Niagara Peninsula Conservation Authority

PORT ROBINSON WEST SUBWATERSHED STUDY

Final Report

April 1999

Totten Sims Hubicki Associates
Ray Blackport (Formerly of Stanley)
Natural Resource Solutions (Formerly Ecologistics)
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INTRODUCTION

The Port Robinson West Subwatershed drains some 14.47 square km of land from between Fonthill east to the Welland Canal. The majority of the watershed is located in the Town of Thorold, however the headwaters to the west are located in Pelham (Fonthill) and a southern portion is located in Welland (see **Figure 1.2.1**). As with most subwatersheds in urbanizing areas, this drainage area is subject to future development pressures. Concerns regarding past impacts on environmental conditions as well as the potential for future impacts has resulted in the completion of this study. The purpose is to provide direction in the future management of the Port Robinson West Subwatershed.

THE PORT ROBINSON WEST SUBWATERSHED

The subwatershed is drained by Singer's Drain which outlets to the Welland Canal (see **Figure 1.2.1**) Singer's Drain has two main tributaries which drain the north and south sections of the watershed. It is predominantly a "natural" stream section, however significant portions have been altered in the past. A significant portion of the main branch and south tributary is a municipal drain which has been straightened, deepened an/or enclosed in the past. Some sections of the headwater tributaries in Fonthill have been enclosed or altered with past development.

There is a current proposal to enlarge Singer's Drain over a central reach to remove sediment deposits and reduce flood potential.

The current land use is predominantly agriculture with some scattered rural residential development and urban development (primarily in Fonthill). A significant industrial development is located in the south east corner of the subwatershed (E.S. Fox Lands).

The soils in the subwatershed are mostly clay tills and relatively flat, except for the headwater areas. These are located in the Fonthill Kame area, which is rolling and contains significant sand deposits. The study has found that the soils have a relatively low potential for infiltration except for the Fonthill Kame area. The higher permeability of the soils in this area allow higher levels of rainwater through the soils and, in part, discharges to the nearby wetlands and wooded areas including the Rose Little Woodlot, Kunda Park and Niagara Street Cataract Road Woodlot/Wetland.

The relatively low permeability of the soils in most of the watershed results in a "flashy" stream system during rainfall events, particularly for developed areas and areas with row crops. In addition, problems with sediment runoff during rainfall events have been observed, particularly on cultivated lands. This results in degraded water quality and sediment deposits in the stream.

There are significant terrestrial features within the subwatershed consisting of woodlots and wetlands. These provide wildlife habitat and help to protect water quality in Singer's Drain and the Welland Canal. A number of these features have been identified as significant on a Provincial level and classified as an Environmentally Significant Area (ESA) or Area of Natural or Scientific Interest (ANSI). They are somewhat disjointed (separate). However, given their proximity to the stream system potential exists to enhance their connection and provide a linear system (see **Figure 4.8.1**).

Singer's Drain has been impacted upon by past land use activities. High sediment loads from soil washoff have resulted in sediment deposits that choke aquatic habitat. In spite of impacts, there is a significant fish population in the stream system. Approximately half of the stream reaches are classed as having medium to high aquatic habitat quality. The habitat is classified as warmwater, however potential exists for coolwater habitat. A weir at the Welland Canal physically separates fish habitat between the Welland Canal and Singer's Drain.

Flooding problems have been experienced along portions of Singer's Drain where buildings are located near the watercourse and at some road crossings. The proposed work on the municipal drain portion are directed at reducing flood potential.

WHAT THIS STUDY IS ABOUT

The purpose of this study is to develop a management strategy to direct future land use and other activities that will affect environmental and resource conditions in the Port Robinson West Subwatershed and Singer's Drain. The key components of the study include.

- Review of background information related to the subwatershed
- Consult with the community to identify and discuss issues
- Carry out an analysis of subwatershed conditions
- Analyze potential impacts of future land use changes
- Develop a management strategy to direct future land use and stream activities

The study findings are discussed in detail in the body of this report. A summary of conditions (discussed in preceding section) management needs and an outline of the management strategy are discussed in this summary.

COMMUNITY INPUT

A comprehensive community participation process was developed and followed to ensure that there was community involvement in the development of a management strategy. The meetings held included:

- A public forum to discuss issues and concerns
- A meeting to discuss findings and management needs
- A public forum to further discuss management needs
- A meeting to present the preliminary management strategy and receive comments

Through the public process a vision was developed for the Subwatershed.

Vision and Elements

The Singer's Drain watershed should be managed to balance the community needs now and in the future for water supply, drainage and agriculture, and environmental needs with protected and enhanced terrestrial and stream conditions that are linked to other areas.

- Protect and enhance natural features
- Provide safe water source
- Improved water quality
- Improved fish habitat
- Link features to Welland Canal and other areas
- Provide for agricultural lands
- Provide trail system
- Environmental education
- Enhance species diversity

- There are sufficient terrestrial features within the subwatershed to provide what is generally considered to be a "good" portion of natural heritage feature coverage and meet the suggested MNR target of 15% (Main, South and Tollgate catchment basins) which is preferred to provide a healthier watershed condition.

MANAGEMENT STRATEGY FOR PORT ROBINSON WEST SUBWATERSHED

In order to provide a comprehensive and effective approach, a management strategy must address not only management needs related to land use activities, but also the opportunities related to overall watershed and stream conditions. A comprehensive management strategy, as with the plan recommended for Port Robinson West, therefore generally has three components.

- Stormwater management measures for drainage of existing and future land use activities
- Land use controls to protect (and enhance) terrestrial features
- Site specific works to mitigate existing problems and provide for remediation

The management strategy, including implementation consideration is outlined in Section 7.0 of the main report. The strategy elements are summarized as follows:

Stormwater Management

1. Stormwater management to provide for flood, erosion and water quality (Level 2) control for new development
   - Use of "at source" controls as a first priority
   - Protection of headwater streams
2. Development of a farm management strategy to reduce existing water quality impacts

Land Use Management

3. Management of land use changes by adopting constraint level 1 and 2 approach to protect recognized terrestrial resource features
4. Developing official plan changes to protect terrestrial features
5. Re-evaluate wetland features
6. Develop flood and fill lines

Site Specific Measures

7. Stream rehabilitation works for Singer's Drain as part of proposed flood mitigation
8. Remove weir at Welland Canal
9. Long term rehabilitation plan for Singer's Drain
10. Remove or modify on-line ponds
11. Develop a flow monitoring plan
12. Carry out water quality monitoring to investigate potential tile bed impacts

NIAGARA PENINSULA CONSERVATION AUTHORITY

PORT ROBINSON WEST
SUBWATERSHED STUDY

1.0 INTRODUCTION

1.1 General

This report provides the basis for a management strategy for the Port Robinson West Subwatershed (Singer's Drain). It has been recognized by the Niagara Peninsula Conservation Authority, City of Thorold, Town of Pelham, City of Welland, Regional Municipality of Niagara and community residents that a management strategy is necessary to guide future land use and natural resource management decisions. This management strategy will provide a background document for the proposed Official Plan update for the City of Thorold and future land use changes proposed in the Town of Pelham and City of Welland.

The study carried out for this report includes the characterization of the Port Robinson West Subwatershed, investigation of potential future land use changes, associated potential impacts and the development of a management strategy for the protection and enhancement of the subwatershed.

1.2 Port Robinson West Subwatershed (Singer's Drain)

The Port Robinson West Subwatershed outlets to the Welland Canal near Port Robinson and drains some 14.47 sq. km. (1,447 ha) of land. The subwatershed is located in the municipalities of Thorold, Pelham and Welland (including Regional Municipality of Niagara) (see **Figure 1.2.1**). The watercourse draining the subwatershed is Singer's Drain. The main branch of this drain is registered as a municipal drain and portions have undergone significant changes in the past, including deepening, diversion and straightening.

The study area includes a portion of land outside the subwatershed in the analysis carried out (see **Figure 1.2.1**). This area is included due to concerns regarding terrestrial features and their connection to Port Robinson Subwatershed features. The external areas are drained by the Towpath Drain and an unnamed drain which outlet to the Welland Canal just south of Singer's Drain.

This watershed is included in the Niagara River Remedial Action Plan (Stage 2). A series of recommendations are included which influence future actions in the watershed (ref – Niagara River Remedial Action Plan – Stage 2 Report. The Clean-up Connection, Environment Canada, 1995).

- Identify and control industrial point source pollution
- Prepare and implement a rural non-point source pollution remediation strategies
- Develop a mandatory septic system re-inspection system to reduce pollutant loadings
- Encourage the use of sound farming practices such as recommended in the Environmental Farm Plan program
- Assess and control sediment loads to the Welland River
- Monitor municipal and industrial point source contaminants
- Develop and implement a Welland River and (Niagara River) Tributaries Monitoring Program
- Support and encourage participation in Canadian Wildlife Services community based wildlife monitoring programs
- Public education programs directed to identifying how the general public can help to reduce impacts be continued and new programs developed

Currently land use is a mixture of agriculture, and urban uses. There are significant terrestrial features from an environmental perspective including several wetland areas and upland woodlots. Research has shown that terrestrial features play a strong role in setting the environmental conditions which exist in any watershed. The wetland areas buffer the stream from existing urban and rural land uses and augment base flows. The wetlands and woodlands provide wildlife habitat and an excellent area for nature viewing, environmental education and aesthetic features to the community. Singer's Drain provides an aquatic feature that is perennial along the main branch.

Some development potential exists within the Port Robinson watershed. The development potential has created the need to define and manage related environmental impacts in the watershed.

1.3 Approach to This Study

A subwatershed plan provides a management strategy that strives to balance land development with the protection, enhancement and rehabilitation of natural features such as woodlots, wetlands, streams and wildlife. As outlined in **Figure 1.3.1**, there are four major phases in a subwatershed plan.

Phase I	-	Review of subwatershed conditions and development of a characterization (how the subwatershed works)
Phase II	-	Further characterization of subwatershed, and data collection (based on focus provided by Phase I). Impact analysis of land use changes and analysis of effectiveness of management scenarios
Phase III	-	Development of a management strategy and Implementation Plan.
Phase IV	-	Implementation and monitoring plan and evaluation/modification of management strategy.

- **Scoped Study**

Although this study provides the comprehensive approach needed for Subwatershed Planning, it is a scoped study as a result of budget limitations and does not provide an in-depth analysis in some areas. Comprehensive hydrologic and water quality modelling has not been carried out. Sufficient analysis has been carried out to support the management strategy and where necessary recommendations are listed for additional analysis prior to implementing land use management items.

- **Study Goal and Objectives**

The project requirements are outlined in the Study Terms of Reference included in **Appendix A.** The goals and objectives are related to all phases (I to IV).

Study Goal

- To develop a management plan for the Port Robinson West Subwatershed which considers the natural resource features and provides for future uses in the subwatershed that recognizes these features and will protect or enhance environmental conditions.

Study Objectives

- To develop a management plan for Port Robinson West Subwatershed such that the watershed goals and objectives can be met in view of the combined impacts of all land use and land use changes existing or expected in this watershed.
- To streamline land use planning and approvals, by determining the boundaries of areas that are regulated or set aside from development based on Provincial and Municipal Policy Statements and legislation
  - Provincially significant wetlands

  - ESAs
  - Floodplains;
- To integrate the Subwatershed Planning process with other related processes:
  - Secondary Plans
  - Comprehensive Environmental Impact Studies under the Provincial Wetlands Policy
  - Class Environmental Assessments for Water Management and Municipal Works
  - Community Plan
- To develop an integrated watershed plan that will provide guidance to local and regional governments in planning future land use, infrastructure, and resource development while at the same time protecting and enhancing the environment. The goals of such a plan will be refined through the Subwatershed Process and will include measures:
  a) To conserve, protect and restore the natural land, water, forest, and wildlife resources of the Port Robinson West Subwatershed.
  b) To restore, protect and enhance water quality and associated aquatic resources and water supplies.
  c) To minimize the threat to life and the destruction of property and natural resources from flooding and erosion, and preserve natural flood plain hydrologic functions.
  d) To ensure public participation in the planning, development, implementation, and monitoring of the watershed management plan.
  e) To provide information on natural heritage features and areas which will assist municipalities in addressing the provincial policy statements, while respecting the rights of individual landowners, and;
  f) To identify stewardship opportunities for the watershed.

- **Study Steps**

The study approach is illustrated in **Figure 1.3.2**, and outlined as follows:

- Review background information and develop a summary including:
  - topographic mapping, air photos, resource maps
  - relevant study reports
  - servicing information
  - available field information (environmental, streamflow, groundwater, etc.)
- Work with steering committee in meeting with community to discuss issues and findings
- Prepare an issues summary and vision
- Carry out site reconnaissance and collect field data
- Carry out analysis to characterize subwatershed
- Identify potential watershed impacts
- Develop a Management Strategy

1.4 Report Structure

The sections and information provided in this report include:

Section 1.0 - Outline of purpose of study and approach
Section 2.0 - Discussion on subwatershed planning in general and legislative framework
Section 3.0 - Outline of the public participation process followed and summary of discussions
Section 4.0 - Characterization of Port Robinson West Subwatershed
Section 5.0 - Impact Analysis

Section 6.0 - Management Opportunities, Plan Development
Section 7.0 - Management Strategy and Implementation Comments

1.5 Source Of Information

Background information consists primarily of design reports and studies for the watershed. A list of reports included in the review are listed in **Appendix B.** Many of these reports have been prepared as part of land use and servicing studies.

Environmental Information
The Ministry of Natural Resources (Fonthill) and the Niagara Peninsula Conservation Authority (NPCA) were contacted for any information on the natural resources in the study area. This included fisheries information, forestry, wetland mapping, wetland evaluation records, Environmentally Significant Area reports as well as base mapping and air photos.

There were several existing reports which had been prepared as part of the Urban Boundary Expansion in Fonthill and for the E.S. Fox lands, see **Figure 1.2.1**. These were reviewed for pertinent information on the resources in the study area.

Information from background sources on vegetation communities, aquatic habitat and species present in the study area was incorporated into this study.

Air photos (1978, 1:10,000) and air photo mosaics (1995, 1:5,000) were reviewed and vegetation communities and watercourses identified. Ontario base maps (1:10,000) were also used.

Field Surveys
Members of the study team visited the study area on several dates. During these field surveys the following tasks were completed:

- **Aquatic Surveys**
  The majority of the creek system was walked to investigate aquatic habitat characteristics. The aquatic survey included:

  - stream course mapping,
  - stream characteristics were recorded including width, depth, substrate, water temperature, turbidity, riparian vegetation,
  - aquatic habitat was identified and described including pools, riffles, channel morphology
  - electrofishing was undertaken at appropriate locations,

- **Terrestrial Surveys**
  A field survey was undertaken to map and describe the terrestrial and wetland features in the study area. Vegetation communities were identified using air photos and base maps prior to the field survey. The community composition and boundaries were refined during the field surveys. All roads in the subwatershed were driven to record information on the vegetation communities visible from the road. Species composition, dominance and maturity were recorded for all areas visible. Selected sites were investigated on foot.

  Aerial photograph interpretation was relied on to determine vegetation for sites which were not visible or inaccessible.

All species of plants and wildlife which were observed during the field survey were recorded. Due to the timing of the field survey, only those plants with persistent identifiable parts were identified.

Hydrogeology
The following information was reviewed as part of the hydrogeology component of the study:

- Drainage Basins in Southern Ontario, Water Resources Map 3002-2, (Ministry of the Environment 1973).
- The Physiography of Southern Ontario, (Chapman and Putnam 1984).
- Topographic mapping
- Quaternary Geology and Industrial Minerals of the Niagara - Welland Area, Southern Ontario Geological Survey, Open File Report 5361, Ministry of Natural Resources (Feenstra 1981).
- Aggregate Resources Inventory of Town of Pelham, Regional Municipality of Niagara, Southern Ontario, Ontario Geological Survey, Aggregate Resources Inventory Paper 4, (Ministry of Natural Resources 1980).
- Ministry of the Environment and Energy (MOEE) Water Well Records for the Niagara Peninsula.
- Town of Pelham, Urban Expansion, Subwatershed Study, (Proctor and Redfern Limited 1996).

Hydrology, Hydraulics, Municipal Services
There is a limited amount of information available on surface water hydrology and hydraulics. Past studies focus on the analysis of Singer's Drain and development within Pelham.

Some surface water level records were collected for a short period during this study (1997/98) primarily for base flows. Floodline mapping has not been prepared for Singer's Drain however a hydraulic model has been developed for Singer's Drain (main branch) and was updated for this study.

Some reports have been prepared for municipal services, primarily looking at future service links between Pelham, Welland and Port Robinson.

Field data were collected for the purposes of this study include low flow and velocity readings, erosion/sedimentation reconnaissance and review of overall drainage characterization.

Land Use
Land use information is readily available from planning documents for all municipalities including Pelham, Thorold, Welland and the Regional Municipality of Niagara. Available planning documents include official plan reports, land use and servicing studies and development plans.

2.0 SUBWATERSHED PLANNING

2.1 Subwatershed Management Strategy

Subwatershed management is intended to augment the land use planning process as well as provide for sound management of environmental conditions and natural resources. Subwatershed plans are based on natural drainage boundaries as opposed to political boundaries in order to better assess and manage the impacts of development on the natural environment.

- **Cornerstones**

Watershed and subwatershed management is an evolving science. These changes are in response to the recognized need to manage our resources based on natural boundaries instead of political boundaries. This approach provides an understanding of how the "natural systems" work which in turn provides a basis for making sound decisions on resource management issues. It is critical to consider societal and economic factors in this process to ensure that the management approach reflects all needs. New management philosophies and tools are being developed to provide the most effective approach to managing our natural resources and guiding future land use decisions. The common thread through this evolving process is that a broad perspective is needed to ensure that the plan meets environmental and societal needs. It is important that watershed management recognizes **environmental, social and economic conditions** to ensure that all three elements are included and provide a "balanced" approach.

- **The Community**

Public participation is a critical component of subwatershed planning. Although a comprehensive, blended (economic, social, environmental) approach is necessary, community needs and values must form the foundation of the management strategy. All current and future residents in a subwatershed form a key component of the subwatershed and must be in general agreement with the management approach for it to be accepted. This is necessary to facilitate implementation and to provide a sustainable plan.

- **Adaptive Environmental Management**

A recent evolution of watershed management is the recognition of the need to provide an **adaptive environmental management approach**. As management tools are refined, new approaches developed and as societal characteristics and needs change, so do management strategies. A management strategy must provide a direction to follow. Just as importantly, it must be flexible so that modifications and "fine tuning" can be carried out.

A monitoring plan is one of the critical elements of a management strategy with specific targets set to be monitored. Performance relative to these targets is used to measure the effectiveness of the management activities in meeting the goals (and targets set). If the targets are not being met, modifications to the strategy can be made to ensure that the management strategy goals can be followed (see **Figure 1.3.1**).

- **Ecosystem Approach**

Given the comprehensive and complex nature of the watershed, an ecosystem approach is required in developing a management strategy. The watershed ecosystem is made up of the wildlife, vegetation, people and physical landscape that occupies the watershed, and by the processes that link these components. Degradation of the quality of any of these components will effect the entire ecosystem. Polluted water or depleted streamflows will have a negative impact on fish. If woodlots and wetlands are removed there will be a loss of wildlife habitat.

These conditions will have a profound effect on the quality of life of the human residents.

The hydrologic cycle diagram (**Figure 2.1.1**) shows the major components of a watershed ecosystem, the linkages between components and the major functions or processes that control the shape and quality of the watershed resources.

The major connecting link in a watershed ecosystem is the flow of water. This flow pattern is called the water budget. How and where the water flows determines the quality of the water, the shape and stability of streambanks, the health and diversity of the vegetation, and the availability of fish and wildlife habitat. In a relatively natural watershed, the flow of water is controlled by topography, soil type and vegetation. As human use of a watershed increases all of these characteristics can change, altering the water budget. The changed water budget then results in changes in the quality of both ground and surface water, the size and shape of stream channels and the stability of streambanks, vegetation cover and fish and wildlife habitat. These changes caused by the change in water budget often reduce the ability of the human population to use and enjoy the resources of the watershed.

The ecosystem approach requires description of ecosystems, description of stresses on the ecosystems and identification of indicators of the health of the ecosystem and the impact of the stresses. An integrated set of policies and management practices must be developed which considers people as an integral part of ecosystems. This is in contrast to the more common approach of relating environmental resources to an independent human population and set of policies. Inherent in the ecosystem approach is the concept of carrying capacity. The application of the concept of carrying capacity requires an attempt to understand the limits of an ecosystem's ability to support various life forms and land use activities. Human activities are then managed in a way that does not exceed these natural limits. When the carrying capacity is respected, the ecosystem remains healthy. When the natural limits are exceeded, the health of the ecosystem declines. The ecosystem approach used in this watershed study used the concepts of carrying capacity and ecosystem health in evaluating land use scenarios and watershed management options.

The major requirement, as well as the major benefit, of the ecosystem approach is that the people planning for human modification of the ecosystem have a basic conceptual understanding of the way in which the ecosystem functions and can anticipate, with some degree of confidence, the impact of human activities on ecological functions.

2.2 Legislative Framework

There is a broad framework of legislation that regulates land use and other activities within a watershed and along streams. The current framework for streams is illustrated in **Figure 2.2.1** and legislation related to issues is outlined as follows.

ONTARIO POLICIES AND REGULATIONS RELATED TO STREAMS

PROBLEM/ISSUE	LEGISLATION/POLICY DOCUMENT	ADMINISTERED BY
• Flood Protection stormwater conveyance design	• Municipal Act	MMAH
	• Planning Act	MMAH
	• Building Code Act	MMAH
	• Conservation Authorities Act	MNR
	• Ontario Reg.	CA

PROBLEM/ISSUE	LEGISLATION/POLICY DOCUMENT	ADMINISTERED BY
	• Lakes and Rivers Improvement Act	MNR
	Navigable Waters Protection Act	TC
	• Floodplain Planning Policy Statement (1988)	MNR
	• Floodplain Criteria (1982)	MNR
	• Beds of Navigable Waters Act	MNR
	• Drainage Act	OMAFRA
	• Public Lands Act	MNR
	• MTO Drainage Manual	MTO
• Sediment and Erosion Control During Construction	• Municipal Act	MMAH
	• Ontario Reg.	CA
	• Endangered Species Act	MNR
	• Environmental Protection Act	MOE
	• Lakes and Rivers Improvement Act	MNR
	• Ontario Water Resources Act	MOE
	• Environmental Contaminants Act	EC
	• Fisheries Act	DFO
• Fisheries Protection	• Endangered Species Act	MNR
	• Fisheries Act	DFO
• Bacteria Control	• Environmental Protection Act	MOE
	• Ontario Water Resources Act	MOE
	• Environmental Protection Act	EC
• Water Quality (Aesthetics)	• Pesticides Act	MOE
	• Environmental Protection Act	MOE
	• Ontario Water Resources Act	MOE
	• Environmental Contaminants Act	EC
• Watershed Planning	• Conservation Authorities Act	MNR
	• Ontario Reg.	CA
	• Crown Timber Act	MNR
	• Drainage Act	OMAFRA
	• Endangered Species Act	MNR
	• Environmental Assessment Act	MNR
	• Environmental Protection Act	MOE
	• Forestry Act	MNR
	• Game and Fish Act	MNR
	• Historical Parks Act	MCCR
	• Lakes and Rivers Improvement Act	MNR
	• Municipal Act	MMAH
	• Ontario Planning and Development Act	MMAH
	• Ontario Water Resources Act	MOE

PROBLEM/ISSUE	LEGISLATION/POLICY DOCUMENT	ADMINISTERED BY
	• Aggregate Resources Act	MNR
	• Planning Act	MMAH
	• Trees Act	MNR
	• Woodlands Improvement Act	MNR
	• Canada Waters Act	EC
	• Canada Wildlife Act	DFO
	• Navigable Waters Protection Act	TC
	• Wetland Policy Statement	MNR
	• Provincial Policy Statement	MMAH

Agencies:			
	MMAH	-	Ministry of Municipal Affairs and Housing
	MNR	-	Ministry of Natural Resources
	CA	-	Conservation Authority
	TC	-	Transport Canada
	OMAFRA	-	Ontario Ministry of Agriculture Food and Rural Affairs
	EC	-	Environment Canada
	DFO	-	Department of Fisheries and Oceans
	MOE	-	Ministry of Environment
	MTO	-	Ministry of Transportation of Ontario

3.0 COMMUNITY PARTICIPATION

3.1 Introduction

Community participation is one of the key elements in developing a subwatershed management strategy. Since the management strategy will guide the future environmental and aesthetic conditions in the subwatershed, it is important to ensure that it reflects the community goals (society needs).

Public meetings and a workshop have been held for the purpose of identifying the key issues and developing a vision and objectives, discussing analysis findings for characterization discussing management needs and in the development of a final management strategy.

3.2 Port Robinson West Subwatershed - Steering Committee

A steering committee was established to guide the development of a management strategy for the Port Robinson West Subwatershed. The committee includes staff members from the agencies that are most active in the management of Port Robinson West Subwatershed and key members of the study consultants.

**Port Robinson West Subwatershed
Steering Committee**

Member	Affiliation
Kathy Menyes	Niagara Peninsula Conservation Authority
Drew Semple	Region of Niagara
Doug Cherrington	Region of Niagara
Adele Arbour	City of Thorold
Tom Doherty	City of Thorold
Mike Marco	City of Welland
Jack Bernardi	Town of Pelham
Anne Yagi	Ministry of Natural Resources
Bob Shannon	Ministry of Environment
Dave Stephenson	Ecologistics/Natural Resource Solutions Inc.
Barb Wiens	Hynde Paul
Ray Tufgar	Totten Sims Hubicki

3.3 Community Meetings

Community involvement in the subwatershed study has been obtained through the following:

- Nov. 17, 1997 - First public meeting and workshop to discuss issues and concerns and develop a watershed vision.
- March 11, 1998 - Public meeting and workshop to discuss potential impacts, opportunities and constraints and management needs.
- April 1, 1998 - Additional public meeting to discuss management needs.
- June 17, 1998 - Meeting to present management strategy and receive comments.

A summary of the discussions held and information provided and received at the meetings is included in **Appendix C.**

- **First Open House** and Workshop (November 17, 1997)

An initial open house was held to present the intended preparation of a subwatershed management plan for Port Robinson West Subwatershed, discuss the proposed approach, receive feedback on issues, concerns and to develop a vision. This information was then used to guide the study approach and focus to ensure that the community concerns were addressed.

The primary area of concern was with respect to flooding and erosion on Singer's Drain. There was also significant discussion with respect to water quality and environmental health. Specific issues that were discussed included.

- Where will peninsula corridor be located
- Do not allow urban development or its impacts
- No cost to landowners for improvements
- Stagnant water in ditches creating health concerns
- Clean out Singer's Drain
- Quality of well water during flood events (dirty water)
- Protect natural areas (wood lots)
- Protect agricultural lands for future use
- Area too sensitive to allow further development (ie. water quality)
- Develop this area to reduce pressure north of Highway 20
- Need more communication on problems and what is being done about it (flooding)
- Increase size of driveway culverts
- Need to expand study area to consider adjacent agricultural lands and natural areas

A questionnaire was provided (see **Appendix C**) to allow the issues to be prioritized (11 returned). The results are summarized as follows:

The issues identified to date are outlined as follows. Please indicate the level of importance by ranking the issues in order (1 for highest).	
	Rank
• Flooding problems have been indicated along Singer's Drain resulting in overtopped roads and flooded property	1
• Erosion problems along Singer's Drain resulting in loss of property	4
• Impacts of land use on water quality	2
• Need to preserve woodlots and wetlands	2
• Need to enhance wooded areas for wildlife and wildlife corridors	3
• Loss of agricultural land for urban development	5

- **Public Meeting** (March 11 and April 1, 1998)

A series of the public meetings and workshops were held to discuss study findings including potential impacts of land use changes and a discussion of issues related to management strategy development. The input received was then used in the development of a management strategy.

A questionnaire was provided related to management (see **Appendix C**). The results of discussions during the meeting and questionnaire are outlined.

A working session was held to discuss specific management issues. Three questions were presented as follows with the resulting discussions.

1. Enhancement of the stream for fish habitat and water quality improvements should involve providing a wide channel. Would this be acceptable?

2. The on-stream ponds degrade water quality by warming the water and adding nutrients. Would their removal be of concern?

3. Some of the wooded areas could be designated for protection from land use changes. Is this a concern?

Specific information received during the workshop and public meeting includes:

- There is general agreement that stream enhancement (for water quality and fish habitat enhancement) would be a beneficial approach to Singer's Drain.
- Concerns were expressed with regard to additional costs and who would fund the work. It was suggested that flood control is the primary objective and enhancement should be included if feasible and affordable.

- As with previous meetings, concerns were expressed with regard to the potential impact of future development and that flood potential reduction should be carried out prior to any new development.
- Concerns were expressed with regard to the removal of the weir at Singer's Drain and the resulting impact on the upstream wetland.
- Some concerns were expressed with regard to the removal of on-line ponds given the aesthetic benefits, however there was general agreement that if it provided significant benefits it should be considered.
- It was indicated that if off-line ponds could still be provided this would be a preferred approach.
- It was generally agreed that environmentally significant terrestrial features should be protected if possible.
- Concern was expressed with regard to further regulation and the loss of landowner rights.

- **Public Meeting June 17, 1998**

A public meeting was held to discuss the proposed management strategy and to receive comments. The meeting was well attended. A presentation of the proposed strategy was provided followed by an open discussion. The comments received were used in the development of the final strategy. Key comments included:

- Some of the constraint area boundaries were questioned resulting in some minor adjustments.
- It was questioned if the removal of the weir at the Welland Canal was viable. It was indicated that additional analysis and an approval process would be necessary.
- There was discussion on the need for a stewardship program to assist in a rehabilitation program.

3.4 Vision and Issues

Based upon the information received during public consultation, a Vision and Issues summary was developed for Port Robinson West Subwatershed.

Vision and Elements

The Singer's Drain watershed should be managed to balance the community needs now and in the future for water supply, drainage and agriculture, and environmental needs with protected and enhanced terrestrial and stream conditions that are linked to other areas.

- Protect and enhance natural features
- Provide safe water source
- Improved water quality
- Improved fish habitat
- Link features to Welland Canal and other areas
- Provide for agricultural lands
- Provide trail system
- Environmental education
- Enhance species diversity

Concerns/Issues

- Flooding - size of channel and culverts
- Solve current problems prior to development
- Who will pay to fix problems?
- Preservation of environmental features

- Poor farming practices add to problems
- Poor water quality
- Sediment in the creek
- Loss of wildlife
- Link stream to Welland Canal
- Clean out Singer's Drain and rehabilitate

4.0 PORT ROBINSON WEST SUBWATERSHED

4.1 Introduction

The Port Robinson West Subwatershed is predominantly an agriculture based watershed area with a significant amount of urban development on the fringe and rural residential along the main roadways. Most of the watershed is made up of relatively flat clay till soils with some sandy hill areas in the headwater areas (Fonthill).

Singer's Drain is a municipal drain and has been straightened and deepened in the past. Changes were made to facilitate agricultural drainage and reduce flooding problems.

Urban storm drainage is primarily provided through roadside ditches with some sections enclosed in culverts. Little stormwater management exists and most drainage work has been carried out to provide outlets for stormwater flow. Existing features and conditions are illustrated in photographs on following pages.

4.2 History of Port Robinson West Subwatershed

The watershed is characterized by both urban and rural activities. Past activities in the area have primarily been agricultural, ranging from fruit to grain crops. The quality of the soils and poor drainage have limited the area from becoming a major crop producing area.

Urban growth has focused in the areas of Fonthill, Welland, Singer's Corners (Port Robinson Road and Merritville Highway), and Port Robinson. Recently there has been a focus on industrial development adjacent to Port Robinson.

The Welland Canal is a major feature in the area and provides an outlet for Singer's Drain. It provides a shipping corridor that has facilitated in the recent industrial growth adjacent to Port Robinson.

4.3 Subwatershed Land Use Characteristics

The Port Robinson West Subwatershed is divided by the municipality of Thorold, Fonthill, Welland and the community of Port Robinson. The main purpose of this study is to consider future urban expansion within each of these communities and the related potential impacts to the watershed area. The City of Thorold, in particular, will be updating their Official Plan which will incorporate land use requirements to protect and or enhance the watershed.

