Pottersburg Creek and Crumlin Drain Subwatershed Study

Main Report

PROPERTY OF
THE CORPORATION OF THE
CITY OF LONDON

ENVIRONMENTAL SERVICES DEPARTMENT
WASTEWATER & DRAINAGE ENGINEERING DIVISION

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Title: Pottersburg Creek and Crumlin Drain Subwatershed Study Main Report
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May 24, 1995

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Dear Messrs. Standish and Goldt:

Final Report - Pottersburg Creek and Crumlin Drain Subwatershed Plan

We are pleased to submit the final report for the Pottersburg Creek and Crumlin Drain Subwatershed Study. The report consolidates earlier documentation that summarized the results of the Phase II, III, and IV investigations.

The focus of this report is the documentation of the process and studies which lead to the selection of the recommended Plan which is detailed in Part D of the report. This report should be read in conjunction with other documents prepared during the course of the London Subwatershed Studies program, namely:

i) The Technical Appendix summarizing the findings of the Detailed Studies;

ii) The London Subwatershed Studies Implementation Plan;

iii) The Draft Terrestrial Resource Strategy; and


The recommended Subwatershed Plan for Pottersburg Creek and Crumlin Drain represents a blueprint for not only sustaining, but enhancing the natural resources of the subwatershed. The development of the Plan involved the collective effort of a skilled Technical Team supplemented by thoughtful input and direction provided by members of the Technical Advisory Committee, citizens, interest groups, agency staff and representatives of the development industry.

We have enjoyed working with you and other members of the Technical Advisory Committee on this interesting study and trust that the findings of this study will benefit the strategic planning initiative of Vision '96.

Yours very truly,

PARAGON ENGINEERING LIMITED

Jack Gorrie, M.A.Sc., P. Eng.

JG/sc

Encl.
Pottersburg Creek and Crumlin Drain Subwatershed Study

Main Report

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PREFACE

The City of London and the Upper Thames River Conservation Authority (UTRCA) jointly initiated the preparation of a subwatershed plan for the Pottersburg Creek and Crumlin Drain Subwatersheds, as well as other subwatersheds in the London Area. Provincial agencies, City and Township staff, interest groups and public representatives were also actively involved in the study. Subwatersheds plans are an essential component of the Vision '96 planning for the City of London. The subwatershed studies provided an opportunity to develop an ecosystem based planning approach which will serve as a basis for future planning decisions. The key ingredients in the development of a successful ecosystem planning vision for the subwatersheds include the following:

- Understanding natural systems and their inter-relationships;
- Understanding watershed uses and development pressures;
- Recognition of agency and landowner issues;
- Identifying rehabilitation and enhancement opportunities;
- Determining appropriate management and monitoring strategies; and
- Formulating creative planning guidelines.

A number of reports were completed as part of the subwatershed process including:

- Background Report - Phase I, Marshall Macklin Monaghan Limited, October 1993
- Water Quality and Quantity Monitoring Program Results, UTRCA, July 1994.
- Phase II/III - Detailed Studies/Management Alternatives (Draft), Part 1 of 2, Paragon Engineering Limited, October 1994.
- Technical Appendix, Paragon Engineering Limited

The following report is the main document which summarizes all of the above with the exception of the implementation report which will be bound under separate cover.

The Subwatershed Study Consulting Team for the Pottersburg Creek and Crumlin Drain Subwatersheds was as follows:

- Paragon Engineering Limited (Prime Consultant)
- Gore & Storrie Limited
- Hough Stansbury Woodland Naylor Dance Limited
- MacNaughton Hermsen Britton Clarkson Planning Limited
- Ortech Corporation
- Golder Associates Ltd.
- Archaeological Research Associates Ltd.
ACKNOWLEDGEMENTS

The Consulting Team gratefully acknowledges the assistance of all agencies, TAC members and individuals who provided input to the study. Specifically, we would like to acknowledge the following individuals and organizations.

Technical Advisory Committee (TAC)

- Mr. Rick Goldt - UTRCA
- Mr. Bill Diver - UTRCA
- Mr. Ron Standish - City of London
- Mr. Brian Turcotte - City of London
- Mr. Doug Stanlake - City of London
- Ms. Bertha Krichker - City of London
- Ms. Nancy McMinn - City of London
- Ms. Sally Colman - Ministry of Natural Resources
- Mr. Harald Schraeder - Ministry of Natural Resources
- Mr. Stewart Thornley - Ministry of Environment & Energy
- Mr. Bob Aggerholm - Ministry of Environment & Energy
- Mr. Bill Armstrong - Ministry of Environment & Energy
- Mr. Henry Komarek - London Development Institute
- Mr. Scott Oliver - Ontario Ministry of Agriculture & Food
- Mr. Roger Moyer - Ministry of Municipal Affairs, London Region
- Mr. Doug Duffin - Agricultural Advisory Committee Representative
- Ms. Jennifer LeBlanc - EEPAC
- Mr. David Matthews - Patrick, Sweet & Associates
- Mr. Dennis Shand - Township of West Nissouri
- Ms. Jackie Vandenelsene - Public
- Mr. Bill DeYoung - Public
- Mr. Les Howey - Public

Appreciation is particularly extended to Mr. Ron Standish of the City of London Vision '96 office and Mr. Rick Goldt of the Upper Thames River Conservation Authority for their guidance and leadership throughout the study. The participation of the landowners and citizens of the watershed who provided input during public meetings is respectfully acknowledged.
EXECUTIVE SUMMARY

The Pottersburg Creek and Crumlin Drain Subwatershed Plan has been prepared to provide broad direction to the City of London, the Upper Thames River Conservation Authority, review agencies, developers, citizens and interest groups regarding measures required to maintain and enhance features, functions and linkages of the subwatersheds in anticipation of future growth to occur as a result of the recent annexation of lands by the City of London.

The Subwatershed Plan identifies areas which should be protected or conserved as a Natural Heritage System, criteria for future urban development, conservation and management practices, and specific projects and programs to improve current subwatershed conditions and increase awareness about what is needed to sustain the features, functions and linkages of the Pottersburg Creek and Crumlin Drain subwatersheds.

Subwatershed Plan Goals and Objectives

The following goals and objectives of the Pottersburg Creek and Crumlin Drain Subwatershed Plan were developed through public consultation early in the London Subwatershed Study process:

1. To protect, enhance and/or restore the watershed ecosystem through cost effective and environmentally sound strategies;
2. To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders; and
3. To provide an ecosystem approach to the planning and management of existing and future land uses.

Subwatershed Study Phasing and Reports

The Pottersburg Creek and Crumlin Drain Subwatershed Study was completed in five phases summarized in the following table:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of Study</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Background Review</td>
<td>October 1993</td>
</tr>
<tr>
<td>Phase II</td>
<td>Detailed Studies</td>
<td>October 1994</td>
</tr>
<tr>
<td>Phase III</td>
<td>Development of Alteration Strategies</td>
<td>December 1994</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Finalization of Recommended Subwatershed Plan</td>
<td>March 1995</td>
</tr>
<tr>
<td>Phase V</td>
<td>Development of Implementation Plan</td>
<td>May 1995</td>
</tr>
</tbody>
</table>

The first phase involved the collection of background information and preparation of the Terms of Reference for the Phase II to V investigations. The completion of each study phase included the preparation of Draft Reports which were reviewed and commented on by members of the Technical Advisory Committee. This Final Report consolidates the Phase II, III and IV reports and incorporates comments and suggestions made by reviewers of the earlier Draft documents.

Additional detailed information on the Phase II Detailed Studies has been prepared under separate cover, in a Technical Appendix document. As well, a separate report summarizing the Implementation Plan for all of the London subwatersheds was prepared as part of the Phase V work program.
Detailed Studies

Ten detailed studies were undertaken to inventory, monitor, model and map features, functions and linkages found in the Pottersburg Creek and Crumlin Drain subwatersheds. Detailed Studies were completed for the following:

1. Land Use 6. Water Quality
2. Geology/Hydrogeology 7. Aquatic Resources
3. Fluvial Geomorphology 8. Terrestrial Resources
5. Rural Point and Non-Point Source Pollution 10. Infrastructure

The detailed study findings were subsequently synthesized to establish an understanding of how the features, functions and linkages are currently sustained in both of the subwatersheds. The synthesis identified alternative management measures to maintain or enhance attributes of the subwatershed in anticipation of future development in the subwatershed and to address current problems noted during the course of completing the detailed studies.

Management Units

Based on the physiographic, geologic, land use and environmental quality conditions, the subwatersheds were divided into the following four management units:

MU5 - Rural Upstream Area
MU6 - Airport Lands
MU7 - Development Area
MU8 - Existing Development Area
MU9 - Crumlin Drain Subwatershed

Four distinct management areas in the Pottersburg Creek subwatershed and one management area for Crumlin Drain can be defined by physiographic, geologic, land use and environmental quality conditions. The management areas represent the rural upper area of Pottersburg Creek (Management Unit 5, or MU5), the Airport Lands development area (MU7), the lower reaches in the existing development area (MU8), and the Crumlin Drain subwatershed (MU9).

Streams in MU5 are all first and second order, and almost all have been channelized to improve agricultural drainage. Streams in MU5 are impaired and support tolerant fish species. There is evidence of groundwater discharge in two areas which supports a Type III fisheries community, including the provincially significant central stoneroller. These areas are the highest quality fish habitat in Pottersburg Creek and Crumlin Drain. Streams in MU5 could be enhanced by removing barriers to fish movement and naturalizing the channel, but are unlikely to attain high quality.

MU6 consists of the 550 ha of the Pottersburg Creek subwatershed that drain the London Airport Lands. The reaches of Pottersburg Creek in this unit are severely degraded and support Type IV aquatic communities. Significant limitations include low baseflow, poor water quality, limited riparian vegetation, watercourse structures and storm water management facilities. There is little opportunity to enhance Pottersburg Creek in this area. Further degradation could result in the reaches of this area no longer supporting fish species.

MU7 represents the main area of future growth in the Pottersburg Creek subwatershed and where land use currently is largely industrial. All reaches, including the main creek are channelized in this area. The fisheries community is severely degraded, and the invertebrate community is impaired, being primarily Type IV and V communities. Extensive rehabilitation is required before this reach of Pottersburg Creek will support intolerant species of aquatic invertebrates and fish. Moderate improvements could result from increasing riparian and instream cover and by eliminating pollution sources.
MU8 is located in the lower reaches of Pottersburg Creek, where lands are largely developed. The main creek through this area is channelized, except for the mouth of the creek which is in a natural state. Most "tributaries" are enclosed in storm sewers. The invertebrate community is impaired and the fisheries community is Type IV, except for the mouth which supports a Type III community, where provincially significant central stonewallers have been found. Significant improvements in water quality and channel configuration are required to make noticeable improvements.

MU9 contains the entire Crumlin Drain subwatershed and the portion of the Waubuno Creek subwatershed downstream to the Thames River. Crumlin Drain contains only first and second order streams, all of which have been channelized. The fisheries communities in Crumlin Drain are all impaired or do not support fisheries. Aquatic invertebrate communities exhibit the lowest quality of all management units. In contrast, Waubuno Creek below the confluence with Crumlin Drain supports a diverse Type IIB fish habitat. Because of its channelized nature and low baseflow, it is unlikely that Crumlin Drain can be significantly enhanced.

**Alternative Subwatershed Management Strategies**

The following three alternative strategies for the Pottersburg Creek and Crumlin Drain Subwatersheds were considered:

1. Maintain the existing ecosystem;
2. Moderate enhancement of the ecosystem functions; and
3. Significant enhancement of the ecosystem functions.

The alternative for the "maintenance of the existing ecosystem functions" would entail appropriate best management practices and land use restrictions designed to maintain and protect the existing systems in the subwatershed. Ecosystem functions including surface water and groundwater interaction, fisheries habitat and water quality, terrestrial habitat, and corridor linkages would be addressed.

The alternative for "moderately enhancing existing ecosystem functions" can be broken down into two major categories. The two categories are to enhance the aquatic ecosystem and the terrestrial system. These alternatives include the identification of candidate areas for rehabilitation, candidate areas for terrestrial enhancement, improvement in the aquatic environment and associated habitat potential, and rehabilitation of tableland woodlots in order to enhance their function in providing terrestrial habitats.

The alternative for the "significant enhancement of the ecosystem functions" builds on the moderate enhancement alternative described above. Further rehabilitation of existing ecological features as well as the creation of new ecological features from both an aquatic and terrestrial perspective, are provided for in this level of enhancement.

**Evaluation of Alternative Subwatershed Management Strategies**

The three alternative management strategies were evaluated with respect to the following criteria:

1. Technical Consideration;
2. Environmental Benefits;
3. Land Requirements/Impacts;
4. Cost;
5. Agency Acceptance; and
Each of the management actions contained in the alternative subwatershed management strategies were ranked as:

**High:** Important to Plan success; highly effective; widespread or important site specific applicability; immediately implementable with likelihood of rapid results; general support.

**Medium:** Important to plan success; moderately or highly effective; general applicability; implementable over the long term; general support to limited resistance.

**Low:** Less important to plan success; moderately to highly effective; less important site specific or general applicability; implementable over the long term or beyond current planning horizon; moderate support to limited resistance.

Input to the ranking of management strategies by the Technical Advisory Committee resulted in the majority of recommended management activities being directed towards significant enhancement of ecosystem functions.

**Recommended Pottersburg Creek and Crumlin Drain Subwatershed Plan**

The recommended Subwatershed Plan for the Pottersburg Creek and Crumlin Drain Subwatersheds consists of a series of management actions, which when applied together will provide a holistic strategy for meeting the Goals and Objectives of the Subwatershed Plan. The recommendations of the Subwatershed Plan fall within the following four categories:

i) Constraint Areas;

ii) Development Criteria;

iii) Conservation and Management Practices;

iv) Specific Projects and Programs.

i) **Constraint Areas**

Recommendations are made with respect to:

a) Category 1 lands - where development is prohibited.

b) Category 2 lands - where the extent of permissible development must be determined through the completion of an Environmental Impact Assessment Study (EIS).

ii) **Development Criteria**

Recommendations are made with respect to:

a) Storm water management criteria for urban development.

b) The need for environmentally sensitive site planning techniques.

c) Erosion and sedimentation control requirements for construction sites, and subsequent inspection and monitoring requirements.

(vi)
iii) Conservation and Management Practices

Recommendations are made with respect to:

a) Practices that should be implemented to reduce point source pollution in the rural areas.
b) Practices that should be implemented to control non-point source pollution in the subwatershed.

iv) Specific Project and Programs

Recommendations are made with respect to:

a) Non-structural programs required to improve current subwatershed conditions.
b) Capital projects required to improve current subwatershed conditions.
PART A

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STUDY CONTEXT
PART A - STUDY CONTEXT

A1.0 INTRODUCTION

A1.1 Background

The City of London has embarked upon a comprehensive process which will establish priorities and plans for the city as it moves into the 21st Century. The need for such planning results from legislation approving London's annexation of lands from adjacent municipalities in January 1993. The City is preparing a number of plans including, among others, a new Official Plan. A study on subwatersheds is one of several initiatives needed to support the Official Plan.

The City of London, in partnership with the Upper Thames River Conservation Authority, the Kettle Creek Conservation Authority, and neighbouring townships therefore undertook a series of subwatershed studies for the creeks and streams which fall within or adjacent to the new city boundary defined by the recent annexation. The subwatershed studies identified important natural resource features, and development strategies to protect and enhance these features as land use change occurs. The subwatershed studies have established plans for management of the subwatersheds and provide input to the City's Official Plan review which is being conducted under the Vision '96 program. Thirteen subwatersheds were investigated, including:

- Stoney Creek;
- Pottsburgh Creek;
- Crumlin Drain;
- Medway Creek;
- Stanton Drains;
- Mud Creek;
- Sharon Creek;
- Upper Dodd Creek;
- Kettle Creek; and
- Several reaches of the Thames Valley lands.

The City of London and the Upper Thames River Conservation Authority retained Paragon Engineering Limited to undertake the subwatershed studies for Pottsburgh Creek and Crumlin Drain, which are summarized in this report.

A1.2 The Subwatershed Plan Process

Bill 75 (City of London Annexation Act) received Royal Assent on December 10, 1992. It established lands to be annexed from the Town of Westminster, the Township of Delaware, North Dorchester and West Nissouri. The Act stated that the City of London shall prepare and adopt an Official Plan (by January 1, 1996) for the lands annexed to the City. In keeping with current Provincial direction, the City of London is preparing the subwatershed studies as input to the preparation of the Official Plan for the recently annexed areas. The recommendations and guidelines resulting from the Subwatershed Plans will form the environmental basis on which the Official Plan and subsequent secondary plans will be developed.

The subwatershed studies were being completed in the following five phases:

- Phase I - Background Review
- Phase II - Detailed Studies
- Phase III - Develop Management Alternatives
- Phase IV - Recommended Management Plan
- Phase V - Implementation and Monitoring
The background review completed in the first phase was undertaken City-wide on all subwatersheds and was completed in 1993. The first phase report included the preparation of Terms of Reference for the individual and grouped subwatershed studies to be completed in Phases II to V. Phase II began in December of 1993 and continued through the summer of 1994. This phase involved data collection, field studies and modelling which allowed the teams to develop an understanding of how each subwatershed functions and what the major problems and limitations are. Through the course of Phase II, public workshops and meetings were held in order to draw from local experience and develop goals and objectives for the Subwatershed Plans.

Phase III began in late summer of 1994 and involved the development of alternative management actions which would address existing problems, prevent future ones, and provide improvements to strengthen the existing ecosystem. Consideration of the latter was necessary because of impacts that have occurred resulting from previous land use practices. The various management actions were organized into a series of alternative strategies, for the purpose of evaluation. The results of the Phase II studies, the possible management actions, alternative strategies and evaluation criteria were documented in an Interim Report completed in October 1994. A summary of the information, including the alternatives and evaluation criteria, were presented to the public through meetings held in November 1994.

Subsequent to the November meetings, evaluations of the different management actions and alternative strategies were conducted by the subwatershed teams. These were submitted to the Technical Advisory Committee for comment. Through the subwatershed team recommendations, meetings with the TAC and discussions with individual agencies, a series of recommended Subwatershed Plans evolved. While the individual plans differ in some details because of the differences between the subwatersheds, the overall content and recommendations of the plans are similar. A description of the evaluation criteria and consultation process used to arrive at the Recommended Plan is provided in Section D of this report and is followed by an overall description of the Subwatershed Plan (including graphical and tabular presentations).

A1.3 Subwatershed Locations and Study Areas

Pottersburg Creek

The Pottersburg Creek subwatershed extends over an area of approximately 49 km². Map A1 illustrates the location of Pottersburg Creek and its watershed in relation to the City of London and several other local subwatersheds. Approximately 60 percent of the subwatershed lies within the boundaries of the City of London. At this time, about 46 percent of the Pottersburg Creek subwatershed has been urbanized. Lands upstream of the existing development are predominantly agricultural.

The lower reaches of the creek, from the Thames River to just north of Dundas Street have been reconstructed as a grass-lined, gabion channel. Continuing north and upstream, the creek remains as a grass-lined channel (with the exception of a few field drains that have been realigned for agricultural practices) past the upstream limits of existing development to the headwaters of Pottersburg Creek.

Crumlin Drain

The Crumlin Drain subwatershed extends over an area of approximately 6 km². Map A1 illustrates the location of Crumlin Drain and its watershed in relation to the City of London, Stoney Creek and Pottersburg Creek. Approximately 99 percent of the watershed lies within the boundaries of the City of London. At this time, about 11 percent of the watershed has been urbanized, the majority of which is located on the eastern side of the watershed. Lands outside the existing development are predominantly agricultural.
The majority of Crumlin Drain remains in its natural state. In the more southern portion of the watershed, the creek remains undeveloped. However, a number of control structures have been constructed and some urbanization has occurred along the northern and eastern reaches.

A2.0 SUBWATERSHED MANAGEMENT APPROACH

A2.1 General

Subwatershed management and planning recommendations for the Pottersburg Creek and Crumlin Drain subwatersheds have been developed using an ecosystem approach. An ecosystem approach to subwatershed management is based on the fact that the natural features and functions of a subwatershed are linked by the movement of water. Changes in the subwatershed that affect this movement of water may, in turn, affect the natural features and functions. Impact assessment of land use change in a subwatershed must consider these fundamental relationships. This relationship is best described, in a general fashion, by the subwatershed concept as illustrated in Figure A1.

A2.1.1 Subwatershed Hydrology

The hydrologic cycle incorporates the concepts of precipitation, surface water runoff, infiltration, groundwater flow and evapotranspiration. The City of London generally receives 800 to 1000 mm of precipitation annually. When this precipitation falls on the landscape, some of the water infiltrates into the soil to become part of the groundwater system. The remainder of the precipitation becomes runoff and forms surface water systems on top of the landscape. To complete the cycle, water is evaporated by the energy from sunlight from surface water systems and transpired by terrestrial vegetation to be put back into the atmosphere.

The water that infiltrates into the groundwater system generally takes one or two pathways through the shallow groundwater system and/or the deeper groundwater system. Groundwater movement in the shallow groundwater system is typically in a lateral direction and will usually follow the topographic features of the landscape. Shallow groundwater will often discharge to surficial water features like wetlands or streams. The deeper groundwater systems are more regional in nature and typically represent regional water supplies. Groundwater flow in the deeper systems need not obey local topographic features, but are most often controlled by more prominent features of a landscape.

The balance between the amount of water that infiltrates into the soil and the amount of water that runs off forming surface water systems, is unique to each subwatershed. The balance is determined by several factors:

i) Soil type which is derived from quaternary geology or surficial geology;

ii) Surface topography; and

iii) Land cover (vegetation and development).

Areas of deep sands and gravel are very permeable and consequently act as areas of high infiltration and groundwater recharge. Conversely, areas of clay and silty clay till are of low permeability and contribute little to groundwater recharge. Landscapes with dense vegetation tend to promote infiltration of rainfall into the soil, however, these same areas will also promote higher levels of evapotranspiration of water back into the atmosphere.
These basic processes of infiltration, runoff and groundwater discharge are important hydrologic functions in the subwatershed. The relationship between areas of surface water infiltration and ground water discharge is an important ecosystem linkage.

A2.1.2 Subwatershed Aquatic and Terrestrial Resources

Natural features of a subwatershed include both aquatic and terrestrial resources. The aquatic resources including fish and invertebrates have an obvious dependence on the subwatershed hydrology. An inventory and analysis of the aquatic resources of a subwatershed is often used as an indicator of the environmental quality within the subwatershed. Certain aquatic species have exacting habitat requirements and are relatively intolerant to pollutant inputs. The presence of these types of species typically indicate a more healthy aquatic ecosystem. Other aquatic species have less exacting requirements and are more tolerant to pollutant inputs. The prominence of these species in the subwatershed aquatic system is indicative of a more degraded system. The quality of the aquatic ecosystem can vary throughout the subwatershed as well, usually depending on upstream land uses. As a general rule, the presence of a diversity of species is considered healthy.

Terrestrial resources in a subwatershed may not be entirely dependent on the hydrologic system, however, they are indirectly linked to the subwatershed hydrology. The presence of vegetation can influence the balance between the amount of water that infiltrates into the soil and the amount of water that runs off in surface water systems. Some vegetation species are indicative of high groundwater tables or wet areas in a subwatershed. Others are more typical of a more dryer soil strata. Vegetation and terrestrial resources also provide wildlife habitat. Many birds and animals depend solely on these terrestrial features for their habitat. Similar to aquatic species, some terrestrial species have more exacting habitat requirements than others. For example, some bird species require larger forest patches that provide a forest interior habitat. The interior habitat is separated from areas that undergo edge effects and influences from urban development and open spaces. Subwatershed ecosystems will typically contain a range of habitats that provide sanction for a range of terrestrial species.

A2.2 A Framework for the Subwatershed Ecosystem

The hydrologic processes, the aquatic resources, and the terrestrial resources in a subwatershed define a unique set of ecosystem functions, attributes, and linkages. The definition of how a subwatershed works in terms of its functions, attributes and linkages provides an overall framework for an assessment of the subwatershed ecosystem in a holistic manner.

Functions are earth and life science processes in the landscape. For example, earth science functions include groundwater recharge and discharge. Life science functions include the provision of wildlife habitat.

Attributes are components of the environment considered to be "special" such as rare species or particularly sensitive populations or habitats.

Linkages are the relationships between the natural landforms and the aquatic and terrestrial resources. For example, stream valley corridors link the upper reaches of the subwatershed to its confluence with the riverine system.

A generic list of subwatershed functions, attributes and linkages is provided in Table A.1.
<table>
<thead>
<tr>
<th>Functional Component</th>
<th>Functional Description</th>
<th>General Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>groundwater recharge</td>
<td>degree of infiltration; dependent upon surficial geology, land use and other considerations on a catchment basis.</td>
<td>geological mapping, catchment boundaries, climatological information.</td>
</tr>
<tr>
<td>groundwater discharge</td>
<td>seepage areas, largely confined to valleylands or wetland areas of tableland.</td>
<td>valleyland limits and wetland information from background sources (Conservation Authorities, OMNR maps).</td>
</tr>
<tr>
<td>flood storage and conveyance</td>
<td>valleylands and wetlands; the latter have varying degrees of functional capability depending upon site specific characteristics.</td>
<td>Conservation Authority flood and fill line mapping; aerial photograph delineation of major valley system limits.</td>
</tr>
<tr>
<td>water quality modification</td>
<td>capability to retain and/or transform quality of overland runoff; dependent upon watercourse and riparian vegetation characteristics.</td>
<td>assessment of permanence of watercourse and degree of vegetative cover.</td>
</tr>
<tr>
<td>Biological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>erosion control</td>
<td>influence of vegetative cover in maintaining steep slopes limiting erosion; mostly contained within valleyland limits.</td>
<td>watercourse temperature and other aquatic &quot;indicators&quot; of integrity (i.e. presence/absence of species.</td>
</tr>
<tr>
<td>wildlife habitat</td>
<td>terrestrial and aquatic habitats available to support both flora and fauna; this is a strong reflection of biodiversity.</td>
<td>valley limits; flood and fill line mapping.</td>
</tr>
</tbody>
</table>

natural vegetation cover and patterns within landscape: OMAF and Forest Resource Inventory mapping with limited field verification.

aquatic ecosystem characteristics (i.e. coldwater vs. warmwater, permanent vs. ephemeral or intermittent).
<table>
<thead>
<tr>
<th>B - Attributes</th>
<th>Functional Component</th>
<th>General Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>rare species</td>
<td>spot locations of individuals and populations of rare species.</td>
<td>OMNR, Conservation Authorities, NGO inventories, databases and rare species mapping.</td>
</tr>
<tr>
<td>critical wildlife habitat</td>
<td>concentrations of species dependent upon a particular area for local, regional or provincial population health.</td>
<td>ESA, life science, ANSI reports.</td>
</tr>
<tr>
<td>unusual vegetation communities</td>
<td>relict community which is unusual on landscape level in term of composition and/or structure.</td>
<td>Information regarding deer concentration areas, heronries, migratory stopovers, etc.</td>
</tr>
<tr>
<td>unusual landforms and fossil assemblages</td>
<td>bedrock outcrops, landforms of interest from research, education and conservation perspectives.</td>
<td>ESA, life science, ANSI reports.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>earth science, ANSI reports; landscape terrain evaluation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C - Linkages</th>
<th>Functional Component</th>
<th>General Information Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>dispersal and movement corridors</td>
<td>terrestrial linkages include vegetated valleyland corridors, contiguous tableland tracts of forest and hedgerows.</td>
<td>vegetation patterns on the landscape and watercourse locations and characteristics; major hedgerows identified from photograph spot-checking.</td>
</tr>
<tr>
<td>hydraulic connections</td>
<td>aquatic corridors including watercourses and waterbodies.</td>
<td>general temperature and water quality information along with an assessment of background data for presence or absence of Indicator species (continuous vs. discontinuous) along a corridor.</td>
</tr>
<tr>
<td></td>
<td>groundwater recharge areas and discharge areas are linked by the hydraulic properties of the soil.</td>
<td></td>
</tr>
</tbody>
</table>
Management of a subwatershed from an ecosystem perspective must address these functional components. Maintenance of the subwatershed functions, attributes and linkages would typically maintain the existing environmental quality. Enhancement of particular functions and/or linkages could improve the environmental quality of the subwatershed. An understanding of how these functional components work together will identify candidate areas for rehabilitation and/or improvement. An evaluation of the subwatershed management options, along with discussions and consensus building among the stakeholders will lead to a Subwatershed Plan that, when implemented, can maintain and enhance the subwatershed functions, attributes and linkages.

A2.3 Potential Impacts of Development on Subwatershed Functions, Attributes and Linkages

A2.3.1 Hydrologic Functions

Changes in land use can affect the natural balance of runoff and infiltration for an area. When lands are developed, the landscape generally becomes more impermeable as a result of increased areas of roofs, roads, driveways and parking lots. Different types of development vary in the amount of landscape that is covered by impermeable surfaces. For example, a commercial development, such as a shopping mall, covers a large portion of the landscape by impermeable surfaces. Single family residential developments put impermeable surfaces over a smaller portion of the landscape and estate residential development has even less impermeable area.

