meetings and provided the following input into the development of the recommended plan:

- Issues, Opportunities and Constraints: the top concerns of landowners are:
  - The maintenance of landowner/property rights
  - A growing body of legislative controls that limit landowners' rights (Green Belt Plan, Nutrient Management Act),
  - An adequate supply of water for irrigation
  - Use and maintenance of municipal drains for land drainage and water conveyance to support agriculture
- Response to the List of Management Recommendations:
  - Landowners were not in favour of any recommendations without clear benefits for agriculture, in particular, any that had potential to remove any land from productive use
  - Landowners identified a number of management actions that were currently practiced that they felt demonstrated environmental stewardship
  - Landowners supported a number of measures, but felt that their implementation should be left to the responsible agency, rather than potentially duplicating effort

- Evaluation Criteria:
  - Landowners ranked the importance of evaluation criteria as follows:

High Importance	Medium Importance	Low Importance
• Land requirements • Cost • Stakeholder/landowner acceptance	• Environmental benefits and impacts • Implementation considerations, including phasing • Recreational and cultural impact	• Ability to meet study objectives and targets • Agency Acceptance

- Implementation Considerations:
    - Before new approaches to managing drains and the lands adjacent to them can be implemented, demonstration or pilot projects are needed to show that the new approaches will benefit agriculture
    - Implementation should build upon, not duplicate existing programs and projects. Where possible agencies need to coordinate their efforts.
    - Incentives programs need to be more responsive to the specialized needs of farmers in the NIAGARA-ON-THE-LAKE watersheds
    - Surface runoff from storm and spring melt events, not irrigation water, is the primary cause of erosion and sedimentation effects in drains and watercourses, water pollution, and nuisance flooding. Implementation efforts need to address solutions to manage the effects of surface runoff on drains and watercourses.

WATERSHED GOALS AND OBJECTIVES

The importance of agriculture to the economic viability of the Niagara-On-The-Lake and the role that landowners play in protecting and maintaining the natural resources of the NOTL watersheds was an underlying theme in the development of the Watershed Goals and Objectives. **It was recognized that the goals and objectives for a healthy natural environment must be consistent with those of achieving long term agricultural sustainability.** It is important to recognize that the strategy is striving to achieve a healthy natural environment within the limits of a sustainable agricultural landscape and that the implementation of measures to protect and enhance the natural environment will proceed based on those measures that are economically feasible.

The following Goals and Objectives were developed for the Watershed Plan, based on the technical studies, Steering Committee input and public input.

Goals

- To protect the natural environments of the NIAGARA-ON-THE-LAKE watershed ecosystem, within the context of a unique, fragile agricultural resource, for the benefit of humans and other terrestrial and aquatic life.
- To promote environmentally sound water management practices that recognizes the interdependencies between the watercourses and the irrigation/drainage system.

Communication & Education

- Demonstrate and promote awareness of the linkages between clean water, healthy lifestyles, and the economic viability of rural and urban land use
- Promote the use of surface and ground water having regard to human, agricultural, and ecological needs
- Promote environmental stewardship of aquatic and terrestrial habitats
- Streamline the regulatory and jurisdictional conflicts affecting rural and urban landowners

Water Quantity

- Manage flooding and erosion risks to human life and property to within acceptable limits
- Maintain, enhance or restore stream processes to support human uses, agricultural needs and natural habitats
- Manage flows to reduce erosion impacts on habitats and property
- Protect groundwater water resources in order to support ecological and human use functions

Water Quality

- Maintain or improve surface/groundwater water quality in order to support ecological, agricultural and other human use functions

- Reduce or eliminate surface films and deposits of non-native materials , nuisance algae growth, turbidity and odour to improve aesthetics of the area's surface waters

Aquatic Communities and Habitats

- Protect, enhance or restore populations of native aquatic species and their habitats

Terrestrial Communities

- Protect, enhance or restore the habitats that support terrestrial species and communities

RECOMMENDED PLAN

Table 7.1 summarizes the recommended management actions and outlines implementation considerations. Some management actions are specifically directed at improving management of instream conditions and streamside conditions of watercourses and selected municipal drains. These management actions (highlighted in purple on Table 7.1) are intended to be applied to the watercourses and drains identified as High and Medium Priority for Implementation on Figure 7.1. Other management actions are intended to change or modify land use practices and may be applied throughout the watershed, as appropriate. These actions were selected based on the evaluation criteria developed in consultation with the Steering Committee and the Public.

During the course of the study, it became apparent that the agricultural community has become disillusioned with government agencies at all levels as a result of a number of recent legislative changes that have impacted on landowner rights. Primary among these are:

- The Greenbelt Plan/Act
- The Fisheries Act
- The Nutrient Management Act

- The Ontario Water Resources Act, in particular Permits To Take Water (PTTW)
- The Region of Niagara's Environmental Policy

The focus of the recommended actions in the watershed plan is to improve environmental conditions for the benefit of agriculture and the environment. In addition the actions address the environmental requirements of the Nutrient Management Act and the Niagara-on-the-Lake Permits To Take Water.

The watersheds of the Niagara on the Lake study area are made up of a network of streams and municipal drains that are supplied with irrigation water from the Welland Canal, the Niagara River and the OPG Reservoir and Tunnel. Some municipal drains simply provide an outlet for field tile drains, while others provide both tile drain outlets and a conduit for irrigation water. The demand for irrigation water within the agricultural community is growing and Niagara-on-the-Lake has already identified the need to expand its PTTW program. The majority of the streams are located downstream of the municipal drain/irrigation system and as such are the principal receiving waters. While many landowners who finance the maintenance of municipal drains and provision of water for irrigation, tend to view municipal drains differently than streams, in reality they are both part of the aquatic environment of the Niagara-on-the-Lake watersheds. The management of the drains is equally important to the maintenance of a healthy aquatic environment and to the sustainability of agriculture as is the management of the streams. While the two features may be treated differently by legislation, they are intrinsically linked in terms of restoring the environmental health of the watersheds to achieve both agricultural and environmental benefits.

Together the recommended actions provide a number of key environmental benefits:

- Water Management: the management actions address flooding of agricultural lands, the effects of surface runoff on drainage features, the need for efficient use of irrigation water and the protection of minimum flows in streams
- Water Quality: the management actions focus on the reduction of nutrient, suspended sediment, bacteria and chloride loadings to drains and streams from urban and rural sources. These measures will ensure a continued, safe supply of clean water for irrigation purposes and to support aquatic life
- Drain Maintenance: measures are recommended to reduce drain maintenance that is costly and has negative impacts on stream habitats; measures focus on reducing erosion and sedimentation of drains
- Stream Erosion Control: an erosion remediation plan and a riparian zone management program are identified to address stream erosion downstream of municipal drains; these measures will further eliminate sources of sediment to streams providing cleaner water for irrigation and reduced impacts on aquatic life
- Terrestrial and Aquatic Resources: Improvements and aquatic habitat enhancements are proposed for lower 4 Mile Creek and the Virgil Reservoirs to promote recreational angling opportunities; measures are proposed to encourage landowners

to continue their good stewardship practice of protecting existing natural features; a program to improve terrestrial habitat linkages along the escarpment is proposed and agencies are encouraged to continue to work with landowners to address conflicts with wildlife

The recommended measures represent the management priorities for maintaining and rehabilitating the watershed to a healthy state, consistent with the need for a long term plan for sustainable agriculture in the study area. The costs of undertaking these recommended measures are significant, but they need to be implemented over the long term to be successful. The costs of undertaking these recommended measures are high, but are expected to be implemented over a multi-year timeframe (10-20 years) largely on a voluntary basis. The recommended measures also encourage continued improvements in land use practices on agricultural, urban and urbanizing lands, to place greater emphasis on reducing contamination of surface waters, and on protecting /enhancing the health of aquatic communities (including fish) in drains and watercourses as a barometer of adequate, high quality water supplies for irrigation and environmental uses. Many of the recommended measures are similar with ones that are being implemented in support of sustainable agriculture in the wine growing areas of California, where similar issues and environmental conflicts occurred in the past.

Achieving this strategic shift to more sustainable use of land and water clearly cannot be achieved without landowner participation; and the economics of agriculture are such that changes will need to occur gradually over time. Several principles of implementation are suggested to guide the implementation of each recommended management action:

- Build confidence between landowners and agencies through regular consultation, brochures and other forms of information exchange
- Provide incentives in the form of financial support for the implementation of recommended measures
- Reward examples of good stewardship through a variety of recognition programs including providing some monetary support through mechanisms such as tax rebates/reductions
- Provide technical support and other in-kind support by building partnerships between landowners, agencies, interest groups
- Illustrate the benefits of good stewardship practices by undertaking demonstration projects, facilitating tours and encouraging community leaders to become “champions” of more sustainable practices

IMPLEMENTATION FRAMEWORK

The completion of the subwatershed study was a cooperative effort involving the NPCA, the Region of Niagara, the Town of Niagara-on-the-Lake and, through consultation, representatives from the public. The recommendations as described in the previous section were discussed with the above noted groups and, as such; do provide a framework for implementing the plan. An Implementation Committee will, however, be required to further

define implementation mechanisms, ensure conformance with component strategies, and assess the effectiveness of the plan and, in general, update and monitor plan implementation.

In terms of administration, it is recommended that an Implementation Committee be formed for the overall subwatershed to oversee plan implementation. The composition of the Implementation Committee should include representation from the Town, the Region, NPCA, the agricultural community and special interest groups.

It is expected that meetings of the Committee would occur on an annual basis. However, several meetings may be required early in the process to fully establish the proposed education/stewardship program. One of the tasks of the Implementation Committee should be to pursue alternative sources of funding (e.g., special interest groups, environmental foundations, corporations) to reduce municipal/provincial/landowner funding requirements.

Table 7.1 Watershed Plan Recommended Actions (see Figure 7.1)

Item	Action	Type of Action			Implementing Agencies									Unit/Initial Costs
		Instream Measure	Streamside Measure	Modification of Land Use Practices	NPCA	NOTL	Irrig./Agr. Committee	Region	OMAFRA	Niagara Parks Com. / NEC	Siol & Crop Assoc.	Landowners	Timeframe	Timeframe: S - within 5 years; M - 5 - 25 years; L - over 25 years
COMMUNICATION AND EDUCATION														
8	develop brochure/educational materials on shoreline erosion, streamlining approvals for land use activities, preferred stabilization techniques, protection of fish and aquatic habitats	X	X	X	L	P	P				P	P	S	existing programs - NPCA
1	Review current incentive programs that target farmers and update to address current issues and problems; provide technical advice and support	X	X	X	L	P			P		P	P	S	existing programs - NPCA
WATER QUANTITY														
10	Minimize flooding of agricultural lands by:				L	P		P				P	S-M	existing programs
10a	upgrading culverts, removing unnecessary weirs	X				L		P				P	M-L	$25,000 - $150,000 per structure
10b	remove excess fill adjacent to drains/watercourses		X			L						P	M	$1,000 - $5,000 per landowner
11	implement state of the art stormwater management facilities – source, conveyance, end of pipe for new/existing developments in urban areas	X	X	X	P	L							S-M	Landowner funded; $500/household for rain barrels; $20,000/impervious ha for SWM ponds; $110,000/impervious ha
13	implement a strategic drain maintenance and management program to reduce costs and improve stability (erosion and sedimentation of drains):				P	L							S-M	$20,000 study; Drain Modification - $500/m drain
13a	design drain morphology to be more self sustaining	X	X		P	L						P	M - L	existing program
13b	introduce grade controls (eg 6 Mile Creek) to reduce erosion risk	X			P	L						P	S - M	$30,000 study; reconstruction costs - $800/m drain
13c	replace rip rapped side slopes with vegetated terraces (low growing vegetation)		X		P	L						P	M - L	$50,000 for demonstration study. Revegetating costs: $10,000/ha
13e	continue to remove any instream structures outside of the irrigation season - consider water conservation measures to manage water use and instream storage requirements	X			P		L					P	M - L	Landowner funded
13f	in areas where fish have access to drains, minimize drain maintenance activities during spring: April 1 – June 30	X	X		P	L						P	S	Landowner funded
14	Review the irrigation management system to identify any existing conflicts in water use among landowners – encourage off-line storage and other water conservation strategies; identify opportunities to maintain baseflow; identify potential downstream impacts on watercourses	X	X	X	P	L						P	S-M	$50,000 study

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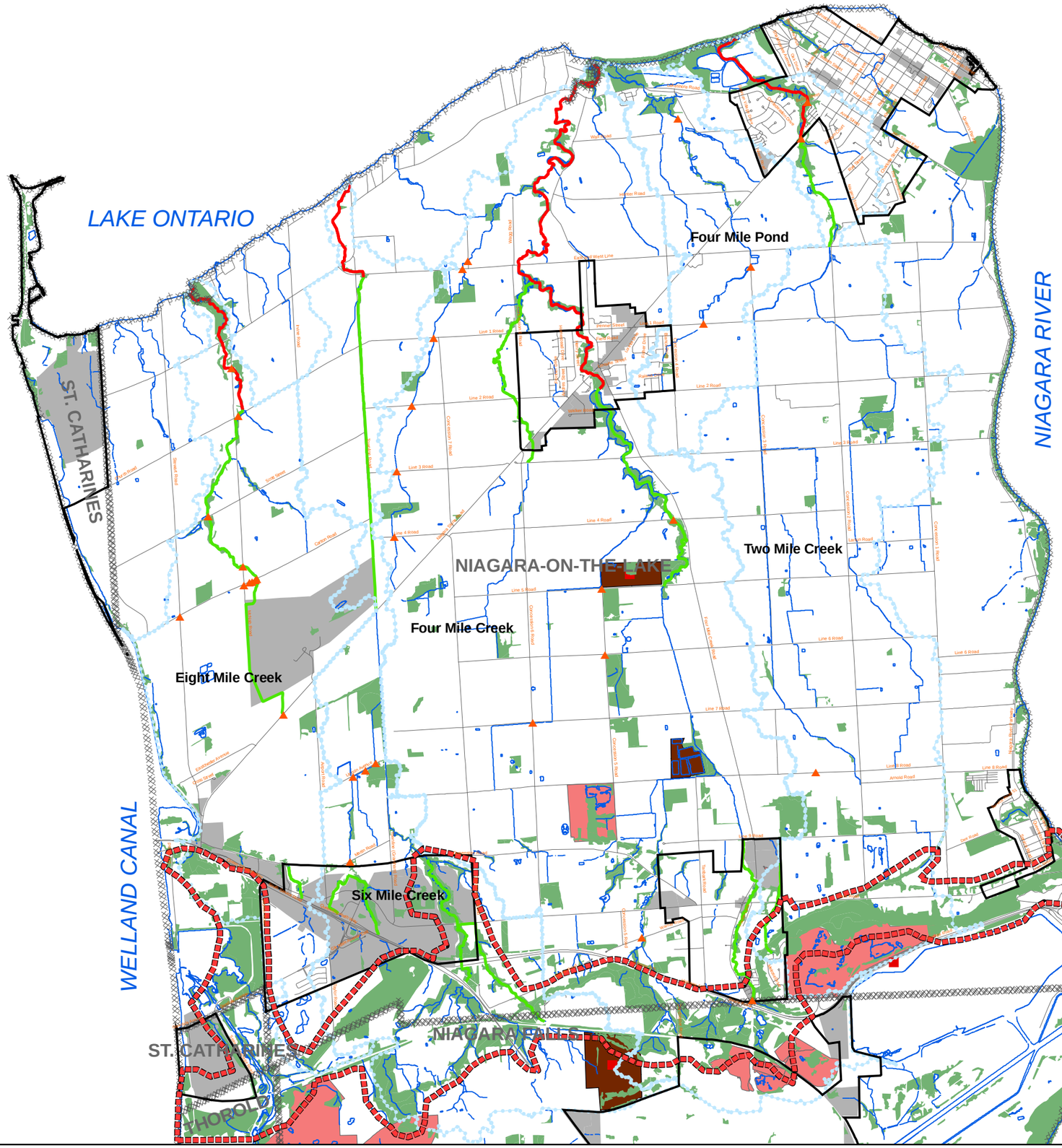
		Instream Measure	Streamside Measure	Modification of Land Use Practices	NPCA	NOTL	Irrig./Agr. Committee	Region	OMAFRA	Niagara Parks Com. / NEC	Siol & Crop Assoc.	Landowners	Timeframe	Timeframe: S - within 5 years; M - 5 - 25 years; L - over 25 years
WATER QUANTITY (Continued)														
15	develop an erosion remediation plan using natural channel design principles for lower watercourses to address erosion and aquatic habitat impacts	X	X		L	P							M	$50,000 study; Remedial costs - $800/m of channel
	WATER QUALITY													
21	implement water quality monitoring program to assess instream water quality for irrigation and aquatic life	X			L		P						S-M-L	$20,000 annually
22	work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff (nutrients, suspended sediments, bacteria, chloride) and contaminated groundwater			X	L				P		P	P	S-M	existing programs
23	work with landowners to manage land use activities adjacent to drains within a buffer zone (targetting a minimum of 3 m on either side); implement a demonstration project		X	X	L	P						P	M	existing programs; 50% cost sharing with landowners
24	implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads.			X		L							S	existing program
AQUATIC RESOURCES														
26	work with landowners to manage land use activities adjacent to watercourses within a buffer zone (targetting a minimum of 5 m on either side); implement a demonstration project		X	X	L	P						P	M	existing programs; 50% cost sharing with landowners; Riparian Planting costs: $10,000/ha
30	implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower 4 Mile Creek, in cooperation with the Irrigation Committee:	X	X		L	P							S - M	$20,000 study; construction costs: $800/m of channel
TERRESTRIAL RESOURCES														
31	work with landowners to protect remaining forest and wetland habitats.			X	L	P				P		P	S-M	existing programs; 50% cost sharing with landowners
32	identify opportunities to create habitat linkages along the Escarpment			X	L	P				P		P	M	existing programs; identify other incentives to take lands out of productive uses
33	work with landowners to develop strategies to manage conflicts between wildlife and crops			X	L				P			P	S	existing programs

HIGHLIGHTED ACTIONS TO FOCUS ON HIGH (S) AND MEDIUM (M) PRIORITY FEATURES AS SHOWN ON FIGURE 7.1.

OTHER ACTIONS TO BE APPLIED WATERSHED-WIDE AS APPROPRIATE

NOTE: L - LEAD STAKEHOLDER; P - PARTICIPATING STAKEHOLDER



LEGEND:

- Urban Areas
- Municipal Boundary
- Watershed
- High Priority for Implementation
- Medium Priority for Implementation

Natural Feature Linkage Opportunities*

- Limit

Natural Feature Protection Opportunity

- Industrial / Commercial Land Use
- Recommended Bridge/Culvert to be Replaced

Landfill / Extraction Uses

- Landfill Site location
- Landfill Sites
- Sand Pits/Quarries

* approximate limit of features to be considered to establish an east - west terrestrial linkage

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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NIAGARA-ON-THE-LAKE WATERSHED STUDY

Framework for Implementation

FIGURE No.

DATE: February 2008

1.0 INTRODUCTION

1.1 General

The Niagara-on-the-Lake (NOTL) watershed study is unique to some degree, compared to studies in other parts of the province for a number of reasons:

- It has a significant rural component, with unique (within Canada) agricultural commodities, including grapes, tender fruits, greenhouse operations, which are the most significant and rapidly growing;
- The management of irrigation systems and municipal drains and the associated conflicts with aquatic habitat objectives is a major issue;
- The Greenbelt Plan and strong legislative protection of farmland has placed significant constraints to urban growth and further emphasized the long term commitment to agriculture;
- The area is home to an unusually high density of "special status" flora and fauna, because of an abundance of Carolinian plant and animal communities;
- Farmers need to be recognized for their past stewardship efforts while being encouraged to continue to improve their environmental Best Management Practices;
- While there are some urbanizing areas that will need guidance in terms of stormwater management, protection of environmental features and protection of groundwater resources, a substantial aspect of the watershed plan and implementation needs to be directed at addressing water quality and quantity issues in existing agricultural and existing urban areas to ensure the long term sustainability of agriculture and natural resources.

The report is assembled with figures and tables following the page that they are first referenced on, except for oversize colour figures, which are placed together at the end of the report. Appendices are submitted in electronic format (and under separate cover).

1.2 Study Area

The study area is shown in Figure 1.1 (Figure 1.2 shows representative photographs, taken in spring 2006). It includes all of the drainage features discharging into the Welland Canal, Lake Ontario and the Niagara River, draining north of the Niagara Escarpment between the Niagara River and the Welland Canal. The following is a key to photos:

Photo	Description	Photo	Description
1	Shoreline east of Welland Canal	14	Greenhouse operation and low bluff shoreline
2	Typical low bluff shoreline erosion	15	Coastal wetlands – Four Mile Creek and Four Mile Pond Creek
3	Typical agricultural land use in western part of watershed	16	Four Mile Creek in Virgil
4	Regional airport	17	Upper and Lower Virgil Reservoirs
	Mouth of Eight Mile Cr	18	Greenhouse operation with off-line irrigation pond
6	Eight Mile Creek at Lakeshore Road	19	Waste lagoons – Four Mile Creek
7	Regional Airport	20	Cannery operation near St. David's

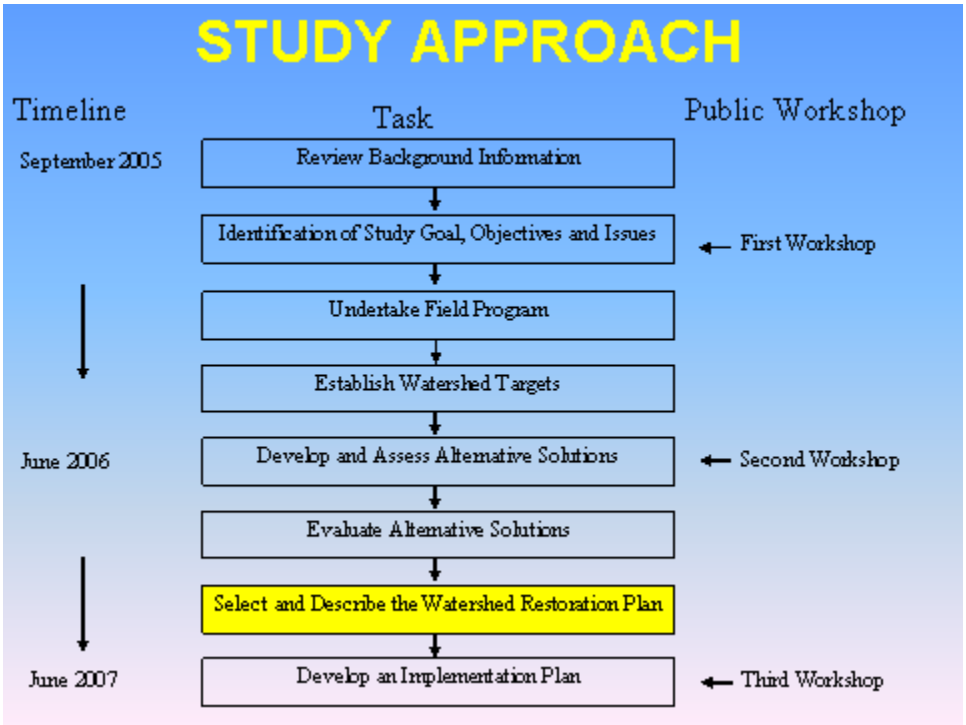
8	Lower Six Mile Creek near Lakeshore Road	21	Upper Four Mile Creek in St. David's
9	Lower Six Mile Creek showing floodplain terrace	22	Moderate bluff shoreline
10	Erosion control work on Airport Drain just upstream of Six Mile watercourse	23	Regional Sewage Treatment Plant and lagoons
11	Mid-reaches of Six Mile Creek	24	Forested valley in lower Two Mile Creek
12	Example of deciduous woodlot	25	Two Mile Creek upstream of East West line
13	Example of deciduous swamp – upper Six Mile Creek	26	Representative land uses: Greenhouses, tender fruits, nursery operations, grapes
		27	Nursery operation

1.3 Study Purpose and Organization

As identified in the Terms of Reference (Appendix A) for the Niagara-on-the-Lake Watershed Study, the intent of the study is to produce a Watershed Management Plan, in consultation with appropriate government agencies, landowners and interest groups that assists with the management of the water, land/water interactions, aquatic life and aquatic resources to protect and improve the health of the ecosystem. It will recommend direction and strategies that will allow the community to care for the watercourses and drains with the objectives of preserving and restoring the drainage features and natural heritage resources to a state which balances both the needs of the landowners and the watershed ecosystem.

By far, the most important component of the study is consultation with landowners, interest groups and others prior to and during all phases leading to the final plan. Most of the study area is privately owned and accordingly, the input from landowners is vital to producing an acceptable and workable plan. Three public meetings were held in order to solicit broad public input at various stages in the development of the Watershed Plan (Appendix B).

The Watershed Study Planning process is shown in the following figure:



The Watershed Plan focuses specifically on maintaining and rehabilitating watershed resources with consideration of input and issues brought forward through public consultation and technical studies. The Plan and Implementation Strategy consider the following:

- Recommendations on stream rehabilitation and restoration measures, both structural and non-structural, municipal and regional policies, educational and outreach programs, and long and short term objectives;
- Projects/programs currently underway;
- Where applicable, all recommendations shall be separated as to ownership, whether publicly owned (Municipality or Region) or private;
- A priority list including estimated costs for projects, activities, policies or other recommendations that are developed by the Plan;
- Recommendations regarding a monitoring program and performance indicators to assist in determining the effectiveness of Watershed Plan implementation;
- Recommendations for financial and information assistance programs that could be considered to assist in implementation of the Watershed Plan.

The watershed plan was coordinated by NPCA and developed in consultation with a steering committee consisting of representatives of the following organizations / departments:

- Niagara-on-the-Lake Council and Staff
- NPCA
- Region of Niagara
- Niagara-on-the-Lake Irrigation / Drainage Committee

2.0 EXISTING CONDITIONS

2.1 Surficial Geology

Surficial geology within the study is illustrated in Figures 2.1 to 2.5. The major landform in the Niagara-on-the-Lake watershed is the Iroquois Plain, extending north of the Niagara Escarpment to Lake Ontario. The Iroquois Plain represents land that was flooded by Lake Iroquois until approximately 10,000 years ago.

The Iroquois deposits include (from north to south) sand, silt and clay that overlie the Halton Till. The Halton Till is a silty-clay, stony till deposited during the last ice advance. The average depth to bedrock is approximately 20 - 25 metres and may comprise significant thickness (several metres) of sand and gravel lenses, particularly at the bedrock interface. This contact zone and the upper part of the bedrock represent a significant regional aquifer. Another local aquifer exists in the St. David's Buried Gorge, and there are reports of artesian conditions here.

Sand and gravel deposits at surface near Lake Ontario represent beaches, shoals, bars and shallow water features deposited by glacial Lake Iroquois before water levels fell to the present-day Lake Ontario. The bedrock over the area north of the Niagara Escarpment is the Queenston Formation, consisting of red shale. In the St. David's area, there exists a buried bedrock valley, the St. David's Buried Gorge, which cuts approximately 60 to 130 m into the bedrock formations and is believed to be a previous alignment of the Niagara River. It is infilled with glacial and interglacial sediments, consisting of fine grained sands with thinly interbedded clay and silt.

Soils generally reflect the surficial geology and are generally sandier in the north and east portions of the study area, with richer, silty loam to clayey loam soils in the central portion of the study area. Natural drainage is generally poor, and as a result, the majority of the land has been extensively tile drained for agricultural purposes. The sandy soils and wet subsoils, combined with the temperate climate make this area ideal for fruit growing.

2.2 Stream Morphology and Erosion

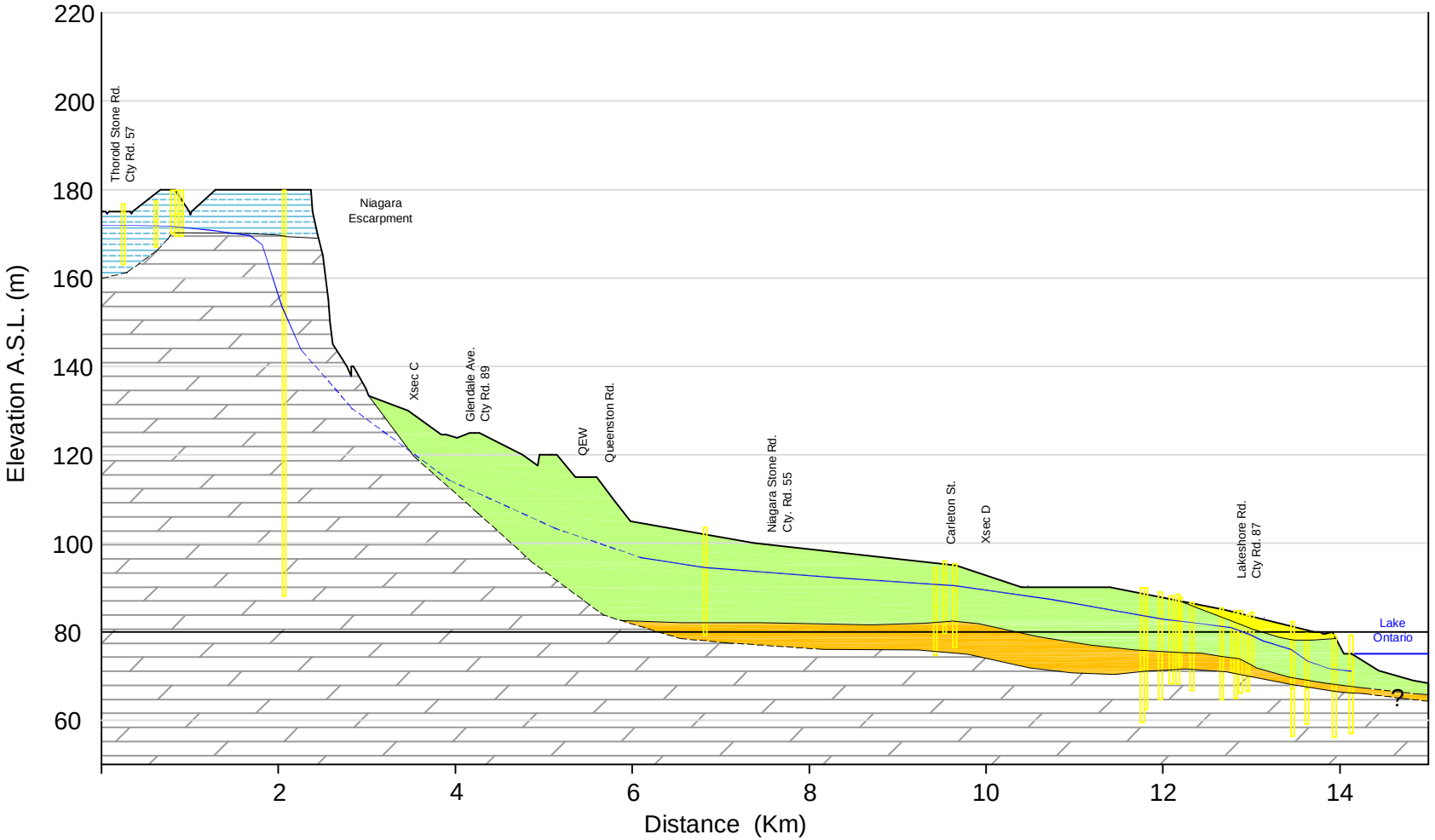
Municipal Drains

A fluvial geomorphic classification system was applied to the municipal drains in the Niagara-on-the-Lake watersheds to characterize them in terms of their stability, their evolution towards a more self-sustaining condition and their ability to transport sediment. This system, which is different than the fish habitat classification system for drains (DFO 2006), can be used to assist in identifying the need for drain maintenance. The classification system is described below and illustrated in Figure 2.6 (Rhoads and Herricks 1996):

South
A

Niagara-on-the Lake
Watershed Study
Geologic Cross-Section
Vertical Exaggeration: 50X

North
A'



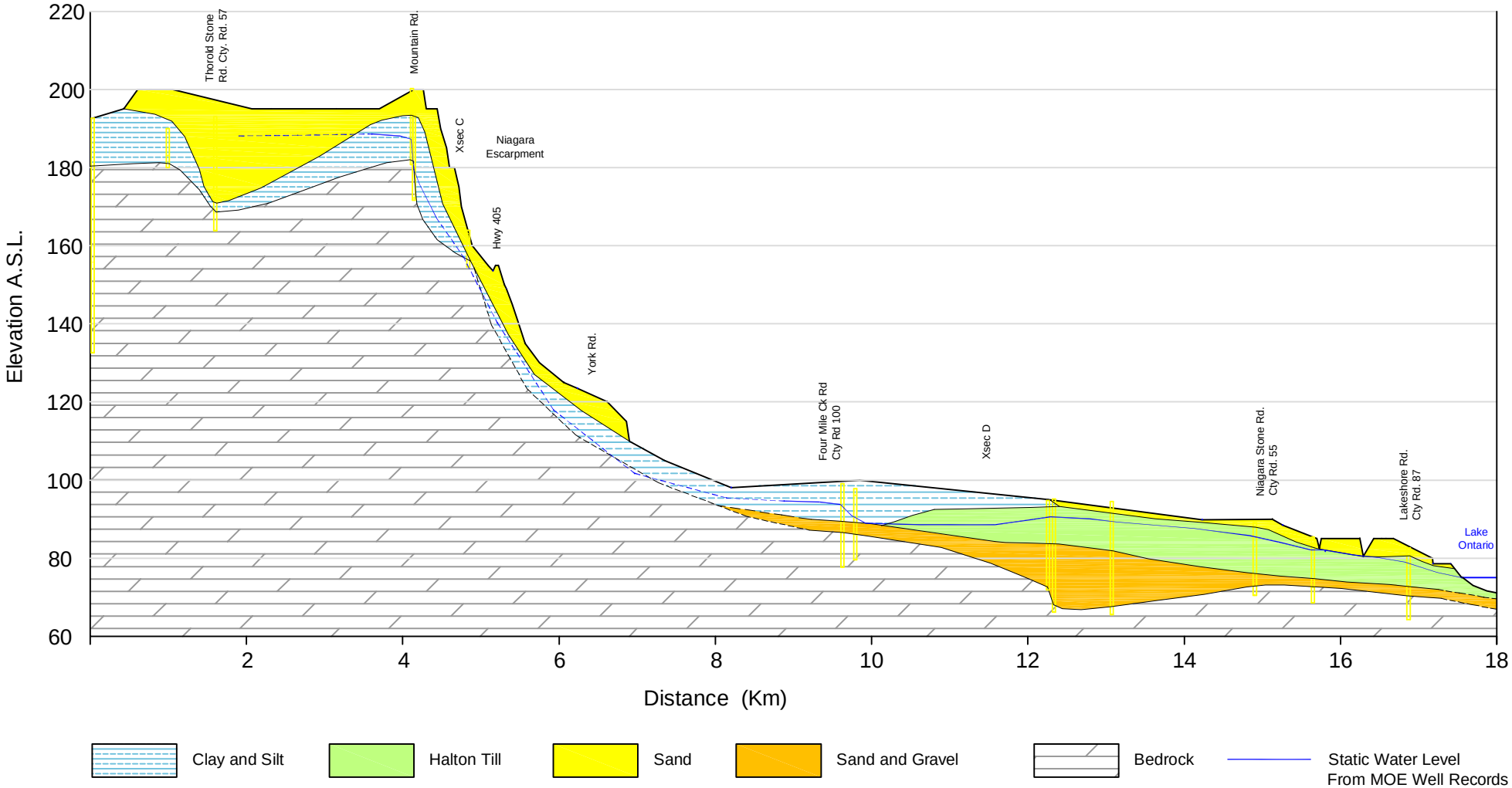
Clay and Silt | Halton Till | Sand | Sand and Gravel | Bedrock | Static Water Level From MOE Well Records

NOTE: Dashed lines are interpolated

South
B

Niagara-on-the Lake
Watershed Study
Geologic Cross-Section
Vertical Exaggeration: 50X

North
B'



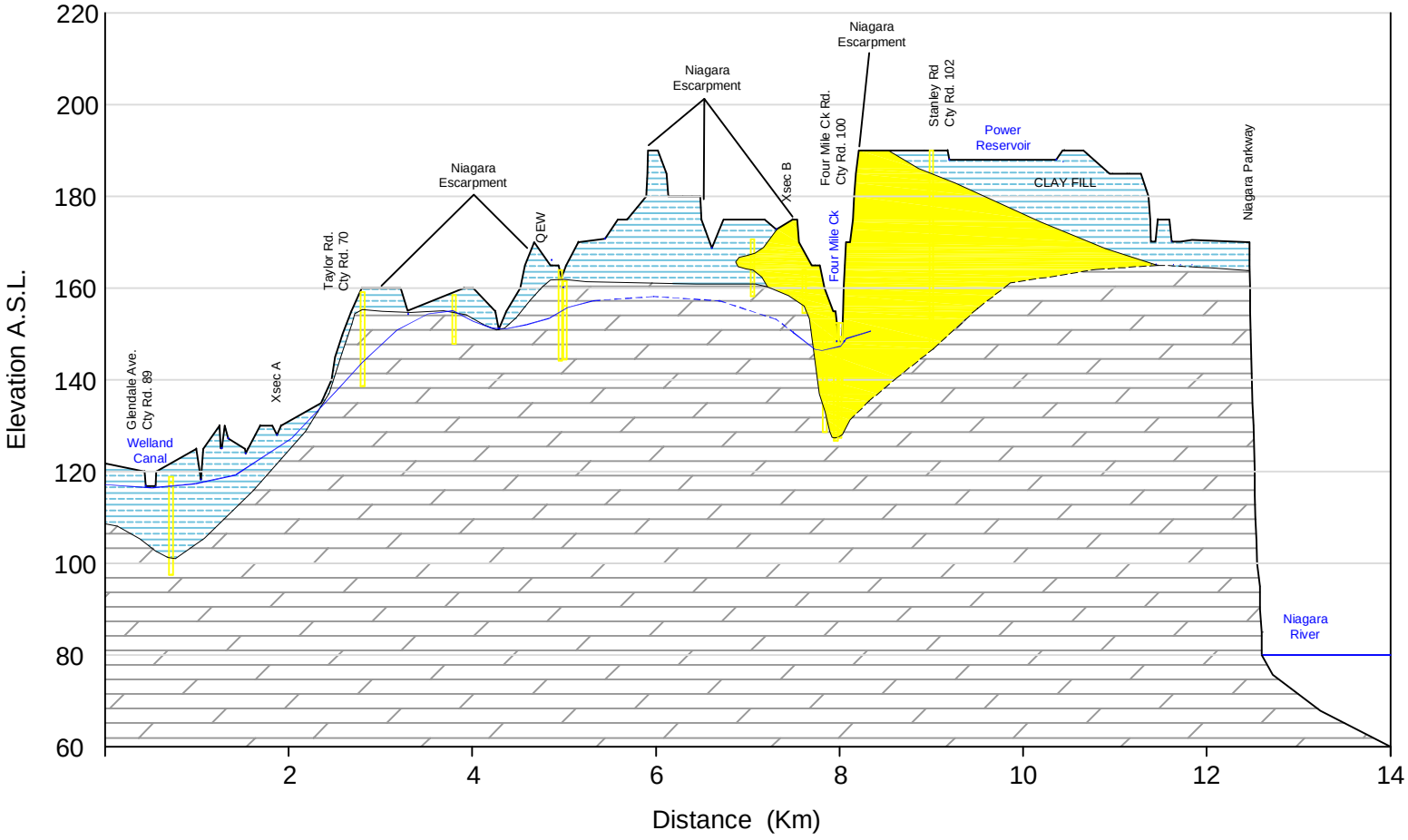
Clay and Silt | Halton Till | Sand | Sand and Gravel | Bedrock | Static Water Level From MOE Well Records