Existing land use in the watershed is primarily Agricultural with a mix of urban and rural residential. **Figure 4.3.1** illustrates existing land use. A significant number of terrestrial resource features (woodlands and wetlands) exist with most of these designated as significant areas. A summary of current land use areas is provided in **Table 4.3.1**

Table 4.3.1
Existing Land Use (ha)

Agricultural		943
Urban (serviced)		204
Rural Residential		60
Terrestrial Features (woodlands, wetlands, stream)		240
	Total	1447

Urban serviced (water, sanitary and storm) lands are located within the Fonthill and Welland area. Storm servicing is primarily through roadside ditches, however some storm sewer or enclosed sections exist. The rural residential areas have private water and sewage services. Recent studies have been carried out to expand and link Fonthill and Welland services with Port Robinson (Region of Niagara, 1997). This will also provide services to the industrial growth area adjacent to Port Robinson.

4.4 Physiography, Soils and Geology

The Port Robinson West Subwatershed is located within the Lake Ontario Basin, north of Welland Ontario. It occupies the north-eastern part of the Welland River Watershed, draining an area of 14.47 km^2 to the Welland Canal at Port Robinson (**Figure 4.4.1**). Drainage is from west to east via two major channels which originate as several smaller tributaries at the upper end of the subwatershed, near Fonthill.

4.4.1 Physiography

The western limit of the subwatershed is formed by the Fonthill Kame Complex, an elevated area composed of permeable deposits ranging from sand and gravel to sand and silt. The remainder of the subwatershed is generally low-lying and is overlain by glaciolacustrine deposits of silt, and clay which form part of the Haldimand Clay Plain. Ground surface elevations decline from west to east in three stages (**Figure 4.4.2**). From the western limit of the subwatershed to just east of Fonthill, at the CN Railway Line, ground surface declines from approximately 237 mAMSL to 193 mAMSL at an average gradient of 49 m/km. From this point to just east of Niagara Road / Merrittville Highway the gradient is much less steep, declining at a rate of about 5 m/km, to about 180 mAMSL. From this point, eastward, ground surface is relatively flat, lying at an elevation of approximately 180 mAMSL.

4.4.2 Surficial Geology

The surficial geology (Feenstra, 1984) in the vicinity of the study area is illustrated in **Figure 4.4.3**. The upper reaches of the subwatershed in the vicinity of Fonthill are dominated by permeable deposits of Lake Warren III (part of the Fonthill Kame Complex). These deposits become finer to the east, ranging from sand and gravel to sand and silt. The remainder of the subwatershed (approximately 85%) is overlain by relatively impermeable materials consisting of deeper water glaciolacustrine deposits of silt and clay. The change in surficial geology coincides with the break in topography, where the area highest in elevation corresponds to the sand and gravel deposits, the area with the steepest gradient corresponds to the sand and silt deposit and the remainder of the area (that with a low or negligible gradient) is overlain by clays and silts.

Total overburden thickness generally decreases from west to east (**Figure 4.4.4**). Within the Fonthill Kame Complex, thickness ranges from about 57 to 69+ m; within the lower lying areas over the remainder of the subwatershed thickness ranges from about 25 to 38.5 m.

4.4.3 Soil Capabilities

Background information related to soil capability indicates that soils within the Port Robinson subwatershed are Class 2 (Soil Capabilities for Agriculture – ARDA, 1968). This class includes soils with moderate limitations that restrict the range of crops or require moderate conservation practices. Generally the soils are deep and are well to imperfectly drained, hold moisture well and are well supplied with nutrients (in a virgin state). They can be managed and cropped without difficulty. Under good management they are moderately high to high in productivity for a wide range of field crops. The limitations within the Port Robinson watershed include low permeability and restricted rooting zone in the lower part of the watershed. Restrictions in the upper part (headwater) are related to slopes that are too steep to use efficiently for agriculture.

More detailed soil capability mapping (ref – Pelham/Thorold/Welland/Development Study) indicates a range of Class 1 to Class 7 (increasing class number indicates higher restrictions to capability) with most soils in the Class 1 to 3 range. Cropping practices in the subwatershed have varied in the past including primarily pasture and row crops. Fruit cropping has been included for agriculture as well as nurseries. Less than half of the area soils are classified as good to fair for tender fruit crops (see ref – Pelham/Thorold/Well and Development Study). Current practices primarily include row crops, pastures and nurseries.

4.4.4 Bedrock Geology

With the exception of the area north of Fonthill, the subwatershed is underlain by the dolostone bedrock of the Lockport Formation (Eramosa Member) to the west and the Guelph Formation to the east (**Figure 4.4.5**). The area north of Fonthill is underlain by an unnamed member of the Lockport Formation which may consist of dolostone with some shale or limestone.

Bedrock topography mapping indicates that bedrock surface west of the contact of the Guelph and Lockport Formations ranges from 130 to 135 mAMSL with the exception of a local bedrock low in the immediate vicinity of Fonthill which drops to an elevation of about 122 m (400 ft.) AMSL. East of the contact bedrock elevations dip gradually to the west for approximately 150 to 145 mAMSL.

4.5 Subwatershed Hydrogeology

4.5.1 Conceptual Hydrostratigraphic Model

A conceptual model of the subwatershed is presented in **Figure 4.5.1,** utilizing a cross-section oriented from west to east across the watershed. The following points are made with respect to the geology, and groundwater and surface water interaction within the watershed (numbered points refer to the numbers on the cross-section):

1. The upper end of the subwatershed consists of permeable (sandy) deposits which often extend to bedrock.
2. The eastern part of the subwatershed is relatively flat, and is predominantly underlain by aquitard (clay) materials, with some sandy pockets. The aquitard forms a sharp contact with the sand deposits to the west.
3. A thin, sand aquifer unit separates the aquitard (unit 2) from bedrock. This unit appears to be hydraulically connected to the sand deposits to the west .
4. The subwatershed is underlain by dolostone bedrock.
5. Precipitation falling within the western half of the subwatershed, could a) runoff, b) recharge radially from the topographic height, to the deeper aquifer units, such as bedrock, or the lower sand, or c) discharge to surface in the vicinity of the clay contact, providing baseflow to area tributaries.

6. The majority of precipitation falling within the eastern half of the subwatershed, will become runoff, rather than infiltration however the limited precipitation that does infiltrate is expected to discharge local tributaries.

4.5.2 Detailed Geologic and Hydrostratigraphic Assessment

Figure 4.5.2 illustrates the location of three geologic cross-sections, constructed across the subwatershed.

Section "A-A" (**Figure 4.5.3**) has been constructed from the topographic high in the west, to just east of the Welland Canal. As in the conceptual model, this cross-section illustrates the extensive sand and gravel deposits in the western portion of the subwatershed, that range in thickness from approximately 62.5 to 85 m. In many cases, a clayey aquitard unit is shown separating this upper sand unit from a lower sand unit and bedrock, however, the aquifer units are assumed to be relatively well connected given the apparent lack of continuity of the aquitard. This area is well drained (ie. good recharge) resulting in poorly defined surface features. The majority of water movement in the subwatershed is controlled by the extensive clay deposits of the Haldimand clay plain, which covers the majority of the area. The Haldimand plain to the east is typically described as clay, and is generally on the order of 25 to 35 m thick. This unit prevents significant infiltration to depth and promotes surface flow, providing well defined surface drainage features. A basal sand unit is identified on the majority of well records utilized for this cross-section. This unit is relatively thin, generally ranging from <1 m to 5 metres thick.

Cross-section "B-B" (**Figure 4.5.4**) is constructed from south to north, at the west end of the subwatershed. In this area, the majority of the subwatershed is overlain by thick (30 to 50 m) clay and clay till deposits, which is underlain by a thin basal sand and gravel unit. However, the western part of the subwatershed, and the area to the immediate east of the subwatershed is overlain by sand deposits, which extend to bedrock, and are connected to the basal aquifer. This indicates that the configuration of the boundary between the Kame complex and the clay plain may be slightly different, than that illustrated by surficial geology mapping. The Kame deposit appears to extend further to the east on the north and south sides of the watershed and not as far east within the central part of the subwatershed. The total area represented by the Kame complex is therefore either similar to, or slightly larger than that interpreted from surficial geology.

Cross-section "C-C" (**Figure 4.5.5**) is constructed from south to north along Niagara Street / Merrittville Highway in the eastern portion of the subwatershed. The dominant overburden material is clay, which is underlain by bedrock. Of note however, are the two thick sequences of sand which in the south at least, appear to be well connected to bedrock and close enough to surface (less than 5 m in one case) to receive infiltrating precipitation directly. The basal sand aquifer is not clearly evident in this cross-section.

4.5.3 Groundwater Recharge

The main recharge area for the subwatershed is the Fonthill Kame Complex, which forms a topographic high at the western limit of the subwatershed. This area represents approximately one sixth (16.7%) of the total area of the subwatershed. Deposits in this area range from sand and gravel to sand and silt, and often extend to bedrock. To the east, the Kame Complex forms a sharp contact with the Haldimand Clay Plain.

Given the underlying stratigraphy, it appears that water infiltrating within the Kame Complex either recharges the deeper groundwater system (i.e. bedrock or a basal sand and gravel), or discharges to surface, as a result of the change in lithology (sand to clay) and the "break" in ground surface slope. The resulting discharge provides a source of baseflow for area tributaries. The large area of the Fonthill Kame Complex recharges underlying aquifers, throughout the area. Regionally, ground water flow is likely radial outward from the Kame Complex. Ground water flow divides will not necessarily follow the surface water flow divides throughout the area.

The dense nature of the clay and clay till materials which overly the remainder of the subwatershed, provide little opportunity for recharge to deeper aquifers, and as a result the majority of precipitation in these areas likely results in runoff to surface watercourses.

4.5.4 Groundwater Flow - Groundwater Discharge and Baseflow Assessment

Baseflow is the component of streamflow originating from groundwater discharge (as opposed to surface water runoff). It is generally estimated by measuring streamflows after an extended period without precipitation. These low flow values are representative of baseflows, since the effects of precipitation have been minimized.

As discussed in Section 4.4, a portion of the water infiltrating to the water table via the Fonthill Kame Complex, likely discharges to ground surface where there is a break in the steepness of the slope, and where the permeable materials of the Kame Complex form a sharp contact with the aquitard materials to the east which forces groundwater to surface. Discharge from the Kame Complex would likely provide baseflow to tributaries in the vicinity of Cataract Road and Rice Rd. The Niagara St. - Cataract Road Woodlots Wetland is also likely an example of this groundwater "upwelling".

Over the remainder of the subwatershed, groundwater discharge would likely be of a local nature given the low gradient, low permeability and close proximity of the water table to ground surface.

Section 5.3 contains estimates of baseflows, under existing conditions and under two development scenarios.

4.6 Groundwater Use

The majority of residents in the subwatershed rely on groundwater as a source of water supply. The western most portion of the subwatershed, within the Town of Pelham, is serviced by water supply wells. The majority of the subwatershed is in the rural area of the City of Thorold and is privately serviced. Most residents have a private well and septic system.

Water well records on file with the Ministry of Environment (MOE) indicate the majority of wells are located in the basal sand and gravel or the underlying bedrock aquitards and are typically 40 to 60 metres in depth. A small number of wells are located in sand and gravel units within the extensive clay units found in the eastern portion of the subwatershed. Most wells produce more than adequate water to meet domestic usage for individual residences and generally have good water quality.

The majority of the subwatershed provides good groundwater protection for the underlying aquifer units given the extensive low permeability clay material throughout the subwatershed. These underlying aquifer units however, are recharged primarily from outside the subwatershed, in particular from the Fonthill Kame Complex. These areas are potentially susceptible to surface sources of contamination in these areas. Some area residents have complained of contaminated surface water entering their supply wells during periods of flooding.

4.7 Hydrology - Surface Water

The Study Area is primarily comprised of agricultural land and open space, and is located within the Town of Pelham, the Town of Thorold, and a small portion in the City of Welland (**Figure 4.3.1**). It is defined as an area that drains into two major branches of the Singer's Drain, the North Branch and the South Branch. The north branch flows from west to east, west of Rice Road, to the north side of Port Robinson Road, then downstream to a confluence point with the south branch. The south branch also drains from west to east from west of Rice Road and continues east to the confluence with the main drain. The main drain outlets into the Welland Canal near the Port Robinson Road Woodlot.

Watershed information as well as a base hydrologic computer model was derived from an Otthymo.89 model, and data developed in the Singer's Corners Municipal Drain Report (1997, Wiebe Engineering Group) and in the Pelham Urban Boundary Expansion Sub-watershed Plan (1996, Proctor and Redfern Ltd.).

4.7.1 Hydrologic Modeling

For modeling purposes, the 1447 hectare watershed, is divided into 18 sub-catchments (Refer to Singer's Drain Watershed **Figure 4.3.1** and model **Figure 4.7.1**).

The drainage areas for each subwatershed are summarized in **Table 4.7.1.** The hydrologic model is included in Appendix D.

Table 4.7.1
Catchment Area Summary

Subarea	Drainage area (ha.)
1	44.0
2	68.9
3	15.2
4	47.1
5	26.5
6	35.6
7	43.5
8	53.6
9	105.9
10	56.0
11	52.0
12	116.2
13	136.1
14	133.1
15	398.1
16	32.1
17	43.6
18	39.5
Total	1447

The updated existing land use and catchment characteristics of the Singer's Drain Watershed were input into the Otthymo.89 hydraulic model. See **Table 4.7.2** for a design flow summary.

Table 4.7.2
Design Flows (CMS)

		Return Period (yrs)				
Area (Fig 4.3.1)	Outlet Location	2	5	10	25	100
4	Rice Road N of Rd.63	1.31	2.07	2.79	3.60	5.00
5	Rice Road at Rd.63	0.22	0.41	0.60	0.83	1.20
6	Rice Road S of Rd.63	1.55	2.45	3.27	4.37	6.00
7	Rice Road N of Merrittville	0.39	0.71	1.00	1.45	2.10
8	Rice Road S Merritville	0.50	0.85	1.22	1.67	2.40
9	Cataract and Rd.63	3.42	5.82	7.98	10.49	14.30
10	Cataract N of Merrittville	1.47	2.66	3.90	5.45	7.80
14	Kottemier N of Rd. 63	5.06	9.40	13.35	18.23	24.92
16	Lot 204/205 Con.	6.90	12.67	18.05	24.61	33.94
18	Welland Canal	7.00	12.91	18.38	25.03	34.51

4.8 Terrestrial Conditions

4.8.1 Introduction

Regional Context

Vegetation in the Niagara Peninsula is exceptionally diverse, with unique biological communities which are more characteristic of southerly forests. The climate here is moderated by Lake Erie and Lake Ontario with the Niagara Escarpment providing a buffer against the colder northern climate influence. A number of tree species that occur in this region are rarely found elsewhere in Canada. Sassafras, tulip-tree, pawpaw and red mulberry are examples of "Carolinian Forest" species with ranges that extend northward into Canada.

The term Carolinian Forest refers to a geographical zone extending from the Carolinas and Georgia to southwestern Ontario and the Niagara peninsula which encompasses three major vegetation associations; Oak/Hickory, Oak/Chestnut and Maple/Beech. The northern boundary of this zone is not clearly defined but is the transitional zone between the predominantly deciduous forests of southern Ontario and the predominantly coniferous forests of the Canadian Shield.

The Singer's Drain subwatershed is located south of the Niagara Escarpment and west of the Welland Canal. Much of this area consists of clay soils which have poor natural drainage and therefore provide marginal agricultural land. The exception to this is the Fonthill Delta Kame with sand and gravel soils located just outside our study area to the north west. This forested area has been designated the Short Hills-St. John's Environmentally Sensitive Area. The ESA is 257 ha in area and has hilly terrain with steep slopes providing the headwaters for Twelve Mile Creek, which is a coldwater stream. The slopes are forested with maple, beech, hemlock, oak and aspen.

In contrast, the forests found in the Singer's subwatershed are smaller and confined to poorly drained areas, plots too small for agricultural use and recreational areas. Maple, beech, oak, hickory, ash and elm are the dominant species. Singer's Drain is a warmwater stream which is heavily influenced by agriculture. The stream channel has been straightened and dredged with poor riparian cover.

4.8.2 Designated Natural Areas

There are several designated natural areas (by MNR and Region of Niagara) found within the subwatershed. These include the Port Robinson Duck Ponds ESA (Environmentally Significant Area) also designated a provincially significant wetland (Port Robinson Woodlot Class 1), Niagara St.-Cataract Road Woodlot provincially significant wetland (Class 3), Rose Little Woodlot ESA and Kunda Park ANSI (Area of Natural or Scientific Interest). These areas are described below and shown on **Figure 4.8.1.**

Port Robinson Duck Ponds ESA (Port Robinson Woodlot provincially significant wetland)
The description of this ESA is extracted from the Environmentally Sensitive Areas report prepared for the Regional Municipality of Niagara (1980). This ESA is located at the mouth of Singer's Drain at the eastern boundary of the study area. The Port Robinson Duck Ponds ESA occupies 59 ha and includes two blocks of woodlot which are separated by a railway line (Brady 1980, Regional Municipality of Niagara 1985). Most of the ESA is an old canal excavation that has been refilled. Two branches of Singer's Drain meet upstream of the railway line and drain this area to the Welland Canal. The railway line blocks drainage and has created several ponds on its upstream side.

Terrain alteration has created low areas surrounded by 8-10 m high ridges of sand and gravel. The ridges have become reforested and support a mature upland forest with sugar maple, beech, pin, red and black oak, black cherry, shagbark hickory and blue beech as well as other species. Willow, basswood, dogwood and arrow-wood are found along the stream channel.

The low lying areas support a wetland which has been designated a provincially significant wetland (Port Robinson Woodlot Class 1). Cattail, rushes, reeds, aquatic grasses, duckweed and arrowhead make up the marsh component of this wetland.

This wetland area (9.1 ha) provides a large area of waterfowl habitat as well as a migratory stopover and a concentration point for waterfowl, raptors and owls.

Niagara St.-Cataract Road Woodlot Provincially Significant Wetland
This 12 ha provincially significant wetland is located west of the corner of Merritt Road and Cataract Road near the southwest corner of the subwatershed. This wetland is mainly deciduous swamp with red maple, bur oak and dogwood. Pin oak, a rare species, is known from this area (MNR 1987).

Vegetation communities were mapped between these two provincially significant wetlands to determine if they could be complexed as one wetland. Based on our study of the area and the 750 m complexing boundary, these two wetlands are not part of the same complex.

Rose Little Woodlot ESA and Kunda Park Forest ANSI
This 26 ha woodlot is located north and south of Merritt Road west of Rice Road. It is fragmented by Merritt Road and many houses and clearings which have been built along this road.

Sugar maple, beech and red oak are the dominant species. A number of Carolinian species are found in this woodlot including tulip tree, pignut hickory, sassafras, eastern flowering dogwood and spicebush. Of special interest is the presence of American chestnut found along the northern edge of the portions of the woodlot north of Merritt Road (Brady 1980, Regional Municipality of Niagara 1985).

A portion of this woodlot has been designated a regionally significant life science ANSI, the *Kunda Park Forest* (Proctor and Redfern 1996). This ANSI is found in the north eastern portion of the woodlot and has been designated as such based primarily on the presence of regionally rare plant species including Carolinian tree species.

4.8.3 Vascular Flora

A total of 137 species of plants have been observed in the subwatershed. A list of these species is included in **Appendix D**. This list has been compiled from plants observed during our field surveys as well as those listed in other background reports and wetland evaluations and is a preliminary list only.

There were 4 rare species of plants observed in the study area (Oldham 1996). These species are shown in **Table 4.8.1.**

Table 4.8.1.
Rare Plant Species found in the Subwatershed

Scientific Name	Common Name	Status	Habitat
Carya glabra *Carya ovalis*	Pignut Hickory	Rare to Uncommon	Upland deciduous forest
Castanea dentata	American Chestnut	Rare to Uncommon	Upland deciduous forest
Quercus palustris	Pin Oak	Rare to uncommon	Damp, poorly drained soils adjacent to swamps
Blephilia ciliata	Downy Woodmint	Extremely rare	Dry woods

Pignut Hickory
This species is present in 7 counties, all in the Carolinian zone of Ontario. This species prefers dry to dry-mesic deciduous forest and savanna. It is rare in Ontario and Canada.

American Chestnut
Chestnut was a major forest species throughout most of eastern North America before the introduction of chestnut blight fungus at the beginning of this century. It now usually occurs only in the form of occasional stump sprouts from persistent root systems. After several years of growth, these sprouts also become susceptible to the blight and usually die before reaching maturity. This tree is found sporadically throughout the Carolinian zone in Ontario. In addition to blighted trees and stump sprouts, mature trees without blight symptoms are occasionally seen (Argus et al 1982-1987).

Pin Oak
This species is found in lowland deciduous forests, hedgerows and forest edges, usually with waterlogged or poorly drained soils. In Ontario, pin oak is found only in the Niagara Peninsula and the Windsor-Sarnia area. This Carolinian species occurs more extensively through the eastern United States.

Downy Woodmint
This plant is known to occupy open ground and thickets on limestone plains. It is extremely rare in Ontario and rare in Canada. This specimen was collected during this study in late fall/early winter and as such, cannot be definitively identified as this species. Further field studies in the spring and summer would be required to verify

this species.

There are a number of plant species which occur in the study area which have been considered rare in the past. A number of these have been "downlisted" as more locations became known. For example, tulip tree, flowering dogwood and southern arrow-wood are all considered common. These species were previously recorded as rare.

4.8.4 Vegetation Units

The character and extent of vegetation types in the subwatershed were documented through field surveys and review of background information and is summarized below. Vegetation units are divided into upland and wetland types and are shown on **Figure 4.8.1.** The relative significance of these communities is summarized at the end of this section.

4.8.5 Upland Vegetation Units

Old Field
A large portion of the study area is occupied by abandoned agricultural land. This land has become overgrown with old field plant species. This type of community is characterized by goldenrods, asters, grasses, wild carrot, milkweed and chicory. Scattered shrubs and small trees are found including white ash, dogwood, hawthorn and buckthorn.

In areas of poor drainage or along streams, open areas are colonized by sedges, cattails, reed canary grass and grey dogwood shrubs.

Scrubland
Dense shrub growth is found to occupy a fairly large portion of the subwatershed. Red-osier dogwood, grey dogwood, alternate leaved dogwood, buckthorn and hawthorn shrubs are the most common. Scrubland areas are typically moist with poor drainage and are unsuitable for agriculture. Grasses, asters, timothy, raspberry and goldenrods make up the groundcover.

Immature Woodlands
The edges of mature woodlands and successional areas are forested with immature trees. These areas are upland or lowland with mixed deciduous cover less than 15 cm dbh (diameter at breast height). White ash, trembling aspen, sugar maple and beech are dominant on drier sites while cottonwood, balsam poplar, red maple and silver maple are found on wetter sites.

These woodlands are fairly dense with a well developed understorey of shrub growth. Buckthorn and dogwood are the most common.

Immature woodlands follow scrubland in the natural succession process. Trees growing in this type of community are accustomed to open conditions and exposure to sun and wind.

Sugar Maple - Red Oak - Beech
Mature upland woodlands in the subwatershed are comprised of sugar maple, red oak, american beech and black cherry. Trees range in size with an average diameter of 25 cm. White birch, black cherry, pin oak, white oak and white ash are also found in these woodlots. Various shrubs and small trees make up the midstorey including beech, blue beech, witch hazel, dogwood and chokecherry. The wooded stands typically include numerous small, shallow depressions that are seasonally wet.

Woodlots in the subwatershed were found to be typical of the Carolinian forest zone with many species which are more common to the south. The Rose Little Woodlot was found to contain tulip tree and sassafras. Sycamore, bitternut and shagbark hickory, swamp white oak and spicebush are Carolinian species which were observed in woodlots during this study.

Conifer Plantation
A few small conifer plantations are found in the subwatershed. These plantings are relatively young, approximately 20-25 years old. White pine, red pine, white spruce and white cedar are the most commonly planted species. Other trees such as Norway spruce have been planted in hedgerows along farm lanes.

4.8.6 Wetland Vegetation Units

Open Water Marsh
There are several ponds in the Port Robinson Woodlot provincially significant wetland which support free floating and submergent vegetation. Duckweed, waterweed and pondweed are found in these marshes. Other areas of open water marsh are found in the woodlots along the south side of Merritt Road.

Emergent Marsh
There are small pockets of emergent marsh vegetation found in the subwatershed which are dominated by cattail, burreed or reed canary grass. Scattered shrubs, arrowhead, purple loosestrife, jewelweed and water plantain are also found in this community. Cattail marsh is commonly found along streams, ponds and ditches which experience fluctuations in water level. The Port Robinson Woodlot provincially significant wetland contains several areas of cattail and burreed marsh in conjunction with shrub swamp, deciduous swamp and upland forest.

Shrub Swamp
Grey dogwood, buckthorn, red-osier dogwood, nannyberry, spirea and willow shrubs dominate wet successional areas. This type of community is found along streams, ditches and poorly drained areas as a transitional zone between wetland and upland communities.

Willow Dominated Swamp
Mature willow trees and willow shrubs were found along watercourses, ditches and low lying areas throughout the subwatershed. This community is characterized by willow, elm and trembling aspen with a thicket of dogwood, buckthorn, hawthorn and grapevine.

Elm - Silver/Red Maple Dominated Swamp
The majority of the soils of the study area are poorly drained, resulting in numerous wet pockets and seasonally wet areas. These areas are unsuitable for agriculture in their natural condition and often are not cleared. The forest which is found in these areas contains tree species which are adapted to wet conditions such as red and silver maple, elm, swamp white oak and balsam poplar as well as dogwood, willow and nannyberry shrubs.

4.8.7 Vegetation Summary

Woodlands
The majority of the subwatershed is dominated by recently abandoned agricultural lands with either field or scrub dominated vegetation. Stands of immature trees are also fairly common in this area. Mature wooded stands are very uncommon in this subwatershed. Not only is there a very low total area of mature woodland, but these stands are generally small and fragmented. The woodlands are primarily found in an east-west orientation along the southern margin of the subwatershed. Some wooded stands are found associated with the edges of the wetlands and watercourse.

As discussed elsewhere, the small depressions within the woodlands and the retention of soil moisture in these stands plays an important role in maintaining baseflow to the watercourse during low flow periods. Many of the woodlands in the area include the significant tree species reported from the subwatershed. The trees in these areas have established with widespreading and shallow root systems. This type of growth form is sensitive to windthrow if exposed to open conditions. The existing stable woodlot edges provide shelter to the interior of the woods and provide an important stabilizing role.

Wetlands
The total area of wetlands in the subwatershed is fairly low. The wetland boundaries delineated during this study were based on application of the standard MNR wetland evaluation mapping approaches. These boundaries do not entirely match the boundaries of the evaluated wetlands in the subwatershed. Despite the season of the field surveys, it is felt that the boundaries delineated in this study are a very accurate representation of the extent of the wetland habitats in the subwatershed. Approval of wetland boundaries and evaluation is the responsibility of the MNR.

Except for a very small wetland pocket found near the confluence of the north and south branches, the wetlands in the subwatershed are spatially separated into two distinct wetland areas. These two wetlands are predominantly a result of two different factors:

(i) The wetlands in the Niagara Street-Cataract Road Wetland are associated with groundwater discharges that occur at the interface between he permeable soils in the headwaters of the subwatershed and the less permeable soils that dominate the remainder of the area.

(ii) The wetlands in the Port Robinson Woodlot wetland are primarily a result of impounded flows in the watercourse. The construction of the railway culvert included a concrete bottom at a higher elevation than the creek channel resulting in impounding of the flows. Similarly wetlands found downstream of the rail lines to the canal appear to have been created by construction of the weir at the mouth of the drain that impounds water. This latter portion of wetland was not included as part of the Port Robinson Woodlot wetland complex.

Numerous small wet pockets are scattered throughout the area including the numerous very small depressions within the woodlots. These small wet features are a result of accumulation of moist in depressions over the fairly impermeable soil layers that dominate the eastern two-thirds of the subwatershed.

The marsh dominated wetland areas typically experience considerable fluctuations in water regime and as such as fairly tolerant to changes in moisture. Wooded wetlands are generally less tolerant to fluctuations in water regime, having established root systems under more stable moisture conditions.

4.8.8 Wildlife

A summary of all species of wildlife recorded in the study area including birds, mammals, reptiles and amphibians is included in **Appendix E**. This list includes all species observed during the field surveys. Since field surveys could not occur during breeding seasons, emphasis has been placed on species recorded in the background information as well as species recorded from our study area in the Atlas of the Breeding Birds of Ontario, Ontario Mammal Atlas and the Ontario Herpetofaunal Summary.

Birds
A total of 100 species of birds have been recorded in the study area. Many of these species such as the song sparrow, eastern meadowlark, american kestrel and great horned owl make use of open field habitat, shrubby areas and small woodlots for feeding and nesting. A number of wetland birds including american bittern, green-backed heron, wood duck and red winged blackbird inhabit the cattail stands and other marshes in the study area.

The woodlots in the study area are used by many species of birds for nesting and for cover. Certain bird species are known as "forest interior-edge" species. These birds require a certain minimum area of forest habitat before they will nest but they will nest within the edge of the forest (generally identified as within 100 m of the edge) or in the interior (greater than 100 m from any edge). Examples of birds in this category include the northern cardinal, black-capped chickadee, eastern wood-pewee, rose-breasted grosbeak and wood thrush (Cadman 1997).

Other bird species are known as "interior" species. For these species small woodlots or larger fragmented woodlots are not adequate. Forest interior habitat now makes up a small portion of the habitat available to birds in southern Ontario. Some interior bird species include ovenbird, veery, cerulean warbler and hairy woodpecker (Cadman 1997).

The number of interior birds found in the study area is small, reflecting the small amount of interior habitat available for them. Some woodlots in the study area such as the Port Robinson Duck Ponds woodlot provide potential forest interior habitat. If left to mature, the amount of successional forest and old field area in the subwatershed combined with the forest cover provides a large block of potential habitat for forest interior birds.

Eleven rare species of birds had been recorded in the vicinity of the subwatershed in the background documents (MNR 1987, Cadman et al 1987, Austen et al 1994). Potential habitat for eight of these rare or threatened species is found in the subwatershed. These species were not observed during the field surveys.

Rare means any indigenous species of fauna or flora which is represented in Ontario by small but relatively stable populations, and/or which occurs at the fringe of its range, and which should be monitored periodically for evidence of a possible decline.

Threatened means any indigenous species of fauna or flora which, on the basis of the best available scientific evidence, is indicated to be experiencing a definite, non-cyclical decline throughout all or a major portion of its Ontario range, and which is likely to become an endangered species if the factors responsible for the decline continue unabated.

The habitat requirements for these birds are described and listed in **Table 4.8.2.**

Table 4.8.2
Rare Birds Recorded in the Study Area

Scientific Name	Common Name	Provincial Status	Habitat
Ixobrychus exilis	Least Bittern	threatened	Cattail marshes, boggy areas, edges of ponds and lakes
Nycticorax nycticorax	Black-crowned Night Heron	rare	Deciduous trees on islands, wooded river banks
Colinus virginianus	Northern Bobwhite	threatened	Grassland, croplands, brushy cover
Parus bicolor	Tufted Titmouse	rare	Mixed deciduous forest, bottomlands and swamps
Thryothorus ludovicianus	Carolina Wren	Insufficient information	Thickets, open deciduous woods
Vireo griseus	White-eyed vireo	rare	Thickets, overgrown fields, young second growth woodlands, swamps
Icteria virens	Yellow-breasted chat	rare	Thickets and dense brushy tangles near streams and pools
Icterus spurius	Orchard oriole	rare	Orchards, farmyards, hedgerows, open wooded areas

Least Bittern
The least bittern is considered as a rare to locally common resident in southern Ontario. This species has experienced slow to rapid declines across its range in Ontario especially since the 1980's. The species was probably more widespread prior to settlement along shoreline and inland marshes. Since then, wetland area in southern Ontario has been reduced. Documented declines of least bitterns are seen in Hamilton, Toronto, Simcoe County, Niagara Peninsula Municipality, Long Point and Waterloo Regional Municipality (Austen et al 1994). Continued pressures on wetlands for development and agriculture have led to the threatened designation of the least bittern. Habitat for this species is present in the marshes and wetlands found in the subwatershed.

Black-Crowned Night-Heron
The black-crowned night-heron is widespread in North America. However, in Ontario, there are few nesting sites, the population is small and the species is at the northern edge of its range. This bird suffered decreases in its population during the 1960's and 1970's which coincided with pesticide-induced declines reported for other fish eating species. It is a colonial nesting bird which nests mainly along the shorelines of the Great Lakes. Black-crowned night-heron numbers have been increasing in recent years. This species was observed in the Port Robinson Woodlot provincially significant wetland (MNR 1987). This wetland provides the only known habitat in the study area for this species.

Northern Bobwhite
The northern bobwhite was a bird originally of savanna/prairie edge habitats. Since settlement, the species has adapted to the agricultural landscape of southern Ontario, and typically occupies areas with grassland, cropland and brushy cover in close proximity to one another. The agricultural land, old field and scrub areas found in the subwatershed provide habitat for this species. Intensive agriculture, hunting and severe winters have caused declines in the population of this species. Their range is restricted to the Carolinian Forest Region. The species now exists in small, localized populations.