The potential impacts of development on water resources are, therefore, primarily influenced by three factors:

a) The amount of landscape that will be developed;

b) The percentage of the landscape that will be covered by impermeable surfaces; and

c) The ability of surficial soils to infiltrate surface water.

The resulting impacts of urbanization (change from a permeable landscape to one which is impermeable) are generally viewed as negative, if not mitigated, because:

a) It reduces the amount of infiltration to recharge the groundwater system. This could affect the use of the aquifer as a drinking water supply and could reduce groundwater discharge to streams, affecting the biological resources and assimilative capacity of the stream; and

b) It increases the amount of storm water runoff, which can increase the amount of water in a stream after a storm (peak flow) and the length of time that flows are elevated (bankfull duration). Both of these are harmful in that they can result in increased flooding, erosion, damage to fish habitat, and risk to human health and safety.

Different subwatersheds respond to development stress in different ways. For example, the maintenance of infiltration is most important in areas where there is an aquifer used for drinking water supply or a fishery dependent on groundwater discharge. Also, the extent to which storm water flows will be increased is dependent on local climatic conditions: in areas where storm volumes are generally small in size, such as in Southern Ontario, some decrease in permeability can generally be accommodated without greatly influencing runoff quantities.
These potential changes to the subwatershed hydrology must be understood before preparing a subwatershed management strategy. A number of hydrologic models are used to determine the response of the subwatershed to rainfall events under existing conditions and under future development scenarios. A comparison of the response under the future development scenario to the response under existing conditions allows the determination of the changes in the hydrologic cycle that could occur.

Development can also have a negative effect on water quality. As land use change occurs, changes in pollutant loadings can also occur which affect the quality of both surface and groundwater. Runoff from developed land has generally been found to carry higher loadings of certain types of pollutants than runoff from undeveloped areas. These may include:

a) Road salt;  
b) Chemicals from commercial (e.g., gas stations, dry cleaners), industrial and transportation sources; and  
c) Lawn fertilizers and pesticides.

On the other hand, some pollutant loadings may be decreased with land development. For example, agricultural chemicals, sediment and nutrient loads may be reduced when certain types of agricultural land are urbanized.

A2.3.2 Potential Impacts on Aquatic and Terrestrial Functions, Attributes and Linkages

Aquatic Resources

A change in the balance between infiltration and runoff can have significant effects on the baseflow in streams. A reduction in the baseflow may change the water temperature as well as the amount of water available for aquatic habitat during drier periods of the year. Some fish species are dependent upon groundwater discharge to streams to provide a suitable habitat. Development that occurs without regard for the maintenance of this balance between infiltration and runoff has the potential to negatively impact such fisheries.

Changes in water quality as a result of development can also impact the subwatershed aquatic resources. Many substances are toxic to aquatic life. For example, heavy metals including arsenic, cadmium, copper, lead, mercury, silver and zinc, among others, are toxic to aquatic life in concentrations above certain threshold limits. Sources of heavy metals could include runoff from roads and industrial discharges.

Nutrients, including agricultural fertilizers, can also impact the aquatic habitat. Typical nutrients include nitrogen compounds, phosphorus and potassium. A particular form of nitrogen known as un-ionized ammonia, is toxic to aquatic life. A major source of this form of nitrogen is runoff from lands on which manure has been spread. Other nutrients, such as phosphorus and potassium, tend to promote algal growth in the receiving waters. Prolific algal growth can decrease dissolved oxygen levels in creeks, rivers and other waterbodies. Aquatic species are dependent on a certain level of dissolved oxygen to be available for their metabolism.
Terrestrial Resources

Land use change can also impact wildlife habitat. An obvious impact is the direct loss of habitat through removal of trees and vegetation or channelization of streams. This scenario leads to a total net loss of habitat in the ecosystem. This is not a desirable result.

Encroachment of development on areas providing terrestrial habitat can also have a negative impact. Changes in the habitat microclimate (wind speed, temperature, lighting, noise) can impact the suitability of a natural area to continue to function as wildlife habitat.

Some species of vegetation are dependent upon groundwater levels. Changes in groundwater levels can result if development plans do not account for the balance between infiltration and runoff and the potential to impact vegetation. For example, inappropriate development adjacent to a wetland has the potential to lower the groundwater table, and subsequently change the availability of water to the wetland vegetation. The wildlife dependent upon the wetland vegetation as habitat would also be impacted.

A3.0 POLICY FRAMEWORK

Development of the Pottersburg Creek and Crumlin Drain Subwatershed Plan (PCCDSP) has been predicated on the existing policy framework for the natural environment. The Subwatershed Plan contains many recommendations intended to guide future planning and management in both the Pottersburg Creek and Crumlin Drain watersheds, including land use planning.

The PCCDSP recommendations have been developed to be consistent with the Comprehensive Set of Policy Statements that have been issued under Section 3 of the Planning Act, as well as other guidelines and policies concerned with the management of physical and ecological features and processes.

The Comprehensive Set of Policy Statements cover a broad range of policy areas affecting matters of provincial interest and the contents for Subwatershed Plans summarized in Table A.2. In addition to the policies noted in Table A.2, a number of other policies, documents and guidelines that have guided recommendations in the SCSP are summarized in Table A.3.

The Pottersburg Creek and Crumlin Drain Subwatershed Management Study has been carried out during a period in which fundamental changes have been made to the way planning is undertaken in the Province of Ontario. The timing of the release of the PCCDSP document finds itself in a transition period, after the time when the Comprehensive Set of Policy Statements apply, but includes various planning documents and development proposals which are not subject to the Comprehensive Set of Policy Statements due to grandfathering under the earlier planning process.

Before the Comprehensive Set of Policy Statements came into effect, many of the policies contained in it were applied by the Province, local municipalities or review agencies, while commenting on planning documents or reviewing development proposals. Consequently, although changes in the submission requirements of proposed developments may have changed since the Comprehensive Set of Policy Statements came into effect on March 28, 1995, many of the policies affecting subwatershed planning and related development considerations had already applied.
<table>
<thead>
<tr>
<th>Policy #</th>
<th>Content for Official Plan</th>
<th>Content for Watershed or Subwatershed Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1.1</td>
<td>Groundwater and surface water</td>
<td>surface and groundwater quality and quantity</td>
</tr>
<tr>
<td>A1.2, A1.4</td>
<td>Natural heritage systems, features and areas</td>
<td>Natural systems linkages and functions</td>
</tr>
<tr>
<td>A1.3</td>
<td>Fish habitat</td>
<td>Fisheries management</td>
</tr>
<tr>
<td>A2</td>
<td>Wetlands</td>
<td>Ecological integrity and carrying capacity</td>
</tr>
<tr>
<td>A3.3</td>
<td>Hazardous and contaminated sites</td>
<td>Enhancement and rehabilitation of natural features</td>
</tr>
<tr>
<td>A3.4</td>
<td>Floods and erosion</td>
<td>Stormwater management; protection of valley systems.</td>
</tr>
<tr>
<td>B5.0</td>
<td>Servicing and infrastructure</td>
<td>Areas suitable for development; best management practices for subdivision design</td>
</tr>
<tr>
<td>B7.0</td>
<td>Development in rural areas</td>
<td>Servicing needs; availability of sewers and water</td>
</tr>
<tr>
<td>B10</td>
<td>Public access to public land and water bodies</td>
<td>Management practices for open space and greenspace corridors</td>
</tr>
<tr>
<td>B12</td>
<td>Significant landscapes, vistas and ridge lines</td>
<td>Areas suitable for development; natural systems and linkages; enhancement and rehabilitation of natural features</td>
</tr>
<tr>
<td>E1, E3</td>
<td>Site design, landscaping, infrastructure and building design</td>
<td>Conservation opportunities for water, energy and the built environment</td>
</tr>
<tr>
<td>F1</td>
<td>Mineral aggregates</td>
<td>Natural systems linkages and functions</td>
</tr>
</tbody>
</table>

NOTE:

Above based upon: Watershed Planning Initiative Science and Technology Task Group (LURA Group, February, 1995)
<table>
<thead>
<tr>
<th>Document/Policy Guidelines</th>
<th>Relevant Agency/Agencies</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Bill 75 - City of London Annexation Act</td>
<td>City of London</td>
<td>1992</td>
</tr>
<tr>
<td>ii) London Middlesex Act</td>
<td></td>
<td>1992</td>
</tr>
<tr>
<td>iii) Official Plan Objectives (Ontario Regulation No. 479/93)</td>
<td>Province of Ontario</td>
<td>1993</td>
</tr>
<tr>
<td>v) Policy Statement-Flood Plain Planning and in particular the One-Zone and Two-Zone policies for flood plains</td>
<td>MMA/MNR</td>
<td>1988</td>
</tr>
<tr>
<td>vi) Fill, Construction and Alterations to Waterways Regulations (Ontario Regulation 154/86 as amended by 631/88), which identifies Upper Thames River Conservation Authority jurisdiction</td>
<td>UTRCA</td>
<td>1988</td>
</tr>
<tr>
<td>vii) Subwatershed Planning</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>viii) Integrating Water Management Objectives into Municipal Planning Documents</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>ix) Water Management on a Watershed Basis: Implementing an Ecosystem Approach</td>
<td>MOEE/MNR</td>
<td>1993</td>
</tr>
<tr>
<td>x) The Department of Fisheries and Oceans for the Management of Fish Habitat and particularly the principle of “No Net Loss of Habitat”</td>
<td>Department of Fisheries and Oceans</td>
<td>1986</td>
</tr>
<tr>
<td>xi) Guidelines on the Use of Vegetative Buffer Zones to Protect Fish Habitat in an Urban Environment</td>
<td>MNR</td>
<td>1987</td>
</tr>
<tr>
<td>xii) Provincial Policy Statement on Wetlands and Implementation Guidelines (1)</td>
<td>MNR/MMA</td>
<td>1992</td>
</tr>
<tr>
<td>xiii) The Interim Storm Water Quality Control Guidelines</td>
<td>MNR/MOEE</td>
<td>1991</td>
</tr>
<tr>
<td>xiv) Fish Habitat Protection Guidelines for Developing Areas</td>
<td>MNR</td>
<td>1994</td>
</tr>
</tbody>
</table>

A.13
<table>
<thead>
<tr>
<th>Document/Policy Guidelines</th>
<th>Relevant Agency/Agencies</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>xvi) Comprehensive Set of Policy Statements</td>
<td>MMA</td>
<td>1994</td>
</tr>
<tr>
<td>xvii) Ontario Food Land Guidelines</td>
<td>OMAF</td>
<td>1978</td>
</tr>
</tbody>
</table>

**NOTE:**

1) Also covered/replaced by the Comprehensive Set of Policy Statements under Section 3 of the Planning Act.
A4.0  SUBWATERSHED MANAGEMENT GOALS AND OBJECTIVES

As a result of public consultation carried out early in the London Subwatershed Study process, a number of goals, policies and objectives were identified, which are summarized in Table A.4. The main goals and objectives the Subwatershed Plan are:

i) Protect, enhance and/or restore the watershed ecosystem through cost effective and environmentally sound strategies;

ii) To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders; and

iii) To provide an ecosystem approach to the planning and management of existing and future land uses.

A5.0  PUBLIC PARTICIPATION

The London Subwatershed Studies benefited from public participation and consultation throughout Phases II to V. This important study component was coordinated by the Upper Thames River Conservation Authority for the Pottersburg Creek and Crumlin Drain Subwatershed Studies. The public participation component consisted of:

- Notification of subwatershed planning activities in three newsletters;
- Presentation of subwatershed findings at four public meetings;
- Discussion of subwatershed planning issues at one workshop; and
- Public involvement in six Technical Advisory Committee meetings and review and comment on the subwatershed planning study reports.

A6.0  REPORT LAYOUT

Part B of this report summarizes the results of the detailed studies completed for the Pottersburg Creek and Crumlin Drain subwatersheds. The detailed studies identify the functions, attributes and linkage features and characteristics found in each subwatersheds. Part C of this report considers the management goals, policies and objectives with respect to the unique characteristics of the Pottersburg Creek and Crumlin Drain subwatersheds and presents a range of management alternatives for each subwatershed. The Recommended Subwatershed Plan and process used in selecting management alternatives are presented in Section D. Study Conclusions and Recommendations are presented in Section E. An Implementation Plan of the Recommended Subwatershed Plan for Pottersburg Creek and Crumlin Drain has been completed as part of an overall document guiding implementation of the Subwatershed Plan recommendations for all subwatersheds in the City of London, and is bound under separate cover.
<table>
<thead>
<tr>
<th>Objective A1: Maintain groundwater supplies and baseflow through preserving or enhancing soil infiltration recharge rates, protecting existing recharge/discharge areas and tributaries which supply or receive groundwater, and managing water taking permits.</th>
<th>Objective B1: Preserve and manage woodlots which are important to the ecological health of the subwatershed.</th>
<th>Objective C1: Control runoff such that it does not unnecessarily increase flood risk and mitigate existing potential flood risk where feasible.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective A2: Maintain or enhance the quality of both groundwater and surface water and reduce sediment loading to watercourses, through erosion and siltation control, maintenance or enhancement of riparian vegetation, rehabilitation of existing erosion prone areas, and control of nutrients, contaminants, litter and trash, from both urban and rural sources.</td>
<td>Objective B2: Maintain or enhance the extent, structure and function of significant natural features including wetlands, areas of natural and scientific interest (ANSIs) and environmentally significant areas (ESAs).</td>
<td>Objective C2: Ensure no increase in flood risk to structures in the flood plain and employ appropriate land use controls and performance standards to control development in flood prone areas.</td>
</tr>
<tr>
<td>Objective A3: Maintain or reduce existing erosion potential through the control of storm runoff, and where practical, restoration of valley walls, streambanks and watercourses to a natural and stable condition.</td>
<td>Objective B3: Maintain or enhance a linked greenspace system which incorporates regulated and other significant natural resource features such as watercourses, wetlands, and significant upland wooded areas, which perform important ecological functions.</td>
<td>Objective C3: Utilize a range of urban and rural storm water management practices directed towards maintaining a natural hydrologic response to rainfall and runoff. Such practices may include where appropriate, consideration of flood plain lands for the implementation of storm water management practices, where there is a clear benefit and where natural functions will be maintained.</td>
</tr>
<tr>
<td>Objective A4: Maintain or enhance the aquatic habitat of the watercourses, by managing and possibly restoring natural vegetative canopy, protecting critical habitats, implementing specific habitat improvements and ensuring an acceptable flow regime.</td>
<td>Objective B4: Preserve the integrity of natural areas by encouraging urban designs that fit into and mesh with the character of the natural areas, by limiting utility crossings and use of the stream valleys as utility corridors, where practical, by establishing setbacks and buffers as appropriate, and by controlling public access to the natural areas in a manner which protects the more sensitive natural features.</td>
<td>Objective B5: Maintain or enhance existing plant and wildlife habitat.</td>
</tr>
</tbody>
</table>
### TABLE A.4, continued

**Subwatershed Goals, Sub-Goals, and Objectives**

#### Goal No. 2: To make the planning and approvals process more efficient by providing clarity, information and a watershed context for watershed stakeholders.

<table>
<thead>
<tr>
<th>D.</th>
<th>E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectively manage the database necessary to protect the ecosystem and aid with decision making.</td>
<td>Develop flexible guidelines directed at implementing future land use changes within the framework of the Subwatershed Plan.</td>
</tr>
</tbody>
</table>

**Objective D1:** Collect and integrate data on the ecosystem to facilitate decision making.

**Objective D2:** Compile all information generated as part of the Subwatershed Planning Study.

**Objective D3:** Input to a data management system which can be readily updated as additional data is collected.

**Objective D4:** Ensure that the data management system is accessible for use in all future studies and impact assessments.

**Objective E1:** Develop an Implementation Guideline Document to clearly define the types of analyses required to support future development applications.

**Objective E2:** Streamline approvals through coordinated agency review effort.

**Objective E3:** Allow flexibility in the design of urban development leading to ecological benefits.

**Objective E4:** Minimize storm water management facilities through coordination of adjacent or regional land development activities.

**Objective E5:** Develop procedures to assist in resolving conflicts between agency guidelines and policies based on the recommendations of the Subwatershed Plan.

### TABLE A.4, continued

**Subwatershed Goals, Sub-Goals, and Objectives**

#### Goal No. 3: To provide an ecosystem approach to the planning and management of existing and future land uses.

<table>
<thead>
<tr>
<th>Objective F1: Endeavour to include public involvement in all aspects of subwatershed management, planning and implementation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective F2: Respond to the need for community access to the natural environment by increasing the number of access points to publicly owned natural areas.</td>
</tr>
<tr>
<td>Objective F3: Clarify public responsibilities and opportunities related to management of the subwatershed.</td>
</tr>
<tr>
<td>Objective F4: Balance diverse public interests related to the protection of the natural environment, access to greenspace systems, urban development, and preservation of heritage features.</td>
</tr>
<tr>
<td>Objective F5: Develop implementation strategies to address the use of greenspace lands as part of park dedication.</td>
</tr>
<tr>
<td>Objective F6: Develop procedures for ongoing monitoring of subwatershed characteristics to evaluate the success of the management plan.</td>
</tr>
</tbody>
</table>
PART B

DETAILED STUDIES
PART B - DETAILED STUDIES

Part B provides a brief description of existing subwatershed features, functions and linkages based on the findings of detailed studies completed in the following areas of study:

i) Land Use;
ii) Geology/Hydrogeology;
iii) Fluvial Geomorphology;
iv) Surface Water Hydrology;
v) Rural Point and Non Point Source Pollution;
vi) Water Quality
vii) Aquatic Resources;
viii) Terrestrial Resources;
ix) Archaeological Resources; and
x) Sanitary Sewage Collection System

The discussion in the following subsections is based on excerpts from the Detailed Study reports which are provided in the Technical Appendix. The findings of each of the Detailed Studies have been used to synthesize an understanding of features, functions and linkages of the current ecosystem of Pottsburgh Creek and Crumlin Drain, which are detailed at the end of this chapter.

B1.0 LAND USE

Land use in the Pottsburgh Creek and Crumlin Drain subwatersheds is summarized in Table B.1 and illustrated on Map B1. Currently, less than 25 percent of the Pottsburgh Creek and 15 percent of the Crumlin Drain watersheds are designated as urban development, the majority of which is in residential use in the City of London (22% and 14% for Pottsburgh Creek and Crumlin Drain, respectively).

The majority of the existing urban development within the Pottsburgh Creek subwatershed exists west of Highway 100. This urban development is a mixture of residential, institutional (including Fanshawe College, The Young Offenders Penitentiary Centre and portion of the London Psychiatric Hospital grounds), and commercial/industrial lands. Immediately north and east of Highway 100 is the Airport property. This transects the Pottsburgh Creek subwatershed. The balance of land use in the subwatershed is primarily agricultural or rural and located in the headwater areas.

The Crumlin Drain subwatershed is for the most part undeveloped or in the process of being developed. A unique characteristic of this subwatershed is that it is 99 percent contained within the City of London.

The land use pattern in the Pottsburgh Creek subwatershed is typical of most subwatersheds in the City of London and in Southern Ontario, with concentrated development occurring in the lower watershed area.
<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area (ha)</th>
<th>Percent of Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pottersburg Creek</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>1,106</td>
<td>22</td>
</tr>
<tr>
<td>Institutional</td>
<td>92</td>
<td>2</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>1,133</td>
<td>23</td>
</tr>
<tr>
<td>Airport Industrial</td>
<td>507</td>
<td>10</td>
</tr>
<tr>
<td>Rural Agricultural</td>
<td>2,183</td>
<td>43</td>
</tr>
<tr>
<td><strong>Crumlin Drain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designated Residential</td>
<td>83</td>
<td>14</td>
</tr>
<tr>
<td>Designated Industrial/Commercial</td>
<td>181</td>
<td>30</td>
</tr>
<tr>
<td>Potential Industrial Growth</td>
<td>340</td>
<td>55</td>
</tr>
<tr>
<td>Rural Agricultural</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>
B2.0 GEOLOGY/HYDROGEOLOGY

The Detailed Study of geology and hydrogeology of the Pottersburg Creek and Crumlin Drain subwatersheds was undertaken using a combination of field study data (from mini-piezometer and seepage meters), and published reports and data (MOEE well drilling records, Pleistocene and Quaternary Geology maps). Groundwater modelling was used to estimate infiltration rates to the shallow and deep groundwater systems.

B2.1 Quaternary Geology

The surficial geology of the subwatersheds is quite complex with alternating exposures of glacial tills, glacio-lacustrine clay, silt and sand, ice contact stratified drift, outwash, and deltaic deposits of sand and gravel. The surficial gravel deposits are situated along the southern and western areas of the subwatershed within the City, as well as around the airport and east of Fanshawe Lake north of Waubuno Creek. Sand deposits flank the gravel deposits in two main areas, around Clarke Road north of Dundas Street, and along Crumlin Road in the Airport area.

The overburden thickness in the subwatershed generally ranges between 25 and 45 metres, overlying a limestone bedrock.

B2.2 Hydrogeology

Groundwater supplies are available in both the overburden and in the bedrock, with approximately 40 percent of existing wells obtaining water from bedrock sources and the remaining 60 percent obtaining water from the overburden sources in the Pottersburg Creek subwatershed. In the Crumlin Drain subwatershed, approximately 20 percent of existing wells obtain water from bedrock sources while the remaining 80 percent obtain water from the overburden.

Shallow groundwater flow typically follows surface topography. Therefore, shallow groundwater flow within the subwatershed is towards Pottersburg Creek and Crumlin Drain. The more permeable deltaic and gravel deposits make higher contributions to baseflow relative to the less permeable soils.

B2.3 Groundwater Modelling

The groundwater modelling for the subwatersheds consists of two numerical models as well as a groundwater balance. A plan view numerical model was used to partition infiltration to either the deeper regional groundwater system or the shallow or local groundwater system. This model considers the aerial distribution of sandy soils and the less permeable till soils across the subwatershed area. The model assumes that the shallow or local groundwater all discharges to Pottersburg Creek and Crumlin Drain and their tributaries. The regional groundwater flow system is assumed to discharge to the upper Thames River.

A cross-sectional numerical model was used to simulate groundwater flow in cross-section. This model provided a means of estimating the amount of groundwater discharge per length of tributary within each of the subwatersheds.

A water balance calculation was carried out for the Pottersburg Creek and Crumlin Drain subwatersheds which partitioned rainfall to infiltration and runoff. The infiltration was subsequently partitioned with a shallow groundwater system and the deeper, more regional groundwater system. The water balance approach utilized the results of the numerical models and the field studies.
The Pottersburg Creek and Crumlin Drain subwatersheds receive approximately 900 mm of rain per year. Approximately 10 percent of this water infiltrates into the ground and becomes part of the groundwater system. The remaining 90 percent of the rainfall either runs off to the surface water system or is taken up through evapotranspiration. Of the 10 percent that infiltrates into the groundwater system, approximately 30 percent enters the deeper or regional groundwater system and the remaining 70 percent remains part of the shallow or local groundwater system. It is this local groundwater system that is responsible for groundwater discharge to Pottersburg Creek and Crumlin Drain and their tributaries. It is estimated that in the eastern area of the subwatershed where sand and gravel deposits exist, infiltration rates are twice that (i.e. 20% of precipitation total) of the remaining subwatershed areas that are covered by clayey tills.

**B3.0 FLUVIAL GEOMORPHOLOGY**

A fluvial geomorphology study was carried out in 1994 with the following main objectives:

- To classify the fluvial geomorphology of Pottersburg Creek and Crumlin Drain by following the Rosgen (1994) method and to categorize the fluvial geomorphology of the drainage basin through morphometric measures and the creek system through hydraulic geometry relations;

- To determine sediment characteristics of bed and bank material;

- To identify, assess, and measure erosion along Pottersburg Creek and Crumlin Drain; and

- To determine the stability of the channel through identification of threshold indices with respect to the movement of bed material.

**B3.1 Fluvial Geomorphology**

Pottersburg Creek and Crumlin Drain were divided into five and two reaches, respectively, as illustrated on Map B2, based on channel conditions and land use characteristics. For these reaches, initial measurements from recent air photos and 1:10,000 topographic maps were made, followed by site specific field work. The results are values or ranges for the classification criteria of entrenchment, width/depth ratio, sinuosity, slope, and channel materials which are presented in Table B.2.

The capital letter under classification column represents the main stream type. The stream types of B and C are common in Southern Ontario and are relatively stable. The G stream type represents a degraded condition where the stream has been removed from its flood plain, due to excessive downcutting and bank erosion, indicated by the low entrenchment value. The number indicates channel material, with a high value indicating fine material, and low values very coarse material. The 5 represents sand and 3-cobbles. The lower case letter is a sub-class indicating an unusual condition, in this case, lower than normal channel slope given the stream type.

Estimates of bankfull flow capacity were made using field measurements and hydraulic calculations at the five cross-section locations noted in Map B2. Table B.3 summarizes the bankfull flow capacity of Pottersburg Creek and Crumlin Drain at each of the noted cross-sections.

**B3.2 Sediment Characteristics**

Bed and bank materials were analyzed using field and laboratory analysis. The sediment in the drainage basin and, more specifically, the material along the bed and banks of channel, exert a strong influence on channel pattern and cross-sectional shape. Information on sediment characteristics is necessary in assessing and determining sensitivity to erosion and ease of transport of bed material. The orientation pattern and distribution of bed material provide an indication of flow conditions and previous sediment movement.
<table>
<thead>
<tr>
<th>Reach</th>
<th>Entrenchment</th>
<th>Width/Depth</th>
<th>Sinuosity</th>
<th>Slope (%)</th>
<th>Channel Materials</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pottersburg Creek</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Headwaters to Middlesex Rd. 27</td>
<td>1.5 to 2.2</td>
<td>8 to 12</td>
<td>1.02</td>
<td>0.27</td>
<td>sand</td>
<td>B5c</td>
</tr>
<tr>
<td>2) Middlesex Rd. 27 to Oxford St. at Airport Rd.</td>
<td>&gt; 1.4</td>
<td>10 to 12</td>
<td>1.01</td>
<td>0.10</td>
<td>sand</td>
<td>G5c</td>
</tr>
<tr>
<td>3) Oxford St. at Airport Rd. to Clark Sd. Rd.</td>
<td>2.0 to 2.5</td>
<td>8 to 12</td>
<td>1.12</td>
<td>0.28</td>
<td>cobbles</td>
<td>C3</td>
</tr>
<tr>
<td>4) Clark Sd. Rd. to Trafalgar Rd.</td>
<td>1.5 to 2.0</td>
<td>10 to 14</td>
<td>1.07</td>
<td>0.23</td>
<td>cobbles</td>
<td>B3c</td>
</tr>
<tr>
<td>5) Trafalgar Rd. to S. Thames River</td>
<td>1.9 to 2.5</td>
<td>8 to 20</td>
<td>1.08</td>
<td>0.47</td>
<td>cobbles</td>
<td>B3c</td>
</tr>
<tr>
<td><strong>Crumlin Drain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Headwaters to Trafalgar Rd.</td>
<td>1.3 to 2.0</td>
<td>5 to 7</td>
<td>1.03</td>
<td>0.37</td>
<td>sand</td>
<td>G5c</td>
</tr>
<tr>
<td>2) Trafalgar Rd. to Gore Rd.</td>
<td>1.3 to 1.6</td>
<td>5 to 8</td>
<td>1.03</td>
<td>0.48</td>
<td>sand</td>
<td>G5c</td>
</tr>
<tr>
<td>3) Gore Rd. to Waubuno Creek</td>
<td>1.5 to 2.0</td>
<td>8 to 10</td>
<td>1.09</td>
<td>1.60</td>
<td>cobbles</td>
<td>B3</td>
</tr>
<tr>
<td>Cross-Section</td>
<td>Bankfull Width (cm)</td>
<td>Bankfull Mean Depth (cm)</td>
<td>Bankfull Velocity (m/s)</td>
<td>Bankfull Discharge (m³/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pottersburg Creek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>1360</td>
<td>46.2</td>
<td>0.7</td>
<td>4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>760</td>
<td>67.9</td>
<td>0.7</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>480</td>
<td>42.0</td>
<td>0.7</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crumlin Drain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>320</td>
<td>37.4</td>
<td>1.3</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>240</td>
<td>46.6</td>
<td>1.4</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Field observations along Pottersburg Creek revealed few mid-channel bars in natural sections, although bars were seen upstream of road crossings. This is due to the channel becoming wide, allowing sediment to be deposited in the centre of the channel. The variability of bed material sizes is due to the selection of cross-sections at pools and riffles. However, the coarse calibre of the bed at P3 and P2 is likely from artificial sources for stabilization in urban areas. The P1 site represents natural material and correlates with published soils and geological information. As this site is composed of sand, greater sediment movement is likely and, thus, is relatively unstable.