NOTE: Dashed lines are interpolated

West
C

Niagara-on-the Lake
Watershed Study
Geologic Cross-Section
Vertical Exaggeration: 50X

East
C'

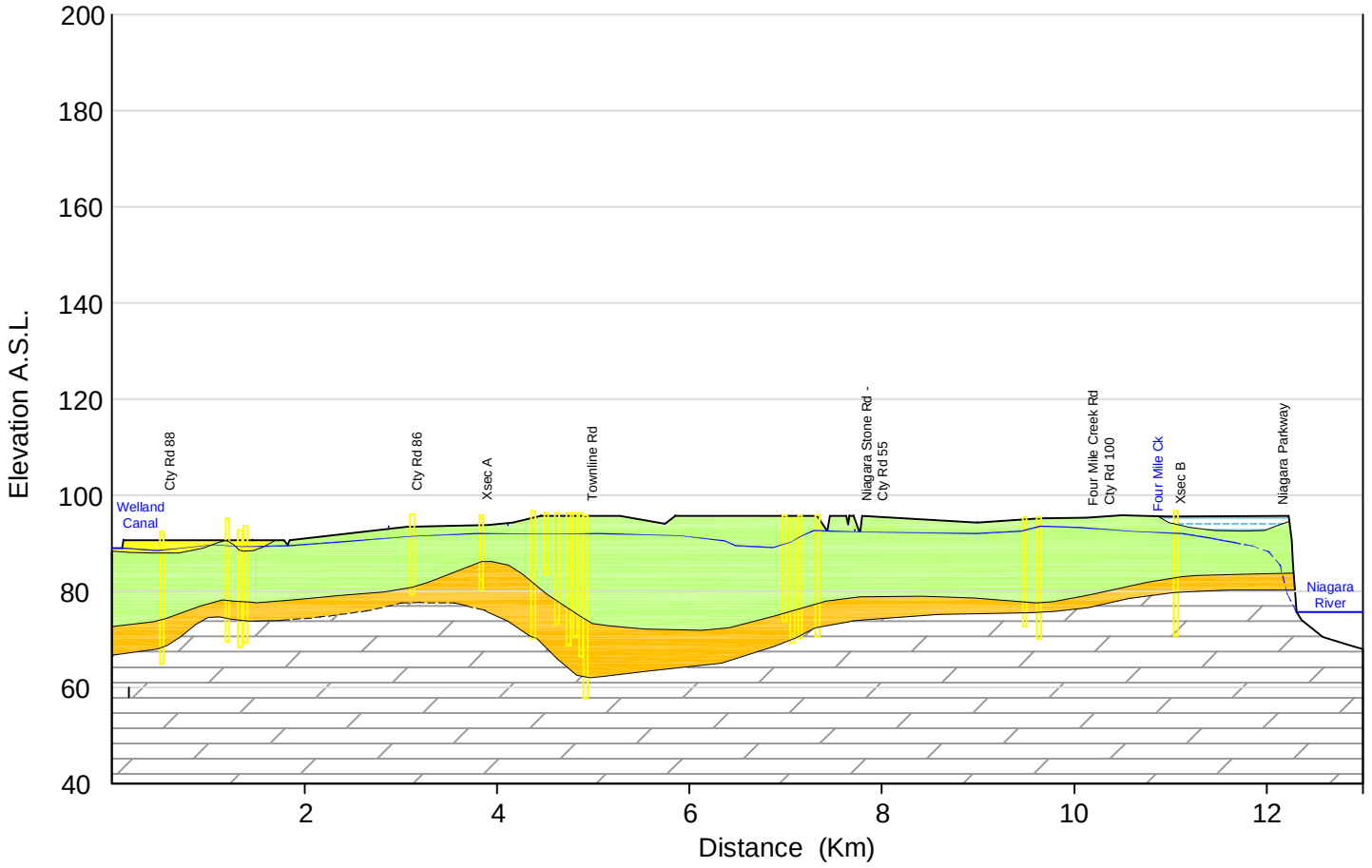


NOTE: Dashed lines are interpolated

West
D

Niagara-on-the Lake
Watershed Study
Geologic Cross-Section
Vertical Exaggeration: 50X

East
D'



Clay and Silt | Halton Till | Sand | Sand and Gravel | Bedrock | Static Water Level From MOE Well Records

NOTE: Dashed lines are interpolated

Type 1 Channel

- Straight or smoothly curving trapezoidal channel with uniform bed
- Result of recent channelization or maintenance

Type 2 Channel

- Straight or smoothly curving trapezoidal channel with unvegetated, migrating alternate bars
- Seems to develop as the result of a high sediment flux into recently channelized reach with adequate transport capacity

Type 3 Channel

- Straight or smoothly curving trapezoidal channel with stable pool-riffle sequences
- Appears to represent a relatively stable morphology that develops in low-energy, gravel-bed channels

Type 4 Channel

- Straight or smoothly curving trapezoidal channel with stable, vegetated alternate bars
- Origin of bars is unclear. Bars clearly depositional features, not the result of bank slumping, but can deflect flow laterally into bank. May be a transitional form leading to a Type 6 channel

Type 5 Channel

- Straight or smoothly curving trapezoidal channel containing a meandering low-flow stream flanked by continuous floodplain
- Appears to be a relatively stable morphology that develops in the smallest headwater streams. May represent containment of meander belt of an underfit stream within the ditch bottom

Type 6 Channel

- Straight or smoothly curving trapezoidal channel containing a meandering stream that impinges upon and erodes the ditch banks
- Appears to be a transitional form leading to destruction of the ditch by a meandering stream as it re-establishes its sinuosity

Type 7 Channel

- Straight or smoothly curving channel with natural cross section that may or may not contain vegetated alternate bars
- Represents straightened sections that were not deepened substantially and that have recovered their geometric, but not their planform properties

Type 8 Channel

- Mildly sinuous meandering channel
- May represent an evolutionary stage subsequent to Type 7 channels, or to Type 6 channels where the ditch has been destroyed. May be an equilibrium state for low-energy meandering channels

Type 9 Channel

- Highly sinuous meandering channel
- May represent an evolutionary stage subsequent to Type 7 channels. Probably an equilibrium state for the largest headwater channels

The majority of the drains are "young", in other words, they have been maintained in a highly modified condition. The drains generally fall into one of three categories: Type 1, 3, or 4.
Most exhibit significant entrenchment (Type 3 or 4), and many are able to convey flows up to the regional storm flow. Most of the main drains have poorly developed instream habitats such as pool:riffle morphology, instream cover in the form of large rock, large woody debris, overhanging woody vegetation; poor riparian cover as a result of regular "brushing"; and over steepened and over hardened banks. As a result, they require regular maintenance, on roughly a 7 year cycle to maintain their conveyance and field drainage functions.

Watercourses

The majority of the watercourses are unstable and entrenched with eroding banks, and many exhibit a gully form as they have downcut into the sandy surficial deposits through which they flow (Figure 2.1). The unstable nature and extensive bank erosion that has occurred in the watercourses is largely a function of changes in the portion of the watershed that drains to these features. Essentially, the extensive network of municipal drains and field tile drains provides for the efficient conveyance of runoff from the flat topography of the middle portions of these watersheds, downstream of the Escarpment. As a result, the hydrology of the watershed is flashy, in some respects more typical of an urban than a rural watershed, and the stream channels are enlarging in response to this change. Urban development also contributes to this effect but to a relatively small extent, proportional to the urbanized portion of the watershed.

The majority of the bank erosion occurring within each of the watercourses represents a source of sediment, however, there are relatively few areas where bank erosion may threaten structures. In terms of prioritizing areas for remedial works, the following is recommended (stream reaches shown in red in Figure 7.1):

- There are several locations in Lower Four Mile Creek downstream of the Virgil Reservoirs, where valley contact erosion is occurring that may threaten structures
- Sediment generating sites (areas of substantial bank erosion) should be addressed on a priority basis in Two, Four, and Eight Mile Creeks where loss of agricultural land is a concern
- Remaining sediment generating sites should be addressed as opportunities arise either through remedial works or riparian habitat enhancement

2.3 Surface Water Flows and Flooding

As part of the Niagara-on-the-Lake Watershed Study, floodplain mapping was undertaken to identify areas susceptible to flooding under Regulatory Flood conditions (Aquafor Beech 2007). The primary function of a floodplain is the conveyance of flood waters during extreme storm events and spring melts. It is dependent upon the shape of the creek, the flow rate and the location of structures (bridges, culverts, buildings, etc.). The 100-year flood profile is used by the Niagara Peninsula Conservation Authority to

regulate development within the floodplain, as mandated by the Conservation Authority's Act.

For this study, floodplain mapping was undertaken for Two Mile Creek, Four Mile Creek, the Four Mile Pond Tributary, Six Mile Creek, and Eight Mile Creek. Mapping extents include both the main channel and tributary reaches with drainage areas greater than 125 hectares.

Hydrologic Model Results

Summarized in Table 2.1 to 2.3 are estimated design flows for the 2-year to 100-year events at various locations within the study watersheds. No long-term streamflow gauge data was available to calibrate the hydrologic models. Flows were also estimated using regional relationships for comparison. The "Index Flood Method", as outlined in the MNR Technical Guidelines for Floodplain Mapping was applied. With the index flood method, the magnitude of the flow in an ungauged watershed is estimated from a frequency curve which has been derived from the frequency curves of other streamflow gauges in the region.

Hydraulic Modeling

The hydraulic analysis was undertaken using the U.S. Army Corps' Hydraulic Engineering Center-River Analysis System (HEC-RAS) which computes water surface profiles using the standard step method and routines to analyze bridge and culvert structures.

A base model was assembled using ArcGIS software and the NPCA digital elevation model (DEM). This spatial data was used to defined channel cross-sections, stream centrelines, overbank locations, and roadway crossing overflow profiles. The base model was then supplemented with hydraulic information gathered through field surveys.

Topographic surveys were undertaken at all culvert and bridge crossing locations in order to collect hydraulic data, including opening dimensions, and invert elevations. Stream "bank-full" channel dimensions were also inspected along various creek reaches and used to supplement the cross-sections of the base model.

Once the setup was complete, the hydraulic model was applied to determine flood profiles. The starting water surface elevation for the models was set at the 100-year flood level for Lake Ontario, 76.15m. Design flow estimates for the 2-year to 100-year storms, as determined from the hydrologic analysis, were applied over the appropriate creek reaches. The model was executed using the "mixed" flow regime option to analyze both subcritical and supercritical conditions.

TABLE 2.1:
TWO MILE CREEK - PEAK FLOW ESTIMATES

Flow Node	Drainage Area (km2)	Peak Flow Estimate (m3/s)				
		2-year	5-year	10-year	25-year	100-year
Two Mile Creek						
node 2MC-1 (200001)	23.7	**10.6**	**13.7**	**16.6**	**21.4**	**29.6**
node 2MC-10 (200010)	5.1	**2.6**	**3.6**	**4.6**	**6.1**	**8.3**
node 2MC-11 (100011)	2.1	**0.9**	**1.3**	**1.6**	**2.2**	**3.1**
node 2MC-13 (100013)	2.1	**1.0**	**1.5**	**1.8**	**2.4**	**3.3**
node 2MC-14 (200014)	6.9	**6.0**	**8.1**	**10.1**	**13.1**	**16.1**
node 2MC-15 (200015)	4.0	**4.1**	**5.4**	**6.7**	**8.5**	**11.3**
node 2MC-16 (200016)	1.8	**1.3**	**1.9**	**2.3**	**3.1**	**4.2**
node 2MC-2 (200002)	22.5	**10.9**	**13.9**	**16.7**	**21.3**	**29.2**
node 2MC-3 (200003)	21.8	**11.0**	**13.9**	**16.6**	**21.2**	**29.2**
node 2MC-4 (200004)	20.5	**10.6**	**13.3**	**15.9**	**20.7**	**28.1**
node 2MC-5/6 (300005)	19.7	**10.6**	**13.2**	**15.8**	**20.8**	**27.9**
node 2MC-6 (200006)	7.7	**3.5**	**4.6**	**5.6**	**7.0**	**9.2**
node 2MC-7 (200007)	0.3	**0.4**	**0.5**	**0.6**	**0.8**	**1.0**
node 2MC-7/9 (300009)	6.1	**2.4**	**3.0**	**3.5**	**4.6**	**6.7**
node 2MC-9 (200009)	5.7	**2.3**	**2.9**	**3.5**	**4.5**	**6.7**
node-2MC-12 (200012)	9.8	**5.5**	**7.2**	**9.1**	**12.1**	**17.9**
node-2MC-13/14 (300014)	9.0	**6.8**	**9.2**	**11.5**	**14.9**	**19.2**
node-2MC-15/16 (300015)	5.8	**5.3**	**7.1**	**8.9**	**11.4**	**15.3**
node-2MC-17 (100017)	3.5	**3.6**	**4.8**	**5.9**	**7.5**	**9.9**
node-2MC-18 (100018)	0.8	**0.7**	**0.9**	**1.2**	**1.5**	**2.1**
node-2MC-5 (200005)	12.0	**7.2**	**8.8**	**10.9**	**14.6**	**18.9**

TABLE 2.2:
FOUR MILE CREEK & FOUR MILE POND TRIBUTARY - PEAK FLOW ESTIMATES

Flow Node	Drainage Area (km2)	Peak Flow Estimate (m3/s)				
		2-year	5-year	10-year	25-year	100-year
Four Mile Pond						
node 4MP-01 (200001)	6.7	**3.9**	**5.4**	**6.8**	**9.0**	**12.3**
node 4MP-02/03	6.3	**4.1**	**5.7**	**7.1**	**9.4**	**12.8**
node 4MP-03	5.3	**3.6**	**4.9**	**6.1**	**8.0**	**10.9**
node 4MP-04/05	5.0	**3.7**	**4.9**	**6.2**	**8.0**	**10.9**
node 4MP-05	3.8	**2.8**	**3.7**	**4.6**	**6.0**	**8.2**
node 4MP-06 (100002)	3.2	**2.6**	**3.5**	**4.4**	**5.7**	**7.6**
Four Mile Creek						
node 4MC-1 (200001)	44.6	**17.4**	**23.9**	**30.3**	**39.5**	**53.6**
node 4MC-1/2	46.2	**17.8**	**24.0**	**30.5**	**39.8**	**54.0**
node 4MC-10 (200010)	4.1	**3.4**	**4.5**	**5.6**	**7.2**	**8.9**
node 4MC-11 (200011)	1.8	**1.6**	**2.1**	**2.5**	**3.2**	**4.3**
node 4MC-117	14.1	**11.3**	**14.5**	**17.3**	**22.9**	**30.3**
node 4MC-117/118 (200017)	15.9	**12.6**	**16.2**	**19.2**	**25.3**	**33.5**
node 4MC-118	1.8	**1.3**	**1.8**	**2.2**	**2.9**	**3.8**
node 4MC-12 (100012)	2.7	**2.5**	**3.3**	**4.1**	**5.3**	**7.0**
node 4MC-13 (200013)	26.0	**17.2**	**22.6**	**27.2**	**34.1**	**44.1**
node 4MC-14 (200014)	25.1	**18.0**	**23.6**	**28.0**	**34.9**	**45.5**
node 4MC-15 (200016)	6.9	**5.1**	**6.9**	**8.6**	**11.2**	**14.9**
node 4MC-15/114 (300017)	24.0	**17.6**	**23.1**	**27.5**	**34.3**	**44.9**
node 4MC-16	3.8	**3.5**	**4.7**	**5.8**	**7.5**	**9.9**
node 4MC-16/116 (100016)	6.0	**5.3**	**7.1**	**8.7**	**11.1**	**14.7**
node 4MC-17/18	13.5	**11.6**	**15.4**	**18.1**	**23.6**	**31.5**
node 4MC-18	12.3	**10.5**	**13.9**	**16.8**	**21.9**	**29.0**
node 4MC-19/24 (300019)	10.9	**9.7**	**12.9**	**16.6**	**21.2**	**27.9**
node 4MC-19A	4.5	**3.5**	**4.9**	**6.1**	**8.0**	**10.8**
node 4MC-19A/22 (200022)	5.4	**4.5**	**6.1**	**7.6**	**9.9**	**13.3**
node 4MC-1M (300001)	46.3	**17.0**	**23.0**	**29.2**	**38.1**	**51.9**
node 4MC-2 (100002)	1.6	**0.7**	**1.0**	**1.3**	**1.8**	**2.4**
node 4MC-20 (100020)	2.0	**1.6**	**2.2**	**2.8**	**3.6**	**4.9**
node 4MC-20/21 (200021)	4.3	**3.4**	**4.7**	**5.9**	**7.7**	**10.5**
node 4MC-21 (200021)	2.3	**1.8**	**2.5**	**3.2**	**4.2**	**5.7**
node 4MC-22 (100022)	0.9	**0.9**	**1.2**	**1.5**	**1.9**	**2.5**
node 4MC-23 (100023)	1.7	**1.3**	**1.9**	**2.4**	**3.1**	**4.2**
node 4MC-24 (200024)	5.5	**5.2**	**6.9**	**9.1**	**11.4**	**14.8**
node 4MC-25 (200025)	4.5	**4.2**	**5.4**	**7.4**	**9.1**	**11.8**
node 4MC-26	2.4	**2.2**	**2.9**	**3.7**	**4.7**	**6.3**
node 4MC-26/27 (100026)	2.9	**2.5**	**3.2**	**4.7**	**5.7**	**7.4**
node 4MC-3 (200003)	35.8	**16.2**	**22.5**	**28.0**	**35.7**	**47.4**
node 4MC-3/4 (300003)	43.0	**17.9**	**25.2**	**31.5**	**40.6**	**55.7**
node 4MC-4 (200004)	7.2	**4.1**	**5.6**	**7.0**	**9.1**	**11.7**
node 4MC-5 (200005)	6.3	**3.9**	**5.3**	**6.6**	**8.5**	**10.5**
node 4MC-6 (100006)	4.2	**2.9**	**3.8**	**4.7**	**6.1**	**8.1**
node 4MC-7	26.0	**15.4**	**21.1**	**26.0**	**33.0**	**42.7**
node 4MC-7/8 (200007)	34.1	**16.4**	**22.8**	**28.2**	**35.8**	**47.8**
node 4MC-8A	5.7	**4.5**	**6.1**	**7.5**	**9.7**	**12.5**
node 4MC-8A/9 (200009)	6.7	**5.4**	**7.2**	**9.0**	**11.6**	**15.1**
node 4MC-8B/9 (200008)	7.1	**5.5**	**7.5**	**9.3**	**12.0**	**15.7**
node 4MC-9 (100009)	1.0	**1.1**	**1.4**	**1.8**	**2.2**	**2.9**

TABLE 2.3:
SIX MILE CREEK - PEAK FLOW ESTIMATES

Flow Node	Drainage Area (km2)	Peak Flow Estimate (m3/s)				
		2-year	5-year	10-year	25-year	100-year
Six Mile Creek						
node 6MC-01 (200001)	17.7	**14.2**	**18.3**	**21.8**	**28.4**	**33.4**
node 6MC-02 (100002)	1.7	**1.3**	**1.8**	**2.2**	**2.9**	**3.8**
node 6MC-03 (200003)	14.5	**12.1**	**15.4**	**18.4**	**24.1**	**27.2**
node 6MC-03/02 (200002)	16.2	**13.4**	**17.2**	**20.6**	**26.9**	**30.5**
node 6MC-04 (200004)	12.9	**10.8**	**13.8**	**16.5**	**21.6**	**29.6**
node 6MC-05 (200005)	3.8	**4.4**	**5.7**	**6.9**	**8.7**	**10.5**
node 6MC-05/06 (300006)	11.6	**9.9**	**13.6**	**17.1**	**21.5**	**29.3**
node 6MC-06 (200006)	7.8	**6.0**	**8.3**	**10.6**	**13.5**	**19.0**
node 6MC-07 (200007)	0.7	**0.8**	**1.1**	**1.3**	**1.7**	**2.2**
node 6MC-08A/9	6.0	**4.4**	**6.2**	**7.8**	**10.2**	**14.2**
node 6MC-08B (200008)	6.2	**4.6**	**6.4**	**8.1**	**10.6**	**14.8**
node 6MC-08B/7 (300008)	7.0	**5.2**	**7.3**	**9.3**	**11.9**	**16.8**
node 6MC-09 (100009)	1.1	**0.8**	**1.1**	**1.4**	**1.9**	**2.6**
node 6MC-10 (100010)	2.0	**1.4**	**2.0**	**2.5**	**3.4**	**4.7**
node 6MC-11(200011)	3.5	**2.6**	**3.7**	**4.7**	**6.2**	**8.4**
node 6MC-11/12 (200012)	4.5	**3.4**	**4.8**	**6.1**	**8.0**	**11.0**
node 6MC-12 (100012)	1.1	**0.8**	**1.1**	**1.4**	**1.9**	**2.6**
node 6MC-13 (100013)	1.2	**1.6**	**2.0**	**2.4**	**3.1**	**4.0**
node 6MC-13/14 (200013)	2.5	**3.0**	**3.9**	**4.7**	**5.9**	**7.8**
node 6MC-14 (100014)	1.3	**1.5**	**1.9**	**2.3**	**2.9**	**3.9**

EIGHT MILE CREEK - PEAK FLOW ESTIMATES

Flow Node	Drainage Area (km2)	Peak Flow Estimate (m3/s)				
		2-year	5-year	10-year	25-year	100-year
Eight Mile Creek						
node 8MC-01 (200001)	15.2	**10.7**	**13.8**	**16.6**	**20.8**	**26.6**
node 8MC-02	10.9	**9.0**	**11.5**	**13.8**	**17.2**	**21.6**
node 8MC-02/08 (200002)	13.2	**10.7**	**13.8**	**16.5**	**20.7**	**26.2**
node 8MC-03	6.0	**5.9**	**7.4**	**8.9**	**10.8**	**13.4**
node 8MC-03/06 (200003)	9.5	**8.3**	**10.7**	**12.9**	**16.0**	**20.1**
node 8MC-04	2.4	**2.7**	**3.5**	**4.3**	**5.4**	**7.1**
node 8MC-04/07 (200004)	4.1	**4.6**	**6.0**	**7.2**	**9.2**	**12.0**
node 8MC-05 (100005)	1.3	**1.5**	**1.9**	**2.3**	**2.9**	**3.8**
node 8MC-08	2.3	**1.8**	**2.4**	**2.9**	**3.8**	**5.0**

Flood Risk at Culvert and Bridge Structures

The model results were reviewed at public road crossings to assess the capacity of the existing culvert and bridge infrastructure. Figure 2.7 and Table 2.4 show hydraulic structures inventoried and indicate whether the structure should be replaced or not based on its capacity. The frequency at which the design flows are estimated to overtop these structures ranges from as little as the 2 year storm, up to the 100 year storm. The hydraulic analysis suggests that some of the structures may be flooded relatively frequently. For some structures, this may be true due to their limited capacity. However, in other cases, historic observations may suggest that flooding is much less frequent. This may be due to:

- the conservative nature of the modeling: modeling may under-estimate "head effects" where storage behind the road crossings could attenuate the incoming flows, thus resulting in an increase in the frequency of flooding of the road at the crossing.

- capacity limitations at downstream structures: for example, an undersized structure located just downstream may cause floodwaters to "backup" and partially submerge upstream structures.

- capacity limitations within downstream channel reaches: limited channel capacity may also result in high tailwater depths at upstream structures, thereby increasing the frequency of flooding.

Floodline Mapping

The 100-year Regulatory flood profile from the hydraulic model was imported into ArcGIS using the HEC-GeoRAS extension. The 100-year flood profile was then spatially rendered, plotted, and intersected with the Digital Elevation Model. A resulting flood surface polygon was obtained and reviewed for accuracy. These flood conditions were then plotted, together with cross-section locations and associated flood elevations, on 1:2,000 scale mapping, provided separately.

Several locations were identified where, due to the very flat topography of the area, shallow spills may occur between tributary subwatersheds. Model results and topography were reviewed at these locations. These spills can be characterized as wide "sheet flow" of 0.1m to 0.2m deep or less. The spill locations were also identified on the floodline mapping.

Key recommendations arising from the floodplain mapping exercise are as follows:

- Detailed floodline mapping on orthophotography was produced for the entire study area. An example is provided in Figure 2.8.
- Floodproofing can address many of the flooding issues, where flood depths are shallow (42 buildings);

TABLE 2.4 - SUMMARY OF FLOOD CHARACTERISTICS AND MITIGATION OPTIONS FOR FLOOD-SUSEPTIBLE ROADS

TWO-MILE CREEK					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Replacement Recommended?**	**Notes**	
Main Branch	Lakeshore Road	23	Concrete Box Culvert 5.969m W x 1.524m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
Main Branch	Butler Street	24	Ellipsoid CSP 2.03m W x 1.31m H	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
Main Branch	Niagara Stone Road	25	Concrete Box Culvert 5.22m W x 1.2m H Twin 0.8m dia Concrete Pipe	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
Main Branch	East and West Line	26	Concrete Box Culvert 8m W x 2.52m H	$Q_{capicity}$ > 100 Year	yes		no		
Main Branch	access road / driveway	27	Concrete Box Culvert 7.3m W x 1.854m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
East Branch	Line 1 Road	47	Concrete Box Culvert 4.8m W x 1.852m H	$Q_{capicity}$ > 100 Year	yes		no		
East Branch	Concession 2 Road	49	Concrete Box Culvert 4.24m W x 1.676m H	$Q_{capicity}$ > 100 Year	yes		no		
East Branch	Line 2 Road	53	Concrete Box Culvert 3.07m W x 1.6m H	$Q_{capicity}$ > 100 Year	yes		no		
East Branch	Line 3 Road	57	Concrete Box Culvert 2.45m W x 1.58m H	$Q_{capicity}$ > 100 Year	yes	yes, but channel capacity also a factor	no	Culvert replacement alone would not eliminate u/s flooding. Floodproofing and/or channel improvements recommended	
East Branch	access road / driveway	61	Twin 1.53m Ø CSP	10 Year < $Q_{capicity}$ < 25 Year	n/a - private structure	yes	no	Floodproofing recommended instead	
East Branch	access road / driveway	63	Concrete Box Culvert 2.18m W x 1.49m H	10 Year < $Q_{capicity}$ < 25 Year	n/a - private structure	yes	no	Culvert replacement alone would not eliminate u/s flooding. Floodproofing recommended instead	
East Branch	Larkin Road	66	Concrete Box Culvert 2.46m W x 1.6m H	25 Year < $Q_{capicity}$ < 100 Year	yes	yes (minor)	no	Floodproofing recommended instead	
East Branch	Line 5 Road	67	Concrete Box Culvert 2.38m W x 1.32m H	$Q_{capicity}$ > 100 Year	yes		no		
East Branch	Line 6 Road	72	Concrete Box Culvert 1.82m W x 0.69m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch	access road / driveway	28	Concrete Box Culvert 6.121m W x 2.3m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
West Branch	Line 1 Road	29	Concrete Box Culvert 6.25m W x 2.78m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch	Line 2 Road	31	Concrete Box Culvert 5.95m W x 3.23m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch	Line 3 Road	33	Concrete Box Culvert 6.08m W x 2.85m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch	Line 4 Road	34	Concrete Box Culvert 5.42m W x 1.95m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
West Branch 13	Line 5 Road	269	Concrete Box Culvert 1.85m W x 1.2m H	$Q_{capicity}$ > 100 Year	yes	yes (minor)	no	Culvert replacement alone would not eliminate u/s flooding. Floodproofing recommended instead	
West Branch 13	access road / driveway	264	1.5m Ø CSP	25 Year < $Q_{capicity}$ < 100 Year	n/a - private structure	yes (minor)	no	Culvert replacement alone would not eliminate u/s flooding. Floodproofing recommended instead	
West Branch 13	access road / driveway	266	Ellipsoid CSP 1.65m W x 0.96m H	5 Year < $Q_{capicity}$ < 10 Year	n/a - private structure		n/a - private structure		
West Branch 13	access road / driveway	267	Ellipsoid CSP 1.65m W x 1m H	5 Year < $Q_{capicity}$ < 10 Year	n/a - private structure		n/a - private structure		
West Branch 13	access road / driveway	268	Ellipsoid CSP 1.65m W x 1.05m H	25 Year < $Q_{capicity}$ < 100 Year	n/a - private structure		n/a - private structure		
West Branch 14	Line 5 Road	36	Concrete Box Culvert 4.86m W x 2m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch 14	Line 6 Road	37	Concrete Box Culvert 4.3m W x 2.15m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch 14	Line 7 Road	38	Concrete Box Culvert 4.25m W x 2.09m H	25 Year < $Q_{capicity}$ < 100 Year	yes	yes (minor)	no	Floodproofing recommended instead	
West Branch 15	Line 8 Road	42	Concrete Box Culvert 2.6m W x 1.24m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes (minor)	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
West Branch 16	Line 8 Road	210	Concrete Box Culvert 2.45m W x 1.49m H	$Q_{capicity}$ > 100 Year	yes		no		
West Branch 16	Concession 2 Road	211	Concrete Box Culvert 2.5m W x 1.57m H	$Q_{capicity}$ > 100 Year	yes		no		
						Total # of culverts to be replaced =	**3**	**Total estimated replacement cost =**	**$600**

1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.

TABLE 2.4 - SUMMARY OF FLOOD CHARACTERISTICS AND MITIGATION OPTIONS FOR FLOOD-SUSEPTIBLE ROADS (continued …)

FOUR-MILE CREEK					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Structure Replacement**	**Notes**	
4MC1	Lakeshore Road	86	Concrete Arc Bridge 16.4m W x 2.93m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC2	Lakeshore Road	273	Concrete Box Culvert 2.97m W x 1.3m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC3	East and West Line	106	Concrete Arc Bridge 15.3m W x 2.43m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC3	access road / driveway	104	Six 0.45m Ø Concrete Culvert	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
4MC3	access road / driveway	105	Twin 1.48m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
4MC4	East and West Line	92	Concrete Box Culvert 2.45m W x 1.8m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC4	Line 1 Road	95	Concrete Box Culvert 1.8m W x 2.1m H	25 Year < $Q_{capicity}$ < 100 Year	yes	yes	yes	Meets road criteria, but upgrade recommended based on u/s flood-susceptible buildings	$200
4MC4	Line 2 Road	96	Concrete Box Culvert 1.25m W x 1.9m H	2 Year < $Q_{capicity}$ < 5 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC4	Line 3 Road	99	Concrete Box Culvert 1.9m W x 1.2m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
4MC4	Line 4 Road	100	Ellipsoid CSP 2m W x 1.4m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
4MC4	Niagara Stone Road	102	Concrete Box Culvert 2.1m W x 1.5m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC4	access road / driveway	91	1.8m Ø CSP	2 Year < $Q_{capicity}$ < 5 Year	n/a - private structure	yes	yes if feasible (private)	Private structure?	$50
4MC4	access road / driveway	103	0.5m Ø Conceret Pipe	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
4MC7	Line 1 Road	107	Concrete Arc Bridge 12.2m W x 3.14m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC7	Niagara Stone Road	108	Concrete Arc Bridge 12.25m W x 3.375m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC7	Line 3 Road	109	Concrete Arc Culvert 8.1m W x 3.665m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 2 Road	274	Concrete Box Culvert 3.352m W x 2.362m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 1 Road	143	Concrete Box Culvert 3.4m W x 2.2m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 2 Road	146	Concrete Box Culvert 3.25m W x 1.8m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	driveway - Concession 6 Road	147	Concrete Box Culvert 3.1m W x 1.7m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
4MC8	Concession 6 Road	148	Concrete Box Culvert 3.1m W x 1.6m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
4MC8	Niagara Stone Road	149	Concrete Box Culvert 3m W x 2.1m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 3 Road	150	Concrete Box Culvert 3.6m W x 1.8m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Concession 6 Road	151	Concrete Box Culvert 3.7m W x 1.7m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 4 Road	152	Concrete Box Culvert 3.7m W x 2.05m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC8	Line 5 Road	153	Concrete Box Culvert 3.7m W x 2m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC14	Line 4 Road	111	Concrete Box Culvert 7m W x 2.1m H	2 Year < $Q_{capicity}$ < 5 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC15	Line 4 Road	110	Concrete Box Culvert 4.3m W x 1.7m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC16A	Line 5 Road	255	Ellipsoid CSP 1.35m W x 0.9m H	5 Year < $Q_{capicity}$ < 10 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC16A	Line 6 Road	258	Ellipsoid CSP 1.14m W x 0.82m H	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC16A	access road / driveway	257	Ellipsoid CSP 1.2m W x 0.88m H	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
4MC16B	Line 5 Road	113	Concrete Box Culvert 3.75m W x 1.95m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC16B	Line 6 Road	115	Concrete Box Culvert 3m W x 1.9m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC16B	Line 7 Road	217	Concrete Box Culvert 2.45m W x 2.2m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC16B	driveway - Line 7 Road	117	Ellipsoid CSP 2.5m W x 1.8m H	25 Year < $Q_{capicity}$ < 100 Year	n/a - private structure		n/a - private structure		
4MC16B	Concession 6 Road	118	Concrete Box Culvert 2.5m W x 1.4m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
4MC17	Line 5 Road	112	Concrete Box Culvert 6.9m W x 1.9m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC17	Line 6 Road	114	Concrete Box Culvert 5.8m W x 2.6m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC17	Line 7 Road	116	Concrete Box Culvert 5.7m W x 2.3m H	25 Year < $Q_{capicity}$ < 100 Year	yes	yes (minor)	no	Floodproofing recommended instead	

1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.

TABLE 2.4 - SUMMARY OF FLOOD CHARACTERISTICS AND MITIGATION OPTIONS FOR FLOOD-SUSEPTIBLE ROADS (continued …)

FOUR-MILE CREEK					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Structure Replacement**	**Notes**	
4MC18	Four Mile Creek Road	254	Concrete Box Culvert 3.1m W x 1.6m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC18	access road / driveway	258	Ellipsoid CSP 1.5m W x 0.9m H	5 Year < Qcapicity < 10 Year	n/a - private structure		n/a - private structure		
4MC18	access road / driveway	252	Concrete Box Culvert 1.18m W x 1.9m	25 Year < Qcapicity < 100 Year	n/a - private structure		n/a - private structure		
4MC18	access road / driveway	253	1.3m Ø CSP	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
4MC18	access road / driveway	261	Ellipsoid CSP 1.4m W x 0.9m H	5 Year < Qcapicity < 10 Year	n/a - private structure		n/a - private structure		
4MC18	access road / driveway	262	Concrete Box Culvert 1.85m W x 1m H	5 Year < Qcapicity < 10 Year	n/a - private structure		n/a - private structure		
4MC18	access road / driveway	263	Concrete Box Culvert 1.6m W x 1.1m H	10 Year < $Q_{capicity}$ < 25 Year	n/a - private structure		n/a - private structure		
4MC19	Line 8 Road	121	Concrete Box Culvert 3m W x 2.3m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC20	Queenston Road	122	Concrete Box Culvert 2.1m W x 1.8m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC21	Queenston Road	123	Concrete Box Culvert 1.9m W x 1.5m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC21	York Road	124	Concrete Box Culvert 1.85m W x 1.6m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC21	Warner Road	126	Ellipsoid CSP 1.35m W x 0.95m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
4MC21	access road / driveway	125	Twin 0.76m Ø Concrete Pipe	2 Year < $Q_{capicity}$ < 5 Year	n/a - private structure		n/a - private structure		
4MC21	access road / driveway	270	1.1m Ø Concrete Pipe	Qcapicity < 2 Year	n/a - private structure		n/a - private structure		
4MC24	Line 8 Road	120	Concrete Box Culvert 4.5m W x 2.1m H	$Q_{capicity}$ > 100 Year	yes		no		
4MC24	Line 9 Road	129	Concrete Box Culvert 3.7m W x 2.5m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
4MC24	Four Mile Creek Road	130	Concrete Box Culvert 1.8m W x 1.5m H	$Q_{capicity}$ > 100 Year	yes	yes	no	Floodproofing recommended instead	
4MC24	driveway - Four Mile Creek Road	131	Ellipsoid CSP 1.8m W x 1.2m H	5 Year < $Q_{capicity}$ < 10 Year	n/a - private structure		n/a - private structure		
4MC24	York Road	132	2.5m Ø CSP	$Q_{capicity}$ > 100 Year	yes		no		
4MC24	driveway - Four Mile Creek Road	134	Twin Ellipsoid CSP 1.6m W x 1.4m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
4MC24	driveway - Four Mile Creek Road	135	Twin Ellipsoid CSP 0.9m W x 0.45m H	$Q_{capicitv}$ < 2 Year	n/a - private structure		n/a - private structure		
4MC24	access road / driveway	136	Elipsoid CSP 1.85m W x 1.15m H	10 Year < $Q_{capicity}$ < 25 Year	n/a - private structure		n/a - private structure		
4MC24	access road / driveway	137	1.65m Ø Concrete Pipe	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
4MC24	Niagara Townline Road	138	Concrete Box Culvert 0.9m W x 1.2m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.						**Total # of culverts to be replaced =**	**12**	**Total estimated replacement cost =**	**$2,250**

FOUR-MILE POND					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Replacement Recommended?**	**Notes**	
Four Mile Pond	Lakeshore Road	1	Two Concrete Box Culvert 2.95m W x 1.45m H 2.95m W x 1.35m H	$Q_{capicity}$ > 100 Year	yes		no		
Four Mile Pond	Access Road	9	Concrete Box Culvert 2.35m W x 1.05m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
Four Mile Pond	Hunter Road	12	Ellispoid Concrete 1.32m W x 1.83m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
Four Mile Pond	Niagara Stone Road	13	Concrete Box Culvert 2.93m W x 1.2m H	$Q_{capicity}$ > 100 Year	yes		no		
Four Mile Pond	access road / driveway	14	1.26m Ø CSP	2 Year < Qcapicity < 5 Year	n/a - private structure		n/a - private structure		
Four Mile Pond	East and West Line	15	1.83m Ø CSP	$Q_{capicity}$ > 100 Year	yes		no		
Four Mile Pond	Concession 3 Road	16	0.9m Ø CSP	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
Four Mile Pond	Line 1 Road	20	Concrete Box Culvert 1.15m W x 1.59m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.						**Total # of culverts to be replaced =**	**3**	**Total estimated replacement cost =**	**$600**

TABLE 2.4 - SUMMARY OF FLOOD CHARACTERISTICS AND MITIGATION OPTIONS FOR FLOOD-SUSEPTIBLE ROADS (continued …)

SIX-MILE CREEK					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Structure Replacement**	**Notes**	
MAIN	access road / driveway	241	Concrete Box Culvert 6.05m W x 2.05m H	25 Year < $Q_{capicity}$ < 100 Year	n/a - private structure		n/a - private structure		
MAIN	Lakeshore Road	156	Concrete Box Culvert 3.65m W x 2.83m H	$Q_{capicity}$ > 100 Year	yes		no		
MAIN	Townline Road	157	Concrete Box Culvert 3.67m W x 2.37m H	$Q_{capicity}$ > 100 Year	yes		no		
MAIN	East and West Line	201	Concrete Box Culvert 3.68m W x 2.53m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
Reach 2	Town line Road	251	Concrete Box Culvert 1.58m W x 1.5m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 2	Church Road	250	Ellipsoid CSP 1.58m W x 0.96m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 3	Line 1 Road	158	Two Ellipsoid CSP 3.61m W x 1.8m H 3.61m W x 2.36m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 3	Line 2 Road	159	Twin Ellipsoid CSP 3.61m W x 2.36m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 3	Line 3 Road	160	Concrete Box Culvert 4.31m W x 2.5m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 3	driveway - Town line Road	161	Arc CSP 5.33m W x 3.12m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
Reach 3	driveway - Town line Road	162	Arc CSP 5.3m W x 3.12m H	25 Year < $Q_{capicity}$ < 100 Year	n/a - private structure		n/a - private structure		
Reach 3	driveway - Town line Road	163	Arc CSP 5.3m W x 3m H	10 Year < $Q_{capicity}$ < 25 Year	n/a - private structure		n/a - private structure		
Reach 3	Line 4 Road	164	Concrete Box Culvert 13.65m W x 2.5m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 3	Niagara Stone Road	165	Concrete Box Culvert 6.7m W x 2.1m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 5	Lincoln Avenue	166	Ellipsoid Concrete 2.2m W x 1.65m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
Reach 5	driveway - Lincoln Avenue	167	Ellipsoid Concrete 2.18m W x 1.48m H	5 Year < $Q_{capicity}$ < 10 Year	n/a - private structure	yes	yes if feasible (private)	Private structure?	$50
Reach 5	driveway - Lincoln Avenue	168	Arc CSP 2.1m W x 1.03m H	$Q_{capicity}$ < 2 Year	n/a - private structure	yes	yes if feasible (private)	Private structure?	$50
Reach 5	Martin Road	171	Ellipsoid Concrete 1.81m W x 1.3m H	10 Year < $Q_{capicity}$ < 25 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
Reach 5	Queenston Road	172	Concrete Box Culvert 3.05m W x 1.54m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	Line 8 Road	169	Concrete Box Culvert 4.84m W x 2.9m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	driveway - Town Line Road (Grantham)	170	Arc CSP 4.33m W x 2.35m H	$Q_{capicity}$ > 100 Year	n/a - private structure		n/a - private structure		
Reach 6	Queenston Road	238	Concrete Box Culvert 3.63m W x 2.54m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	York Road	177	Concrete Box Culvert 2.94m W x 2.4m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	QEW to Concession Road 6	n/a	Concrete Box Culvert 3.06m W x 1.83m H	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	QEW Sta. 11+015	n/a	Concrete Box Culvert 1.83m W x 1.83m	$Q_{capicity}$ > 100 Year	yes		no		
Reach 6	QEW Sta. 11+528	n/a	Concrete Box Culvert 2.44m W x 1.25m	$Q_{capicity}$ > 100 Year	yes		no		
						Total # of culverts to be replaced =	**4**	**Total estimated replacement cost =**	**$500**

1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.