Tufted Titmouse
The tufted titmouse is a woodland bird which favours mixed or deciduous forests, moist bottomlands and swamps. This bird is widespread throughout the eastern United States and has only recently been recorded in Ontario. It appears to be expanding its range northward and has become established in certain areas of the province, notably, the Niagara Peninsula. Other birds have been reported around Lake Simcoe, Rondeau Provincial Park and Essex County. The deciduous upland and lowland woods in the study area provide potential habitat for this species.

Carolina Wren
The Carolina wren is another species whose range has been slowly expanding northward. It is now a rare permanent resident in the Carolinian Forest region east to Kingston and north to Simcoe County. The species was markedly reduced by bad winters throughout its eastern North America range in 1976-1978. The Carolina wren is at the northern limit of its range and is limited by cold weather. More information is needed to determine its status. Suitable habitat for the Carolina wren is found in the study area.

White-eyed Vireo
The white-eyed vireo is a southern species whose Canadian breeding range is restricted to extreme southwestern Ontario. This bird has been expanding the northern edge of its range probably as a result of habitat created by human activity. The largest population is known from Point Pelee although individuals may nest anywhere in the Carolinian Forest Region. The Ontario population is small and localized. Suitable habitat for this species is found in the subwatershed.

Yellow-breasted Chat
A decline in the yellow-breasted chat has been reported across its range in eastern North America. This bird is found in the prairies, southern British Columbia and southwestern Ontario. Ontario's breeding population is small with regular breeding sites at Point Pelee National Park and Pelee Island. Outside of these areas, breeding is sporadic and often is indicated by only one pair. The scrub and shrub swamps found in the subwatershed provide suitable habitat for this species.

Orchard Oriole
The orchard oriole has long been known to breed along the north shore of Lake Erie, east to London. It has been expanding its range eastward and northward over the past 100 years. This species reaches the northern extreme of its eastern North America breeding range in southern Ontario. Steady decreases in population numbers in Niagara and Haldimand-Norfolk have been reported recently due to loss of woodlots in these region and pesticide application to orchards. Efforts should be made to protect open second growth woodlands in the Carolinian Forest Region where this species nests. Suitable habitat for this species is found in the subwatershed.

Mammals

Twenty-one species of mammals are known from the subwatershed. This includes species observed during the field surveys as well as species known from background information sources including the Ontario Mammal Atlas (Dobbyn 1994).

Most of the species recorded in this area are commonly found in rural areas in close proximity to settlement. The mammals listed make use of open fields, scrubby areas and forested lands.

The southern flying squirrel is the only significant species known in the study area. This species was documented in the vicinity of the subwatershed in the Ontario Mammal Atlas (Dobbyn 1994). The southern flying squirrel occupies deciduous forests of eastern North America. Within Ontario, this species is most commonly found in the Carolinian Forest north of Lake Erie, but can also occasionally be found throughout the rest of southern Ontario, north to Deep River and Parry Sound District.

The southern flying squirrel is only found in areas with mature hardwood forests, particularly maple, beech and oak. This type of habitat is found in the study area. The flying squirrel's close association with the Carolinian Forest has prompted its rare status.

Amphibians and Reptiles

Ten species of amphibians and reptiles have been recorded in the study area from field surveys, background reports and the Ontario Herpetofaunal Summary (1985, 1986). There were no significant species recorded in the study area.

Wildlife Summary

The consolidation of wildlife species information highlights a number of key habitat issues.

- As discussed under vegetation, the remnant woodland in the subwatershed is very low and consists of small isolated fragments. The small size and fragmented character of this wooded habitat means that limited habitat is currently available in the subwatershed for forest wildlife species. Species that prefer edge habitats or immature woods can be found in the area, but few sensitive forest species are anticipated. From a regional perspective, there are few large wooded areas adjacent to the subwatershed, except for the woods associated with Twelve Mile Creek.
- The abundance of field and scrub habitats in the area provides considerable habitats for a range of wildlife that prefer open habitats and immature woods.
- Some of the sensitive forest bird species reported from the vicinity of the Singer's Drain may actually be breeding in the Twelve Mile Creek system. Some breeding pairs may venture into the subwatershed to attempt to nest, but nesting success and population sustainability is severely limited due to the lack of forest cover. The same assessment or conclusion is anticipated to hold true for the flying squirrel.
- Linkages between habitat patches in the subwatershed were investigated by reviewing the arrangement of contiguous wooded and wetland habitats. The current alignment of woods and wetlands along the east-west axis of the subwatershed has a terminus in a large wooded block outside the subwatershed (the E.S. Fox lands). This wooded block is fairly continuous with other wooded habitats associated with the extreme downstream portions of the subwatershed (in the vicinity of the Port Robinson Woodlot). This configuration of habitats appears to represent a fairly continuous habitat that may act as a potential wildlife movement corridor.

4.9 Aquatic Habitat

4.9.1 Introduction

Analysis of the aquatic habitat conditions in the watercourse was accomplished by subdividing the drain into a number of definable reaches. Stream reaches were identified and are shown on **Figure 4.9.1.** These reaches were delineated on the basis of homogenous habitat features that distinguished them from adjacent portions of the watercourse. Each reach was categorized according to the criteria outlined in **Table 4.9.1**

Table 4.9.1
Criteria for Stream Reach Categorization

Features Required for Inclusion in Category	Category 1 High	Category 2 Medium High	Category 3 Medium	Category 4 Medium Poor	Category 5 Poor
Perennial flow present	*	*			
Instream fish habitat features present (i.e. riffles Structure, undercut banks, etc.)	*	*			
High quality riparian buffer present	*				
Mature trees providing canopy over watercourse	*				
Meander geometry (Sinuosity) present	*				
Not directly adjacent to agricultural activities	*	*			
Immature riparian buffer present		*			
Meander geometry (sinuosity) present but limited		*	*		
Limited amount of mature trees providing canopy		*	*		
Perennial flow is present but flow volume is small			*	*	
Evidence of channel maintenance (dredging and cleanout) without impact to riparian vegetation			*		
Adjacent to, but not noticeably impacted by, Agricultural activities			*		
Evidence of channel maintenance activities with Impact to riparian vegetation				*	
Limited riparian vegetation consisting of non Woody terrestrial species or aquatic emergence				*	
No overhead canopy covering stream				*	
Indirectly impacted by agricultural activities				*	
Intermittent flow					*
Heavy impact from agricultural activities, Receiving direct runoff from agricultural drainage					*
No riparian vegetation					*
Often Ploughed through					*

Proctor and Redfern (1996) suggested that MNR designated the Singer's Drain as a warm water migratory watercourse, however the Niagara District Fisheries Management Plans does not recognize this status. The Ministry of Natural Resources have reviewed the findings of the aquatic survey completed as part of this study, and have suggested that the potential for a cool water fish community exists in portions of Singer's Drain.

4.9.2 Resident Fish Population

An inventory of the fish community in the watercourse was carried out using a backpack electroshocker. A total of 39 stations were surveyed. Sampling station locations are shown on **Figure 4.9.1** Field collection records, summarizing habitat at each sampling station, are included in **Appendix F.** A standard methodology sampling approach was taken between stations by sampling the same distance of stream as well as sampling for roughly the same amount of time at each location. Station length was maintained at 20 m of stream (both sides). Duration of electroshocking ranged from 150 to 250 seconds at each station. Results of this survey are shown in **Table 4.9.2**

Table 4.9.2
Results of Electroshocking Survey

Station (Fig 4.9.1)	Length of Station (meters)	Duration of Electroshocking (seconds)	Fish Captured by Species and Number					
			Central Mudminnow	Brook Stickleba	Brown Bullhead	Pearl Dace	Fathead Minnow	Pumpkinseed
1	20	200	1					
2	20	210	1	1				
3	30	200	1	1				
4	20	200						
5	20	150	1				1	
6	20	150	9	1			3	
7	35	220	8			1		
8	20	175	5	10				
9	20	150	30	4	1			
10	20	170	27	1			1	4
11	20	250	21	1			1	
12	20	190	12	5			2	
13	20	180	3					
14	20	210						
15	20	230						
16	20	150						
17	20	100		1				
18	20	170						
19	20	195						
20	20	240	1					
21	20	230						
22	20	230						
23	20	250						
24	20	220						
25	20	215						
26	20	180						
27	20	220	1					
28	20	240	13					
29	20	210						
30	20	230						
31	20	240						
32	20	240	3					
33	20	180	2					
34	20	245						
35	20	180						
36	20	215						
37	20	180						
38	20	180						
39	20	210						
TOTALS		**8035**	**139**	**25**	**1**	**1**	**8**	**4**

A total of 178 fish were captured at 39 stations. The most common fish was the central mudminnow (*Umbra limi*) which represented 78% of the total catch by number. This species is generally associated with habitat conditions such as heavily vegetated ponds or the pools of small creeks where the bottom has a thick layer of organic material. They are also known to be tolerant of low oxygen conditions and have a swim bladder that provides some respiratory function (Scott and Crossman 1973). The heavy sediment conditions in the Singer's Drain are favourable to use by this species.

The second most common fish in the catch was the brook stickleback (*Culea inconstans*) which represented 14% of the total catch by numbers. The brook stickleback is one of the most widely distributed stream fishes in southern Ontario and is tolerant of a wide range of water quality and aquatic habitat conditions.

The fathead minnow (4% of catch) is found in the muddy pools of headwaters, creeks and small rivers and is tolerant of degraded habitat conditions (i.e. high turbidity, elevated temperature, low dissolved oxygen and intermittent flow) (Page and Burr 1991)

The presence of pearl dace (Margariscus margarita) in the Singer's Drain is unusual. The habitat of this species in southern Canada is typically cool, clear headwater streams (Scott and Crossman 1973). Additionally, this species is usually found in streams with sand or gravel substrate (Page and Burr 1991). Analysis of the habitat conditions at Station 8 where this fish was captured indicate that the watercourse was classified as high quality aquatic habitat and had aquatic habitat features including undercut banks and some gravel substrate. The presence of this species in the watercourse suggests that improved habitat conditions throughout the watercourse might lead to a change in species composition from more tolerant species to species which favour improved water quality and habitat conditions.

The other two species, brown bullhead (*Ictalurus nebulosis*) and Pumpkinseed (*Lepomis gibbosus*). Both of these species are usually found in association with ponds and would not be expected in a watercourse like the Singer's Drain. The presence of an artificially widened and deepened portion of the watercourse at Stations 9 and 10 provides habitat opportunities not present elsewhere in the system, for these species.

Aquatic Habitat Summary

The Singer's Drain provides aquatic habitat conditions consistent with MNR's type 3 aquatic habitat classification. The MNR has suggested that a potential cool water fishery could occur in some portions of the Singer's Drain. Additional information on thermal characteristics in the creek would be required to delineate these areas. The further division of the reaches of the drain into the five categories provides additional information on the quality of the habitat and provides guidance in terms of potential and property for enhancement. Two key habitat quality "break points" are noted based on the five categories:

i) Categories 1 and 2 include reaches with good channel geometry such as meanders. Categories 3 to 5 include reaches that are basically straightened channels with poor channel geometry.

ii) Categories 1, 2 and 3 include reaches with woody riparian vegetation, while reaches in categories 4 and 5 do not have woody riparian vegetation.

Reaches that fall into the first two categories are generally restricted to the downstream portions of the subwatershed (especially east of Kottemeier Road). This translates into sections of the drain with natural geometry being restricted to this portion of the subwatershed. Reaches with woody riparian vegetation (categories 1 through 3) extend much further into the subwatershed, especially along the southern branch. The northern branch has very limited riparian vegetation (these reaches are also exhibit some of the poorest channel geometry).

4.9.3 Resident Benthos

No historical information exists on the benthic macroinvertebrate communities in the watercourse. Similarly, benthic invertebrate collection and analysis was outside of the scope of this study. Given the degraded habitat conditions and the tolerant fish species present it is likely that the invertebrate community is also dominated by tolerant, non sensitive species, however additional investigations into the benthic community could be used to explore key potential cool water habitats, trouble spots, etc.

4.9.4 Water Quality

There is no historical information available for surface water quality in the Singer's Drain. Visual observations suggest an extremely high suspended solids load consisting mainly of suspended clay. Agricultural runoff, particularly in the headwater areas, with no riparian buffer, produces heavy sediment loads with new-crop operations. In some parts, Coliform bacteria levels are probably elevated due to cattle and other livestock watering in the creek as well as potential malfunction sewage system tile bed requested by area residents. Nutrient levels may also be elevated from agricultural runoff although visual evidence (excessive plant and algae growth) are not evident, even in the quieter, ponded areas of the watercourse. The absence of industrial facilities in the watershed probably results in heavy metals and non-agricultural organic compounds being present at ambient levels only.

Specific concerns were raised during the public meetings with regard to the potential for sewage system breakouts. Bacteria samples were taken (single samples on April 14, 1998) to identify any potential problems. The results are outlined in Table 4.9.3

Table 4.9.3
Bacteria Samples

Location	Count (CFU/100 ml)		
	E Coli	F Coli	Total Coli
Merrittville Hwy (N. Branch)	1500	1600	110,000
Merrittville Hwy (S. Branch)	500	830	150,000
Kottmeier	1000	1400	270,000
Outlet	70	70	1,100

The results indicate a significant potential for sewage system discharge to the creek. The water is not safe for body contact (except possibly at the outlet). The highest counts are in the headwater areas indicating that breakouts could be occurring in this area but the lower value at Merritt Road indicates that significant die-off could be occurring with no additional loadings in this area. This value is somewhat suspect since time period of approximately 48 hours would be necessary for this degree of die-off and the travel time of flow between Merrittville and the outlet would be shorter than this. Additional samples would be necessary for more detailed conclusions. In addition, biological and thermal monitoring at strategic locations could also provide valuable information in this regard.

4.9.5 On-Line Ponds

A number of relatively small on-line ponds are found along the Singer's Drain. These ponds are generally small, created by installation of culverts, in some cases inadvertently and in other cases for aesthetic purposes.

An array of three on-line ponds is located on the south branch approximately 100 m upstream of the confluence with the north branch. These ponds appear to be used for aesthetic purposes. The banks of these ponds are lined with mown grass to the banks, although some scattered shrubs (willows and dogwoods) are also found along the banks in some locations.

The shallow and unshaded character of these ponds creates a partial barrier to fish species due to the lack of, or degraded nature of, the habitats within the ponds. During periodic high flows these ponds become considerably enlarged and flood adjacent lawn areas.

Other on-line ponds are found at locations along the channel where culverts restrict flows. A number of these restrictions have created wetlands, for example in the Port Robinson Duck Ponds ESA area. These impounded areas have created valuable wetland habitats. Several smaller ponds are found along the main channel. These smaller pond habitats are generally vegetated with wetland species, such as cattails and grasses and create less of a barrier than the three ponds described above.

Fish movement through the ponds is unlikely to be greatly impeded, since the fish community currently found in the drain is not overly mobile. Even if the weir at the canal is removed and more mobile fish species from the canal enter the Singer's Drain system, other downstream barriers (ie. ponds, culverts) are likely to impede fish moving up the drain as far as the three man-made ponds. Therefore the future management of these ponds should focus on enhancing potential nutrient, and secondarily temperature, conditions within and downstream of these ponds.

Some restoration measures can be used to enhance the habitat conditions within these ponds. These include:

- removal of the on-line ponds,
- re-configure the ponds to make them off-line,
- implement pond management techniques, such as planting woody plants along banks,
- avoiding mowing grass to the above,
- installation of cover structures at the ponds (ie. riparian vegetation).

A number of these measures can be implemented by landowners in concert to enhance these ponds. Some assistance to landowners may be available from municipal or provincial programs.

4.9.6 Channel Morphology

The majority of the Singer's Drain has been artificially modified such that determination of original channel morphology is difficult. However, certain sections have remained relatively undisturbed and offer an opportunity to gain insight into pre development, natural channel characteristics of the watercourse. To this end, Reach S14 (see **Figure 4.9.1**), in the Port Robinson Duck Pond ESA, was chosen as the least disturbed reach and channel characteristics were measured here to gain insight into the type of channel which once existed and could exist in the future with rehabilitation.

The following channel characteristics were measured:

Bankfull width
Bankfull Depth
Floodprone Area Width
Meander Belt Width
Change in streambed elevation (by survey over three meander lengths)
Stream Valley length (over three meander lengths)
Length along thalweg (over three meander lengths)

These field measurements were used to calculate the following stream class characteristics

Width:Depth Ratio	18
Streambed slope	0.003

Sinuosity	1.3
Entrenchment	2.8

The watercourse at this location (Reach S14) is contained within a single channel, has bed material consisting mainly of silt/clay and has morphological characteristics as noted above. It can therefore be categorized as a C6 channel as per the Rosgen (1994) classification system (see **Figure 4.9.2)**. This is fairly common for Ontario streams in clay and alluvial soils. Streams could tend to an E type in flat areas (i.e. marsh lands) or B type in steeped gradient, where the streams may be incised (i.e. downcutting into soil). Any attempt to rehabilitate degraded aquatic habitat in the watershed should include in its goals, the movement toward a channel morphology that satisfies the C6 classification criteria. There is however a recognition that, in moving towards a C6 channel form, other constraints may preclude the design of a C6 channel. These constraints include:

- Inability to secure enough private land to allow formation of a belt width and meander pattern, consistent with the C6 design

- The presence of existing features (culverts, weirs, and ponds) which may not allow the streambed to be restored to its natural slope

- Flood control requirements which drive the shape of the channel over and above the natural requirements of the channel

4.10 Physical Stream Conditions, Hydraulics

Singer's Drain has been channelized over much of its length in the past. Currently, it appears that approximately 25 % of the length of watercourse (major branch and tributaries) has not been changed in the past or is in a "natural state" (i.e. may have been channelized but has changed back to a meandering stream). Singer's Drain is a municipal drain for much of its length which indicates that changes may occur under the Drainage Act (i.e. excavation) with the costs shared by the Owner whose land is drained by the Creek.

One of the most significant concerns raised by the community is the flood potential along Singer's Drain and sediment depositon that occurs, further reducing capacity. There is a proposal to improve the stream capacity by deepening and widening a section of Singer's Drain and increasing road crossing capacity.

The hydraulic analysis carried out investigates the channel capacity and potential for erosion and sediment deposition.

The stream bed profile is illustrated in **Figure 4.10.1.** The streambed slope varies significantly. The flatest slope (i.e. 0.06%) is in the lower reaches, typical for most watersheds. The central portion (Port Robinson to upstream of Merritville) is significantly steeper (0.33%). The upper portion to Fonthill becomes flatter again at 0.18%. The stream slope provides a physical characteristic that affects stream conditions. Sedimentation is apparent in the lower reach which reduces the quality of aquatic habitats. Most erosion sites were observed in the steeper central reaches and significant deposition is again observed in the upper reach (below Fonthill).

The HEC2 computer model program was used to determine hydraulic information for the stream. Results are based on modifications done to a model developed by Weibe Engineering (1997) for the Singer's Municipal Drain report. The topographic data input for the model reflects only the north branch of the watershed. Stream sections range from approximately 650m west of Rice Road to 1000m west of the Welland Canal. (See Figure 4.3.1) The estimated flood elevations are listed in Table 4.10.1.

Table 4.10.1
Flood Elevation Estimates (m)
(See Figure 4.3.1 for Section locations)

SECTION NUMBER	FLOOD ELEVATION				REMARKS
	2 YEAR	5 YEAR	25 YEAR	100 YEAR	
0.10	176.18	176.45	176.82	177.06	
0.20	176.28	176.60	177.02	177.29	
0.30	176.30	176.62	177.04	177.31	
1.00	176.31	176.64	177.08	177.35	
95.00	176.34	176.69	177.14	177.44	
120.20	176.35	176.69	177.13	177.29	Kottmeir Road
150.00	176.38	176.79	177.44	177.91	
200.00	176.40	176.80	177.45	177.92	
510.00	176.50	176.92	177.55	178.01	
524.00	176.48	177.42	177.88	178.08	Farm Crossing
595.00	176.67	177.51	177.99	178.21	
631.00	176.65	177.50	177.99	178.21	Farm Crossing
755.60	176.83	177.59	178.07	178.37	Hwy. 406
800.00	176.88	177.66	178.31	178.83	
900.00	176.92	177.67	178.33	178.83	
1000.00	176.98	177.70	178.35	178.85	
1050.00	177.01	177.71	178.36	178.86	
1084.80	177.04	177.71	179.02	179.24	Hansler Road
1200.00	177.20	177.82	179.09	179.23	
1273.40	177.35	177.83	179.44	179.46	Farm Crossing
1300.00	177.48	178.02	179.60	179.84	
1550.00	178.10	178.42	179.62	179.87	
1616.90	178.48	178.78	179.80	180.23	Port Robinson
1700.00	178.56	178.88	179.89	180.33	
1865.40	179.13	179.47	180.23	180.75	Farm Crossing
1900.00	179.46	180.06	181.07	181.20	
2000.00	179.53	180.08	181.07	181.20	
2050.00	179.70	180.12	181.07	181.19	
2093.50	179.88	180.20	181.15	181.30	Merritteville Hwy.
2196.00	180.48	180.73	181.29	181.45	
2300.00	180.66	180.91	181.39	181.55	
2500.00	181.06	181.31	181.73	181.88	
2750.00	181.56	181.82	182.23	182.37	
2857.00	181.77	182.03	182.44	182.58	
2957.00	181.97	182.23	182.63	182.78	
3040.00	182.14	182.40	182.83	182.95	
3099.00	182.27	182.50	183.04	183.35	Driveway Crossing
3120.00	182.38	182.70	183.33	183.57	
3140.00	182.39	182.70	183.37	183.56	Cataract Road
3182.00	182.48	182.82	183.54.	183.63	
3282.00	182.85	183.04	183.51	183.60	
3357.00	183.22	183.69	184.29	184.35	

The hydraulic data resulting from the 5 year and 25 year storm event is summarized in **Table 4.10.2 and Table 4.10.3**

Table 4.10.2
Channel and Structure Capacity
Flow Velocities (m/s)

Location	Station Chainage	Flow Velocity 5 Year	Flow Velocity 25 Year	Channel Capacity
Catchment 16	0+000.1	1.85	2.18	2 Year
Catchment 14	0+100	1.35	1.91	100 Year
Catchment 14	0+950	0.56	0.64	2 Year
Catchment 12	1+850	1.30	0.89	50 Year
Catchment 12	2+872	1.32	1.17	100 Year
Catchment 9	3+207	0.29	0.32	

Note: Flow velocities are at channel locations that are not near any obstruction. Channel capacity is defined to be the point when the water surface overtops the defined channel banks.

An inventory of hydraulic structure data was developed (road crossings) using existing backwater models and collected field data. A summary is provided in **Table 4.10.3 and 4.10.4**

Table 4.10.3
Flood Elevation
At Upstream section of Crossings and at crossings

Location	Station	Low Chord Elevation	Water Surface Elev. (m) 5 Year	Water Surface Elev. (m) 25 Year	Flow Velocity (m/s) 5 Year	Flow Velocity (m/s) 25 Year	Channel Capacity	Structure Capacity
Crossing	120.20	177.69	177.12	177.42	1.130	1.60		50 Year
Channel section	125.00		177.17	177.55	0.680	0.86	2 Year Storm	
Crossing	630.80	176.62	178.45	178.71	0.660	0.75		<2 Year
Channel section	632.00		178.45	178.71	0.440	0.57	2 Year Storm	
Crossing	755.60	178.71	178.45	178.79	1.050	1.47		10 Year
Channel section	760.00		178.52	178.93	0.460	0.50	2 Year Storm	
Crossing	1084.80	177.93	178.81	179.29	0.780	1.04		2 Year
Channel section	1090.00		178.85	179.36	0.200	0.19	2 Year Storm	
Crossing	1273.40	178.68	179.03	179.57	1.210	1.53		2 Year
Channel section	1278.00		179.12	179.71	0.450	0.41	2 Year Storm	
Crossing	1616.90	179.20	179.2	179.8	1.270	0.63		10 Year
Channel section	1620.00		179.27	179.82	0.720	0.21	5 Year Storm	
Crossing	2093.40	181.48	181.1	180.79	0.800	0.82		10 Year
Channel section	2093.50		181.1	180.78	0.840	0.95	100 Year Storm	
Crossing	3141.60	183.20	183.58	183.58	1.390	1.49		<2 Year
Channel section	3145.00		183.6	183.61	0.630	0.69	2 Year Storm	

The hydraulic analysis indicates that at the 2 year level flow velocities are generally in the range of .01 to .5 m/sec with a maximum of 2.0 m/sec. The lower velocities indicate a significant potential for sediment deposition observed in Singer's Drain.

Table 4.10.4

PORT ROBINSON STRUCTURE SUMMARY

No.	Location	Station	Type of Structure	Span	Total Rise	Max. Effective Area	Cover	Capacity	Remarks
North Branch									
1	Rice Rd., N of Port Robinson	N/A	Pipe Arch	1.5m	1.0m	0.98 sq. m	1.5m	2 year	D/S channel eroded, heavily protected
2	Port Robinson and Cataract Rd.	3+140	Pipe Arch	2.2m	1.6m	2.90 sq.m	.25m	2 year	
3	Merrittville Hwy, N of Port Robinson	2+093.5	Reinforced Conc.	3.6m	2.0m	7.2 sq. m	0.3m	10 year	D/S channel eroded, top of footings exposed
4	Port Robinson E of Merrittville Hwy.	1+616.9	Reinforced Conc.	3.6m	1.2m	4.32 sq.m	1.2m	10 year	Channel bank erosion u/s side, ponded water D/S side
South Branch									
5	Cataract Rd. N of Merritt Rd.	N/A	Round CMP	1.8m Dia.	1.2m	1.80 sq.m	0.25m	2 year	Flooded area, water level is 0.5m below pipe obvert
6	Merrittville Hwy. N of Merritt Rd.	N/A	Reinforced Conc.	3.0m	1.07m	3.21 sq.m	0.3m	10 year	Water level is 0.6m above SB, water is ponded, not draining
Downstream confluence of north and south branches									
7	Port Robinson at Hansler	1+084.8	Twin structural plate	2 x 2.6m dia.	1.50m	6.50 sq.m	1.0m	2 year	45 degree skew, conc. headwall U/S side
8	Hwy 406, N of Port Robinson	0+755.6	Reinforced Conc.	3.6m	2.7m	9.72 sq.m	3.3m	10 year	
9	Kottmeier Rd. N of Port Robinson	0+120.2	Reinforced Conc.	4.2m	2.52m	10.6 sq.m	0.1m	25 year	Water level 0.9m above SB, ponded water not draining
10	Weir at Welland Canal	N/A	Reinforced Conc.	6.0m	0.75m	4.5 sq.m	2.5m		Depth of water over weir, 35mm, flows into energy dissipation area
									2.5m L x 6m W x 2.2m H, outlets to 1.2m dia. CMP and
									discharges into Welland Canal. water level at Welland Canal
									was 0.6m below pipe obvert
Contributing Branches									
11	Kottmeier Rd. S of Hurricane Rd.	N/A	Round CMP	1.5m dia.	1.2m	1.4 sq.m	2.0m	5 year	Channel banks eroded at U/S side
12	Port Robinson Rd. E of Kottmeier Rd.	N/A	Pipe arch	0.9m	0.8m	0.48 sq.m	1.0m	2 year	

Observations:

1. All of the structures appear to be in fair condition, in many cases as shown, the cover over the structure is well below the minimum requirement of 0.6m
2. There appears to be flooding throughout the entire drain, areas specifically in the top reaches are flooded both in the drain and the surrounding land
3. The drain in many places is blocked with debris and plant growth, stagnant pools of water are abundant throughout
4. Several structures are undersized, however the capacity of those structures can not be maximized due to flat longitudinal slope.

The channel and structure (road crossing) capacities are very low. Channel and structure capacity are, for the most part near the 2 year storm event. This is consistent with the frequent flooding problems experienced along the main branch of Singer's Drain.

Flood elevations provided in the available modelling are plotted on **Figure 4.3.1**. These floodlines are approximate since the mapping accuracy is not suitable for floodline mapping purposes. They do provide, however, an illustration of flood prone areas. The areas of highest flood potential are found to be along Port Robinson Road, between Hansler Road and upstream of Cataract Road (likely to Rice Road). This is consistent with past reported flood problems and the hydraulic structure assessment.

This flood potential has led to the initiation of a proposal for drainage improvements to Singer's Drain (1997, Wiebe Engineering Group). This report proposes a deepening of the existing watercourse and replacement of road crossings. This will increase the overall capacity of the system, however no provisions have been made for fisheries habitat protection.

4.11 Characterization Summary

The Port Robinson West Subwatershed has a number of good quality environmental features, particularly terrestrial features, that provide significant habitat for wildlife. The upper reaches of Singer's Drain are degraded, however the lower reaches are in reasonable condition and support a number of fish species. A number of the current features are linked with other physical characteristics that provide some excellent environmental amenities. Current land use and drain reconstruction works in the past have had negative environmental impacts, particularly on stream conditions.

The physiography and geology of the subwatershed provides two distinct areas. The headwater area within Fonthill is made up of an area with considerable relief and sandy soils. The mid and lower portions of the watershed are relatively flat with clay soils. The upper sandy area provides for infiltration and base flows to the creek as well as the deeper groundwater system.

Wetland and woodland areas are located along and adjacent to Singer's Drain, particularly the south branch. The wetlands provide a source of base flow for aquatic habitat.

A number of findings were made with respect to the subwatershed characterization as well as sensitivities to potential impacts associated with land use changes.

Physiography – Stream Flow

- Singer's Drain, including the headwater reaches are open for most of its length, although portions have been straightened and/or deepened. Most of the headwater reaches now exist as roadside ditches, however they have, for the most part, been left as open grassed swales.
- Flood potential is significant along Singer's Drain and most of the channel and crossings have 2 year capacity. There is not a well defined floodplain and encroachment of development along the Creek has resulted in significant flood potential.
- The watershed is predominantly agricultural in land use. Urban growth would result in significant impact to the watershed and stream system if flows are not controlled (flooding, erosion).
- There is some erosion along Singer's Drain at isolated locations. Sedimentation is more of a problem due to flat slopes and resulting low velocity.

Aquatic Conditions

- Regional groundwater flows are generally from the west to east carrying deeper groundwater from the Fonthill area to the Welland Canal area.
- Recharge to sandy soils in the Fonthill area appears to provide groundwater discharge to wetlands in the Niagara Street – Cataract Road wetland area.
- Base flows along Singer's Drain, except for what discharges from the upper sandy soils are primarily from creek bank discharge (local groundwater input).
- Characterization of water balance and base flows indicates that the sandy area in the headwater areas contribute to base flow. In the lower reaches, base flow is mostly from stream bank contributions.
- On-line ponds are located at various points. These affect water quality by increasing temperatures and adding nutrients, thereby degrading downstream aquatic habitat.
- A number of warmwater fish species were found in Singer's Drain with the most predominant being Central Mudwinnow, Brook Stickleback, Brown Bullhead, Pearl Dace, Fathead Minnow and Pumpkinseed. The presence of Pearl Dace indicates a relatively good habitat and that opportunities exist for stream rehabilitation.
- Aquatic habitat conditions are primarily classified as warmwater bait fish although potential cool water habitats may exist in some locations. Conditions are generally highest in quality in the lower reaches.
- A weir located at the Welland Canal (and fluctuating water levels in the canal) provide a barrier to fish movement in and out of the canal. Other barriers in the form of on-line ponds exist.
- There are opportunities to improve the riparian habitat along Singer's Drain which will improve water quality and fishery habitat.
- Consideration should be given to removing some on-line ponds (or provide a low flow by-pass) to improve water quality.

Terrestrial Conditions

- A number of significant wetlands and woodlots exist. Some are currently protected by zoning including:
  - Port Robinson Duck Ponds ESA
  - Port Robinson Woodlot Wetland - PSW
  - Niagara St. Cataract Road Woodlot - Provincially Significant Wetland
  - Rose Little Woodlot ESA
- The significant terrestrial features have been classified, primarily for the significance of the vegetation within them. The Port Robinson Duck Pond is also recognized as a migratory stopover point.
- Wooded areas vary significantly from recognized areas of high quality (vegetation and habitat) to scrubland that has been left fallow.
- A number of the terrestrial areas are isolated or have weak linkages. There are opportunities to link these areas particularly along the south branch of Singer's Drain.

4.12 Watershed Goal and Objectives

Based upon the characterization findings for the watershed (how it works), the project focus, and the community input, a goal and objectives set are provided.

Vision (Goal) for Port Robinson West Subwatershed

The Port Robinson Subwatershed should be managed to balance the community needs now and in the future for water supply, drainage and agriculture, and environmental needs with protected / enhanced terrestrial and stream conditons that are linked to other areas.