Over the length of Crumlin Drain, no mid-channel bars were observed. As well, the traditional pool-riffle pattern, which accounts for variability of bed material, was only observed downstream of Gore Road. This is attributable to a straight channel and relatively steep slope. The calibre of the bed material is greater in the downstream area (south of Gore Road) which is likely a function of naturally occurring coarse material and selective removal of finer sediments. Upstream, the bed material is primarily sand which correlates with surrounding soils. Ripples were observed upstream of C1, indicating critical flows have occurred and that the sand bed is susceptible to movement and scour.

Field analysis of bank material and bank conditions was completed to determine erosion characteristics and sensitivity of the stream banks to change in flow regime. The bank material along Pottersburg Creek is relatively fine-grained and matches well with the soils and geological information of the basin. As well, the bank angles indicate a traditional, stable shape, with few excessively steep profiles. A concern is the lack of mature vegetation along the bank, which may eventually result in some instability.

The upstream sites along Crumlin Drain (C1) exhibit finer material than would be expected, given the sandy soils of the basin. The bank material exhibited some variability in the vertical profile. The finer material likely represents alluvial or high flow deposits along the channel margin. The bank angles are steep with little vegetation, indicating a greater degree of instability. Additional information on bank erosion characteristics is provided in the following sections.

**B3.3 Channel Erosion**

Erosion as a means of sediment supply is a natural river process, necessary to maintain channel stability. Changes to flow regime, sediment inputs and channel form lead to excessive erosion to channel bed and banks. Table B.4 lists locations where channel erosion was evident during the 1994 field program and provides a description of the erosion problem.

Thresholds for movement of material were calculated using sediment characteristics and fluvial geomorphology information. It was found that bed material at P1, C1 and C2 would move at conditions below bankfull. The most sensitive locations in Pottersburg Creek were P3 due to a high steep bank and P1 due to bank material and lack of vegetation. The banks along Crumlin Drain are more sensitive due to steep banks, little vegetation and sandy material. Additional details on the fluvial geomorphology, sediment characteristics and erosion assessment are provided in the Technical Appendix.

**B3.4 Summary**

From the above investigation it is apparent that the physical conditions and attributes of Pottersburg Creek are quite different than the Crumlin Drain. Although the Crumlin Drain subwatershed has little development, the watercourse is in a degraded condition, due to a high degree of entrenchment. Crumlin Drain is also susceptible to bank erosion and bed scour, especially upstream of Gore Road.
The channel pattern and form of Pottersburg Creek is relatively stable, although a reach near the airport is degraded due to entrenchment and bank erosion. This particular reach is also likely to experience bed scour at conditions significantly below bankfull. The portion of the creek in the urban area is less sensitive, with little erosion within the channel.

<table>
<thead>
<tr>
<th>TABLE B.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Erosion Sites</td>
</tr>
<tr>
<td>Location</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>POTTERTSBURG CREEK</strong></td>
</tr>
<tr>
<td>East of Middlesex Road 27</td>
</tr>
<tr>
<td>Northeast of Airport and through Airport property</td>
</tr>
<tr>
<td>Southwest of Oxford Street and Highway 100</td>
</tr>
<tr>
<td>North of Gore Road</td>
</tr>
<tr>
<td>South of Hamilton Road</td>
</tr>
<tr>
<td><strong>CRUMLIN DRAIN</strong></td>
</tr>
<tr>
<td>South of Trafalgar Road</td>
</tr>
<tr>
<td>Gore Road Bridge Area</td>
</tr>
<tr>
<td>South of Gore Road</td>
</tr>
</tbody>
</table>

**B4.0 SURFACE WATER HYDROLOGY**

The main objectives of the Detailed Hydrologic Study were:

- To inventory current drainage conditions in the subwatershed;
- To collect field measurements of flow data;
- To prepare an event-based hydrologic model for calculation of peak flow conditions; and
- To prepare a continuous hydrologic model for synthesizing general flow conditions and sedimentation characteristics.

**B4.1 Current Drainage Conditions**

Drainage in the Pottersburg Creek and Crumlin Drain subwatersheds consists of natural reaches, urbanized reaches, and agricultural reaches. Agricultural and urban uses have influenced drainage conditions in most of the subwatershed. Agriculture is the most prominent land use in the upper reaches, and as a result, many of the headwater tributaries have been channelized as agricultural drains and receive input from tile drains. The lower reaches of both the Pottersburg Creek and Crumlin Drain watercourses are somewhat natural, however, it does receive storm water runoff from adjacent urban development. Drainage features are illustrated on Map B3.
B4.1.1 Pottersburg Creek

Natural Channel Reaches

Pottersburg Creek has remained largely unaltered in two distinct areas of the subwatershed. The first area is located north of Dundas Street to the limits of the existing urban development. Extending upstream, Pottersburg Creek and its tributaries remain as a natural watercourse, although manicured parkland and residential lands encroach the banks in some areas. There are very few trees lining the channel and the banks appear well vegetated and stable.

The second area where the creek has remained in a close to natural state is the northern reaches. Within the rural setting, north of the airport, Pottersburg Creek consists of one main reach made up of a series of agricultural drains. Moving upstream from the airport, Pottersburg Creek is known as government drain and in the most northern reaches as Lee and Donkers Drain. This section of Pottersburg Creek flows primarily through agricultural lands in a narrow channel that exhibits a somewhat angular flow path. The vegetative buffer along this reach varies from open pasture to thick vegetation with stable vegetated banks.

The Terrestrial Component Study identified very few wetlands within the Pottersburg Creek watershed. Wetlands attenuate runoff and can mitigate water quality somewhat, although they will have virtually no impact on runoff volumes. Wetlands also intercept surface runoff from surrounding lands.

Urbanized Channel Reaches

Map B3 illustrates the extent of urbanized channel reaches in the Pottersburg Creek subwatershed. From just north of Dundas Street downstream to the Thames River, Pottersburg Creek is primarily a channelized watercourse with an average slope of 0.5 percent. Erosion is limited, primarily because of the size of the gabions and large cobbles which dominate the bed and banks. Riparian vegetation is generally natural. There is very little aquatic riparian habitat.

Agricultural Channel Reaches

As illustrated on Map B3, a substantial part of the Pottersburg Creek subwatershed is served by tile drains and municipal drains. These drainage features have a significant effect on the hydrologic characteristics of the watershed, primarily because they intercept potential groundwater recharge. This results in increased flow shortly after a runoff event and reduced baseflow during dry weather periods.

B4.1.2 Crumlin Drain

Natural Reaches

Crumlin Drain has remained largely unaltered throughout the majority of the subwatershed. The main channel has a relief of approximately 20 metres and an approximate slope of 0.50 percent. Ground elevations range from a low of 248 metres at the confluence with Waubuno Creek to 280 metres at the northwestern tip of the watershed. There are three distinct reaches within the subwatershed. The first reach originates just upstream of Dundas Street and extends to its confluence with the Crumlin Municipal Drain located just south of Trafalgar Road. This section of Crumlin Drain flows primarily through agricultural lands, but occasionally passes through some developed areas of the subwatershed. There are very few trees lining this section of the drain and a vegetative buffer has been maintained with the exception of some of the residential areas.
The second reach begins at the confluence of Crumlin Municipal Drain and extends downstream to the confluence of the Mossop Award Drain. This reach, although small, is at the centre of the watershed where all of the source tributaries combine together into one creek. The majority of this reach flows through a rural setting and dense vegetation occupies both banks along this portion of the watercourse.

The third reach begins at the confluence with the Mossop Award Drain and extends south to the confluence with Waubuno Creek. This portion of the drain is densely vegetated with trees and undergrowth.

**Agricultural Channel Reaches**

A significant part of the Crumlin Drain subwatershed is served by tile drains and Municipal Drains. These drainage features impact the hydrologic characteristics of the watershed as mentioned above (See Section on Pottersburg Creek).

**B4.2 Measured Flow Conditions**

Measured flow information for Pottersburg Creek and Crumlin Drain was available from September 1993 to March 1994 and March 1994 to July 1994, respectively, from continuous monitoring gauges which the UTRCA had installed at Trafalgar Street and Gore Road (Pottersburg Creek and Crumlin Drain respectively), and from spot measurements of baseflow carried out during the course of the Subwatershed Studies. A detailed summary of flow measurements is provided in the Technical Appendix.

To summarize the streamflow monitoring data, maximum flow measured at the Pottersburg Creek and Crumlin Drain gauges were 3.65 m³/s and 4.09 m³/s, respectively, which is considerably less than the 2-year peak flow for Pottersburg Creek and just higher than the 25-year for Crumlin Drain (See Section B4.3). Flow measurement data available for the Pottersburg Creek gauge (Trafalgar Street) indicate that the creek is continuously flowing along the main channel, while spot measurements indicated that some of the upper reaches have intermittent flow. Flow measurements data for the Crumlin Drain gauge (Gore Road) were limited. However, based on the available continuous and spot measurements data available, it would appear that a large portion of Crumlin Drain has only intermittent flow in the summer months.

**B4.3 Hydrologic Modelling - Peak Flow Analysis**

The INTERHYMO hydrologic computer model was used for modelling the hydrologic response of Pottersburg Creek and Crumlin Drain for design storm events ranging from the 1:2-year to 1:250-year return period design storm events. The event simulation modelling involved the completion of the following components:

i) Model Set-up - this component involved discretization of the subwatershed into smaller subcatchments for which land cover, soils and topographic conditions were determined for calculations of runoff hydrographs;

ii) Model Calibration - this component involved calibration of model input parameters such that peak runoff rates measured in the field could be reasonably predicted using the hydrologic model; and

iii) Calculation of design flows - this component involved executing the calibrated hydrologic model using the range of design rainfall storms to determine peak flow runoff rates and volumes at points of interest throughout the subwatershed.
Details of the above three components of the peak flow modelling are provided in the Technical Appendix.

Table B.5 summarizes the peak flow conditions for a range of design storm events for Pottersburg Creek upstream of the London Airport, Clarke Side Road and the confluence of Pottersburg Creek with the North Thames River. Table B.5 also includes a summary of the peak flow conditions for Crumlin Drain downstream of Trafalgar Street and at the confluence of the Crumlin Drain with Waubuno Creek. The results summarized in Table B.5 indicate that for Pottersburg Creek, larger peak flows are generated from extreme rainfall events, whereas for Crumlin Drain, a combination of rainfall and snowmelt events will generate larger peak flows. The peak flows were used as inputs to the HEC-2 hydraulic models which were used to calculate flood elevations, and hence generate flood plain mapping for each subwatershed, and represent constraint areas for development, based on the Provincial Policy Statement for Hazard Lands.

B4.4 Hydrologic Modelling - Continuous Simulation

The QUALHYMOMO hydrologic computer model was used for modelling the hydrologic response of both the Pottersburg Creek and Crumlin Drain subwatersheds to a long-term record of precipitation data. The main objective of the continuous simulation models was to establish existing erosion indices at the cross-section locations which were analyzed in the fluvial geomorphology detailed study. Results of this detailed analysis are provided in the Technical Appendix.

B4.5 Other Hydrologic Analysis

A low flow analysis for Pottersburg Creek and Crumlin Drain was undertaken to determine the low flow conditions which could occur under extreme drought conditions. An understanding of low flow conditions in each subwatershed is important to assess baseflow maintenance, aquatic habitat conditions, water quality and waste assimilation characteristics. A number of techniques can be used to estimate design low flows, but the most common method applied involves the use of long-term hydrometric data records. Unfortunately, hydrometric data available for Pottersburg Creek and Crumlin Drain is limited. Consequently, in order to assess the design low flow conditions, hydrometric records at nearby Water Survey of Canada (WSC) gauges on Wye Creek, Waubuno Creek and Medway Creek were used to determine the design low flows for Pottersburg Creek and Crumlin Drain (at the confluences with the North Thames River and Waubuno Creek, respectively). The design low flows, summarized in Table B.6, which indicates that even under extreme drought conditions, some flow in Pottersburg Creek is maintained. However, under these same conditions Crumlin Drain will approach a non-flow scenario.

B5.0 RURAL POINT AND NON-POINT SOURCE POLLUTION

Lands within the north and east regions of the Pottersburg Creek and Crumlin Drain subwatersheds predominantly support agricultural activities. The activities contribute to overall rural runoff quality and stream loading through both non-point (soil and crop management practices) and point (acute infrastructural and livestock management practices) sources.

The detailed study and evaluation of rural non-point and point source loading involves both inventory and analytical tasks. A number of essential objectives were identified and applied to develop a clear understanding of the spatial distribution of loading sources and their relationship to rural land use within the subwatersheds. These objectives included:

1) The identification of current livestock and tillage management practices and cropping patterns;

B.14
TABLE B.5
Event Simulation Peak Flow Summary
Under Existing Conditions

<table>
<thead>
<tr>
<th>Location</th>
<th>Runoff Generated by Rainfall Event (m$^3$/s)</th>
<th>Runoff Generated by Rainfall-Snowmelt Event (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Return Period</td>
<td>Return Period</td>
</tr>
<tr>
<td></td>
<td>2-year</td>
<td>5-year</td>
</tr>
<tr>
<td>Pottersburg Creek</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream of London Airport</td>
<td>2.8</td>
<td>7.7</td>
</tr>
<tr>
<td>At Clark Side Road</td>
<td>8.2</td>
<td>14.5</td>
</tr>
<tr>
<td>(35.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At Confluence with North Thames River</td>
<td>28.1</td>
<td>49.8</td>
</tr>
<tr>
<td>(109.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crumlin Drain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream of Trafalgar Road</td>
<td>0.4</td>
<td>1.1</td>
</tr>
<tr>
<td>At confluence with North Thames River</td>
<td>0.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

NOTES:

1) An aerial reduction of approximately 93 percent was used, brackets represent non-aerial reduced flows.
2) An aerial reduction of approximately 88 percent was used, brackets represent non-aerial reduced flows.
The 2 to 100-year storms were not aerial reduced.
TABLE B.6

<table>
<thead>
<tr>
<th>Month</th>
<th>Pottersburg Creek Monthly $7Q_{20}$ ($m^3/s$)</th>
<th>Crumlin Drain Monthly $7Q_{20}$ ($m^3/s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>0.033</td>
<td>0.004</td>
</tr>
<tr>
<td>June</td>
<td>0.009</td>
<td>0.001</td>
</tr>
<tr>
<td>July</td>
<td>0.005</td>
<td>0.001</td>
</tr>
<tr>
<td>August</td>
<td>0.003</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>September</td>
<td>0.005</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

NOTE:

* $7Q_{20}$ - 7 day average flow to occur once in twenty years.

2) An assessment of the contribution of these practices and patterns to stream loading in terms of the physical character of the land base on which they are performed; and

3) An evaluation of the effectiveness and practicality of implementing various remedial prescriptions and their application in the optimum reduction of loading through management initiatives.

The study commenced with an inventory and mapping of factors that potentially contribute to stream loading. Background information, including environmental studies, literature and data pertaining to subwatershed agricultural characteristics and activities was compiled. Reconnaissance level field surveys were conducted to verify, update and expand on this information. Assessments were made of the compatibility of the activities observed with the land base in terms of their potential contribution to loading or runoff quality. Information was compiled in a GIS base and an overall characterization of potential loading under existing conditions was made. Areas of concern were then identified with respect to the relative impact magnitude and significance of agricultural operations in relation to watershed biophysical attributes. Quality improvement opportunities were determined through analytical modelling and the hypothetical application of a series of BMPs at areas of concern throughout the subwatersheds.

The following sections summarize the results of the inventory and analysis completed to fulfill the requirements of objectives 1 and 2. The evaluation and identification of opportunities for improving rural non-point and point loading sources and water quality in both the Pottersburg Creek and Crumlin Drain subwatersheds area summarized in Part C, and detailed in the Technical Appendix.
B5.1 Subwatershed Agricultural Land Use and Tillage Practices

The predominant agricultural activity in the subwatersheds is the growing of common field crops such as winter and spring grains, corn and soybeans. The crops are grown both on a cash basis or as feed in support of the numerous dairy and beef livestock operations distributed throughout the rural areas of the subwatersheds. Some smaller traditional or recently-established locations of specialty or market garden produce are present east of the airport and in the southeast areas of the Crumlin Drain subwatershed.

Field survey of crops and tillage practices was conducted the week of 94-05-09 with a recheck and confirmation conducted 94-06-13. The time frame was considered ideal as evidence of both field overwintering conditions and spring planting preparation would be available. Late planted fields were rechecked the week of 94-06-20.

The current study included a field verification and updating of the OMAF Land Use Systems Maps for the subwatersheds. The update revealed that the mapping had generally retained its validity, particularly in the more rural portions of the subwatersheds. Some notable changes were observed that are particularly relevant to the C values applied in the determination of potential annual soil loss.

The major changes observed were:

- The area of continuous row cropping systems and corn systems had increased slightly, mostly replacing hay and/or mixed rotational systems;
- Smaller, intense grazing areas were observed in some areas otherwise predominantly under continuous row crop; and
- In the urban-rural fringe, land use had remained generally static, with no overly apparent changes in land tenure from traditional farm operator to speculative investment having occurred to increase the incidence of idle land grazing areas or more intensive cropping from the traditional rotation-type systems.

The changes in land use between 1983 and the present are outlined in Table B.7 Current (1994) Agricultural Systems in the subwatersheds are depicted in Map B4.

During field surveys, an inventory of in-place remedial and conservation practices was made. The locations of areas of conservation tillage, grassed waterways and buffer strips were noted and mapped. The locations of practices that may enhance erosion and sediment loading were also noted, with an emphasis in areas of the medium sediment load priority class in proximity to surface waters.

The locations and character of in-place remedial and best management practices are shown in Map B5. Also shown are areas currently in need of remedial and best management practice applications to reduce sediment loading to the surface waterways and drains. Many of these latter areas contain headwater beds that are presently tilled and under crop production during the growing season. Grassed waterway systems in these locations would greatly reduce the amounts of sediments and nutrients entering the water system from field runoff.
<table>
<thead>
<tr>
<th>Category</th>
<th>1983-94</th>
<th>83 (%)</th>
<th>94 (%)</th>
<th>Diff (%)</th>
<th>94 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Row Crop</td>
<td>392.41</td>
<td>7.0</td>
<td>462.2</td>
<td>8.2</td>
<td>+69.79</td>
</tr>
<tr>
<td>Corn System</td>
<td>782.18</td>
<td>13.9</td>
<td>796.57</td>
<td>14.1</td>
<td>+14.38</td>
</tr>
<tr>
<td>Mixed and Mixed Grain Systems</td>
<td>925.42</td>
<td>16.4</td>
<td>875.61</td>
<td>15.6</td>
<td>-49.81</td>
</tr>
<tr>
<td>Hay and Grazing Systems</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Idle Land (5-10 years)</td>
<td>67.38</td>
<td>1.2</td>
<td>85.82</td>
<td>1.5</td>
<td>+18.44</td>
</tr>
<tr>
<td>Idle Land (10+ years) and Hay Systems</td>
<td>248.40</td>
<td>4.4</td>
<td>190.95</td>
<td>3.4</td>
<td>-57.45</td>
</tr>
<tr>
<td>Forest</td>
<td>231.06</td>
<td>4.1</td>
<td>235.71</td>
<td>4.2</td>
<td>+4.65</td>
</tr>
<tr>
<td>Built-Up Areas</td>
<td>2983.95</td>
<td>53.0</td>
<td>2983.95</td>
<td>53.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5630.81</td>
<td>100.0</td>
<td>5630.81</td>
<td>100.0</td>
<td>0</td>
</tr>
</tbody>
</table>
B5.2 Non-Point Source Pollution

The section identifies the relative contributions of land management and cropping practices to stream loading under current conditions. Potential Average Annual Soil Loss and Delivery Ratios were estimated under cropping and management factors in light of the subwatershed's inherent soil, landform and natural vegetation character. An Environment Canada model based on the Universal Soil Loss Equation was used to estimate surface soil erosion and sediment delivery ratios. Specific details of the modelling are provided in the Technical Appendix.

Table B.8 summarizes the potential soil losses based on the up-to-date agricultural land use mapping, and provides a comparison against potential soil loss based on the 1983 land use information. Map B6 illustrates the distribution of potential soil loss throughout the agricultural areas of the subwatershed.

Table B.9 outlines the soil losses in the Pottersburg Creek and Crumlin Drain subwatersheds under tillage conditions of total conventional, current conservation and total conservation practices.

Under current (1994) conditions within the subwatersheds, conservation tillage practices occur on about 100 ha, or 4 percent of the cultivated agricultural land base. Conservation tillage practices presently account for an overall 3 percent reduction in potential soil loss on an annual basis. Reductions are greatest in areas of continuous row cropping systems on lands of medium potential soil loss (6.3%) and in areas of corn systems on lands of medium potential soil loss (6%). All other areas of potential annual soil loss and cropping systems were mostly devoid of conservation tillage practices.

A determination of reduction in soil loss under conditions of conservation tillage throughout the subwatersheds was made so as to illustrate the degree of sediment load reduction possible through shifts to best management practices. Table B.10 outlines the potential reductions in soil losses achievable as a percentage of overall soil loss reduction in relation to the amount of land base on which the system and soil loss classification is found. Greatest response and benefit from efforts to reduce sediment loading through conservation tillage initiatives would be realized through the targeting of areas having the greatest potential for reduction on the smaller land bases. Upon further examination of results presented in Table B.10, the greatest amounts of soil loss take place on a relatively small proportion of land. For example, a move towards conservation tillage practices within all remaining and unpracticing continuous row cropping would realize a quarter (i.e. 25.1%) of the overall potential reduction but need extend only to a sixtieth (15.5%) of the land base. If all mixed rotational systems were further included, almost 60 percent of the total potential soil loss reduction could be achieved by delivering conservation tillage programs to under half (i.e. 40.9%) of the total unbuilt area of the subwatersheds. The effectiveness of a program in which key areas for the delivery of conservation tillage are identified may be frustrated due to the general homogeneity of the land base and the distribution of the cropping system types. The medium potential annual soil loss class lands support the majority of agricultural activities to which programs would be delivered and the reductions achievable are mostly of even proportions in terms of the system land base distribution. While the targeting of continuous row cropping systems is a logical initiative, effective extension of the program to corn and mixed rotational systems would require more study as to the relative contributions of individual farm operation characteristics to stream loading.

Current (1994) Sediment Load Priority Management Areas for the Pottersburg Creek and Crumlin Drain subwatersheds are depicted in Map B7. The map locates priority management areas and assumes no remedial measures are in place. In this format, areas of priority management which are integral to relevant long term sediment load control are identified. If appropriate remedial measures are currently in place, monitoring of the higher priority areas should be performed to ensure the measures' continued integrity, effectiveness and potential for enhancement.

B.21
<table>
<thead>
<tr>
<th>Potential Soil Loss Classification</th>
<th>1983 Area (ha)</th>
<th>1983 % of Total</th>
<th>1983 Potential Soil Loss (t/ha/yr)</th>
<th>1994 Area (ha)</th>
<th>1994 % of Total</th>
<th>1994 Potential Soil Loss (t/ha/yr)</th>
<th>Change Area (ha)</th>
<th>Change % of Total</th>
<th>Change Potential Soil Loss (t/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.29</td>
<td>0</td>
<td>21</td>
<td>+2.29</td>
<td>0</td>
<td>+21</td>
</tr>
<tr>
<td>M</td>
<td>2041.79</td>
<td>36.3</td>
<td>9188</td>
<td>2059.05</td>
<td>36.8</td>
<td>9310</td>
<td>+27.26</td>
<td>+0.5</td>
<td>+123</td>
</tr>
<tr>
<td>L</td>
<td>545.79</td>
<td>9.7</td>
<td>&lt;1092</td>
<td>516.08</td>
<td>9.2</td>
<td>1032</td>
<td>-29.71</td>
<td>-0.5</td>
<td>-60</td>
</tr>
<tr>
<td>U</td>
<td>3043.23</td>
<td>54.0</td>
<td>---</td>
<td>3043.39</td>
<td>54.0</td>
<td>---</td>
<td>+0.16</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
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<td>100.0</td>
<td>10280</td>
<td>5630.81</td>
<td>100.0</td>
<td>10363</td>
<td>N/A</td>
<td>N/A</td>
<td>+84</td>
</tr>
<tr>
<td>Cropping System</td>
<td>All Conventional Tillage</td>
<td>Current (1994) Conservation Tillage</td>
<td>All Conservation Tillage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Total</td>
<td>Very High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Continuous Row Crop</td>
<td>0</td>
<td>0</td>
<td>2079</td>
<td>15</td>
<td>2094</td>
<td>0</td>
<td>0</td>
<td>1950</td>
<td>15</td>
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<tr>
<td>Corn Rotational System</td>
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<td>3573</td>
<td>5</td>
<td>3578</td>
<td>0</td>
<td>0</td>
<td>3360</td>
<td>5</td>
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<td>Mixed Grain System</td>
<td>0</td>
<td>0</td>
<td>860</td>
<td>4</td>
<td>864</td>
<td>0</td>
<td>0</td>
<td>860</td>
<td>4</td>
</tr>
<tr>
<td>Mixed Rotational System</td>
<td>0</td>
<td>21</td>
<td>3040</td>
<td>237</td>
<td>3298</td>
<td>0</td>
<td>21</td>
<td>3040</td>
<td>237</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>529</td>
<td>529</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>529</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>21</td>
<td>9552</td>
<td>790</td>
<td>10343</td>
<td>0</td>
<td>21</td>
<td>9210</td>
<td>790</td>
</tr>
</tbody>
</table>

NOTES:

- Very High - >11 t/ha/yr
- High - 7-11 t/ha/yr
- Medium - 2-7 t/ha/yr
- Low - <2 t/ha/yr
### TABLE B.10

Possible Reductions in Potential Annual Soil Loss Through Adoption of Conservation Tillage by Cropping System and Soil Loss Classification

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>Soil Loss Classification *</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Reduction</td>
<td>% Land Base</td>
<td>% Reduction</td>
<td>% Land Base</td>
<td>% Reduction</td>
<td>% Land Base</td>
<td>% Reduction</td>
<td>% Land Base</td>
<td>% Reduction</td>
<td>% Land Base</td>
<td>Total</td>
</tr>
<tr>
<td>Continuous Row Crop</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>25.1</td>
<td>15.5</td>
<td>0.2</td>
<td>0.3</td>
<td>25.3</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>Corn Rotational System</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>33.2</td>
<td>28.3</td>
<td>0.1</td>
<td>0.1</td>
<td>33.3</td>
<td>28.4</td>
<td></td>
</tr>
<tr>
<td>Mixed Grain System</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>5.5</td>
<td>7.2</td>
<td>0.1</td>
<td>0.1</td>
<td>5.6</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>Mixed Rotational System</td>
<td>---</td>
<td>---</td>
<td>0.2</td>
<td>0.1</td>
<td>33.0</td>
<td>25.4</td>
<td>2.6</td>
<td>4.5</td>
<td>36.8</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>Other and Existing Conservation Tillage</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>3.7</td>
<td>---</td>
<td>14.8</td>
<td>---</td>
<td>18.5</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>---</td>
<td>---</td>
<td>0.2</td>
<td>0.1</td>
<td>96.8</td>
<td>80.1</td>
<td>3.0</td>
<td>19.8</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

* Very High - >11 t/ha/yr  
High - 7-11 t/ha/yr  
Medium - 2-7 t/ha/yr  
Low - <2 t/ha/yr
The potential for higher priority management class lands in the Pottersburg Creek and Crumlin Drain subwatersheds is mitigated by both the generally level topographical character and predominance of rotational agricultural land use systems. Product mapping reveals only a small area in the Crumlin Drain as being of high priority management class. Areas of a medium priority management class are generally adjacent to the streambeds and follow the courses up through to headwater regions. Low priority areas for sediment load management predominate in headwater regions. Topographies here are generally flat to depressional and many of these areas are under permanent forest cover.

B5.3 Rural Point Loading Sources

This section of the report identifies the relative contributions of livestock management and supporting infrastructure to coliform and phosphorus loading under current and hypothetical remedial conditions. Livestock stream access and milkhouse waste were considered as continuous inputs. Manure storage/feedlot runoff and manure spread runoff were considered as pulse or rainfall event contributors.

B5.3.1 Clean-up Rural Beaches (Curb) Model

The CURB model used in this study for estimating point source contributions is based on formulas developed from the UTRCA (Hayman, 1988) from a Pollution from Livestock Operations Predictor (PLOP) developed by Ecologistics Limited (1988). Changes and generalizations were required to these models in the current study because some of the more detailed site specific and operator survey information was unavailable at the current study’s level of reconnaissance.

The UTRCA CURB model endeavours to consider all sources of coliform and phosphorus inputs associated with rural point sources, including septic systems and sewage, and urban non-point sources. On site investigation and interviews were not conducted in the current study and therefore the level of detail was limited to that available from roadside reconnaissance and interpretation. Livestock access, milkhouse wastes, manure/feedlot runoff and manure spreading information was gathered and recorded with a data collection emphasis on those livestock operations within 150 m of a watercourse.