TABLE 2.4 - SUMMARY OF FLOOD CHARACTERISTICS AND MITIGATION OPTIONS FOR FLOOD-SUSEPTIBLE ROADS (continued …)

EIGHT-MILE CREEK					Structure Replacement Assessment				Estimated Culvert Replacement Costs ($1,000's)
Branch	**Structure**	**Structure ID**	**Desciption**	**Flood Frequency**	**Does Structure have Sufficient Capacity? (1)**	**Does Structure Contribute to Flooding of upstream Buildings?**	**Structure Replacement**	**Notes**	
Main	Lakeshore Road	202	Concrete Box Culvert 6.1m W x 2.35m H	$Q_{capicity}$ > 100 Year	yes		no		
Main	McNab Road	203	Concrete Box Culvert 4.9m W x 1.3m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
Main	Church Road	204	Ellipsoid Concrete 3.5m W x 2.7m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
Main	McNab Road	205	Twin Ellipsoid Concrete 3.1m W x 2m H	25 Year < $Q_{capicity}$ < 100 Year	yes		no		
8MC2	Scott Street	208	Ellipsoid Concrete 3.9m W x 2.2m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding	$200
8MC2	NcNab Road	218	Ellipsoid Concrete 2.21m W x 1.55m H	2 Year < $Q_{capicity}$ < 5 Year	no	yes	yes	Upgrade based on frequency of road flooding and u/s buildings	$200
8MC2	Carlton Road	219	Concrete Box Culvert 3.03m W x 2.12m H	10 Year < $Q_{capicity}$ < 25 Year	no		yes	Upgrade based on frequency of road flooding Also requires upgrading of driveway culverts #221, 222, 223	$200
8MC4	Niagara Stone Road	231	Ellipsoid Concrete 2.2m W x 1.62m H	5 Year < $Q_{capicity}$ < 10 Year	no		yes	Upgrade based on frequency of road flooding	$200
8MC4	Queenstone Road	234	Concrete Box Culvert 1.82m W x 1.53m H	$Q_{capicity}$ > 100 Year	yes		no		
8MC4	York Road	233	Concrete Box Culvert 1.84m W x 1.52m H	$Q_{capicity}$ > 100 Year	yes		no		
8MC6	driveway - Carlton Road	221	0.76m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure	yes	yes if feasible (private)	Private structure? Upgrade in conjunction with culvert #219.	$50
8MC6	driveway - Carlton Road	222	0.88m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure	yes	yes if feasible (private)	Private structure? Upgrade in conjunction with culvert #219.	$50
8MC6	driveway - Carlton Road	223	Concrete Box Culvert 1.44m W x 1.1m H	$Q_{capicity}$ < 2 Year	n/a - private structure	yes	yes if feasible (private)	Private structure? Upgrade in conjunction with culvert #219.	$50
8MC6	McNab Road	224	Concrete Box Culvert 1.32m W x 0.96m H	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
8MC6	driveway - Carlton Road	224	0.85m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
8MC6	driveway - Carlton Road	226	0.9m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
8MC6	driveway - Carlton Road	227	0.9m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
8MC6	driveway - Carlton Road	228	0.9m Ø CSP	$Q_{capicity}$ < 2 Year	n/a - private structure		n/a - private structure		
8MC6	Stewart Road	229	Ellipsoid Concrete 0.9m W x 0.5m H	$Q_{capicity}$ < 2 Year	no		yes	Upgrade based on frequency of road flooding	$200
8MC8	McNab Road	206	Ellipsoid Concrete 1.8m W x 1.7m H	$Q_{capicity}$ > 100 Year	yes		no		
8MC8	Scott Street	207	Ellipsoid Concrete 1.75m W x 1.6m H	$Q_{capicity}$ > 100 Year	yes		no		
						Total # of culverts to be replaced =	**11**	**Total estimated replacement cost =**	**$1,750**

1. Assumed minimum level of service for municipal roads is capacity to convey 20-year design storm.

- Culvert replacement is recommended where roads flood frequently or backwater causes upstream flooding (33 structures – 27 buildings);
- In one case (along Conc. 2 near Line 4), channel capacity improvements are recommended (600m within Two Mile Creek – 14 buildings).

2.4 Shoreline Hazard Mapping

As part of the Niagara-on-the-Lake Watershed Study, a review of the Shoreline Management Plan was undertaken to address regulatory requirements associated with dynamic beach conditions (Hall Coastal Company Limited 2007). The Lake Ontario Shoreline Management Plan (Dillon 1994) provides a general overview of the study area from a coastal processes perspective, with general information regarding the shoreline geology and the environmental variables that affect the relevant coastal processes. Within the Niagara-on-the-Lake study area, four dynamic beach reaches were identified:

- Jones Beach (Port Weller Beach)
- Eight Mile Creek Barrier Beach
- Four Mile Creek Barrier Beach
- Two Mile Creek Barrier Beach

The existing reach designation and hazard mapping prepared in 1994 was reproduced as part of this study and the sections associated with the barrier beaches were updated, based on the provincial hazard policies with respect to dynamic beaches (HCCL 2006). The provincial hazard policies are based on the expected hazards associated with:

- Flooding processes
- Erosion processes
- Dynamic beach processes

The governing hazard limit is the greatest of the three possible hazard delineations; the hazard lines are then mapped in accordance with these generally defined hazards.

The Regulatory Flood Hazard Limit considers the combined effect of the 100 year water level (including static level + wind setup) and a flood allowance for wave uprush and other water related hazards.

The Erosion Hazard Limit takes into consideration many physical and environmental factors, including: shoreline geology and orientation; wave action; water levels; nearshore currents; groundwater; ice; and wind. It accounts for the establishment of a stable slope, a shoreline recession based on the average annual recession rate and an erosion allowance.

The Dynamic Beach Hazard Limit takes into account the Flood Hazard Limit plus a 30 m dynamic beach allowance. The landward extent of this limit may be increased further where the beach is found to be erosional or receding, or decreased where the landward extent of the beach is confined by a cliff or bluff; has a narrow barrier beach with a

waterbody (such as a coastal marsh or river mouth) behind it; or has low lying dunes and beach deposits landward of the barrier beach.

The general shoreline includes a wide range of shoreline conditions, ranging from steep bluffs to low-lying sandy and marshy shoreline areas. Shoreline characteristics consist of a significant depth of sand till overlying the bedrock within the western portions of the area, which is overlain by a relatively thin veneer of silt till and silt. This veneer is substantially thicker in the vicinity of the Port Weller Jetties. To the east of the study area, the bedrock is considerably higher, approaching low water datum. A total of 23 littoral zones exist within the study area within 3 broad littoral subcells:

- Port Weller, extending easterly for between 1 and 2 km, with net westerly sediment transport potential
- A small subcell centred at Stewart Road with negligible sediment transport potential, and
- Between Stewart Road, easterly to the Niagara River, with net easterly sediment transport potential.

In general, for the littoral reaches that do not include dynamic beaches; the standard 15 m setback from the 100 year flood line was considered the appropriate flood hazard regulatory limit. Also the standard 3:1 stable slope allowance was found to be the appropriate erosion hazard limit.

The Jones Beach, Four Mile Beach and Two Mile Beach are all considered to be in a stable condition, although there are some uncertainties with respect to both Four Mile and Two Mile beaches. Accordingly, a dynamic beach regulatory setback has been identified for these features, in association with the Regulatory Flood limit and backshore characteristics. The Eight Mile Barrier Beach was found to be erosional in nature, and therefore both the dynamic beach regulatory setback, plus the erosion regulatory setback were applied.

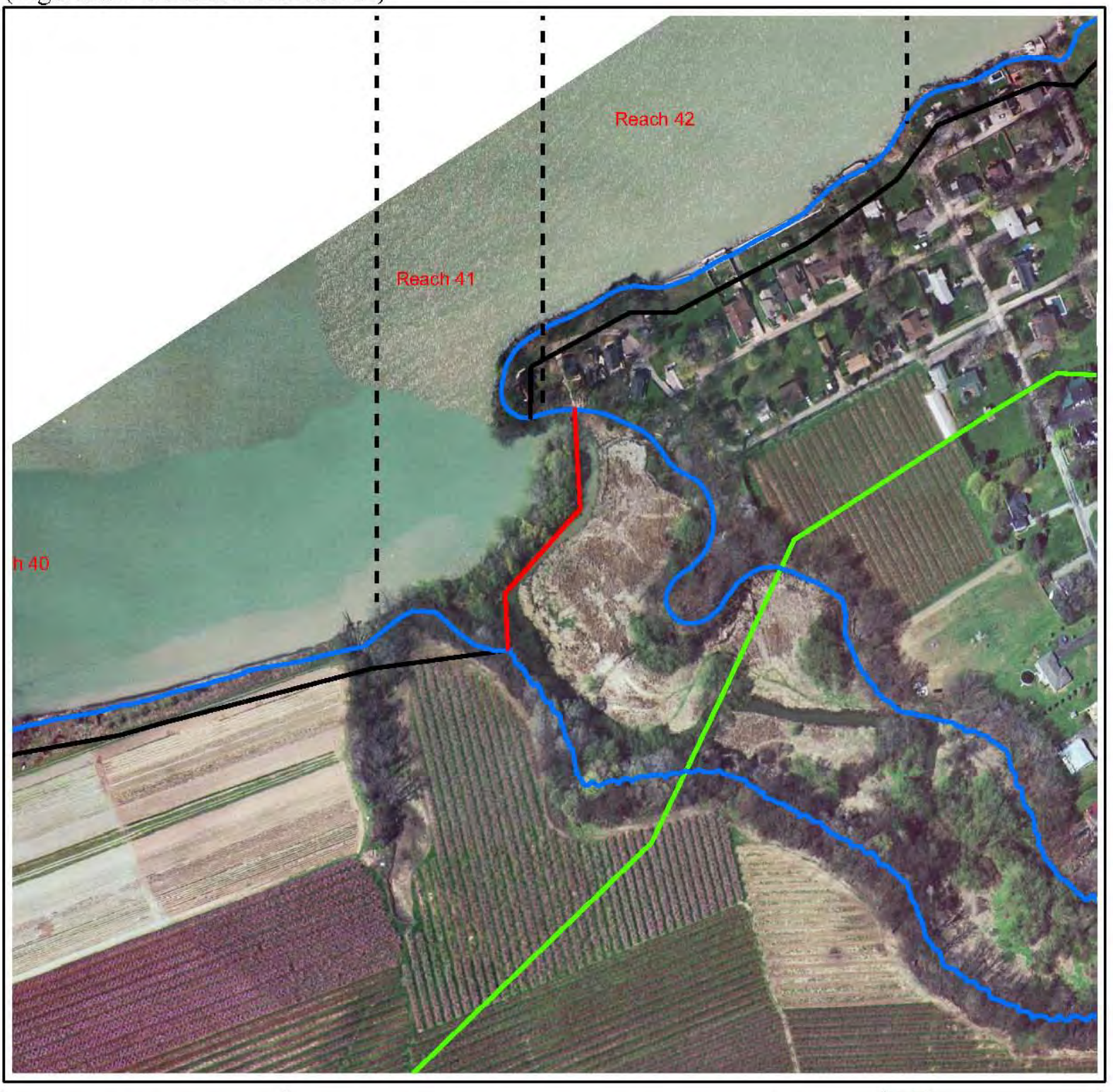
In general, there are no private structures that fall within the regulatory dynamic beach setback. There are a few structures that fall within the regulatory flood limit, in the vicinity of Four Mile Point. On the other hand, there are numerous private structures that fall within the Regulatory Erosion setback. An example of the Shoreline mapping is shown in Figure 2.9.

2.5 Niagara-on-the-Lake Irrigation System

Niagara-on-the-Lake has its own local drainage legislation as a result of passage of a private member's bill initiated by the local growers (Appendix C). The legislation was passed in 1988 allowing the municipality to regulate irrigation within its jurisdiction. It allows irrigation systems, including pumps, drains, etc. to be financed, built and maintained to serve local agricultural needs. The Act has many similarities to the Drainage Act.

Regulatory Shoreline Hazards

Reach 41 & 42
(Eight Mile Creek to Fire Lane 14)



Legend

- Regulatory Flood Level
- Regulatory Flood Hazard Limit
- Regulatory Erosion Hazard Limit
- Regulatory Dynamic Beach Limit

0 25 50 100 150 200 Meters

N
W E
S

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics

Irrigation water to supply agriculture historically was available from several sources:

1. a siphon/pump withdraws water from the OPG reservoir (capacity of about 3,000 US gal/min) that discharges to the Harrison Drain system (Two Mile Creek headwaters). Niagara-on-the-Lake is proposing to add additional capacity of about 5,000 US gal/min from a pump intake in the Niagara River near this location.
2. during the time that the Ontario Power Generation (OPG) tunnels were being built, a siphon/pump was installed to provide for a potable water supply for St. David's. This is referred to as a recharge pump system, because water is more or less pumped into the ground, and then pumped out to provide a water supply. Beginning in the 1980's, St. David's has been supplied with an alternative source of potable water, and the system has been used to provide irrigation water to Four Mile Creek through a surface water link. This system has a capacity in the order of 4,000 US gal/min. In the 1960's, the Virgil Dams were built for the purposes of irrigation and, to a limited extent, flood control. The dams are managed during the irrigation season (roughly May 15 – September 15) to supply irrigation water to agricultural lands generally downstream of the reservoirs (there are some landowners who also withdraw water from the reservoirs).
3. When the Welland Canal was built in the 1930's, a siphon/pump was constructed (the Carleton siphon) to provide irrigation water to local landowners (4,000 US gal/min capacity). This siphon continues to provide water to the Airport, Bright and Lavigne drains (parts of Eigth Mile and Six Mile Creeks). The Carleton siphon also can be used to fill portable water tanks/water trucks that may be used for activities such as pest control, irrigation, etc. In 2001, the Eastchester siphon/pump (4,000 US gal/min) was constructed to provide addition irrigation water to the drains in Eight Mile and Six Mile Creeks. This siphon also can supply irrigation water to the drains in the western portion of the Four Mile Creek watershed.
4. Currently, Niagara-on-the-Lake also has plans to add additional siphon/pump capacity (in the order of 4,000 US gal/min) to service lands in the southern part of their jurisdiction (headwaters of the western part of Four Mile, as well as Six Mile and Eight Mile) more or less south of Queenston Road.

The total volume of water currently used in the system is 17,850 US gal/min. as follows:

- Eastchester Pump (Welland Canal): 4,000 US gal/min. expanded by another 4,000 US gal/min
- Carlton Pump/Siphon (Welland Canal): 650 US gal/min.
- Queenston (D Line) Pump (Niagara River): 5,000 US gal/min.
- OPG Reservoir: 3,200 US gal/min
- OPG Canal: 1,000 US gal/min

At this time, there are still some landowners who withdraw water from the Niagara River to meet their needs and are not contributors to the Niagara-on-the-Lake irrigation system.

Drains that form part of the irrigation system (including the watercourses), fall into three categories:

- municipal drains
- municipal and irrigation drains
- irrigation drains

Drains classified as irrigation drains generally are not maintained, but are provided with irrigation water. Municipal drains are regularly maintained, but do not necessarily carry irrigation water. Municipal and irrigation drains are treated as both. There are numerous small on-line dams that are also used to temporarily store water for local use. While some of these are left in year-round, others may be removed during the non-irrigation season. Generally, these do not represent an obstacle to large fish (salmon, trout).

Drains are maintained on a 6 – 10 year cycle that may include:

- Brushing – to remove woody vegetation that hampers water flow and may reduce channel capacity
- Bottom cleaning – lowering of the drain invert, generally to alleviate problems with clogged tile drains (sediment build-up)
- Leveling banks – periodically, leveling the "spoils" from dredging the drains that otherwise may act as levees
- In some cases, more significant works are needed for example to address bank erosion along the drain

The Airport Drain (Six Mile Creek) was originally called the Townline Drain and was a project initiated by the two adjoining townships to alleviate flooding that was occurring between Eight Mile and Four Mile Creeks. In this regard it was considered a relief drain to address flooding problems.

Generally the irrigation season runs from May 15 – September 15, however, the season may be extended a couple of weeks on either side of these target dates to meet local needs (for example strawberry growers).

Landowners pay for the right to use the irrigation system. Fees are in the order of $10/ac (varies by type of agriculture). This is a maintenance fee; there may also be a capital fee collected, depending on the need for new capital works associated with the irrigation system.

The pumps/siphons are manually operated. While they have the capacity to run continuously, this is not necessarily how they operate. The drainage superintendent monitors water requirements through contact with local landowners and adjusts supply to meet demand. The existing system represents an investment in the order of $3,000,000. There are about 140 landowners that use the irrigation system, including; growers (grapes, tender fruits), nursery operators, greenhouses, golf courses.

The recent Region of Niagara Raw Water for Irrigation Study – Phase 1 and 2 (STANTEC 2006, 2007) studied the Niagara-on-the-Lake system as a model and proposed an enclosed irrigation network (at a cost in the order of $69 million) to replace

it. While this may be a more efficient use of water, there are clearly cost issues as well as environmental ones. For example, if the irrigation water was removed from the drains, there would be a significant loss of flow to each of the watercourses, recognizing that the current system supplies more water than is used.

2.6 Groundwater Resources

NPCA has recently completed a Regional Groundwater Study (NPCA 2005) that provides a detailed review of regional groundwater conditions. Some of this material is summarized below. The NPCA currently operates one groundwater monitoring station in Niagara-on-the-Lake as part of the Provincial Groundwater Monitoring Network. The Niagara-on-the-Lake station monitors ambient groundwater quantity and quality in the shallow overburden aquifer of the Lake Iroquois Sandplain. Groundwater quality data collected to date indicates that nitrate concentrations are elevated at this station.

The majority of water wells within the Niagara-on-the-Lake watershed tap the contact between sand and gravel and the bedrock. The Queenston shale, underlying the area north of the Niagara Escarpment, is generally "tight" and is a marginal aquifer in and of itself, below the uppermost several metres. The major aquifer is the contact between gravel and the bedrock.

A minority of wells produce sufficient water for domestic purposes from the thicker deposits of sand (e.g. Four Mile Creek) or from sand and gravel lenses within the Halton Till above the bedrock interface.

NPCA has developed a system of groundwater monitoring stations in partnership with MOE through the Provincial Groundwater Monitoring Network that provide data on both water quality and quantity. Groundwater quality monitoring indicates that levels of chloride and nitrate are elevated in some shallow wells and most bedrock wells are characterized by elevated sulphur concentrations. While many wells existing within the NOTL, municipal water is available throughout its jurisdiction.

The following information was taken from the NPCA Groundwater Study Report (2005). The susceptibility of an aquifer to contamination is a function of the susceptibility of its recharge area to the infiltration of contaminants. A number of factors may influence the susceptibility of an aquifer. Areas of high recharge are generally more susceptible to groundwater contamination than areas where recharge is restricted. In addition, unconfined aquifers having little cover of fine-grained material are susceptible to contamination and fractured bedrock is highly susceptible because of rapid rates of groundwater flow and less potential for attenuation of contaminants.

Groundwater intrinsic susceptibility from surface contamination for the uppermost significant aquifer was assessed using information contained within the MOE Water Well Information system (WWIS) for the NPCA's jurisdiction (see excerpt from Figure 3.1

from the NPCA Groundwater Study on the following page) and following MOE methodology. Within the uppermost groundwater flow system, areas of high, medium and low susceptibility were identified using MOE susceptibility classes (high <30, medium = 30 to 80, and low > 80). Areas of medium (green) or high (yellow) susceptibility result from the presence of high permeability units in the overburden with little, or no, low conductivity layers overlying the uppermost aquifer. These include the St. David's Buried Gorge and the Iroquois Sand Plain within the Niagara-on-the-Lake watersheds. High (yellow) susceptible areas also include the Niagara Escarpment and the Onondaga Escarpment where the bedrock outcrops or is overlain by thin (i.e. < 5m) deposits (yellow outlined in red). Areas of low (blue) susceptibility correspond to thick deposits of clay and silt of the Haldimand Clay Plain, which restricts the downward movement of infiltrating surface water, making the underlying groundwater much less susceptible to associated contamination.

The majority of the watershed is characterized by surface conditions that resulted in a low (blue) to moderate (green) susceptibility to groundwater contamination as shown on the excerpt from Figure 3.1 on the following page, reproduced from the NPCA Groundwater Study. The NPCA report should be consulted for a more detailed discussion and discussion of limitation of the mapped information.

Groundwater Recharge and Discharge

The regional hydrogeology, including recharge and discharge functions, has been covered by NPCA Groundwater Study (2006) by Waterloo Hydrogeologic Inc. and others. The salient features are summarized in the Potential Groundwater Recharge map (Figure 2.10).

Recharge Potential	Annual Range (mm)	Type examples
High	>150 mm	Lake Iroquois beach sand and lacustrine sand overlying Halton Till
Moderate	150 mm	Exposed Halton Till.
Low	50 - 100 mm	Clay-rich lacustrine deposits south of Lake Iroquois Beach.
Not classified	Not available	Man-made fill (e.g. Welland Canal dredge spoils)

Infiltration Potential

Preservation of post-development infiltration is an important consideration and can be derived from monthly and annual water balances. In the urbanizing areas of Virgil, St. David's, Niagara-on-the-Lake and portions of St. Catharines, an area-wide water balance was calculated.

The water balance was performed for three scenarios:

Excerpt from Figure 3.1 NPCA Groundwater Study (2005).

- Residential development consisting of thinly-rooted lawns on silty clay loam soil, with a water retention of 100 mm;;
- Pre-development conditions of silt loam with deeply rooted pasture vegetation or fine sand loams with orchards (both of which have approximately 250 mm water retention); and,
- Silt loam with a mature forest cover, for a water retention of 400 mm.

Water retention (mm)	Typical soils and vegetation	Type areas	Annual precipitation (mm)	Evapotrans-piration (mm)	Water surplus (mm)	Annual infiltration (mm)	Annual runoff (mm)
100	Clay/silt loam, turf cover (Oneida, Chinguacousy Jeddo soils)	Urban areas with lawns	913.2	577.2	336	50-100	286 - 236
250	Silt loam over Halton Till, pasture or fine sand loam over Halton Till. Orchards (Grimsby, Vineland, Brantford, Toledo soils)	Virgil, St. David's NOTL, orchard and pasture land	913.2	610.2	303	150	153
400	Silt loam, forest cover	Mature forest areas	913.2	622.2	291	200	91

NOTES:
Monthly temperature and precipitation: 1971-2000 climate normals for Niagara Falls, Ontario.
Monthly evapotranspiration (ET) calculated according to Thornthwaite and Mather (1957)
Water surplus = annual precipitation minus annual evapotranspiration.
Infiltration rates from Gerber and Howard (2002).
Runoff = water surplus minus infiltration

This example indicates that urbanization increases the water surplus by approximately 30 mm/year due exclusively to reduced evapotranspiration (ET). Infiltration of water into the ground will be reduced by 50 to 100 mm/year by a change of vegetation from, for example, orchards and pasturelands to turf.

The major impact of urbanization will be the increased runoff (amounting to 80 to 130 mm/year) and decreased infiltration (50 to 100 mm/year), both of which could conceivably be doubled as a result of a post-development increase in impervious cover of up to 50% for residential neighbourhoods (roofs, paved roads and driveways, etc).

Rural Groundwater – Surface Water Interactions

The largest inputs of chloride are related to road salt (Ecoplans 2005), private septic systems and agricultural fertilizers. For this reason, chloride is a valuable marker for anthropogenic inputs to the environment. It is also a good surrogate parameter for measuring the overall stresses associated with land use activities (typically urban, but in this case also agriculture) – it is an "early-warning" of impending degradation of water quality.

- Chloride, once dissolved in water, remains in solution and is not removed from surface water and groundwater by natural means;
- conductivity (or electrical conductance) in water is mainly due to chloride content and conductivity can be inexpensively and accurately measured in the field or with logging instruments;
- Although no PWQO exists for chloride, most studies relate the desirable concentration at <250 mg/L, which is the current Ontario Drinking Water Standard.

Previous studies of the behaviour of chloride in Highland Creek (a highly urbanized watershed in Toronto – Scarborough) have demonstrated that less than half of the chloride in road salt is removed annually by runoff, whereas the remainder infiltrates to groundwater and is subsequently discharged to streams as baseflow (Howard and Haynes, 1997). The implication is that chloride levels will continue to increase in groundwater discharging to surface water in areas where chloride discharges occur, even if inputs such as road salting and fertilizer use (for example potash) were to cease.

Fertilizers contain three essential nutrients, namely nitrogen, potassium and phosphorus. Nitrogen in fertilizers is present in several forms: ammonium, nitrate, ammonia or urea. The amount of nitrogen ranges from 21% for ammonium sulphate to 82% for liquid ammonia. Most fertilizers contain potassium as muriate of potash (potassium chloride - KCl).

Like chloride, nitrate is soluble in water and any excess over what plants require will be lost to surface water through runoff, erosion or tile drainage. Excess nutrients will also reach shallow groundwater by several routes:

- Direct pathways such as improperly abandoned water wells and irrigation wells;
- Leaching of nutrients below the root zone of plants due to over-irrigation; and,
- Infiltration of ponded water through groundwater mounding;

Since more than half the chloride applied to roads in urbanized area is transferred to groundwater, it is reasonable to expect than more than half of any excess nitrate in agricultural areas would also be transferred to groundwater.

2.7 Water Quality

The NPCA collects monthly grab samples from 2 locations in the watershed: on Four Mile and Two Mile Creeks at Lakeshore Road, and also collects benthic invertebrate samples at 9 locations. Benthic invertebrate monitoring began in 2001 and grab sampling began in 2003. In 2004, water samples from the Virgil reservoirs were analyzed for a variety of contaminants including trace metals, some inorganics, pesticides, bacteria and other synthetic organic compounds. The results of this testing indicated that for all but three parameters, water quality in the reservoirs meets the Canadian Environmental Quality Guidelines (CWQG) for Irrigation water. Exceedences occurred for chloride, total dissolved solids, total coliforms and E.coli; however these were only minor and typical of surface water throughout the NPCA watershed. The NPCA grab sampling station on Four Mile Creek is operated in partnership with the MOE and is part of the Provincial Water Quality Monitoring Network. Water quality testing in Two and Four Mile Creeks at Lakeshore Road by NPCA suggested the following:

- Frequent exceedances for nitrate, total phosphorus, suspended solids, chloride (Two Mile Creek only), and bacteria (Two Mile Creek only) occurred
- Water quality generally meets objectives for irrigation water quality
- Water quality is generally impaired due to nutrient enrichment

As part of the Niagara-on-the-Lake Watershed study, the project team undertook a limited water quality sampling program at 10 locations throughout the Niagara-on-the-Lake watersheds. Sampling was completed on four occasions, as follows:

- July 26, 2006 – representing dry weather conditions, when the irrigation system was in operation
- September 13, 2006 – representing wet weather conditions, when the irrigation system was in operation
- October 6, 2006 – representing wet weather conditions, when the irrigation system was in shut down
- November 28, 2006 – representing dry weather conditions, when the irrigation system was not in operation

A total of 10 locations were sampled, as follows:

Station 8.1: Eight Mile Creek @ bridge on Lakeshore Road
Station 8.2: Eight Mile Creek @ culvert on McNab Road just north of Carlton St
Station 6.1: Six Mile Creek @ bridge on Townline Road just north of East West Line
Station 6.2: Six Mile Creek @ bridge on Niagara Stone Road
Station 4.1: Four Mile Creek @ major meander feature west of Four Mile Creek Road just north of Wall Road
Station 4.2: Four Mile Creek @ bridge on Line 5 Road (upstream of Virgil Reservoirs)
Station 4.3: Four Mile Creek @ bridge/culvert on York Road just west of Paxton Lane
Station 2.1: Two Mile Creek, just upstream of Lakeshore Road
Station 2.2: Two Mile Creek @ bridge on Line 2 Road just west of Concession 1 Road
Station 2.3: Two Mile Creek @ bridge on Line 2 Road just east of Concession 3 Road

Stations were selected in order that comparisons could be made between the lower and upper watershed in each of the 4 main watersheds. The upstream sample locations were also chosen to be downstream of the point were irrigation water entered the watercourses. Stations 4.2 and 4.1 were located upstream and downstream of the Virgil Reservoirs to compare the inlet and outlet water quality of the reservoirs.

On two occasions, July and September, 5 samples (Stations 8.1, 6.1, 4,1, 4.2, 2.1) were analyzed for pesticides and synthetic organic compounds. On all occasions, samples from all ten locations were analyzed for the following:

- General chemistry – including nutrients, chloride, total suspended sediments
- Trace metals – including copper and zinc
- Bacteria – E. coli

The pesticide/synthetic organic compound analyses were consistent with the NPCA results, suggesting that there are no surface water concerns with respect to these chemicals, on a watershed scale. Samples were generally below detection limits and thus generally considered safe for irrigation use and for the protection of aquatic life. The list of parameters is as follows:

SEMIVOLATILES	Dimethoate	Benzene	Chlordane (Total)
2,3,4,6-Tetrachlorophenol	Dinoseb	Carbon Tetrachloride	DDT+ Metabolites
2,4,5-T	Malathion	Chlorobenzene	Dieldrin
2,4,6-Trichlorophenol	Metolachlor	Methylene Chloride(Dichloromethane)	g-Chlordane
2,4-D	Metribuzin (Sencor)	Tetrachloroethylene	Heptachlor
2,4-Dichlorophenol	Ethyl Parathion	Toluene	Heptachlor + Heptachlor epoxide
Alachlor	Pentachlorophenol	Trichloroethylene	Heptachlor epoxide
Aldicarb	Phorate	Vinyl Chloride	Lindane
Atrazine	Picloram	**SEMIVOLATILES**	Methoxychlor
Desethyl-atrazine	Prometryn	Temephos	o,p-DDT
Atrazine + Desethyl-atrazine	Simazine	**HERBICIDES**	Oxychlordane
Bendiocarb	Terbufos	Diquat	p,p-DDD
Bromoxynil	Triallate	Glyphosate	p,p-DDE
Carbaryl	Trifluralin	Paraquat	p,p-DDT
Carbofuran	Benzo(a)pyrene	**NP PESTICIDES/HERBICIDES**	**PCBs**
Chlorpyrifos (Dursban)	**VOLATILES**	Diuron	Aroclor 1016
Cyanazine (Bladex)	1,1-Dichloroethylene	Guthion (Azinphos-methyl)	Aroclor 1221
Diazinon	1,2-Dichlorobenzene	**OC PESTICIDES**	Aroclor 1232
Dicamba	1,2-Dichloroethane	a-Chlordane	Aroclor 1242
Diclofop-methyl	1,4-Dichlorobenzene	Aldrin	Aroclor 1248
			Aroclor 1254
			Aroclor 1260
			Total PCB

Table 2.5. Water Quality Results 2006

Station	Date	Flow (m3/s)	Total Suspended Solids (mg/l)	Total Phosphorus (mg/l)	Ammonia Nitrogen (mg/l)	Nitrate Nitrogen + Nitrite Nitrogen (mg/l)	Chloride (mg/l)	Copper (mg/l)	Zinc (mg/l)	*E.coli.* (count/ 100 ml))
8.2	26-Jul	0.28	3	0.015	0.05	nd	21	0.002	nd	140
	13-Sep		23	0.075	nd	9.9	98	0.004	0.012	>200
	6-Oct	0.44	34	0.51	0.15	8.4	56	0.01	0.023	17000
	28-Nov	0.18	13	0.07	0.13	0.5	34	0.002	nd	70
8.1	26-Jul	0.25	26	0.044	0.06	0.2	23	0.003	0.007	>200
	13-Sep		36	0.083	0.06	0.9	48	0.004	0.012	>200
	6-Oct	0.63	46	0.44	0.15	9.8	51	0.012	0.028	2000
	28-Nov	0.21	8	0.074	0.11	1.2	38	0.002	nd	70
4.3	26-Jul	0.17	23	0.029	0.14	2.1	64	0.003	0.009	>200
	13-Sep		20	0.044	0.41	3.3	115	0.002	0.008	>200
	6-Oct	0.11	7	0.032	0.87	3.4	128	0.002	0.008	<1.8
	28-Nov	0.08	3	0.026	0.79	5.5	150	nd	nd	130
4.2	26-Jul	0.16	32	0.061	0.07	1.7	62	0.003	0.009	>200
	13-Sep		42	0.24	0.08	3.1	81	0.008	0.025	>200
	6-Oct	0.63	49	0.31	0.16	1.9	54	0.013	0.032	6800
	28-Nov	0.08	8	0.29	0.21	4.2	130	0.002	0.013	130
4.1	26-Jul	0.31	43	0.027	0.14	1.8	63	nd	0.013	>200
	13-Sep		35	0.29	0.08	3.5	110	0.004	0.014	>200
	6-Oct	3.60	110	0.31	0.16	4.2	55	0.013	0.033	<1.8
	28-Nov	0.21	21	0.17	0.19	3.4	78	0.004	0.006	23
2.3	26-Jul	0.04	5	0.033	0.07	0.6	40	0.002	nd	>200
	13-Sep		50	0.38	0.08	5.6	66	0.009	0.026	>200
	6-Oct	0.57	23	0.3	0.12	7	42	0.007	0.02	11000
	28-Nov	0.07	7	0.071	0.17	4.7	97	0.002	nd	>1600
2.2	26-Jul	0.10	4	0.086	0.07	0.2	23	0.002	0.006	>200
	13-Sep		9	0.37	0.13	2.7	24	0.005	0.012	>200
	6-Oct	0.28	15	0.18	0.16	13	28	0.005	0.013	13000
	28-Nov	0.01	19	0.11	0.22	17	46	0.002	0.005	540
2.1	26-Jul	0.08	13	0.11	0.08	1.1	58	0.003	0.008	>200
	13-Sep		73	0.083	0.06	2.2	113	0.003	0.017	>200
	6-Oct	1.32	35	0.36	0.11	6	36	0.008	0.023	4500
	28-Nov	0.10	6	0.08	0.17	7.1	79	0.002	nd	920
6.2	26-Jul	0.16	10	0.025	0.06	0.1	27	0.003	0.007	120
	13-Sep		110	0.14	0.06	1.7	168	0.01	0.032	>200
	6-Oct	0.54	76	0.31	0.1	1.5	69	0.011	0.032	7800
	28-Nov	0.04	16	0.032	0.15	0.5	190	0.003	nd	240
6.1	26-Jul	0.19	7	0.012	0.05	nd	31	0.002	nd	110
	13-Sep		130	0.17	0.07	0.9	181	0.009	0.032	>200
	6-Oct	0.85	110	0.26	0.11	2.7	59	0.014	0.039	23000
	28-Nov	0.05	5	0.018	0.13	1.7	170	0.002	nd	140

8.1 8 Mile Creek @ bridge on Lakeshore Road

8.2 8 Mile Creek @ culvert on McNab Road just north of Carlton St

6.1 6 Mile Creek @ bridge on Townline Road just north of East West Line

6.2 6 Mile Creek @ bridge on Niagara Stone Road

4.1 4 Mile Creek @ major meander feature west of Four Mile Creek Road just north of Wall Road

4.2 4 Mile Creek @ bridge on Line 5 Road

4.3 4 Mile Creek @ bridge/culvert on York Road just west of Paxton Lane

2.1 2 Mile Creek, just upstream of Lakeshore Road

2.2 2 Mile Creek @ bridge on Line 2 Road just west of Concession 1 Road

2.3 2 Mile Creek @ bridge on Line 2 Road just east of Concession 3 Road

Table 2.5 presents results of the other sample analyses from the water sampling program and are summarized below.

In general, there were no clear trends in receiving water concentrations between samples collected during the irrigation season, versus those collected outside of the irrigation season. The results from the July 26 samples were in some cases lower than results on the other collection dates, perhaps indicating that there are few dry weather sources of nutrients, bacteria and suspended sediments, however results still generally exceeded guidelines. Since only one sample is available from each condition (ie wet/dry, irrigation/no irrigation), it is difficult to draw conclusions. Wet weather samples (collected during a runoff event) generally had higher concentrations of nutrients, bacteria, suspended sediments and metals than corresponding dry weather samples. Metals concentrations were generally below PWQO's under both dry and wet conditions.