Objectives

- Improve existing drainage conditions to mitigate current flooding problems and erosion.
- Improve the function of the existing drainage system to reduce sedimentation problems and erosion.
- Improve water quality in the stream, particularly related to sediment in the water.
- Protect and enhance the existing natural features as possible.
- Improve the fish habitat conditions including the removal of barriers to Welland Canal.
- Provide for continued agricultural uses.
- Provide a trail system within the environmental features for education and recreational uses.
- Enhance the diversity of wildlife in the environmental resource areas.
- Provide guidelines for future urban development, particularly related to drainage requirements.

5.0 IMPACT ANALYSIS

5.1 Land Use Scenarios

Land use changes within the Port Robinson West Subwatershed were considered to evaluate the potential for impact on environmental conditions and hydrologic conditions in Singer's Drain. Hydrologic modelling was carried out to assess potential impacts.

There is currently no defined potential for future growth within the subwatershed. Currently expansion has occurred to the east from Fonthill, north from Welland and the industrial area near Port Robinson. Recently a Secondary Plan was prepared for remaining lands on the east side of Fonthill.

Servicing proposals have been developed illustrating potential service links between Fonthill, Welland and Port Robinson as illustrated in **Figure 5.2.1.**

Based on past growth patterns and future servicing direction it appears that the highest potential for growth is in the southern half of the subwatershed.

Two land use scenarios were developed for comparison purposes. These do not reflect planned future development, but only potential scenarios for analysis purposes. A future scenario includes urban development proposed for Fonthill and urban development south of Port Robinson Road. An ultimate development scenario assumes full development in the watershed. The future development assumed includes a mix of urban and rural residential with a small portion of industrial and commercial.

The land use scenarios developed are illustrated in **Figure 5.2.1**

5.2 Hydrologic Analysis

Impact Analysis

The base model provided from previous reports (Proctor & Redfern, 1996) was modified to include the latest revisions to the water-shed area and the characteristics of the sub-catchments within it. Three models were developed to reflect runoff conditions for the 2, 5, 10, 25, and 100 year event storms based on land use: Existing Conditions, Future Conditions, and Ultimate Conditions. (See Otthymo.89 input parameters; **Tables 5.2.2, 5.2.3, 5.2.4).**

Land Use

Hydrologic modeling with Otthymo.89 was generated based on the potential land use areas for the Singer's Drain watershed. Presently, the majority of the watershed is agricultural with urban development located in the Town of Pelham. The potential for future changes in the land use is summarized in **Table 5.2.1**, and shown on **Figure 5.2.1.**

Potential land uses:
1. Conservation land
2. Low Density Rural
3. Urban Service
4. Agricultural

Table 5.2.1
Land Use Areas

Land use type	Area (ha)		
	Existing	Future	Ultimate
Conservation	240	240	240
Low Density Rural	60	193	837
Urban Service	204	222	350
Agricultural	943	792	20
Total	1447	1447	1447

A summary of design flow data obtained from the modeling output for the existing, future and ultimate potential land use areas is listed in **Table 5.2.5.**

Table 5.2.5
Design Flows (cms)

AT OUTLETS (cu.m/s)		**EXISTING**		**FUTURE** Uncontrolled		**ULTIMATE** Uncontrolled	
		Return period		Return Period		Return Period	
Area (Fig 4.3.1)	Outlet Location	2	100	2	100	2	100
4	Rice Road N of Rd.63	1.31	5.00	2.44	8.06	2.44	8.06
5	Rice Road at Rd.63	0.22	1.20	0.94	3.84	0.94	3.84
6	Rice Road S of Rd.63	1.55	6.04	1.94	6.52	1.94	6.52
9	Cataract and Rd.63	3.42	14.27	4.82	15.84	6.94	24.04
8	Rice Road S Merrittville	0.50	2.36	1.74	6.77	1.74	6.77
7	Rice Road N of Merrittville	0.39	2.14	1.22	4.85	1.22	4.85
10	Cataract N of Merrittville	1.47	7.82	4.47	16.79	4.47	16.79
13	Confluence N & S Branch	4.88	22.9	10.73	29.84	14.2	40.09
14	Kottemier N of Rd. 63	5.06	24.92	10.01	31.93	14.85	42.31
13	Upstream of confluence	1.55	8.38	6.27	18.31	6.27	18.31
17	Upstream of confluence	0.43	1.97	1.32	4.31	1.70	5.12
16	Lot 204/205 Con.	6.90	33.94	11.31	39.21	23.57	76.9
18	Welland Canal	7.00	34.51	11.43	40.02	23.56	76.68

The hydrologic analysis demonstrates a significant potential for increase in peak flows and flood damages on Singer's Drain if stormwater management is not provided. The overall increase at the Welland Canal (for 100 year design event) is 16% for future conditions and 121% for ultimate conditions. The increase in flood elevations without stormwater management (to existing flow levels) are summarized in **Table 5.2.6.**

Similarly, there is an increase in runoff volume of 43% for future conditions and 126% for ultimate conditions (2 year event). This increase in runoff volume under the 2 year event will result in a significant increase in erosion potential.

Table 5.2.2

Otthymo Input Parameters

Existing Conditions (see Fig 5.2.1)

Catchment Area Number (Fig 4.3.1)	Drainage Area(ha)	Dir. Conn. xinmp.%	Total imp. Timp. %	CN	Slope %	T peak (hr)
1	44.00	N/A	N/A	84	N/A	0.40
2	68.90	N/A	N/A	82	N/A	0.42
3	15.20	0.15	0.3	78	3.0	N/A
4	47.10	N/A	N/A	71	N/A	0.67
5	26.50	N/A	N/A	71	N/A	0.62
6	35.60	N/A	N/A	71	N/A	0.62
7	43.50	N/A	N/A	71	N/A	0.56
8	53.60	N/A	N/A	71	N/A	1.17
9	105.90	N/A	N/A	71	N/A	1.00
10	56.00	N/A	N/A	71	N/A	0.65
11	52.00	N/A	N/A	71	N/A	1.17
12	116.20	N/A	N/A	71	N/A	1.60
13	136.10	N/A	N/A	71	N/A	2.50
14	133.10	N/A	N/A	71	N/A	1.67
15	392.30	N/A	N/A	71	N/A	2.10
16	32.11	N/A	N/A	71	N/A	0.60
17	43.62	N/A	N/A	71	N/A	0.70
18	39.50	N/A	N/A	71	N/A	0.90

Table 5.2.3

Otthymo Input Parameters

Future Conditions (see Fig 5.2.1)

Catchment Area Number (Fig 4.3.1)	Drainage Area(ha)	Dir. Conn. xinmp.%	Total imp. Timp. %	CN	Slope %	T peak (hr)
1	44.00	N/A	N/A	84	N/A	0.40
2	68.90	N/A	N/A	82	N/A	0.42
3	15.20	0.15	0.3	78	3.0	N/A
4	47.10	0.35	0.45	78	1	N/A
5	26.50	0.2	0.4	78	1	N/A
6	35.60	0.2	0.4	78	0.8	N/A
7	43.50	0.2	0.25	78	0.6	N/A
8	53.60	0.2	0.25	78	0.5	N/A
9	105.90	N/A	N/A	71	N/A	1.00
10	56.00	0.2	0.25	0.3	78	N/A
11	52.00	0.2	0.25	78	0.4	N/A
12	116.20	N/A	N/A	71	N/A	1.60
13	136.10	0.2	0.25	78	0.25	N/A
14	133.10	N/A	N/A	71	N/A	1.67
15	392.30	N/A	N/A	71	N/A	2.60
16	32.11	N/A	N/A	71	N/A	0.65
17	43.63	0.3	0.35	78	N/A	0.70
18	39.50	N/A	N/A	71	N/A	0.90

Table 5.2.4

Otthymo Input Parameters

Ultimate Conditions (see Fig 5.2.1)

Catchment Area Number (Fig 4.3.1)	Drainage Area(ha)	Dir. Conn. xinmp.%	Total imp. Timp. %	CN	Slope %	T peak (hr)
1	44.00	N/A	N/A	84	N/A	0.40
2	68.90	N/A	N/A	82	N/A	0.42
3	15.20	0.15	0.3	78	3.0	N/A
4	47.10	0.35	0.45	78	1	N/A
5	26.50	0.2	0.4	78	1	N/A
6	35.60	0.02	0.4	78	0.8	N/A
7	43.50	0.2	0.25	78	0.6	N/A
8	53.60	0.2	0.25	78	0.5	N/A
9	105.90	0.2	0.25	78	1	N/A
10	56.00	0.2	0.25	78	0.3	N/A
11	52.00	0.2	0.25	78	0.4	N/A
12	116.20	0.2	0.25	78	0.3	N/A
13	136.10	0.2	0.25	78	0.25	N/A
14	133.10	0.4	0.4	82	0.3	N/A
15	392.30	0.3	0.4	82	0.25	N/A
16	32.11	0.3	0.4	78	0.25	N/A
17	43.62	0.4	0.4	78	0.17	N/A
18	39.50	N/A	N/A	71	N/A	0.90

Table 5.2.6
Increase in Flood Elevations (m)

Station (Fig 4.10.1)	Location	Existing land use		Proposed land use		Ultimate land use	
		2 year	100 year	2 year	100 year	2 year	100 year
125.0	Kottmeier Rd	176.82	178.21	177.22	178.59	177.52	178.91
632.0	Farm Crossing	177.89	179.02	178.50	179.17	178.72	179.36
760.0	Hwy 406	177.92	179.02	178.57	180.15	178.94	181.07
1090.0	Hansler Rd	178.08	179.71	179.02	180.18	179.35	181.08
1278.0	Farm Crossing	178.20	179.95	179.38	180.22	179.71	181.09
1620.0	Port Robinson Rd	178.79	180.73	179.50	180.82	179.98	181.11
2093.5	Merritt Rd	180.52	180.84	180.84	181.54	181.08	181.64
3145.0	Cataract Rd	183.58	183.64	183.61	183.61	183.61	183.65

Flow Control Requirements

An analysis was carried out to identify the storage requirements (i.e. stormwater management) to control peak flows to current levels with future development. This was carried out by including storage areas in the hydrologic model with the maximum discharge set at existing levels. The required storage volumes are summarized in **Table 5.2.7.**

Table 5.2.7
Storage Volume Required
to Control Peak Levels to Existing

Development Condition	Storage Required (cu.m.)		Storage Required (cu.m/ha.)	
	2 yr. event	100 yr. Event	2 yr. event	100 yr. Event
Future	35,890	109,460	24.8	75.6
Ultimate	111,050	302,930	76.7	209.4

5.3 Hydrogeology

Groundwater Balance and Low Flows

The water balance for the watershed is an estimation of the amount of water entering and leaving the subwatershed. For simplification purposes the following equation is used to summarize the relationship between the various components of the water balance (assuming that the amount of water entering the system is equivalent to that leaving the system):

Precipitation = Evapotranspiration + Water Surplus (Infiltration + Surface Runoff)

The net input into the system is derived from precipitation based recharge but may also include groundwater flow from outside of the defined watershed boundary (which is based on surface water divides). The amount of water leaving the system is made up of baseflow at the downstream end of the watershed, (regional) groundwater flow out of the watershed across any of the watershed boundaries and any water taking within the watershed that is moved and used out of the watershed area. Water taking within the watershed that is subsequently recharged into the system (i.e. via septic systems recharging groundwater or sewage treatment plants discharging into the stream system) may represent movement of groundwater from a more regional system to a more local system within the watershed or a "short-circuit" of a normal flow path within the watershed. This is not factored into the overall water balance because it does not represent a net loss (or gain) to the system. The water balance, although difficult to refine in detail on a watershed basis, provides a good first approximation of the groundwater linkages throughout the watershed.

Existing Conditions

A water balance calculation was prepared previously by Jagger Hims Limited for the Town of Pelham's proposed Urban Boundary Expansion Area to be located at the north end of the subwatershed. The analysis was completed utilizing the Thornthwaite Method (Thornthwaite 1948) and the 30 year average monthly precipitation and temperature data listed in Canadian Climate Normals - Temperature and Precipitation 1951 to 1980 (Environment Canada 1980). A water surplus of 249 mm/year was calculated, based on average annual precipitation of 878 mm and evapotranspiration of 629 mm/yr.

The water surplus is the amount of water available for infiltration or runoff, after evapotranspiration. Infiltrating water is available to recharge deeper groundwater systems and move outside the subwatershed, or discharge to surface water as baseflow. In order to estimate baseflow, the watershed was divided into two sections: one with high permeability and one with low permeability. Assumptions were made with respect to the proportion of the water surplus which recharged deeper groundwater, discharged to surface as baseflow, and that which resulted in surface runoff. The highly permeable area (ie. the western portion containing the Fonthill Kame Complex) represents about 16.7 % of the total land area of the subwatershed, while the low permeability portion makes up the remaining 83.3%. Infiltration rates through the high permeability and low permeability units are estimated to be 200 mm/year and 50 mm/year respectively. For calculation purposes, two approaches were taken, to provide a bracket for the range of baseflow:

i.) All water infiltrating the Kame Complex is available as baseflow (i.e. there is no recharge to the deeper groundwater system) and

ii) Only fifty percent of water that infiltrates within the permeable area is assumed to be available as baseflow. As before, all water infiltrating within the impermeable area is available as baseflow.

Based on these assumptions, annual baseflow estimates for the entire subwatershed range from 548,490 to 705,470 m^3/yr , with approximately equal amounts being contributed by the high permeability and low permeability areas. This is equivalent to a baseflow of 1.9 to 2.4 $l/s/km^2$, or 27.5 to 34.7 l/s at the outlet to the Welland Canal. These baseflows are typical of a subwatershed with limited groundwater discharge, as is the case throughout the majority of the subwatershed. It is, emphasized however, that these numbers are estimates, and that no long term baseflow data has been collected. During the study period (late fall, early spring) several site visits were made and surface flow was estimated to be approximately 50 l/s (combined surface and base flow).

Future Conditions

For the purpose of calculations it is assumed that development would increase the proportion of impervious surfaces, and therefore there would be less area available for infiltration. The degree of impact would depend on the relative change in infiltration between the original soils and the developed area. The impact on the water balance and baseflows of two development scenarios are evaluated, using the following assumptions:

i) The water surplus is still 249 mm (i.e.: no increase or decrease in evapotranspiration, as a result of development)

ii) Developed areas result in a 20 % reduction of land area available for infiltration.

In the first scenario, all lands south of Port Robinson Rd. are developed (**Table 5.2.1**). This is approximately equivalent to half of the each of the existing high permeability and low impermeability areas, and as a result the total land area available for recharge within half of each of the permeable and impermeable areas was reduced by 20% to account for the increase in imperviousness. The resulting average baseflow estimates range from 1.7 to 2.1 $l/s/km^2$, a reduction of 10 % for the entire subwatershed.

In the second scenario, the subwatershed is fully developed (**Table 5.2.1**), and therefore there is a 20 % reduction in the total land area available for infiltration. As a result, the average estimated baseflow decline 20% to 1.5 to 1.9 $l/s/km^2$. These values are considered worst case conditions as there are no controls or management practices in place to maintain or enhance recharge.

5.4 Aquatic Resources

As discussed in Section 4, the Singer's Drain has experienced a history of human influences that has resulted in a predominately degraded aquatic system. Key issues associated with the past impacts on the aquatic resources include straightening of the channel, removal of riparian vegetation, loss of natural vegetation in the subwatershed and sedimentation.

Based on the amount of idle farm land currently in the subwatershed, it is likely that sediment conditions in the drain may have been worse historically when the fields were actively farmed. Channel modifications have continued as a result of flooding, sediment loads, and residential development in the subwatershed. Future residential development in the subwatershed may have a number of key impacts, as follows:

(i) Further removal of existing natural vegetation

Removal of existing natural vegetation is anticipated to accompany future development. Although portions of the subwatershed, for example the southern branch, have reasonably vegetated subwatersheds, residential development can be expected to result in conversion of current open habitats, and perhaps even some woodlots, into residential lots. This loss of vegetation can further reduce the storage of surface water that these areas of natural vegetation provide. This role is important for the maintenance of baseflow to the watercourse during drier seasons.

Portions of the subwatershed currently support natural vegetation that covers more than 30% of the subcatchment basin land area. This is particularly true for the southern tributary and areas near the confluence of the drain with the canal. Other portions of the subwatershed, especially the north branch, currently have less than 10% cover of natural vegetation. Research in other subwatersheds has suggested that the percent cover of natural vegetation should be in the order of 30%. The MNR currently has a target of 15% forest cover in watersheds. Coverage as low as 8 to 10% are typically associated with degraded aquatic habitat conditions.

(ii) Loss of Riparian Vegetation

Residential development may result in further loss of existing riparian vegetation. Although the current extent of woody riparian vegetation extends well into portions of the subwatershed, this vegetation is often a simple and narrow strip of shrubs or a few trees. These stands of vegetation may appear marginal in themselves, but their important role as riparian vegetation must also be considered.

(iii) Channelization
Past development in the subwatershed has resulted in a simplification of the drain's geometry. This is reflected in straightened channels, as well as trapezoidal cross sections. Ditch maintenance that may occur associated with development can increase the extent of these modifications. Modifications to channel geometry can also occur in residential developments.

These types of impacts result in considerable negative impacts to the aquatic habitats in the subwatershed. Not only habitat losses seen in the immediate vicinity of these types of modifications, but downstream impacts to habitat are also seen. The loss of natural meander patterns typically results in a loss of aquatic habitat diversity, as well as erosion.

(iv) Water Quantity/Quality
Discharge of water with low quality can occur during and after construction. Typical erosion control and stormwater management measures are generally used to mitigate these types of impacts. Although the aquatic organisms observed in the drain are generally tolerant to degraded conditions (especially low oxygen and turbidity), further reductions in quality can further reduce the extent, abundance and diversity of aquatic species.

Flooding has been reported as a problematic factor in portions of the study area. Flow regimes that are not typical of the system can be a result of not only channel morphology changes, but also inadequately controlled stormwater discharges. Provision of a natural floodplain and use of appropriate stormwater management can help correct this impact.

5.5 Terrestrial and Wetland Resources

The analysis of potential impacts to terrestrial and wetland habitats include the following three types:

(i) Reduction in Habitat Area
Although the current cover of natural vegetation in the subwatershed is approximately 50%, the cover of mature woodland and wetlands is fairly low. The distribution of these types of habitats varies across the subwatershed, as discussed above. Development typically results in an overall loss of natural vegetation cover, as it is converted to residential uses. Although field and immature habitats are more likely to be lost, some loss of mature stands can also be expected. Protection of the wetlands is partially accomplished by the Provincial Wetlands policy, but many of the wetlands in the subwatershed are currently not mapped as part of the provincially significant wetlands.

Loss in habitat area will not only impact baseflow in the watercourse (as discussed above), but will also potentially result in a loss of plant and wildlife species (including rare species).

(ii) Changes in Habitat Type
Although this impact is related to the above, the impacts of changes of woods to open habitats, fields and scrub dominated stands to grass lawns, etc, can result in considerable change to the abundance and diversity of wildlife in an area. Residential development will lead to loss of habitat area, but also reduction in habitat complexity. At the same time conversion of active farm lands to fields and maturity of old fields can be expected as land speculation and time lags associated with the development approvals process. However, these trends are generally only temporary.

Soil moisture regimes can potentially occur as a result of changes to groundwater infiltration and discharge, as well as surface water drainage associated with development. These changes can cause a change in soil moisture to the point of impacting wetland vegetation.

(iii) Impacts to Linkages

Continuity of habitats is difficult to maintain in developed areas. Road crossings as well as fragmentation of habitats for residences and other uses generally results in not only loss of habitat area, but also loss of connectivity between habitat patches. Currently the east-west band of woodlands and wetlands found along the south margin of the subwatershed appears to be fairly continuous. Development in this area may affect this continuity (this includes the eventual construction of the mid-peninsula expressway).

Currently the E.S. Fox lands appear to play a potential linkage role, in that they connect the linear array of woods along the south of the subwatershed with the woods in the Port Robinson Woodlot area. Conversion of these lands to residential or industrial development may impact this connectivity.

The area and percent cover of the vegetation communities within each of the 18 subcatchments in the Singer's Drain were determined. These areas area summarized in **Table 5.5.1**, along with total areas for main catchments for the South Branch, North Branch, Main Branch (downstream of the confluence of the North and South Branches), as well as the tributary flowing into the Main Branch from the north, and the portion of the Tollgate catchment included in this study.

Since there is currently an abundance of old field and other immature vegetation types in the Singer's Drain subwatershed, most of the subcatchments have over 30% cover of natural vegetation (except for subcatchments 1 and 17). Historically, the subwatershed had more intensive agriculture. If current old field habitats and scrub were active under active agriculture, most subcatchments would have less than 30% cover and many less than 15% cover of natural vegetation.

Wetlands cover approximately 5.3% of the Singer's Drain and 3.1% of the Tollgate drainage areas. Many of the subcatchments have little or no wetland area, while only three of the subwatersheds have over 10% cover of wetlands (subcatchments 11, 16, and 18).

Woodlot cover in the Singer's Drain subwatershed is approximately 11.1% (including mature maple-oak-beech stands, as well as plantations and immature woods). The Tollgate system includes 28% of woods, of which approximately 30% falls within the draft approved E.S. Fox lands.

In a typical development scenario, little old field or scrub areas would normally be retained, and when urban pressure is high, immature wooded and plantation stands may also be removed. Under this scenario, only subcatchments 7, 8, 16, and 18 would have mature woods and wetlands accounting for more than 30% of the area. Under a complete intensive build-out of the subwatershed, there would be less than 30% cover including all of the four main subcatchments. If immature woods, planations and mature woods, as well as wetlands could be retained, the following categories of subcatchments would be anticipated, based on residual cover:

Subcatchments with less than 5% cover (1, 2, 4, 5, and 12)
The residual cover of natural vegetation is so low in these subcatchments that extensive restoration of the remaining open field and scrub areas would be required. These subcatchments are found in the headwater areas and along the North Branch. This extent of restoration may not be possible in these areas.

Subcatchments with between 5 and 15% cover (6, 9, 13, 14, and 17)
In order for these subcatchments to achieve approximately 30% cover, would require retention of all existing woods and wetlands, as well as restoration of about as much additional field and scrub habitats. These subcatchments are primarily found in the middle of the subwatershed. Based on total areas, a number of these subcatchments have sufficient open field areas that could be restored,

Table 5.5.1 Areas of Vegetation Units within Subcatchments in the Port Robinson West Subwatershed.

Vegetation Units	Subcatchments (Map 5.2.1) 1		2		3		4		5		6		7		8		9		10		11		12	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
old field		0.0	17.4	25.2	10.8	71.1	5.9	12.5	3.0	11.3	0.3	0.8	16.5	39.7	12.0	22.4	12.5	11.8	22.7	40.5	32.5	62.5	43.0	37.0
agricultural land		0.0		0.0		0.0	16.6	35.2	11.7	44.2	27.8	78.1	6.8	16.3	4.6	8.6	59.0	55.7	14.8	26.4	4.2	8.1	52.2	44.9
built-up	44.0	100.0	49.6	71.9	0.2	1.3	24.6	52.2	11.8	44.5	1.7	4.8	3.8	9.1	9.2	17.2	27.8	26.3		0.0		0.0	20.0	17.2
scrubland		0.0		0.0		0.0		0.0		0.0	1.7	4.8		0.0		0.0	0.9	0.8	3.2	5.7		0.0		0.0
immature woods		0.0	2.0	2.9	0.4	2.6		0.0		0.0		0.0		0.0		0.0		0.0	5.5	9.8	5.1	9.8	1.0	0.9
maple-oak-beech		0.0		0.0	3.8	25.0		0.0		0.0	2.6	7.3	13.5	32.5	21.4	39.9	2.2	2.1	1.6	2.9		0.0		0.0
plantation		0.0		0.0		0.0		0.0		0.0		0.0		0.0	6.4	11.9	3.5	3.3	3.2	5.7		0.0		0.0
cattail marsh		0.0		0.0		0.0		0.0		0.0		0.0	0.6	1.4		0.0		0.0		0.0	1.5	2.9		0.0
open water marsh		0.0		0.0		0.0		0.0		0.0		0.0	0.4	1.0		0.0		0.0		0.0	0.2	0.4		0.0
willow swamp		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
shrub swamp		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
deciduous swamp		0.0		0.0		0.0		0.0		0.0	1.5	4.2		0.0		0.0		0.0	5.0	8.9	8.5	16.3		0.0
total	44	100	69	100	15.2	100	47.1	100	26.5	100	35.6	100	41.6	100	53.6	100	105.9	100	56	100	52	100	116.2	100

	13		14		15		16		17		18		Total		Main Branch		North Trib		North Branch		South Branch		Tollgate	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
old field	73.8	54.2	42.5	31.9	83.1	20.9	3.2	10.0	3.0	6.9	0.5	1.3	383.0	26.5	49.2	19.8	83.1	20.9	82.1	18.5	168.3	47.2	90.0	37.6
agricultural land	14.6	10.7	58.0	43.6	214.0	53.7	10.4	32.4	32.0	73.4	6.4	16.2	533.0	36.8	106.8	43.0	214.0	53.7	167.3	37.6	45.0	12.6	16.0	6.7
built-up	15.7	11.5		0.0	11.8	3.0		0.0		0.0		0.0	220.0	15.2		0.0	11.8	3.0	179.6	40.4	28.9	8.1	38.0	15.9
scrubland	16.3	12.0	16.7	12.5	13.5	3.4	0.8	2.5	4.1	9.4	17.0	42.9	74.0	5.1	38.6	15.5	13.5	3.4	2.6	0.6	19.5	5.5	21.0	8.8
immature woods	5.0	3.7	3.0	2.3	7.9	2.0		0.0		0.0	9.8	24.7	40.0	2.8	12.8	5.2	7.9	2.0	3.0	0.7	16.0	4.5	28.0	11.7
maple-oak-beech		0.0	7.3	5.5	36.3	9.1	7.2	22.4		0.0	0.8	2.0	97.0	6.7	15.3	6.2	36.3	9.1	4.8	1.1	40.3	11.3	30.0	12.5
plantation		0.0	0.4	0.3	2.7	0.7	2.4	7.5	4.5	10.3	0.3	0.8	23.0	1.6	7.6	3.1	2.7	0.7	3.5	0.8	9.6	2.7	9.0	3.8
cattail marsh	1.4	1.0		0.0	1.2	0.3	2.6	8.1		0.0	4.8	12.1	12.0	0.8	7.4	3.0	1.2	0.3		0.0	3.5	1.0		0.0
open water marsh	0.5	0.4		0.0	6.7	1.7	1.1	3.4		0.0		0.0	9.0	0.6	1.1	0.4	6.7	1.7		0.0	1.1	0.3		0.0
willow swamp	1.2	0.9	5.2	3.9		0.0		0.0		0.0		0.0	6.0	0.4	5.2	2.1		0.0		0.0	1.2	0.3	0.3	0.1
shrub swamp		0.0		0.0	3.4	0.9	3.2	10.0		0.0		0.0	7.0	0.5	3.2	1.3	3.4	0.9		0.0		0.0	4.0	1.7
deciduous swamp	7.6	5.6		0.0	17.7	4.4	1.2	3.7		0.0		0.0	44.0	3.0	1.2	0.5	17.7	4.4	1.5	0.3	23.1	6.5	3.0	1.3
total	136.1	100	133.1	100	398.3	100	32.1	100	43.6	100	39.6	100	1448	100	248.4	100	398.3	100	444.4	100	356.5	100	239.3	100

however, the location of these areas would likely unfairly burden landowners with idle land compared to those with active agriculture.

Subcatchments with between 15 and 30% cover (3, 10, 11, and 15)
A number of these areas have close to the approximate target of 30% cover. These subcatchment areas include the lands near the Niagara St-Cataract Rd wetland complex. Retention of the wooded and wetland habitats as well as some additional areas around these patches has the potential to provide 30% cover.

Subcatchments with over 30% cover (7, 8, 16, and 18)
These subcatchments currently have more than 30% cover of woods and wetlands. This includes the areas around the Rose Little woodlot, and the Pt Robinson woodlot.

The distribution of the subcatchments results in the Main Branch, South Branch and the Tollgate areas having between 20 and 30% cover if all woods and wetlands were retained. While the North Branch would have as low as 2.9% cover and the Northern Tributary (subcatchment 15) would have 19.1% cover. Given this distribution, it is reasonable that retention of the woods and wetlands, as well as some adjacent naturally vegetated buffer around these features would achieve an overall target of 30% cover within the Main, South and Tollgate catchment basins. This highlights the very low cover in the North Branch and suggests that restoration efforts should focus on the creation of natural habitats in this portion of the Port Robinson West Subwatershed. MNR's target of 15% wooded cover appears achievable in the watershed as a whole, as well as in most subcatchments.

5.6 Opportunities, Constraints and Management Needs

The subwatershed conditions analysis of watershed functions and analysis of potential impacts provides an assessment of opportunities, constraints, and management needs (to protect and enhance watershed conditions). The opportunities, constraints and management needs are summarized as follows.

- Significant flood potential exists along Singer's Drain, primarily in the centre reach along Port Robinson Road. Measures are necessary to reduce flood potential.
- Portions of Singer's Drain provide the opportunity for rehabilitation, where not constrained by encroachment. Rehabilitation would improve sediment movement and fish habitat. This would restore some of the fishery resource lost due to past land use impacts.
- Removal of the barrier at the Welland Canal would provide for fish passage in and out of the canal when water levels are high (early spring to late fall). Based on field surveys the ability of fish moving into the Singer's Drain from the canal may be limited by existing barriers such as the CNR rail tracks.
- There are significant terrestrial features that influence hydrologic functions on Singer's Drain and provide wildlife habitat. Some are protected by current zoning. The function of these areas is important to conditions in Singer's Drain.
- Without stormwater management, future urban development will result in significant increases in peak flows and runoff volume during storm events. Controls are needed to prevent increases in flood damages and erosion along the creek.
- Existing terrestrial features provide a linear link along portions of the Singer's Drain, particularly the south branch. However not all areas are connected, and opportunities exist to provide a greenspace linkage in conjunction with a creek corridor.
- It is important to provide for and protect a stream corridor along Singer's Drain. This will provide:
  - Protection from further encroachment along Singer's Drain and further increase in flood potential;
  - A buffer along the creek to protect bank contributions to base flow;
  - A buffer along the creek to protect water quality and enhance fish habitat.

- Groundwater development within the "impermeable" area of the subwatershed will likely not result in significant impacts since there is little natural opportunity for infiltration under the existing conditions. There is limited opportunity in this area to aid infiltration given the tight nature of the soils, the shallow water table, and the fact that there is little vertical gradient to create a "force" to move the water downward.
- Within the Kame area, development could reduce recharge to depth, and to surface water tributaries to the east, as well as the Niagara Street Cataract Road Wetland. However the magnitude of the potential groundwater impact is difficult to determine without a more detailed assessment of surface water features, particularly in the vicinity of the wetland. At source infiltration should be promoted in this area where possible. The permeable nature of the soils and the deep water table within this area are appropriate conditions to optimize at source infiltration.
- There are sufficient terrestrial features within the subwatershed to provide what is generally considered to be a "good" portion of natural heritage feature coverage and meet the suggested MNR target of 15% (Main, South and Tollgate catchment basins) which is preferred to provide a healthier watershed condition.

6.0 SUBWATERSHED MANAGEMENT PLAN DEVELOPMENT

6.1 Introduction

The subwatershed characterization and analysis of potential impacts provides the basis for identifying the opportunities and constraints in Section 5.6. This provides the basis for considering various management measures available and developing the most effective approach to meet the watershed goals and objectives, summarized as follows:

6.2 Management Opportunities

- **General**

The consideration of management opportunities and solution of a management approach was carried out in two steps:

i) Various management measures were considered and evaluated for use taking into account existing watershed conditions, and the potential impacts (without control) of future land use changes. These measures were considered to resolve existing watershed problems and mitigate potential impacts.

ii) Overall approaches to watershed management were considered for the study area to meet the watershed goals and objectives given the existing conditions and potential land use impacts.

The first stage in the selection process considers the various measures available given watershed conditions and provides a means of selecting the most effective measures. The second stage considers overall approaches that could be used for the watershed system and selects a preferred approach.

- **Management Measures**

Watershed management measures can take a broad form, ranging from policies on regulations that apply to the overall watershed, to the implementation of a detention area to provide flow control from a specific drainage area. Management measures can also vary in the type of control provided, ranging from single purpose detention facilities for peak flow reduction to wetland areas that provide water quality control, base flow enhancement and flow control.

These measures, or a portion of them, are commonly referred to as “Best Management Practices”. This terminology indicates that consideration must be given to the control requirements of the watershed and the effectiveness of the control measure in selecting the “best” measure to use.