A summary of average values depicting typical operation inputs of the various sources is provided in Table B.11. Within the Pottersburg Creek and Crumlin Drain subwatersheds, a total of 32 livestock operations were identified and of which 8 were within 150 m of an open watercourse and 9 were considered of potential high priority ranking.

B5.3.2 Point Loading Source Model Results

The CURB model results provide estimates of daily and annual pollutant loading rates. Detailed model results are provided in the Technical Appendix. A general discussion on the effect of point sources is provided below.

Of the sources considered, livestock access contributes 92 percent of the raw fecal coliform input on a continuous daily basis and 81 percent annually in spite of its consideration as an input for only 180 days of a given year. During an event situation, livestock access contributes more than 63 percent of total raw coliform input. On an annual basis, raw coliform input from livestock access of 180 days is almost 6 times that of total event-related input. It is apparent that livestock access can be a major contributor to raw fecal coliform inputs in comparison to other considered sources in the Pottersburg Creek and Crumlin Drain subwatersheds.
Total Phosphorus

Milkhouse wastes contribute 92 percent of total phosphorus input on a daily continuous basis and 98 percent of continuous input annually. During a single event condition, manure/feedlot runoff may contribute 39 percent of total input phosphorus. On an annual basis, however, milkhouse wastes appear to be the largest single contributor of the sources considered, providing 98 percent of total continuous input and 6 times in excess of annual total pulse inputs.

B5.3.3 Priority Management Areas

The assessment of priority ranking to a given livestock operation was performed by first determining an average or typical situation within the subwatersheds (Table B.11) and then comparing individual operations to this information. Emphasis was placed on those operations within 150 m of the watercourse and livestock head above the subwatersheds average. In consideration of a potential inconclusive assessment of milkhouse waste contributions at the reconnaissance level, all apparent dairy operations were identified. Overt evidence of in-place remedial measures was considered in the overall ranking.

Continuous Loading

Livestock Access

Unhindered livestock access to Pottersburg Creek and Crumlin Drain tributaries was observed at 5 of the 32 livestock operations in the subwatersheds (Map B8). Of the 5, 2 access locations supported herds in excess of the average herd size of 28 head. These 2 locations may provide up to 71 percent of the total raw fecal coliform input related to livestock access in the subwatersheds.

Milkhouse Wastewater

Twelve livestock operations in the subwatersheds support dairy cattle breeds although observation at the reconnaissance level could not confirm milkhouse infrastructure at all of these locations. Three of the twelve operations were located within 150 m of a streamcourse (Map B8). If untreated direct discharge or baseflow of milkhouse wastewater from these operations is assumed, then their contributions to overall point source phosphorus input on an annual basis may reach 25 percent of the sources considered.

Pulse or Event Loading

Feedlot/Manure Storage

Eight livestock operations have manure storage or feedlot areas ranging in size from approximately 100 to 500 m² and are located within 150 m of an open watercourse. Up to seven of these operations have the potential for runoff occurrence with four of these having feedlot/storage areas in excess of average for the subwatersheds (i.e. >306 m²). These four operations, however, have been identified as high priority for reasons other than potential manure/feedlot runoff sources.
<table>
<thead>
<tr>
<th></th>
<th>Subwatersheds Area (ha)</th>
<th>Livestock Operations (#)</th>
<th>Density (#/km²)</th>
<th>Livestock Access</th>
<th>Milkhouse Washwater</th>
<th>Feedlot/Manure (150 m)</th>
<th>Potential High Priority Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (Agricultural Land Base)</td>
<td>5,631</td>
<td>32</td>
<td>0.57</td>
<td>Sites (#)</td>
<td>Discharge Sources (#)</td>
<td>Sources (#)</td>
<td>Density (#/km²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>12</td>
<td>8</td>
<td>0.14 (0.30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average Length of Access (m)</td>
<td>Density (#/km²)</td>
<td>Density (#/km²)</td>
<td>Average Storage Area (m²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>130</td>
<td>28</td>
<td>306</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average Animal Units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Density (#/km²)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.19)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Spills

No agricultural operation-related spills have been reported to the MOEE in the Pottersburg Creek and Crumlin Drain subwatersheds in the past two years (P. Huras, pers. comm.).

At this level of study, MOEE reports of spills are the best available source of information. No indications of recent spills were forthcoming during field survey. A better idea of the extent of spills and particularly those that go unreported will require more in-depth study and landowner contact together with some moral suasion to reduce the report compelling thresholds.

Manure Spread

The spreading of livestock manure on fields is an economic, environmentally sound and beneficial fertility and soil management practice if conducted in a logical and responsible manner. Problems arise mainly from overspreading (i.e. too many animal units per unit area) or the application in proximity to a receiving surface watercourse. The estimated livestock unit to farm acreage ratio is 0.4 which is less than the "best" rating of 0.5 as provided by OMAFRA (1994). No farms were assessed as being priority on the basis of coliform or phosphorus inputs resulting from the spreading of manure.

5.4 Summary and Conclusions

An inventory of agricultural land use, land base and agricultural activities was undertaken in the Pottersburg Creek and Crumlin Drain subwatersheds for the purposes of modelling the contribution of rural point and non-point sources to stream loading.

The distribution and proportions of cropping system types in the subwatersheds have remained relatively static over the past decade, with only small increases in the incidence of continuous row cropping and corn systems, mostly at the expense of hay and mixed systems. Conversion of agricultural or rural land to built-up or developed land has not been evident. Cropping system changes have resulted in a relatively very small increase of less than 1 percent in potential annual soil losses due to erosion. The majority of lands are of a medium potential annual soil loss class (2 to 7 t/ha/yr) and no significant areas of high management priority were identified. Conservation tillage practices are currently in use at a number of areas in the subwatersheds, but could be further extended to key areas to realize a substantial reduction in actual sediment loading to surface waters. A program targeting continuous row cropping and corn rotational systems in areas of medium potential soil loss may realize 60 percent of the soil loss reductions possible and need to cover less than half of the agricultural land base. If best management tillage practices were extended to all operations, a reduction of 33 percent in potential annual soil losses could be realized, bringing annual losses to about 6900 tonnes or an average of 2.7 tonnes per year for each hectare of non-urban land.

Riparian buffer strips and forests are best management practice land uses deemed effective in reducing stream loading. In the Pottersburg Creek and Crumlin Drain subwatersheds, riparian character is mostly appropriate for the effective filtering of surface loading sediments. Some headwater areas where tillage is occurring through the streambed would benefit from the establishment of grassed waterways.

A number of agricultural operations in the subwatersheds were identified as potential point source contributors. Of the sources considered, livestock access contributes more than 92 percent of the raw fecal coliform input on a continuous daily and 81 percent on an annual basis. Two of the five access areas identified may provide up to 71 percent of this input. Of the point sources considered, milkhouse waste may contribute up to 98 percent of annual continuous phosphorus loading.
In the Pottersburg Creek and Crumlin Drain subwatersheds, land use and tenure have apparently remained relatively static over the past decade. In the Pottersburg Creek area, this condition may be due to the location of the airport lands which act as a buffer between the rural and built-up sections of the subwatersheds. Any changes in land tenure and economies have not overly influenced land use to the point where the contributions of rural point and non-point source loadings have been greatly affected. While it is apparent that some efforts have been made to mitigate loadings at many of the traditional source problem locations, a continued program in key rural areas of the subwatersheds would further improve the quality of water entering the urban reaches of Pottersburg Creek and the Crumlin Drain.
B6.0 WATER QUALITY

A detailed water quality monitoring program was carried out by the Upper Thames River Conservation Authority for the Pottersburg Creek and Crumlin Drain subwatersheds. This section summarizes the results of the UTRCA monitoring program.

Summaries of the water quality results for Pottersburg Creek and Crumlin Drain are presented in Tables B.12 and B.13, respectively. Surface water samples were taken between August 1993 and June 1994 for two locations on Pottersburg Creek and three locations on Crumlin Drain. The sampling locations included:

Pottersburg Creek
- Station 1 - Oxford and Crumlin downstream of bridge (PA);
- Station 2 - Bridge at Trafalgar Road (PL);

Crumlin Drain
- Station 1 - Highway 2 (C2);
- Station 2 - Storm drain at Crumlin Road (CS); and
- Station 3 - Logger box culvert at Gore Road.

Sampling events covered both wet weather and dry weather conditions, that input, explains the wide range in parameter values measuring during the monitoring program.

The water quality monitoring program tested the water samples for a wide-array of parameters. The parameter results in Table B.12 and Table B.13 were selected since they are typically the ones most impacted by land use change. The parameters can be broken down into the following classes:

- Bacteria;
- Nutrients;
- Heavy metals;
- Dissolved oxygen; and
- Water temperature.

Stations from Pottersburg Creek urban areas exhibit lower E. Coli bacteria levels than Crumlin Drain, which is mostly agricultural. Agricultural land use is dominated by cultivated crops and pasture which might provide coliform inputs into the system.

Nutrients such as nitrate and total phosphorus are an essential element for aquatic life. However, excessive amounts of nutrients can lead to uncontrolled algae and plant growth. High levels of nutrients are most often associated with agricultural land use. Total phosphorus concentrations were in excess of the recommended 0.03 mg/l for all stations. Total phosphorus has the most stringent guidelines and is typically the limiting factor with respect to nutrients. Generally, higher metal concentrations can be associated with urban land use. However, the sampling did not indicate a higher trend in the median concentration of metals in more urban areas.

The maximum water temperature recorded in either stream was 23.5°C. This occurred in Pottersburg Creek at Trafalgar Road in May of 1994. The dissolved oxygen concentration ranged from a low of 2 mg/l in August of 1993 (Station 1 - Crumlin Drain) to a high of 15.0 mg/l (Station 2 - Pottersburg Creek) in February of 1994. Pottersburg Creek, in general, had dissolved oxygen levels in excess of the recommended guidelines for cold water species (Water Quality Report, UTRCA, 1994). A threshold range of dissolved oxygen for which cold water fish species can survive is between 5 to 9.5 mg/l.
<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Provincial Guidelines</th>
<th>National Guidelines</th>
<th>Station Number</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Station 1</td>
<td>Station 2</td>
<td>Station 1</td>
<td>Station 2</td>
<td>Station 1</td>
<td>Station 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
</tr>
<tr>
<td>E. Coli Bacteria (Count/100 ml)</td>
<td>100</td>
<td>--</td>
<td>10</td>
<td>3100</td>
<td>1000</td>
<td>10</td>
<td>4203</td>
<td>1000</td>
</tr>
<tr>
<td>(Recreational Swimming)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Solids (mg/l)</td>
<td>--</td>
<td>&lt; 10% of background levels (aquatic)</td>
<td>11.7</td>
<td>43.9</td>
<td>21.0</td>
<td>6.0</td>
<td>74.4</td>
<td>43.8</td>
</tr>
<tr>
<td>Ammonia¹ (mg/l)</td>
<td>--</td>
<td>0.08 - 2.5</td>
<td>0.013</td>
<td>0.471</td>
<td>0.065</td>
<td>0.005</td>
<td>0.383</td>
<td>0.018</td>
</tr>
<tr>
<td>(temp + pH dependent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>--</td>
<td>10.0 (drinking water)</td>
<td>0.8</td>
<td>6.1</td>
<td>4.0</td>
<td>0.9</td>
<td>4.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Total Phosphorus (mg/l)</td>
<td>0.03</td>
<td>--</td>
<td>0.011</td>
<td>0.214</td>
<td>0.039</td>
<td>0.011</td>
<td>0.179</td>
<td>0.096</td>
</tr>
<tr>
<td>Potassium (mg/l)</td>
<td>--</td>
<td>2.0</td>
<td>4.3</td>
<td>2.6</td>
<td>1.6</td>
<td>3.8</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>4 (warm water)</td>
<td>6 (warm water)</td>
<td>2.8</td>
<td>14.1</td>
<td>9.2</td>
<td>5.3</td>
<td>15.0</td>
<td>11.5</td>
</tr>
<tr>
<td>9.5 (cold water) (Aquatic Life)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper² (ug/l)</td>
<td>5 ug/l (Aquatic)</td>
<td>1.0 mg/l (drinking water)</td>
<td>0.002</td>
<td>0.006</td>
<td>0.005</td>
<td>0.003</td>
<td>0.014</td>
<td>0.008</td>
</tr>
<tr>
<td>Iron (mg/l)</td>
<td>0.3 mg/l (aquatic)</td>
<td>0.3 mg/l (aquatic &amp; drinking water)</td>
<td>0.150</td>
<td>0.690</td>
<td>0.422</td>
<td>0.080</td>
<td>1.580</td>
<td>0.740</td>
</tr>
<tr>
<td>Lead² (mg/l)</td>
<td>&lt;0.025 mg/l (aquatic)</td>
<td>0.05 mg/l (drinking water)</td>
<td>0.015</td>
<td>0.000</td>
<td>0.015</td>
<td>0.015</td>
<td>0.060</td>
<td>0.015</td>
</tr>
<tr>
<td>Manganese (mg/l)</td>
<td>--</td>
<td>0.05 (aesthetics)</td>
<td>0.018</td>
<td>0.139</td>
<td>0.040</td>
<td>0.007</td>
<td>0.107</td>
<td>0.053</td>
</tr>
<tr>
<td>Water Quality Parameter</td>
<td>Provincial Guidelines</td>
<td>National Guidelines</td>
<td>Station Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-------------------------</td>
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<td></td>
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<td>Station 1</td>
<td>Station 2</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
</tr>
<tr>
<td>Zinc (mg/l)</td>
<td>0.03 (aquatic)</td>
<td>5 (drinking water)</td>
<td>0.003</td>
<td>0.030</td>
<td>0.010</td>
<td>0.017</td>
<td>0.050</td>
<td>0.016</td>
</tr>
<tr>
<td>Water Temperature (°C)</td>
<td>--</td>
<td>--</td>
<td>1.0</td>
<td>21.5</td>
<td>13.6</td>
<td>1.5</td>
<td>23.5</td>
<td>14.8</td>
</tr>
</tbody>
</table>

NOTES: Exceeds provincial guidelines.
Min  Minimum
Max  Maximum
Med  Median
--  data not available
1. Where a range has been specified, concentrations vary due to temperature and pH.
2. Where a range has been specified, concentrations vary due to $\text{CO}_2$ concentrations.
### TABLE B.13

Summary of Water Analysis at Three Stations on Crumlin Drain  
(August 1993 - June 1994)

<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Provincial Guidelines</th>
<th>National Guidelines</th>
<th>Station Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Station 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>E. Coli Bacteria</td>
<td>100</td>
<td>--</td>
<td>180</td>
</tr>
<tr>
<td>(Count/100 ml)</td>
<td>(Recreational Swimming)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended Solids (mg/l)</td>
<td></td>
<td>&lt; 10% of background levels (aquatic)</td>
<td>8.7</td>
</tr>
<tr>
<td>Ammonia¹ (mg/l)</td>
<td></td>
<td>0.08 - 2.5 (temp + pH dependent)</td>
<td>0.023</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td></td>
<td>10.0 (drinking water)</td>
<td>0.1</td>
</tr>
<tr>
<td>Total Phosphorus (mg/l)</td>
<td>0.03</td>
<td>--</td>
<td>0.045</td>
</tr>
<tr>
<td>Potassium (mg/l)</td>
<td></td>
<td>--</td>
<td>2.4</td>
</tr>
<tr>
<td>Copper² (ug/l)</td>
<td>5 ug/l (Aquatic)</td>
<td>1.0 mg/l (drinking water)</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>2-6 ug/l (aquatic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (mg/l)</td>
<td>0.3 mg/l (aquatic)</td>
<td>0.3 mg/l (aquatic &amp; drinking water)</td>
<td>0.106</td>
</tr>
<tr>
<td>Lead² (mg/l)</td>
<td>.025 mg/l (aquatic)</td>
<td>0.05 mg/l (drinking water)</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>1-7 ug/l (aquatic)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B.36
**TABLE B.13**

Summary of Water Analysis at Three Stations on Crumlin Drain
(August 1993 - June 1994)

<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Provincial Guidelines</th>
<th>National Guidelines</th>
<th>Station Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>Manganese (mg/l)</td>
<td>–</td>
<td>0.05 mg/l (aesthetics)</td>
<td>0.047</td>
</tr>
<tr>
<td>Zinc (mg/l)</td>
<td>0.03 mg/l (aquatic)</td>
<td>5 mg/l (drinking water)</td>
<td>0.009</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>4 (warm water)</td>
<td>6 (warm water)</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>9.5 (cold water)</td>
<td>9.5 (cold water)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Aquatic Life)</td>
<td>(aquatic life)</td>
<td></td>
</tr>
<tr>
<td>Water Temperature (°C)</td>
<td>–</td>
<td>–</td>
<td>1.1</td>
</tr>
</tbody>
</table>

**NOTES:**
- **Exceeds provincial guidelines.**
- Min, Maximum, Median
- data not available
- 1. Where a range has been specified, concentrations vary due to temperature and pH.
- 2. Where a range has been specified, concentrations vary due to CaCO₃ concentrations.
Based on the summary presented herein, and the water quality and quantity monitoring program results from the UTRCA, a number of parameters were identified at above average levels in Pottersburg Creek and Crumlin Drain. These included:

- E. Coli bacteria;
- Dissolved solids;
- Nitrite;
- Calculated hardness;
- Sodium;
- Beryllium; and
- Manganese.

The documentation also indicated that the respective creeks maintained higher water quality in relation to the other creeks in regard to:

<table>
<thead>
<tr>
<th>Crumlin Drain</th>
<th>Pottersburg Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temperature; and</td>
<td>• Dissolved oxygen;</td>
</tr>
<tr>
<td>• Nitrate</td>
<td>• Temperature;</td>
</tr>
<tr>
<td></td>
<td>• Phosphorus;</td>
</tr>
<tr>
<td></td>
<td>• Aluminum; and</td>
</tr>
<tr>
<td></td>
<td>• Titanium.</td>
</tr>
</tbody>
</table>

The remaining water quality parameters were considered to be at acceptable levels in both Pottersburg Creek and Crumlin Drain.

Based on the summary presented herein and the water quality and quantity monitoring program results from the UTRCA, the water quality in Pottersburg Creek and Crumlin Drain is typical for the land uses within the subwatersheds. Nutrients are elevated throughout the subwatershed. This, combined with the high bacteria counts in the upper reaches of the subwatershed, supports the findings of the detailed study on Rural Point and Non Point Source Pollution. Agricultural land uses in the upper reaches of the creek system are likely responsible for elevated nutrients and bacteria loadings.

The urban areas of the subwatershed tended to have higher heavy metal concentrations. This is indicative of typical urban runoff.

**B7.0 AQUATIC RESOURCES**

The detailed study of aquatic resources involved extensive field sampling and analysis of benthic macroinvertebrates and fish found in watercourses throughout the Pottersburg Creek and Crumlin Drain subwatersheds. The inventory and analysis of aquatic resources was completed by BEAK Consultants Limited (1994).

The main objectives of the aquatic resources detailed study were to:

1) Use quantitative and qualitative sampling to evaluate the existing fisheries, fish habitat and benthic invertebrates in Pottersburg Creek and Crumlin Drain and its tributaries;

2) Identify significant fisheries components (i.e. spawning and nursery habitat, migration routes, rare and sportfish etc.);

3) Use benthic-invertebrates information to describe the health of the subwatershed; and
4) To prepare an overall strategy for aquatic resources in the subwatershed which identifies opportunities for protection, enhancement and/or restoration that is consistent with future development in the subwatershed.

The following is a brief summary of the results of the field studies completed by BEAK (1994) which addresses objectives 1, 2 and 3. (Strategies for aquatic resources protection, enhancement and/or restoration are discussed in Parts C and D). For more detailed information on aquatic resources management in Pottersburg Creek and Crumlin Drain, refer to BEAK (1994).

**B7.1 Benthic Invertebrates**

Benthic invertebrates were sampled at 11 locations in Pottersburg Creek and Crumlin Drain noted in Map B9. Sampling locations were based on the results of field reconnaissance that considered stream order, adjacent land use, point source locations and stream morphology. Two reference stations (R1 and R2) also sampled were selected on the basis of the extent of riparian cover, and represented healthy benthic macroinvertebrate communities.

Data analysis techniques used consisted of biotic indices and statistical applications. Briefly they are summarized as:

**Biotic Indices**

- Number of taxa per sample, number of taxa per station, and taxa density (per m²);
- Presence or absence of indicator species;
- EPT index (used as a relative measure of pollution-sensitive invertebrates);
- Bio Map Water Quality Index (WQI);
- Percent contribution of dominant taxa;
- Hydropsychidae/trichoptera index; and
- Percent abundance of shredders.

**Statistical Applications**

- Cluster analysis for grouping stations with similar features;
- Discriminant analysis;
- Correlation-matrix analysis for relating observations with land use;
- Bivanate plots for determining the linearity of relationships with land use; and
- Multiple-regression analysis for use in predicting biotic metrics.

Table B.14 summarizes the methodology used to classify invertebrate communities.
### TABLE B.14
Framework of Aquatic Ecosystem Goals and Objectives
For London Area Subwatershed Management Plans

<table>
<thead>
<tr>
<th>Restoration/Rehabilitation/Enhancement</th>
<th>Mitigation/Protection</th>
<th>Degradation/Disturbance/Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type IA Intolerant Coldwater Community</td>
<td>Type IIA Highly Diverse Warmwater Community</td>
<td>Type IVA Tolerant Warmwater Community</td>
</tr>
<tr>
<td>Type IB Tolerant Coldwater Community</td>
<td>Type IIB Diverse Warmwater Community</td>
<td>Type IVB Highly Tolerant Warmwater Community</td>
</tr>
<tr>
<td>Type V No Aquatic Community</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**INVERTEBRATES**

<table>
<thead>
<tr>
<th>Type I Stable Coldwater Community</th>
<th>Type II Stable Warmwater Community</th>
<th>Type III Unstable Warmwater Community</th>
<th>Type IV Impaired Warmwater Community</th>
<th>Type V Severely Impaired Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>WQI &gt; 13 EPT ≥ 15</td>
<td>WQI &gt; 12 EPT ≥ 10</td>
<td>WQI 10-12 EPT ≥ 5</td>
<td>WQI 6-10 EPT ≤ 2</td>
<td>WQI ≤ 6 EPT ≤ 2</td>
</tr>
</tbody>
</table>

At least four of the following:

- Amphipinmenura
- Leuctra
- Haploperla
- Ectopria
- Heterotrissocladius
- Eukiefferiella
- Rhyacophila

At least five of the following:

- Acronura
- Isoperla
- Taniopteryx
- Paraleptophlebia
- Serratella
- Chirono
- Rhyacophila
- Diamesa
- Lumbriculus variegatus
- Turbellaria
- Eukiefferiella

At least six of the following:

- Turbellaria
- Baetis
- Caenis
- Stenacron
- Tricorythodes
- Cheumatopsyche
- Hydropsyche
- Neophylax
- Optioservus
- Steninla
- Micropsectra
- Simuliidae

At least four of the following:

- Sialis
- Berosus
- Cheumatopsyche
- Hydropsyche
- Dubiraphia
- Proboezia
- Cryptochironomus
- Paratanytarsus
- Rhenotanytarsus
- Chaetocladius
- Hemerodromia
- Helobdella

At least five of the following:

- Nais
- pardalis/bretsch eri
- Limnodrilus
- hoffmeisteri
- L. claparedianus
- Tubifex
- Sparganophilus
- Berosus
- Proboezia
- Chironomus
- Phyla

**NOTES:**

1) Blacknose shiner, sand shiner, rosieface shiner, river chub.
2) Hornyhead chub, emerald shiner, common shiner, blacknose shiner, striped shiner, spottail shiner, rosieface shiner, spotfin shiner, sand shiner, redfin shiner, blacknose dace, longnose dace, mimico shiner.
3) Fathead minnow, northern redbelly, blunt nose minnow, goldfish, creek chub, brassy minnow, golden shiner.
Water Quality Index Results

The Water Quality Index ratings at the sampling stations in Pottsburgh Creek and Crumlin Drain are summarized in Table B.15. Based on the WQI ratings, all stations in Pottsburgh Creek were impaired with the exception of Station B8 which was unimpaired. In Crumlin Drain, the WQI ratings indicated that water quality was impaired through the subwatershed.

Cluster Analysis Results

The results of the benthic invertebrate sampling for all subwatersheds were compiled for cluster analysis.

Pottsburgh Creek stations 1, 2, 3 and 11 fell within Cluster 5, which were characterized by invertebrate communities reflecting the poorest water quality reaches in all of the London subwatersheds. The other four quantitative stations (5, 6, 8 and 9) were in Cluster 3, which exhibit moderately-impaired water quality. These Pottsburgh Creek stations were dominated by facultative to tolerant taxa, but also had high numbers of mayflies and taxa, and low numbers of oligochaetes.

The cluster analysis placed stations 2, 3 and 4 in Cluster 5, representing the poorest water quality in the London subwatersheds. Station 5 was grouped in Cluster 4, considered a moderately-stressed community, and Station 1 was in Cluster 3 which represents the second-least stressed invertebrate community.

B7.2 Fish Populations

BEAK Consultants Limited completed a fisheries study of Stoney Creek in 1994. Sampling was completed at ten locations in Pottsburgh Creek and seven locations in Crumlin Drain noted in Map B9. Detailed information regarding sampling locations and protocols is available in the Aquatic Resources Management report prepared by BEAK (1994).

The BEAK fisheries data were evaluated with the use of an Index of Biotic Integrity (IBI). IBI analysis incorporates a range of ecological characteristics (species richness and composition, trophic composition, etc.) as described by 11 metrics (number of native fish species, number of darter species, proportion of omnivorous cyprinids, etc.). The attributes are assigned values of 5, 3, or 1, from "best" to "worst", according to whether the value is similar to, deviates from, or differs strongly from expected values. Expected values were determined based on published literature sources. Sites of highest quality have the highest scores, typically in the range of 49 to 55. Based on the scores, health categories are assigned ranging from "excellent" to "very poor". Table B.16, and Table B.17 summarize the IBI results at the sixteen sampling locations for Pottsburgh Creek and Crumlin Drain respectively, and one additional station downstream on Waubuno Creek above its confluence with the Thames River.

Game fish are essentially absent from the Pottsburgh Creek subwatershed with the exception of smallmouth bass at one location in Pottsburgh Creek. The fish community is primarily dominated by suckers and minnows. The IBI (Index of Biological Integrity) results indicated that eight stations are poor, and two (stations 1 and 10) are fair. The better quality stations are situated near the headwaters and mouth of Pottsburgh Creek. Two provincially significant fish species were documented in Pottsburgh Creek: central stoneroller and greenside darter. The stoneroller was found at stations 1, 2, 3, 6, 7 and 10, while the presence of greenside darter was confirmed only at Station 1.

Within Crumlin Drain, only 12 species of fish were caught. Other studies have reported three additional fish species from Crumlin Drain: northern redbelly dace, yellow bullhead, and longear sunfish.