Chloride: Chloride concentrations were generally high, averaging over 75 mg/l with a range from 21 – 190 mg/l. While in some cases, wet weather concentrations were greater than dry weather concentrations, high concentrations occurred under both conditions, suggesting that sources of chloride are not necessarily event related. Sources may include groundwater inputs as a result of road salt and septic systems, surface water inputs from fertilizers (such as potash or potassium chloride). Road salt may also be a surface water source in winter. Inputs of chloride also may be linked to irrigation, since crop irrigation may dissolve chloride and deliver it to streams, either through groundwater, runoff or field tile drainage. Chloride from septic systems may also be delivered to streams if septic systems become connected to field tile drains. High chloride concentrations may be a stress to aquatic life and also affect the quality of irrigation water. The federal guideline for irrigation for specific crops (eg. Plums) is 100 mg/l and the federal guideline for protection of fisheries is 250 mg/l.

Ammonia Nitrogen: Nitrogen compounds, including ammonia nitrogen, are typically found in surface waters that are contaminated by agricultural/urban runoff, leachate from septic systems or point sources such as discharges from greenhouses and storm sewers. Ammonia is a concern when present in surface waters, because it may be toxic to fish. Its toxicity is linked to water temperature and pH. None of the observed concentrations exceed the guideline; however, there are several results that are at the limit. Based on these results, stressful and potentially toxic conditions may exist in mid summer when water temperatures may be higher and when irrigation weirs are installed to hold back water. High levels of nitrogen compounds also affect the quality of irrigation water, primarily as it relates to a drinking water source for livestock. The PWQO is 0.02 mg/l (depending on temperature and pH).

Nitrate and Nitrite: Like ammonia, these compounds are found in surface waters contaminated by agricultural/urban runoff, leachate from septic systems or point sources such as discharges from greenhouses and storm sewers. The CWQG interim guideline for nitrate is 13 mg/l. In general, high nitrate and nitrite levels are not runoff related,

however there are several samples where concentrations approach/exceed the CWQG, suggesting that levels are sufficient to cause stress to aquatic life. High levels of nitrogen compounds also affect the quality of irrigation water, primarily as it relates to a drinking water source for livestock.

Copper and Zinc: Copper and zinc concentrations are below the PWQO but generally increase during runoff events. Generally, high copper and zinc concentrations are indicators of urban dry and wet weather sources. Trace metals can be toxic to aquatic life. The PWQO's are 0.005 mg/l for copper and 0.02 mg/l for zinc.

Total Phosphorus: Phosphorus sources are typically fertilizers, although septic systems and municipal sewage are also sources. In general, phosphorus levels are within 1 to 2 times the PWQO during dry weather events, but increase to 1-2 orders of magnitude above the guideline of 0.03 mg/l during runoff events. Lowest phosphorus concentrations occurred at station 4.3, on Four Mile Creek at York Road in St. David's.

Total Suspended Sediments: Total suspended sediments concentrations in surface waters typically result from soil and stream bank erosion during runoff events. In general, TSS concentrations greater than 25 mg/l may cause stress to aquatic life. Dry weather concentrations of TSS are generally low in the study area < 10 mg/l. Exceptions are the station downstream of Virgil reservoirs and the municipal drains in Two Mile Creek that cross Line 2 Road. Wet weather concentrations throughout the watershed approach or exceed 25 mg/l, with some concentrations exceeding 100 mg/l, indicating stressful conditions for aquatic life. High suspended sediment concentrations also negatively affect the quality of irrigation water.

E. coli: *E.coli* bacteria in surface waters indicate contamination from human/animal fecal material. Sources may include manure from agricultural operations or spread on crops; faulty septic systems and municipal sewage. The PWQO of 100 counts/100 mls is exceeded at most locations. Concentrations greater than 4500 counts/100 mls occurred at most stations, except in Four Mile Creek in St. David's and at the Creek mouth.

Benthic Invertebrate Results

Benthic invertebrates, snails, clams, crayfish, aquatic insects and worms, that live in the watercourses, have been found to be indicators of water quality. The numbers and types of invertebrates and their known sensitivity to nutrient enrichment and toxic effects of contaminants can be used to assess general water quality conditions of the streams in which they live. Typical measures include the following:

- **Total number of organisms**: the density of organisms found at a station is a general indicator of water, with high densities often suggesting nutrient enrichment and low densities indicating potential toxic effects
- **Number of species**: generally the more species that are present the better the quality of the water

- **EPT Taxa**: the number of sensitive aquatic insects in the Ephemeroptera (mayflies), Plecoptera (Stoneflies) and Trichoptera (caddisflies) orders is an indicator of good water quality
- **BIOMAP Index**: the BIOMAP index is calculated by adding up the numbers of different species multiplied by a sensitivity factor that ranks each species according to its sensitivity to pollution. The higher the BIOMAP score, the better the water quality.

Aquatic invertebrates were collected from 13 stations throughout the Niagara-on-the-Lake watersheds and results are tabulated below:

	8 Mile @ Lakeshore	8 Mile @ Church Road	4 Mile @ Lakeshore	4 Mile West Trib @ Penner	4 Mile north of Virgil Dam	4 Mile @ 5th Line	4 Mile @ Paxton Lane	6 Mile @ East West Line	6 Mile @ Line 1	6 Mile north of 4th Line	2 Mile @ Lakeshore	2 Mile @ Line 1 & Conc. 3	6 Mile @ Townline & Line 8
	1	2	4	5	6	7	8	9	10	11	12	13	15
TOTAL NUMBER OF ORGA	369	203	2256	940	1220	1652	2263	163	1548	624	419	1909	634
TOTAL NUMBER OF TAXA	23	25	27	14	33	30	25	27	31	36	31	26	28
EPT Taxa	1	1	2	0	2	2	2	2	5	6	2	1	5
BioMAP Index	8.3	7	7.5	6.5	6.4	6.9	7	5.1	5	6.9	7	5.5	9.3

Biomap scores suggest that the watercourses are moderately to highly enriched with nutrients with values of less than 7 indicating highly enriched and impaired conditions. This would suggest that the stations near the creek mouths of Two, Four, Six and Eight Mile creeks are moderately enriched, as well as Eight Mile Creek at Church Road, Four Mile Creek at Paxton Lane and Six Mile Creek at Townline & the extension of Line 8. The EPT taxa suggest that all stations are highly enriched with the exception of Six Mile Creek at Line 1, near 4th Line and at Townline & the extension of Line 8. Total number of taxa is highest at the "following stations: Four Mile Creek north and south of the Virgil Dams; Two Mile Creek and Lakeshore; Six Mile Creek at Line 1 and north of 4th Line. Based on Total Taxa, these stations would be considered to have the best water quality. The low densities at the two Eight Mile Creek stations, Six Mile Creek north of 4th Line and at Townline and Line, and Two Mile Creek at Lakeshore suggest poor water quality. These results are consistent with the routine monitoring results collected by NPCA.

The benthic results do not provide a very clear picture of water quality conditions other than to suggest that all stations exhibit nutrient-rich or impaired water quality conditions.

Stream Temperatures

Three continuous temperature recorders were installed from early May until October 2006 in the following locations:

- Eight Mile Creek about 500 m downstream of Lakeshore Road
- Four Mile Creek just upstream of Penner Street
- Two Mile Creek about 50 m upstream of Lakeshore Road

The resulting temperature graphs are shown in Figure 2.11. The following points are notable:

- All locations would be classed as warmwater streams with midsummer maximum temperatures reaching/exceeding 28 C
- The thermographs exhibit very similar trends with Two Mile Creek having slightly lower temperatures, followed by Eight Mile Creek, then Four Mile Creek
- A diurnal temperature fluctuation in the order of 4-5 C occurs throughout the period of record
- A significant drop in temperature occurs around May 22 – 24, which may represent the point when the irrigation system was turned on. Other than this observation, it is difficult to attribute any other temperature effects to the irrigation system, however it is possible that the irrigation system may have a moderating effect on midsummer maximum temperatures
- Relative to the records on Two Mile Creek and Eight Mile Creek, it does not appear that the Virgil Reservoirs exert a significant warming effect on lower Four Mile Creek

2.8 Aquatic Resources

Fish Communities

A total of 14 locations were inventoried in late fall 2005 to characterize existing fish communities using a backpack electofisher. Results are presented in Table 2.6. A total of 19 fish species were collected during the survey, which included stations in watercourses and municipal drains. Previous studies by NPCA also recorded goldfish and 3 spine stickleback from these watersheds.

Adult chinook salmon were observed/captured in the lower reaches of all the major watercourses: Two, Four, Six, and Eight Mile Creeks and move upstream in all of these systems until instream barriers prevent further migration. Dead salmon were observed in the irrigation channel along Carleton Road, west of Eight Mile Creek. Juvenile Chinook salmon were found in Six Mile Creek at Line 1 and between 4th Line and Carlson Road, and at Two Mile. Creek at Lakeshore Road. Adult rainbow trout were captured in both Six Mile and Two Mile Creek. A juvenile brown trout was captured in Two Mile Creek at Lakeshore Road.

No fish were captured in Four Mile Creek along Paxton Lane in St. David's and only one Green sunfish was captured in Four Mile Pond Creek (also known as 3 Mile Creek). Green Sunfish, Creek Chub, White Sucker, Common Shiner, Bluntnose Minnow and Round Goby (an introduced species) were generally found throughout the watercourses and drains inventoried.

Figure 2.11
Temperature 980978 Niagara-on-the-Lake
Eight Mile Creek

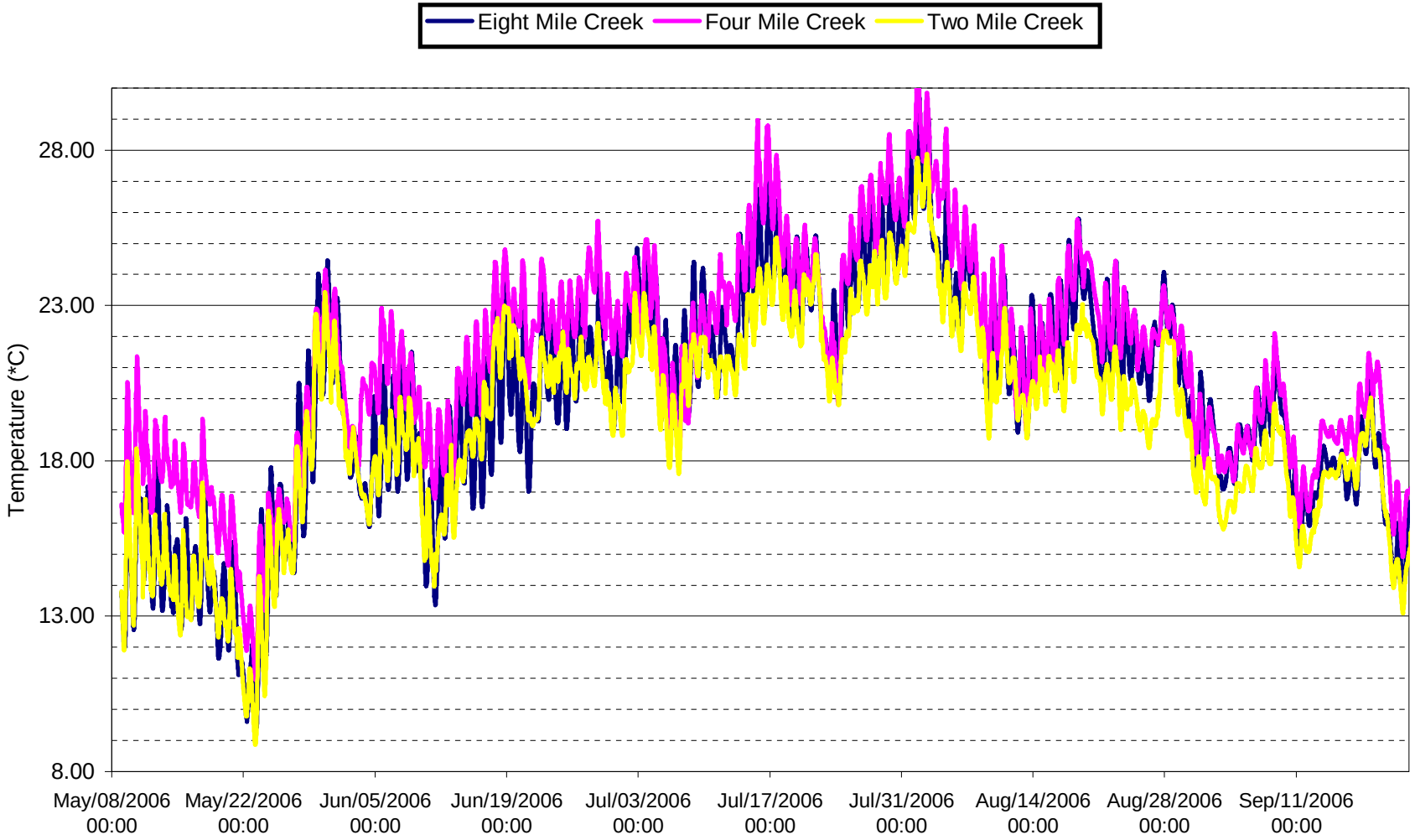


Table 2.6. Fish species captured														
	8 Mile @ Lakeshore	8 Mile @ Church Road	4 Mile @ Lakeshore	4 Mile West Trib @ Penner	4 Mile north of Virgil Dam	4 Mile @ 5th Line	4 Mile @ Paxton Lane	6 Mile @ East West Line	6 Mile @ Line 1	6 Mile north of 4th Line	2 Mile @ Lakeshore	2 Mile @ Line 1 & Conc. 3	4 Mile Pond Ck @ Lakeshore	6 Mile @ Townline & Line 8
Station	**Stn 1**	**Stn 2**	**Stn 4**	**Stn 5**	**Stn 6**	**Stn 7**	**Stn 8**	**Stn 9**	**Stn 10**	**Stn 11**	**Stn 12**	**Stn 13**	**Stn 14**	**Stn 15**
fishing seconds	595	672	930	407	426	344	368	648	824	422	772	479	244	478
area fished (m2)	250	60	100		125			50	50	50	100	75	25	40
Species							NOFISH							
Chinook Salmon	1	*			*			*			4			
Rainbow Trout								1	1		3	*		
Brown Trout											1			
Pumpkinseed		8									5			2
Green Sunfish	3		31	18	344	35			3		25		1	6
Bluegill			7											
Longear x Pumpkinseed					7									
Smallmouth Bass	5		6							4	7			
Creek Chub	13	27		35		1		31	53	33	9	7		59
White Sucker	4	16	1					3	8	7	1			5
common Shiner	9	2						8	6	6	3			
Striped Shiner											2			
Emerald Shiner	5		7								3			
Golden Shiner					1									
Bluntnose Minnow	13	20	5						70	58	49	16		2
Fathead Minnow			2						1		1	15		4
Carp					34	3			3	2				
Round Goby		1	2					11	1	7	1			
Gizzard Shad			105											
*** adult fish observed**														

A drive-by inventory of watercourses and drains in the watersheds was completed in the summer of 2006, as well as on several other occasions in 2006 during water quality sampling runs, to observe baseflow conditions.

Features were classified according to the following definitions (Agricultural Drain Maintenance in southern Ontario. (DFO 2002)) which are intended to be used for municipal drain classification purposes:

- Intermittent Streams: these features are dry for at least 3 months of the year, except after storms;
- Permanent Streams: these features flow permanently (meaning that they do not fit the definition of Intermittent Streams) or are permanently wetted

The following observations were made:

1) Watercourses south of municipal drains crossing York Road:
   a) the majority of these features are intermittent, except for:
   b) the headwater tributary of Six Mile Creek, west of Concession 7 Road; two headwater tributaries of Four Mile Creek, one east of Concession 5 Road, and one at York Road west of Paxton Lane. These tributaries are permanent.
2) Municipal drains and minor watercourses draining directly to Lake Ontario and the Niagara River are all intermittent
3) Two, Four, Six and Eight Mile watercourses downstream of the municipal drains are all permanent streams, although flows are significantly augmented by the irrigation system
4) The major drains linking the permanent headwater tributaries of Six Mile and Four Mile Creeks to the downstream watercourses are permanent, although flows are significantly augmented by the irrigation system
5) The portion of the municipal drain on Two Mile Creek between East West Line and Niagara Stone Road and the two western drains discharging to Four Mile Creek between Line 1 and their confluence with the creek are considered permanent, although flows are/maybe significantly augmented by the irrigation system
6) All other municipal drains are considered intermittent, although in some cases, their flows are significantly augmented by the irrigation system

Fish communities associated with each of the above features are as follows, based on the fish inventory work "(the numbered fish community types described below correspond to the numbered watercourse/drainage features described in the previous paragraph):

1) Two different communities exist:
   a) These features support fish on a seasonal basis only
   b) These features support a tolerant fish community with typical species: creek chub, bluntnose minnow, stickleback
2) These features support a highly tolerant fish community with typical species: creek chub, bluntnose minnow, and stickleback. They may also harbour a number of lake species, depending on whether there is sheltered habitat at the mouth of the feature
3) These watercourses support a tolerant/diverse warmwater fish community, represented by smallmouth bass, various sunfish species, white sucker, a variety of

minnows including common/striped shiner and creek chub. In addition, they support a migratory coldwater fish community including Chinook salmon, rainbow and brown trout, and have potential to support a tolerant coldwater fish community represented by juvenile Chinook salmon. Temperatures are considered too warm to support successful production of other salmonid species.

4) These features support a tolerant warmwater fish community including sunfish, creek chub, white sucker
5) These features support the same community as item 4.
6) These features support fish on a seasonal basis only. When flows are augmented by the irrigation system, these features may support a tolerant warmwater fish community including sunfish, creek chub, and white sucker.

For the watercourses and drains that support tolerant/diverse warmwater fish communities or migratory coldwater fish communities, there are a number habitat limitations:

- Water quality conditions in these features, as well as in the municipal drains that discharge into them, are poor due to nutrient enrichment that is sufficient to cause stress to fish communities. Chlorides, ammonia nitrogen, nitrates and nitrites, phosphorus and suspended sediment concentrations reach levels that are stressful to fish. In many cases, field tile drainage systems contribute to rapid delivery of excess nutrients and chloride to streams. The presence of numerous weirs within the municipal drains has the potential to create stagnant conditions that may cause further water quality impairment.
- Most features exhibit some degree of pool:riffle morphology, however erosion and sedimentation processes have created unstable conditions
- Instream cover is generally poor, although it is fair to good in the watercourses where there is more woody debris as these features have been protected to some degree by more well defined valley systems
- Riparian cover is generally poor throughout these features. Both the width of the undisturbed riparian zone and its quality in terms of frequency of disturbance of the vegetation contribute to reduced functions, in terms of water quality/runoff attenuation as well as bank stability
- Stream hydrology contributes to habitat instability. Because of the extensive network of municipal drains, stream hydrology is flashy for a rural watershed which results in both entrenchment and widening of stream channels

The existing municipal drain and irrigation system has been integral to the development of agriculture in the region, for over half a century and has changed the character of the aquatic systems within the watersheds. It is also important to recognize that the irrigation system and the network of municipal drains have had a number of positive impacts on fish and fish habitats, including the following:

- The irrigation system creates a source of baseflow or significantly enhances baseflows in many watercourses and municipal drains during the irrigation season, which also corresponds to important spawning periods for most warmwater fish

- The municipal drain system has created fish habitat in some cases, where none previously existed, and in other cases has enlarged existing drainage features and augmented flow through irrigation which has improved access for fish to these habitats

Municipal Drain Classification

A municipal drain classification system was developed by DFO to establish a protocol for protecting fish habitat in municipal drains for drain maintenance operations. Figure 2.12 shows the classified drains within the Niagara-on-the-Lake watersheds. The following table explains the classification system:

Type	Flow	Temperature	Species	Time Since Last Clean Out	Authorization
A	permanent	cold/cool/ unknown	no trout or salmon	n/a	class A
B	permanent	warm	top predators (bass, pike, muskie, crappie)	less than 10 years	class B
C	permanent	warm	baitfish	n/a	class C
D	permanent	cold/cool/ unknown	trout and/or salmon	n/a	project specific
E	permanent	warm	top predators (bass, pike, muskie, crappie)		project specific
F	intermittent	n/a	n/a	n/a	conditional

Drain maintenance activities may require a review and approval from NPCA (acting on behalf of DFO) or DFO depending on the sensitivity of the habitat in the drain. Drain construction and maintenance activities may also require a review and approval from

NPCA under the new general regulations (Ontario Regulation 155/06). This is summarized below:

Class Authorization A, B, C
Authorized Activities:
- brushing of side slope
- bottom cleanout
- debris cleanout
- full cleanout (Type C only)

Specific Terms and Conditions:
- width:depth ratio not increased
- shade producing side unaltered
- specific timing restrictions
- sediment control
- work in water only when flows are not elevated
- replanting of bank vegetation

Project Specific Evaluations: D & E
Drain types D and E are sensitive to maintenance activities. This however does not necessarily mean that work cannot proceed in these drains. These projects will be evaluated on a project by project basis to determine if the effects of maintenance can be mitigated. In some cases, a project specific authorization under the Fisheries Act may be required.

F Drains
F drains are intermittent systems and therefore a harmful alteration, disruption or destruction of fish habitat will not occur in these systems for cleanout work provided the following conditions are met:
- work is done in the dry
- all disturbed soils are stabilized upon completion of work

Contact with NPCA is required for any activities associated with Type D and E drains; for full cleanout of Type A and B Drains and for other activities associated with all drain types if they vary from the prescribed activities or terms and conditions outlined above.

Based on the fisheries work completed, the existing classification should be reviewed, as irrigation system operation complicates the interpretation of the DFO classification system. At this time, no changes to the Drain Classification system are proposed, however the Classification System needs to be reviewed in the context of the Niagara-on-the-Lake irrigation system, since the irrigation system changes a number of intermittent drains into permanent drains.

Fish Habitat Classification

Fish habitat falls into 1 of 3 categories: Type 1, Type 2 or Type 3, which has been determined by the Ministry of Natural Resources (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 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.

Figure 2.12 shows the fish habitat classifications within the Niagara-on-the-Lake watersheds. Based on the fish inventory work, the following changes to the habitat classification are recommended:

- Eight Mile Creek: main watercourse downstream of Niagara Stone Road;
- Six Mile Creek: main watercourse downstream of Niagara Stone Road and the headwater features upstream of Queenston Road, highlighted as Type 2 (Figure 2.12);
- Four Mile Creek: main watercourse downstream of the lower Virgil Dam; The Virgil Reservoirs; Four Mile Creek from the upper Virgil Reservoir to Line 5;
- Two Mile Creek: main watercourse downstream of Niagara Stone Road

2.9 Terrestrial Resources

Vegetation

Thirty four vegetation communities were noted in the study area: six cultural types, 1 beach-bar, 1 bluff, 4 marsh types, 6 swamp types and 14 forest types as shown in the following table (also Table 2.7 and 2.9):

ELC Code	Community Series	Ecosite	Number of communities in each ecosite	Total vegetation communities
CUM	Cultural Meadow	Mineral Cultural Meadow	1	1
CUT	Cultural Thicket	Mineral Cultural Thicket	2	2
CUW	Cultural Woodland	Mineral Cultural Woodland	2	2
CUP	Cultural Plantation	Coniferous Plantation	1	1
BBS	Beach/Bar	Mineral Shrub Beach/Bar	1	1
BLO	Bluff	Mineral Open Bluff	1	1
MAS	Shallow Marsh	Mineral Shallow Marsh	1	3
		Organic Shallow Marsh	2	
MAM	Meadow Marsh	Mineral Meadow Marsh	1	1
SWD	Deciduous Swamp	Oak Mineral Deciduous Swamp	2	6
		Maple Mineral Deciduous Swamp	2	
		Mineral Deciduous Swamp	2	
FOD	Deciduous Forest	Dry-Fresh Oak Deciduous Forest	3	14

Table 2.7: Niagara on the Lake Vegetation Communities

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
Cultural						
CUM1-1	Dry-Moist Old Field Meadow	• Height: 1-2m • Cover: >60% • Red-osier dogwood (*Cornus stolonifera*) dominant species • The occasional green ash (*Fraxinus pensylvanica*) and pin oak (*Quercus palustris*) are emerging within the community and growing between 10-25m in height, but covering only 10-25% of the canopy)	• Height: 0.5-1m • Cover: >60% • Wild carrot (*Daucus carota*) dominant with tall goldenrod (*Solidago altissima*) growing abundantly	• Height: 0.2-0.5m • Cover: >60% • Non-native herbaceous vegetation dominate the understory • Alsike clover (*Trifolium hybridum* ssp. *elegans*) and Kentucky bluegrass (*Poa pratensis* ssp. *pratensis*) dominate this layer • Annual ragweed (*Ambrosia artemisiifolia*) and tufted vetch (*Vicia cracca*) grow abundantly in this layer	• N/A	• Community has a history of human disturbance due to agricultural practices. These agricultural practices have since halted and the open landscape has been left to naturalize. However, non-native species have been the first to colonize (as is common) the disturbed soil, thus creating a community dominated by non-native species.
CUT1	Mineral Cultural Thicket	• Height: 10-25m • Cover: 25-35% • Black walnut (Juglans cinera), white pine (Pinus strobus), and green ash are the predominant species in the canopy	• Height: 2-10m • Cover: >60% • Common crabapple (*Malus pumila*) and dotted hawthorn (*Crataegus punctata*) grow abundantly in the sub-canopy	• Height: 1-2m • Cover: >60% • Grey dogwood (*Cornus foemina* ssp. *racemosa*), tartarian honeysuckle (*Lonicera tatarica*), and riverbank grape (*Vitis riparia*) all grow abundantly in this layer	• Height: 0.2-0.5m • Cover: >60% • Red raspberry (*Rubus idaeus* ssp. *melanolasius*) and garlic mustard (*Alliaria petiolata*) are abundant on the ground • Yellow avens (*Geum aleppicum*) is found occasionally in this layer	• This young successional community is a matrix of cultural thicket intermixed with white pine plantation.
CUT1-4	Gray Dogwood Cultural Thicket	• Height: 10-25m • Cover: 10-25% • Shagbark hickory (Carya ovata) pin oak, green ash, and bur oak (*Quercus macrocarpa*) grow occasionally in this sparsely vegetated layer	• Height: 2-10m • Cover: 25-35% • Green ash and dotted hawthorn are the dominant vegetation in the sub-canopy • The occasional grey dogwood and red-osier dogwood are also found in this layer	• Height: 0.5-1m • Cover: 35-60% • European buckthorn (*Rhamnus cathartica*) and grey dogwood are the predominant species in the understory	• Height: 0.2-0.5m • Cover: >60% • Tall goldenrod, western poison ivy (*Rhus rydbergii*), one-sided aster (*Symphyotrichum lateriflorum*), and Virginia creeper (*Parthenocissus inserta*)	• A drain flows through the center of the thicket. The drain is approximately 1m wide, very turbid, and flowing slowly. • This is a young community; in the early successional stages.
CUW1	Mineral Cultural Woodland	• Height: 10-25m • Cover: 30-50% • No one species dominates this layer; hybrid willow (*Salix* x *rubens*), black walnut, pin oak, and green ash all grow occasionally in this layer	• Height: 2-10m • Cover: >60% • European buckthorn dominates the sub-canopy. However this coverage is patchy; covering some areas densely and other areas sparsely.	• Height: 1-2m • Cover: 25-35% • Grey dogwood, riverbank grape, and young white elm trees (*Ulmus americana*) grow occasionally in this layer	• Height: 0.2-0.5m • Cover: 10-25% • The ground layer contains a variety of herbaceous vegetation which mainly includes: rosy sedge (*Carex rosea*), white avens (*Geum canadense*), lady's thumb (*Polygonum persicaria*), and marshpepper smartweed (*Polygonum hydropiperoides*)	• A creek, 2m wide and 10cm deep, flows north through this community. The water is flowing at a rate of approximately 1m/sec. The banks of this creek are 2m high and have a 45^{o} slope.
CUW1-A	Black Walnut Cultural Woodland	• Height: 10-25m • Cover: 35-60% • Butternut (*Juglans cinerea*) and black walnut (*Juglans nigra*) dominate the vegetation composition in the canopy	• Height: 2-10m • Cover: 10-25% • This community layer consists of deciduous trees including: hawthorn (*Crataegus* sp.), hop hornbeam (*Ostrya virginiana*), and green ash	• Height: 1-2m • Cover: >60% • The majority of the understory consists of successional vegetation • The understory is dominated by black raspberry (*Rubus occidentalis*) • Hawthorn, tartarian honeysuckle, and multiflora rose (*Rosa multiflora*) all grow abundantly in this layer	• Height: 0.2-0.5m • Cover: >60% • The predominant species in the ground layer are: enchanter's nightshade (*Circaea lutetiana* ssp. *canadensis*) and jewelweed (*Impatiens capensis*)	• This community contains a great amount of butternut trees

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
CUP3	Cultural Plantation	• Height: 10-25m • Cover: >60% • Coniferous trees have been planted in rows in this community and have grown into the canopy layer	• Height: 2-10m • Cover: 10-25% • Few coniferous trees are growing in this vegetation layer due to the canopy trees blocking the light to the trees below and since the trees were all planted at the same time, they are all relatively the same height (in the canopy)	• Height: 1-2m • Cover: 10-25% • A few shrubs constitute the understory • The predominant shrub is European buckthorn	• Height: 0.2-0.5m • Cover: 35-60% • Non-native herbaceous vegetation dominates the ground layer	
Beach/Bar						
BBS1	Mineral Shrub Beach/Bar	• Height: 1-2m • Cover: 25-35% • Sandbar willow (*Salix exigua*) grows abundantly in the canopy	• N/A	• Height: 0.5-1m • Cover: 10-25% • Young Siberian elm trees (*Ulmus pumila*) are the only vegetation growing in this layer.	• Height: 0.2-0.5m • Cover: 10-25% • Oak-leaved goosefoot (*Chenopodium glaucum* ssp. *glaucum*) grows abundantly in this layer	• The beach community is very disturbed. There are algae in the water, a significant amount of vegetation has been trampled, and structures have been built on the sand.
Bluff						
BLO1	Mineral Open Bluff Ecosite	• Height: 1-2m • Cover: 10-25% • A few black walnut, common crabapple, and European alder (*Alnus glutinosa*) grow in the canopy	• N/A	• N/A	• Height: 0.2-0.5m • Cover: 10-25% • Orchard grass (*Dactylis glomerata*), colt's foot (*Tussilago farfara*), meadow timothy (*Phleum pretense*), and English plantain (*Plantago lanceolata*)	• The black walnut trees are leaning but are in good condition. • Bank swallows were noted nesting in holes in the bluff.
Marsh						
MAS2-1	Cattail Mineral Shallow Marsh	• Height: 1-2m • Cover: >60% • Narrow-leaved cattail (*Typha angustifolia*) dominates this community layer • Reed canary grass (*Phalaris arundinacea*) grows occasionally in this layer	• Height: 0.5-1m • Cover: 35-60% • Jewelweed is abundant in this layer • A wide range of other herbaceous species are found occasionally in the sub-canopy	• Height: <0.2m • Cover: 25-35% • Canada clearweed (*Pilea pumila*) and yellow cow-lily (*Nuphar variegate*) grow abundantly in this layer. • Also found in this layer are the occasional: climbing nightshade (*Solanum dulcamara*) and riverbank grape	• N/A	• Carp have churned up the substrate in the lagoons.
MAS3-1	Cattail Organic Shallow Marsh	• Height: 1-2m • Cover: >60% • Narrow-leaved cattail dominates the canopy vegetation in this community • Reed canary grass grows abundantly in the canopy	• Height: 0.5-1m • Cover: 35-60% • Jewelweed and American stinging nettle (*Urtica dioica* ssp. *gracilis*) are abundant in this layer • A variety of herbaceous vegetation grow occasionally in this layer	• N/A	• N/A	• This community differs from the other shallow cattail marsh by that this marsh is situated on organic soils, as opposed to mineral. • The marsh is inundated with water for the majority of the year.
MAS3-7	Bur-reed Organic Shallow Marsh	• Height: 11-25m • Cover: <10% • This sparsely vegetated canopy contains a few white willow (*Salix alba*), European alder, and green ash	• Height: 1-2m • Cover: >60% • Large bur-reed (*Sparganium eurycarpum*) dominates this layer • Jewelweed grows abundantly in the sub-canopy	• Height: 0.5-1m • Cover: >60% • Devil's beggar-ticks (*Bidens frondosa*) grows abundantly in the understory, while nodding beggar-ticks (*Bidens cernua*) grow occasionally	• N/A	• This is the Lausdowne Pond, upon which people used to skate in the 1970s.

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
MAM2-9	Jewelweed Mineral Meadow Marsh	• Height: 0.2-0.5m • Cover: >60% • Jewelweed is the dominant vegetation in this community • Also growing abundantly in this layer is fox sedge (*Carex vulpinoidea*)	• Height: <0.2m • Cover: >60% • Spreading bentgrass (*Agrostis stolonifera*) is dominant in the sub-canopy • Field horsetail (*Equisetum arvense*) grows abundantly in this layer, as well as a variety of occasional herbaceous vegetation	• N/A	• N/A	• At the edge of the community is a ditch with water flowing through it. The ditch is approximately 0.6m wide.
Swamp						
SWD1-1	Swamp White Oak Mineral Deciduous Swamp	• Height: >25m • Cover: >60% • Swamp white oak (*Quercus bicolor*) dominates the canopy in this community • Silver maple (*Acer saccharinum*) and bur oak also grow abundantly in this layer	• Height: 2-10m • Cover: >60% • Green ash is the predominant species in the sub-canopy	• Height: 1-2m • Cover: 35-60% • Prickly ash (*Zanthoxylum americanum*) grows in abundance in the understory	• Height: <0.5m • Cover: 25-35% • Rice cutgrass (Leersia oryzoides) is the dominant species in the ground layer • A variety of herbaceous vegetation also grow occasionally in this layer	• This community type is provincially rare (S2S3) in Ontario. • There is no standing water in this community, but the soil is very moist.
SWD1-3	Pin Oak Mineral Deciduous Swamp	• Height: >25m • Cover: >60% • Pin oak and white elm are the predominant species in the canopy	• Height: 2-10m • Cover: 35-60% • European buckthorn is the shrub which dominates the sub-canopy	• Height: 1-2m • Cover: 10-25% • European buckthorn is the predominant species in the understory, along with an abundance of climbing poison ivy (*Rhus radicans* ssp. *negundo*)	• Height: <0.5m • Cover: 25-35% • Climbing poison ivy is also abundant in the ground layer • Garlic mustard is the second most abundant species in the ground layer	• This pin oak swamp is provincially rare (S2S3) in Ontario.
SWD3-2	Silver Maple Mineral Deciduous Swamp	• Height: >25m • Cover: >60% • Silver maple dominates the canopy in this swamp • White elm grows abundantly in this layer • A variety of oaks grow occasionally in the canopy: red oak (*Quercus rubra*), bur oak, and pin oak	• Height: 2-10m • Cover: 10-25% • The sub-canopy is far less vegetated than the canopy, containing only the occasional white elm and basswood (*Tilia americana*)	• Height: 1-2m • Cover: 35-60% • European buckthorn is the most abundant species in this layer • Other vegetation growing occasionally in this layer includes: red oak, pin oak, and Japanese barberry (*Berberis thunbergii*)	• Height: <0.2m • Cover: 35-60% • Fowl manna-grass (*Glyceria striata*) and western poison ivy are abundant in this layer, along with a variety of herbaceous plants growing occasionally in the community	• The man-made pond within this community is dominated by lesser duckweed (*Lemna minor*). • No standing water was found in the community at the time of the site visit in August, however there are large areas where water could potentially pool. • The topography of this community is relatively uniform with very low micro-hummocks with western poison ivy and other herbaceous plants on them. • There is some evidence of recent logging in this community, especially at the edge of the swamp, but not in the wetter areas. • European buckthorn is the only major invasive vegetation in the swamp community.
SWD3-4	Manitoba Maple Mineral Deciduous Swamp	• Height: 10-25m • Cover: >60% • Manitoba maple and white ash (*Fraxinus americana*) are the dominant species in the canopy	• Height: 2-10m • Cover: 35-60% • Manitoba maple dominates this layer of the community • White ash, dotted hawthorn, and European buckthorn all grow	• Height: 0.5-2m • Cover: 35-60% • An abundance of shrubs and herbaceous plants grow in the understory including: red-osier dogwood, grey dogwood, garlic mustard, jewelweed, Virginia creeper, and one-sided	• Height: <0.2m • Cover: 25-35% • Garlic mustard and common mallow (*Malva neglecta*) are the most common species in the ground layer • Other species growing abundantly in this	

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
			occasionally in the sub-canopy	aster	layer include: spreading bentgrass and ground ivy (*Glechoma hederacea*)	
SWD4-A	Alder Mineral Deciduous Swamp	• Height: 10-25m • Cover: >60% • Very large European alders (*Alnus glutinosa*) dominate the vegetation in the swamp. At one location these alders are 60cm in diameter (approximately 30 years old) and drain a substantial amount of water out of the saturated ground around them. • Crack willow grows abundantly in this layer • Cottonwood (*Populus deltoides* ssp. *monilifera*) dominates patches of the canopy	• Height: 2-10m • Cover: 35-60% • European alder is the dominant vegetation in the sub-canopy • Also found growing occasionally in this community layer are: European weeping birch (*Betula pendula*), Manitoba maple, tree-of-heaven (*Ailanthus altissima*), Norway maple (*Acer platanoides*), sweet cherry (*Prunus avium*), and black cherry (*Prunus serotina*)	• Height: 0.5-1m • Cover: 25-35% • Norway maple and Manitoba maple are two of many occasional species found in this vegetation layer. There are the predominant species in this layer.	• Height: 0.2-0.5m • Cover: >60% • Jewelweed, Canada clearweed, garlic mustard, rice cutgrass (*Leersia oryzoides*), and enchanter's nightshade all grow abundantly in the understory	• This community is dominated by non-native species. • In addition to the non-native species there is human disturbance at one location. At this location, there is a large quantity of broken concrete, bottles, and other garbage in the swamp. This community must have been used as a landfill in the past. • At another location the swamp is located in the riparian area around a creek (1m wide). This creek has been dredged in the past to depths of 1.5m. The creek flows to the north, and at the time of the site visit the water was flowing at 0.5m/sec. Many trees have been planted in the riparian zone and the surrounding area is mowed regularly. Natural debris which falls in the adjacent area is routinely cleared away by the landowner.
SWD4-1	Willow Mineral Deciduous Swamp (Willow Organic Deciduous Swamp)	• Height: 10-25m • Cover: >60% • Crack willow (*Salix fragilis*) dominates the canopy in this community • Manitoba maple and green ash are occasional in the canopy	• Height: 2-10m • Cover: 35-60% • Manitoba maple and green ash comprise the entire sub-canopy	• Height: 1-2m • Cover: 25-35% • Green ash, red-osier dogwood, and European buckthorn are all found occasionally in this layer	• Height: 0.5-1m • Cover: 35-60% • Jewelweed grows abundantly in the ground layer, while bristly sedge (*Carex comosa*) is found occasionally	• A creek flows swiftly through this community. • The community is located in a transitional area at the bottom of a slope. • The swamp is situated on organic soils; not mineral. However there is no classification in the ELC Guide (1998) for a willow organic deciduous swamp type, nor is there a general organic deciduous swamp classification. Therefore the closest classification is the willow mineral deciduous swamp.
Forest						
FOD1	Includes: <u>FOD1-A</u> Dry-Fresh Bur Oak Deciduous Forest <u>FOD1-1</u> Dry-Fresh Red Oak Deciduous Forest <u>FOD1-4</u> Dry-Fresh Mixed Oak Deciduous Forest	• Height: 10-25m • Cover: >60% • Red oak grows abundantly in the canopy • Black oak (*Quercus velutina*) and American beech are also occasionally found in this vegetation layer	• Height: 2-10m • Cover: >60% • Hop hornbeam and cherry trees (sweet cherry and black cherry) are the predominant species in the sub-canopy • The occasional sassafras tree (*Sassafras albidum*) are also located in the sub-canopy	• Height: 1-2m • Cover: 35-60% • A variety of vegetation comprises the understory, the majority of which includes: climbing poison ivy, grey dogwood, european buckthorn, sassafras, and witch-hazel (*Hamamelis virginiana*)	• Height: 0.2-1m • Cover: >60% • Enchanter's nightshade, garlic mustard, climbing poison ivy, jewelweed, and false solomon's seal (*Maianthemum racemosum* ssp. *racemosum*) are the predominant species in this layer	• The bur oak forest is relatively successional, but it is a high quality forest in terms of the vegetation species and condition. • A drainage channel runs through the mixed oak forest. • A butternut tree was found in the red oak forest.