For the purposes of comparison, watershed management measures were considered to belong to one of three categories:

i. Watershed scale measures
Watershed scale measures include those that are most effective on a watershed scale such as land use policies, control regulations or policies directed at controlling watershed use activities.

ii. Source control measures and
Source control measures refer to facilities that generally are applied to control problems at the source rather than after it enters the receiving stream.

iii. In stream measures.
In stream measures are applied within the receiving watercourse to mitigate problems that are specific to a stream reach.

Measures in each category are outlined as follows:

1. **Watershed Scale**

- Land use Designation – Identifying and protecting significant terrestrial features of environmental importance. Setting land use controls for environmental protection.
- Regulation – Setting control levels (i.e. peak flow control) or practices under existing policies.
- Floodplain Regulation – Establishing floodlines and filllines to regulate land use in hazard areas.
- Spill Management – Working with industries in the development of plans to minimize the risk of spills to the storm drainage system .
- Agriculture Land Use Practices – Working with agricultural industry to adopt practices to minimize impacts to streams.
- Land Acquisition – Acquiring land to provide a benefit to watershed conditions (i.e. purchase of flood prone areas, wetlands, woodlots).
- Top Soil Preservation – Regulations to minimize loss of top soil.
- Public Education – Encouraging wise management practices (i.e. do not dump oil in catch basins, clean up litter and animal feces).
- Private Sewage System Management – Establishing programs to monitor sewage discharge and measures to mitigate impacts.

2. **Source Control**

- Siltation Control (Urban) – Prevent silt from entering streams from new development.
- Lot Grading – Encourage overland drainage on grassed areas, minimize sewer system use.
- Vegetative Buffers – Tree and shrub buffers along streams.
- Infiltration/Recharge – Using infiltration trenches, basins, soakaway pits, to maintain flows to ground water system, in areas of highly permeable soils and a drop water table.
- Extended Detention – Storage and slow release of stormwater to maintain base flows, provide erosion control and allow for sediment removal.
- Filtration – Filter stormwater runoff to trap pollutants.
- Wet ponds and wetlands – For the storage of stormwater for peak flow control, to allow sediment removal, to encourage groundwater recharge and improve water quality.
- Grassed Waterways – To provide natural drainage characteristics, improve water quality and provide for infiltration.
- Water Quality Inlets – Attached to catchbasins to encourage the removal of sediments and improve water quality.
- Agricultural Runoff Control – Through the use of settling basins to remove sediments and improve water quality.
- Operations and Maintenance – Street sweeping and regular inspection/maintenance of source control facilities.
- Public Education – Changing public behaviour to eliminate dumping of pollutants that can pollute streams.

1. **Instream Measures**

- Peak Flow Control – With detention basins to reduce peak flows and flooding.
- Channelization and Culvert Replacement – To increase stream capacity or mitigate erosion.
- Channel Rehabilitation – To provide for natural channel features to reduce erosion provide for water quality and fish habitat enhancement.
- Berming – To protect buildings from flooding.
- Flood Proofing – Of structures to minimize flood damage.
- Dredging – Of streams to increase capacity and lower flood levels.
- Diversion – Of streams to increase capacity and lower flood levels.
- Diversion – Of an entire stream peak flows only to reduce flood flow downstream.
- Streambank Linings – To stop or prevent erosion using either a hard lining (concrete or rock) or a vegetative lining (bioengineering).
- Fish Habitat Creation – Including deflectors, cover structures, spawning habitat, etc. Implemented to compensate for habitat lost due to channelization, dredging, or channel hardening, or to enhance conditions where possible.

6.3 Evaluation of Measures

In considering the watershed management measures available for use in the Port Robinson West Subwatershed, a comparison was carried out considering a number of factors:

- The general effectiveness of the measure in the area of concern for the watershed
  - flood/erosion control
  - environmental protection and enhancement
  - water quality/biological control
  - base flow
  - aesthetics/recreation

- The effectiveness of the various measures based upon past pilot studies and monitoring of use ("Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs", Schueler 1987).

- The relative implementation and operating costs involved with the measures.

- Public acceptance based upon information received during the study and from general public opinion survey information ("Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs", Schueler 1987).

To provide a method of comparing the various methods available, a ranking system was developed with the results outlined in **Table 6.3.1.** A comparative ranking is provided in the right hand column under "Benefit" with the highest ranking being the most preferred. The following methods were used in developing the ranking.

- The categories were developed to relate to the areas of interest (i.e. flooding, erosion control, environmental concerns, etc.).

- The first seven columns refer to general effectiveness which could relate to most applications of the measure.

TABLE 6.3.1

PORT ROBINSON WEST SUBWATERSHED EVALUATION OF MANAGEMENT OPPORTUNITIES

	Flood Control	Streambank Erosion Control	Water Quality Control	Biological	Aesthetics /Recreation	Base Flow	Surface Erosion	Cost	Public Acceptance	Benefit
1 Watershed Scale Measures										
- Land Use Designation	5	5	3	8	8	5	5	0	5	44
- Regulation	5	0	3	3	3	0	0	8	8	30
- Floodplain Regulation	5	5	3	3	5	3	3	0	3	30
- Spill Management	0	0	3	3	0	0	0	8	8	22
- Agricultural Land Use Practices	3	3	5	5	0	5	10	8	8	47
- Land Use Controls	5	5	7	7	10	8	5	0	0	47
- Land Acquisition	8	3	7	7	10	5	5	-10	3	38
- Top Soil Preservation	0	3	10	5	3	0	10	0	3	34
- Private Sewage System Management	0	0	10	5	5	0	0	-3	5	22
2 Source Control										
- Siltation Control Devices (Urban)	3	3	5	5	1	0	5	5	8	35
- Lot Grading	0	0	3	3	0	0	5	3	8	22
- Vegetative Buffers	0	5	7	10	10	8	3	0	8	52
- Infiltration / Recharge (Impermeable)	3	5	5	5	0	2	3	3	5	31
- Infiltration / Recharge (Permeable)	5	8	8	8	0	8	3	3	5	48
- Extended Detention	8	8	7	5	0	3	3	3	3	40
- Filtration	3	3	7	7	3	5	3	3	3	14
- Wet Ponds	8	3	7	3	3	3	5	2	5	39
- Wetlands	3	3	7	8	5	2	3	2	5	38
- Grassed Waterway	3	5	3	5	5	8	2	5	8	43
- Water Quality Inlet	0	0	3	3	0	0	0	3	0	6
- Agricultural Runoff Control	0	5	8	8	3	0	10	0	8	43
3 Instream Measures										
- Peak Flow Control (Detention)	10	2	0	0	1	0	3	3	3	22
- Channelization	10	8	-7	-7	-5	0	0	-5	0	-16
- Channel Rehabilitation	10	8	3	5	3	3	3	-3	3	35
- Berming	5	0	3	0	3	0	0	3	-3	11
- Flood Proofing	5	0	0	0	0	0	0	3	-3	5
- Dredging	8	-3	3	0	-5	2	0	3	-5	3
- Diversions (Total)	10	5	-7	-7	-7	-10	0	-5	-5	-26
- Diversions (Peak)	10	3	3	3	0	0	0	-4	0	15
- Streambank Linings (Concrete/Rock)	0	10	-7	-7	-10	0	0	-3	-5	-22
- Vegetative Streambank Lining	0	5	5	7	7	0	0	5	8	37

Range: 10 High Effectiveness
0 No effect or not applicable
-10 High Disbenefit or Negative Impact

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- The last two columns (mostly public acceptance) relate more to application in the watershed area under study since public opinion was included in the development or ranking.
- The ranking ranges from 10 (highest effectiveness) to – 10 for the greatest negative impact.
- The ranking was added with equal weighting to provide a total ranking for each measure. A second ranking scheme was carried out with each column weighted based upon public input (i.e. higher weighting given to environmental control and flood control). It was found to have little impact on the overall ranking.

It must be recognized that this ranking only provides a measure of the relative benefits of the measures considered. An absolute comparison cannot be made since a combination of measures is generally required for a complete and comprehensive management plan. For example, spill management cannot provide complete water quality protection and requires additional measures such as source control or instream measures to provide a complete approach. This method does, however provide a means of comparing and selecting measures for use in a management approach or considering the suitability of possible measures.

6.4 Application to Subwatershed

In considering the application of a broad range of options to the Port Robinson West Subwatershed, the options were compared to the watershed requirements developed through watershed analysis. **Table 6.3.2** provides a summary of the watershed requirements expressed as needs, objectives and constraints under each of the categories identified; hydrogeology, water quality, environmental, flooding, erosion and land use. The table also provides a summary of the control options available to meet the requirements (column 3) and the constraints to the use of those options (column 4) based upon watershed conditions or the measures themselves.

This table then provides the basis for the selection of management approaches for the watershed leading to the development of a management plan.

6.5 Subwatershed Management Plan Development

6.5.1 General

Watershed management options were selected and evaluated for use in the Management Strategy for the Port Robinson West Subwatershed. The consideration of options was carried out in two steps.

i) Options were initially considered to address specific problem areas or existing problems (i.e. flood damage centres) that would lead to separate solutions from an overall watershed management approach.

ii) Options that apply to the overall watershed and specifically to new urban development were considered and evaluated from an overall watershed standpoint.

This approach provides a short list of options to be evaluated and the provision of specific recommendations to mitigate existing problems as well as identifying overall watershed management measures required.

TABLE 6.3.2

PORT ROBINSON WEST SUBWATERSHED

OPTION EVALUATION

ISSUES	NEEDS/OBJECTIVE/ CONDITIONS	CONTROL OPTIONS	CONSTRAINTS
Hydrogeology	- Base flow maintenance - Infiltration (water quality) - Suitable soils limited to upper part of subwatershed	- Infiltration measures - Land use control - Extended detention	- Limited suitable soils - Depth to bedrock
Water Quality	- Phosphorous/Nitrogen - Sediment - Toxic substances - Dissolved Oxygen/BOD - Temperature - Interrelationships between phosphorous, base flow, temperature	- Buffering - Land use control - Siltation control - Filtration - Extended detention - Wet ponds - Wetlands - Grassed waterways - Spill management - Regulation - Water quality inlet	- Land requirements - Public acceptance - Design constraints - Cost (land acquisition)
Environmental	- Fish habitat - Environmental Sensitive Areas - Aesthetics / Recreation - Streambank Vegetation / Habitat	- Buffers - Grassed waterways - Land acquisition (plus above) - Stream rehabilitation	- Land requirements - Public acceptance - Design constraints - Cost (land acquisition)
Flooding	- Protection of life and property - Flood Damage Centres in Downstream Areas - Floodway /Valley System - Potential increase in flooding	- Peak flow control - Channelization - Berming / Flood Proof - Dredging - Diversions - Land Use Control - SWM measures	- Land requirements - Public acceptance - Cost - Environmental impacts - Over control of peak flows not feasible
Erosion	- Sediment loadings - Potential increase in erosion - Rate of erosion	- Channelization - Diversions - Land Use Control - Situation Control - Buffers - Vegetative livings - Hard lining - SWM (volume)	- Public acceptance - Cost - Environmental impacts - Land impacts
Land Use	- Community Needs: Residential, Industrial, Commercial, Institutional, Parks, Open Spaces, Servicing - Aesthetics - Environmental conditions - Flood plain	- Flood plain - Buffer system - Grassed waterways - Land use controls - residential - agricultural - ESA - Land use regulations	- Public acceptance - Development pressures - Planning policies - Existing land use regulations - Costs

6.5.2 Development of a Management Strategy

In considering specific requirements the subwatershed can be divided into two district areas and requirements outlined for each.

1. **Headwater Areas – (Fonthill)**

   - The headwater area has significant urban area with expansion proposed to the east to Rice Road.
   - Current drainage, primarily consists of roadside ditches with little piped drainage. Stormwater management is proposed for future development areas.
   - Some headwater streams extend into the proposed development areas.
   - Lands in this area have significantly higher infiltration potential than the lower part of the watershed.
   - The groundwater infiltration feeds base flow on the main branch in the lower watershed.
   - Future urbanization in this area will result in significant increases in peak flows in the lower watershed without flow control measures.
   - Significant terrestrial features (wooded areas) exist in the southern part of this area that provide a significant hydrologic and ecological function.

2. **Lower Watershed**

   - Significant flood potential exists along Singer's Drain, primarily in the centre reach along Port Robinson Road. Measures are necessary to reduce flood potential.
   - Portions of Singer's Drain provide the opportunity for rehabilitation, where not constrained by encroachment. Rehabilitation would improve sediment movement and fish habitat. This would restore some of the fishery resource lost due to past land use impacts.
   - Removal of the barrier at the wetland canal would provide for fish passage in and out of the canal when water levels are high (early spring to late fall).
   - There are significant terrestrial features that influence hydrologic functions on Singer's Drain and provide wildlife habitat. Some are protected by current zoning. The function of these areas is important to conditions on Singer's Drain.
   - Without stormwater management future urban development will result in significant increases in peak flows and runoff volume during storm events. Controls are needed to prevent increases in flood damages and erosion along the creek.
   - The low capacity of the stream system and road crossings and sediment problems make it impractical to provide over control (flood storage) upstream.
   - Existing terrestrial features provide a linear link along Singer's Drain, particularly the south branch. These areas are not all connected, however opportunities exist to provide a greenspace linkage in conjunction with a creek corridor.
   - It is important to provide for and protect a stream corridor along Singer's Drain. This will provide:
     - Protection from further encroachment along Singer's Drain and further increase in flood potential;
     - A buffer along the creek to protect bank contributions to base flow;
     - A buffer along the creek to protect water quality and enhance fish habitat.
   - Development within the "low permeability" area of the subwatershed will likely not result in significant impacts on groundwater since there is little natural opportunity for infiltration under the existing.

Mitigation or control measure options were considered for specific requirements of the watershed under the components outlined in the watershed analysis. The consideration of these specific requirements and selected measures are outlined in the following sections.

- **Hydrologic – Flood Control, Conveyance**

Flooding problems have been identified along Singer's Drain and have been assessed in recent analysis (Singer's Corners Municipal Drain – Engineers Report, Wiebe Engineering Group 1997).

The analysis indicates that significant flood potential exists along the main branch in the Port Robinson Road, Cataract Road area. The proposed works include channel reconstruction to deepen and enlarge the existing watercourse and crossings.

Alternate measures were considered as follows:

- Diversions – The area being considered for flood protection is localized, however other flood prone areas exist. Diversion of flood flows does not provide a viable option since a suitable outlet does not exist and it would not be feasible to deal with all flood prone areas.
- Flow controls – Given the minimal capacity that exists in the current drainage system (1:2-1:10 year) it is not practical to provide flood storage facilities with sufficient capacity.
- Flood proofing – flood depths are too high and flood areas too dispersed for flood proofing to provide a viable option.

The proposed channelization works provides the most effective approach to flood damage reduction for the area being considered. The proposed work includes:

- Clean out the main channel from downstream of Kottmeir Road to upstream of Cataract Road to lower invent – widen some sections
- Replace undersized culverts
- Clean out and widen portions the south branch, and improve some culvert crossings

The measures outlined essentially include deepening and enlarging the existing watercourse which also removes the sediment that has deposited over time. It also involves increasing capacity through changes to hydraulic structures.

The proposed works, however do not provide any environmental enhancement and will result in environmental degradation through the removal at existing aquatic habitat structure (unless it is replaced).

Environmental enhancement potential exists along the stream sections where work is proposed. This can be accomplished by deepening and enlarging the stream cross-section with the inclusion of natural channel principles. This would include the following:

- Construct a channel form that provides a "meandering" low flow channel using "flow regime" principles.
- Providing pools and riffle features for fish habitat.
- Provide, if possible floodplain pools on wetlands for nutrients and fish habitat.
- Include vegetated floodplain and banks to shade the stream and improve water quality.

This approach meets the needs of the watershed system by mitigating past impacts and increasing the resilience of the stream system to accommodate future land use changes. This enhancement should be provided for any proposed channel works now and in the future.

- **Stormwater Management**

Stormwater management will be necessary with all new development to provide flow control and water quality control.
The objectives to be met include:

- flow control to maintain existing peak levels
- flow and volume control to mitigate erosion and base flows
- water quality control to protect or enhance downstream areas

Peak flow control requirements have been discussed in Section 5.2 of this report. Conventional stormwater detention facilities can be provided to control peak flows to existing levels. Centralized facilities can be provided to minimize maintenance needs.

Some **erosion** is occurring along Singer's Drain, however it does not present a significant problem at this time. The potential exists for increased potential with future development and SWM controls are needed to avoid impacts. The approach presented in the current MOE Guidelines (Stormwater Management Practices, Planning and Design Manual, MOEE 1994). These guidelines are currently being updated including SWM requirements for erosion control. The updated requirements should be applied when available.

Limited **water quality** analysis was carried out, however the results obtained indicated that sediment loading, nutrient and bacteria problems exist in the watershed. Other pollutant loadings likely exist typical to urban and agricultural sources (i.e. oils, grease, pesticides). No evidence of particularly high point source problem areas was found.

Stormwater management controls are required for water quality control. The relative effectiveness of the control options has been summarized in **Table 6.3.3.** The relative effectiveness is based upon the comparison of BMP measures and available data on effectiveness ("Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs", Schueler 1987). This comparison is related directly to problems and potential impacts that exist in the study area.

Table 6.3.3 suggests that for water quality and environmental control purposes, **vegetation buffers** are an effective method to achieve the watershed goals and objectives. For this reason, vegetative buffers are considered a part of the BMP measures for the watershed. Vegetative buffers act as filter strips to remove pollutants before they enter the creek. One major reason for their efficiency is the greater uptake and long-term retention of nutrients in the forest biomass ("Controlling Urban Runoff, A Practical Manual for Planning and Designing Urban BMPs", Schueler 1987). Vegetative buffers also offer other benefits including an excellent wildlife habitat while providing aesthetic value and recreational opportunities. Other control options should also be incorporated into the plan where applicable. Options such as spill management and regulation enforcement should be apart of any watershed management plan. Where applicable, other control options may be selected to address the watershed issues.

Stormwater management measure selection should be provided to meet the **Level 2** requirements from the MOEE Guidelines (MOEE 1994). **At source controls** are the preferred approach since they provide the most effective water quality control.

Infiltration opportunities are available in the headwater reaches of the watershed as outlined in Section 5.3 of this report. Infiltration is necessary to control runoff from the headwaters for peak flows control and erosion control and to maintain base flows downstream.

TABLE 6.3.3
RELATIVE EFFECTIVENESS OF CONTROL OPTIONS

ISSUE	NEED /OBJECTIVE/ CONDITION	GRASSED SWALES	VEGETATION BUFFER (Approx. 15 m Wide)	ARTIFICIAL WETLANDS	DRY PONDS	EXTENDED DETENTION PONDS	RETENTION (WET) PONDS	LAND USE CONTROL	SILTATION CONTROL DEVICES	FILTRATION	SPILL MANAGEMENT	REGULATION	WATER QUALITY INLET
WATER QUALITY	- PHOSPHORUS / NITROGEN	M	M	L	L	M	M	M	L	M	L	L	L
	- SUSPENDED SOLIDS	M	M - H	M	L	H	H	L	H	M	L	L	L
	- HEAVY METALS	M	H	M	L	H	H	L	M	M	L	L	L
	- DISSOLVED OXYGEN / BOD	M	H	M	L	M	M	L	L	L	L	L	L
	- TEMPERATURE	M	M - H	L	L	L	L	L	L	L	L	L	L
	- BASE FLOW	M - H	M	L	L	L	L	L	L	M	L	L	L
	- INTERRELATIONSHIP BETWEEN PHOSPHERUS BASE FLOW. TEMPERATURE	M	M - H	L	L	L - M	L - M	L	L	L - M	L	L	L
	- SPILLS	L	L	L	L	L	H	L	L	L	H	L	L
	- LAKE ONTARIO IMPACTS	L	M	M	L	M	M	M	L	M	L	L	L
ENVIRONMENTAL	- STREAM EROSION	L - M	L - M	L	H	H	L	L	M	L	L	L	L
	- AQUATIC	L	M	H	L - M	M - H	H	M	M	M	L	L	L
	- WILDLIFE HABITAT	M	H	H	H	H	H	L	L	L	L	L	L
AESTHETIC		M	H	M	M	L - M	M	L	L	L	L	L	L
RECREATION		L	H	M	M - H	L	H	L	L	L	L	L	L
PUBLIC ACCEPTANCE		H	H	M	M	L - M	M - H	H	H	L	H	H	L
OVERAL EFFECTIVENESS RATING		L - M	M - H	M	L - M	M	M - H	L - M	L - M	L - M	L - M	L	L

L = LOW POTENTIAL EFFECTIVENESS
M = MEDIUM POTENTIAL EFFECTIVENESS
H = HIGH POTENTIAL EFFECTIVENESS

SOURCE: MARSHALL MACKLIN MONAGHAN, 1991
SCHUELER, 1987

- **Servicing Requirements**

The existing headwater streams should be maintained to aid in controlling peak flows and protect water quality. This is compatible with the existing approach to the use of roadside ditches. There may be some need to deepen the existing drainage courses to ensure that safe conveyance is provided. If deepening is found necessary a natural channel approach should be used with riparian enhancement for quality control and bank stabilization.

Existing drainage boundaries are to be maintained to avoid increasing flood and erosion potential in the existing watercourses.

- **Rehabilitation Measures**

Existing problems have been identified in the form of flood potential, erosion water quality and environmental degradation. Enhancement opportunities exist which also provide the opportunity to increase the subwatershed "resiliency" or ability to withstand future urban development and ensure that environmental degradation does not occur.

Stream rehabilitation should be carried out where the potential exists to provide for additional controls to mitigate past impacts and improve environmental conditions.

- **Environmentally Significant Areas**

A number of areas of environmental significance have been identified in the watershed that play a number of roles

- Wildlife habitat
- Significant vegetation
- Vegetative diversity
- Base flow to creek
- Store water during rainfall events

Areas have been identified for protection based upon the features that exist and function provided. Protection of these areas in the form of buffers is necessary to ensure that the form and function are protected.

7.0 MANAGEMENT STRATEGY

7.1 Recommendations

A Management Strategy for the Port Robinson West Subwatershed is provided based upon the existing watershed conditions, objectives set for the watershed and the potential impacts identified. This section provides a summary of the selected management measures and discusses implementation requirements. The recommendations including any relevant specific targets are outlined in the following sections.

It is important to recognize that no single recommendation or group of recommendations are sufficient to meet all of the watershed objectives. The recommendations are interrelated and in order to provide full protection of the watershed and meet the goals set, all recommendations should be followed.

The management strategy has three major components.

- **Stormwater management practices** (BMP's) related to future and existing land uses to protect and enhance surface, groundwater and related environmental conditions.
- **Land use controls** in the form of constraints to protect terrestrial features and provide environmental protection.
- **Site specific measures** to remediate existing problems (i.e. flooding) and provide for rehabilitation.

The recommended management approach and agencies that would be involved in implementation are listed as follows:

AM - Area Municipalities
RMON - Regional Municipality of Niagara
NPCA - Niagara Peninsula Conservation Authority

Stormwater Management

1. Stormwater management is required for all new development for water quality and quantity in accordance with the following: **AM NPCA**
   - Stormwater management plans are required for future development to meet the following targets.
     - Maintain existing infiltration levels in constraint level 2 lands. Approximate target for open soils in headwater is 250 mm per year (to be confirmed by field investigations).
     - Maintain existing peak flow levels for all design events from 2 to 100 year level.
     - Provide erosion control by meeting 25 mm, 24 hour storage target as outlined in MOEE (1994) Manual.
   - Stormwater management plans should be developed based on the following:
     - At source controls continue as a first priority.
     - Continue use of roadside ditches.
     - Retain defined headwater stream systems.
     - Wetlands systems are preferred for water quality control to minimize temperature impacts
     - To minimize maintenance, centralized facilities should be applied to provide SWM controls not met by at source measures.

- Stormwater management features are not permitted in Constraint level 1 lands (see Recomendation 3) (significant terrestrial features). Consideration can be given to their location in Constraint level 2 lands as long as the function of that area is protected.
- Provide water quality control to meet level 2 requirement as outlined in MOEE (1994) Manual.

- Peak flow control is necessary to ensure that flood potential is not increased. Preliminary volumes required are included in **Table 5.2.1.** Peak flow control should be included for all design events, 2 yr to 100 yr inclusive. Preliminary locations for SWM ponds are illustrated on **Figure 7.1.1**. Final siting and sizing of any required ponds should be completed as part of a stormwater drainage plan.

- Erosion control practices are to be applied in accordance with the MOEE Stormwater Management Practices Planning and Design Manual (1994) which includes 25 mm of storage for 24 hours.

- Water quality control practices should be provided to meet MOEE Stormwater Management Practices Planning and Design Manual (MOEE 1994) for Level 2 streams. The primary area of concern includes sediment, nutrients and bacteria. Sediment forebays should be provided with each SWM facility.

- At source BMP's should be provided where practical. Area municipalities should use roadside ditches for drainage where possible as well as retaining open watercourses. Combined drainage systems could be applied which include a combination of surface drainage (ie. shallow swales) with a sewer system. Infiltration trenches or soak-away pits would be applicable in the Fonthill Kame area. A "Sclection Tool" for alternate drainage systems is currently being developed which would assist in the development of these drainage systems (1999, Selection Tool for Roadway Drainage Systems, TRCA).

- Defined headwater stream systems be retained where possible and used as part of the drainage system. These areas are being refined in the Pelham planning process. Definition of the stream corridors will be provided at the draft plan or secondary plan stage.

- A drainage plan be prepared for any new development proposal to show compliance with the recommendations of this study.

2. A Farm Management Strategy should be developed and implemented **NPCA AM**

   - Measures should be directed specifically at nutrient management, sediment control and preservation of headwater streams. This would include stream buffers, nutrient management plans and stream rehabilitation.

Land Use Management

3. In directing future land use decisions and development review, it is recommended that a constraint designation be adopted to protect terrestrial and stream features that exist. **AM RMON NPCA**

Based on a comparison of the current character of the terrestrial, wetland and aquatic habitats in the subwatershed, in comparison with the potential development impacts, constraints were identified. The locations of these zones are shown on **Figure 7.1.1.** For the purposes of this report, the following constraint levels are recommended

Constraint Level 1

Constraint Level 1 represents the highest level of constraint for development in the subwatershed. This category includes natural features that are either protected by current designations, as well as features that are significant in terms of the future health of the subwatershed system. Development within Constraint level 1 areas is to be excluded.

The following features are included in Constraint Level 1:

Terrestrial

(i) Mature upland woodlots (these features are recognized in the Regional Tree Cutting Bylaw)

Wetland

(i) All wetland areas as shown on the vegetation community map.

Aquatic

(i) All reaches of the Singer's Drain.

Buffer zones will be required around each of these features (for example, Pelham currently uses a 15m buffer). Once established, the buffer zone is recommended to be a Constraint Level 1 feature. A number of factors must be considered on a site-specific basis for determining buffer widths/characteristics, including:

- the sensitivity of both flora and fauna;
- the sensitivity of the habitat as a whole;
- slopes or other terrain characteristics;
- water levels, fluctuations and movement;
- presence of surface or groundwater discharges;
- vegetation type at habitat edge and in setback;
- control of soil erosion, sediment, and pollutants;
- moisture regime;
- significant features, rare habitat;
- essential features, biological health;
- microclimate;
- wind characteristics and protection;
- integrity of the landscape unit;
- human use of the habitat;
- type of adjacent use; and
- corridor/open space linkages.

Site-specific details regarding the proposed development (type and density of development, amount of impervious surface, proposed services, and drainage) as well as the proposed use or treatment in the buffer area (ownership, maintenance, trails) must also be taken into consideration.

The constraint lands illustrated on **Figure 7.1.1** include lands identified along Towpath Drain and in that subwatershed. These areas are based on available information and have not been investigated in detail as with the Singer's Drain subwatershed areas. Additional field verification should be carried out prior to providing these areas an official planning status.

Constraint Level 2
The second level of constraint is recommended to include features that are not protected by current designations, but are deemed to have a considerable value in the subwatershed. The adjacent lands, as defined in the Provincial Policy Statement, are zones within which there is a potential interaction with the nearby significant natural resource. The adjacent land zones are recommended for inclusion in this constraint level. These zones are triggers that differ from setbacks, in that they are dimensions that are intended to trigger environmental studies. Generally these are horizontal distances measured from the boundary of some feature. If an undertaking is proposed within this zone, studies are required to assess impacts and, in some cases, set buffers/setbacks.

The following features are recommended for Constraint Level 2:

Terrestrial
(i) 50 m adjacent lands around mature woodlands
Research into the potential impacts of urban development on woodland systems, has shown that in some cases the impacts of residential development on woodlots occurs when development is within 200 m of the woodlot edge. However, the standard provincial adjacent lands zone of 50 m is deemed sufficient to capture the range of potential impacts in light of the character of the woods in the subwatershed.

(ii) immature woods and plantations
The low percent cover of mature woods in this subwatershed, suggest an increase in woodlot cover would potentially result in a significant benefit to the surface water, plant and wildlife components of the subwatershed. Many of these stands will also be covered by the Regional Cutting Bylaw.

(iii) scrub and field habitats that represent critical linkages
In order to improve the connectivity between habitats within the subwatershed, it is recommended that scrub and field habitats that potentially act as critical components of ecological corridors be included in Constraint Level 2.

Wetland
(i) 120 m adjacent lands zone around all wetlands (as per the provincial policy statement)
Based on the characteristics of the groundwater resources in the subwatershed, maintenance of some of the wetlands in the area will require care be taken in the headwater portions of the subwatershed where infiltration occurs. Therefore these areas are also recommended for this category.

Aquatic

(i) 30 m adjacent lands zone along all tributaries (as per provincial policy statement)

(ii) Areas with high potential for infiltration be regarded as constraint level 2 lands. Existing infiltration levels have been determined to be important to downstream conditions and should be maintained. Urban land uses are permitted with measures to maintain infiltration capacity. Levels of infiltration are to be field tested at Draft Plan stage to set specific target levels. The area of high infiltration includes the Fonthill Kame Complex (**Figure 4.4.3**).

Constraint Level 3

All other lands within the subwatershed fall into this category. Future development within the subwatershed is recommended to focus on these lands, having regard for overall subwatershed goals.

4. The significant woodlands and wetlands areas be assessed for designation for protection under the proposed Official Plan revisions. A wildlife corridor plan should be developed to enhance the connectivity of the terrestrial features. Consideration should be given to developing connections to the 12 Mile Creek corridor, and to habitats along the Welland Canal. This will assist to enhance wildlife habitat and increase wildlife population. Action should also be taken to provide for public access through the development of trail systems within or adjacent to the natural heritage areas. **NPCA AM RMON**

5. Wetland areas be re-evaluated using current 1993/94 MNR evaluation system. **MNR**

6. Flood and Fill lines be developed for Singer's Drain and for designation in the Official Plan revisions. Land use controls should be developed to regulate future uses in hazard lands. This can be accomplished through the NPCA under the Conservation Authorities Act or with a Municipal Fill By-law. **NPCA AM**

Site Specific Measures

7. Modifications to the Singer's Drain are proposed under the Drainage Act including deepening of the watercourse and replacement of a number of culvert crossings. This provides a reduction in flood capacity although significant flood potential will still exist. **NPCA AM**

   Consideration should be given to providing stream rehabilitation when the channel deepening is carried out from Kottmeier Road to Merritville Highway. This would require providing a wider cross-section (i.e. 20 meters at floodway base) with a low flow stream and vegetated banks. Removal of any impediments to fish movement should also be included.

   It is recommended that a flood damage reduction study be carried out to investigate flood potential in more detail, develop and evaluate flood control options, and identify further measures that could be carried out. A significant flood potential exist with related threat to homes. In addition, problems have been reported with respect to surface water entering private wells during periodic flood events and contaminating water supplies.

8. Examination and potential removal of the weir at the mouth of the drain. Further detailed examination and study will be required but this option has the potential to improve both the flow and connectivity to the canal. Once this connection occurs, changes in channel slope may result in improved substrate for potential spawning. At a minimum, the provision of a refuge for canal based fish is seen as a benefit. Examination of this measure should give consideration to potential impacts to the Towpath Road and canal as well as the wetland that exists upstream of the weir. Based on the investigations carried out in this study it is judged that this measure is feasible and that it will not result in any negative impacts and further that the connection of fish habitat to the Welland Canal will be of benefit to both the Canal and Singers Drain through the provision of a food source, refuge and potential spawning areas. This outlet and weir is under the control of the St. Lawrence Seaway Authority. Any changes need to be carried out with their cooperation and involvement. **NPCA AM**

9. Carry out stream rehabilitation on a priority basis as follows: **NPCA AM**

   (1) Enhancement of the watercourse geometry through reconstruction of the channel **from Kottmeier to the confluence of the north and south branches** (including removal of any barriers to fish movement). This section of the watercourse is immediately upstream of the 'best' watercourse habitats in the area and restoration of this reach would potentially extend the length of this higher quality habitat. As well, the current location of the watercourse and adjacent land uses appears to provide a good potential actually achieve the restoration without significant impact to current users.