B.42
<table>
<thead>
<tr>
<th>Station</th>
<th>Total Density (m$^2$)</th>
<th>No. of Taxa (quantitative)</th>
<th>Total Taxa</th>
<th>Water Quality Index</th>
<th>EPT Index</th>
<th>Oligochaeta (%)</th>
<th>Ephemeroptera (%)</th>
<th>Plecoptera (%)</th>
<th>Trichoptera (%)</th>
<th>Coleoptera (%)</th>
<th>Chironomidae (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>15509</td>
<td>55</td>
<td>70</td>
<td>12.43</td>
<td>15</td>
<td>0</td>
<td>12</td>
<td>29</td>
<td>13</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>R2</td>
<td>4935</td>
<td>41</td>
<td>55</td>
<td>11.80</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>8</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Crumlin Drain</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>B1</td>
<td>7079</td>
<td>41</td>
<td>49</td>
<td>8.98</td>
<td>5</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>25</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>B2</td>
<td>9663</td>
<td>35</td>
<td>40</td>
<td>7.24</td>
<td>3</td>
<td>9</td>
<td>2</td>
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<td>9</td>
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<td>5.95</td>
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<td>51</td>
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<td>14249</td>
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<td>4.23</td>
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<td>Pottermoor Creek</td>
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</tr>
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</tr>
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<td>8.64</td>
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<tr>
<td>B8</td>
<td>9021</td>
<td>42</td>
<td>60</td>
<td>12.32</td>
<td>10</td>
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<td>7</td>
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<td>20</td>
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<td>57</td>
<td>6.82</td>
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<td>22</td>
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<td>2</td>
<td>9</td>
<td>1</td>
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</table>

**TABLE B.15**

Summary of Biotic, Ablotic and Land Use Statistics for Reference and Crumlin Drain and Pottermoor Creek Benthic Macroinvertebrate Sampling Stations
### TABLE B.15, continued

**Summary of Biotic, Abiotic and Land Use Statistics for Reference and Pottensburg Creek and Crumlin Drain Benthic Macrincr Alicntracrake Sampling Stations**

<table>
<thead>
<tr>
<th>Station</th>
<th>Gastropoda (%)</th>
<th>Pelecypoda (%)</th>
<th>Hydropsychidae (%)</th>
<th>shredders (%)</th>
<th>D.O (mg/L)</th>
<th>Temperature (°C)</th>
<th>pH</th>
<th>Conductivity (umhos/cm)</th>
<th>Water Velocity (m/sec)</th>
<th>Water Depth (cm)</th>
<th>Stream Order</th>
<th>Stream Width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crumlin Drain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>C1</td>
<td>1</td>
<td>0</td>
<td>100</td>
<td>3</td>
<td>10.9</td>
<td>8</td>
<td>7.6</td>
<td>752</td>
<td>0.40</td>
<td>25</td>
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<td>100</td>
<td>0</td>
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<td>8</td>
<td>7.9</td>
<td>418</td>
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<td>15</td>
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<td>1.5</td>
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<td>1</td>
<td>0</td>
<td>99</td>
<td>0</td>
<td>9.4</td>
<td>8</td>
<td>7.7</td>
<td>848</td>
<td>-</td>
<td>20</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>C4</td>
<td>2</td>
<td>3</td>
<td>80</td>
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<td>1.5</td>
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<td>3</td>
<td>10.3</td>
<td>7</td>
<td>7.8</td>
<td>797</td>
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</tr>
<tr>
<td>B1</td>
<td>5</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>12.4</td>
<td>4</td>
<td>7.9</td>
<td>640</td>
<td>0.50</td>
<td>25</td>
<td>3</td>
<td>8.0</td>
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<tr>
<td>B2</td>
<td>4</td>
<td>15</td>
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<td>7.0</td>
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<td>29</td>
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<td>2</td>
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<td>3</td>
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<td>Poor</td>
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<td>Poor</td>
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TABLE B.16
Summary of Index of Biotic Integrity (IBI) Results, Pottersburg Creek
May 1994
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<td>Very Poor</td>
<td>Poor</td>
<td>Very Poor</td>
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</table>

**TABLE B.17**  
Summary of Index of Biotic Integrity (IBI) Results, (Crumlin Drain)  
May/June 1994
Within Crumlin Drain, the IBI indicated that all stations are poor, very poor, or supported no fish species, except Station 2, which was fair. A single brown trout was caught at Station 7, although the overall IBI indicated poor conditions due to low species diversity (4 species) and a predominance of tolerant minnow species and brook stickleback. Station 2, near the lower end of Crumlin Drain, supported eight fish species including the northern hog sucker, which is relatively intolerant of organic pollution.

At Station 1, situated below Crumlin Drain on Waubuno Creek, 18 fish species were caught, and the IBI indicated good conditions from a fisheries perspective. Intolerant species such as northern hog sucker, river chub, and rosyface shiner were present. This station also supported smallmouth bass and four darter species.

Central stoneroller and greenside darter were also present in Crumlin Drain. The stoneroller was present at stations 1, 2 and 5 and the greenside darter was documented at stations 1 and 2.

For each of five target fish species, a Habitat-Suitability Index (THSI) was developed based on existing models which were modified for the London subwatershed study area. The five fish species were largemouth bass (Micropterus salmoides), smallmouth bass, rainbow trout, brown trout, and green sunfish (Lepomis cyanellus). The THSI models use up to 16 habitat variables which are grouped into 5 habitat components including stream morphology, riparian habitat, instream cover, water temperature, and flow. The geometric mean of these components at each reach was used for the models; however, it should be noted that the THSI analyses did not include potentially important habitat components such as water quality and predator-prey interactions. In addition, it should be noted that the quality of data used for the THSI models was highly variable or absent; and as a result, relatively subjective professional judgement was used to derive some of the input values. Results of the THSI analyses are detailed in the report prepared by BEAK.

Based on the analyses for the fish sampling stations and habitat assessments, reaches of Pottersburg Creek and Crumlin Drain and their tributaries were classified with one of the stream types in Table B.18. Map B10 illustrates the stream-type by reach, based on criteria in Table B.18 and an invertebrate criteria (Table B.14). The stream-type classifications are intended to represent potential self-sustaining communities.

The Pottersburg Creek fish community is predominantly types IV and V. These are tolerant to highly-tolerant warmwater communities and those areas supporting no fish. Upstream of the airport, some order 2 streams are type II or III, and type III communities occur downstream of the airport in some order 3 streams. Type II streams are diverse warmwater streams, and type III communities are moderately-tolerant communities.

The Crumlin Drain aquatic communities are Type IV and V, which include tolerant warmwater communities and severely impaired communities that do not support fish populations. Waubuno Creek near the Thames River is a diverse warmwater fish community. Some of the species documented here may be transients that have moved up from the Thames River.
<table>
<thead>
<tr>
<th>Restoration/Rehabilitation/Enhancement</th>
<th>Mitigation/Protection</th>
<th>Degradation/Disturbance/Damage</th>
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<tr>
<td>Type IA Tolerant Coldwater Community</td>
<td>Type IIA Diverse Warmwater Community</td>
<td>Type III Moderately Tolerant Warmwater Community</td>
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<tr>
<td>Type IIB Intolerant Coldwater Community</td>
<td>Type IIB Diverse Warmwater Community</td>
<td>Type IVA Tolerant Warmwater Community</td>
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<td>Type IVC Highly Tolerant Warmwater Community</td>
<td>Type V No Aquatic Community</td>
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**FISHERIES**

<table>
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<th>Minimum of one of the following fish species:</th>
<th>Minimum of 18 fish species, including at least 6 of the following:</th>
<th>Minimum of 14 fish species, including at least 4 of the following:</th>
<th>Minimum of 10 fish species, including at least 2 of the following:</th>
<th>Minimum of 4 fish species, including at least 1 of the following:</th>
<th>Minimum of 1 of the following fish species:</th>
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</thead>
<tbody>
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<td>• brook trout</td>
<td>• northern hog sucker</td>
<td>• northern hog sucker</td>
<td>• pumpkinseed/bluegill</td>
<td>• carp</td>
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<tr>
<td>• sculpin</td>
<td>• pike</td>
<td>• largemouth bass</td>
<td>• goldfish</td>
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<tr>
<td>• brown trout</td>
<td>• smallmouth bass</td>
<td>• blackside darter</td>
<td>• brown bullhead</td>
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<tr>
<td>• rainbow trout</td>
<td>• Iowa darter</td>
<td>• greenside darter</td>
<td>• brook stickleback</td>
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<tr>
<td>• chinook salmon</td>
<td>• longear sunfish</td>
<td>• redhorse</td>
<td>• central mudminnow</td>
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<tr>
<td>• yellow perch</td>
<td>• Iowa darter</td>
<td>• central stoneroller</td>
<td>• omnivorous minnow</td>
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<tr>
<td>• walleye</td>
<td>• yellow perch</td>
<td>• insectivorous minnow</td>
<td>2</td>
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<tr>
<td>• stonecat</td>
<td>• intolerant minnow</td>
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</tbody>
</table>

**NOTES:**

1) Blacknose shiner, sand shiner, rosiface shiner, river chub.
2) Hornyhead chub, emerald shiner, common shiner, blacknose shiner, striped shiner, spottail shiner, rosiface shiner, spottin shiner, sand shiner, redfin shiner, blacknose dace, longnose dace, mimic shiner.
3) Fathead minnow, northern redbelly, blunt nose minnow, goldfish, creek club, brassy minnow, golden shiner.
Changes in Fisheries Classification System

In March of 1994, the MNR published the Fish Habitat Protection Guidelines for Developing Areas which presented a revised methodology for classifying fisheries habitat. Unfortunately, the aquatic resources component of the study was too far along to revise all of the previously completed work. For this reason, it was decided to make use of the previous MNR Classification System. However, to allow translation of fisheries habitat from the old to the new Classification System, the following general guideline can be applied to watercourses in the Pottersburg Creek and Crumlin Drain subwatersheds.

<table>
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<th>Community Type</th>
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<tr>
<td>IVA, IV, V, IVB</td>
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<tr>
<td>V, IVB</td>
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</table>

Type 1 habitats are defined as critical for the maintenance of productive capacity of the management unit, and require a high level of protection from the effects of development. Type 1 habitats are generally important, as reproductive habitats and fish community utilization may vary considerably on a seasonal basis. Type 1 habitats are generally healthy, stable systems which require little in the way of restoration or rehabilitation.

Type 2 habitats are defined as important but less critical to productive capacity than Type 1 habitats. The Type 2 habitats are generally more common than are Type 1 habitats, and may represent degraded Type 1 habitats which may warrant restoration, enhancement or rehabilitation. These habitat require a moderate level of protection from development activities, but also may have great potential for restoration or enhancement to increase productive capacity in a management unit.

Type 3 habitats are defined as having low productive capacity and do not have reasonable potential for enhancement or restoration. While these habitats are generally extremely degraded, some do support aquatic communities, or potentially affect the productive capacity of aquatic communities in downstream reaches.

B7.3 Limiting Factors

Pottersburg Creek upstream of the airport is degraded primarily due to channelization for agricultural purposes. This results have several effects on aquatic communities.

- There is a lack of riparian habitat. This results in a low input of natural nutrients from leaves, which reduces the number of shredding invertebrates plus the predatory invertebrates and fish that prey on them. In addition, water temperatures are higher due to lack of shading, and there is minimal instream cover from fallen limbs. Instream wood is a requirement for several species of aquatic invertebrates, and it also provides cover, food, and habitat diversity for fish.

- There are few, if any, pools or riffles. Invertebrate and fish species requiring deeper areas or fast-flowing water are usually absent, and there are no winter refugia.

- The substrate tends to be fine (clay, silt, sand) which is unsuitable for most sensitive species of invertebrates and precludes spawning by fish species that require gravel or coarser material.

- Tile drainage and overland flow from agricultural land results in nutrient concentrations that are high enough to promote growth of algae and aquatic macrophytes. This results in overnight oxygen depletion and elimination of sensitive invertebrate and fish species.
At the London Airport, the creek passes under the airport through a large culvert for a considerable distance. This area was not examined during this study, but it may inhibit upstream movement of fish. There may be inadequate flows through the area during low-flow periods due to a large culvert with very shallow water, or water velocities may be too high to permit fish passage.

Downstream of the airport, Pottersburg Creek is channelized and hardened, and it also receives storm water. There is also heavy contamination of the substrate by oily substances. The oils, nutrients, and lack of habitat diversity significantly limit aquatic invertebrate and fish populations.

Below Dundas Road, habitat conditions in Pottersburg Creek improve slightly. This area has a higher gradient, well-sorted riffle areas, and relatively-good riparian habitat. However, there are few pools.

The upper portions of Crumlin Drain are channelized and straightened, with few pools and riffles, and sand is the predominant substrate. These result in the same problems that occur in the upper reaches of Pottersburg Creek.

B8.0 TERRESTRIAL RESOURCES

B8.1 Background and Terrestrial Wetland Policy Development

The terrestrial and wetlands component of the subwatershed plan builds on the Draft Terrestrial Resource Strategy (DTRS) prepared by Terra Geographical Studies Inc. (1994) and incorporates field data collected by the Upper Thames River Conservation Authority (UTRCA) and by Jane Bowles and her field assistants.

The DTRS summarizes policies that protect or may affect terrestrial and wetland resources, and one of the primary objectives of the DTRS is to provide a basis for land use policies to protect, enhance and restore ecosystems within the subwatersheds. In addition to simply using existing policies to achieve this objective, the DTRS summarizes the current state of knowledge of landscape ecology principles. Discussions are provided on biodiversity, wetlands, woodlands, riparian vegetation and stream corridors, and hedgerows. Potential effects of development on terrestrial and wetland ecosystems are also summarized in the DTRS.

The DTRS notes that the amount of natural habitat in all thirteen subwatersheds currently being studied by the City of London is lower than the majority of southern Ontario, which is typically 15 to 25 percent. Therefore, the DTRS recommends that all existing natural areas be protected, where feasible, and that efforts be made to naturalize additional areas.

All vegetation patches 4 ha and larger were mapped in the DTRS. This size was selected based on a literature review, plus the fact that this is the minimum size woodlot that may provide habitat for forest interior species.

The vegetation patches that were mapped were not restricted to forests and wetlands. Meadows, old fields, shrublands, prairies, and savannahs are also included.

Patches smaller than 4 ha were mapped by the DTRS if they met one of the following conditions:

- A patch less than 4 ha is located 100 m or less from a mapped patch if the land between the patches is absent of any permanent disturbance which may act as a permanent barrier to flora or fauna (e.g. roads, railroads, buildings).

- A patch less than 4 ha is located 100 m or less from another patch smaller than 4 ha if the total area of the two or more patches is 4 ha or more, and there is no permanent disturbance between the patches.
Areas such as naturalizing land (such as abandoned farm land), agricultural land, watercourses, and utility corridors are not considered to be permanent barriers to movement of flora and fauna among patches.

After the release of the DTRS, vegetation patches were examined in the field to determine if additional patches should be included in the mapping, and if all mapped patches were still present.

The DTRS mapped zones and areas within the City of London. Zones are broad areas with similar characteristics due to existing policies, environmental considerations, or the distribution of vegetation patches within them. The areas are the vegetation patches mapped by the UTRCA.

Four types of zones and four area types were defined by the DTRS. Table B.19 summarizes the types of zones and areas, and recommendations that may be associated with each type. The zones and areas are defined in more detail below.

**Type A Zone**

Type A zones (See Table B.19) are areas where existing provincial policies or guidelines provide clear guidance for the protection of features and systems, or allow protective measures to be taken by controlling development. Type A zones contain one or more of the following features:

- A provincially significant wetland;
- A provincially significant life sciences Area of Natural or Scientific Interest (ANSI);
- Regional floodplains as indicated by regulatory floodline mapping;
- A setback of 30 m from coldwater streams and 15 m from other watercourses.

**Type B Zone**

Type B zones are areas where there are strong reasons for promoting the retention, restoration, and replacement of natural vegetation on the basis of subwatershed water-related processes. They are defined as follows:

- Stream corridors as defined by OMNR (1991) and supported by the Comprehensive Set of Policy Statements (OMMA, 1994). This definition includes the following:
  - The stream;
  - Floodplain’
  - Stream valley walls’
  - Riparian vegetation and habitat; and
  - Related source areas such as springs and seepage areas

It is recommended that the OMNR (1991) definition of stream corridor be expanded to include areas within mapped fill lines and the outer limit of those mapped patches defined as partly or entirely riparian.

- Other bases as defined and supported by interdisciplinary discussions at the subwatershed level, notably areas of groundwater discharge and recharge.
<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Recommendations Which May Be Associated With Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A Zone</td>
<td>Zone for which there exist specific provincial policies: e.g. 15 m strip along streams and regulated floodplain.</td>
<td>Retention of any existing vegetation. Top priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type B Zone</td>
<td>Zone along stream corridors (as specified in OMNR, 1991, recommendations) of specific importance to water-related process.</td>
<td>Retention of any existing vegetation. Second priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type C Zone</td>
<td>Zone between sufficiently close Type 1, 2 and/or Type 3 areas, not necessarily along stream corridors.</td>
<td>Third priority areas for restoration and replacement.</td>
</tr>
<tr>
<td>Type D Zone</td>
<td>Zone outside of Type A, B, or C Zones.</td>
<td>No specific policy recommendations except general policies which apply to all zones.</td>
</tr>
<tr>
<td>Type 1 Area</td>
<td>Vegetation patch which includes Life Science ANSI, Class 1-3 wetland, or ESA (Candidate ESA within City of London).</td>
<td>Complete protection of functions and feature including scoped EIS for developments in proximity.</td>
</tr>
<tr>
<td>Type 2 Area</td>
<td>Vegetation patch which meets does not meet the criteria for Type 1, 2, or X.</td>
<td>Retention including scoped EIS for certain developments in proximity.</td>
</tr>
<tr>
<td>Type 3 Area</td>
<td>Vegetation patch which is isolated (not within 100 m of other patches and not connected by Type C Zone), not in Type A or B Zones, and is either old field, early successional woodland, or plantation.</td>
<td>Retention, restoration, or replacement.</td>
</tr>
<tr>
<td>Type X Area</td>
<td>Vegetation patch within City of London boundaries which might meet Candidate ESA status but for which site access was refused.</td>
<td>Requirement that study be conducted before development near these areas to determine if they qualify as either Type 1 or 2 Areas.</td>
</tr>
</tbody>
</table>

Source: DTRS
Type C Zone

Type C zones are areas where there are strong reasons for promoting the retention, restoration, and replacement of natural vegetation on the basis of terrestrial biology features not primarily related to water-related processes but complementary to these. Type C zones are defined as follows:

- Areas between vegetation patches where restoration and replacement of natural vegetation would result in a reduction of fragmentation and a marked increase in the effective size of the resulting unified patch.

- Potential upland corridors which would connect upland patches to the connected system defined by the Type A and B zones. Corridor width should be a minimum of 100 m and preferably 200 m or more.

- Areas where there is a need for increased width of riparian corridor to provide terrestrial linkage functions. Corridors 15 to 30 m wide along some watercourses may not provide an adequate corridor for some terrestrial features.

- Areas where designation as a Type C zone would provide benefits to the terrestrial and wetland system. These would be special cases that do not meet any of the previous three points. Rationale for these will be explained in subwatershed studies.

Type D Zone

The Type D zone is all areas outside of Zones A, B, and C.

Type 1 Area

A Type 1 Area is a vegetation patch which contains features recognized as biologically significant by other specified studies. A vegetation patch is a Type 1 Area if it is one or more of the following:

- A provincially significant wetland;

- A provincially significant life sciences ANSI;

- A candidate ESA within the City of London boundaries; and

- A Significant Natural Area, as defined by Hilts and Cook (1982), outside of the City of London boundaries.

Type 2 Area

A Type 2 Area is a vegetation patch which does not meet the criteria for Type 1, 3 or X areas. These are the majority of patches identified by the DTRS. They include all patches along stream corridors, all wetlands, and most tableland forest patches.

Type 3 Area

A Type 3 Area is isolated, not in Type A or B zones, and is either old field, early successional woodland, or plantation. A vegetation patch is a Type 3 Area if it meets all of the following criteria and it is not a Type 1 or X area:

- The vegetation patch is isolated (i.e. more than 100 m from the closest patch, or separated by a road, railroad, or other built structure) and likely to remain isolated (i.e. it has not been connected by a Type C Zone in the DTRS or the subsequent subwatershed analysis).
- The vegetation patch is located entirely out of Type A or B zones.
- The vegetation patch consists primarily (>80%) of old field, early successional woodland, or plantation.

**Type X Area**

A Type X Area is one that might be a Type 1 Area after additional field work. A vegetation patch is a Type X Area if it meets all of the following criteria:

- It is not a Type 1 Area based on existing data.
- It is located within the City of London boundaries.
- It was considered to be of Candidate ESA potential, but field work was not possible because of access refusal by all or most of the landowners.

The DTRS presented a map of the entire study area (all 13 subwatersheds) which depicted the patches and zones, and maps were also plotted for each individual subwatershed. The DTRS did not differentiate among Type 1, 2, 3, and X vegetation patches. This analysis was completed by the UTRCA. The UTRCA and Terra Geographic Studies Inc. jointly determined which vegetation patches satisfied one or more of the criteria as an ESA.

### B8.2 Woodlots, Wetlands and Vegetation

For the purposes of the terrestrial biology and wetlands component, the Pottersburg Creek and Crumlin Drain subwatersheds have been considered a single landscape. Map B11 shows the location, size and shape of the 74 patches of natural vegetation that are present (64 in Pottersburg Creek and 10 in Crumlin Drain).

The combined area of the patches is approximately 372 ha, which represents about 6.6 percent of the subwatersheds. As can be seen from the figure, most of the patches are small, irregularly shaped, and relatively isolated. There are few large, contiguous patches of natural habitat in the subwatersheds, with the largest natural area completely within the subwatershed being 24.8 ha in area.

Patch size is a critical factor in determining what wildlife species a natural area can support. The percentage of patches occurring in the various size thresholds are summarized below in Table B.20.

Over half the patches are less than 4 ha in area and will provide no habitat for forest-interior species. Only one patch (4033) is larger than the 30 ha that is typically required for true forest-interior birds species. There are, however, three other patches over 20 ha that have the potential to support some area-dependent species.

The majority of the patches are immature to intermediate-aged deciduous woodlots. Common dominant or co-dominant tree species are red or white ash, red or silver maple, sugar maple, white elm, and oaks. Coniferous cover is rare and occurs primarily in plantations, although there is one natural stand dominated by tamarack. Some of the riparian areas are dominated by large willows.
Map B11 also indicates patch area types and Zone Types A, B and C, as identified in the Draft Terrestrial Resource Strategy (DTRS), prepared by Terra Geographical Studies Inc. (1994). There are few Type 1 areas (No Development Areas), mostly associated with riparian habitat along Pottersburg Creek and Crumlin Drain. The downstream cluster of patches on Pottersburg Creek are considered to be functionally a part of the Meadowlily Woods complex. Patch 4005 is a pure stand of tamarack, the only one in the Pottersburg and Crumlin Drain subwatersheds, and the regionally significant pale-spike lobelia occurs in this stand. Patch 5005 is a preliminary candidate ESA based on the presence of the provincially rare and nationally vulnerable Cooper’s Hawk.

The majority of areas are Type 2 (Restricted Development Areas). Although these may not support any known significant species or features, they are responsible for the overall landscape richness of the subwatersheds, and constitute 90 percent of the natural habitat.

A single patch (4022) was designated Type 3 (Areas for Restoration or Replacement). It is an immature, isolated area of regenerating barren and scattered elm.

Patches 4033, 4034 and 4047 have also been identified as preliminary candidate ESAs. They are located east and northeast of the airport. Areas 4033 and 4034 are considered a complex which has a large size, it is a representative pre-settlement landforms with 80 percent native plant species, and the provincially rare and nationally endangered Acadian Flycatcher apparently nests there. Patches 4047 supports one rare plant species. No further consideration of Candidate ESAs was given since the Townships are not in favour of ESA designations at this time.

Zone C areas have been shown exactly as indicated in the DTRS. However, they will be evaluated in Phase III of the subwatershed study, and the potential for creating additional linkages in what is now considered Zone D will be examined.
The areas and zones were defined in detail in the Terrestrial Resource Detailed Study, as were policies and recommendations that may be associated with these designations. The area and zone types may be defined as follows:

<table>
<thead>
<tr>
<th>Areas:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>No Development Area</td>
</tr>
<tr>
<td>Type 2</td>
<td>Restricted Development Area</td>
</tr>
<tr>
<td>Type 3</td>
<td>Areas for Restoration or Replacement</td>
</tr>
<tr>
<td>Type X</td>
<td>Areas Requiring Future Investigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zones:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone A</td>
<td>Protected Zone</td>
</tr>
<tr>
<td>Zone B</td>
<td>Aquatic Enhancement Zone</td>
</tr>
<tr>
<td>Zone C</td>
<td>Terrestrial Enhancement Zone</td>
</tr>
<tr>
<td>Zone D</td>
<td>All Other Areas</td>
</tr>
</tbody>
</table>

There are no provincially significant wetlands in the subwatersheds. An area of approximately 5 ha of patch 5005 on Crumlin Drain is wetland habitat, but it is not of provincial significance. As this area contains no known significant species, it is unlikely that further investigations will result in it being elevated to provincial status. No other wetland communities larger than 2 ha have been identified in the subwatersheds.

Buffers of 100 and 200 m were applied to all of the patches (Map B11). As can be readily seen, there is very little forest-interior habitat in the subwatersheds. There are 8 patches of habitat 100 m or farther from a parent patch edge. These total about 30.9 ha, or 0.5 percent of the subwatersheds. There are no forested areas that are at least 200 m from an edge. Thus, habitat for forest-interior species is very limited in the Pottersburg Creek and Crumlin Drain subwatersheds.

**B8.3 Wildlife**

A list of the wildlife species found in the subwatersheds (Table B.21) was compiled based on the field work conducted by Jane Bowles (1994), which includes only bird species that probably nested in the subwatershed (although the Cooper’s Hawk is listed). It should be emphasized that the wildlife list is probably far from complete. Field work was conducted only in a sub-sample of patches, with an emphasis on forested habitat. Grasslands, disturbed areas and developed areas were under-represented in the inventory. In addition, many secretive species such as small mammals were probably overlooked by the inventory.

In all, a total of 49 wildlife species were recorded: 3 amphibians, no reptiles, 40 breeding birds, and 6 mammals. All species observed are common except the Cooper’s Hawk (previously discussed) and the Acadian Flycatcher. The Acadian Flycatcher is provincially and nationally significant. It is a forest-interior species that prefers mature deciduous stands. It was found in patch 4033, which contains one of the largest blocks of forest interior in the subwatersheds.

As would be expected based on the habitat present, forest-interior birds are relatively rare in the subwatersheds. Species that appear to be absent as breeders from the Pottersburg Creek and Crumlin Drain subwatersheds include Yellow-bellied Sapsucker, Pileated Woodpecker, Red-breasted Nuthatch, Brown Creeper, Winter Wren, Veery, Hermit Thrush, Yellow-throated Vireo, Black-throated Green Warbler, Black-and-white Warbler, Northern Waterthrush, and Scarlet Tanager. In general, a very low diversity of wildlife species was recorded.

B.58
<p>| Wildlife Observed in the Pottersburg Creek and Crumlin Drain Subwatersheds |
|---|---|
| <strong>AMPHIBIANS</strong> | |
| Spring Peeper | Hyla crucifer |
| Striped Chorus Frog | Pseudacris triseriata |
| Northern Leopard Frog | Rana pipiens |
| <strong>BIRDS</strong> | |
| Green Heron | Butorides virescens |
| Wood Duck | Aix sponsa |
| Cooper's Hawk | Accipiter cooperi |
| Red-tailed Hawk | Buteo jamaicensis |
| Ruffed Grouse | Bonasa umbellus |
| American Woodcock | Scolopax minor |
| Mourning Dove | Zenaida macroura |
| Black-billed Cuckoo | Coccyzus erythropthalmus |
| Great Horned Owl | Bubo virginianus |
| Downy Woodpecker | Picoides pubescens |
| Hairy Woodpecker | Picoides villosus |
| Northern Flicker | Colaptes auratus |
| Eastern Wood-Pewee | Contopus virens |
| Acadian Flycatcher | Empidonax virescens |
| Great Crested Flycatcher | Myiarchus cinerinus |
| Blue Jay | Cyanocitta cristata |
| American Crow | Corvus brachyrhynchos |
| Black-capped Chickadee | Parus atricapillus |
| White-breasted Nuthatch | Sitta carolinensis |
| House Wren | Troglodytes aedon |
| Wood Thrush | Hylocichla mustelina |
| American Robin | Turdus migratorius |
| Gray Catbird | Dumetella carolinensis |
| Brown Thrasher | Toxostoma rufum |
| Cedar Waxwing | Bombycilla cedrorum |
| European Starling * | Sturnus vulgaris |
| Red-eyed Vireo | Vireo olivaceus |
| Yellow Warbler | Dendroica petechia |
| Ovenbird | Seiurus aurocapillus |
| Common Yellowthroat | Geothlypis trichas |
| Northern Cardinal | Cardinalis cardinalis |
| Rose-breasted Grosbeak | Pheucticus ludovicianus |
| Indigo Bunting | Passerina cyanea |
| Field Sparrow | Spizella pusilla |
| Song Sparrow | Melospiza melodia |
| Red-winged Blackbird | Agelaius phoenicus |
| Common Grackle | Quiscalus quiscula |
| Brown-headed Cowbird | Molothrus ater |</p>
<table>
<thead>
<tr>
<th>Wildlife Observed In the Pottersburg Creek and Curnlin Drain Subwatersheds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BIRDS</strong></td>
</tr>
<tr>
<td>Northern Oriole</td>
</tr>
<tr>
<td>House Finch</td>
</tr>
<tr>
<td>American Goldfinch</td>
</tr>
<tr>
<td><strong>MAMMALS</strong></td>
</tr>
<tr>
<td>Eastern Cottontail</td>
</tr>
<tr>
<td>Eastern Chipmunk</td>
</tr>
<tr>
<td>Woodchuck</td>
</tr>
<tr>
<td>Grey Squirrel</td>
</tr>
<tr>
<td>Raccoon</td>
</tr>
<tr>
<td>White-tailed Deer</td>
</tr>
</tbody>
</table>

**NOTE**

* Introduced Species
Only five forest-interior or area-sensitive bird species were documented during the breeding season. The Wood Thrush was seen in three patches, while the remaining four species (Ruffed Grouse, Hairy Woodpecker, Acadian Flycatcher, Ovenbird) were found in one patch each.

Patch 4033 supported four of the five area-sensitive or forest-interior species (all but the Ovenbird). The other patches supporting these specialized species were 4047 (Wood Thrush) and 4058 (Wood Thrush, Ovenbird).