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
FOD2-4	Dry-Fresh Oak-Hardwood Deciduous Forest	• Height: >25m • Cover: >60% • Red oak dominates the canopy vegetation. • Silver maple is also found occasionally in this layer.	• Height: 10-25m • Cover: >60% • Silver maple, green ash, and red oak both grow abundantly in this layer.	• Height: 2-10m • Cover: 25-35% • Silver maple, green ash, and white ash comprise the understory	• Height: 0.2-0.5 • Cover: 35-60% • Garlic mustard, enchanter's nightshade, and false solomon's seal dominate the ground layer in the forest	• A butternut tree was found in the forest. • The red oak forest has no evidence of logging; it is a rather open forest. The ground layer vegetation is sporadic and patchy. The forest is diverse because of its size, as opposed to the density of the varying vegetation. The forest is location on flat tableland. There may have been some small pools in this forest, but they have long since dried up at the time of the field work. • This parts of this forest are highly disturbed: • At one location, people are clearing the natural debris, free-range chickens are feeding on the vegetation, and sheds and equipment are located in the forest. The creek that runs through this community has been fenced off. The creek is deeply incised and has no floodplain vegetation. • At another location, the understory is not well stratified and may have been grazed by cattle in the past. There is also evidence of recent logging.
FOD4	Includes: <u>FOD4-A</u> Dry-Fresh Deciduous Forest <u>FOD4-2</u> Dry-Fresh White Ash Deciduous Forest	• Height: >25m • Cover: >60% • This community type is highly variable. Only one of the communities could be classified to vegetation type (white ash forest). The other communities have very diverse canopies which contain a variety of trees including: red oak, shagbark hickory, white ash, and sweet cherry. • The white ash forest is dominated by white ash	• Height: 10-25m • Cover: 35-60% • The sub-canopy is equally as diverse as the canopy including many of the same species such as: sweet cherry, shagbark hickory, white ash, and silver maple.	• Height: 1-2m • Cover: 35-60% • A variety of vegetation types comprise the understory including trees, shrubs, and herbaceous vegetation. The plants which comprise the majority of this layer include: blue beech (*Carpinus caroliniana* ssp. *virginiana*), white ash, alternate-leaved dogwood (*Cornus alternifolia*), red raspberry, garlic mustard, and spicebush (*Lindera benzoin*)	• Height: 0.2-0.5m • Cover: >60% • The ground layer is comprised of a variety of herbaceous vegetation which predominantly includes: Canada anemone (*Anemone canadensis*), western poison ivy, Virginia creeper, and garlic mustard	• The creek running through the white ash forest contains carp. • There is also a creek running through the highly varied deciduous forest.
FOD5	Includes: <u>FOD5-1</u> Dry-Fresh Sugar Maple Deciduous Forest <u>FOD5-5</u> Dry-Fresh Sugar Maple-Hickory Deciduous Forest	• Height: >25m • Cover: >60% • Sugar maple is the dominant species in the canopy • Red oak, white oak (Quercus alba), American beech, and white ash are also found occasionally in this layer	• Height: 10-25m • Cover: >60% • Sugar maple is the dominant species in the sub-canopy • In the sugar maple-hickory forest, shagbark hickory is also dominant in the sub-canopy • Also found occasionally in this layer are: basswood, American beech, and white ash	• Height: 1-2m • Cover: 10-25% • Sugar maple saplings are the dominant species in the understory • In the sugar maple-hickory forest, shagbark hickory saplings are co-dominant with the sugar maple saplings in the understory	• Height: 0.2-0.5m • Cover: 25-35% • Virginia creeper, garlic mustard, western poison ivy, and upright yellow wood sorrel (*Oxalis stricta*) are the most abundant species in the ground vegetation layer.	• These are good quality forests in general. • Portions these forests have been heavily logged. • There are areas of rock outcroppings in parts of the forest which are associated with the escarpment. • The strongest Carolinian elements are in the valleys or along the ravines; not at the top of the escarpment.

ELC Code	Vegetation Community	Canopy	Sub-canopy	Understory	Ground	Comments
FOD7	Lowland Forests Includes: <u>FOD7-2</u> Fresh-Moist Ash Lowland Deciduous Forest <u>FOD7-3</u> Fresh-Moist Willow Lowland Deciduous Forest <u>FOD7-4</u> Fresh-Moist Black Walnut Lowland Deciduous Forest <u>FOD7-5</u> Fresh-Moist Black Maple Lowland Deciduous Forest	• Height: 10-25m • Cover: >60% • Each vegetation community type is dominated in the canopy by the respective trees including: green ash, crack willow, black walnut, and black maple (*Acer saccharum* ssp. *nigrum*)	• Height: 2-10m • Cover: >60% • This community layer consists of a variety of deciduous trees including: Manitoba maple, green ash, black maple, cockspur hawthorn (*Crataegus crus-galli*), and basswood	• Height: 0.5-1m • Cover: >60% • Shrubs such as tartarian honeysuckle, grey dogwood, round-leaved dogwood (*Cornus rugosa*), black raspberry, and red-osier dogwood are abundant in the understory • Tree saplings such as green ash, Manitoba maple, and black walnut are also found occasionally in this vegetation layer	• Height: 0.2-0.5m • Cover: >60% • The predominant species in the ground layer are: Virginia creeper, bristly sedge, garlic mustard, jewelweed, tall goldenrod, black raspberry, and enchanter's nightshade	• These communities are typically located in the floodplain of a watercourse. • The ash lowland forest is very disturbed in some areas where trails have been cleared for hiking. In another area of this forest, a dirt bike course has been cleared along the floodplain. This community is also typically associated with a watercourse. In one case, a landowner is pumping water out of the creek. There are also areas where flood channels are evident (but dry at the time of the site visit in June). There are also patches of this forest that contain a great amount of non-native vegetation in the ground layer. • The willow lowland forest community is located along an old creek channel and there signs of occasional flooding (debris, etc.) in the forest. Portions of this community are quite narrow along the channel. These narrow portions have lower vegetation diversity than the other parts. • Butternut trees are abundant in the black walnut lowland forest. The black walnut forest is located on very flat topography with deeply incised gullies and temporary channels flowing through. Parts of this community are quite dense in the understory. There is a moderate amount of noise in this community from the nearby highway.
FOD9	Includes: <u>FOD9-A</u> Fresh-Moist Oak Deciduous Forest <u>FOD9-4</u> Fresh-Moist Shagbark Hickory Deciduous Forest	• Height: 10-25m • Cover: >60% • Pin oak, bur oak, and shagbark hickory are the dominant species in these communities • Blue beech and bur oak are also very abundant in this layer	• Height: 2-10m • Cover: 35-60% • Shagbark hickory, blue beech, hop hornbeam, and white ash are all abundant in the sub-canopy	• Height: 1-2m • Cover: 10-25% • Prickly ash, grey dogwood, and western poison ivy are abundant in this layer • Other species found occasionally in this community layer include: white ash, European buckthorn, and black cherry	• Height: 0.2-0.5m • Cover: 25-35% • Western poison ivy is the most abundant species in the ground layer • Other species which grow occasionally in the ground layer include: staghorn sumac, white ash saplings, enchanter's nightshade, Virginia creeper, wild crane's-bill (*Geranium maculatum*)	• The oak forest appears to have been drained. It may have been wetter in the past. There is the occasional pool of water, but the majority of the pools were dry at the time of the site visit in June.

Table 2.8: Significant flora

Scientific Name	Common Name (	Rarity Status					Location				
		G Rank	S Rank	COSEWIC	MNR	Niagara-Haldimand					Habitat
Carex lupuliformis	Hop-like Sedge (F)	G4	S1	END	END-R						deciduous swamp
Carex squarrosa	Squarrose Sedge (G)	G4G5	S2			R0					cultural woodland
											cultural meadow
											meadow marsh
Asimina triloba	Pawpaw (H)	G5	S3			R8					deciduous forest
Saururus cernuus	Lizard's Tail (I)	G5	S3								deciduous forest
Quercus palustris	Pin Oak (J)	G5	S3			R10+					deciduous forest
											deciduous forest
											cultural thicket
											cultural woodland
											deciduous forest
											deciduous forest
											deciduous forest
											deciduous forest

Scientific Name	Common Name ( )	Rarity Status					Location				
		G Rank	S Rank	COSEWIC	MNR	Niagara-Haldimand					Habitat
											deciduous swamp
											cultural meadow
											deciduous forest
											cultural woodland
											deciduous swamp
											Anthropogenic
											deciduous forest
Carya glabra	Pignut Hickory (K)	G5	S3			R3					deciduous forest
											deciduous forest
											deciduous forest
Juglans cinerea	Butternut (L)	G3G4	S3?	END	END	SR					bluff
											cultural woodland
											deciduous forest
											meadow marsh
											deciduous forest
											deciduous forest

Table 2.9: Niagara on the Lake vegetation communities. Provincially rare vegetation communities are indicated with an asterix (*).

ELC Code	Vegetation Community
Cultural	
CUM1-1	Dry-Moist Old Field Meadow
CUT1	Mineral Cultural Thicket
CUT1-4	Gray Dogwood Cultural Thicket
CUW1	Mineral Cultural Woodland
CUW1-A	Black Walnut Cultural Woodland
CUP3	Coniferous Plantation
Beach/Bar	
BBS1	Mineral Shrub Beach/Bar
Bluff	
BLO1	Mineral Open Bluff Ecosite
Marsh	
MAS2-1	Cattail Mineral Shallow Marsh
MAS3-1	Cattail Organic Shallow Marsh
MAS3-7	Bur-reed Organic Shallow Marsh
MAM2-9	Jewelweed Mineral Meadow Marsh
Swamp	
SWD1-1*	Swamp White Oak Deciduous Swamp
SWD1-3*	Pin Oak Mineral Deciduous Swamp
SWD3-2	Silver Maple Mineral Deciduous Swamp
SWD3-4	Manitoba Maple Mineral Deciduous Swamp
SWD4-A	Alder Mineral Deciduous Swamp
SWD4-1	Willow Mineral Deciduous Swamp
Forest	
FOD1-A	Dry-Fresh Bur Oak Deciduous Forest
FOD1-1	Dry-Fresh Red Oak Deciduous Forest
FOD1-4	Dry-Fresh Mixed Oak Deciduous Forest
FOD2-4	Dry-Fresh Oak-Hardwood Deciduous Forest
FOD4-A	Dry-Fresh Deciduous Forest

ELC Code	Vegetation Community
FOD4-2	Dry-Fresh White Ash Deciduous Forest
FOD5-1	Dry-Fresh Sugar Maple Deciduous Forest
FOD5-5	Dry-Fresh Sugar Maple-Hickory Deciduous Forest
FOD7-2	Fresh-Moist Ash Lowland Deciduous Forest
FOD7-3	Fresh-Moist Willow Lowland Deciduous Forest
FOD7-4	Fresh-Moist Black Walnut Lowland Deciduous Forest
FOD7-5	Fresh-Moist Black Maple Lowland Deciduous Forest
FOD9-A	Fresh-Moist Oak Deciduous Forest
FOD9-4	Fresh-Moist Shagbark Hickory Deciduous Forest

* These communities are provincially rare in Ontario.

		Dry-Fresh Oak-Maple-Hickory Deciduous Forest	1	
		Dry-Fresh Deciduous Forest	2	
		Dry-Fresh Sugar Maple Deciduous Forest	2	
		Fresh-Moist Lowland Deciduous Forest	4	
		Fresh-Moist Oak-Maple-Hickory Deciduous Forest	2	
Total Number of Communities				**34**

Swamp White Oak Deciduous Swamp is a provincially significant vegetation community with a rarity status of S2/S3 . Pin Oak Mineral Deciduous Swamp is also provincially rare in Ontario with a rarity status of S2/S3.

Of the 313 total flora species within the Niagara on the Lake study area, 7 of these species are of provincial significance within Ontario (Table 2.8). One of these 7 significant species has a status of S2: Squarrose Sedge (*Carex squarrosa*). The remaining 6 species have a status of S3. In total, there were 30 locations for significant provincially plants found in the study area; the majority of which were found in deciduous forest habitat.

Sixty-four species are considered locally rare in Niagara Region.

A total of 11 Carolinian and Southern indicator species (per Riley 1989) were found within the study area (Table 2.10). The greatest number of Carolinian and southern species were found in the Maple Mineral Deciduous Swamp ecosite (SWD3) and the Dry-Fresh Oak Deciduous Forest ecosite (FOD1).

Of the total number of vegetation plots surveyed in this study area, the Carolinian species were found at the following percentage of these plots:

- Tulip tree: 4%
- Pawpaw: 1%
- Sycamore: 1%
- Pignut hickory: 4%
- Black walnut: 18%
- Pin oak: 20.5%
- Black oak: 2.5%
- Virginia knotweed: 19%
- Running strawberry-bush: 2.5%
- Hop-like sedge: 1%
- Squarrose sedge: 4%

Table 2.10: Carolinian species in the study area (* indicates an endangered species as designated by COSEWIC and MNR)

	Scientific Name	Common Name	Rarity Status			Vegetation Community											
			G Rank	S Rank	NiagHald	CUM1	CUT1	CUW1	MAM2	SWD3	SWD4	FOD1	FOD4	FOD5	FOD7	FOD9	Anthropogenic
	Magnoliaceae																
	Liriodendron tulipifera L.	Tulip Tree	G5	S4	R6	x				x		x	x				
	Annonaceae																
	Asimina triloba (L.) Dunal	Pawpaw	G5	S3	R8									x			
	Platanaceae																
	Platanus occidentalis L.	Sycamore	G5	S4													
	Juglandaceae																
	Carya glabra (Miller) Sweet	Pignut Hickory	G5	S3	R3							x	x				
	Juglans nigra L.	Black Walnut	G5	S4			x	x	x	x	x	x		x	x		
	Fagaceae																
	Quercus palustris Muenchh.	Pin Oak	G5	S3	R10+	x	x	x		x					x	x	x
	Quercus velutina Lam.	Black Oak	G5	S4	SR							x	x				
	Polygonaceae																
	Polygonum virginianum L.	Virginia Knotweed	G5	S4			x			x		x		x	x	x	
	Celastraceae																
	Euonymus obovata Nutt.	Running Strawberry-bush	G5	S5										x			
	Cyperaceae																
*	Carex lupuliformis Sartw. ex Dewey	Hop-like Sedge	G4	S1						x							
	Carex squarrosa L.	Squarrose Sedge	G4G5	S2	R0	x		x									
Total Number of Carolinian Species in each Community Type						3	3	3	1	5	1	5	3	4	3	2	1

Pin oak was a prevalent tree species in the study area. Black walnut was also abundant in the study area, although it is suspected that some of these walnut trees could have been planted. Virginia knotweed was also a common herbaceous species in this area.

Wildlife

Natural habitat in the study area was largely confined to discreet, widely separated patches of forest, with very little substantial connection between them except for narrow agricultural drains. There were very few species adapted to breeding in the agricultural land between agricultural patches. The only larger area of connected habitat occurs along the escarpment. However, most of the habitat along the escarpment consists of forest and some thicket; there are few wetlands. Wetland habitat in the study area occurs mainly along the Four Mile Creek valley.

Amphibians

Surveys of early spring breeding amphibians were conducted as drive-by surveys from roads in mid-April 2006. Additional information on amphibians that breed later in the season was obtained in the course of intensive surveys. The area is notable for its lack of herpetofauna (reptiles and amphibians). Breeding habitats for species that breed in early spring, and make use of vernal pools (American toad, wood frog, spring peeper, gray treefrog and western chorus frog), is very scarce in the study area. Only one major breeding habitat was noted: the lagoon at the north end of the study area (Four Mile Pond), where abundant toads were heard during the breeding season. Three minor breeding habitats were noted in natural areas where small choruses of western chorus frogs and American toads were heard. There were also several locations where one or two American toads were heard in fields, indicating that small wet depressions in fields were used as breeding habitat by these adaptable species. However, no spring peepers, wood frogs or gray tree frogs, which have more stringent habitat requirements, were heard in the study area on any of the surveys. Western chorus frogs, which require vernal pools in successional habitat, were heard in five locations in the study area. The Herpetofaunal Summary Database (Oldham and Weller 2000), which summarizes reptile and amphibian records for Ontario dating back to the early 1900s, indicates that though these are some of the most common frog species in most parts of Ontario (including the western portion of the Niagara Peninsula), they are extremely scarce in the study area.

Only one other amphibian was found: a redback salamander, in the Woodend Conservation Area on the Niagara Escarpment, at the south end of the study area. A survey of records in the Herpetofaunal summary database indicates almost no records for redback salamanders in the study area, except along the Escarpment. Only one other salamander species has been reported from the study area in the Herpetofaunal Summary: red-spotted newt, which has been noted along the Escarpment and in one location on the north shore, in the vicinity of Four Mile Creek Pond.

Reptiles

No reptiles were found in the study area. The Ontario Herpetofaunal Summary database (Oldham and Weller 2000) shows that records of reptiles (both turtles and snakes) are extremely scarce in the study area, except for a few records along the escarpment. The records from the escarpment are mainly common species adapted to forested habitat (and a number of other habitats) such as eastern garter snake and Dekay's brown snake. The reason for the scarcity of species is likely lack of connectivity in the landscape, as most habitat patches are relatively isolated.

Breeding Birds

The taxonomic group with the highest diversity in the study area was birds. The diversity of species is low compared with many other areas of agricultural habitat in Ontario.

Most species found were those adapted to almost any habitat (such as American robin, song sparrow, northern cardinal and blue jay), which were noted in hedgerows, along agricultural drains, scattered trees, in most patches of natural habitat and around farm houses. The greatest diversity of breeding birds was associated with larger patches of forested habitat, and larger marshes. Few species nested in the agricultural matrix around forest patches. There was very little evidence of species nesting in orchards (birds were actively deterred from orchards), though there were a few thicket-nesting species that nested in vineyards (cedar waxwing, field sparrow and American goldfinch). A few species were noted mainly in manicured areas of farm properties, such as northern mockingbird and house finch.

The most common type of natural habitat in the study area was forest. In forest patches there were many species adapted to a wide variety of forest patch sizes and forest edges, such as great-crested flycatcher, gray catbird, red-eyed vireo and black-capped chickadee. Forest area-sensitive species, those which nest only in larger patches of forest and tend to become rare in fragmented landscapes, were rare, consisting only of two records for hairy woodpecker, one for red-breasted nuthatch and two records for Scarlet Tanager.

The few areas of marsh on Four Mile Creek pond and on the Four Mile Creek Reservoir mainly supported species adapted to a wide variety of floodplain habitats such as red-winged blackbird, warbling vireo and yellow warbler. Common yellowthroat, which nests in cattail marshes and thicket swamps, was noted in a few locations along Four Mile Creek and below the Escarpment. Only one area-sensitive species specific to marshes was noted: a marsh wren, on the Four Mile Creek pond.

Birds specific to successional habitat, such as thicket-nesting and grassland species, were also very rare, because of the lack of successional habitat. Savannah sparrow, a grassland species which is somewhat area-sensitive, was noted in a few locations in fields below the Escarpment. Highly area-sensitive grassland species, upland sandpiper and bobolink, were noted in only one location; a fallow field southeast of the intersection of Concession 7 and Line 8. Several savannah sparrows were noted in this location as well.

Mammals

A small number of mammal species were noted in the study area, mainly common species of urban and agricultural habitats such as opossum, raccoon, coyote and skunk. As with reptiles and amphibians, there are few records of small mammals in the study area, and the only species of small mammal found during this study (other than squirrel and chipmunk) was meadow vole. European hare, a species restricted to large grasslands (which is non-native), was noted in the same location as the only area-sensitive grassland bird species in the study area, in a fallow field southeast of Concession 7 and Line 8.

Significant Species

No significant amphibian, reptile or mammal species were noted. Two provincially rare bird species were noted: tufted titmouse (S2S3) and red-headed woodpecker (S3) . Both were found in forest habitat. Red-headed Woodpecker is considered a Species of Concern in Canada and Ontario. It nests in dead tree cavities in swamps and forests, and is considered a species at risk because of competition for habitat with European starling, a non-native species that also nests in tree cavities.

Tufted titmouse also nests in tree cavities. Its preferred habitat is deciduous forests with abundant tall understory vegetation and a dense canopy (Grubb and Pravasudov 1994). It is tolerant of isolated habitat. It is restricted to nesting in the southernmost parts of Ontario, as it does not migrate and cannot withstand severe winters. The Niagara Region is the largest centre of distribution for this species in Ontario (it is also found in the southwestern part of the province). Its range has expanded considerably in Ontario since the 1980s (Ontario Breeding Bird Atlas 2007).

One species noted in several locations in the study area, Carolina wren, is considered uncommon in Ontario (S3S4), as it is also restricted to the southern part of the province. However, this species is more common in the Niagara Region than it is in almost any other part of Ontario (BSC 2007). Carolina wren can nest in a wide variety of habitats, including manicured gardens, thickets and forests.
Its range has also expanded significantly in the province during the past few decades.

2.11 Land Use

Existing and future landuses are shown in Figure 2.14, including the Niagara Escarpment Planning Area and the Greenbelt/Region of Niagara Natural Heritage designations, based on mapping available through the Region of Niagara and the Town of Niagara-on-the-Lake. The areas shown within the Urban Area boundaries represent the future urban areas. Agricultural land use is shown, based on dated information from OMAFRA (1983).

The study area includes the municipalities of Niagara-on-the-Lake, St. Catharines and Niagara Falls, with the majority of the lands falling within Niagara-on-the-Lake.

Agriculture is the dominant land use with grape and tender fruits, nurseries and greenhouse operations making up the majority of the agricultural land uses. Since the time of the mapping, both vineyards and greenhouse/nursery operations have expanded into many of the areas shown as intensive/non-intensive agriculture to the extent that livestock and traditional agricultural cash crops are very limited.

Other land uses include old landfills, aggregate operations, agriculture-related commercial development, and food processing.

2.12 Summary of Existing Conditions

The major landform in the Niagara-on-the-Lake watershed is the Iroquois Plain, extending north of the Niagara Escarpment to Lake Ontario. The topography is very flat. The overburden materials are sandy in the northern and eastern portions of the study area, with the middle part of the study area comprised of silty and clayey till materials. This distribution of materials is also reflected in soils which tend to be sandy loams in the north and silty to clayey loams in the central part of the watershed. The soils tend to be easily eroded by stream channels, while the middle of the watershed is generally poorly drained.

In order to farm these lands, an extensive network of field tile drains, municipal drains and irrigation canals has been constructed. This network of drainage features connects the headwater areas on the Escarpment with the watercourses in the northern part of the watersheds. Essentially, the extensive network of municipal drains and field tile drains provides two important functions:

- the efficient conveyance of runoff from the flat topography of the middle portions of these watersheds, downstream of the Escarpment,
- the conveyance of irrigation water to the agricultural operations located throughout the watershed

As a result of this efficient drainage network, the hydrology of the watershed is flashy (i.e. storm runoff is delivered rapidly to drainage features), in some respects more typical of an urban than a rural watershed, and the stream channels (shown in red in Figure 7.1) are enlarging in response to this change. Urban development also contributes to this effect but to a relatively small extent, proportional to the urbanized portion of the watershed (see Urban Areas in Figure 7.1). Erosion and sedimentation of municipal drains and watercourses is also extensive, requiring regular drain maintenance and leading to significant gullying in the watercourses, as they have widened and deepened to accommodate flows. Examples of gullying can be found in the lower portions of Two, Four and Six Mile Creeks (shown in red in Figure 7.1).

The irrigation system, with proposed expansion, is capable of providing about 45,000 US gal./min of irrigation water that is pumped from the Welland Canal, the Niagara River and OPG facilities (the reservoir and tunnel), into the main system of municipal drains and watercourses. Landowners pay for the right to access this water and for the upkeep of the irrigation and drainage system. Irrigation water has also enhanced flows in many streams and municipal drains providing habitat for warmwater fish and even some coldwater migratory species.

Water quality conditions in the municipal drains and watercourses are impaired as a result of nutrient enrichment, bacterial contamination, high suspended sediments levels and high chloride levels. In particular, concentrations of Total Phosphorus and ***E.coli*** bacteria were orders of magnitude above the Provincial Water Quality Guidelines throughout the watershed. While levels of these contaminants are within federal irrigation water guidelines, they occur at levels that are stressful to aquatic life and degrade the quality of irrigation water. Sources of these contaminants include agricultural fertilizers, faulty septic systems, road runoff, point discharges such as field tile drains, storm sewers, and urban land uses. These sources enter surface drainage features through runoff, groundwater discharge and tile drainage systems. While irrigation water entering the drains is relatively clean, it rapidly becomes contaminated with these pollutants.

Regular municipal drain maintenance, including brushing, debris removal, dredging and erosion controls are necessary to facilitate water conveyance and land drainage, however these activities impair fish habitat and cause erosion and sedimentation in watercourses downstream. The lack of streamside vegetation along many watercourses and drains allows runoff carrying the above noted contaminants to enter these features unimpeded causing further water quality degradation. While revegetating these areas would help reduce erosion, sedimentation and water quality degradation effects, vegetated riparian areas may harbour pests that affect crop productivity and may take productive lands out of agricultural uses.

The remaining natural features within the study area are primarily limited to areas along the Escarpment and some woodlots and riparian lands. Though small and few in numbers, these areas sustain a high diversity of flora and fauna and provide habitat for many Carolinian species that are rare in Ontario. While these areas persist as a result of the good stewardship efforts of landowners, they continue to be under threat as urban and rural land use activities intensify. As areas urbanize, it is difficult to protect the form and function of existing natural areas such as woodlots and wetlands. Many agricultural landowners also noted that these features are sometimes considered a threat to agriculture because they harbour wildlife and pests, and also could be developed for agriculture. In the public meetings, it was identified that incentives are needed to encourage landowners to protect these features. Although there are few opportunities to develop quality naturally vegetated wildlife corridors along the watercourses and drainage features, there exist a number of large natural areas distributed in an east-west direction along the

Escarpment that offer potential as a corridor and core natural habitat for the region's flora and fauna.

3.0 ISSUES, OPPORTUNITIES AND CONSTRAINTS

Based on the technical studies, a preliminary list of issues, opportunities and constraints to meeting the watershed goals and objectives was developed as follows:

- **Water for Irrigation (availability, quality) –** the sustainability of agriculture depends on access to a sufficient supply of clean water for irrigation
- **Municipal Drain Maintenance and conflicts with Fisheries –** maintenance of municipal drains is essential for the provision of irrigation water and to drain lands for agricultural purposes. This is the primary function of municipal drains, however, these municipal drains and the watercourses into which they drain also support fish communities that may be negatively affected by drain maintenance activities. The presence of municipal drains and irrigation water has created and enhanced some aquatic habitats for fish.
- **Erosion and Sedimentation of Watercourses –** the construction and operation of the municipal drains and the operation of the irrigation system have caused erosion and sedimentation of the watercourses into which they drain. This leads to a need to maintain the drains regularly to ensure proper conveyance of water and drainage of land and also degrades the quality of habitat in the watercourses for aquatic communities
- **Water quality degradation from nutrient, bacteria, suspended sediment and chloride inputs from rural areas –** Use of fertilizers on agricultural lands, faulty septic systems, discharges from greenhouse operations all have potential to degrade water quality. The irrigation system, the network of municipal drains and the extensive tile drainage system create an efficient drainage network to deliver these contaminants to drains and watercourses. Degraded water quality in drains and watercourses negatively affects aquatic communities and the quality of water for irrigation. Clean water for irrigation is of paramount importance to landowners.
- **Impacts on Agricultural Lands from Wildlife –** a variety of conflicts between wildlife and production of grapes and tender fruits, as well as nursery operations exists. Deer, birds, rodents, plant diseases that may reduce crop yields through damage and disease are key concerns.
- **Quality/Quantity of well water –** there are some general concerns about the quality of private well supplies, in particular there are elevated levels of chloride and nitrates in local groundwater supplies
- **Protection of existing natural areas –** the remaining natural areas within the study area are of high quality and provide habitat for many sensitive flora and fauna. They have been protected through good stewardship practices by landowners, but face risks associated with intensifying rural and urban land uses
- **Lack of Riparian Vegetation –** both watercourses and municipal drains are poorly buffered by riparian vegetation resulting in a reduction of the functions of the buffer to attenuate runoff and reduce loading of nutrients, suspended sediments and bacteria. Landowners are concerned that riparian vegetation harbours insect and wildlife pests, plant diseases and occupies valuable farmland.

- Lack of Baseflow – without the operation of the irrigation system, many drainage features would lack sufficient baseflow to support more sensitive fish species
- Private Property Flooding/Erosion – flooding of agricultural lands affects the ability of landowners to farm their lands; soil erosion and erosion of the municipal drains removes productive soil and degrades watercourses
- High Flows and Pollutants from Urban Storm Sewers – urban stormwater from existing urban areas and from future urban areas can increase runoff and may be a source of nutrient, bacteria, suspended sediment and trace metal loading to streams
- Virgil Reservoirs – the reservoirs may be a sink for nutrients, bacteria, suspended sediment leading to poor water quality in the reservoirs
- Sources of Pollution to Streams (e.g. Landfills, aggregates, industry) – there are a number of local land uses that have the potential to negatively affect groundwater and surface water supplies

Highlighted issues above represent the priority issues from a technical perspective.

Based on the first public open house, participants identified **irrigation**, **drainage**, and **property rights** as the most important issues. Specific comments about these issues included:

Irrigation
- Water for irrigation is very important and many farmers have made investments in equipment.
- The importance of irrigation should be included in the study.
- Municipal drains are used to distribute water for irrigation.
- Irrigation is needed for crops.
- Irrigation is essential – particularly for tender fruits – as climate change is making summers hotter.

Drainage
- The drains require maintenance so they allow the flow of water.
- Farmers use municipal drains for drainage. Farmers need an outlet for their drainage tiles and need to be able to drain their fields; otherwise, they cannot farm.
- Drainage is important for crops.
- There is liability issues associated with drainage.

Property rights
- Individual property rights must be looked at. People are walking across farm properties and trespassing.
- Homes in areas designated as natural systems face renovation or rebuilding restrictions.
- There needs to be greater enforcement of the trespassing act to prevent people from trespassing onto farms.
- Property rights are of paramount consideration.

- There is a need for greater consultation between agencies and farmers.

Other issues raised included:

- The diversion of water from the canal to maintain irrigation;
- Liability – the current legal climate leaves farmers vulnerable;
- Rapid run off – there is vertical drainage into Four-Mile Creek;
- Erosion;
- Sediment in water courses;
- Balancing the ecosystem with agriculture and the economy; and
- Awareness of how drainage ditches are classified.

4.0 WATERSHED GOALS AND OBJECTIVES

4.1 Goals and Objectives

The importance of agriculture to the economic viability of the Niagara-On-The-Lake and the role that landowners play in protecting and maintaining the natural resources of the NOTL watersheds was an underlying theme in the development of the Watershed Goals and Objectives. **It was recognized that the goals and objectives for a healthy natural environment must be consistent with those of achieving long term agricultural sustainability.** It is important to recognize that the strategy is striving to achieve a healthy natural environment within the limits of a sustainable agricultural landscape and that the implementation of measures to protect and enhance the natural environment will proceed based on those measures that are economically feasible.

The following Goals and Objectives were developed for the Niagara-on-the-Lake watershed, based on the technical studies and input from the Steering Committee, and the public at the Open Houses.

Goals

- To protect the natural environments of the Niagara-on-the-Lake watershed ecosystem, within the context of a unique, fragile agricultural resource, for the benefit of humans and other terrestrial and aquatic life.
- To promote environmentally sound water management practices that recognizes the interdependencies between the watercourses and the irrigation/drainage system.

Communication & Education

- Demonstrate and promote awareness of the linkages between clean water, healthy lifestyles, and the economic viability of rural and urban land use
- Promote the use of surface and ground water having regard to human, agricultural, and ecological needs
- Promote environmental stewardship of aquatic and terrestrial habitats
- Streamline the regulatory and jurisdictional conflicts affecting rural and urban landowners

Water Quantity

- Manage flooding and erosion risks to human life and property to within acceptable limits
- Maintain, enhance or restore stream processes to support human uses, agricultural needs and natural habitats
- Manage flows to reduce erosion impacts on habitats and property
- Protect groundwater water resources in order to support ecological and human use functions

Water Quality

- Maintain or improve surface/groundwater water quality in order to support ecological and human use functions

- Reduce or eliminate surface films and deposits of non-native materials , nuisance algae growth, turbidity and odour to improve aesthetics of the area's surface waters

Aquatic Communities and Habitats
- Protect, enhance or restore populations of native aquatic species and their habitats

Terrestrial Communities
- Protect, enhance or restore the habitats that support terrestrial species and communities

4.3 Public Consultation Summary

A total of 3 public open houses were held as follows:
- April 20, 2006: to introduce the study and obtain feedback on goals, objectives and issues
- June 20, 2006: to review and comment on the long list of management objectives and the draft evaluation criteria
- June 19, 2007: to review and comment on the recommended plan and implementation recommendations and to identify willingness to participate in implementing the plan

Open House Number 1

This workshop was held to introduce the Niagara-on-the-Lake (NOTL) Watershed Plan project to the community and to provide participants with the opportunity to provide feedback into the study. Specifically, the purpose of the Public Workshop #1 was to:

- Introduce the Niagara-on-the-Lake Watershed Study and the planning team; and
- Share ideas on issues, goals and objectives for the future of the Niagara-on-the-Lake Watershed.

A total of 48 participants participated in the workshop. A complete list of participants is included in Appendix B.

The three most common issues included **irrigation**, **drainage**, and **property rights**. Specific comments about these issues included:

Irrigation
- Water for irrigation is very important and many farmers have made investments in equipment.
- The importance of irrigation should be included in the study.

- Municipal drains are used to distribute water for irrigation.
- Irrigation is needed for crops.
- Irrigation is essential – particularly for tender fruits – as climate change is making summers hotter.

Drainage

- The drains require maintenance so they allow the flow of water.
- Farmers use municipal drains for drainage. Farmers need an outlet for their drainage tiles and need to be able to drain their fields; otherwise, they cannot farm.
- Drainage is important for crops.
- There are liability issues associated with drainage.

Property rights

- Individual property rights must be looked at. People are walking across farm properties and trespassing.
- Homes in areas designated as natural systems face renovation or rebuilding restrictions.
- There needs to be greater enforcement of the trespassing act to prevent people from trespassing onto farms.
- Property rights are of paramount consideration.
- There is a need for greater consultation between agencies and farmers.

Other issues raised included:

- The diversion of water from the canal to maintain irrigation;
- Liability – the current legal climate leaves farmers vulnerable;
- Rapid run off – there is vertical drainage into Four-Mile Creek;
- Erosion;
- Sediment in water courses;
- Balancing the ecosystem with agriculture and the economy; and
- Awareness of how drainage ditches are classified.

Goals and Objectives

Participants were asked if they agreed with the study goal and if anything was missing from it or should be changed.

The most common addition mentioned was the **importance of irrigation**. Many of the participants felt that the importance of irrigation should be included in the study goal. Other suggested topics to incorporate into the study objectives included:

- The **impact of existing, new and proposed regulations** on farming, on individual properties, and on people in neighboring properties;
- **Property rights;** and
- **Protection for farmers** and their livelihoods.

Many of the participants felt that **drainage ditches should be removed** from the study objectives. It was felt that these are man-made and are not streams.

Open House Number 2

This workshop – the second in a series of public consultation workshops – was held to receive feedback on the "long list" of management actions that could be undertaken as part of the Niagara-on-the-Lake (NOTL) Watershed Plan; and the proposed evaluation criteria that will be used to create a "short list" of management actions for further consideration.

Specifically, the objectives of the workshop were to:

1. Communicate the "long list" of management actions.

2. Obtain feedback on the "long list" of actions, including:
   - Priority management actions;
   - Management actions that should not be considered; and
   - Any actions missing from the list.

3. Introduce the proposed criteria for choosing between management actions.

4. Obtain feedback on the criteria.

A total of 44 participants – mostly from the NOTL agricultural community – participated in the workshop. A complete list of participants is included in Appendix B.

Submission from Agricultural Landowners

John Kirkby presented a written submission that was endorsed by 42 signatories from a meeting of NOTL Agricultural Landowners on June 15, 2006. The following provides a concise summary of their concerns – the full submission is presented in Appendix E.

- The Agricultural Landowners reviewed 34 management actions (34 management actions are provided in the meeting's workbook);
- Concern that many of the 34 management actions are currently being carried out by other agencies;
- Concern that other individuals responding to the 34 management actions are not aware of other agency initiatives and potential overlap;

- Suggest that the NOTL Watershed study is taking place during an incredibly busy time of year for growers;
- It is important to remember that most of the land being studied in this study is on agricultural land;
- The irrigation system in NOTL has been operating informally for several years, concern that there is not an action plan to identify base flows within the watershed, and that the primary focus is on irrigation purposes for fish habitat;
- The existing irrigation system in NOTL (managed by Irrigation/Drainage Supervisor) has 139 growers who have contributed funds to the system; the system operates from May 15 – September 15 annually. Concern that the study team has not considered this system;
- Concern regarding the overall financial responsibility for the study, and that there is no apparent analysis of costs associated with the 34 management actions; and
- Suggest that the NPCA distribute existing booklets/information on land and water management to landowners adjacent to the study area.

Response to Questionnaire

Question 1: Management Actions

1A. Priority Management Actions

The two most commonly prioritized action items included:

Management Action #24: Implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads; and

Management Action #10a: Minimize flooding of agricultural lands by: upgrading culverts, removing weirs.

Other prioritized management actions included:

- Management Action #2a: The irrigation and drainage management system;
- Management Action #2c: The operation of Virgil Reservoirs;
- Management Action #10: Minimize flooding of agricultural lands;
- Management Action #12: Implement state of the art stormwater management facilities – source, conveyance, end of pipe for existing developments, where warranted (within villages);
- Management Action #21: Implement water quality monitoring program to assess impacts of drains on watercourses;
- Management Action #22: Work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff and contaminated groundwater; and,

- Management Action #23: Work with landowners to develop a 6m buffer zone (3 m on either side) adjacent to drains (and manage uses within the buffer); implement a demonstration project.
- Management Action #32: Identify opportunities to create habitat linkages along the Escarpment

Question 2: Evaluation Criteria

Participants reviewed the list of 8 evaluation criteria being considered to develop a "short list" of management actions for further consideration.