   (2) Enhancement of the watercourse geometry through reconstruction of the channel from the **confluence of the north and south branches along the south branch to wooded and wetland areas to** west (including removal of any barriers to fish movement). This section is immediately upstream of the above reach and would be next phase in the channel reconstruction. Restoration of this section of channel, especially provision of riparian habitats along the creek, will provide a potential habitat linkage from the woods and wetlands in the Cataract Road – Niagara Street area to the woods and wetlands in the Port Robinson Woodlot area. This importance of this connectivity will increase when the construction on the E.S. Fox lands impacts the current linkages

   (3) Provision of **woody riparian vegetation** at strategic locations. Reaches currently described as category 4 and 5 have little of no woody riparian vegetation. These areas should be focused on for the planting of woody vegetation.

10. A plan be developed at identifying on-line ponds that can be removed or modified to off-line ponds. This will require contact with landowners to discuss remediation opportunities and gain their co-operation. **NPCA AM**

11. Install a continuous stream gauge at the mouth of the Creek for a period of 2-3 years to provide additional information on base flows and storm flows for model calibration. **NPCA**

12. There is significant potential that some tile beds for private sewage systems are malfunctioning. A testing program for bacteria in Singer's Drain should be initiated with field checks for evidence of breakouts. **RMON, MPCA**

We would suggest monitoring of 8 to 12 points along Singer's Drain for bacteria at a frequency of 6 times over the spring to identify any differences in problem areas. Possible locations include Rice Road at the three main tributaries. Cataract Road – main branch and tributary, two tributaries at confluence (near Port Robinson Road), the main branch and tributary of Kottmeier Road and at the outlet. A field reconnaisance (and possibly sampling) of the areas with the highest bacteria counts should then be carried out to investigate signs of breakout or other sources of contamination. Once sources are established a remediation plan can be developed and implemented.

7.2 Implementation

A number of factors related to implementation of the recommendations include:

Planning

- The hazard land designations (flood and fill lines) are required which will affect the planning approach to new development proposals. The recommendations of this study need to be incorporated into the plan review stage.
- Agency co-ordination will be required to ensure that a consistent approach is used (NPCA, RMON, AM).

SWM Design

- Drainage designs should consider at source controls as outlined in the current MOEE guidelines (MOEE 1994).
- Water quality control should be provided for level 2 streams as appropriate using the MOEE guidelines (MOEE 1994).
- Water quantity control should be provided to limit peak flows to existing levels up to and including the 100 year design storm level. The drainage areas should be analyzed on a sub-area basis illustrated on **Figure 4.3.1.**
- Sample Criteria for use in the layout of SWM facilities is provided in (**Appendix 6**). This criteria is in use at the Region of Waterloo and City of Guelph and provides information for dimensioning, planting types and planting density. It is recommended as suitable for the Port Robinson West Subwatershed, however, if applied, the plant species listed should be reviewed and modified as necessary to what is suitable for the subwatershed.
- Erosion control should be provided by the storage of a 25 mm event for 24 hours (4 hour Chicago distribution). This is consistent with the MOEE Guidelines (Stormwater Management Practices Planning and Design Manual - 1994).
- If infiltration is provided as part of a SWM facility, analysis is required to ensure the protection of groundwater supply sources.

Stream Rehabilitation and Farm Management

- The study recommendations include the rehabilitation of Singer's Drain and implementation of Farm Conservation Plans where possible. This will improve water quality in the stream and enhance fish habitat. Additional work is necessary to develop detailed plans however the scope of work should include the following:

- **Stream Rehabilitation** - Streams should be allowed to follow a natural meandering pattern where possible to provide a "dynamic balance" for aquatic habitat. It will likely not be economically feasible to change the pattern of straightened sections of Singer's Drain, however, if the opportunity does arise a natural channel approach should be followed. This would include the removal of barriers to fish movement. Any municipal drain cleanouts should provide for stream enhancement wherever possible. Riparian enhancement should be provided by planting trees and shrubs along the stream corridors or allowing the corridor to regenerate. If it is not possible to allow both sides to regenerate, one side should be considered (south or west) to reduce water temperature.
  Any rehabilitation works will need to be carried out in co-operation with the landowners. Land will be required to create a meander belt width and flood plain.
- **Farm Management Plan** - Farm management plans should include a variety of measures aimed at reducing water quality impacts. These include stream buffers (outlined above), conservation tillage, nutrient management, and grassed waterways.
- **On-Line Pond modification or removal** - A modification or removal plan will be required for on-line ponds. This should be carried out in co-operation with the landowner to develop an approach that meets the multiple objectives that exist (aesthetics, irrigation source).

Monitoring

The aquatic habitat provided in the creek has the potential to provide cool water habitats in some locations, but additional information on water quality, especially thermal characteristics and other parameters is warranted. In order to provide this additional information, as well as to provide for future monitoring and detection of changes in the acquatic habitats, biological monitoring is recommended. This monitoring should also include water quality parameters, especially temperature, dissolved oxygen, as well as bacteria.

The details of the existing benthic community are not documented at the time of writing this report. Future biomonitoring using benthic invertebrate sampling may provide valuable information. Selection of the monitoring stations should be an iterative process, however based on existing information, the following key monitoring locations are recommended (based on the stream reach identification numbers used on **Figure 4.9.1**).

South Branch
S47 – on small tributary, before confluence with main branch
S33 – downstream of the Cataract Rd wetland complex
S27 – upstream of on-line ponds
S13 – downstream of on-line ponds and upstream of confluence with north branch

North Branch
S41 and S39 – on small bributaries, before confluence with main branch
S37 – flood prone area, subject to potential future drainage works
S16 – above confluence with south branch

Main
S4, S19, S17 – on small tributaries, above confluence with main branch
S5 – upstream of Pt Robinson wetlands
S1 – above weir

A number of these recommended stations may experience dry conditions, making sample collection impossible. Additional sample locations may be warranted as further water quality and biological monitoring results become available.

A continuous stream flow guage should be installed at the outlet to the Welland Canal. This will provide information useful in stream design as well as the evaluation of base flows in Singer's Drain.

RHT/sk
April 1999
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Erosion along Streambanks

Sediment Deposition

Poor Quality Riparian Vegetation

Sediment Loads from Agricultural Lands

Roadside Ditches in Headwater

Area of Recurring Flooding

Vegetated Tributary Channel

Unprotected Tributary – Sediment Load

Figure 1.3.1

SUBWATERSHED PLANNING PROCESS

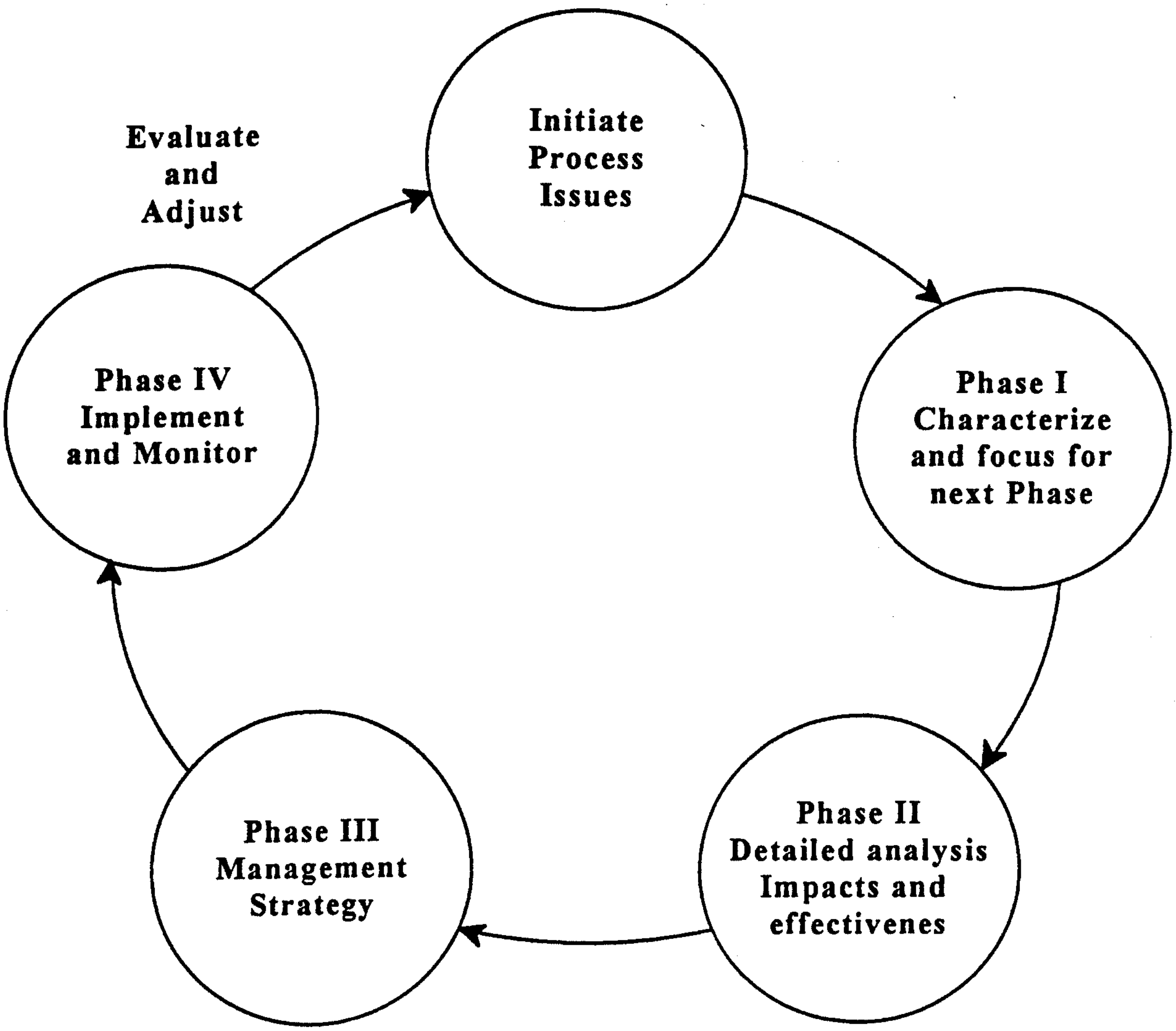


Figure 1.3.2
Study Process

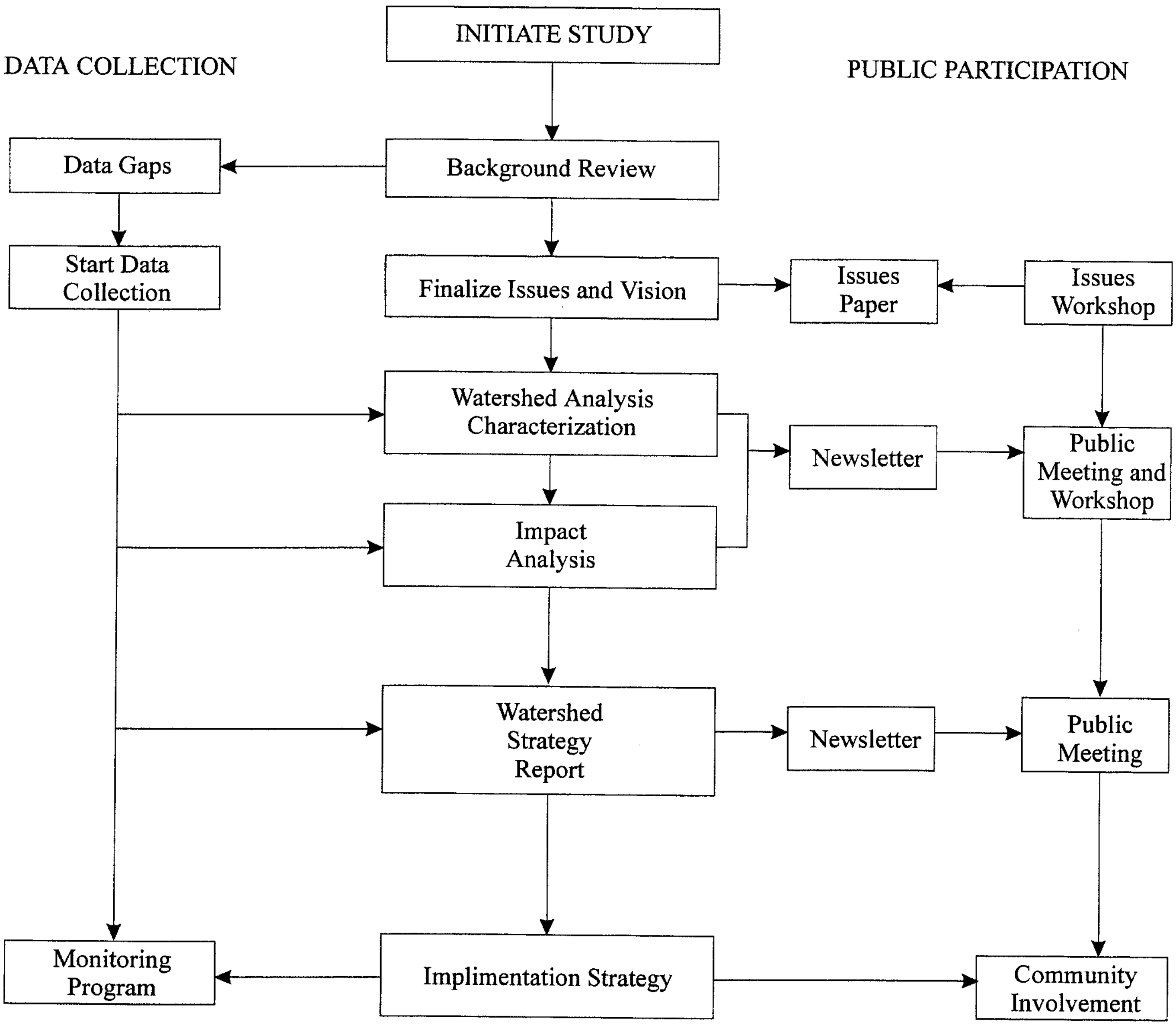


Figure 2.1.1

Hydrologic Cycle Components

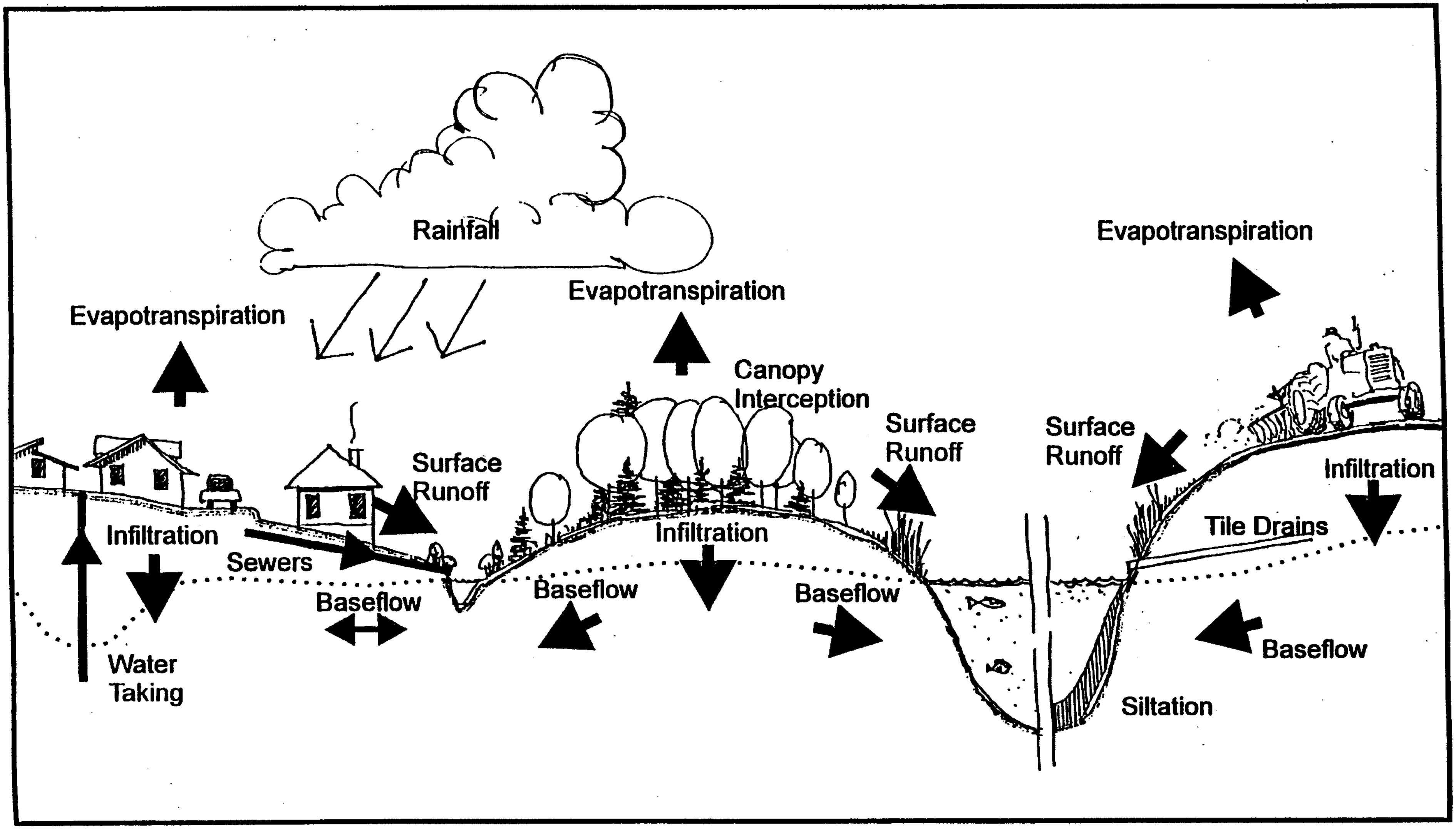
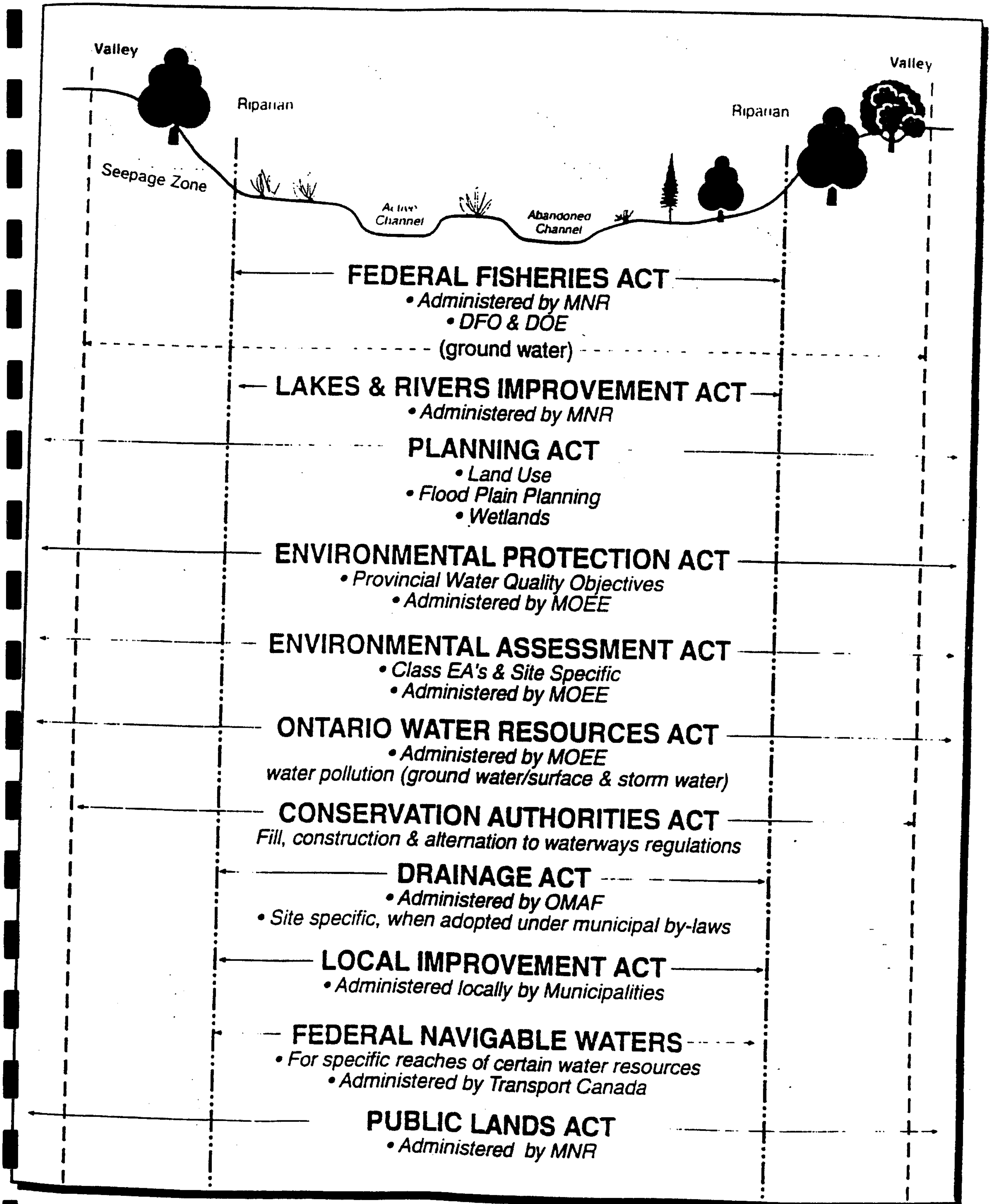
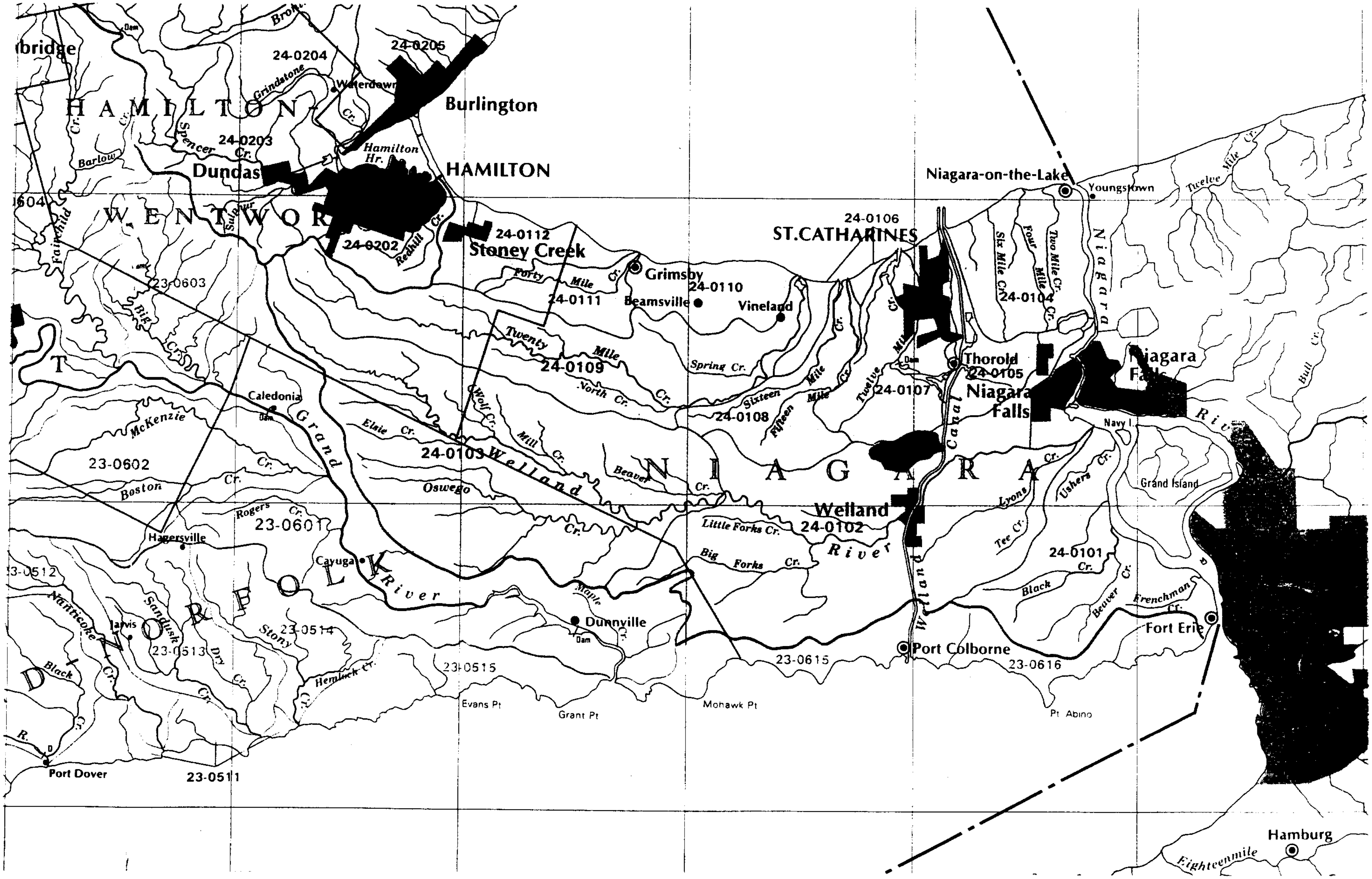


Figure 2.2.1
Legislation Affecting Stream Systems

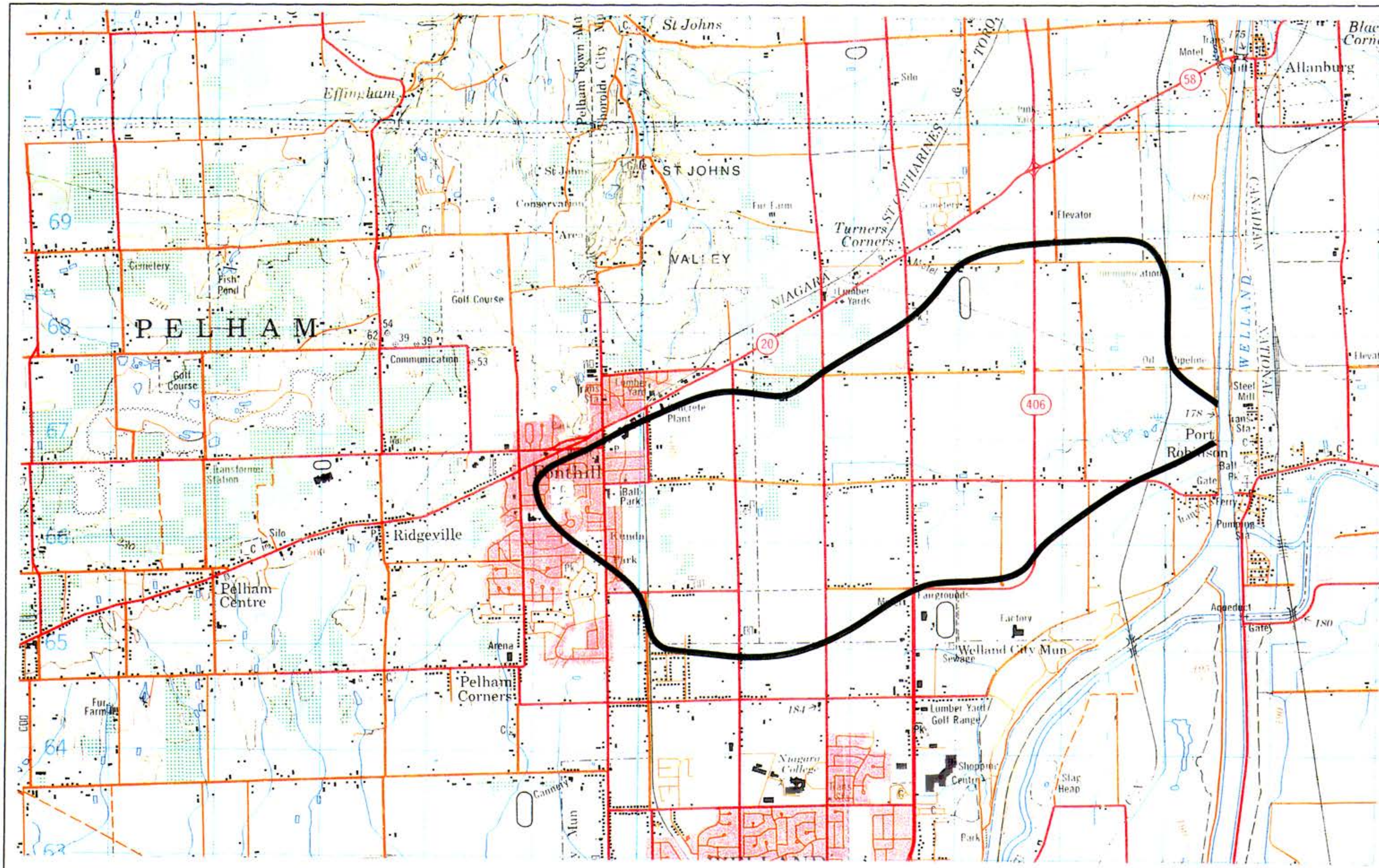


After Metropolitan Toronto & Region Conservation Authority "Valley & Stream Corridor Management Program" Draft April 1993.
Arrows idicate extent of application of the legislation across the valley.