Table B.22 lists the three significant plant species that have been documented in the Pottersburg Creek subwatershed. They include one that is rare in Canada and Ontario, and two that are rare in Middlesex County. They were found in Patches 4033, 4047 and 4058.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Status</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iris virginica</td>
<td>Southern Blue Flag</td>
<td>R2</td>
<td>4033</td>
</tr>
<tr>
<td>Amelanchier sanguinea</td>
<td>Juneberry</td>
<td>R4</td>
<td>4047</td>
</tr>
<tr>
<td>Carex jamesii</td>
<td>James’ Sedge</td>
<td>CA ON</td>
<td>4058</td>
</tr>
</tbody>
</table>

**NOTES:**
- R2 Rare in Middlesex County, 2 Sites
- CA Nationally Rare
- ON Provincially Rare
B9.0 ARCHAEOLOGICAL RESOURCES

The archaeological assessment background study for the study area resulted in the identification of four registered and two unregistered archaeological sites. As well, examination of published and unpublished studies of built heritage for the study areas have resulted in the identification of 70 locations of standing or extinct buildings. The standing structures represent the 19th to early 20th century architectural development of the London area, particularly of the rural and early urbanized communities such as Rebecca, Crumlin, The Gore and Pottersburg. The extinct structures, and the locations of the early settlers noted in the study area represent potential historic archaeological sites. Map B12 notes the location of many of these sites. A listing of archaeological and potentially significant sites is provided in the Technical Appendix.

B9.1 Historical Development

Based on the data, there were notable peaks in the prehistoric and historic development activity (i.e. draining/clearing) which can be used to explain existing conditions. The Iroquoian period (AD 900-1500) saw swidden agriculture, which involved the clearing of trees for fields/gardens. Pioneer plants, such as white pine, moved into these open areas after the fields were abandoned (particularly in the sandy areas). During the early European period (1820-1850) three was a lot of tree clearing, but neither of the two streams were used for power (i.e. mills). The late European period (1850-1900) saw urbanization/industrialization, particularly of the Pottersburg and The Gore areas. This period also saw continued land clearing, channelization of streams, and infilling, which in turn caused increased streamflows and erosion. The cumulative effects of these impacts can be seen in many of the erosion and flooding problems of the recent past, but in the last two decades society has become more protective of the environment.

B9.2 Site Specific Studies

Further archaeological studies are needed to assist in predicting potential heritage resource impacts in the study areas. Studies are required because much of the undeveloped lands within the Pottersburg Creek subwatershed are under pressure in the form of residential and industrial developments as the City of London expands to urbanize areas now within its 1993 boundaries. Other pressures on potential archaeological resources include aggregate extraction in parts of the subwatershed. These and other development impacts may unknowingly damage or destroy unregistered archaeological sites. It would therefore be appropriate for any development proposals in the study area be subject to a required cultural heritage resource assessment prior to any soil disturbances, at the planning stage. This assessment process would be funded by the proponents (public and private sector), and all cultural resources would be inventoried (i.e. archaeological sites, built heritage), and heritage management options would be developed (i.e. preservation or mitigation). Cultural heritage assessments should also be required for so-called "previously developed lands" in the 19th century communities of Geary's Corners and Ballymote, particularly if the "previous development" involved impacts which did not strip topsoil or otherwise deeply disturb soils. It has been proven that in many urban settings where development occurred prior to 1960, archaeological remains have remained intact below road beds, yards and infilled lands.
B.10 SANITARY SEWAGE COLLECTION SYSTEM

B10.1 General

The developed area in the Pottersburg Creek subwatershed within the former City of London municipal boundary is serviced by an existing sanitary sewer system. The many kilometres of concrete and PVC (plastic) pipe, at depths ranging from 2.4 to 6.1 m and installed in a granular trench, collect sanitary sewage from the existing homes, and the commercial and industrial establishments within the watershed. The Pottersburg trunk sewer generally follows the creek watercourse, which is standard for the design of sanitary sewer systems.

Originally, sewage disposal for the first few residences in the Pottersburg Creek area, which were constructed in a predominantly rural setting, was achieved by septic tank systems. Those systems have been abandoned over the years with the installation of sanitary sewers such that there would be little if any present risk of groundwater contamination.

There would also be little risk of groundwater contamination from the sewage collection system that might result from exfiltration. Generally, due to low pipe flow conditions relative to the pore pressures of the groundwater within the soils surrounding the sewers, groundwater tends to infiltrate to the sanitary sewer system, and accumulate in volume along the length of the collection system. This infiltration can occur throughout the system from the house connection to the downstream outlet including cracks at manholes or pipe joints along the system.

Groundwater infiltration to sanitary sewer systems can be a problem in some areas for the sewer system operating authority which in this case is the City of London. The volumes of clean water that accumulate in the system tend to be higher during extended periods of wet weather, which sometimes causes the theoretical gravity capacity of the sewers to be exceeded. In that case, the system can become surcharged which could result in exfiltration. Generally, any exfiltration or groundwater flow to the sewer system tends to flow along the granular trench of the sewer.

More importantly, however, during periods of sewer system surcharge, loss of sewage to the local surface watercourse can occur through different means. At certain critical locations on the system, the surcharging could be significant enough to overflow at one or two manhole locations which might bring some hydraulic relief to the system and reduce the risk of upstream basement flooding, but would result in discharge of raw sewage to the environment.

To prevent basement flooding, sewer operating authorities will sometimes install high-level connections or overflows from the sanitary sewer to the adjacent storm sewer or directly to the surface watercourse to relieve the sewer system during storm events. In addition, to prevent flooding of the downstream pumping station and/or upstream basements, the pumping stations are often designed with overflows to the surface water system. It is noted that approvals for such facilities are governed by the Environmental Protection Act and tend to be permitted as an alternative to basement flooding where it cannot otherwise be prevented.

Under previous standard design practices in London and elsewhere in Ontario, the footing drain around the basement foundation of houses was connected to the sanitary system. This practice was followed primarily for cost reasons due to the ease of connection of the footing drain to the sanitary service to the house, and to avoid enlarged and/or deepened storm sewer systems.
Alternative design practices have now been in place in London since approximately 1985 to reduce the impact of wet weather on the trunk sanitary sewers and the sewage treatment plants. New homes are required to connect their footing drain and other clean water connections to the local storm sewer. The City of London has adopted this design practice by-law due to the problems encountered with basement flooding and the overflow of pumping stations and treatment works during extended wet weather periods. Footing drains are now connected to a sump pump in the basement of the house which discharges the groundwater to the surface or directly to pipe connections to the local storm sewer system which are installed for that purpose.

B10.2 Existing Subwatershed Conditions

The Pottersburg Creek sanitary sewer system collects sewage from a large area of industrial, commercial and residential development in east London. The sewer system generally drains the land from north of Oxford Street to the Pottersburg sewage treatment plant on the south branch of the Thames River. The trunk sewer follows the east bank of Pottersburg Creek from approximately the intersection of Clarke Road and Oxford Street to the treatment plant.

As in a number of other areas of the City, much of the existing Pottersburg Creek sanitary drainage area serves residential areas where the footing drains are connected to the sanitary systems. Also, due to a number of factors including soil conditions, poor lot grading in some areas, and the general flatness of the drainage area, large volumes of surface water and groundwater are collected by the sanitary sewer system which flows to the treatment plant on the Thames River. Existing City of London by-laws now prohibit the connection of footing drains and storm drains to the sanitary sewer system, however, in the older areas of the City, it would be cost prohibitive to require that thousands of private homes have their storm or groundwater connections removed from the sanitary sewer system.

Most of the downstream sections of the trunk sewer, from approximately Trafalgar Street to the treatment plant, are presently at capacity and frequently experience surcharging during wet weather. Basement flooding investigations and sewer hydraulics analysis work, completed in the mid-1980s, have confirmed that sewage overflows from the sewer system to Pottersburg Creek have occurred, with an estimated frequency of about 5-10 times per year. Due to the difficulty in the monitoring and measuring of such occurrences, no estimates are available of the durations of such occurrences or the volume of sewage that was released to the surface watercourse.

In 1986, a new sanitary pumping station was installed on the Pottersburg Creek trunk sewer system at Clarke Road to divert upstream flows to an alternate main branch of the sewer system on Speight Boulevard. This facility was designed and constructed to relieve basement flooding problems in the Culver Drive area as well as to reduce surcharging in the trunk sewer from approximately Clarke Road to Trafalgar Street. Downstream of Trafalgar Street where the diverted sewage re-enters the trunk sewer system, surcharging problems and overflows to the creek still persist, however, the risk of basement flooding in the upstream areas has been reduced significantly. In the downstream areas of the sanitary sewer system where surcharging still persists, the sewer is deep enough that basement flooding is not a problem.

The City of London proposes to twin the Pottersburg Creek sanitary sewer from Trafalgar Street downstream to the treatment plant to eliminate the sewer surcharging and overflows to the creek. With the installation of the new pumping station upstream at Clarke Road, according to staff of the City Engineer’s Department, most of the overflow connections to the storm sewer have been removed as the surcharging and basement flooding problems have been alleviated. No accurate records are available to identify the number of overflows which still exist, and again based on the difficulty of monitoring, no data are available to describe the frequency or extent of sanitary sewer overflows to the storm sewer system. The new City of London sanitary sewer system master plan will continue to be used to design and construct improvements to the sewage collection and treatment system to reduce basement flooding and sewer overflow conditions.
B.11 SUMMARY OF THE EXISTING POTTERSBURG CREEK AND CRUMLIN DRAIN SUBWATERSHED ECOSYSTEM

This section of the report is intended to synthesize the information presented in the detailed studies into a common framework that can be used in identifying alternative management measures in the development of the Pottersburg Creek and Crumlin Drain Subwatershed Management Plan. The ecosystem framework presented earlier including subwatershed functions, attributes and linkages, is used to describe how the Pottersburg Creek and Crumlin Drain Subwatershed works.

The last section of this chapter describes how these ecosystem functions, attributes and linkages might be impacted through future development of the subwatershed. The nature of the potential impacts will form the basis of the subwatershed management strategy.

B11.1 Pottersburg Creek and Crumlin Drain Watercourses

Pottersburg Creek and the Crumlin Drain are tributaries of the South Branch of the Thames River. From Thamesford to its confluence with the North Branch of the Thames, the South Branch flows through broad gravel terraces in a shallow channel. Pottersburg Creek flows south to its confluence with the South Branch of the Thames River on the east side of the City of London.

Pottersburg Creek is somewhat more elongated and flatter than Stoney Creek, with an average basin slope of 0.3 percent. Pottersburg Creek has its headwaters in the sand silt tills of the Arva Moraine with some clay silt and clay materials in the north central portion of the watershed. The basin is bisected by two gravel outwash deposits of glacial origin in the central area, with a gravel sand and silt till deposit found on the east central boundary of the basin. The tills predominate the drainage area of Pottersburg Creek, with the exception of lacustrine sand deposits in the vicinity of the London Airport, along with some deltaic gravel deposits west of the airport. Pockets of sand are found in the southern portion of the watershed adjacent to the main branch of Pottersburg Creek, and immediately above the confluence with the South Branch of the Thames River, peat, muck and marl are found.

The Crumlin Drain has its confluence with Waubuno Creek which subsequently flows into the South Branch of the Thames River east of the Pottersburg Creek confluence. The Crumlin Drain watershed comprises primarily sandy silt tills, with the exception of sand deposits on either side of the northern half of the subwatershed.

As in the Stoney Creek subwatershed, both Pottersburg Creek and the Crumlin Drain exhibit bed and bank material distributions that characterize the underlying physiography. The upper reaches of Pottersburg Creek show a relatively small pavement and sub-pavement grain size of 0.7 and 0.1 m respectively. Downstream of the airport, the channel and bed materials reflect man-made alterations due to stream improvements, and the grain size distributions would not be representative of natural channel formation processes. The upper reaches of Crumlin Drain have a pavement and sub-pavement size of 15 and 0.3 mm respectively, reflecting the gravelly till contribution to this reach, while downstream the grain sizes decrease, although they again are strongly influenced by man-made channel alterations and are not typical of channel formation processes. Channel erosion in Pottersburg Creek and the Crumlin Drain have been affected significantly by man-made alteration, resulting in channel straightening and attendant slope steepening. Combined with a predominance of tight materials, lack of riparian vegetation, and cattle access, erosion potential is higher in both these watersheds than in Stoney Creek.

Both Pottersburg Creek and Crumlin Drain exhibit smaller baseflow than Stoney Creek because of the tighter soils and the more localized contributing of shallow groundwater recharge.
B11.2 Subwatershed Functions

Subwatershed functions are described below in terms of hydrological functions and biological functions.

B11.2.1 Hydrological Functions

Figure B1 provides a conceptual illustration of some of the features and natural processes occurring in the Pottersburg Creek and Crumlin Drain subwatersheds.

Groundwater Recharge

Groundwater recharge is an important hydrologic function in that it replenishes the groundwater system. High permeability soils (sands and gravels) tend to infiltrate a higher amount of rainfall and thus perform a high level of groundwater recharge. Less permeable soils (silt and clays) tend to generate more runoff as opposed to infiltration and thus perform less of groundwater recharge function.

The soils of the Pottersburg Creek and Crumlin Drain are overall less permeable than those in Stoney Creek. However, some deposits of sand and gravel are scattered throughout the subwatershed.

Groundwater Discharge

Groundwater discharge plays an important role in supplying a baseflow to the watercourses. Groundwater discharge occurs when groundwater seeps from the soil to the surface water system. Discharge is typically prevalent along the valley walls of stream corridors, through the stream bed itself and in wetlands. The rate of groundwater discharge will depend on the soil type and the driving head in the discharge area.

Flood Storage and Conveyance

Conveyance of storm water in a manner that does not present a risk to human health and safety is desirable for watercourses near areas of development. The hydrologic and hydraulic modelling carried out on the subwatersheds resulted in the delineation of floodplains for the Regulatory event. The modelling indicated that the Regulatory event flow was, for the most part, contained within the stream valley. However, one uninhabited structure in Pottersburg Creek was found to be inundated by the Regulatory event flow for existing conditions.

From a fluvial geomorphological standpoint, the primary function of the watercourse is to transport sediment through the stream course system. Erosion and sedimentation processes are common in any watercourse, and it is the event driven flows that transport this sediment load through the system. The Crumlin Drain subwatershed system, in particular, is sensitive to any flow increases transporting too much sediment.
Water Quality Modification

Water quality modification functions pertain to the ability of vegetation to filter contaminants (primarily sediment) from surface water runoff. Riparian vegetation also functions to shade the surface water aiding in the maintenance of cooler water temperatures. Vegetated buffer strips along the watercourses provide this water quality modification function. Wetlands can also provide a water quality function through the uptake of nutrients in the wetland vegetation. Riparian vegetation characteristics throughout both subwatersheds are variable. Some of the tributaries have limited buffer areas, and in some locations are actively cultivated. However, for some of the central and lower reaches on each subwatershed, the tributaries are buffered by natural and planted vegetation.

B11.2.2 Biological Functions

Erosion Control

An erosion control function is performed by the ability of vegetation to increase the soil's tolerance to erosion caused by either water or wind. The root network of vegetation plays a key role in erosion protection. Cropping practices and agricultural areas help to control soil erosion and the subsequent sediment deposition in nearby watercourses. Riparian vegetation along the streambank and within the stream corridor help to control erosion of the streambank itself along much of Pottersburg Creek and Crumlin Drain.

Wildlife Habitat

The provision of habitat for wildlife is a critical function that has obvious sensitivities to land use change. Both terrestrial and aquatic habitats play prominent roles in the watershed ecosystem. Forested areas provide habitat for both birds and animals; wetlands provide habitat for a unique range of species; and that the watercourses within the subwatershed provide habitat for a variety of aquatic species.

Terrestrial

The terrestrial resources detailed study for the Pottersburg Creek and Crumlin Drain Subwatershed Study identified 77 forested patches within the subwatershed. The patches varied in size from less than 4 hectares to several in the range of 30 to 49 hectares. Within the newly annexed area, 22 of these forested patches exist. These Patch numbers are summarized in Table B.23 and are located on Map B1. Insensitive development in this area could result in the direct loss of these forested habitats.
TABLE B.23

<table>
<thead>
<tr>
<th>Forested Patches within Annexed Area (Future Development Area)</th>
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<tr>
<td>4008</td>
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<td>4009</td>
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<td>4038</td>
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<tr>
<td>4039</td>
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</table>

Aquatic

The various watercourses within the Pottsburgh Creek and Crumlin Drain subwatershed provide habitat to support a variety of warmwater fish species.

Two provincially significant fish species were documented in Pottsburgh Creek and Crumlin Drain: central stone roller and greenside darter. The central stoneroller is a member of the minnow family. In Canada, it occurs only within the Thames River drainage system upstream of London. Thus, the populations in the Thames River system are of national significance.

The greenside darter is also restricted to southwestern Ontario and the largest Canadian population is in the Thames River. It prefers streams with a coarse substrate and a good sequence of pools and riffles. High turbidity and sedimentation are deleterious to this species.

Game fish are essentially absent from the Pottsburgh Creek subwatershed with the exception of smallmouth bass at one location in Pottsburgh Creek. The fish community is primarily dominated by suckers and minnows. This is indicative of the poor IBI results in 8 of 10 stations in Pottsburgh Creek.

Crumlin Drain species predominantly consisted of tolerant minnow species and brook stickleback. IBI results were generally poor and very poor. However, the northern hog sucker (relatively intolerant to organic pollution) was found in the lower portion of Crumlin Drain near its confluence with Waubuno Creek.

B11.3 Subwatershed Attributes

B11.3.1 Rare and/or Endangered Species

Rare and/or endangered species often have exacting requirements for habitat in order to continue in existence. The central stone roller and greenside darter are both significant species. The nationally endangered Acadian Flycatcher is thought to nest in forest patches 4033 and 4034. The provincially rare and nationally vulnerable Cooper’s Hawk was noted in Patch 5005. The Regionally significant pale-spine lobelia occurs in Patch 4005.
B11.3.2 Unusual Vegetation

Unusual vegetation communities are typically valued greater than common types of vegetation. Patch 4005 is a pure stand of tamarack, the only one in the subwatershed.

B11.3.3 Unusual Landforms

Unusual landforms are often declimated as Earth Science Areas of Natural and Scientific Interest (ANSI). An example of an unusual landform is the Arva Moraine. There are no similar landforms in the Pottersburg Creek and Crumlin Drain subwatersheds. The results of the Archaeological Study component did identify the stream valley corridors as having potential for archaeological significance.

B11.4 Subwatershed Linkages

B11.4.1 Dispersal and Movement Corridors

Terrestrial wildlife movement corridors typically occur along contiguous tracts of forested land. These tend to be in forested stream valley corridors or along connected tracts of tableland forests. Terrestrial linkages can cross watershed boundaries and provide linkages to the surrounding bio-region.

Aquatic linkages include migratory watercourses for fish.

Map B11 identifies Type A zones. These zones support wildlife dispersal and movement functions. These zones are also coincidental with watercourses and therefore support movement of aquatic species.

B11.4.2 Hydraulic Linkages

Linkages can also be evident between areas with high infiltration functions and the areas of groundwater discharge. This important linkage defines a clear relationship between land use and the maintenance of baseflow.

Figure B1 presents a conceptual summary of the Pottersburg Creek and Crumlin Drain Subwatershed ecosystem and supporting hydrologic functions.

B11.5 Subwatershed Management Units

In order to further refine the analysis of existing conditions in Pottersburg Creek and Crumlin Drain, the subwatersheds have been broken down into management units for ease of description and for the evaluation of development management strategies in Part C of this report.

The delineation of the management units (MU) was based on several factors including:

- Physiography;
- Geology;
- Land Use; and
- Environmental Quality.

The management units are illustrated on Map B13 with MU5 corresponding to the Rural Upstream Area of Pottersburg Creek, MU6 representing the Airport Lands, MU7 the future development area of Pottersburg Creek, MU8 the existing development within Pottersburg Creek and MU9 representing all of Crumlin Drain.
B11.5.1 Rural Upstream Area (MU5)

This unit consists of Pottersburg Creek above the London Airport. This area is agricultural, and the streams are all first and second order. Virtually all streams have been channelized to improve agricultural drainage.

Generally, MU5 supports an impaired Type IV aquatic community (Map B14). The macroinvertebrates are dominated by highly tolerant species, and some of the invertebrates are adapted to life in intermittent streams. Fish communities in this unit are dominated by tolerant species such as brook stickleback, white sucker and minnows, but least darter and johnny darter are relatively common.

The major limitations to aquatic resources are low baseflow, riparian cover which is predominantly grasses or shrubs, and monotonous habitat with few pools or riffles and very little instream cover.

There is evidence of groundwater discharge in two areas. Fisheries Station 8, situated on the main channel near the headwaters, supports a Type III community as well as the provincially and nationally significant central stoneroiler. As the creek enters the airport, the benthic community exhibits a high EPT Index value of 10 and a high Water Quality Index value (12.3). These were the highest scores attained on these indices in the Pottersburg Creek and Crumlin Drain subwatersheds. The presence of cool water, and intolerant species of caddisfly and waterpenny beetle is indicative of groundwater upwelling.

BEAK (1994) suggested that there may be a barrier to upstream movement of fish in the vicinity of the airport. The long culverts which convey flow under the airport may be acting as a barrier.

Streams in this unit could be enhanced slightly by removing barriers to fish movement and naturalizing the channel, but they are unlikely to attain high quality. They could be further degraded through increased nutrient inputs or reductions in baseflow due to loss of riparian vegetation, decreased groundwater discharge, or land use changes.

B11.5.2 Airport Lands (MU6)

This unit consists of the London Airport lands which total 550 ha or 20 percent of the Pottersburg Creek watershed (Delcan, 1985). The airport lands slope gently from the northeast to the southwest with elevations ranging from 278 to 270 m. This Management Unit in Pottersburg Creek has its own Airport Master Plan and is governed by Transport Canada. Although recommendations are made for this area in Part C of this report, MU6 was not studied in detail. However, it is recommended that the Airport Lands adhere to the criteria stipulated for development in the Pottersburg Creek Subwatershed Plan.

A number of contamination sources exist at the airport, including:

- Runaway De-icing;
- Aircraft De-icing;
- Petroleum Products; and
- Sewage Treatment.
Pottersburg Creek is routed through a series of culverts as it crosses through the Airport Lands. The tributaries in MU6 are severely degraded and support Type IV communities. Significant limitations include low baseflow, poor water quality, limited riparian vegetation, structures and other storm water management facilities. There is little opportunity to enhance the watercourse in this area without directly impacting the Airport operation. Further degradation of MU6 may lead to the stream no longer being able to support any fish species.

B11.5.3 Development Area (MU7)

MU7 is the main stem of Pottersburg Creek and its tributaries between Clarke Road and the airport. This is an industrial portion of the City, and all streams, including the main stem of Pottersburg Creek, are channelized. Many of the lower order streams are hardened or completely enclosed. Oil and grease contamination is prevalent throughout this reach, particularly near storm sewer outfalls and at Industrial Road.

The fisheries community indicates severe degradation, with apparent complete absence of smallmouth bass, sunfish species, river chub and northern hog sucker. The fish populations are dominated by minnows, white sucker, and brook stickleback, although darters occur sparingly.

The invertebrate community is also indicative of impaired conditions, representative primarily of Type IV communities; some main stem stations support Type III communities, while some tributaries are Type V (Map B14). The low densities of blackflies and hydropsychid caddisflies suggests that siltation may be a problem.

Significant limitations in this unit are oil and grease contamination, channelization, general lack of riffles and pools, limited amounts of riparian vegetation and inputs of storm water.

In 1984, the Ontario Ministry of the Environment (MOE) completed an investigation of the presence of PCBs in the soils along Pottersburg Creek. As a result of that investigation, a remediation program was developed and implemented for the removal and containment of soils containing PCBs from the Walker Drain, the confluence of the Walker Drain and Pottersburg Creek, and from Pottersburg Creek along a section of the creek adjacent to the General Motors plant property, in Kwanis Park from Dundas Street to the CNR, and from the CNR south to approximately Eldorado Drive.

Containment of the PCB containment soils involved the design and construction of a temporary/permanent inground vault on former Westinghouse property which was acquired by the Ministry of Government Services (MGS) for that period.

Extensive rehabilitation is required before this reach of Pottersburg Creek will support intolerant species of aquatic invertebrates and fish. Increasing riparian and instream cover and eliminating pollution sources would moderately improve conditions.

B11.5.4 Existing Development (MU8)

MU8 is the remainder of the Pottersburg Creek watershed, from Clarke Side Road downstream to the mouth at the Thames River. The upper third of the area is mixed industrial/residential, while the downstream portion is residential.
The main stem of the creek is intact, but the tributaries are essentially enclosed in storm sewers. Except near its confluence with the river, almost all of Pottersburg Creek in this unit (and throughout the watershed) is channelized. In the lower portions downstream of Dundas Street, much of the channel is hardened with gabions.

Riparian cover is sparse (16%) in this reach, with existing cover being predominantly willow trees. Even under the trees, much of the area is manicured for parklands or for golf courses.

The fisheries community is a Type IV community except near the mouth, which supports a Type III community (Map B14). However, the creek throughout this unit was used by spawning central stonerollers and white suckers. The mouth of the stream, essentially the only natural channel in the watershed, is the only location where smallmouth bass and the provincially and naturally significant greenside darter were confirmed.

The invertebrate populations are typical of a Type IV impaired community. Highly-tolerant oligochaete species dominated the samples. The composition of the invertebrate assemblage suggests that high water temperatures, low dissolved oxygen concentrations, nutrient enrichment and turbidity are problems. Significant improvements in water quality and in channel configuration are required to make noticeable improvements in the lower portion of Pottersburg Creek.

**B11.5.5 Crumlin Drain (MU9)**

MU9 contains the entire Crumlin Drain subwatershed and also extends from the confluence with Waubuno Creek downstream to the mouth of Waubuno Creek at the Thames River. This portion of Waubuno Creek may potentially be affected by changes in the Crumlin Drain subwatershed.

Crumlin Drain contains only first and second order streams, all of which have been channelized. A tributary entering from the west has been converted into a series of storm water management facilities. Riparian vegetation is sparse, the channel contains little to no cover, and pools and riffles are absent.

The fisheries communities of Crumlin Drain are all Type IV [Map B14] (impaired) except for a tributary entering from the east, which supported no fish. The fish assemblage was dominated by minnows and brook stickleback. A single greenside darter and six central stonerollers, both provincially and nationally significant species, were collected near the mouth of Crumlin Drain just upstream of Waubuno Creek. A single brown trout was caught in a first order portion of Crumlin Drain. BEAK suggested that it had come from a pond or some other refugium, as summer water temperatures in Crumlin Drain exceed the tolerances of brown trout.

The aquatic invertebrate communities exhibit the lowest quality of all the management units. Water quality values are among the lowest in all of the subwatersheds, and indicate that all of Crumlin Drain is impaired.

In contrast, Waubuno Creek below the confluence with Crumlin Drain supports a diverse (Type IIB) fish community. Eighteen species were documented here, including four darter species, smallmouth bass, rock bass, and northern hog sucker. Central stoneroller and greenside darter were common, with 21 and 48 being collected, respectively. Because of its channelized nature and low baseflow, it is unlikely that Crumlin Drain can be significantly enhanced. It could be further degraded by increased inputs of sediments or nutrients, or reductions in baseflow due to loss of riparian vegetation, decreased groundwater discharge, or changes in land use.
PART C

DEVELOPMENT AND EVALUATION OF ALTERNATIVE SUBWATERSHED MANAGEMENT STRATEGIES
PART C - DEVELOPMENT AND EVALUATION OF ALTERNATIVE SUBWATERSHED MANAGEMENT STRATEGIES

C1.0 IMPACT ASSESSMENT

This section of the study report addresses the potential impacts of future land use changes on the features, functions and processes of the Pottersburg Creek and Crumlin Drain Subwatersheds. The potential impacts will result from changes in the hydrogeologic and surface water systems, as well as a result of development adjacent to the proposed Greenspace System.

C1.1 Future Land Use

The future development scenario included urbanization of the subwatershed up to the new City of London municipal boundary in both the Pottersburg Creek and Crumlin Drain catchments (See Map C1).

C1.2 Subwatershed Functions

The sensitivity of the Pottersburg Creek and Crumlin Drain subwatershed was evaluated based on the existing subwatershed ecosystem functions, attributes and linkages. The following sections describe these sensitivities.

C1.2.1 Subwatershed Functions

Water Balance

Urbanization of the subwatershed will tend to change the water balance, particularly in the areas underlain by sands and gravels. The hydrogeologic models predicted negligible change in the balance between infiltration and runoff areas in the whole watershed as noted in Figure C1. This is because the area to be developed is predominantly underlain by tighter, less permeable soils.