High Importance	Medium Importance	Low Importance
• Land requirements • Cost • Stakeholder/landowner acceptance	• Environmental benefits and impacts • Implementation considerations, including phasing • Recreational and cultural impact	• Ability to meet study objectives and targets • Agency Acceptance

Additional comments on criteria included:

- Some participants indicated that the evaluation criteria are too vague

Question 3: Additional Comments

A number of questions, concerns and suggestions were raised at the meeting:

- Some participants requested that meetings are not held during farmer's busy time of year – the next meeting should not be held until after fall harvest.
- Overall, the study should look to improve access to all areas for irrigation purposes.
- Some participants expressed concern regarding duplication of studies that are being conducted by different Agencies.
- Concern about overall cost of recommendations and who is going to pay other than landowners, general public or the Province.
- Request for explanation or information regarding what incentive programs are currently available to landowners.
- Tailor the timing of the process to allow for heavier participation on behalf of the stakeholders. Horticultural industry workload May – October restricts essential participation required to provide proper analysis.

- Sustainable agriculture should be a primary driver in any plan. Balancing sustainable agriculture with the natural environment is a doable long-term goal that is and must be a priority of any NPCA study.

Study Goals

The goals for the NOTL Watershed Plan, as revised based on feedback from Public Workshop #1, are:

To protect the natural environment of the Niagara-on-the-Lake watershed ecosystem, within the context of a unique, fragile agricultural resource, for the benefit of humans and other terrestrial and aquatic life.

To promote environmentally sound water management practices that recognizes the interdependencies between the watercourses and the irrigation/drainage system.

Open House Number 3

In the third open house, participants were asked to respond to a questionnaire asking them to indicate their willingness to participate in implementing any of the recommended actions by:

- participating in workshops providing information on how to implement the action
- participating in a tour illustrating examples of the management action
- volunteering to have a demonstration project implemented on your property
- implementing the management action if provided with incentives to do so

About 20 people attended the open house, but only 4 questionnaires were returned. Based on the response and discussions with individuals at the meeting, there was some interest in participating in measures to improve the drainage systems and watercourses, however, most felt that more justification for the measures was required, and in particular the benefits to agriculture needed to be clearly shown. Agricultural landowners also felt strongly that incentives were necessary if implementation was to be successful, since the environmental benefits that could be realized from implementing the measures were societal benefits, not just individual benefits.

5.0 LONG LIST OF BEST MANAGEMENT PRACTICES

To address the prioritized list of Issues, and the concerns raised in the public open houses, a long list of Best Management Practices were developed. These are listed under the major categories of Objectives below.

COMMUNICATION AND EDUCATION

1. Review current incentive programs that target farmers and update to address current issues and problems
2. implement a program to educate residents about the region's agriculture and its special needs, including:
    a. the irrigation and drainage management system
    b. the rationale for various agricultural practices used to produce grapes and tender fruits
    c. the operation of Virgil Reservoirs
3. provide educational/awareness material on landowner rights, trespass issues
4. develop guidelines summarizing legislation affecting landowners and explain how each piece of legislation affects activities on their property
5. provide a "one window" contact/source to answer questions about legislation
6. set up a committee of agencies, interest groups, landowners to address legislative gridlock and conflicts
7. develop workshops training sessions to encourage/educate landowners on good stewardship of aquatic and terrestrial habitats
8. develop brochure/educational materials on shoreline erosion, approvals, preferred stabilization techniques, protection of fish and aquatic habitats
9. Educate landowners re. benefits of riparian buffers

WATER QUANTITY

10. Minimize flooding of agricultural lands by:
    a. upgrading culverts, removing weirs
    b. remove excess fill adjacent to drains/watercourses
    c. increase capacity of channels/floodplain
11. implement state of the art stormwater management facilities – source, conveyance, end of pipe for new developments
12. implement state of the art stormwater management facilities – source, conveyance, end of pipe for existing developments, where warranted (within villages)
13. implement a strategic drain maintenance and management program to reduce costs and improve stability (erosion and sedimentation of drains):
    a. design drain morphology to be more self sustaining
    b. introduce grade controls (eg Six Mile Creek) to reduce erosion risk
    c. replace rip rapped side slopes with vegetated terraces (low growing vegetation)
    d. replace weirs with off-line irrigation ponds, where possible

e. remove any instream structures outside of the irrigation season - consider water conservation measures to reduce dependency on instream dams (see Water Quantity)
f. in areas where fish have access to drains, minimize drain maintenance activities during spring: April 1 – June 30

14. Review the irrigation management system to identify any existing conflicts in water use among landowners – encourage off-line storage and other water conservation strategies; identify opportunities to maintain baseflow; identify potential downstream impacts on watercourses
15. develop an erosion remediation plan using natural channel design principles for lower watercourses to address erosion and aquatic habitat impacts
16. review current levels of private water well use versus municipal supply.
17. identify active PTTW (groundwater) to ensure that impacts on baseflow are minimized
18. review Walker Landfill proposal re: impacts on baseflow to Six Mile and potentially Eight Mile Creek to ensure baseflow reductions are minimized
19. Review existing aggregate operations to assess potential impacts on groundwater levels and stream base flows
34. Where development opportunities exist, develop reach-based concept plans for each shoreline management reach to address aggradation/recession and aquatic habitat issues.

WATER QUALITY

20. review operation of Virgil Reservoirs and recommend measures to reduce resuspension of sediment and encourage littoral zone aquatic plant growth
21. implement water quality monitoring program to assess impacts of drains on watercourses
22. work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff and contaminated groundwater
23. work with landowners to develop a 6m buffer zone (3 m on either side) adjacent to drains (manage uses within the buffer); implement a demonstration project
24. implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads.
25. undertake a water and sediment quality monitoring program of Virgil Reservoirs to identify nutrient sources (insitu versus upstream)

AQUATIC COMMUNITIES AND HABITATS

26. work with landowners to manage land use activities adjacent to watercourses within a 10 m buffer zone (5 m on either side); implement a demonstration project
27. review water withdrawals from watercourses with the Irrigation Committee and landowners to maintain instream flows

29. implement a community-based restoration program for upper Four Mile Creek, focused on creating a vegetated buffer zone and stabilizing the stream using natural channel design principles
30. implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower Four Mile Creek, in cooperation with the Irrigation Committee:
    a. review water level management (maintain constant/rising water levels through to June 30)
    b. undertake riparian and littoral zone plantings

TERRESTRIAL COMMUNITIES

31. work with landowners to protect remaining forest and wetland habitats.
32. identify opportunities to create habitat linkages along the Escarpment
33. work with landowners to develop strategies to manage conflicts between wildlife and crops

A more detailed description of each measure is provided in Table 5.1. For each measure the following are provided:

- description of the action
- definition of problem addressed
- solution and benefits provided by the action
- environmental benefits and disadvantages

Table 5.1 - 1 of 8
WATERSHED MANAGEMENT ACTIONS

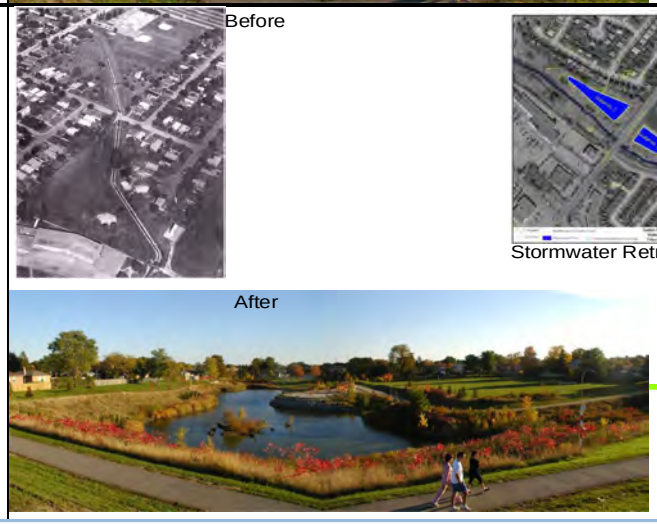
Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
10 *Minimize flooding of agricultural lands by:* **A) Upgrading culverts, remove weirs** **B) Removing excess fill adjacent to drainage feature** **C) Increase capacity of drainage feature**	A) Culverts may be open spanning structures or closed; weirs may be permanent or temporary B) Fill may be graded to the same level as surrounding land or removed offsite C) The drainage feature may be widened or deepened to increase its capacity to carry water	During major storm events, agricultural lands are flooded reducing crop yield, causing soil erosion and limiting access to crops: A) Undersized culverts and weirs reduce the capacity of drainage features to carry flood waters, resulting in flooding of agricultural lands B) Placing fill adjacent to drainage features may prevent floodwaters from reaching the drain extending the length of time lands are flooded C) Drains may be undersized relative to the size of frequent storm events, resulting in frequent flooding of adjacent lands		A) Larger culverts can be installed to reduce "backwater" effects; weirs can be removed in favour of constructing offline ponds for irrigation B) Lowering the elevation of the banks of the drainage feature to surrounding land level C) Increasing the capacity of the drain allows frequent storms to be contained in the drain	☛ less potential for soil erosion and sedimentation of drainage features ☛ fewer restrictions on fish movement ☛ increased potential for erosion of drains ☛ reduction in riparian/floodplain habitats
11 *Implement State-of-the-Art Stormwater Management for new developments*	These are structural and non-structural measures for controlling flooding, runoff, erosion, sediment and pollutants from urban land uses. Current technologies recognize the need to treat rainwater and stormwater as a resource to be protected and managed, and can be applied at different scales from individual properties, to subdivisions to watershed-wide. The 4 categories of urban Best Management Practices are: A) source controls; B) conveyance controls; C) stormwater ponds; and D) stream restoration	Urban development changes the character of the land resulting in increased runoff and reduced infiltration of water into the ground. This results in increased flooding and erosion of watercourses, reduced stream base flows; increased sediment loads and increased water temperatures. These changes degrade fish and wildlife habitat and increase the risk of flood and erosion damages on adjacent lands		By incorporating Urban BMP's into new developments, the pre-development hydrologic regime can be preserved, thus preventing the problems associated with increased runoff. Careful planning of urban development ensures that these measures can be accommodated during the construction phase.	☛ reduced runoff ☛ reduced sediment loading and erosion of watercourses ☛ improved fish and wildlife habitat ☛ improved water quality and moderated stream temperatures ☛ enhanced base flow ☛ need for more education/awareness of measures ☛ facilities require additional lands ☛ increased operations and maintenance costs
12 *Implement State-of-the-Art Stormwater Management for existing developments*	These are structural and non-structural measures for controlling flooding, runoff, erosion, sediment and pollutants from urban land uses. Current technologies recognize the need to treat rainwater and stormwater as a resource to be protected and managed, and can be applied at different scales from individual properties, to subdivisions to watershed-wide. The 4 categories of urban Best Management Practices are: A) source controls; B) conveyance controls; C) stormwater ponds; and D) stream restoration	Urban development changes the character of the land resulting in increased runoff and reduced infiltration of water into the ground. This results in increased flooding and erosion of watercourses, reduced stream base flows; increased sediment loads and increased water temperatures. These changes degrade fish and wildlife habitat and increase the risk of flood and erosion damages on adjacent lands		By retrofitting Urban BMP's into existing developments, the pre-development hydrologic regime can be partially restored thus addressing some of the problems associated with increased runoff. Generally retrofitting can only be applied to a portion of existing development (10-50%) due to technical limitations and lack of landowner support	☛ reduced runoff ☛ reduced sediment loading and erosion of watercourses ☛ improved fish and wildlife habitat ☛ improved water quality and moderated stream temperatures ☛ enhanced base flow ☛ need for more education/awareness of measures ☛ facilities require additional lands ☛ increased operations and maintenance costs

Table 5.1 - 2 of 8
WATERSHED MANAGEMENT ACTIONS

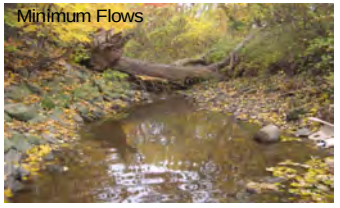
Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
13 ***Implement a strategic drain maintenance and management program to reduce costs and improve stability (reduce erosion and sedimentation in drains) by:*** **A) Design drain morphology (pattern) to be self-sustaining** **B) Introduce grade controls** **C) Replace hard bank treatments with vegetated terraces** **D) Replace weirs with off-line irrigation ponds** **E) Remove weirs outside of the irrigation season** **F) Minimize drain maintenance from April - June**	A) Use of terraces and a low flow channel with grade controls or meanders to reduce gradient B) Grade controls constructed out of natural materials to reduce gradients and increase channel roughness C) Vegetated terraces using low shrubs/groundcovers D) Off-line irrigation ponds can provide a reserve water supply E) Removable weirs consist of stop log structures that can be easily removed F) April – June time period is prime fish spawning period	Constructed drains are often over-wide, deep with steep gradients and steep, hardened side slopes. Weirs often are introduced to reduce water flow rates and increase water depths for access of irrigation pumps. This channel form is not self sustaining resulting in: A) Bank erosion or slumping B) Sediment accumulation C) Shallow water depths at low flow, limiting water access for irrigation and use by fish C) Lack of shading by vegetation and water stagnation resulting in growth of algae As a result, frequent maintenance is required including dredging, erosion controls and brushing.	 Typical Drain 	 Off-Line Irrigation Pond  Off-Line Irrigation Pond	Implementing measures to create a more self sustaining drain morphology will reduce the frequency of drain maintenance.	☛ reduced erosion and sedimentation ☛ reduced flooding ☛ improved riparian vegetation ☛ more efficient use of irrigation water ☛ Enhanced aquatic habitats ☛ additional land for off-line irrigation pond ☛ low growing vegetation requires some maintenance ☛ small increase in land requirements for drain
14 ***Complete a review of the irrigation system to identify water use conflicts; encourage water conservation including off-line storage; identify minimum flow requirements; identify potential downstream impacts***	As part of managing the irrigation and drainage system and planning for the future, it is important to ensure that existing supplies are used efficiently and potential environmental effects are identified. An investigation of the current rates of use and water use allocation would ensure all users have sufficient access to water. Key environmental concerns need to be identified, particularly minimum flow requirements and potential downstream effects (eg. erosion). Opportunities to provide off-line storage for irrigation	There are increasing demands for irrigation water and NOTL is looking at providing additional capacity. At the same time, it is not clear how efficiently current supplies are being used and what effects the current system has on downstream watercourses.	 Stream Bank Erosion  Stream Bank Erosion	 Minimum Flows  Suspended Sediment/Water Quality	Assess the current irrigation and drainage system to identify opportunities to improve the efficiency of water use, identify potential impacts on downstream watercourses and encourage water conservation	☛ more efficient use of irrigation water ☛ enhances aquatic habitats ☛ improved baseflow ☛ reduced erosion and sedimentation ☛ land requirements for off-line ponds ☛ more careful water budgeting
15 ***Develop an erosion remediation plan using natural channel design for watercourses to address erosion and fish habitat impacts***	Based on identified sites in watercourses, develop reach-based erosion management plan to address erosion problems and enhance fish habitat. Natural channel design encourages the re-establishment of natural morphology (meandering pool: riffle streams) using natural materials where possible for bank stabilization.	There are numerous erosion sites in the lower watercourses, some of which threaten buildings or represent sediment sources. There is no comprehensive strategy to address erosion problems, and continued erosion results in loss of land and degrades fish habitat. Traditional erosion controls tend to transfer the problem downstream, causing additional erosion	 Traditional Erosion Control  Natural Channel Design	 Natural Channel Design	Erosion control using natural channel design principles, address erosion problems by re-establishing natural channel morphology (pattern) and combined with use of natural material for bank stabilization helps prevent erosion problems from migrating downstream	☛ reduced erosion ☛ reduced sedimentation ☛ enhanced fish habitat ☛ improve natural channel morphology ☛ some additional land requirements

Table 5.1 - 3 of 8
WATERSHED MANAGEMENT ACTIONS

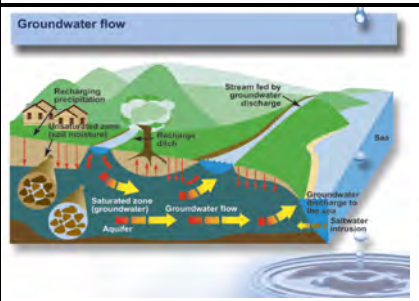
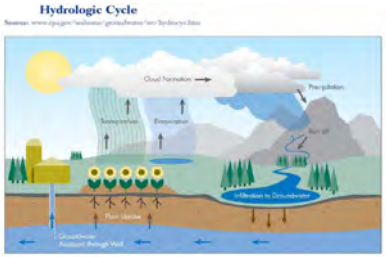
Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
16 *Review current levels of private well use versus municipal supply*	Municipal water supplies are generally available through the municipality, however many landowners still rely on private wells. An investigation of the current levels of use and quality/quantity issues associated with private wells would be completed.	Many private wells are still in use within the municipality, even though municipal water supplies are available. There are some concerns about the quality and water supply for private wells and it is unclear what impact these wells have on base flows of watercourses.	 	Complete an investigation of private well use to determine level of use, water quality/quantity issues and potential impacts on groundwater levels and stream base flows	☛ improved groundwater quantity and quality ☛ improved stream base flows ☛ updated inventory of water wells and private well use ☛ n/a
17 *Complete an inventory of active Permits (PTTW) to take Water to ensure that impacts on stream baseflow are minimized*	Contact holders of PTTW to confirm current levels of groundwater use and monitoring programs	There are a number of existing PTTW, however it is unclear what impact these groundwater withdrawals are having on local water tables and stream baseflows		Develop an inventory of current levels of groundwater use to ensure that local water tables and stream baseflows are not impacted.	☛ improved baseflows ☛ reduced groundwater contamination ☛ improved groundwater quantity ☛ n/a
18 *Review Walker landfill proposal re: impacts on baseflow to 6 Mile and 8 Mile Creeks*	The Environmental Assessment for the Walker Landfill has identified potential reduction in groundwater supply as a result of landfill development/expansion. A review of the potential impacts and proposed monitoring program would be completed to assess impacts to 6 Mile and 8 Mile Creeks	Current base flows in 6 Mile and 8 Mile Creek are currently very low. Any additional reductions would result in limitations for fish and potentially impact availability of water for irrigation		A review of the potential impacts and proposed monitoring program would be completed to assess impacts to 6 Mile and 8 Mile Creeks. The review would recommend possible mitigation measures to offset base flow losses.	☛ improved baseflows ☛ reduced groundwater contamination ☛ improved groundwater quantity ☛ n/a

Table 5.1 - 4 of 8
WATERSHED MANAGEMENT ACTIONS

Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
19 ***Review existing aggregate operations to assess potential impacts on groundwater levels and stream baseflows***	Review the PTTW of aggregate operations to determine current levels of groundwater use and review monitoring programs to identify potential impacts on groundwater table and stream baseflows	Current levels of groundwater use are not known and it is not clear if local water tables and stream base flows are affected	 	Review the PTTW of aggregate operations to determine current levels of groundwater use and review monitoring programs to identify potential impacts on groundwater table and stream baseflows	☛ improved baseflows ☛ reduced groundwater contamination ☛ improved groundwater quantity ☛ n/a
20 ***Review operations of Virgil Reservoirs to reduce resuspension of sediment and encourage littoral zone aquatic plant growth***	Review the current reservoir operation in terms of timing and extent of drawdowns. Identify possible changes to encourage aquatic plant growth. Undertake a pilot study to establish aquatic plants in the littoral zone.	The current operational practice may inhibit establishment of aquatic plants and result in resuspension of sediments and/or transport of sediments downstream. This results in degraded aquatic habitats both in and downstream of the reservoirs. Increased turbidity of irrigation water may also affect irrigation equipment and crop productivity	 Virgil Reservoirs  Lower Virgil Dam 	Re-establishment of littoral zone aquatic plants will stabilize sediment and reduce re-suspension. Modifications to reservoir operations may reduce the export of suspended sediment to the lower watercourse.	☛ reduced sediment loading/transport ☛ improved aquatic habitat ☛ reduced nutrient loads ☛ increased operations/maintenance costs ☛ more careful auditing of irrigation needs downstream of reservoirs
21 ***Implement a water quality monitoring program to assess the water quality in drains and watercourses***	Assess the water quality (nutrients, bacteria, suspended sediment, trace metals, pesticides and organic compounds) of selected drains and watercourse to characterize wet weather and dry weather water quality. Emphasis is on comparing water quality conditions to provincial standards for protection of aquatic life. Identify potential point and non-point sources of contaminant and nutrient loading.	Currently this little information on the surface water quality of streams and drains. It is not clear if water quality conditions are stressful to aquatic life.	   	Complete a wet and dry weather survey of streams and drains within the NOTL watershed to document existing water quality conditions.	☛ document current water quality conditions ☛ identify potential sources of nutrient and contaminant loading ☛ establish a benchmark water quality condition for future monitoring and to assess benefits of remedial actions ☛ analytical costs

Table 5.1 - 5 of 8
WATERSHED MANAGEMENT ACTIONS

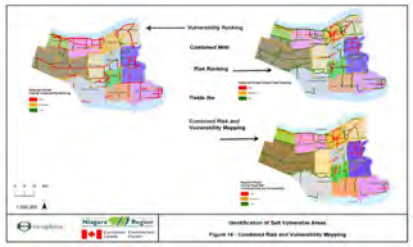
Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
22 *Manage nutrient (nitrogen and phosphorus) and pesticide use to reduce potential for contamination of runoff and groundwater*	Ensure that proper application rates and timing of application for nutrients and pesticides are adhered to. Identify buffer areas where reduced use of these materials may be possible to avoid direct impacts on surface waters. Develop individual landowner nutrient/pesticide management plans for agricultural lands	There is potential for nutrients and pesticides used in crop production to enter surface and ground waters, resulting in elevated levels of these parameters. Elevated levels may pose a concern to aquatic life and also may affect the quality of irrigation water for downstream users.		Work with landowners to ensure that application rates and timing of applications for nutrient and pesticide are appropriate to soil and crop conditions. Complete soil testing to confirm requirements. Develop appropriate buffers adjacent to drains/watercourses to reduce potential loading to drainage features. Complete as part of environmental farm plans.	☛ reduced nutrient and pesticide loading to drainage features ☛ reduced groundwater contamination ☛ protect/enhance aquatic habitats ☛ reduced soil loss and sedimentation ☛ reduced application in buffer areas may affect crop yield
23 *Work with landowners to develop a 6 m buffer zone (3 m on each side) adjacent to drains*	Limit types of crops and/or application rates of nutrients/pesticides within a 6m buffer area (3 m on each side) along drains.	Intensive cropping practices adjacent to drains have potential to result in increased loading of nutrients, sediment and pesticides to drains. This may result in increased stress to aquatic life and affect the quality of irrigation water for downstream landowners		Establish a 6 m buffer zone (3 m on each side) along drains where less intensive cropping practices are implemented and/or application rates of nutrients/pesticides are reduced	☛ reduced nutrient and pesticide loading to drainage features ☛ reduced groundwater contamination ☛ protect/enhance aquatic habitats ☛ reduced soil loss and sedimentation ☛ reduced application in buffer areas may affect crop yield
24 *Implement the recommendations of Niagara Region's Salt Vulnerability Study and extend it to cover local roads*	The Salt Vulnerability Study identified areas that are sensitive to contamination by salt within the watershed. Careful management of use of road de-icing materials, including road salt and other de-icing materials is recommended.	Levels of chloride in surface and groundwater are increasing within the watershed. These increasing chloride levels, while currently below levels that represent a threat to plant and animal life and humans, need to be managed to protect beneficial uses of local water supplies.	 	Initiate a road de-icing management program to reduce chloride loading to surface and ground waters.	☛ reduced chloride loads ☛ improved surface and groundwater quality ☛ protect aquatic habitats ☛ reduced sedimentation ☛ increased maintenance costs ☛ more careful monitoring of winter road conditions

Table 5.1 - 6 of 8
WATERSHED MANAGEMENT ACTIONS

Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
25 ***Undertake a water and sediment monitoring program of Virgil Reservoirs to identify nutrient/pesticide sources (within the reservoirs and upstream)***	Undertake a water and sediment testing program to identify levels of nutrients and pesticides in the reservoirs and upstream. Use this information to identify the contribution of various sources of these materials to downstream watercourses.	The export of nutrients and pesticides from Virgil reservoir may create stress to aquatic life in 4 Mile Creek and may affect the quality of irrigation water for downstream users.	 Virgil Reservoirs  Lower Virgil Dam 	Document levels of nutrients and contaminants in water and sediments in Virgil Reservoirs compared to upstream sources. This information can be used to determine the relative importance of different sources of contamination in water discharging from the reservoirs and whether levels represent a threat to aquatic life or affect the quality of irrigation water.	☛ reduced sediment loading/transport ☛ improved aquatic habitat ☛ reduced nutrient loads ☛ n/a
26 ***Work with landowners to develop a 10 m buffer zone (5 m on each side) adjacent to watercourses***	Limit types of crops and/or application rates of nutrients/pesticides within a 10m buffer area (5 m on each side) along watercourses.	Intensive cropping practices adjacent to watercourses have potential to result in increased loading of nutrients, sediment and pesticides to drains. This may result in increased stress to aquatic life and affect the quality of irrigation water for downstream landowners	 	Establish a 10 m buffer zone (5 m on each side) along drains where less intensive cropping practices are implemented and/or application rates of nutrients/pesticides are reduced	☛ reduced nutrient and pesticide loading to drainage features ☛ reduced groundwater contamination ☛ protect/enhance aquatic habitats ☛ reduced soil loss and sedimentation ☛ reduced application in buffer areas may affect crop yield
27 ***Review water withdrawals from watercourses with the Irrigation Committee and landowners to maintain instream flows***	Review current operations to identify potential conflicts among water users and identify instream flow requirements to ensure water supplies are available to all users as well as to provide minimum flows to watercourses, where feasible	There is currently an increasing demand for irrigation water leading NOTL to seek to expand its pumping capacity. Currently it is not known whether water use conflicts exist or whether excess flows are available to provide base flow to watercourses	 Nursery/Greenhouse  Golf Course Tender Fruits and Grapes 	Complete an audit of water users to document current demand and identify any water use conflicts. Identify periods of peak demand and whether excess water may be available to augment base flows in watercourses.	☛ more efficient use of irrigation water ☛ improved base flows ☛ enhanced aquatic habitats ☛ n/a

Table 5.1 - 7 of 8
WATERSHED MANAGEMENT ACTIONS

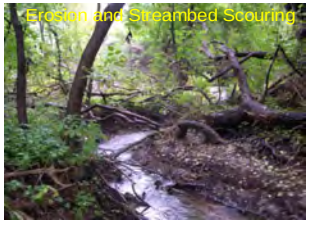
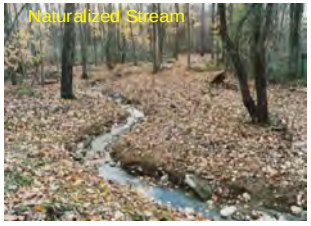
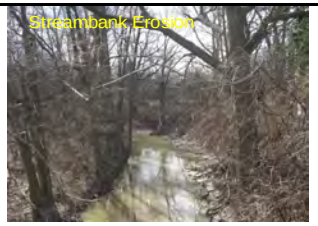
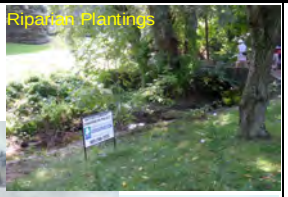
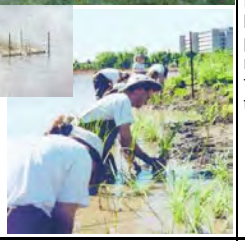
Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
29 ***Implement a community-based restoration program for upper 4 Mile Creek within St. David's, focused on creating a vegetated buffer zone and stabilizing the stream***	A replanting plan to restore the riparian zone along upper Four Mile Creek will be developed for implementation by landowners. Reach-based stream restoration plans using natural channel principles will be prepared to restore natural morphology and improve instream habitats. These concept plans will form the basis of a restoration plan to be implemented by landowners with community support.	Natural riparian habitats along upper 4 Mile Creek have been largely replaced with urban land uses. The stream channel has been de-stabilized as a result of land use changes, resulting in loss of streambed materials, eroding banks, channel abandonment, large debris jams. While there is evidence that stream temperatures are cool/cold, much of the necessary habitat to support resident coldwater fish has been lost.	  Erosion and Streambed Scouring	 Manicured banks  Naturalized Stream	Replanting of the riparian zone along upper Four Mile Creek will re-established shading and provide some bank stability. Reach-based stream restoration plans using natural channel principles will restore natural morphology (stream meanders, pool/riffle patterns) and improve instream habitats (including rehabilitating the stream bed).	☛ reduced erosion and sedimentation ☛ enhance aquatic habitat ☛ improve riparian vegetation ☛ improve natural channel morphology ☛ landowners would lose some uses within the riparian zone ☛ some additional land requirements for stream restoration
30 ***Implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower Four Mile Creek, in cooperation with the Irrigation Committee***	Develop stream restoration and riparian planting plans for lower Four Mile Creek (in Virgil) to address erosion problems and degraded aquatic habitats. Undertake a habitat enhancement program within Virgil Reservoirs consisting of littoral zone plantings (aquatic plants) and modifications to reservoir operations (where feasible) during April to June to enhance fish spawning.	Lower Four Mile Creek within Virgil has a number of areas of stream bank erosion representing sediment sources and in some cases threats to buildings/structures. In addition, high suspended loads and localized stream bed erosion and sedimentation have degraded fish habitat. The reservoirs currently offer productive fish habitat for warmwater species, but spawning and nursery habitat may be limited by lack of littoral zone vegetation and reservoir operations.	 Streambank Erosion  Natural Channel Design	 Riparian Plantings  Wetland plantings 	Develop stream restoration and riparian planting plans for lower Four Mile Creek (in Virgil) to address erosion problems and degraded aquatic habitats. Undertake a habitat enhancement program within Virgil Reservoirs consisting of littoral zone plantings (aquatic plants) and modifications to reservoir operations (where feasible) during April to June to enhance fish spawning.	☛ reduced erosion and sedimentation ☛ enhanced aquatic habitat ☛ protect/enhance forest/wetland habitats ☛ may affect irrigation water use during spring (April – June)
31 ***Protect remaining wetland and forest features***	Encourage landowners to continue to protect remaining wetland and forest features on their property.	Wetlands and forests have largely disappeared from the landscape within the NOTL watershed. Loss of wetland and forest habitat eliminates the habitat of many wildlife and fish species. In addition, wetlands can serve important functions of moderating runoff rates and improving water quality of watercourses. Forests can also moderate the effects of snowmelt runoff.	 Upper Six Mile Creek  Upland Forest	 Eight Mile Creek Wetland  Swamp forest	Encourage landowners to continue to protect remaining wetland and forest features on their property.	☛ improved water quality ☛ improve riparian vegetation ☛ protect forest/wetland habitats ☛ protect habitats for special status species ☛ land requirements to maintain wetlands/forests ☛ potential to attract wildlife that may reduce crop productivity

Table 5 .1 - 8 of 8
WATERSHED MANAGEMENT ACTIONS

Management Action	Description	Problem		Solution	Environmental Benefits / Disadvantages
32 ***Identify opportunities to create habitat linkages along the Escarpment***	Some of the more extensive natural areas within the NOTL watershed occur along the Escarpment, including some features on public lands. Opportunities to provide natural habitat linkages along this east-west corridor would be identified to enhance the corridor function of these features.	Forest and wetland habitats within the NOTL watershed are very limited and there is very little opportunity to provide wildlife corridors along the existing drainage and watercourse network. On the other hand, there are some extensive natural habitats along the Escarpment, however the corridor function of these features is also limited because they exist as isolated features.	 Linkage Opportunities – Niagara Escarpment	Identify opportunities to rehabilitate areas that would provide linkages between existing habitats along the Escarpment. These may be on a combination of public and private lands.	☛ protect forest/wetland habitats ☛ protect habitats for special status species ☛ land requirements to maintain wetlands/forests ☛ potential to attract wildlife that may reduce crop productivity
33 ***Work with landowners to develop strategies to manage conflicts between wildlife and crops***	Identify the types of habitats and species of wildlife that are of concern. Identify strategies that would reduce the exposure of crops to wildlife damage, while maintaining some habitats for these species. Develop lists of plant materials for use along riparian buffer areas that would reduce the potential of attracting nuisance wildlife.	Wildlife cause crop damage and may otherwise limit crop productivity. Natural areas such as woodlots and riparian areas have potential to attract nuisance wildlife and increase potential for crop damage.		Identify the types of habitats and species of wildlife that are of concern. Identify strategies that would reduce the exposure of crops to wildlife damage, while maintaining some habitats for these species. Develop lists of plant materials for use along riparian buffer areas that would reduce the potential of attracting nuisance wildlife.	☛ improve riparian vegetation ☛ protect forest/wetland habitats ☛ protect habitats for special status species ☛ land requirements to maintain wetlands/forests ☛ potential to attract wildlife that may reduce crop productivity
34 ***Where development opportunities exist, develop reach-based concept plans for each shoreline management reach to address aggradation/recession and aquatic habitat issues.***	The Lake Ontario shoreline	The Lake Ontario shoreline consists of a number of reaches that include bluffs, dynamic beaches, coastal wetland/barrier beaches. A number of these features are stable, while others may be aggrading/receding as a result of lake erosion processes. Adjacent land uses include public lands, agricultural lands and rural residential/cottage lands. Pressure for growth is primarily limited to redevelopment of existing properties. Some stabilization measures have been constructed by landowners. This piece meal approach to shoreline stabilization is not effective and may be aggravating erosion/aggradation elsewhere.		Develop reach-based concept plans, where development opportunities exist, to coordinate stabilization measures and ensure that problems are not transferred to adjacent reaches. Incorporate fish habitat enhancement appropriate to the reach type (bluff, beach, coastal wetland) to address impacts on fish habitat.	☛ reduced erosion and sedimentation ☛ enhanced aquatic habitat ☛ stabilization of shorelines ☛ cost of works greater than individual project works

6.0 SELECTION OF A PREFERRED PLAN

Input from Open Houses

The public meetings were well attended by a group of landowners representing grape and tender fruit growers, nursery and greenhouse operators, most of whom also contribute to and rely on the Niagara-on-the-Lake's irrigation system. This group dominated the meetings and in the second open house presented a collective response to the ranking of the long list of management recommendations. The responses of this group to the two workshops can be briefly summarized as follows:

- Watershed Goals and Objectives:
    - the watershed goals and objectives need to recognize that the long term sustainability of agriculture is fundamental to the area's economy and a healthy natural environment can only be achieved in the context of sustainable agriculture
    - municipal drains should be treated differently than watercourses in terms of watershed goals and objectives because they are privately owned and maintained at landowners expense for agricultural purposes

In the words of one landowner: "Sustainable agriculture should be a primary driver in any plan. Balancing sustainable agriculture with the natural environment is a doable long-term goal that is and must be a priority of any NPCA study."

- Issues, Opportunities and Constraints: the three top concerns of landowners are:
    - The maintenance of landowner/property rights
    - A growing body of legislative controls that limit landowners' rights (Green Belt Plan, Nutrient Management Act,
    - An adequate supply of water for irrigation
    - Use and maintenance of municipal drains for land drainage and water conveyance to support agriculture
- Response to the List of Management Recommendations:
    - The group was not in favour of any recommendations without clear benefits for agriculture, in particular, any that had potential to remove any land from productive use
    - The group identified a number of management actions that were currently practiced that they felt demonstrated environmental stewardship
    - The group supported a number of measures, but felt that their implementation should be left to the responsible agency, rather than potentially duplicating effort

- Evaluation Criteria:
    - The group felt that cost was the over-riding factor limiting the implementation of most measures
    - A secondary criteria would be a clear benefit to agriculture

High Importance	Medium Importance	Low Importance
• Land requirements • Cost • Stakeholder/landowner acceptance	• Environmental benefits and impacts • Implementation considerations, including phasing • Recreational and cultural impact	• Ability to meet study objectives and targets • Agency Acceptance

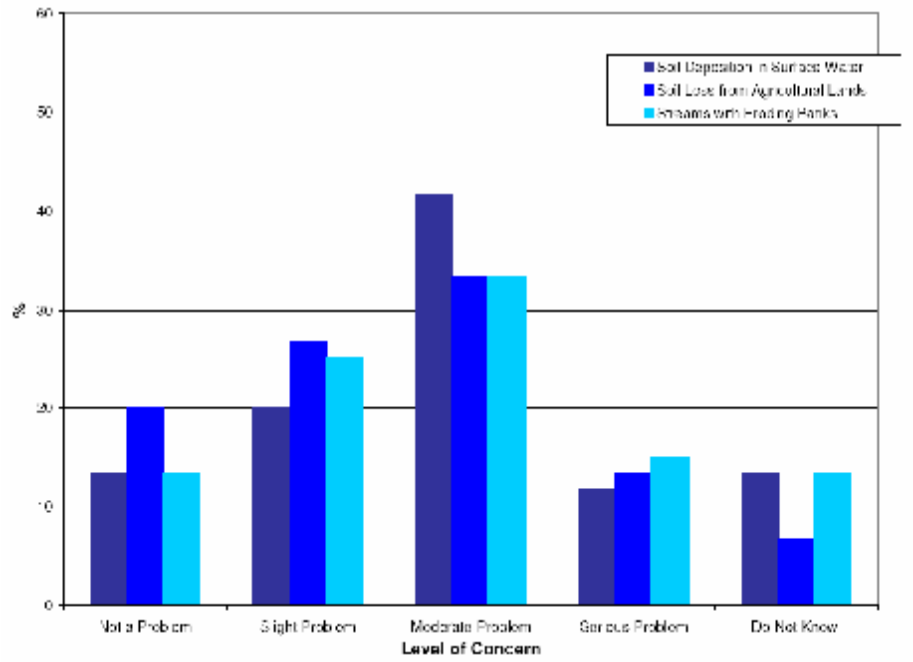
- Implementation Considerations:
    - Before new approaches to managing drains and the lands adjacent to them can be implemented, demonstration or pilot projects are needed to show that the new approaches will benefit agriculture
    - Implementation should build upon, not duplicate existing programs and projects. Where possible agencies need to coordinate their efforts.
    - Incentives programs need to be more responsive to the specialized needs of farmers in the NOTL watersheds
    - Surface runoff from storm and spring melt events, not irrigation water, is the primary cause of erosion and sedimentation effects in drains and watercourses, water pollution, and nuisance flooding. Implementation efforts need to address solutions to manage the effects of surface runoff on drains and watercourses.