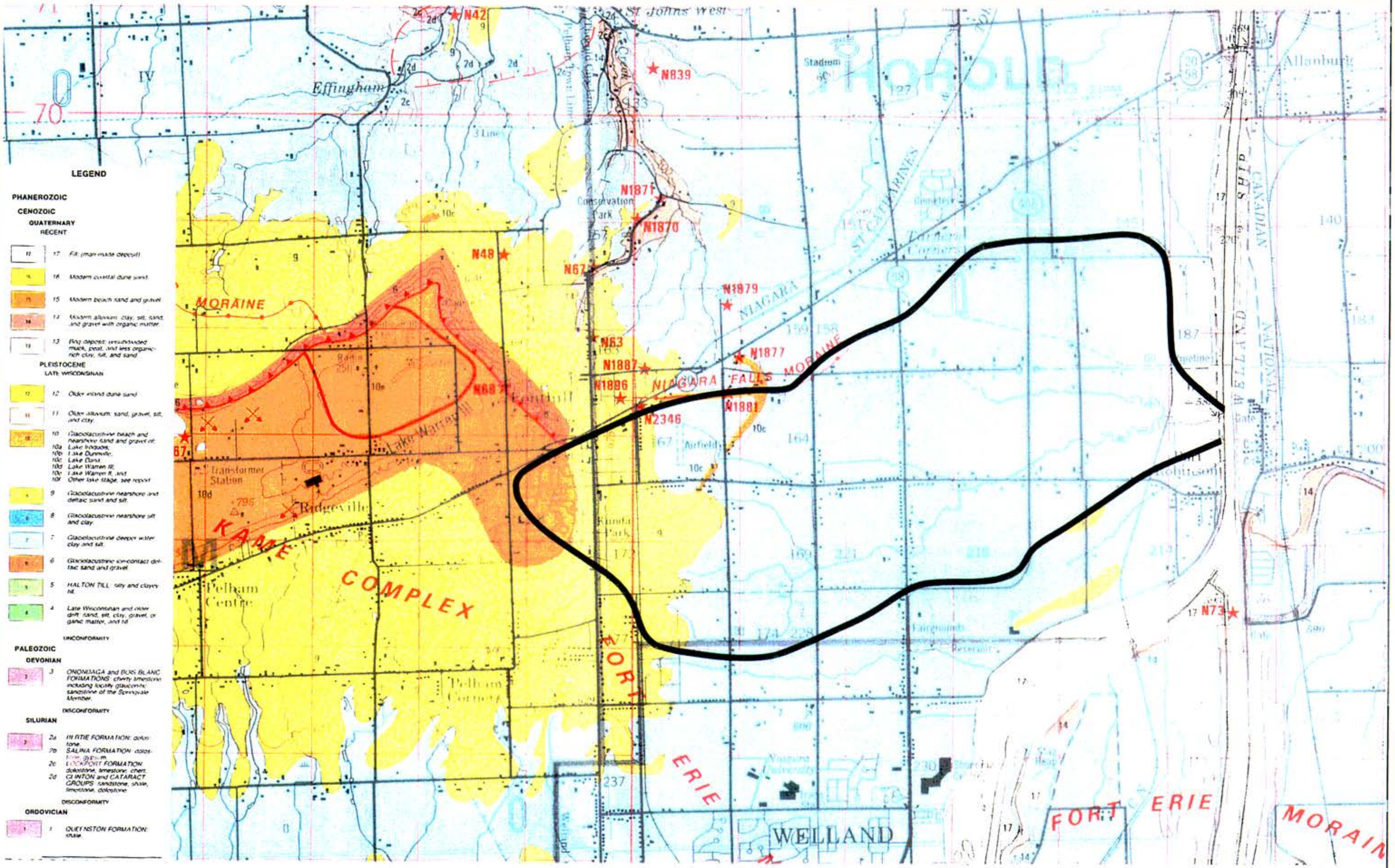
SOURCE: "Southern Ontario Drainage Basins." (1973). Ministry of Natural Resources Water Resources Map3002-2. Scale 1:500,000

TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) NATURAL RESOURCE SOLUTUIONS	Project	PORT ROBINSON WEST SUBWATERSHED STUDY	
	Title	WATERSHED SETTING	FIGURE 4.4.1
	Scale	1:500,000	Date APR. /98



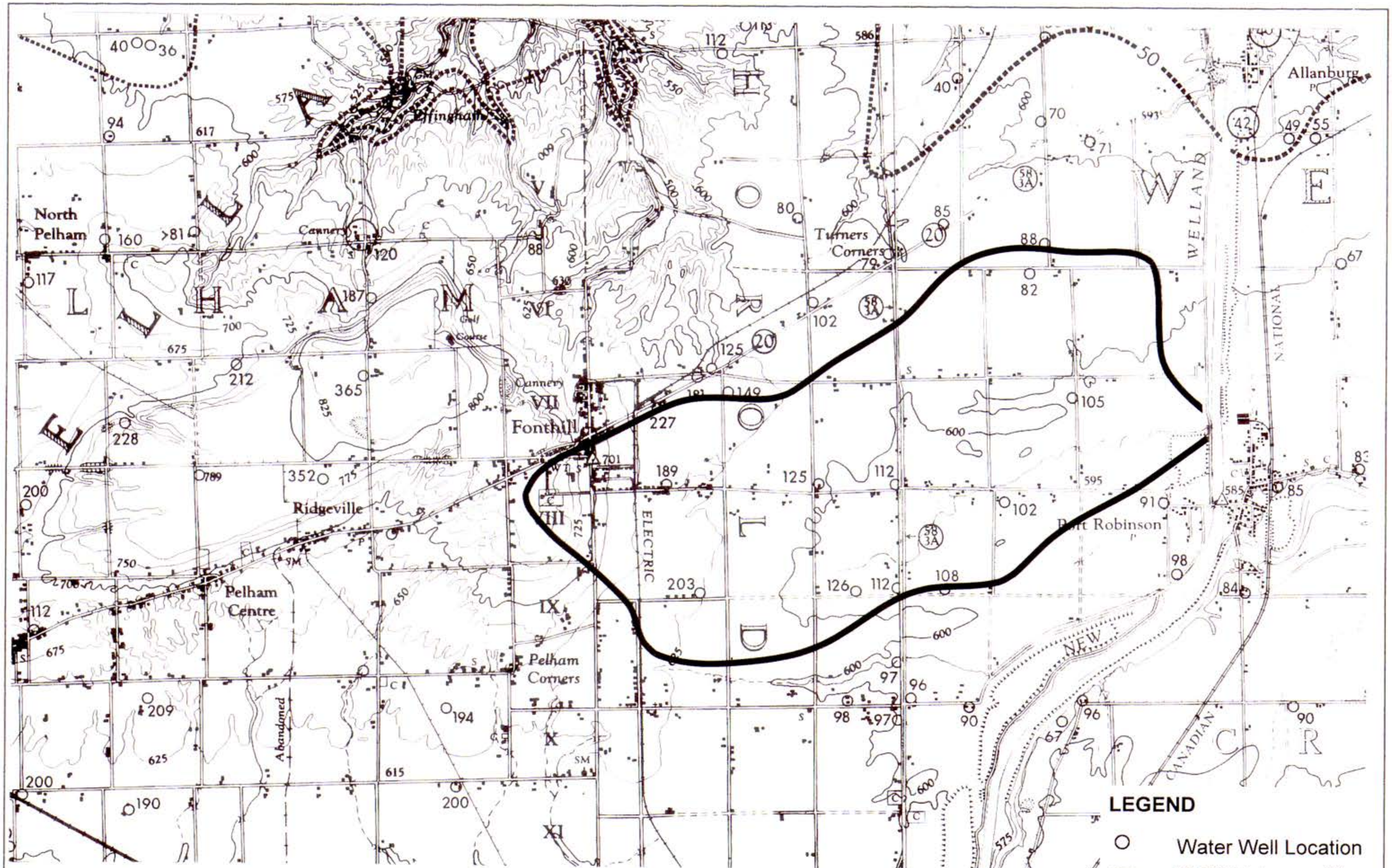
SOURCE: Niagara. (1984). Energy, Mines and Resources National Topographical Series Map 30 M5 &M6. Edition 6. Scale 1:50,000

TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) NATURAL RESOURCE SOLUTUIONS	Project	PORT ROBINSON WEST SUBWATERSHED STUDY	
	Title	TOPOGRAPHY AND DRAINAGE	FIGURE 4.4.2
	Scale	1:50,000	Date APR. /98



SOURCE: Feenstra, B.H. (1984). "Quaternary Geology of the Niagra-Welland Area." Ontario Geological Survey. Map 2496. Scale 1:50,000

TOTTEN SIMS HUBICKI ASSOCIATES LIMITED	Project	PORT ROBINSON WEST SUBWATERSHED STUDY		
RAY BLACKPORT (FORMERLY OF STANLEY)	Title	SURFICIAL GEOLOGY		FIGURE 4.4.3
NATURAL RESOURCE SOLUTUIONS	Scale	1:50,000	Date APR. /98	



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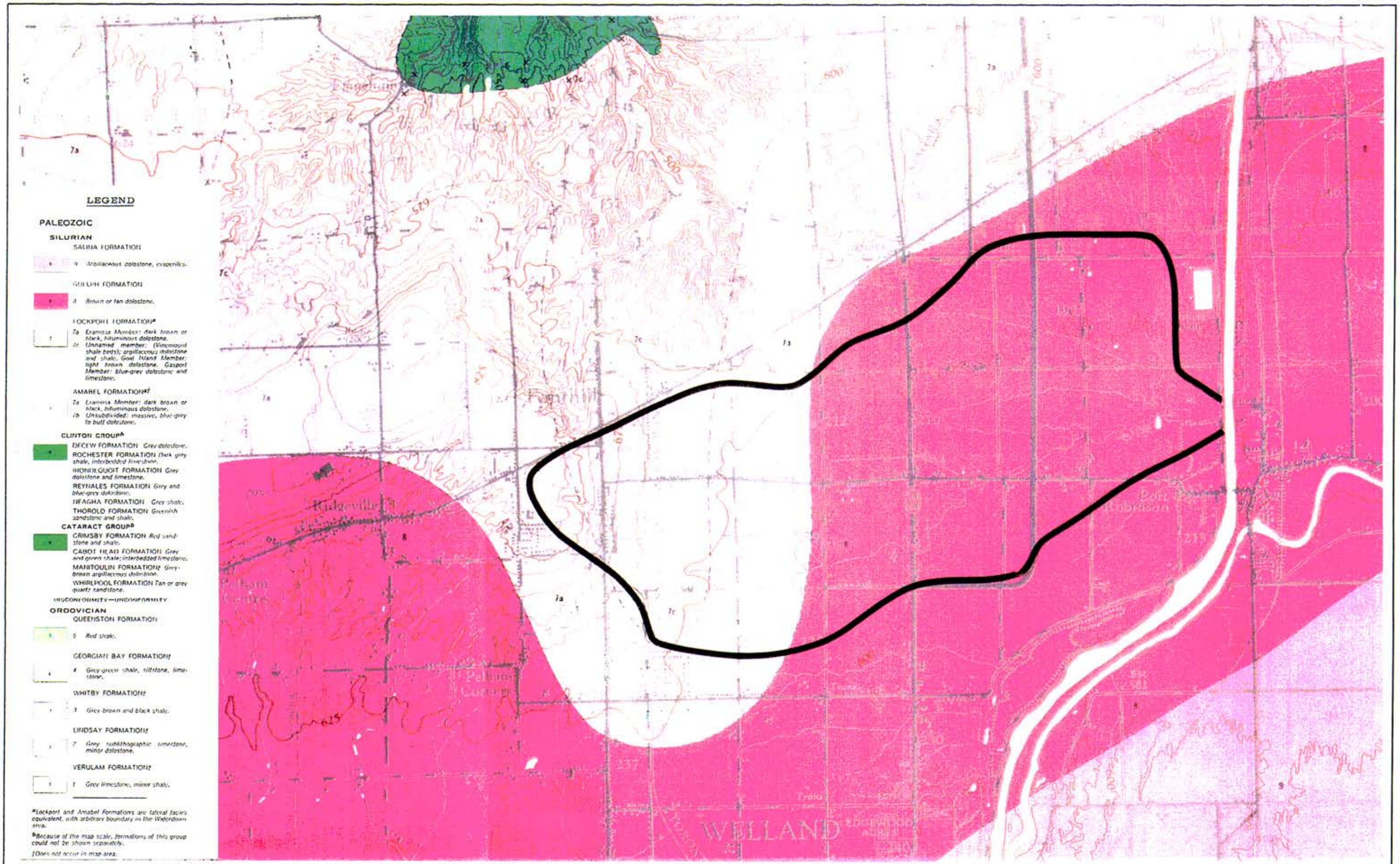
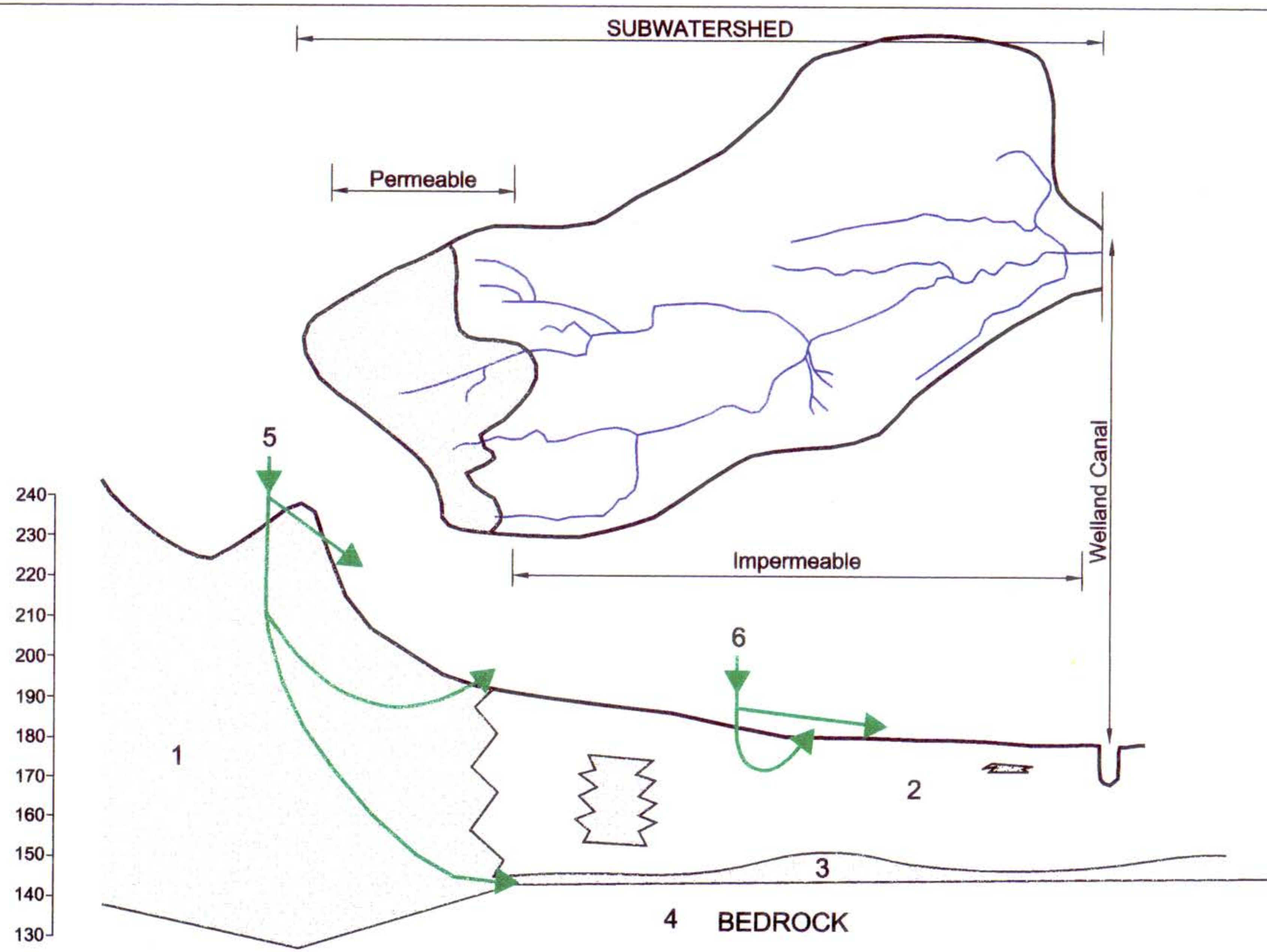
NATURAL RESOURCE SOLUTUIONS

Project	PORT ROBINSON WEST SUBWATERSHED STUDY		
Title	DRIFT THICKNESS		FIGURE 4.4.4
Scale	1:50,000	Date APR. /98	



SOURCE: "Niagara: Paleozoic Geology." (1976). Ontario Division of Mines. Map 2344. Scale 1:50,000

TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) NATURAL RESOURCE SOLUTUIONS	Project	PORT ROBINSON WEST SUBWATERSHED STUDY	
	Title	BEDROCK GEOLOGY	FIGURE 4.4.5
	Scale 1:50,000	Date APR. /98	



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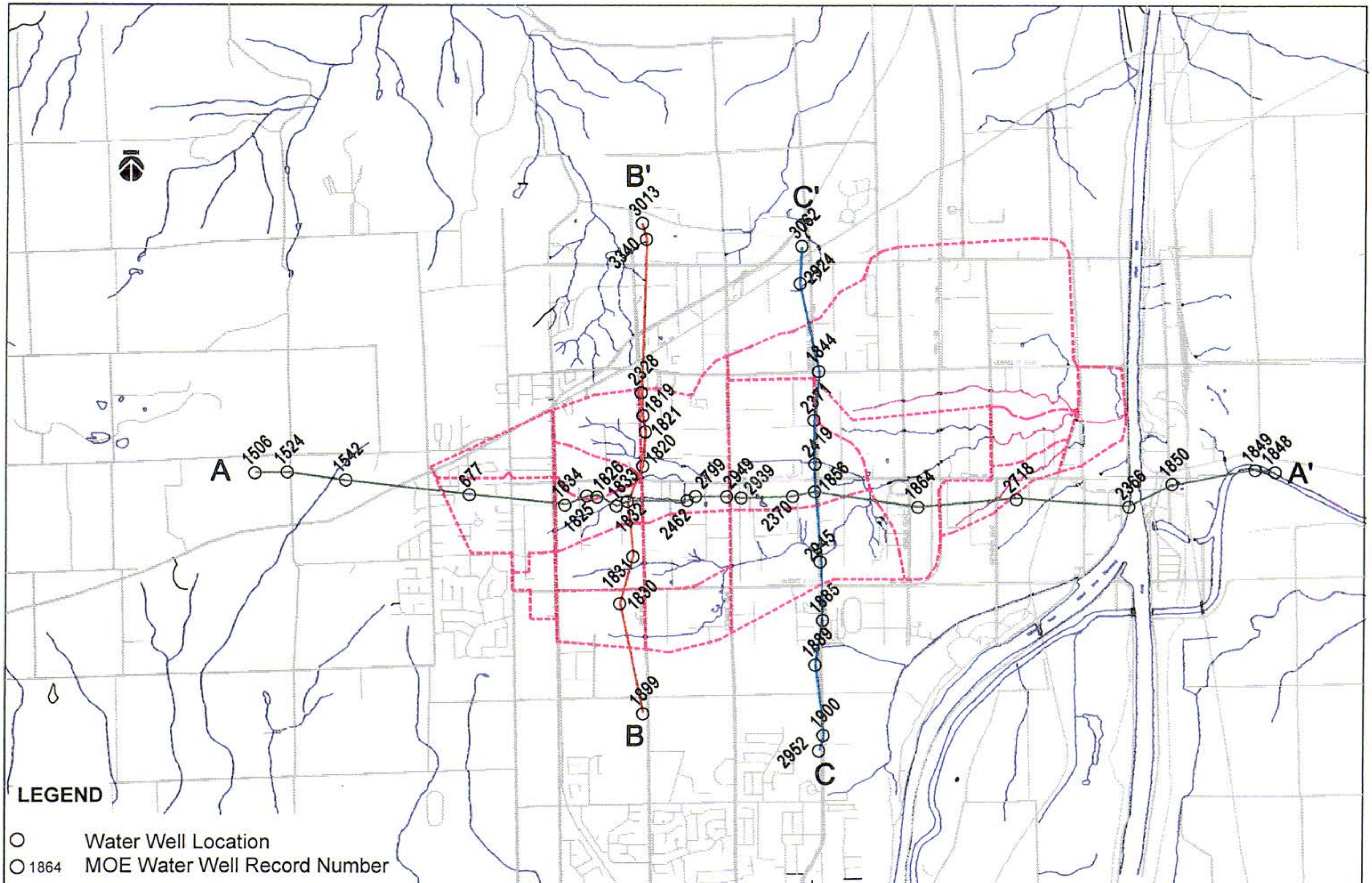
	Title CONCEPTUAL HYDROSTRATIGRAPHY		FIGURE 4.5.1
	Scale N.T.S.	Date APR. /98	



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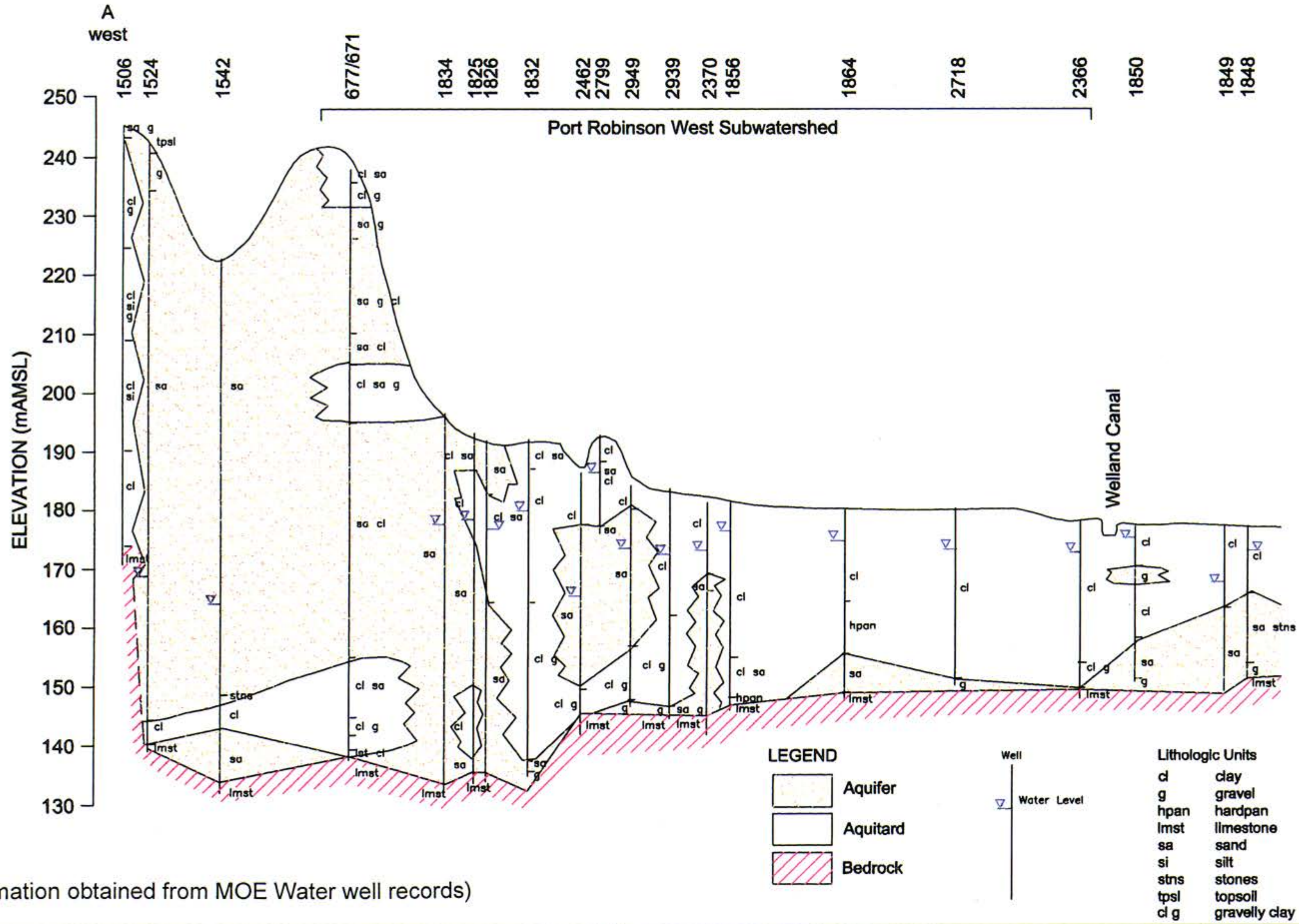
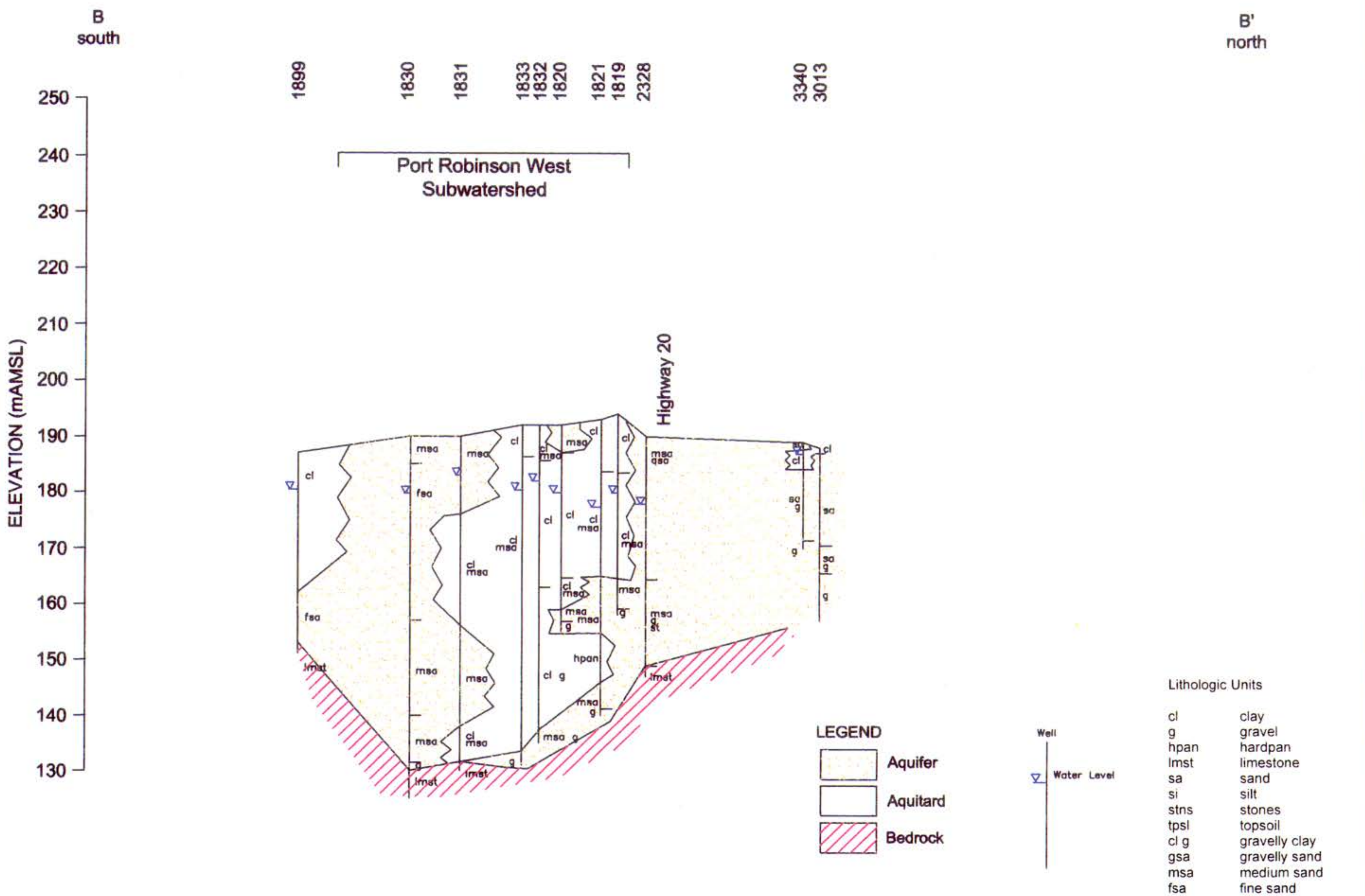
RAY BLACKPORT (FORMERLY OF STANLEY)	Title	GEOLOGIC CROSS–SECTION LOCATION	FIGURE
NATURAL RESOURCE SOLUTUIONS	Scale 1:50,000	Date APR. /98	4.5.2



(Information obtained from MOE Water well records)

TOTTEN SIMS HUBICKI ASSOCIATES LIMITED	Project PORT ROBINSON SUBWATERSHED STUDY		
RAY BLACKPORT (FORMERLY OF STANLEY)	Title CROSS – SECTION A – A'		FIGURE 4.5.3
NATURAL RESOURCE SOLUTUIONS	H. Scale 1:50,000	Date APR. /98	



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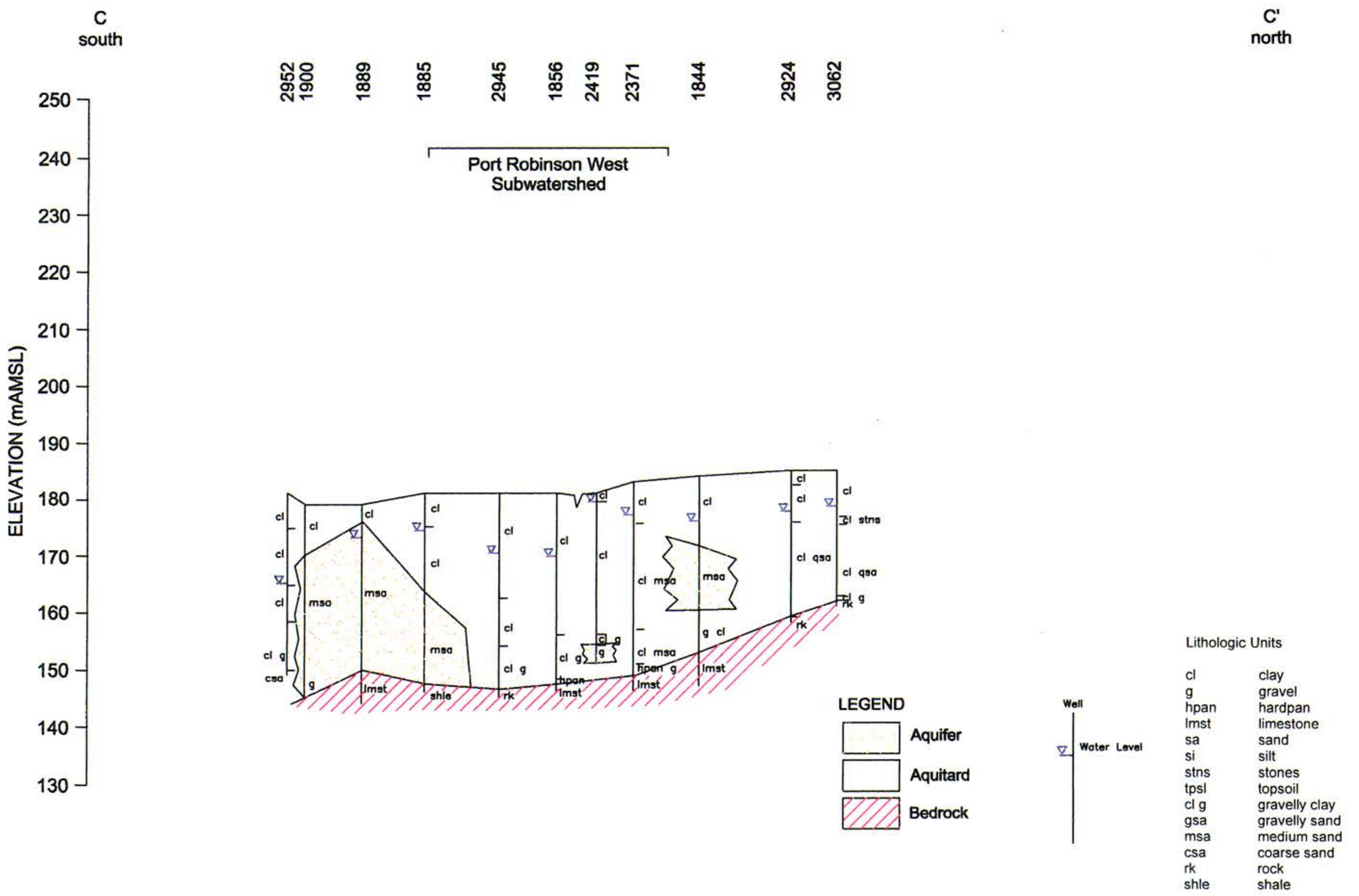
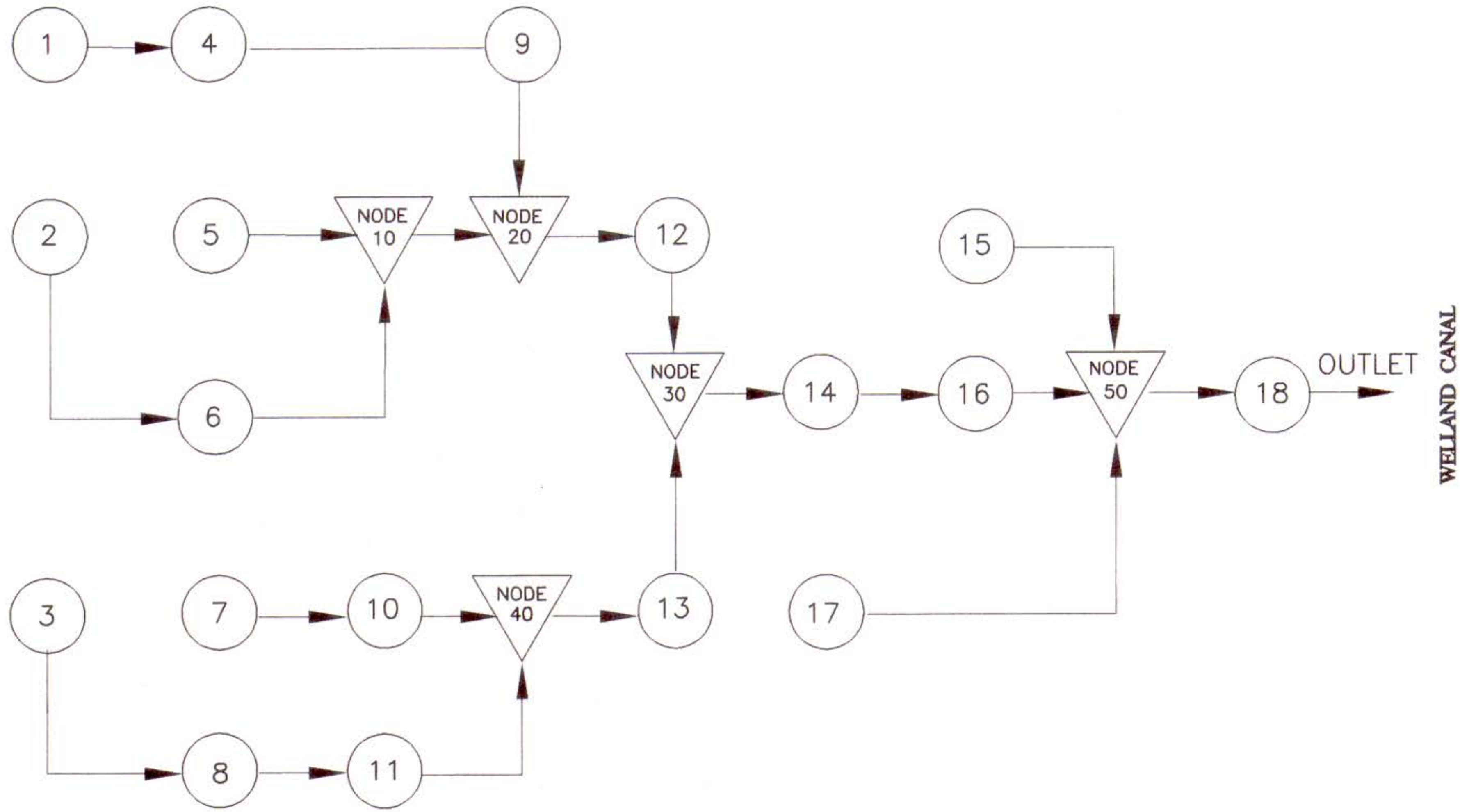
	H. Scale 1:50,000	Date APR. /98	