Peak Flow Impacts

The alternative land use scenarios were applied to the event simulation model to estimate the potential impact of land use changes on peak flow rates generated by the various design storms. The results are presented in the Technical Appendix. The existing condition flows for the 2, 5, 25, 100 and 250 year range from 28.1 to 90.9 m³/s for Pottersburg Creek and 0.6 to 8.2 m³/s for Crumlin Drain. This is contrasted to the ultimate condition flows of 31.8 to 101.4 m³/s and 9.8 to 50.2 m³/s for Pottersburg Creek and Crumlin Drain, respectively. Based on a review of the findings, the following are concluded:

i) High density or industrial ultimate development conditions would slightly increase the magnitude of the peak flows in the Pottersburg Creek; and

ii) Industrial ultimate development conditions would increase the magnitude of the peak flows in Crumlin Drain by 6 times.
Flow Duration

Existing flow conditions in MU8 and MU9 currently exceed a discharge of 0.20 m³/s 5.6 percent and 1.1 percent of the time for Pottersburg Creek and Crumlin Drain, respectively. It increases to 6.0 percent and 2.7 percent of the time for the ultimate condition scenario. As the amount of urban area increases, so does the duration and frequency of runoff in Pottersburg Creek and Crumlin Drain stream flows (See Technical Appendix for modelling results).

Erosion Indices

The existing conditions model indicated that some erosion potential currently exists for both the Pottersburg Creek and Crumlin Drain. The ultimate condition model erosion potential increased by as much as an order or magnitude and two orders of magnitude times the existing erosion potential for Pottersburg Creek and Crumlin Drain, respectively. The erosion potential increases considerably as more land is urbanized (See Technical Appendix).

Sediment Loading

Existing conditions indicated that a suspended solids concentration of 10 mass units/m³ was exceeded 6.8 percent and 2.3 percent of the time for Pottersburg Creek and Crumlin Drain, respectively. The corresponding values of the ultimate scenario condition were 6.3 percent and 4.4 percent. These results imply that the frequency of higher suspended solids concentrations will be maintained for Pottersburg Creek and will increase for Crumlin Drain.

Flood Risk

Regulatory flood elevations for both existing and ultimate conditions were calculated for Pottersburg Creek. A review of the existing Regulatory floodline mapping indicates 28 structures that are within the floodplain (Based on Hurricane Hazel) and 27 structures for ultimate conditions (Based on 250-year event).

Regulatory flood elevations were also calculated for Crumlin Drain for both existing and ultimate conditions. A review of the Regulatory floodlines indicates the absence of structures within the floodplain for existing conditions and 4 structures for ultimate conditions, respectively. These structures are all located just downstream of the Highway 2 crossing. Flow control measures sized for the Regulatory Storm are not recommended for future development since the impact on existing structures is limited to 4. Alternatively, it is suggested that site specific protection measures or consideration of a Two Zone Policy Area be reviewed in this location.

Aquatic and Terrestrial Habitat

Impacts on terrestrial habitat can be quantified by the number and quality of forested patches impacted. There is a potential to impact 22 forest patches. Aquatic habitat would also be impacted indirectly through an increase in pollutant loadings.
C1.2.2 Subwatershed Attributes and Linkages

The central stoneroller and greenside darter could be impacted in several ways. Loss of habitat through stream channelization or increased erosion could occur. Degraded water quality could also result from an increase in urban runoff which could further cause impact to these species.

Forested patch 5005 is within the area to be developed. The nationally vulnerable Cooper’s Hawk was spotted in this area. Development must have consideration for these species.

The relationship between infiltration and groundwater discharge is not highly sensitive in the Pottersburg Creek and Crumlin Drain subwatershed. Map C2 illustrates the areas that are most sensitive to future development.

C1.3 Opportunities to Modify Subwatershed Hydrology

An analysis has been completed on each subwatershed to test the sensitivity of the subwatershed and its hydrologic response to various watershed management practices. Management practices tested for each subwatershed included:

- Peak flow attenuation;
- Extended detention for water quality treatment;
- Incorporation of infiltration practices; and
- Increasing existing forest-cover by a factor of 2.

These management practices primarily impact the hydrologic cycle portion of the subwatershed ecosystem. The ecosystem components that can be impacted through these management practices are illustrated on Figure C1. The remaining sections of this chapter describe the ecological characteristics, sensitivities, opportunities and constraints of the subwatersheds and the various management units.

Flood Risk

Flood risk can be managed by ensuring that peak flows are attenuated for the 2 to 100-year return period storms as development proceeds. Based on impervious ratios of 35 and 50 percent respectively, volumes required for peak flow attenuation would range from 200 to 300 m³/ha, respectively.

Flow Regime/Erosion Indices

Section C1.2.1 described the nature of the increases in flow duration and erosion potential that would result from future development. These flow characteristics can be modified with the incorporation of extended detention storage in storm water management facilities. Extended detention can take several forms, including wet ponds, dry ponds, and possibly even constructed wetlands. Extended detention volumes necessary to modify the flow regime and reduce post-development erosion indices range from 70 to 130 m³/ha of development for the scenarios considered. This volume would be in addition to the volume required for peak flow attenuation. With the implementation of peak flow control and infiltration erosion indices (See Figure C2 and C3) will be considerably reduced. In addition, flow duration values would approach existing conditions.
FIGURE C2
Pottersburg Creek Erosion Indices (Section P3)

Erosion Index (Pa.S)

<table>
<thead>
<tr>
<th>Exist</th>
<th>Ultimate (No Control)</th>
<th>Ultimate (Peak Control)</th>
<th>Ultimate (Peak Control &amp; Inflit)</th>
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Station 1  Station 2  Station 3

Bed-Bank Position

Ultimate Condition Represented by 50% Impervious
20mm of Roof Top Runoff was Infiltrated
25mm Event - 24 Hr Draindown (Water Quality)
FIGURE C3
Crumlin Drain Erosion Indices (Section C2)

Ultimate Condition Represented by 50% Impervious
20mm of Rooftop Runoff was Infiltrated
25mm Event - 24 Hr Draindown (Water Quality)
Groundwater/Infiltration

Analyses were carried out to investigate the impact of infiltration practices on the subwatershed hydrology. In an effort to protect future groundwater quality, it would be reasonable to assume the infiltration of only roof top runoff, as this runoff would be relatively clean. The analysis indicated that the existing infiltration in the Pottersburg Creek and Crumlin Drain subwatersheds can be maintained with the incorporation of infiltration practices for roof runoff. The distribution of the sand and gravel deposits and the lower existing infiltration rates makes maintenance and even enhancement of existing infiltration feasible. However, lot level infiltration facilities designed to infiltrate the first 20 mm of roof runoff would maintain infiltration in the subwatershed.

Map C3 illustrates existing infiltration potential in Pottersburg Creek and Crumlin Drain.

The use of a combination of infiltration practices, extended detention storage, and peak flow attenuation would allow the most efficient use of best management practices for subwatershed management. The volume requirements stated above for flow duration and peak flow attenuation could be reduced by as much as 30 percent with the incorporation of infiltration practices. However, site specific hydrogeological investigations will be required to specifically determine the infiltration capability on a lot-by-lot basis.

Forest Cover

An analysis was carried out on the impact of an increase in forest cover on the subwatershed hydrology. Forest cover can impact both peak flow and the evapotranspiration portion of the water balance.

The analysis indicated that the doubling of the existing area of forest cover in the Stoney Creek subwatershed would have a negligible impact on peak flows at the outlet of the subwatershed. On a local basis, the impact of increased forest cover would be an approximate 25 percent decrease in the peak flow generated from a 25 mm storm. The effect of this decrease is lost as the flow is routed down through the subwatershed to the outlet.

Further analysis indicated that the increased forest-cover has the most beneficial impact when carried out in less permeable or till like soils. Increasing forest cover in a tighter till soil would also increase the evapotranspiration portion of the water balance. However, the infiltration portion of the water budget surplus is maintained or even increased. In this case, the direct runoff portion of the water budget surplus is decreased, with beneficial effects on peak flow control and erosion potential.

Increased forest-cover in sand and gravel type soils will increase the evapotranspiration component of the water balance, thus reducing the surplus available for infiltration and runoff. Furthermore, the amount of loss to evapotranspiration outweighs the increase that would be gained in infiltration potential.
C2.0 ALTERNATIVES FOR SUBWATERSHED MANAGEMENT

C2.1 Background

The intent of this section is to provide the information required to arrive at a preferred management strategy for the Pottersburg Creek and Crumlin Drain Subwatersheds. A menu of alternatives that address a range of management objectives from maintaining the existing ecosystem function to significant enhancement of existing ecosystem function is provided. Finally, this section of the report provides an evaluation of the alternatives based on their ability to meet the subwatershed goals and objectives as well as their practicality for implementation. The subwatershed management strategy is based on a number of principles:

i) The subwatershed management strategy must be founded on the ecology of the subwatershed;

ii) The strategy must provide a reasonable range of alternatives for subwatershed management; and

iii) The strategy must allow quantitative targets for subwatershed management to be set.

C2.2 Alternatives for Subwatershed Management

In keeping with the principles mentioned above, management alternatives will fall into three categories. These are:

- Maintenance of the existing ecosystem functions;
- Moderate enhancement of the ecosystem functions; and
- Significant enhancement of the ecosystem functions.

The alternative for the "maintenance of the existing ecosystem functions" would entail appropriate best management practices and land use restrictions designed to maintain and protect the existing systems in the subwatershed. Ecosystem functions including surface water and groundwater interaction, fisheries habitat and water quality, terrestrial habitat, and corridor linkages would be addressed.

The alternative for "moderately enhancing existing ecosystem functions" can be broken down into two major categories. The two categories are to enhance the aquatic ecosystem and to enhance the terrestrial system. These alternatives would include the identification of candidate areas for rehabilitation, candidate areas for terrestrial enhancement, improvement in the aquatic environment and associated habitat potential, and rehabilitation of tableland woodlots in order to enhance their function in providing terrestrial habitats.

The alternative for the "significant enhancement of the ecosystem functions" builds on the moderate enhancement alternative described above. Further rehabilitation of existing ecological features as well as the creation of new ecological features from both an aquatic and terrestrial perspective, are provided for in this level of enhancement.
C2.3 Management Strategy Components

The following sections describe the implementation requirements and benefits of the three alternatives described above. Table C.1 provides a summary of the management requirements under the categories of flood potential, flow regime/erosion potential, groundwater/infiltration resources, water quality, aquatic resources and terrestrial resources. The reader should be aware that these six categories (types of ecosystem functions) are inherently linked to each other in the real ecosystem. This connectivity is not captured when portrayed in a categorized tabular format.

Each of the management strategies are being described in a cumulative manner. In other words, the significant enhancement also includes the moderate enhancement and maintenance alternatives previously described. This is to avoid unnecessary reiteration.

C2.3.1 Alternative 1 - Maintain Ecosystem Functions

The detailed studies carried out on the subwatersheds outlined the functions performed by the various subwatershed components. Maintenance of these functions would maintain the status quo of environmental quality within the subwatershed. This alternative could also be described as a "no net loss" scenario, particularly as it relates to aquatic and terrestrial habitat (See Map C4).

Flood Risk

Important existing hydrologic functions include the conveyance of storm water, provision of storm water storage, and water quality modification. Management strategies in support of these functions include a reduction in post-development peak flows to meet pre-development peak flows, and maintenance of the natural features of the watercourses in order to maintain their role in flow attenuation and storm water storage. On a management unit basis, this translates to the following:

i) For the rural upper reaches (MU5), maintenance of existing flood risk is not an issue. However, any future development within the designated Regulatory Floodplain should be prohibited.

ii) For the development area (MU7), the existing development area (MU8) and Crumlin Drain (MU9), maintenance of existing flood risk can be achieved by the following:

- Prohibiting new development from occurring within the delineated Regulatory Floodplain;

- Requiring that new development and re-development incorporate at-source controls that reduce the post-development peak flow to pre-development levels for the 2 to 100-year storms; and

- Development or intensification in areas contributing to flow tributaries of Pottersburg Creek or Crumlin Drain should be required to comment on potential inputs to downstream flooding.
<table>
<thead>
<tr>
<th>Maintain Ecosystem Function</th>
<th>Flooding Potential</th>
<th>Flow Regime, Erosion Potential</th>
<th>Groundwater Infiltration</th>
<th>Water Quality</th>
<th>Aquatic Resources</th>
<th>Terrestrial Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no increase in flood risk</td>
<td>peak flow attenuation volume control</td>
<td>maintain current infiltration rate</td>
<td>maintain existing temperature regime</td>
<td>maintain natural channels where they exist</td>
<td>maintain existing riparian vegetation and headwater woodlots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flow duration control</td>
<td>no increase risk to groundwater quality</td>
<td>do not aggravate existing nutrients and bacteria problem areas</td>
<td>maintain fish and benthic communities</td>
<td>maintain Type I and II forest patches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maintain erosion indices</td>
<td>fix existing erosion sites</td>
<td></td>
<td>maintain existing stream classification</td>
<td>maintain wetlands and ESAs</td>
</tr>
<tr>
<td>Moderate Enhancement of Ecosystem Function</td>
<td>reduce flood risk in existing development areas</td>
<td>modify flow duration to dampen response to storms</td>
<td>enhance infiltration</td>
<td>limit livestock access to streams</td>
<td>remove barriers to fish movement</td>
<td>improve shape of woodlots that currently have forest interior habitat</td>
</tr>
<tr>
<td></td>
<td>reduce floodplain width in areas to be developed</td>
<td>reduce erosion indices</td>
<td>reduce risk to groundwater contamination</td>
<td>clean-up point source agricultural sites</td>
<td>retrofit agricultural drains to incorporate meanders</td>
<td>re-vegetate stream corridors</td>
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<td></td>
<td></td>
<td>encourage conservation tillage in high and medium priority areas</td>
<td></td>
<td>retrofit existing storm water management facilities</td>
<td>restore pool-riffle sequences</td>
<td>discourage mowing lawns to stream bank</td>
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<tr>
<td></td>
<td></td>
<td>rehabilitate existing ploughed swales to grassed waterways</td>
<td></td>
<td>public education</td>
<td>increase frequency of stream cleaning</td>
<td></td>
</tr>
<tr>
<td>Significant Enhancement of Ecosystem Function</td>
<td>same as above</td>
<td>divert existing storm sewers to Thames River</td>
<td>same as above</td>
<td>treat storm water prior to discharge to stream (existing)</td>
<td>rehabilitate existing gabion lined channels to a natural state</td>
<td>increase forest patch size to gain interior habitat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>encourage planting in tighter (llt) soils</td>
<td></td>
<td></td>
<td>re-naturalize channels</td>
<td>create new forest patches which contain interior habitat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>create new aquatic habitat</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>further improve stream classification</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>create grasslands, prairies, savannahs</td>
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</tbody>
</table>

TABLE C.1
Summary of Management Alternatives
Flow Regime/Erosion Potential

The primary fluvial geomorphological function is movement of water and sediment. The creek system, pattern and shape are derived from the movement of water and sediment. In-channel forms such as pools and riffles, allow storage and release of water and sediment throughout the year. The fluvial geomorphology of the creek has been classified and described as either stable or degraded. Stable reaches or sections become degraded if the movement or balance between water and sediment is altered. Controls should be recommended for development to ensure sediment loadings do not increase from existing levels. On a management unit basis, the above translates to:

i) For the rural area (MU5), the existing flow regime and erosion potential can be maintained by ensuring that the existing riparian vegetation and maintaining the existing types of agricultural practices;

ii) For the development area (MU7), the existing development area (MU8) and Crumlin Drain (MU9), the existing flow regime and erosion potential can be maintained by incorporating extended detention for the 25 mm storm into the storm water management ponds, as well as taking advantage of infiltration practices wherever possible. Site specific analysis on the actual amount of infiltration to be expected will result in the potential reduction of volume required for extended detention.

Groundwater/Infiltration

An important hydrogeological function in each of the subwatersheds is the infiltration and subsequent discharge of groundwater. Rainfall infiltrates into surface soils, replenishing groundwater aquifers, which in both subwatersheds are used to supply water for domestic, agricultural and industrial uses. Groundwater discharge provides a steady baseflow of cool, clean water to area watercourses.

Maintaining the existing balance of groundwater recharge and discharge is a key component in protecting local sensitive ecosystems such as wetlands, fish spawning areas, and woodlots. Areas which are the most sensitive to disruption of the groundwater recharge/discharge function are those where permeable soils (sands and gravels) occur at or near the ground surface. Urban development in these areas could potentially cause a decrease in infiltration, resulting in a lower groundwater table and a decrease in groundwater discharge to nearby watercourses or wetlands. Maintenance of the groundwater recharge/discharge function would include the incorporation of infiltration practices in conjunction with future development in areas of permeable soils.

Maintaining the chemical quality of local groundwater resources is also a significant issue for both subwatersheds, especially in the rural areas where groundwater is an important source of drinking water. Maintenance of the groundwater resource during urban development would include land-use planning to avoid placing high risk urban activities (such as petroleum outlets or users of industrial chemicals) in sensitive areas.

The above translates into the following:

i) For the rural area (MU5), although urban development is not proposed for this portion of the subwatershed, any new development that does take place should incorporate infiltration facilities in the sand and gravel areas.
ii) For the development area (MU7), the existing development area (MU8) and Crumlin Drain (MU9), existing infiltration rates can be maintained by ensuring that lot level infiltration practices are incorporated in the sand and gravel areas as new development proceeds. These infiltration practices will be designed to infiltrate 20 mm of runoff from roof tops.

**Water Quality**

Water quality is of primary importance to the aquatic resources. Water quality facilities designed to address the more frequent (25 mm or less) events should be incorporated in any future development. On a management unit basis, this translates into the following:

i) For the rural area (MU5), any new development that does take place in this management unit should incorporate lot level water quality controls.

ii) For the development area (MU7), existing water quality can be maintained through the incorporation of lot level water quality best management practices as development proceeds. As well, existing erosion sites within the management unit (as identified in Section B3.0 of this report) should be addressed in order to prevent further degradation of water quality. Oil and grease has appeared to be a problem in this particular management unit in the past. The source of the oil and grease contamination should be ascertained, and remediated.

iii) For the existing development area (MU8), and Crumlin Drain (MU9), existing water quality can be maintained through the incorporation of at-source water quality management practices as development proceeds within this particular management unit.

**Aquatic Resources**

No net loss of aquatic habitat is a general policy of the Canada Fisheries Act (DFO, 1986). Management strategies would include the delineation of sensitive aquatic habitats and subsequent protection of these areas as well as requirements for habitat replacement should future land use impact existing habitat areas. Some reaches of the subwatersheds continue to undergo degradation as a result of existing development. The ability of the stream course to provide aquatic habitat is being lost in these areas. Maintenance of the existing system in this case would entail a minimum of rehabilitation along these impacted reaches of the subwatersheds. The above translates into the following:

i) The aquatic resources of the rural area (MU5) can be maintained by:

   - Continuing existing agricultural practices;
   - Maintaining existing riparian vegetation and headwater woodlots;
   - Ensuring that groundwater recharge areas are maintained.

ii) For the development area (MU7), the following measures are required to maintain the aquatic resources:

   - Define and eliminate the source of oil and grease contamination. Continued discharge of these substances has the potential to further degrade not only this unit, but also MU8 which is downstream; and
   - Control storm water quality and quantity from proposed developments.
iii) For the existing development (MU8), the quality of the aquatic resources can be maintained by:

- Maintaining existing riparian vegetation;
- Maintaining the natural channel near the mouth of the creek; and
- Controlling storm water quality and quantity from new development.

iv) It is imperative that the quality of Crumlin Drain (MU9) be maintained so that Waubuno Creek is not degraded. This can be accomplished by:

- Maintaining existing riparian cover;
- Continuing existing agricultural practices; and
- Designing storm water management facilities for new developments to maintain existing water quality and quantity.

Terrestrial Resources

No net loss of terrestrial features would also be required in order to maintain the existing ecosystem functions. The terrestrial resource strategy identified terrestrial features that were valued for their habitat. These features would be maintained and protected. Other terrestrial features were considered to be somewhat common. These features could be modified or replaced only if no net loss of terrestrial habitat was achieved.

The maintenance of ecosystem functions can be further facilitated through the strategic planning for a city-wide interconnected open space system including stream valley corridors, tableland parkland and connecting linkages. This would allow for the establishment of buffers between new development and natural areas, protection of remnant woodland areas, wetlands and aquatic habitats, and the provision of Open Space areas in which to incorporate storm water management areas and infiltration facilities. In addition, opportunities would be provided for recreation purposes, such as nature observation and recreational trails development.

The above indicated that the Type 1 and 2 patches found throughout the subwatersheds (MU5, MU6, MU7, MU8, MU9) should be maintained. If they are further fragmented, additional wildlife species will disappear from the subwatershed. Type 3 patches are less important and they may be sacrificed, but only if suitable and at least equal habitat is provided elsewhere.

C2.3.2 Alternative 2 - Moderate Enhancement of Ecosystem Functions

Flood Risk

Moderate enhancement of the conveyance properties of Pottersburg Creek and Crumlin Drain, leading to a reduction in flood risk can be accomplished by providing over control for the 100-year and other return period storms. However, since there is no development proposed for the upper rural reaches coupled with the fact that flood risk is not an issue presently, nor is anticipated to be in the future, this is not recommended at this time (See Map C5).
Flow Regime/Erosion Potential

Opportunity for the moderate enhancement of the existing erosion potential exists only in the rural areas (MU5) where there is an opportunity to:

i) Limit livestock access to the stream thereby reducing streambank degradation;

ii) Encourage conservation tillage in high and medium potential sediment load areas; and

iii) Encourage the establishment of buffer strips and riparian habitat along streams.

Moderate enhancement of the remaining reaches (MU6, MU7, MU8, MU9) is not an option at this time.

Groundwater/Infiltration

Moderate enhancement of existing infiltration is not applicable to the rural upper area (MU5) since it lies outside of the City of London lands.

For the Airport Lands (MU6) and development area (MU7), existing infiltration can be enhanced in Pottersburg Creek by the incorporation of at-source infiltration practices as development proceeds.

Since infiltration practices are likely non-existent in the lower developed reaches of Pottersburg Creek (MU8), it may be possible to disconnect roof leaders from the storm sewer system to rear yard ponds or infiltration trenches and areas where existing development overlies sand and gravel. These areas are shown on Map C3.

Existing infiltration can be enhanced in the Crumlin Drain (MU9) subwatershed throughout the incorporation of infiltration best management practices that infiltrate the first 25 mm of roof runoff.

Water Quality

Moderate enhancement of Pottersburg Creek and Crumlin Drain water quality has been identified as an attainable enhancement goal. This translates into the following (on a management unit basis):

i) For the rural area (MU5), moderate enhancement would involve:
   - Further investigate if milkhouse wastewater is being discharged to watercourses, and encourage proper management of discharges if necessary.
   - Follow up on feedlot and manure storage facilities that have been identified as priority sites.

ii) For the development area (MU7) and the Crumlin Drain area (MU9), moderate enhancement would involve:
   - Retrofit existing storm water management facilities to improve water quality.
• Design new developments and retrofit existing areas to minimize storm water runoff by encouraging features such as swales, ponding of water on roofs and parking lots, curbless streets, perforated pipes, and constructed infiltration areas, where feasible. New developments should be designed to minimize the area that becomes impervious.

• Initiate an education program for residential landowners to discourage use of fertilizers and chemicals and washing cars where runoff will go directly into the storm sewer system. The program could also be extended to include management of pet wastes, direction of eavestrough flows onto lawns, etc. Similar programs have been used effectively by some municipalities to assist in the reduction of storm water volume and an improvement in its quality.

• Increase the frequency of street cleaning to minimize the amount of solids in storm water.

iii) For the existing development area (MU8), moderate enhancement would involve:

• Increasing the amount of tree cover along the channel.

• Habitat could be enhanced by using natural channel design diversity habitat and create pools. This could possibly be done by a volunteer group with technical advice provided by the Conservation Authority or MNR. This type of project may also be eligible for funding as a Community Fisheries Involvement Program (CFIP). It would need to be carefully planned to ensure that it did not induce flooding and that the weirs did not block upstream movement by fish.

Aquatic Resources

Enhancement of the aquatic system would entail improvement in water quality and the habitat provisions function of the stream course. The management strategy would include the identification of reaches within the subwatersheds that have the most potential for improvement. These would likely be the reaches of the subwatersheds that are found in the more permeable soils. The detailed aquatic studies found that the most limiting feature of the subwatersheds was the lack of baseflow. Therefore, stream course reaches where baseflow could be improved through infiltration practices would be prime candidates for rehabilitation.
Planting of riparian vegetation in areas where vegetation does not exist would also improve the aquatic system. Vegetation would provide shading to the watercourse which would improve the temperature as well as provide a food source to the aquatic ecosystem. Riparian vegetation would also enhance the stability of creek banks, thus reducing erosion potential. The above translates into the following on a management unit basis:

i) The streams in the rural area (MU5) and in the airport area (MU6) are essentially all first and second order drainage ditches, some of which are intermittent. One potential limiting factor to aquatic resources in the lower portion of MU5 (and top of MU6) is an apparent barrier to upstream movement of fish in the vicinity of the airport. The following management practices are suggested to moderately enhance aquatic resources in these two areas.

- Investigate to see if there is a barrier to fish movement at the airport. The creek travels under the airport for a distance of approximately 500 m. This could act as a barrier to fish in a number of ways: there could be a drop at the downstream end of the culvert, the culvert may be so wide that water depths are inadequate to allow fish passage, or the gradient of the culvert may be too steep. Alternatively, it may be a behavioral avoidance reaction to travelling so far within an enclosed channel.

If the problem is a drop at the end of the culvert, it could be back-flooded with a series of natural stone weirs. The drop between successive pools should be no more than 10 to 15 cm to allow fish passage.

The most likely problem is that the culvert is too wide for the normal baseflow of the stream. This could be alleviated by installing a narrower low-flow channel within the existing culvert, possibly by using curb barriers.

If the gradient is too steep, flows can be slowed by installing baffles at right angles to the flow. This provides areas of still water where fish can rest, and also provides habitat for aquatic invertebrates.

Discussions with Transport Canada will be required to see if any of these management alternatives are required or feasible.

- When drain clean-out is required, Drainage Engineers should be encouraged to consider construction of a meandering channel with vegetated banks as opposed to straight channels. The meandering channels tend to be more stable and therefore require less frequent maintenance. At the same time, they have a greater potential to provide aquatic habitat.

- Encourage the establishment of buffer strips and riparian habitat along watercourses.

ii) The following management practices are suggested to moderately enhance aquatic resources in the development area (MU7):

- Increase the amount of tree cover along the channel.
Habitat could be enhanced by establishing a series of natural stone weirs to diversify habitat and create pools. This could possibly be done by a volunteer group with technical advice provided by the Conservation Authority or MNR. This type of project may also be eligible for funding as a Community Fisheries Involvement Program (CFIP). It would need to be carefully planned to ensure that it did not induce flooding and that the weirs did not block upstream movement by fish.

The existing development area (MU7) is very similar in characteristics to MU7 and experiences much the same limitations to aquatic resources. Therefore, all of the management practices suggested for MU7 are applicable to MU8. The following additional suggestions may enhance aquatic resources in MU8.

- Encourage golf courses along the stream to minimize the use of herbicides and fertilizers.
- Discourage mowing of lawns to the stream's edge in parks and in residential areas.

Crumpin Drain (MU9) consists entirely of first and second order drainage ditches. The following management strategies are suggested to moderately enhance the aquatic resources of MU9.

- Increase the amount of tree cover along the channel and encourage the establishment of buffer strips.
- Encourage conservation tillage practices in potential medium sediment load zones.
- Limit livestock access and follow up on feedlots and manure storage facilities.
- When drain clean-out is required, Drainage Engineers should be encouraged to consider construction of a meandering channel with vegetated banks as opposed to straight channels.
- Investigate the contribution of septic discharges to the stream and develop appropriate remedial plans if required.

**Terrestrial Resources**

Two strategies have been developed to moderately enhance terrestrial resources: improving riparian habitat and increasing the amount of forest-interior habitat.

The plans deviate somewhat from the recommendations of the DTRS. The DTRS defined Type C Zones, which were areas between closely-spaced patches, and recommended that these zones be naturally-vegetated to connect patches. In many cases, the connections were narrow and were essentially all edge habitat, and naturally vegetating them would result in the loss of agricultural land.
Therefore, we have not included many of the Type C Zones in our vision of a moderately enhanced subwatershed. The addition of more edge habitat to join forests may be counterproductive. This creates more habitat for edge species such as white-tailed deer and common species of passerine birds. Although it is desirable to have healthy deer populations, they are greatly increasing in numbers and have the potential to become overabundant. Linking patches has the potential to allow the spread of weed species from one woodlot to another. For those patches that currently support forest-interior bird species, the connections frequently do not create more habitat for these sensitive species. Indeed, they may be adversely affected by improving habitat for edge species and predators.