Landowner Survey

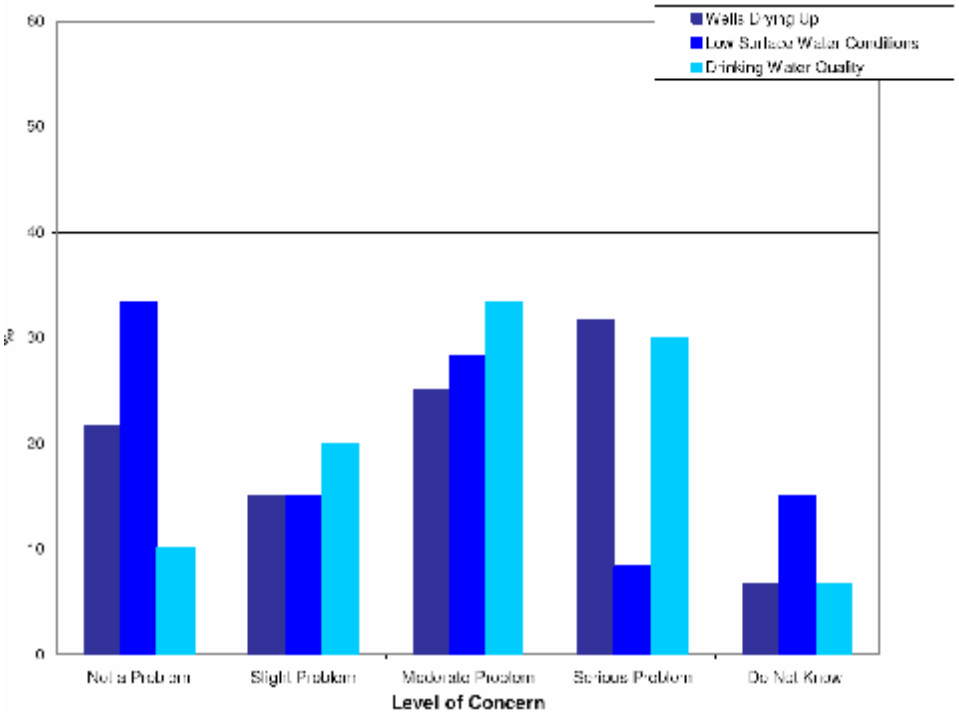
NPCA distributed a landowner survey to Ontario Federation of Agriculture members within their jurisdiction, and received 60 responses out of 255 mailouts within Niagara-on-the-Lake. The primary issues of concern identified through the survey were virtually identical to those from the open houses:

- Maintenance of irrigation for agriculture
- Property/landowner rights and infringement of legislation on those rights
- Erosion of streams and shorelines

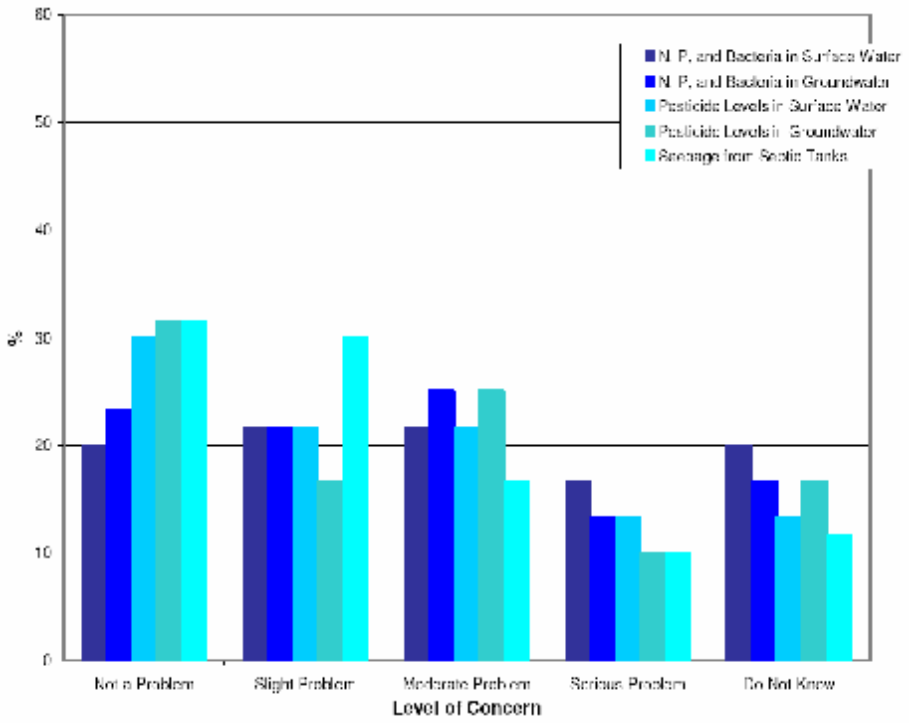
The results of the survey with respect to these issues are summarized in the following charts:



Erosion and sedimentation was generally perceived to be a problem by the majority of respondents.

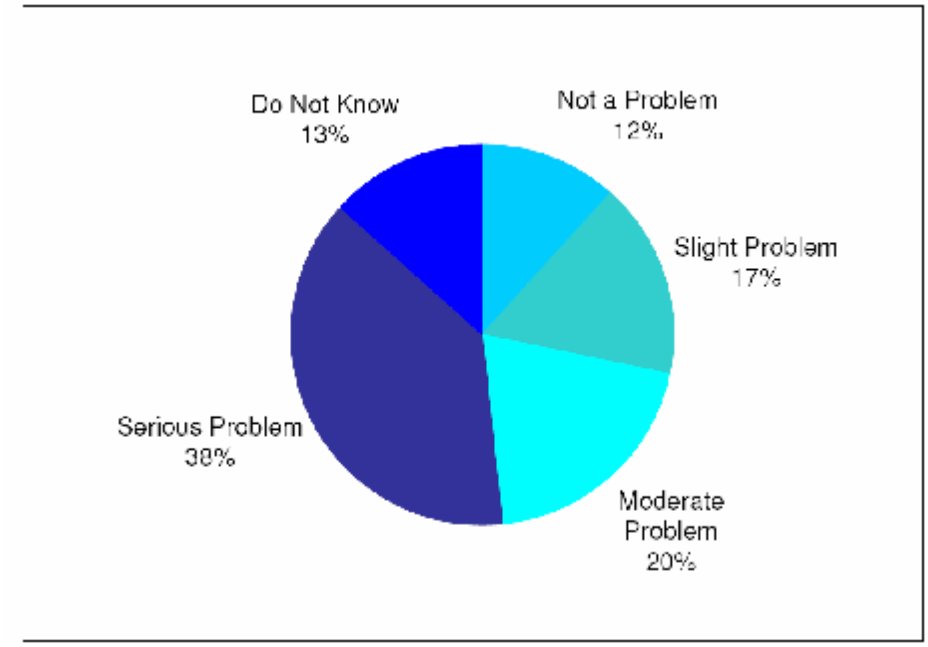


The availability and the quality of water were perceived to be a problem by most respondents.



Water quality in surface and groundwater supplies was considered to be a problem by most respondents.

Legislative Controls



Level of Concern – Cost of Complying with Land Use Regulations

Most respondents considered land use regulations to be a serious problem.
The following table, taken from the NPCA's Twenty Mile Creek Watershed Study, provides a summary of relevant provincial and federal legislation:

BOX 2 - MAJOR WATER RESOURCES LEGISLATION GOVERNING WATER MANAGEMENT IN ONTARIO

LAW	DESCRIPTION (RELATED TO WATER PROTECTION)	GOVERNMENT AGENCY
FEDERAL LEGISLATION		
Fisheries Act	Protects fish and fisheries habitat	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	Controls the manufacture, transportation, use, disposal of chemicals and waste that is not adequately regulated by other legislation	Environment Canada
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
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
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
Pesticides Act	Protects Ontario's land, and surface and ground water resources from damage due to improper use of pesticides	Ministry of the Environment
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
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
Municipal Act	Grants municipalities the power to pass bylaws related to water resources (e.g., bylaws that prohibit negative impacts on drains, dam construction and operation, and straightening of watercourses)	Ministry of Municipal Affairs and Housing
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

In addition, there are a number of other relevant Acts:

Green Belt Plan and Act: this protects sensitive natural areas and agricultural lands. In particular it protects all agricultural lands within Niagara-on-the-Lake.

Region of Niagara Environmental Protection Policy: The Region recently passed its environmental protection policy that identified environmental features and corridors within the Region that should be protected. Included in this designation were a number of stream corridors, including portions of Four Mile Creek that are municipal drains.

Town of Niagara On the Lake Act: this is a private members bill that gives Niagara-on-the-Lake the authority to maintain and manage the municipal drains and irrigation system within its jurisdiction, including apportioning the associated costs to the landowners using the system. The Act is similar to the Drainage Act, however it does not take precedence over the Drainage Act or the Conservation Authorities Act.

Niagara-on-the-Lake Permits to Take Water: Niagara-on-the-Lake has a number of water taking permits that allow the Town to withdraw water from the Welland Canal, the Niagara River and the Ontario Power Generation's pumped storage reservoir and tunnel. These permits require Niagara-on-the-Lake to monitor its withdrawals and also address the environmental impacts of irrigation water released into the municipal drains and watercourses within the Niagara-on-the-Lake.

Environmental Ranking of Management Actions

Table 6.1 provides a summary of environmental benefits of each of the long list of management actions. The list of environmental benefits is linked to the list of issues, opportunities and constraints:

- Reduced Flooding
- Reduced Erosion and Sedimentation
- Reduced Soil Loss
- More efficient use of irrigation water
- Improved Baseflow
- Groundwater quantity
- Reduced Sediment loads
- Reduced Nutrient, Chloride and Bacteria Loads
- Reduced Groundwater Contamination
- Improve natural channel morphology
- Improve riparian vegetation
- Protect/Enhance instream habitats
- Protect/Enhance forest/wetland habitats
- Protect Habitats for special status species
- Improved environmental Stewardship
- Reduce Regulatory/Jurisdiction conflicts

6.1 Evaluation of Management Actions

The long list of management actions was ranked, based on the following evaluation criteria:

- Ability to meet study objectives and targets
- Land Requirements
- Cost
- Stakeholder/Landowner acceptance
- Agency acceptance
- Recreational and cultural impact

Table 6.2 shows the results of the ranking of management actions based on the evaluation criteria.

TABLE 6.1 IDENTIFICATION OF ENVIRONMENTAL BENEFITS OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	WATERSHED BENEFITS															
		Reduced Flooding	Reduced Erosion and Sedimentation	Reduced Soil Loss	More efficient use of irrigation water	Improved Baseflow	Groundwater quantity	Reduced Sediment loads	Reduced Nutrient, Chloride and Bacteria Loads	Reduced Groundwater Contamination	Improve natural channel morphology	improve riparian vegetation	Protect/Enhance instream habitats	Protect/Enhance forest/ wetland habitats	Protect Habitats for special status species	Improved environmental Stewardship	Reduce Regulatory/ Jurisdiction conflicts
	COMMUNICATION AND EDUCATION																
1	Review current incentive programs that target farmers and update to address current issues and problems															X	X
2	implement a program to educate residents about the region's agriculture and its special needs, including:															X	
2a	the irrigation and drainage management system																
2b	the rationale for various agricultural practices used to produce grapes and tender fruits																
2c	the operation of Virgil Reservoirs																
3	provide educational/awareness material on landowner rights, trespass issues															X	X
4	develop guidelines summarizing legislation affecting landowners and explain how each piece of legislation affects activities on their property																X
5	provide a "one window" contact/source to answer questions about legislation																X
6	set up a committee of agencies, interest groups, landowners to address legislative gridlock and conflicts																X
7	develop workshops training sessions to encourage/educate landowners on good stewardship of aquatic and terrestrial habitats															X	
8	develop brochure/educational materials on shoreline erosion, approvals, preferred stabilization techniques, protection of fish and aquatic habitats															X	X
9	Educate landowners re. benefits of riparian buffers															X	

TABLE 6.1 IDENTIFICATION OF ENVIRONMENTAL BENEFITS OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	WATERSHED BENEFITS																
		Reduced Flooding	Reduced Erosion and Sedimentation	Reduced Soil Loss	More efficient use of irrigation water	Improved Baseflow	Groundwater quantity	Reduced Sediment loads	Reduced Nutrient, Chloride and Bacteria Loads	Reduced Groundwater Contamination	Improve natural channel morphology	improve riparian vegetation	Protect/Enhance instream habitats	Protect/Enhance forest/ wetland habitats	Protect Habitats for special status species	Improved environmental Stewardship	Reduce Regulatory/ Jurisdiction conflicts
	WATER QUANTITY																
10	**Minimize flooding of agricultural lands by:**																
10a	**upgrading culverts, removing weirs**	X															
10b	**remove excess fill adjacent to drains/watercourses**	X															
10c	**increase capacity of channels/floodplain**	X															
11	**implement state of the art stormwater management facilities – source, conveyance, end of pipe for new developments**	X	X			X	X	X	X								
12	**implement state of the art stormwater management facilities – source, conveyance, end of pipe for existing developments, where warranted (within villages)**	X	X			X	X	X	X								
13	**implement a strategic drain maintenance and management program to reduce costs and improve stability (erosion and sedimentation of drains):**																
13a	**design drain morphology to be more self sustaining**		X	X				X			X		X				
13b	**introduce grade controls (eg 6 Mile Creek) to reduce erosion risk**		X	X				X					X				
13c	**replace rip rapped side slopes with vegetated terraces (low growing vegetation)**		X	X				X			X	X	X				
13d	**replace weirs with off-line irrigation ponds, where possible**		X						X				X				
13e	**remove any instream structures outside of the irrigation season - consider water conservation measures to reduce dependency on instream dams (see Water Quantity)**				X								X				
13f	**in areas where fish have access to drains, minimize drain maintenance activities during spring: April 1 – June 30**												X				

TABLE 6.1 IDENTIFICATION OF ENVIRONMENTAL BENEFITS OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	WATERSHED BENEFITS															
		Reduced Flooding	Reduced Erosion and Sedimentation	Reduced Soil Loss	More efficient use of irrigation water	Improved Baseflow	Groundwater quantity	Reduced Sediment loads	Reduced Nutrient, Chloride and Bacteria Loads	Reduced Groundwater Contamination	Improve natural channel morphology	improve riparian vegetation	Protect/Enhance instream habitats	Protect/Enhance forest/ wetland habitats	Protect Habitats for special status species	Improved environmental Stewardship	Reduce Regulatory/ Jurisdiction conflicts
	WATER QUANTITY (continued)																
14	Review the irrigation management system to identify any existing conflicts in water use among landowners – encourage off-line storage and other water conservation strategies; identify opportunities to maintain baseflow; identify potential downstream impacts on watercourses		X		X	X											
15	develop an erosion remediation plan using natural channel design principles for lower watercourses to address erosion and aquatic habitat impacts		X					X			X	X	X				
16	review current levels of private water well use versus municipal supply.						X										
17	identify active PTTW (groundwater) to ensure that impacts on baseflow are minimized					X	X										
18	review Walker Landfill proposal re: impacts on baseflow to 6 Mile and potentially 8 Mile Creek to ensure baseflow reductions are minimized					X	X										
19	Review existing aggregate operations to assess potential impacts on groundwater levels and stream base flows					X	X										
34	Where development opportunities exist, develop reach-based concept plans for each shoreline management reach to address aggradation/recession and aquatic habitat issues.		X										X				
	WATER QUALITY																
20	review operation of Virgil Reservoirs and recommend measures to reduce resuspension of sediment and encourage littoral zone aquatic plant growth		X					X	X								
21	implement water quality monitoring program to assess impacts of drains on watercourses								X				X				
22	work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff and contaminated groundwater								X	X			X				
23	work with landowners to develop a 6m buffer zone (3 m on either side) adjacent to drains (manage uses within the buffer); implement a demonstration project		X	X				X	X			X					
24	implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads.								X	X			X				

TABLE 6.1 IDENTIFICATION OF ENVIRONMENTAL BENEFITS OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	WATERSHED BENEFITS															
		Reduced Flooding	Reduced Erosion and Sedimentation	Reduced Soil Loss	More efficient use of irrigation water	Improved Baseflow	Groundwater quantity	Reduced Sediment loads	Reduced Nutrient, Chloride and Bacteria Loads	Reduced Groundwater Contamination	Improve natural channel morphology	improve riparian vegetation	Protect/Enhance instream habitats	Protect/Enhance forest/ wetland habitats	Protect Habitats for special status species	Improved environmental Stewardship	Reduce Regulatory/ Jurisdiction conflicts
25	undertake a water and sediment quality monitoring program of Virgil Reservoirs to identify nutrient sources (insitu versus upstream)		X					X	X								
	AQUATIC COMMUNITIES AND HABITATS																
26	work with landowners to manage land use activities adjacent to watercourses within a 10 m buffer zone (5 m on either side); implement a demonstration project		X	X				X	X		X	X	X				
27	review water withdrawals from watercourses with the Irrigation Committee and landowners to maintain instream flows				X	X							X				
29	implement a community-based restoration program for upper 4 Mile Creek, focused on creating a vegetated buffer zone and stabilizing the stream using natural channel design principles							X	X		X	X	X				
30	implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower 4 Mile Creek, in cooperation with the Irrigation Committee:																
30a	review water level management (maintain constant/rising water levels through to June 30)				X								X				
30b	undertake riparian and littoral zone plantings		X									X	X				
	TERRESTRIAL COMMUNITIES																
31	work with landowners to protect remaining forest and wetland habitats.													X	X		
32	identify opportunities to create habitat linkages along the Escarpment													X	X		
33	work with landowners to develop strategies to manage conflicts between wildlife and crops													X	X		

TABLE 6.2 EVALUATION OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	EVALUATION CRITERIA					
		Ability to meet study objectives and targets	Land Requirements	Cost	Stakeholder/Landowner acceptance	Agency acceptance	Recreational and cultural impact
	COMMUNICATION AND EDUCATION						
1	Review current incentive programs that target farmers and update to address current issues and problems	H	NA	L	M	H	
2	implement a program to educate residents about the region's agriculture and its special needs, including:	M	NA	L	M	M	M
2a	the irrigation and drainage management system						
2b	the rationale for various agricultural practices used to produce grapes and tender fruits						
2c	the operation of Virgil Reservoirs						
3	provide educational/awareness material on landowner rights, trespass issues	L	NA	L	M	M	M
4	develop guidelines summarizing legislation affecting landowners and explain how each piece of legislation affects activities on their property	M	NA	L	M	M	
5	provide a "one window" contact/source to answer questions about legislation	L	NA	L	L	M	
6	set up a committee of agencies, interest groups, landowners to address legislative gridlock and conflicts	H	NA	L	L	M	
7	develop workshops training sessions to encourage/educate landowners on good stewardship of aquatic and terrestrial habitats	M	NA	L	M	M	M
8	develop brochure/educational materials on shoreline erosion, approvals, preferred stabilization techniques, protection of fish and aquatic habitats	M	NA	L	M	H	M
9	Educate landowners re. benefits of riparian buffers	L	NA	L	L	M	NA

TABLE 6.2 EVALUATION OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	EVALUATION CRITERIA					
		Ability to meet study objectives and targets	Land Requirements	Cost	Stakeholder/Landowner acceptance	Agency acceptance	Recreational and cultural impact
	WATER QUANTITY						
10	Minimize flooding of agricultural lands by:	H	L-M	L-H	M	M	L
10a	upgrading culverts, removing weirs	H	L	M	H	M	L
10b	remove excess fill adjacent to drains/watercourses	H	L	L	M	M	L
10c	increase capacity of channels/floodplain	L-M	M	H	L	L-M	L
11	implement state of the art stormwater management facilities – source, conveyance, end of pipe for new developments	M	M	M	L-M	M	L
12	implement state of the art stormwater management facilities – source, conveyance, end of pipe for existing developments, where warranted (within villages)	L	H	H	L	L-M	L
13	implement a strategic drain maintenance and management program to reduce costs and improve stability (erosion and sedimentation of drains):	H	L	H	L-M	M	NA
13a	design drain morphology to be more self sustaining	M	L	M	L	M	NA
13b	introduce grade controls (eg 6 Mile Creek) to reduce erosion risk	M	L	M	L	M	NA
13c	replace rip rapped side slopes with vegetated terraces (low growing vegetation)	M	M	L-M	L	M	NA
13d	replace weirs with off-line irrigation ponds, where possible	M	H	M-H	L	L-M	NA
13e	remove any instream structures outside of the irrigation season - consider water conservation measures to reduce dependency on instream dams (see Water Quantity)	M	L	L	L-M	M-H	NA
13f	in areas where fish have access to drains, minimize drain maintenance activities during spring: April 1 – June 30	M	L	L	M	M-H	L
14	Review the irrigation management system to identify any existing conflicts in water use among landowners – encourage off-line storage and other water conservation strategies; identify opportunities to maintain baseflow; identify potential downstream impacts on watercourses	H	M	L	L	M-H	M

TABLE 6.2 EVALUATION OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	EVALUATION CRITERIA					
		Ability to meet study objectives and targets	Land Requirements	Cost	Stakeholder/Landowner acceptance	Agency acceptance	Recreational and cultural impact
	WATER QUANTITY (continued)						
15	develop an erosion remediation plan using natural channel design principles for lower watercourses to address erosion and aquatic habitat impacts	H	M-H	M	L-M	M	L
16	review current levels of private water well use versus municipal supply.	L	NA	L	L	M	NA
17	identify active PTTW (groundwater) to ensure that impacts on baseflow are minimized	L	NA	L	L	M	NA
18	review Walker Landfill proposal re: impacts on baseflow to 6 Mile and potentially 8 Mile Creek to ensure baseflow reductions are minimized	L	NA	L	L	M	NA
19	Review existing aggregate operations to assess potential impacts on groundwater levels and stream base flows	L	NA	L	L	M	NA
34	Where development opportunities exist, develop reach-based concept plans for each shoreline management reach to address aggradation/recession and aquatic habitat issues.	L	M	M-H	L	M	L
20	review operation of Virgil Reservoirs and recommend measures to reduce resuspension of sediment and encourage littoral zone aquatic plant growth	L	NA	L	L-M	M	L-M
	WATER QUALITY						
21	implement water quality monitoring program to assess impacts of drains on watercourses	H	NA	L-M	M-H	M-H	L-M
22	work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff and contaminated groundwater	H	L	L	M	M-H	M
23	work with landowners to develop a 6m buffer zone (3 m on either side) adjacent to drains (manage uses within the buffer); implement a demonstration project	M	M	L	L-M	M	L-M

TABLE 6.2 EVALUATION OF MANAGEMENT ACTIONS

	MANAGEMENT ACTIONS	EVALUATION CRITERIA					
		Ability to meet study objectives and targets	Land Requirements	Cost	Stakeholder/Landowner acceptance	Agency acceptance	Recreational and cultural impact
	WATER QUALITY (continued)						
24	implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads.	H	NA	M	M	M	M
25	undertake a water and sediment quality monitoring program of Virgil Reservoirs to identify nutrient sources (insitu versus upstream)	M	NA	L-M	L-M	M-H	M
	AQUATIC COMMUNITIES AND HABITATS						
26	work with landowners to manage land use activities adjacent to watercourses within a 10 m buffer zone (5 m on either side); implement a demonstration project	H	M-H	L-M	L-M	M	L-M
27	review water withdrawals from watercourses with the Irrigation Committee and landowners to maintain instream flows	H	NA	L	L-M	M-H	L-M
29	implement a community-based restoration program for upper 4 Mile Creek, focused on creating a vegetated buffer zone and stabilizing the stream using natural channel design principles	L	M	M	L-M	L-M	L
30	implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower 4 Mile Creek, in cooperation with the Irrigation Committee:	M	M	M	L-M	M	M
30a	review water level management (maintain constant/rising water levels through to June 30)	L	NA	L	M	H	M
30b	undertake riparian and littoral zone plantings	M	M-H	L-M	L	M	L
	TERRESTRIAL COMMUNITIES						
31	work with landowners to protect remaining forest and wetland habitats.	H	M	L	M	H	M
32	identify opportunities to create habitat linkages along the Escarpment	M	M-H	L	M	H	M
33	work with landowners to develop strategies to manage conflicts between wildlife and crops	H	M	L	M-H	H	NA

7.0 RECOMMENDED WATERSHED PLAN AND IMPLEMENTATION STRATEGY

7.1 Recommended Plan

Table 7.1 summarizes the recommended management actions and outlines implementation considerations. These actions were selected based on the evaluation criteria outlined in Section 6.

During the course of the study, it became apparent that the agricultural community has become disillusioned with government agencies at all levels as a result of a number of recent legislative changes that have impacted on landowner rights. Primary among these are:

- The Greenbelt Plan/Act
- The Fisheries Act
- The Nutrient Management Act
- The Ontario Water Resources Act, in particular Permits To Take Water
- The Region of Niagara's Environmental Policy

The focus of the recommended actions in the watershed plan is to improve environmental conditions for the benefit of agriculture and the environment. In addition the actions address the environmental requirements of the Nutrient Management Act and the Niagara-on-the-Lake Permits To Take Water.

The watersheds of the Niagara on the Lake study area are made up of a network of streams and municipal drains that are supplied with irrigation water from the Welland Canal, the Niagara River and the OPG Reservoir and Tunnel. Some municipal drains simply provide an outlet for field tile drains, while others provide both tile drain outlets and a conduit for irrigation water. The demand for irrigation water within the agricultural community is growing and Niagara-on-the-Lake has already identified the need to expand its PTTW program. The majority of the streams are located downstream of the municipal drain/irrigation system and as such are the principal receiving waters. While many landowners who finance the maintenance of municipal drains and provision of water for irrigation, tend to view municipal drains differently than streams, in reality they are both part of the aquatic environment of the Niagara-on-the-Lake watersheds. The management of the drains is equally important to the maintenance of a healthy aquatic environment and to the sustainability of agriculture as is the management of the streams. While the two features may be treated differently by legislation, they are intrinsically linked in terms of restoring the environmental health of the watersheds.

Together the recommended actions provide a number of key environmental benefits:

- Water Management: the management actions address flooding of agricultural lands, the need for efficient use of irrigation water and the protection of minimum flows in streams

Table 7.1 Watershed Plan Recommended Actions (see Figure 7.1)

Item	Action	Type of Action			Implementing Agencies									Unit/Initial Costs
		Instream Measure	Streamside Measure	Modification of Land Use Practices	NPCA	NOTL	Irrig./Agr. Committee	Region	OMAFRA	Niagara Parks Com. / NEC	Siol & Crop Assoc.	Landowners	Timeframe	Timeframe: S - within 5 years; M - 5 - 25 years; L - over 25 years
COMMUNICATION AND EDUCATION														
8	develop brochure/educational materials on shoreline erosion, streamlining approvals for land use activities, preferred stabilization techniques, protection of fish and aquatic habitats	X	X	X	L	P	P				P	P	S	existing programs - NPCA
1	Review current incentive programs that target farmers and update to address current issues and problems; provide technical advice and support	X	X	X	L	P			P		P	P	S	existing programs - NPCA
WATER QUANTITY														
10	Minimize flooding of agricultural lands by:				L	P		P				P	S-M	existing programs
10a	upgrading culverts, removing unnecessary weirs	X				L		P				P	M-L	$25,000 - $150,000 per structure
10b	remove excess fill adjacent to drains/watercourses		X			L						P	M	$1,000 - $5,000 per landowner
11	implement state of the art stormwater management facilities – source, conveyance, end of pipe for new/existing developments in urban areas	X	X	X	P	L							S-M	Landowner funded; $500/household for rain barrels; $20,000/impervious ha for SWM ponds; $110,000/impervious ha
13	implement a strategic drain maintenance and management program to reduce costs and improve stability (erosion and sedimentation of drains):				P	L							S-M	$20,000 study; Drain Modification - $500/m drain
13a	design drain morphology to be more self sustaining	X	X		P	L						P	M - L	existing program
13b	introduce grade controls (eg 6 Mile Creek) to reduce erosion risk	X			P	L						P	S - M	$30,000 study; reconstruction costs - $800/m drain
13c	replace rip rapped side slopes with vegetated terraces (low growing vegetation)		X		P	L						P	M - L	$50,000 for demonstration study. Revegetating costs: $10,000/ha
13e	continue to remove any instream structures outside of the irrigation season - consider water conservation measures to manage water use and instream storage requirements	X			P		L					P	M - L	Landowner funded
13f	in areas where fish have access to drains, minimize drain maintenance activities during spring: April 1 – June 30	X	X		P	L						P	S	Landowner funded
14	Review the irrigation management system to identify any existing conflicts in water use among landowners – encourage off-line storage and other water conservation strategies; identify opportunities to maintain baseflow; identify potential downstream impacts on watercourses	X	X	X	P	L						P	S-M	$50,000 study

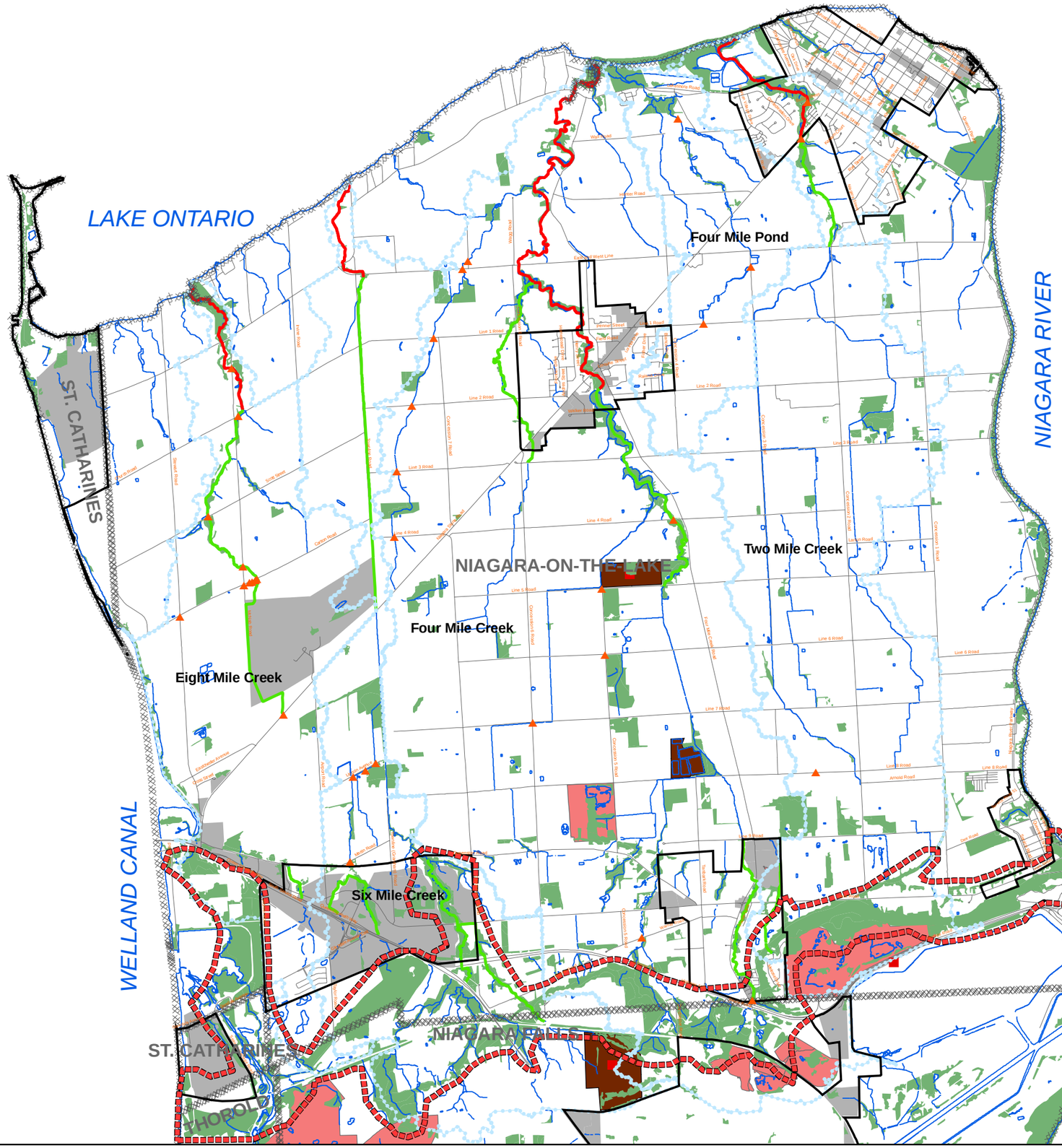
Table 7.1 Watershed Plan Recommended Actions (see Figure 7.1)

Item	Action	Type of Action			Implementing Agencies									Unit/Initial Costs
		Instream Measure	Streamside Measure	Modification of Land Use Practices	NPCA	NOTL	Irrig./Agr. Committee	Region	OMAFRA	Niagara Parks Com. / NEC	Siol & Crop Assoc.	Landowners	Timeframe	Timeframe: S - within 5 years; M - 5 - 25 years; L - over 25 years
WATER QUANTITY (Continued)														
15	develop an erosion remediation plan using natural channel design principles for lower watercourses to address erosion and aquatic habitat impacts	X	X		L	P							M	$50,000 study; Remedial costs - $800/m of channel
	WATER QUALITY													
21	implement water quality monitoring program to assess instream water quality for irrigation and aquatic life	X			L		P						S-M-L	$20,000 annually
22	work with landowners to manage nutrient (nitrogen and phosphorus) and pesticide use and reduce potential for contaminated runoff (nutrients, suspended sediments, bacteria, chloride) and contaminated groundwater			X	L				P		P	P	S-M	existing programs
23	work with landowners to manage land use activities adjacent to drains within a buffer zone (targetting a minimum of 3 m on either side); implement a demonstration project		X	X	L	P						P	M	existing programs; 50% cost sharing with landowners
24	implement the recommendations of the Region's Salt Vulnerability study and extend it to cover local roads.			X		L							S	existing program
AQUATIC RESOURCES														
26	work with landowners to manage land use activities adjacent to watercourses within a buffer zone (targetting a minimum of 5 m on either side); implement a demonstration project		X	X	L	P						P	M	existing programs; 50% cost sharing with landowners; Riparian Planting costs: $10,000/ha
30	implement a community-based fish habitat improvement plan for Virgil Reservoirs and lower 4 Mile Creek, in cooperation with the Irrigation Committee:	X	X		L	P							S - M	$20,000 study; construction costs: $800/m of channel
TERRESTRIAL RESOURCES														
31	work with landowners to protect remaining forest and wetland habitats.			X	L	P				P		P	S-M	existing programs; 50% cost sharing with landowners
32	identify opportunities to create habitat linkages along the Escarpment			X	L	P				P		P	M	existing programs; identify other incentives to take lands out of productive uses
33	work with landowners to develop strategies to manage conflicts between wildlife and crops			X	L				P			P	S	existing programs

HIGHLIGHTED ACTIONS TO FOCUS ON HIGH (S) AND MEDIUM (M) PRIORITY FEATURES AS SHOWN ON FIGURE 7.1.

OTHER ACTIONS TO BE APPLIED WATERSHED-WIDE AS APPROPRIATE

NOTE: L - LEAD STAKEHOLDER; P - PARTICIPATING STAKEHOLDER



LEGEND:

- Urban Areas
- Municipal Boundary
- Watershed
- High Priority for Implementation
- Medium Priority for Implementation

Natural Feature Linkage Opportunities*

- Limit

Natural Feature Protection Opportunity

- Industrial / Commercial Land Use
- Recommended Bridge/Culvert to be Replaced

Landfill / Extraction Uses

- Landfill Site location
- Landfill Sites
- Sand Pits/Quarries

* approximate limit of features to be considered to establish an east - west terrestrial linkage

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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NIAGARA-ON-THE-LAKE WATERSHED STUDY

Framework for Implementation

FIGURE No.

DATE: February 2008

- Water Quality: the management actions focus on the reduction of nutrient, suspended sediment, bacteria and chloride loadings to drains and streams from urban and rural sources. These measures will ensure a safe supply of clean water for irrigation purposes and to support aquatic life
- Drain Maintenance: measures are recommended to reduce drain maintenance that is costly and has negative impacts on stream habitats; measures focus on reducing erosion and sedimentation of drains
- Stream Erosion Control: an erosion remediation plan and a riparian zone management program are identified to address stream erosion downstream of municipal drains; these measures will further eliminate sources of sediment to streams providing cleaner water for irrigation and reduced impacts on aquatic life
- Terrestrial and Aquatic Resources: Improvements and aquatic habitat enhancements are proposed for lower Four Mile Creek and the Virgil Reservoirs to promote recreational angling opportunities; measures are proposed to encourage landowners to continue their good stewardship practice of protecting existing natural features; a program to improve terrestrial habitat linkages along the escarpment is proposed and agencies are encouraged to continue to work with landowners to address conflicts with wildlife

7.2 Implementation Considerations

There are over 130 landowners representing tender fruit growers, vineyards, nurseries and greenhouses that depend on municipal drains and irrigation water for their livelihood and the recommended measures are costly to implement. This group, in part represented by the Niagara-on-the-Lake Irrigation Committee, is key to the successful implementation of the recommended watershed plan.

The recommended measures represent the management priorities for maintaining and rehabilitating the watershed to a healthy state, consistent with the need for a long term plan for sustainable agriculture in the study area. The costs of undertaking these recommended measures are high, but are expected to be implemented over a multi-year timeframe (10-20 years) largely on a voluntary basis. The recommended measures also encourage continued improvements in land use practices on agricultural, urban and urbanizing lands, to place greater emphasis on reducing contamination of surface waters, and on protecting /enhancing the health of aquatic communities (including fish) in drains and watercourses as a barometer of adequate, high quality water supplies for irrigation and environmental uses.

Achieving this strategic shift to more sustainable use of land and water clearly cannot be achieved without landowner participation and the economics of agriculture are such that changes will need to occur gradually over time. Several principles of implementation are suggested to guide the implementation of each recommended management action:

- Build confidence between landowners and agencies through regular consultation, brochures and other forms of information exchange

- Provide incentives in the form of financial support for the implementation of recommended measures
- Reward examples of good stewardship through a variety of recognition programs including providing some monetary support through mechanisms such as tax rebates/reductions
- Provide technical support and other in-kind support by building partnerships between landowners, agencies, interest groups
- Illustrate the benefits of good stewardship practices by undertaking demonstration projects, facilitating tours and encouraging community leaders to become "champions" of more sustainable practices

Existing Programs

NPCA actively implements agricultural, water quality and wildlife stewardship programs by combining funding programs from Remedial Action Plans, federal, provincial and even corporate/non-government agencies to encourage farmers to change their agricultural practices. While regulatory measures are in place to address agricultural sources of pollution through the Nutrient Management Act, stewardship measures and incentive programs have proven to be the most effective approach. Despite the existence of many funding programs, available resources fall short of meeting the need.

There are also a number of Federally funded agricultural stewardship programs:

- Canada Ontario Farm Stewardship Program
- Greencover Canada
- Canada Ontario Water Supply Expansion Program
- Can-Adapt – Agricultural Environment Stewardship Initiative
- Habitat Stewardship Program

Together, these programs provide funding on a cost-shared basis, with the program covering 30 – 50 % to a maximum of $5,000 - $20,000 for a range of measures, including:

- Manure storage and handling facilities
- Farmyard runoff control
- Shelterbelts and windbreaks
- Farm waste management (storage and handling of hazardous materials)
- Riparian plantings and riparian management (including offstream watering sites)
- Water well management
- Erosion control – riparian lands and fragile lands
- Conservation farming practices – conservation tillage, strip cropping, equipment modifications, cover crops, integrated pest management, irrigation management)
- Ponds for agricultural purposes

The NPCA has a cost-sharing program that offers local landowners financial incentives to implement water quality and habitat improvement projects on their properties. In addition to providing financial assistance to landowners, NPCA staff will conduct one-on-one site visits and assist with hands-on restoration activities as well as providing technical advice about environmental concerns. To date, NPCA programs have included the completion of over 700 water quality and habitat improvement projects. This includes the implementation of over 400 Best Management Projects (BMP) such as manure storage improvements, nutrient / waste water improvements, livestock management projects, and conservation farm practices. In addition, over 300 shelterbelt, riparian buffer and wetland / woodland restoration projects have been implemented.