TOTTEN SIMS HUBICKI ASSOCIATES LIMITED
RAY BLACKPORT (FORMERLY OF STANLEY)
NATURAL RESOURCE SOLUTUIONS

Project	PORT ROBINSON SUBWATERSHED STUDY
Title	CROSS – SECTION C – C'
H. Scale	1:50,000
Date	APR. /98

FIGURE
4.5.5



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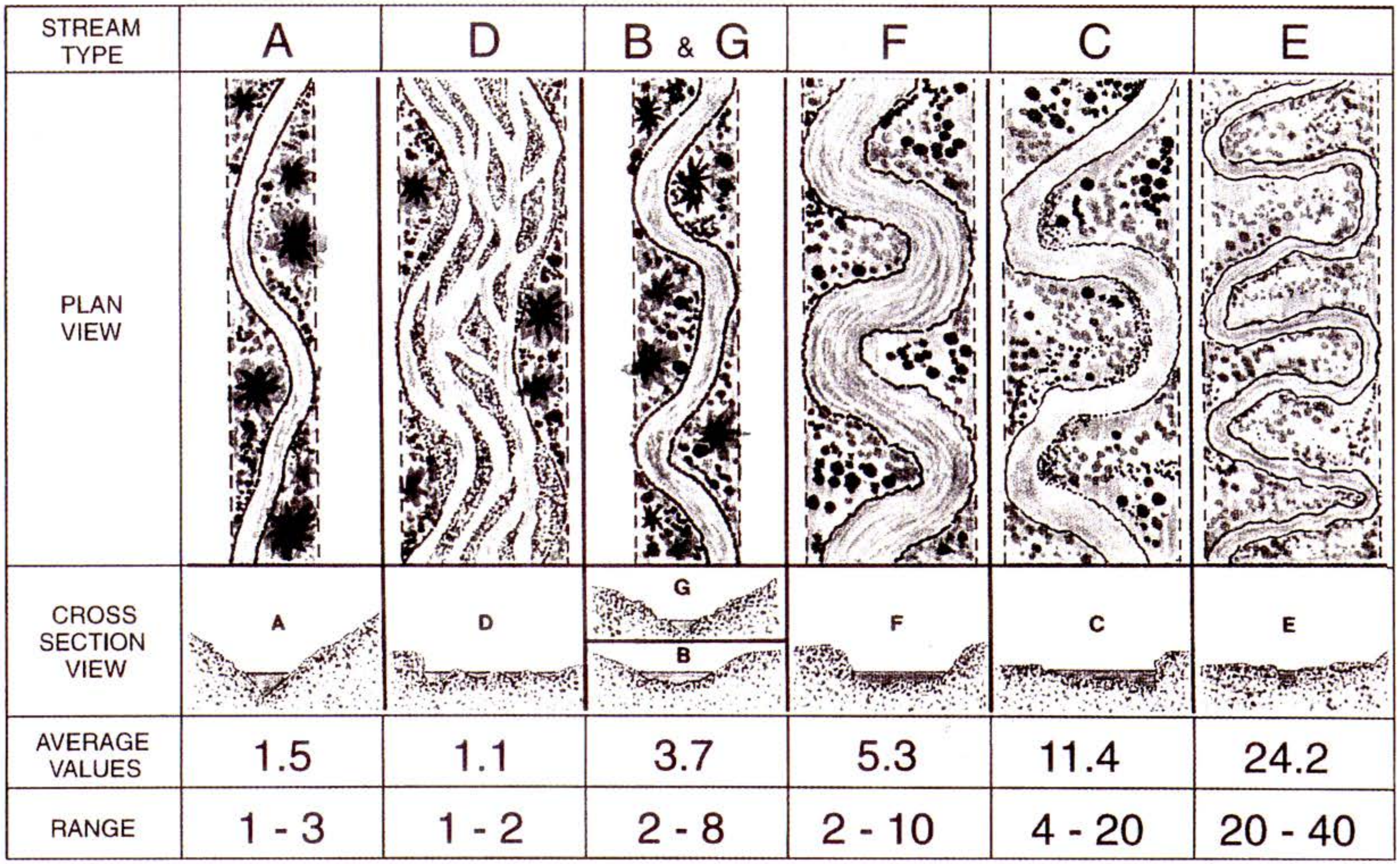
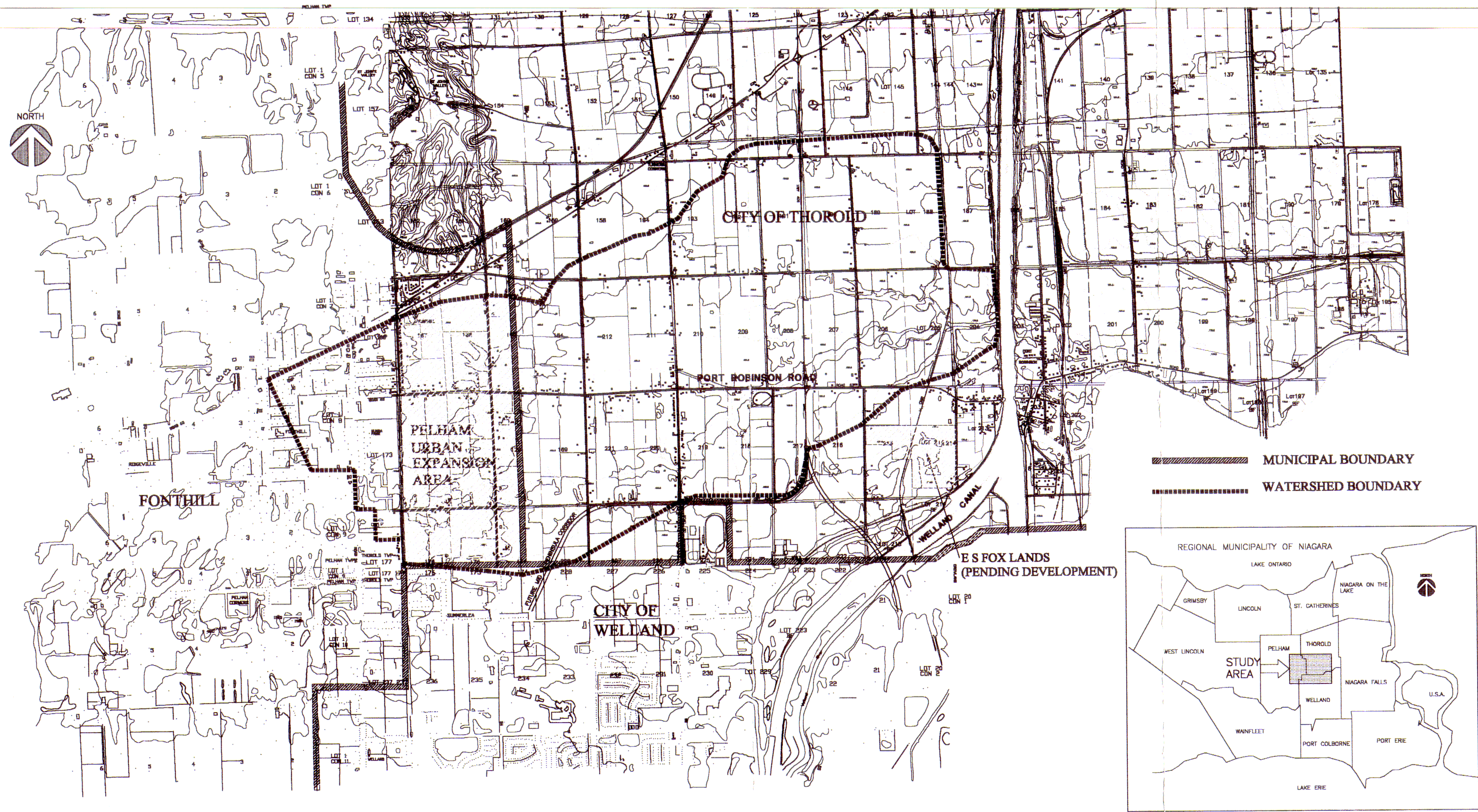
STANLEY CONSULTING GROUP LTD	Title	MODEL SCHEMATIC		4.7.1
ECOLOGISTICS LIMITED	Scale	N.T.S.	Date MARCH 1998	

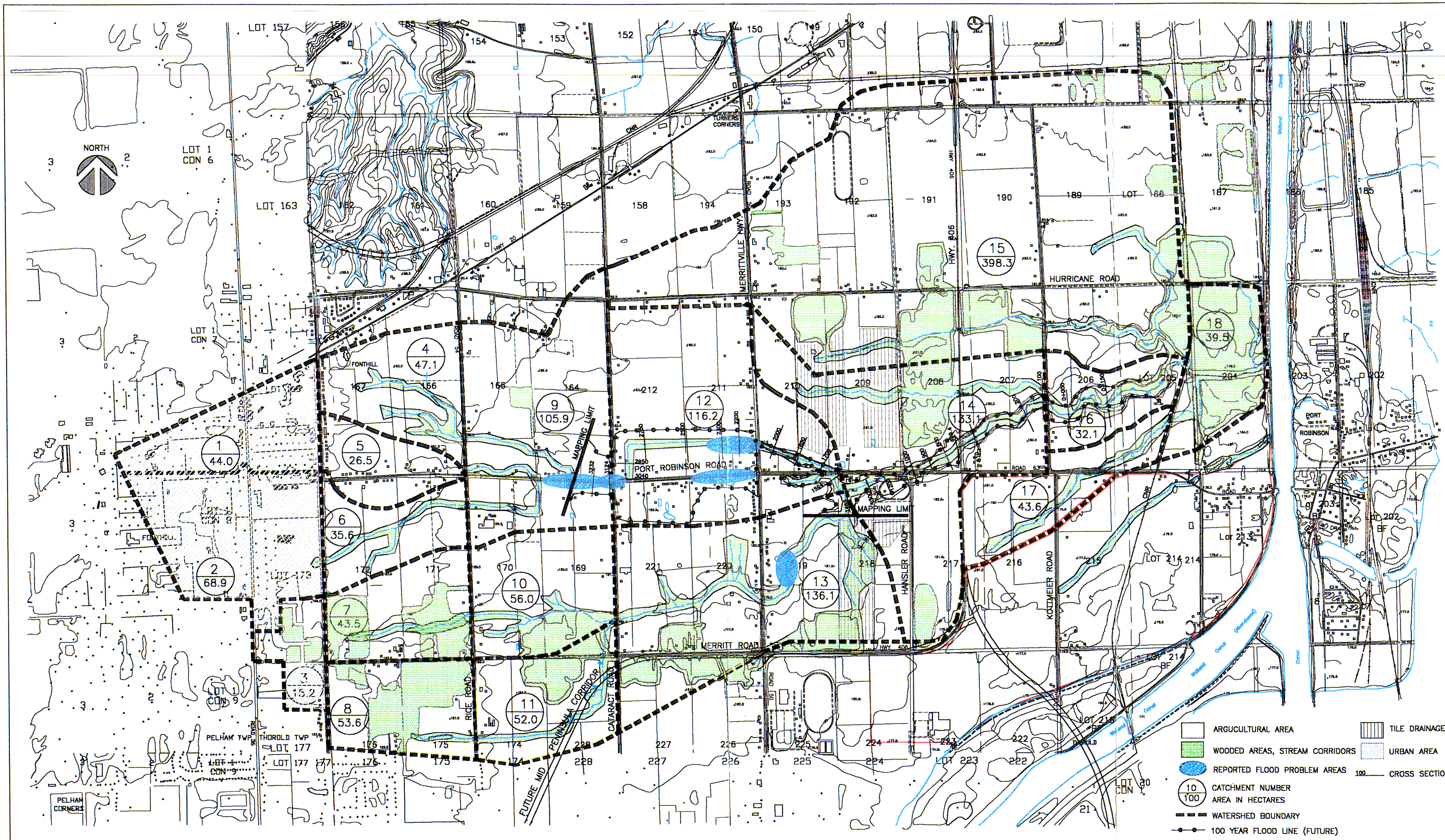
Figure 4.9.2
Stream Types



Reference: D. Rosgen, Applied River Morphology, 1996



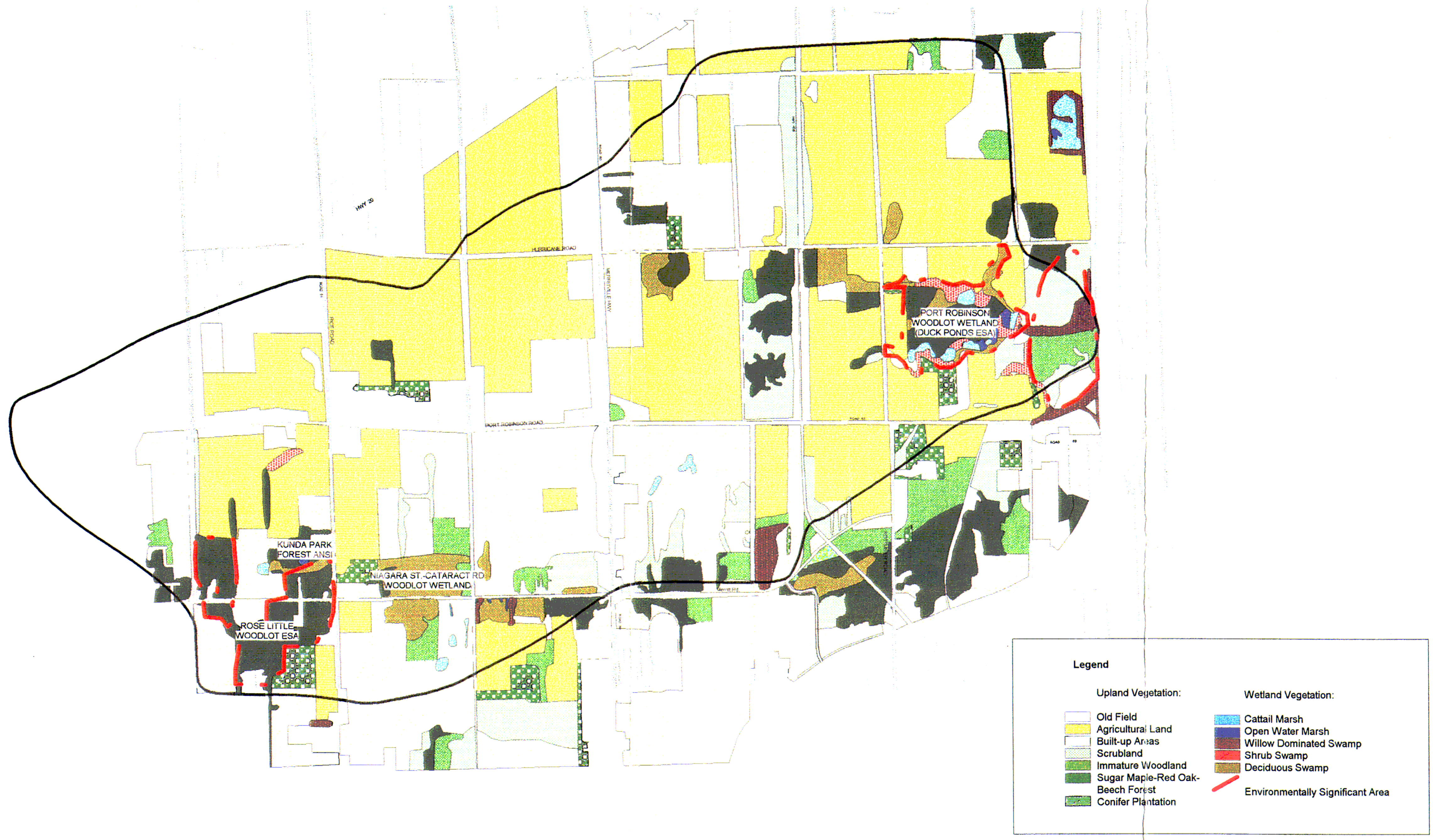
TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) NATURAL RESOURCE SOLUTIONS	SINGERS DRAIN WATERSHED SCALE : 1 : 40000	Project: PORT ROBINSON SUBWATERSHED STUDY Title: WATERSHED LOCTION MAP Date: MARCH 1998	1.2.1



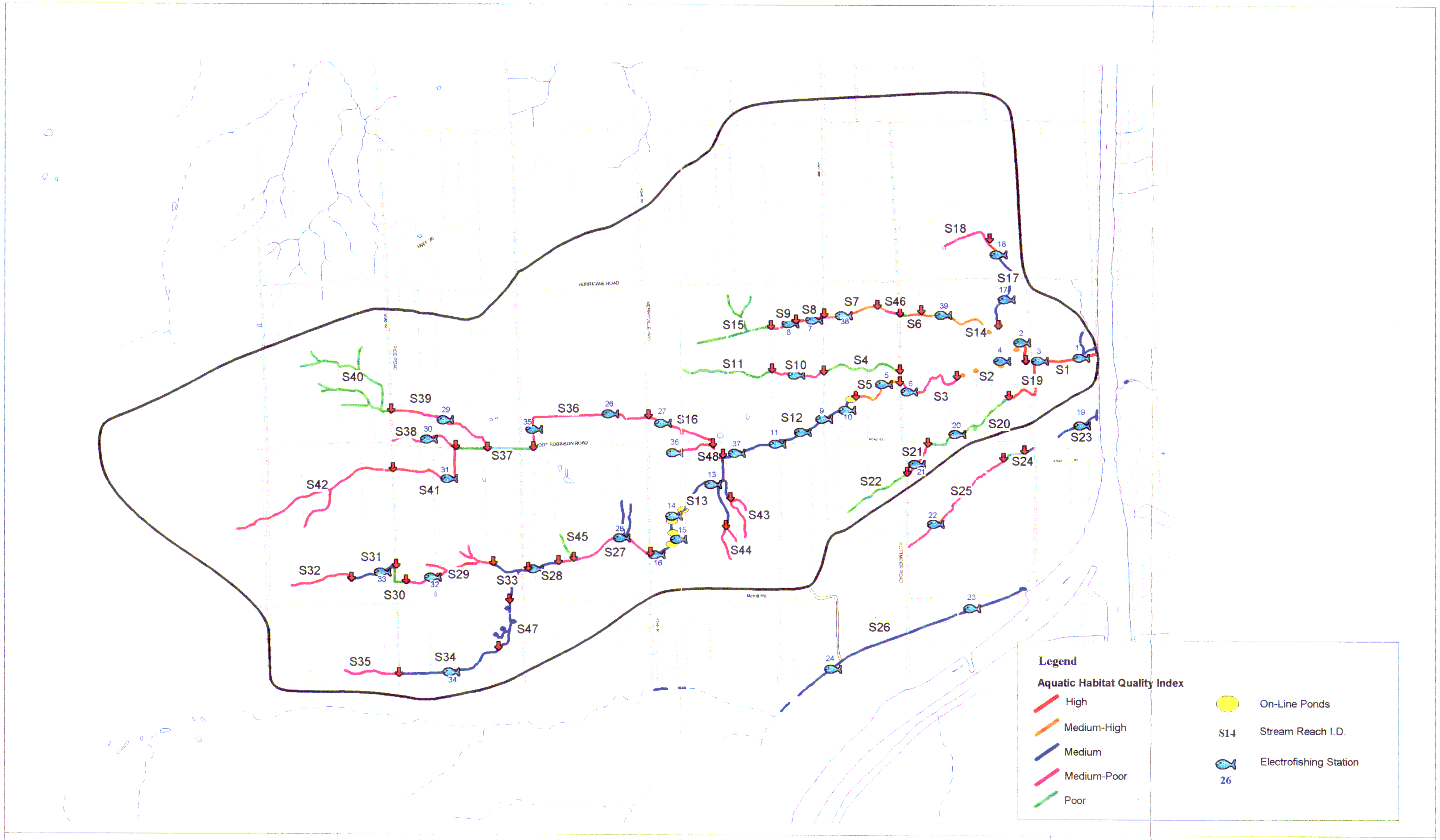
TOTTEN SIMS HUBICKI ASSOCIATES LIMITED
RAY BLACKPORT (FORMERLY OF STANLEY)
NATURAL RESOURCE SOLUTIONS

SINGERS DRAIN WATERSHED
SCALE : 1 : 20000

Project	PORT ROBINSON SUBWATERSHED STUDY	4.3.1
Title	EXISTING LAND USE, DRAINAGE AREAS	
Date	MARCH 1998	



TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) ECOLOGISTICS LIMITED	SINGERS DRAIN WATERSHED SCALE : 1 : 23000	Project: PORT ROBINSON SUBWATERSHED STUDY Title: TERRESTRIAL RESOURCES Date: NOVEMBER 1998	4.8.1



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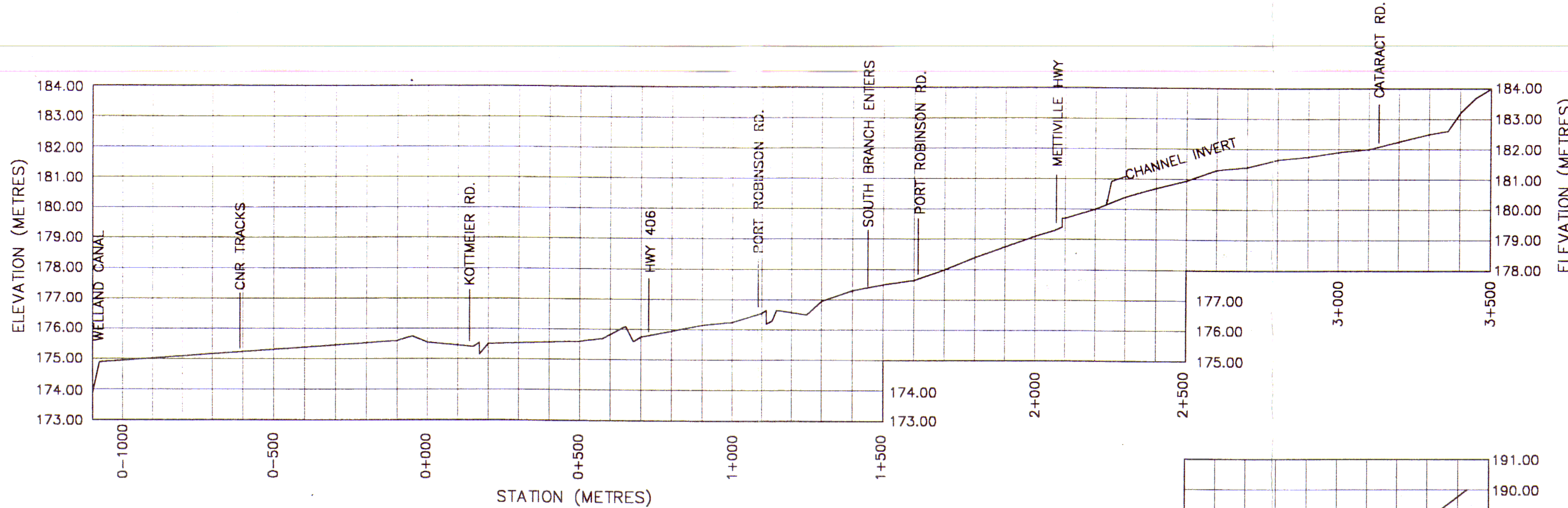
RAY BLACKPORT (FORMERLY OF STANLEY)
ECOLOGISTICS LIMITED

SINGERS DRAIN WATERSHED
SCALE 1 : 23000

Project	PORT ROBINSON SUBWATERSHED STUDY
Title	AQUATIC RESOURCES
Date	NOVEMBER 1998

4.9.1



NORTH BRANCH

SOUTH BRANCH

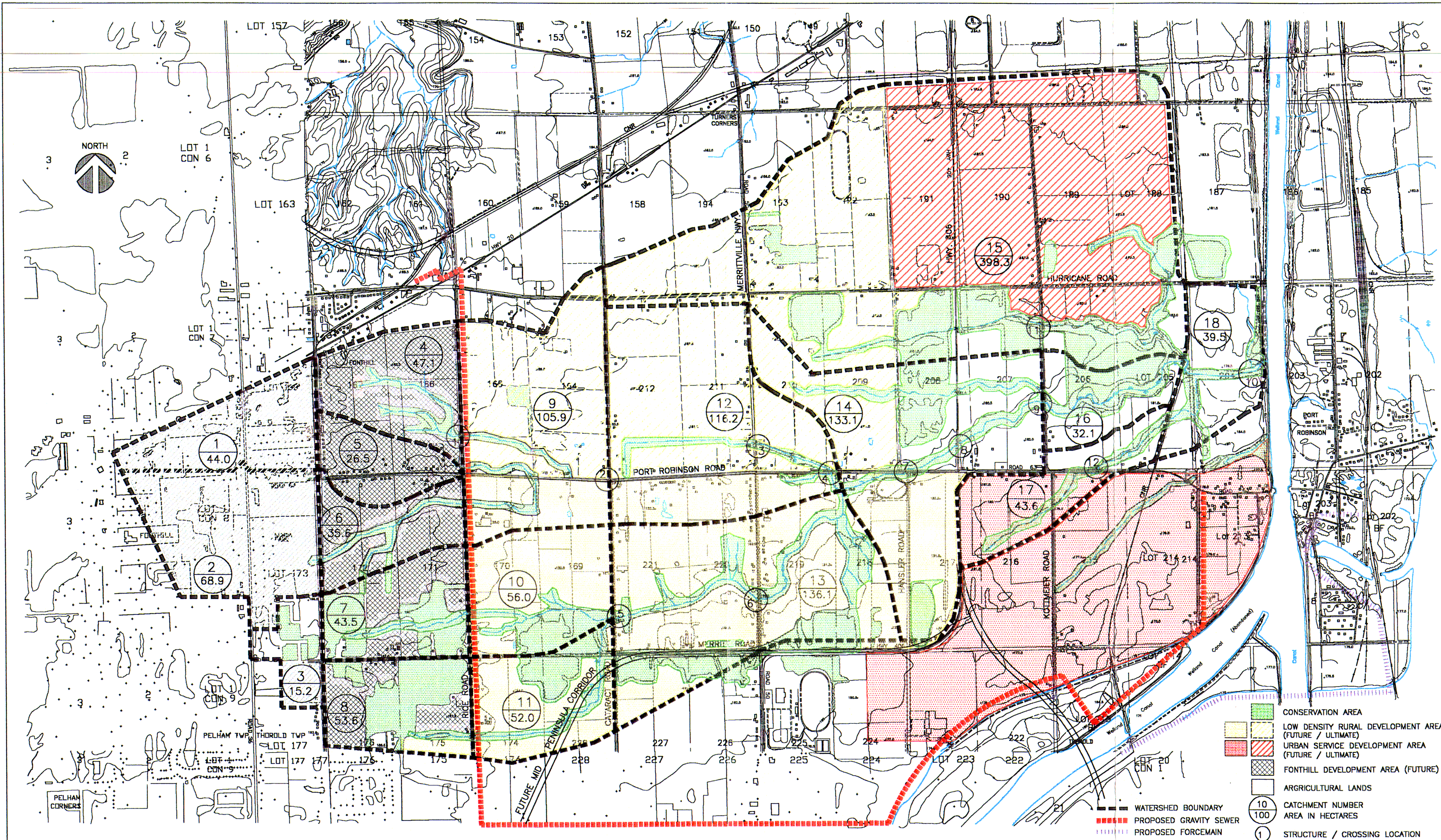
TOTTEN SIMS HUBICKI ASSOCIATES LIMITED
RAY BLACKPORT (FORMERLY OF STANLEY)
NATURAL RESOURCE SOLUTIONS

SINGERS DRAIN WATERSHED

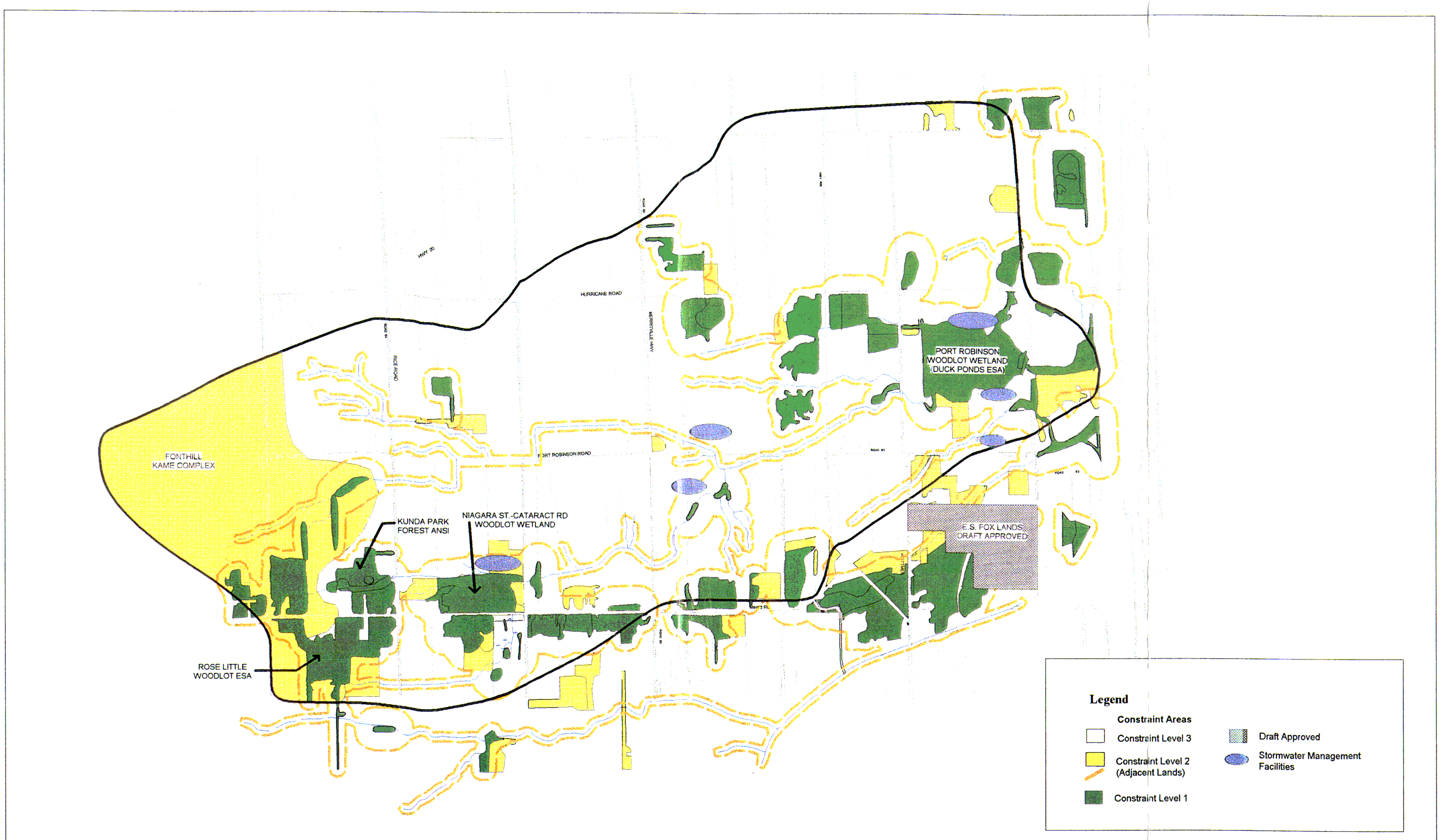
SCALE : HORZ.: 1:15,000
VERT.: 1:150

Project	PORT ROBINSON SUBWATERSHED STUDY
Title	STREAM PROFILE
Date	MARCH 1998

4.10.1



TOTTEN SIMS HUBICKI ASSOCIATES LIMITED RAY BLACKPORT (FORMERLY OF STANLEY) NATURAL RESOURCE SOLUTIONS	**SINGERS DRAIN WATERSHED** SCALE : 1 : 20000	Project: PORT ROBINSON SUBWATERSHED STUDY Title: HYDROLOGIC MODEL POSSIBLE LAND USE SCENARIO–FUTURE AND ULTIMATE Date: MARCH 1998 5.2.1



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