NPCA staff are familiar with other funding agencies and their programs and can offer a "one window" approach to landowners to blend existing programs wherever possible in order to achieve the best financial / environmental scenario for the landowner. For example, NPCA's programs can be blended with other programs, for example NPCA can provide a top up of the grant under the Environmental Farm Plan (EFP) Program up to 75%.

NPCA also has a number of cost sharing programs with support from the Niagara RAP and the Niagara Water Quality Protection Strategy (NWQPS) that target agricultural lands. Generally, grants are available from $5,000 - $12,000 representing 50 – 75 % of the project value and cover the range of projects lists under the federal programs above. In addition, funding for demonstration projects is available through the NWQPS.

7.3 Plan Administration

The completion of the watershed study was a cooperative effort led by the NPCA with participation by an advisory committee made up of representatives of the Town of Niagara-on-the-Lake and the Region of Niagara. The recommendations as described in this Plan were discussed with the above noted groups and presented to the public through a series of open houses, and, as such, provide a framework for implementing the plan. An Implementation Committee will, however, be required to further define implementation mechanisms, ensure conformance with component strategies, assess the effectiveness of the plan and, in general, update and monitor plan implementation.

In terms of administration, it is recommended that an Implementation Committee be formed for the Watershed to oversee plan implementation. The composition of the Implementation Committee should include representation from the NPCA, the Town of Niagara-on-the-Lake, the agricultural community (for example, through the Town's Irrigation and Agricultural Committees) and special interest groups. The committee's initial focus should be on implementation of the recommended actions within the priority areas identified in figure 7.1, and on seeking support from within the agricultural community for pilot projects.

It is expected that meetings of the Committee would occur on an annual basis. One of the tasks of the Implementation Committee should be to pursue alternative sources of funding (e.g., special interest groups, environmental foundations, corporations, landowners) to augment municipal/provincial funding sources.

7.4 Public Education / Stewardship

Stewardship is a shared responsibility. NPCA is actively involved with its partners: municipalities, government agencies, community groups, and landowners in researching and planning for the effective management of the NOTL watershed. As NPCA completed watershed studies, and other projects, our understanding of the watershed ecosystem improves. Using this scientific data, NPCA's stewardship and restoration program strategically focuses on current watershed priorities to implement the recommendations.

During the course of the study, landowners raised concerns that many of the management actions identified in the recommended plan were already the responsibility of other agencies. NPCA recognizes this and the intent of each management action is not to duplicate the efforts of others but to coordinate the efforts of all agencies under the "umbrella" of a watershed plan to ensure not only that there is no duplication of effort, but also that nothing is missed. The recommended plan looks to identify synergies and joint opportunities among the various agencies and their programs.

Landowner Outreach

Watershed Stewardship and Restoration recognizes the importance of landowners and residents in the future health of the watershed system. With more than 93% of the land in the watershed privately owned, landowners play a critical role. NPCA shares information and fosters good stewardship practices with landowners through workshops, site visits, phone calls, newsletters, and targeted mailings. Stewardship programs provide advice on forest management, naturalization, stream, pond and wetland management, wildlife management water quality problems, flooding and erosion problems and agricultural matters.

Key landowners properties with important natural features or high potential for restoration can be reached through an intensive Conservation Planning Service. This program builds landowner understanding of the opportunities and constraints of their property, establishes a long-term relationship with these important stewards, and provides a range of management options that encourages restoration.

Community Outreach

Stewardship reaches out to other client groups. Staff provide talks to clubs, schools, and community groups and participate in workshops and tours to groups and individuals.

NPCA actively works with many community groups and other non-government organizations.

Community Support & Volunteer Coordination

Staff facilitate the implementation of stewardship related projects by others. For example, NPCA promotes 'work days' which are hosted by various groups such as the Friends of One Mile Creek. Support includes volunteer coordination, promotion, technical advice, staff involvement and use of NPCA's tools and equipment. Hundreds of volunteers contribute thousands of hours to these varied programs including tree plantings, cleanups, stream restoration, and monitoring. These programs can be promoted through newsletter, the website, and regular email updates.

NPCA can also form collaborations with watershed groups to focus on geographic priorities. As a partner in grassroot community collaborations, stewardship staff provide substantial technical input and guidance to the other partners.

NPCA provides technical advice, support letters for grants, in-kind support, and limited financial assistance. In the years to come, stewardship outreach could focus more on fostering relationships with these independent projects to encourage additional initiatives.

Restoration Services

Stewardship staff carry out a number of restoration projects on private and public lands. A reforestation program using seedlings expands existing forests, fills in gaps in forest cover, and reduces soil erosion. The costs are shared with the landowner. Naturalization planting using larger trees and shrubs provide buffer strips along streams and wetlands as part of the naturalization program. Fisheries programs undertaken stream rehabilitation and erosion projects, on-line pond, dam and barrier mitigation and wetland creation projects.

Agricultural Outreach

Stewardship staff provide support for rural water quality programs that encourage best management practices by farmers. Staff provide site visits, technical advice, and support with funding applications. The objective is to provide assistance through grants and technical advice to farmers to protecting water quality.

7.5 Monitoring

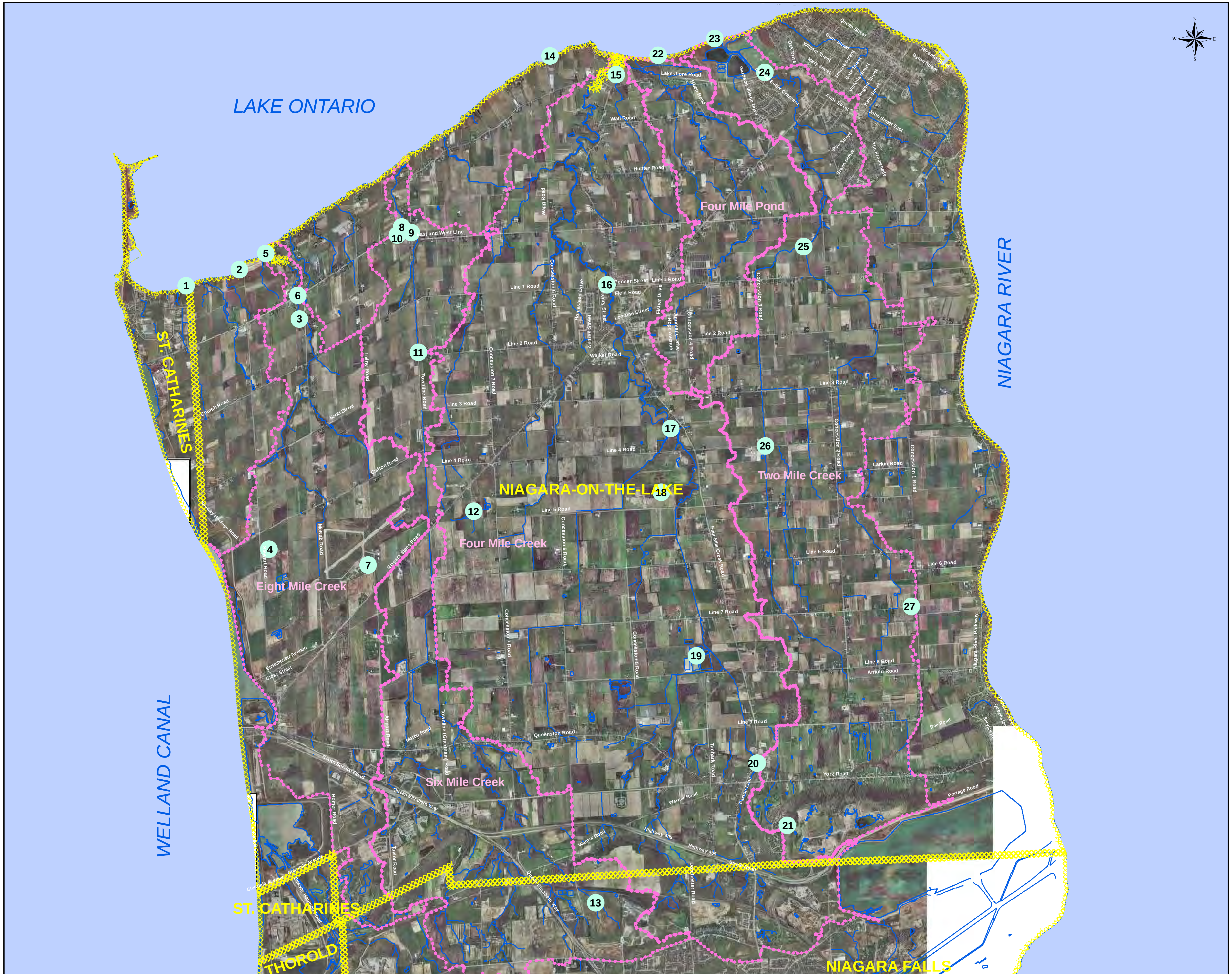
Several monitoring programs are currently underway within the NPCA Watershed. Some of these programs are taking place on a watershed scale, while others are subwatershed in scale focusing on distinctive water quality or water management issues. The basis for the monitoring programs supports the principles of Adaptive Environmental Management. This allows the NPCA to test management alternatives and assess their effectiveness.

This facilitates evaluation and updates to NPCA's plans, decisions and priorities over time. NPCA already undertakes an integrated monitoring program that addresses: precipitation, water quantity and quality, groundwater quantity and quality, fish and fish habitat, and benthic invertebrate monitoring. In addition to these monitoring components, monitoring of erosion and stream morphology, and terrestrial habitats/communities would round out the watershed monitoring program.

The purpose of the monitoring program is to protect and improve water quality, water quantity, biological diversity, and biological productivity in the NOTL Watershed. The integrated monitoring program focuses on a diverse range of monitoring parameters that act as indicators of ecosystem health. Integrating expertise from such disciplines as meteorology, hydrogeology, hydrology, terrestrial, fluvial geomorphology, water quality, and biology allows for many facets of the environment to be simultaneously analyzed. Figure 8.1 illustrates a conceptual impact model for the IWMP. This impact model establishes the linkages between the issues affecting the Watershed and its overall health. The intent of the integrated watershed monitoring program is to detect environmental changes (both spatially and temporally) within the Watershed over time.

The ongoing results of an integrated monitoring program are documented in annual reports. In the longer term, a 5-year summary of the program and the identification and discussion of spatial trends can be examined.

FIGURES



KEY MAP

LEGEND:

Municipal Boundary

Watershed

Photo Location

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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NIAGARA-ON-THE-LAKE WATERSHED STUDY

Study Area & Photo Location

FIGURE No. 1.1

DATE: February 2008

Niagara-on-the-Lake Watershed Study

Figure: No. 1.2
Representative Photographs

8 Mile Creek

6 Mile Creek

4 Mile Creek

2 Mile Creek

LAKE ONTARIO

NIAGARA RIVER

WELLAND CANAL

ST. CATHARINES

NIAGARA-ON-THE-LAKE

THOROLD

Four Mile Pond

Two Mile Creek

Four Mile Creek

Eight Mile Creek

Six Mile Creek

A-A'

B-B'

C-C'

D-D'

KEY MAP

LEGEND:

- Municipal Boundary
- Watershed
- Escarpment
- Iroquois Shoreline
- Geological Cross-Section

Surficial Geology

- Fill (Man-Made)
- Sand and Gravel
- Sand
- Silt
- Clay
- Halton Till
- Bedrock

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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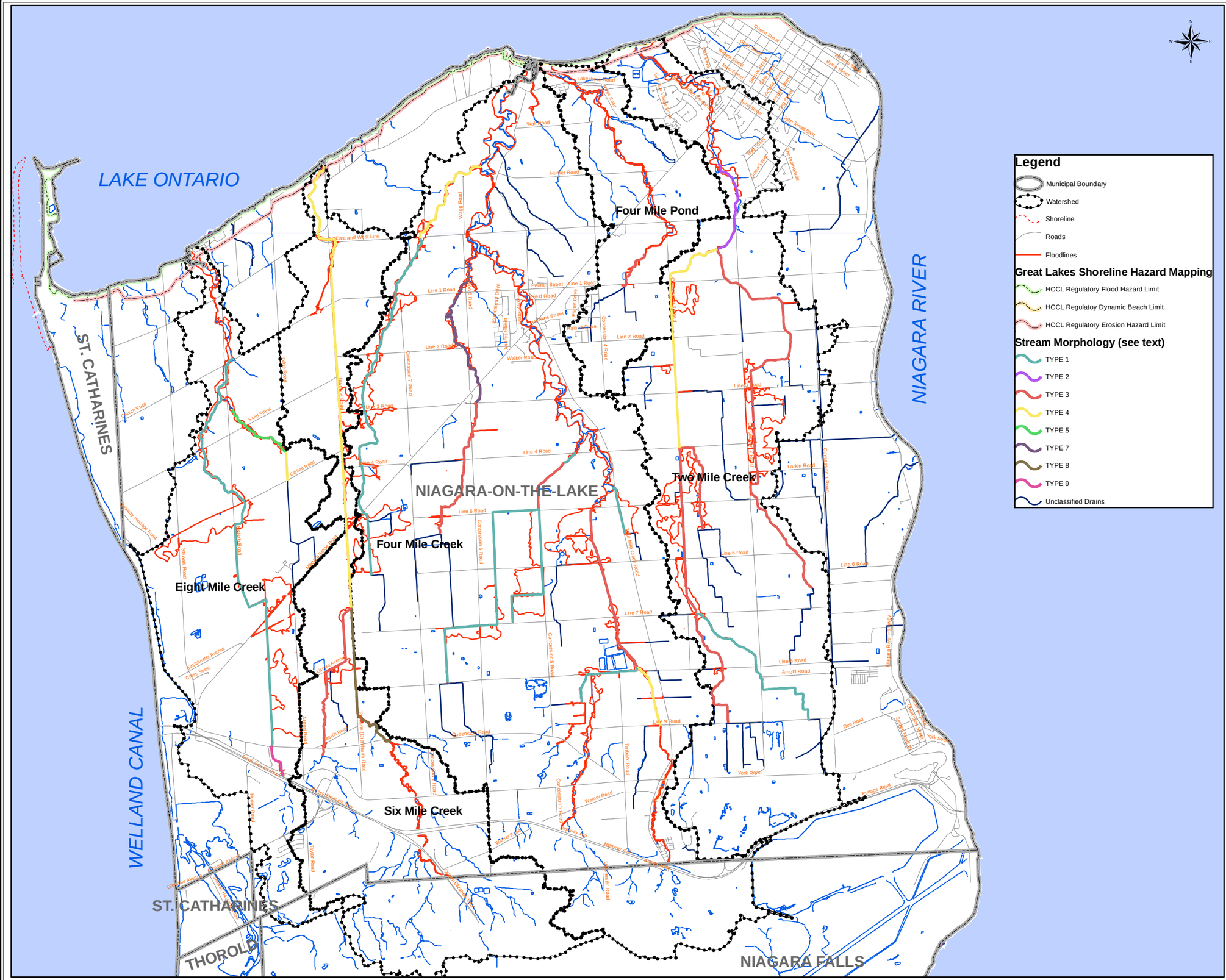
NIAGARA-ON-THE-LAKE WATERSHED STUDY

Surficial Geology

FIGURE No. 2.1

DATE: February 2008



LEGEND:

NOTES:

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Kilometers

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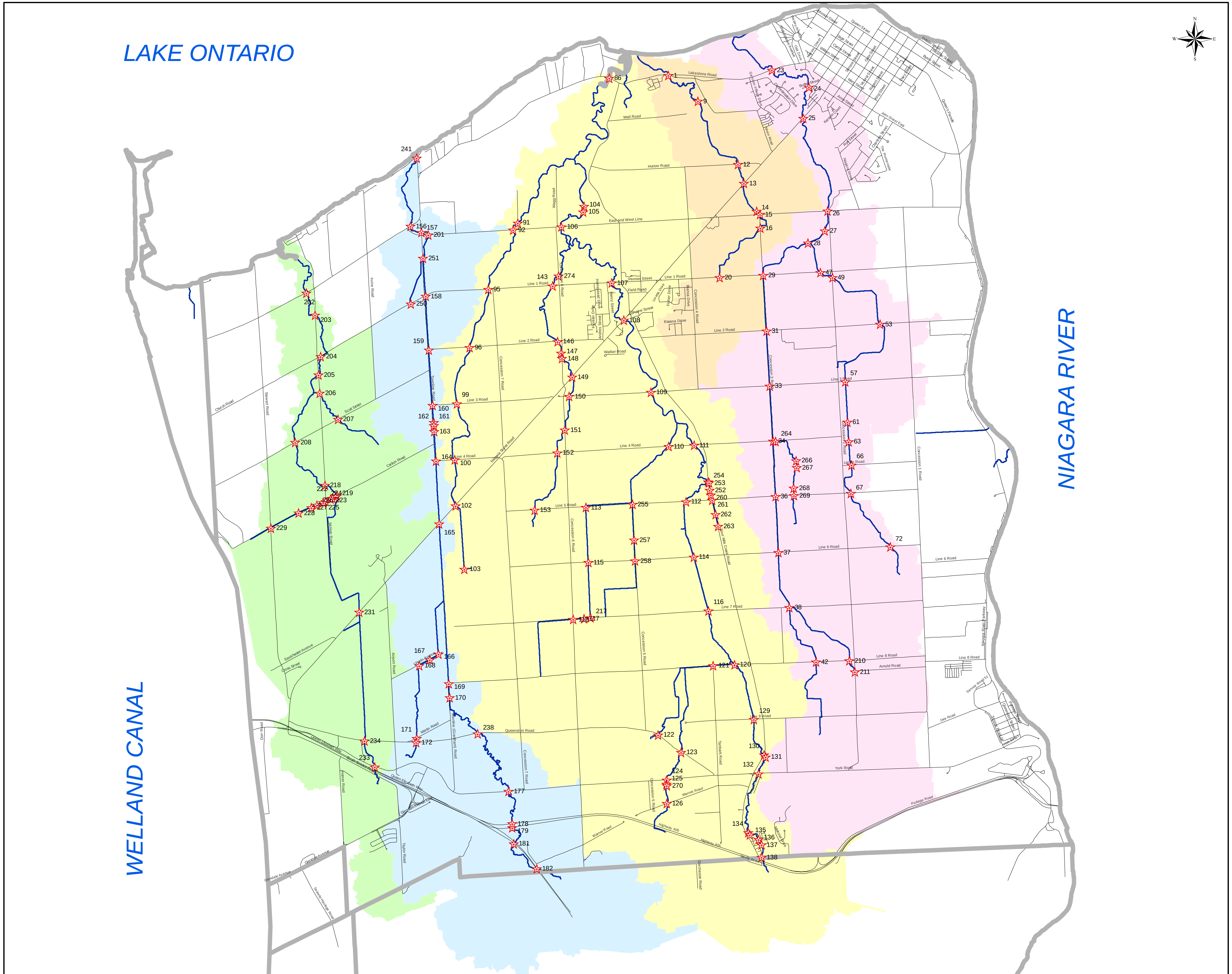
NIAGARA-ON-THE-LAKE WATERSHED STUDY

Water Resources

FIGURE No. 2.6

DATE: February 2008



LEGEND:

- Municipal Boundary
- Roads
- Bridge/Culvert Structure

Watersheds

- Eight Mile Creek
- Four Mile Creek
- Four Mile Pond
- Six Mile Creek
- Two Mile Creek

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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NIAGARA-ON-THE-LAKE WATERSHED STUDY

Hydraulic Structures

FIGURE No. 2.7

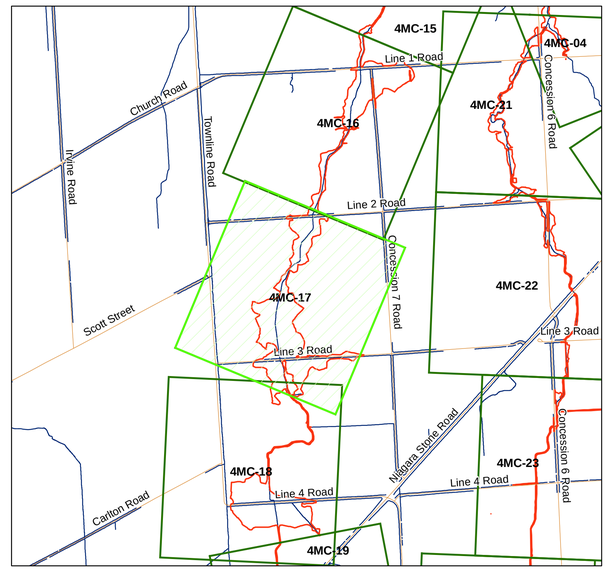
DATE: February 2008

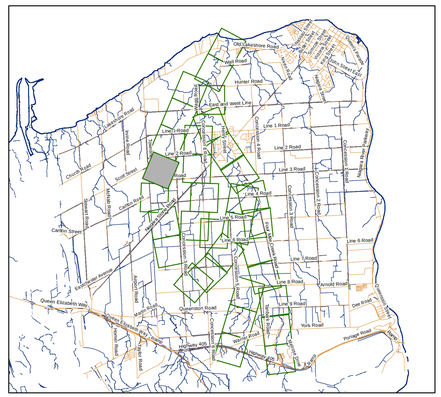
FOUR MILE CREEK

100 YEAR REGULATORY FLOODPLAIN MAPPING

Sheet No.

4MC-17 Figure 2.8





Legend

- 100 Year Storm Floodline
- Potential Shallow Spill Location
- Station, 100 Year Flood Elevation
- Roads
- Creek
- Contours - 1m Interval

AUGUST 2007

0 200 400 Meters

N E S W

NOTES:

1) Produced By Aquafor Beech Limited For NPCA
2) Digital Terrain Model and Orthoimage provided by NPCA (Date: 2002)
3) North American Datum 1987
   Universal Transverse Mercator (6^0) Projection
   Zone 17, Central Meridian 80^0 West

LICENSED PROFESSIONAL ENGINEER
G.R.FREW
08/08/07
PROVINCE OF ONTARIO

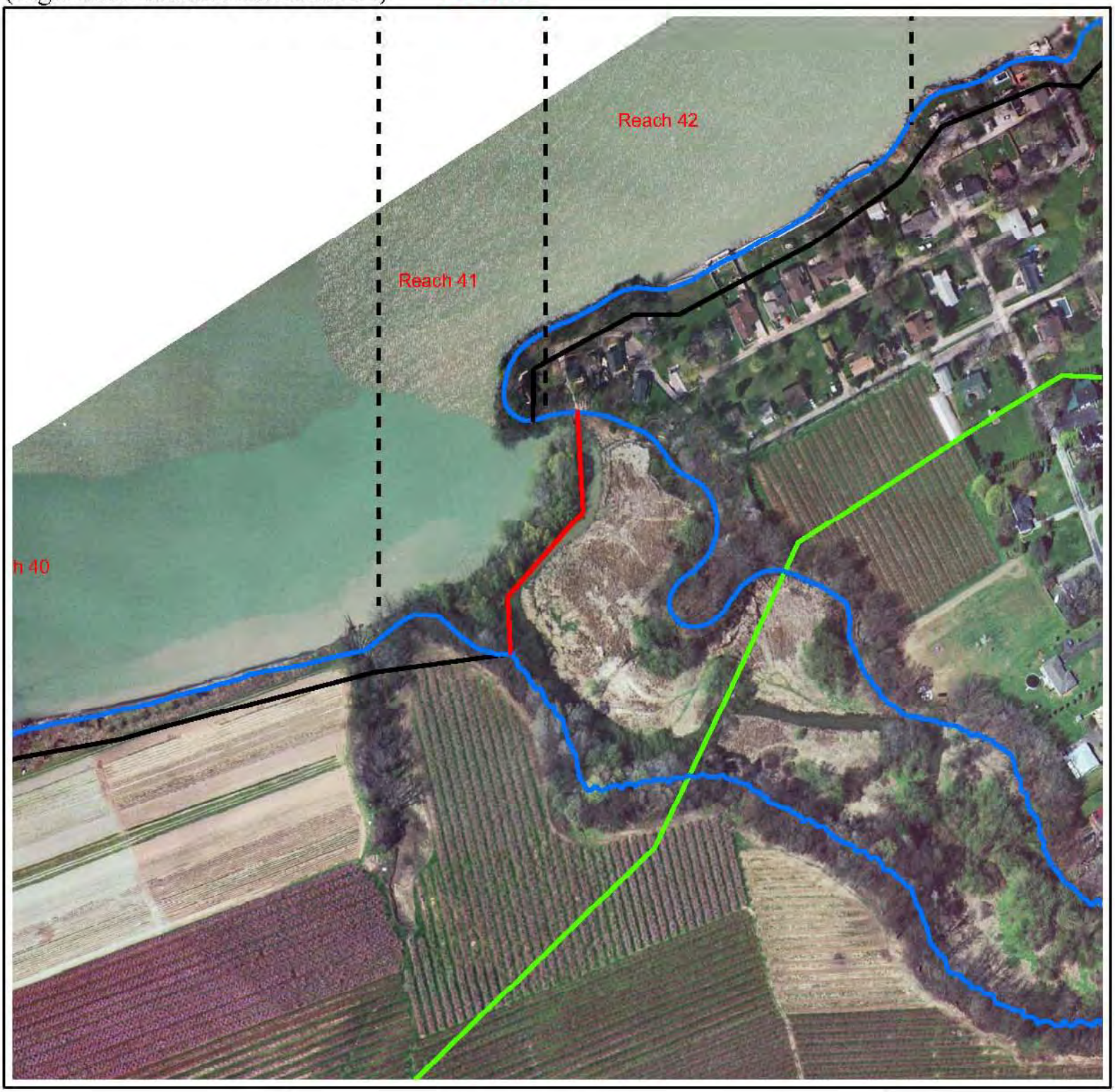
NIAGARA PENINSULA CONSERVATION AUTHORITY

Aquafor Beech Limited

Regulatory Shoreline Hazards

Reach 41 & 42
(Eight Mile Creek to Fire Lane 14)

Draft



Legend

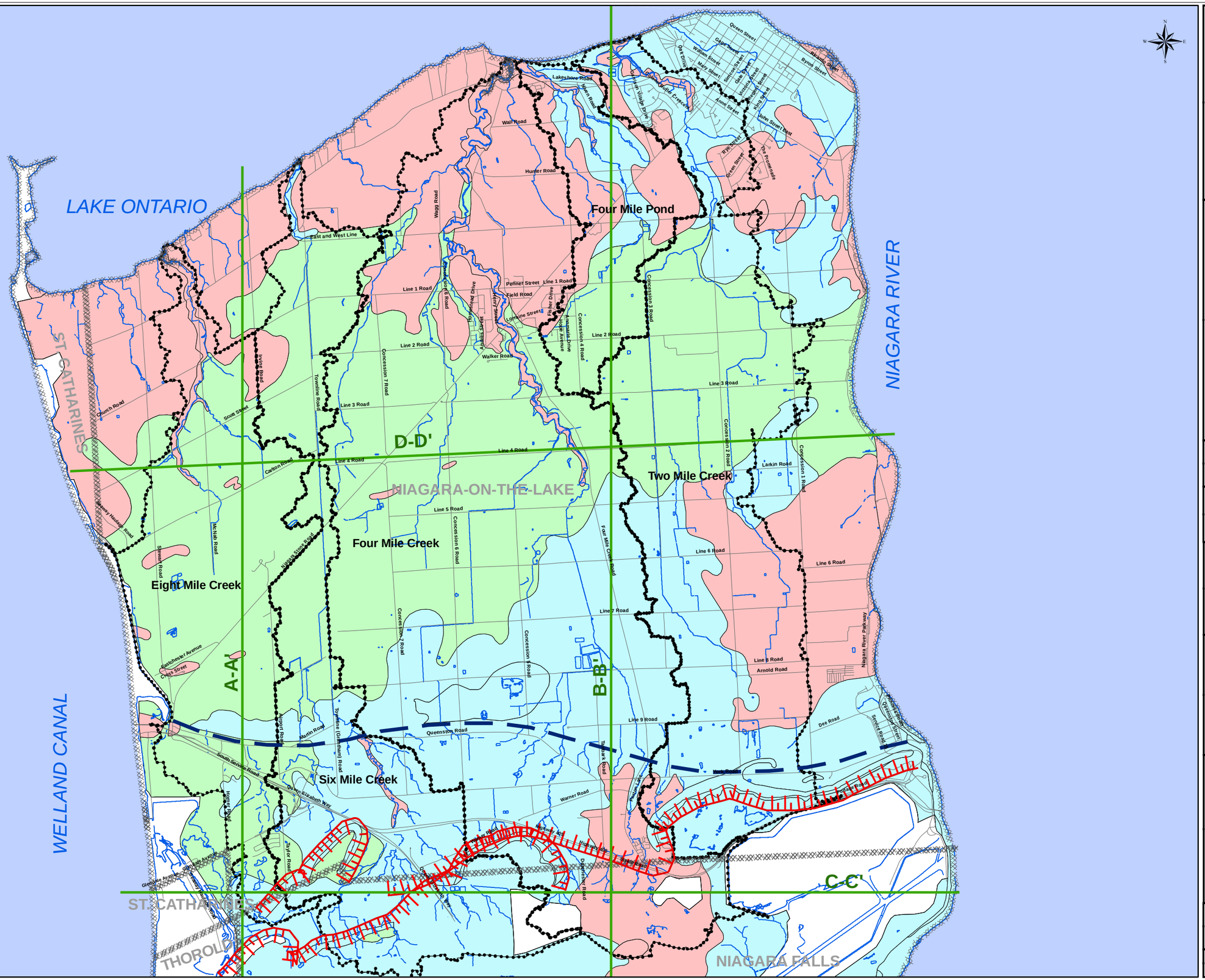
- Regulatory Flood Level
- Regulatory Flood Hazard Limit
- Regulatory Erosion Hazard Limit
- Regulatory Dynamic Beach Limit

Figure 2.9

N
W E
S

0 25 50 100 150 200
Meters

HCCL
Coastal & River Engineering
Water Resources & Environmental Hydraulics



KEY MAP

LEGEND:

- Geological Cross-Section
- Iroquois Shoreline
- Escarpment
- Municipal Boundary
- Watershed

Potential Groundwater Recharge

- Low Recharge
- Moderate Recharge
- High Recharge
- Not Classified

NOTES:

Base Mapping was provided by NPCA

0 2 4

Kilometers

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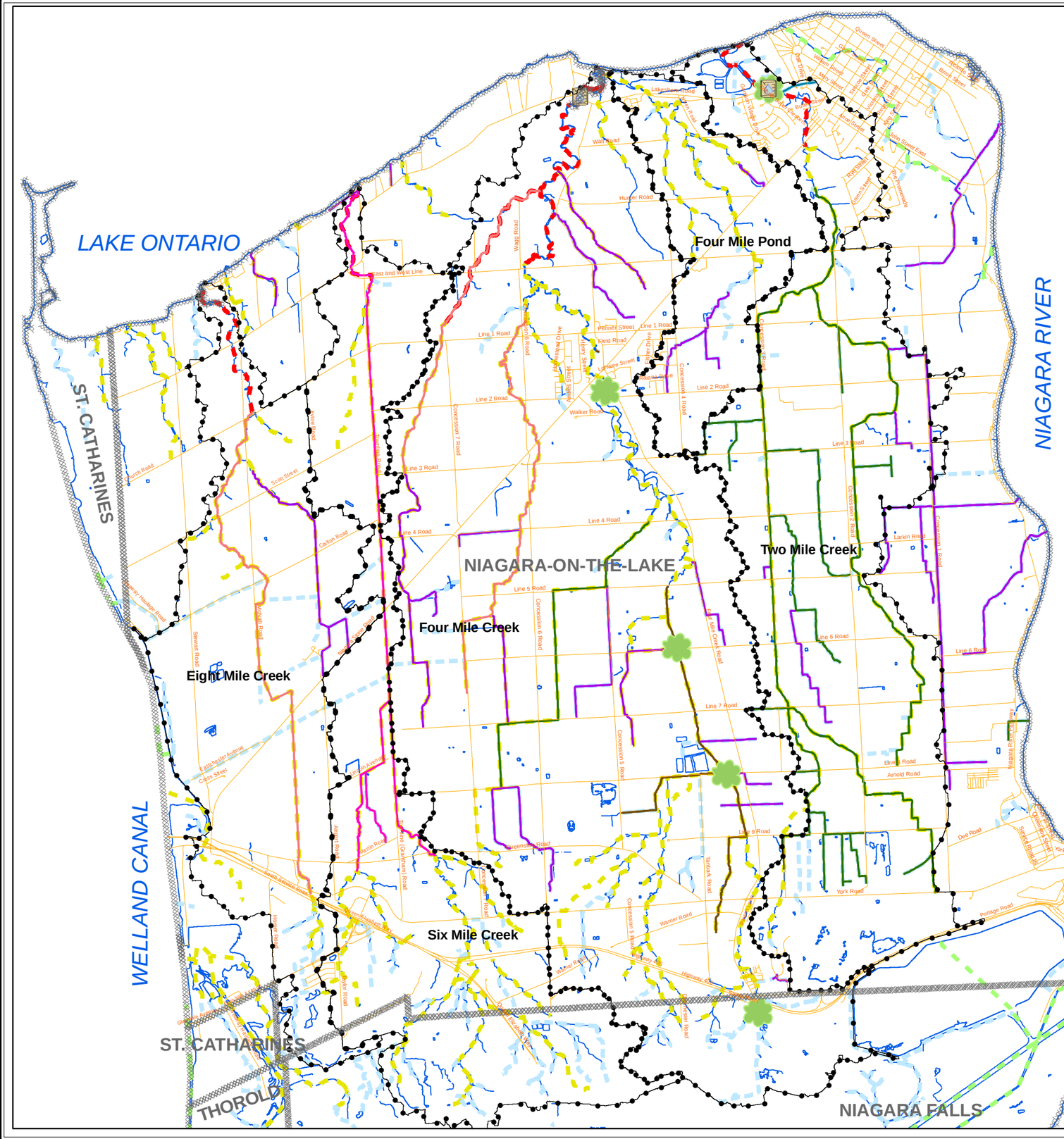
NIAGARA-ON-THE-LAKE WATERSHED STUDY

Potential Groundwater Recharge

FIGURE No. 2.10

DATE: February 2008



Legend

- Municipal Boundary

Code

- Watershed
- NPCA General Water Quality Site
- NPCA Bio Map
- Roads

DFO Municipal Drain Classification

- Class A
- Class B
- Class C
- Class D
- Class E
- Class F

MNR Stream Classification

- 'Critical' Type 1
- 'Important' Type 2
- 'Marginal' Type 3
- 'Unclassified' No Data

KEY MAP

LEGEND:

NOTES:

Base mapping was provided by NPCA

0 2 4

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Aquafor Beech Limited

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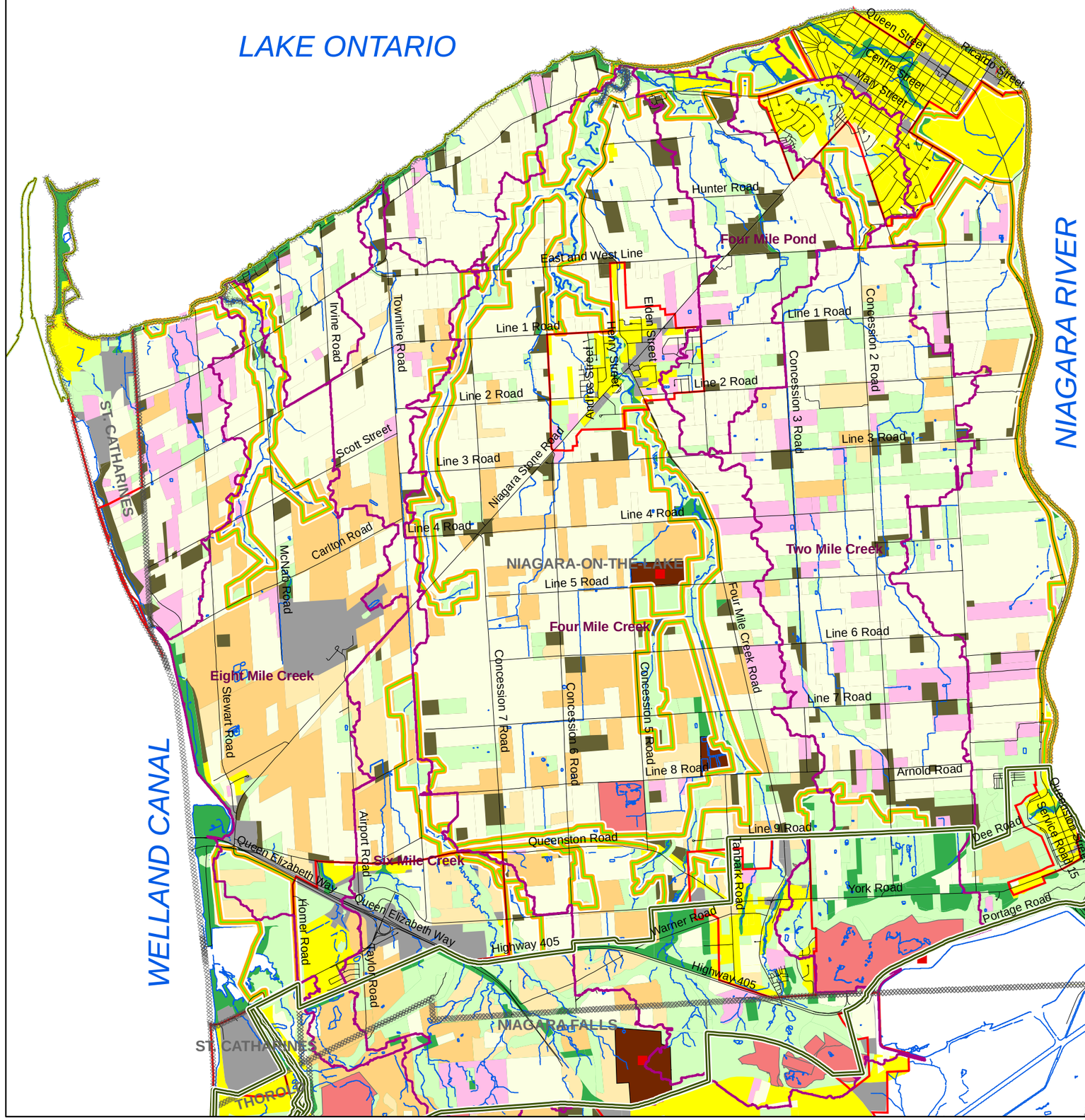
NIAGARA-ON-THE-LAKE WATERSHED STUDY

Aquatic Resources

FIGURE No. 2.12

DATE: February 2008



Legend

- NEC
- Municipal Boundary
- Roads
- Watershed
- Shoreline
- Sand Pits/Quarries
- Urban Areas
- Natural Heritage System
- Landfill site Location
- Landfill Sites

Land Use

- Agricultural Unclassified
- Environmental Conservation/Protection
- Industrial / Commercial
- Residential Areas

Agricultural Crop Systems (1983)

- FRUIT AND GRAPE
- SPECIALTY AGRICULTURE
- INTENSIVE FIELD CROP SYSTEM
- NON-INTENSIVE FIELD CROP SYSTEM
- NON-AGRICULTURAL SYSTEM

KEY MAP

LEGEND:

NOTES:

Base mapping was provided by NPCA

0 2 4

Kilometers

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NIAGARA-ON-THE-LAKE WATERSHED STUDY

Land Use

FIGURE No. 2.14

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