From an ecological restoration perspective, it is frequently better to increase the size and improve the shape of existing woodlots, or even to create new patches, rather than to create corridors. As stated in the DTRS and in Part B of this report (detailed studies), corridors should be a minimum width of 100 m, and even these will appear as entirely edge from a bird’s perspective. A 100 m wide, 1 km long corridor will consume an equal sized 10 ha of land, but will provide no forest-interior. In contrast, a 10 ha square will provide a 1.4 ha of forest-interior.

In addition to recommending tree planting in riparian corridors, the size and shape of existing woodlots would be improved. Emphasis is on patches that presently contain forest-interior habitat, or those where forest-interior can be created utilizing a minimum of land.

Additional opportunities for the enhancement alternative of ecosystem functions can be found within an expanded greenspace system. This would include the incorporation into the open space system of utility corridors, such as pipelines and hydro corridors, abandoned rail and road rights-of-way and drainage areas, and the protection or re-establishment of hedgerows and fencerows, through new development areas or within the existing agricultural areas. The revegetation of these corridors would enhance habitat linkages between tableland woodlot areas and the creek valley corridors, while providing for increased recreational opportunities such as trails development.

In the Pottersburg Creek and Crumlin Drain subwatersheds, the moderate enhancement alternative adds 235.8 ha of forest. This brings the total forested area to 609.1 ha, or 10.8 percent of the subwatersheds. The amount of forest 100 m or more is increased from 22.2 ha to 122.2 ha, which represents 2.2 percent of the subwatersheds compared to the existing 0.4 percent. Currently, there is no forested habitat 200 m or farther from edge. With the moderate enhancement, there will be 27.9 ha of deepwoods habitat, which is 0.5 percent of the subwatershed.

Rural Areas

The Section B5 identified a number of agricultural practices that are likely contributing pollutants to the Pottersburg Creek and Crumlin Drain systems. Programs or strategies designed to address these concerns could help to improve the overall environmental quality of the Pottersburg Creek and Crumlin Drain systems.

C2.3.3 Alternative 3 - Significant Enhancement of Ecosystem Functions

This section describes the management strategies that would be required to significantly enhance the ecosystem functions for the subwatershed management units. It should be noted that the management strategies are being described in a cumulative manner. In other words, the significant enhancement described in this section also includes the moderate enhancement described and the maintenance alternatives described previously (See Map C6).
Significant enhancement of ecosystem functions primarily reflects the creation of new aquatic and terrestrial habitat. However, a number of other areas have been identified as strategies that can be undertaken to significantly enhance the ecosystem and have been listed where appropriate.

Flow Regime/Erosion Potential

The naturalization of some reaches of the subwatersheds would also improve the aquatic system. This would be of particular importance in the Pottersburg Creek System because several areas were identified where the stream channel is already degraded. Modification to the stream channel to concentrate flow in order to provide adequate depths during low flow as well as appropriate meanders and pool and riffle sequences could be carried out.

The creation or restoration of meanders and pool-riffle sequences would entail strategies for protecting banks and reducing scour to the bed. This would reduce erosion while restoring or enhancing natural water and sediment conveyance.

Water Quality

Measures considered as significant enhancement would include retrofitting of existing storm water management facilities, end of pipe treatment on existing storm sewers, and creation of new wetland complexes.

Specific water quality measures which could be applied to the developed reaches include:

- Treatment of existing storm water discharges prior to discharge to Pottersburg Creek and Crumlin Drain. This could either be an at-source or end-of-pipe solution.
- Divert storm water away from Pottersburg Creek and Crumlin Drain to another receiving body such as the North Thames River or Waubuno Creek, respectively. The potential effects of this on flows in each area have to be considered.

Aquatic Resources

Specific management strategies as they apply to the management of aquatic resources include the following:

i) The following management practices are suggested to significantly enhance aquatic resources in the future development (MU7) and existing development (MU8) areas.

- Convert the stream back into a natural channel. This would involve re-digging and shaping the channel so that it has a natural meander within the floodplain, and has a properly-spaced sequence of pools and riffles. Care would be necessary to ensure that the flood capacity of the channel was not diminished, and that sediments were not introduced into the stream.
- Treatment of existing storm water discharges prior to discharge to Pottersburg Creek. This could either be an at-source or end-of-pipe solution.
Since much of the streambank is hardened in MUG, restoration of this portion of the stream may be more expensive and may result in the destruction of previous lands capital works. However, if a natural channel is established upstream to the airport (MUG) and water quality is improved, Pottersburg Creek downstream of the airport has the potential to support smallmouth bass, darters, suckers and a variety of minnow species.

The potential aquatic communities types that could be achieved as a result of the significant enhancement are illustrated on Map G7.

Terrestrial Resources

The significant enhancement of terrestrial resources focuses on enlarging existing patches event more than the previous alternative.

In the Pottersburg and Crumlin Drain subwatersheds, the significant enhancement results in the addition of another 197 ha of forested area. The subwatersheds would be 14.3 percent forested, which is still relatively low. However, due to the already urbanized nature of the significant subwatersheds below the airport, further increases in natural area are not possible unless a significant amount of agricultural land is taken out of production. With the significant enhancement alternative, the Pottersburg Creek and Crumlin Drain subwatersheds would contain 252.3 ha of forested land 100 m or farther from edge and 76.6 ha 200 m from edge, 1.4 and 4.5 percent of the subwatersheds respectively.

C2.3.4 Summary

A summary of the three management strategy components (by management unit) pertaining to flood potential, flow regime/erosion potential, groundwater infiltration, water quality and aquatic resources is provided in Table C.2.

Terrestrial resources have been analyzed on a subwatershed basis (as opposed to by management unit) with the various strategies appearing in Table C.3.

Part D of the report summarizes the approach used at arriving at the preferred plan, which is also detailed in Part D.
<table>
<thead>
<tr>
<th>Hydrological Targets</th>
<th>5 Rural Area Upstream of City of London</th>
<th>6 Airport Lands</th>
<th>7 Development Area</th>
<th>8 Existing Development</th>
<th>9 Crumlin Drain</th>
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</table>

**Flow Duration**: N/A

**Peak Flow Attenuation (m³/ha)**: 375

**Erosion Indices**: 100

**Runoff Volumes (mm)**: 25

**Infiltration**:

**Grassed Waterways (km)**: 0.5, 1.0, 2.5

**Peak Flow Attenuation (m³/ha)**: 375

**Extended Detention (m³/ha)**: 100

**At-Source Controls (m³/ha)**: 100

**On-lot Dry Wells (mm of runoff from impervious surfaces)**: 25

**Disconnection of Roof Leaders (%)**: 100

**Drain Maintenance**: Continue periodic maintenance

**Periodic maintenance**: N/A

**Note:**

1) 0, 0, 0 refers to actual number corresponding to the three potential levels of management:
- maintain existing environmental quality;
- moderate enhancement; and
- significant enhancement.

C.28
<table>
<thead>
<tr>
<th>Water Quality Targets (2)</th>
<th>5 Rural Area Upstream of City of London</th>
<th>6 Airport Lands</th>
<th>7 Development Area</th>
<th>8 Existing Development</th>
<th>9 Crumlin Drain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Sediment (mg/l)</td>
<td>&lt;150, &lt;75, &lt;50 (2)</td>
<td>&lt;150, &lt;75, &lt;50</td>
<td>&lt;150, &lt;75, &lt;50</td>
<td>&lt;150, &lt;75, &lt;50</td>
<td>400, 200, 50</td>
</tr>
<tr>
<td>Total Phosphorus (mg/l)</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.1, &lt;0.07, &lt;0.03</td>
<td>&lt;0.3, &lt;0.1, &lt;0.5</td>
</tr>
<tr>
<td>Nitrite (mg/l)</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.1, &lt;0.05, &lt;0.03</td>
<td>&lt;0.2, &lt;0.05, &lt;0.03</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>&lt;8.3, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
<td>&lt;8.0, &lt;3.0, &lt;1.0</td>
</tr>
<tr>
<td>Fecal Coliform (counts per 100 ml)</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
<td>&lt;150, &lt;100, &lt;50</td>
</tr>
<tr>
<td>EPT Index</td>
<td>5-7, 5-8, 8-10</td>
<td>5-10, 8-10, 8-10</td>
<td>0-5, 2-5, 5-10</td>
<td>5, 5, 5-10</td>
<td>2.5, 2.5, 2.5</td>
</tr>
<tr>
<td>WQI Score</td>
<td>6-8, 8-10, 10-12</td>
<td>8-12, 10-12, 12-12</td>
<td>8-8, 10-12, 12-12</td>
<td>7-8, 8-10, 10-12</td>
<td>4-8, 6-10, 8-10</td>
</tr>
<tr>
<td>Percent of Point Sources Remediated</td>
<td>3, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
</tr>
</tbody>
</table>

### Water Quality Strategies

| Percent Cattle Access Points Eliminated | 0, 50, 100 (7) (3) | N/A | N/A | N/A | 0, 100, 100 (1) |
| Percent Milkhouse Waste Discharges Eliminated | 0, 50, 100 (12) | N/A | N/A | 0, 100, 100 (1) | N/A |
| Percent of Manure Storage Problems Eliminated | 0, 50, 100 (8) | N/A | N/A | N/A | N/A |
| Percent of Septic Fields Inspected within 30 m Buffer (4) | 0, 50, 100 (to be determined) | 0, 50, 100 | 0, 50, 100 | N/A | 0, 50, 100 |
| Percent of Erosion Priority Areas Addressed through Conservation Tillage | 0, 50, 100 | N/A | 0, 50, 100 | N/A | 0, 50, 100 |

### NOTES:

1. Parameters concentrations are for discharge targets.
2. (2) (5) is the number of occurrences in management unit.
3. Faulty septic systems are to be replaced.

C.29
<table>
<thead>
<tr>
<th>Water Quality BMP's</th>
<th>5 Rural Area Upstream of City of London</th>
<th>6 Airport Lands</th>
<th>7 Development Area</th>
<th>8 Existing Development</th>
<th>9 Crumlin Drain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent SWM Facilities Retrofitted</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0, 50, 100</td>
</tr>
<tr>
<td>Percent Landowners Receiving Educational Material</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
<td>25, 50, 100</td>
</tr>
<tr>
<td>Percent Priority Areas in Conservation Tillage</td>
<td>25, 50, 100</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>25, 50, 100</td>
</tr>
<tr>
<td>Percent of Farms with Environmental Management Plans</td>
<td>10, 25, 50</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>10, 25, 50</td>
</tr>
<tr>
<td>Percent Streambank Tread (buffers)</td>
<td>18.9, 29.2, 63.8</td>
<td>0.0, 0.0, 0.0</td>
<td>25.4, 47.6, 47.6</td>
<td>62.1, 91.3, 91.3</td>
<td>33.3, 55.0, 97.5</td>
</tr>
<tr>
<td>Percent Streambank Grassed or in Shrub</td>
<td>36.1, 91.5, 0.9</td>
<td>62.2, 62.2, 62.2</td>
<td>0.0, 0.0, 0.0</td>
<td>5.2, 0.0, 0.0</td>
<td>2.5, 2.5, 2.5</td>
</tr>
<tr>
<td>Aquatic Habitat Targets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishery Type</td>
<td>IV-V, IV-V, IV</td>
<td>IV, IV, IV</td>
<td>IV, III-IV, III-V</td>
<td>III-V, III-V, III-V</td>
<td>IV-V, IV-V, IV</td>
</tr>
<tr>
<td>Aquatic Strategies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance of Stream Provided with Rock Walls (km)</td>
<td>0, 0, 0</td>
<td>0, 0, 0</td>
<td>0, 3.0, 3.0</td>
<td>0, 0, 0</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td>Distance of Channel Naturalized (km)</td>
<td>0, 0, 0</td>
<td>0, 0, 1.0</td>
<td>0, 0, 3.0</td>
<td>0, 0, 4.5</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td>Percent of Barriers Removed</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
<td>0, 50, 100</td>
</tr>
</tbody>
</table>

**NOTE:**

5) IV-V, IV-V, IV - Where two fishery types are given for one management level, they refer first to the main branch and second to the tributary.
<table>
<thead>
<tr>
<th>Terrestrial Resources Summary</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrestrial (1)</strong></td>
<td></td>
</tr>
<tr>
<td>Percent Natural Area</td>
<td>7, 14, 20</td>
</tr>
<tr>
<td>Percent Forest</td>
<td>6.6, 10.8, 14.3</td>
</tr>
<tr>
<td>Percent Forest 100 m or Greater from Edge</td>
<td>0.4, 2.2, 4.5</td>
</tr>
<tr>
<td>Percent Forest 200 m or Greater from Edge</td>
<td>0.0, 0.5, 1.4</td>
</tr>
<tr>
<td>Percent Prairie and Savannah</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td>Percent Grassland and Old Field</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td>Retaining Regulated Floodplain</td>
<td>4.4</td>
</tr>
</tbody>
</table>

**NOTES:**

1) All percentages are of the total subwatershed area.
2) The three numbers correspond to the three management levels.
PART D

SUBWATERSHED MANAGEMENT PLAN

PARAGON
PART D - SUBWATERSHED MANAGEMENT PLAN

D1.0 EVALUATION CRITERIA AND CONSULTATION PROCESS

The intent of the Management Plan is to identify the management requirements and implementation framework which will be necessary to maintain, protect and enhance the natural attributes of the watershed.

D1.1 Evaluation Criteria

Different management actions and alternative strategies were presented in Part C. In developing a Recommended Draft Subwatershed Plan, these alternatives were evaluated against a series of criteria developed for all subwatershed group studies. A listing and a brief description of the evaluation criteria are provided below:

Technical Considerations: Each potential management action or option was evaluated for technical feasibility. This included consideration of physical limitations for specific options (e.g. soil capacity for infiltration), usefulness or effectiveness, and limitations in the ability to implement actions. The latter limitations were established based on experience in other areas, and did not generally preclude the selection of the option but rather pointed to the need for improvement in program delivery.

Environmental Benefit: The overall environmental benefits ascribed to each option were established based on the problems that exist, the predicted results of implementing the action and experience with its application in other areas. It should be recognized that while each action results in specific benefits, it is the cumulative effect of a combination of actions which improves ecological integrity and results in the largest environmental benefit.

Land Requirements/Impacts: Many of the possible actions require the use of land which could be used for other purposes. Other management actions have impacts on the current use of the land (e.g. for agriculture). Each action was therefore evaluated in terms of its land requirements or land use impacts. The emphasis within the City of London in lands affected by the new Official Plan, was on land requirements outside of regulated areas. The emphasis outside the City was on impacts to current land use practices.

Cost: Cost estimates were made and used in the evaluations of options which would involve public funding. Actions that would be implemented by the private sector were not costed because the majority of actions, for example, storm water quality and quantity facilities are required by provincial regulations or guidelines. Costs were not established for lands to be included in a natural heritage system, although the area of these lands (of different types), were documented and used in evaluating the strategies.

Agencies Acceptance: The Subwatershed Plans are being prepared under a partnership involving municipal and provincial agencies, each of which has mandates, regulations and guidelines. Each option was therefore evaluated in terms of the anticipated support and acceptance which could be expected from the different agencies.

Public Acceptance: Each subwatershed team has held two public meetings prior to the evaluation of alternatives. In addition, each team's Technical Advisory Committee included public representatives who had participated in the study process since the beginning of Phase II. Based on the input received from these sources, the potential options were evaluated based on expected public support and acceptance. The evaluation sought to capture a sense of the general public, recognizing that landowners will have specific concerns for options which affect their lands.
Ranking of Management Actions

Each of the management actions contained in the plan is recommended for implementation. It is recognized however, that some actions are more important, more effective, or easier to successfully implement than others. The recommended Plan therefore contains a column which indicates the relative ranking of the action within the plan. The ranking represents the subwatershed team’s judgement of the importance of the action to the successful implementation of the plan. It is an aggregate rank, determined by considering the importance and effectiveness of the action, the ability to implement in the short term or long term, the comprehensiveness of application and the support for implementation.

High: Important to plan success; highly effective; widespread or important site specific applicability; immediately implementable with likelihood of rapid results; general support.

Medium: Important to plan success; moderately or highly effective; general applicability; implementable over the long term; general support to limited resistance.

Low: Less important to plan success; moderately to highly effective; less important site specific or general applicability; implementable over the long term or beyond current planning horizon; moderate support to limited resistance.

The evaluation criteria listed above formed the basis for recommending the elements of a preliminary Subwatershed Plan. In most cases (excepting physical infeasibility) the evaluations did not result in discarding action immediately. Rather, the results for the evaluations were used as input to the consultation process which led to the selection of the Draft Subwatershed Plans.

D1.2 Subwatershed Plan Consultation Process

The consultation process involved a public open house and public meeting held on November 22, 1994, as well as a series of meetings with the Technical Advisory Committee. A slide presentation of the subwatershed was provided at the onset of the public meeting. The objective of the open house and public meeting was to obtain public opinion with respect to:

- Specific comments relating to any of the alternative management strategies;
- The importance of each component, for example, aquatic resources within each alternative management strategy; and
- The importance or ranking of each of the following criteria: technical feasibility, public acceptance, environmental enhancement, cost, land requirements, used in the evaluation process.

Meetings that were subsequently held with the Technical Advisory Committee were used to further elaborate on each of the strategies and to bring consistency to the approaches used by each of the consultant teams working on each of the studies.

A number of comments were received during the subwatershed study process from both agencies and the public sector. Every effort was made to incorporate these comments into the final document. However, often comments were of a competing or conflicting nature and therefore some compromises were made.
D2.0 SELECTION/DESCRIPTION OF THE RECOMMENDED PLAN

D2.1 Selection of Recommended Plan

The Recommended Plan is described in Section D3 and is illustrated on Map D1. The recommended Subwatershed Plan is similar, with the exceptions noted in Chapter 3, to the significant level of enhancement plan as defined in the Part C report. The rationale for selecting the recommended Subwatershed Plan is provided below.

Technical Considerations: It is felt that technically any of the three alternative plans could be achieved. Therefore, this criteria does not have considerable influence in selecting a preferred plan.

Environmental Benefit: The environmental benefit of the Recommended Plan is considerable, in that an attempt will be made, in the long term, to restore or enhance many of the environmental resources that once existed within the subwatershed. These include:

- A healthy and functional terrestrial ecosystem capable of supporting various species of plants, birds and wildlife;
- A healthy aquatic ecosystem supporting a diverse warm water fishery in the main stream, and a tolerant warm water fishery in most other continuously flowing tributaries;
- Protection/restoration of the stream, over the long term, such that protection of public/private property is achieved and aquatic/terrestrial targets are met;
- Long term reduction of key water quality parameters (total phosphorus, total solids and bacteria) necessary to meet the above objectives;
- Protection of existing groundwater supplies (from a quantity and quality perspective); and
- Protection of the existing levels of flood protection and level of convenience against flooding at crossings.

Land Requirements/Impacts: The recommended Subwatershed Plan ensures that lands that are necessary to meet the above noted environmental benefits are set aside. These areas include significant terrestrial features, and lands for storm water management facilities. The requirement for additional lands such as non-significant vegetation features will be determined as Area Plans, Draft Plan or Site Plan studies are conducted.

Cost: The majority of the costs associated with any of the strategies is related to the construction of storm water management facilities. These facilities are required for any of the three alternative plans. The remaining costs, will likely be borne by the public sector. However, rural stakeholders may be required to absorb some portion of the costs associated with rural management options. Discussions with both the regulatory agencies and the public suggested that effort should be spent to define funding alternatives, such that the recommended Subwatershed Plan, as described, can be implemented.

Agency Acceptance: The recommended Subwatershed Plan, as described, is consistent with the preference of a majority of the agencies which participated on the TAC. Considerable discussion was held with the TAC, especially with respect to the selection of a preferred Terrestrial Strategy.
Public Acceptance: Through the series of open houses and public meetings and questionnaires, the public indicated that improvement in the environmental health of Pottersburg Creek and Crumlin Drain was important. Furthermore, the public indicated that enhancement of the existing ecological health of Pottersburg Creek and Crumlin Drain is something that should be done through the recommendations of the Subwatershed Plan. These two points were considered selecting the recommended Subwatershed Plan.

D2.2 General Description of the Subwatershed Plan Recommendations

The following subsections provide a description of what the recommended Subwatershed Plan has been prepared to achieve with respect to the various plan components. The sections describe general considerations of maintaining or enhancing terrestrial and aquatic ecology, stream morphology, flooding, groundwater, and water quality conditions in the subwatersheds.

D2.2.1 Terrestrial Ecology

The strategy builds on the Draft Terrestrial Resource Strategy (DTRS) prepared by Terra (1994) and interpretative and field data compiled by UTRCA and Bowles (1994). The DTRS summarizes policies that protect or may affect terrestrial and wetland resources. One of the primary objectives of the DTRS was to provide a basis for land use policies to protect, enhance and restore ecosystems within the subwatersheds. In addition, the DTRS summarized the current state of knowledge of landscape ecology principles. The DTRS noted that the amount of natural habitat in all thirteen subwatersheds is lower than the majority of southern Ontario, and recommended that all natural areas be protected wherever possible. In order to increase the extent of natural areas, the DTRS recommended a balanced strategy of retention, restoration and replacement of existing features, and also management of lands adjacent to terrestrial features. Following discussions with members of the TAC and the subwatershed consultants, it was agreed that the terrestrial features and other lands serving key ecosystem functions should be subdivided as follows:

Category 1: All Provincially Significant Areas (PSAs) and Environmentally Sensitive Areas (ESAs within the City boundaries), areas within floodlines or fill lines, and adjacent to or contiguous to designated streams; and

Category 2: Other remaining vegetation patches not in Category 1 and of more significance than the remaining terrestrial patch designation (i.e. > 4 ha), all areas serving an important recharge function, terrestrial corridors and anti-fragmentation areas, and vegetation areas contiguous to non-designated streams.

Remaining Terrestrial Patches: Includes other terrestrial patches for which regard should be given.

Both Category 1 and 2 features would be identified in the Official Plan schedules. Category 1 would be identified for protection/enhancement/restoration and transfer into public ownership. Category 2 would be identified for protection/enhancement/restoration through other mechanisms and possibly replacement with appropriate compensation and mitigation.

The Category 1 areas include two patches (4003 and 4034) that were originally recommended as candidate ESA complex, as well as several woodlots that are situated adjacent to watercourses or the flood lines (See Table D.1). However, upon further study patches 4033 and 4033 were found to be located outside of the City of London. Hence, there are currently no recommended patches for inclusion as ESAs into the Official Plan. Together, the Category 1 terrestrial areas constitute approximately 61.4 ha, or 1.1 percent of the Pottersburg Creek and Crumlin Drain subwatersheds.
<table>
<thead>
<tr>
<th>Patch No.</th>
<th>Riparian Vegetation Contiguous to a Designated Watercourse</th>
</tr>
</thead>
<tbody>
<tr>
<td>4002</td>
<td>X</td>
</tr>
<tr>
<td>4003</td>
<td>X</td>
</tr>
<tr>
<td>4004</td>
<td>X</td>
</tr>
<tr>
<td>4005</td>
<td>X</td>
</tr>
<tr>
<td>4015</td>
<td>X</td>
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<td>4016</td>
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<td>5001</td>
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<tr>
<td>5002</td>
<td>X</td>
</tr>
<tr>
<td>5005</td>
<td>X</td>
</tr>
</tbody>
</table>
In Category 2, several anti-fragmentation areas were identified that link some features, thereby increasing the core area of patches. Several small and medium-sized woodlots were connected to provide larger support areas. Some of the anti-fragmentation areas also function as wildlife corridors, while others are adjacent to watercourses and will improve aquatic habitat. The core area of patches 4033 and 4034 will be increased by adjacent anti-fragmentation areas which will also provide a linkage along the nearby watercourses. Anti-fragmentation areas are further discussed in Section D3.

D2.2.2 Aquatic Ecology

The aquatic resources of Pottersburg Creek and Crumlin Drain are of low quality due to channelization, limited riparian vegetation and degraded water quality. Specific management techniques that have been recommended to enhance aquatic ecology include planting riparian vegetation and establishing buffer areas along watercourses, elimination of barriers to fish movement, establishment of grassed waterways in headwater tributaries, elimination of point sources of contaminants, reduction of non-point sources, construction of rock weirs in the stream to create a series of pools and riffles, and renaturalization of selected reaches of the watercourses. These strategies are outlined in Table D.1.

D2.2.3 Stream Morphology

The detailed studies carried out as part of the subwatershed planning process described the fluvial geomorphology of the Pottersburg Creek and Crumlin Drain subwatershed systems. The Pottersburg Creek system was found to have relatively low relief and sinuosity, indicating significant artificial straightening in both the urban and rural areas. Between Middlesex Road 27 and Oxford Street, Pottersburg Creek is in a degraded condition as a result of excess down-cutting and bank erosion. The Crumlin Drain was similarly found to have low relief and sinuosity, again indicating artificial straightening throughout the watercourse. The bed material within Crumlin Drain is mobile at velocities below bankfull, and as a result, has a high susceptibility to erosion. With the implementation of erosion control measures as development proceeds, combined with the rehabilitation proposed under special programs and stream bank erosion projects, an enhanced level of stream morphology will result.

D2.2.4 Flooding

The Pottersburg Creek floodplain is confined to a riparian corridor throughout the majority of the urban reaches, between the Thames River and the London Airport. However in some areas, the floodplain encroaches onto private property and these lands are at risk during the Regulatory Flood event. Many undersized culverts or bridges exist in the Pottersburg Creek system, which results in elevated backwater elevations behind these structures. Notably, backwater flooding is experienced upstream of the CN Rail crossing, Trafalgar Road, Brydges Street, Third Street, Industrial Road, and upstream of Runway 14-33 at the London Airport. The floodplain of Pottersburg Creek significantly widens between Industrial Road and Crumlin Road as a result of low-lying topography and undersized structures. This area has been the subject of detailed analyses on behalf of private landowners and the City of London Economic Development Department, to assess the potential for the recovery of floodplain lands.
As indicated in Part C, currently 27 structures are located within the Regulatory Floodplain under ultimate development conditions with the floodplain of Pottersburg Creek being sensitive to changes in the hydrologic flow regime. However, since the 250-year event has replaced Hurricane Hazel as the Regulatory event, the floodplain has been narrowed with fewer houses in the floodplain than in previous studies. Therefore the Recommended Subwatershed Plan is recommending management actions to control peak flow, utilizing storm water management techniques for design events ranging from the 2-year to the 100-year return period storms. Although the elimination of floodplain storage between Industrial Road and Crumlin Road is not desirable and contravenes the floodplain management objectives of the Subwatershed Plan, there may be an opportunity to manipulate the floodplain storage in this area, subject to review of detailed studies related to the impacts of lost floodplain storage and the potential for improving the ecological health of this degraded stream reach. The opportunity of working with development proponents in this area to achieve and improve ecological system may offset the loss in floodplain storage.

The Crumlin Drain floodplain is also confined to the riparian corridor through the study area. As mentioned in Part C under ultimate conditions, 4 structures are situated in the Regulatory floodplain. However, all of the structures are located just downstream of the Highway 2 crossing. In addition, the floodplain of the Crumlin Drain has little impact on the adjacent land uses within the drainage area. However, the floodplain and erosion characteristics within the Crumlin Drain are sensitive to changes in the hydrologic flow regime and therefore peak flow attenuation for events ranging from the 2 to 100 year return period storms is being recommended for development lands within the Crumlin Drain watershed area.

D2.2.5 Groundwater

The detailed studies summarized in Part B of the Subwatershed Plan identified a complex surficial geology within the Pottersburg Creek and Crumlin Drain subwatersheds. The surficial geology can range from a glaciolacustrine clay to sands and gravels. Surficial granular sediments occur over approximately 39 to 42 percent of the watershed area. The buried sand and gravel layers are local in nature and do not form continuous units across the subwatersheds. In general, local groundwater flow occurs at shallow depths within the granular overburden sediments. It is estimated that approximately 70 percent of the total infiltration recharges to the local flow system, resulting in baseflow to the streams. The local groundwater systems are important in generating baseflow for Pottersburg Creek and the Crumlin Drain. Although the surficial geology is complex and variable, there is a good infiltration capability within the subwatershed areas. Therefore, management actions are proposed to ensure that where development occurs in areas of surficial, permeable soils, that means to maintain infiltration rates are examined during site specific hydrogeologic studies.

The Subwatershed Plan mapping does not illustrate a continuous, significant recharge potential area, but rather the plan proposes a management action that requires infiltration measures be investigated as development proceeds.
D2.2.6 Water Quality

The detailed studies carried out on water quality within the Pottersburg Creek and Crumlin Drain Subwatershed Study indicated that water quality is a concern as a result of rural point and non-point source pollution, as well as pollutants in urban runoff. Generally, high nutrient and bacteria levels were observed in Pottersburg Creek and Crumlin Drain as a result of agricultural activities. As well, elevated concentrations of heavy metals were detected, which are related to surface runoff from urban land uses. The Pottersburg Creek and Crumlin Drain systems have existing urbanized areas without water quality controls. Agricultural operations have the potential to generate bacteria and nutrient laden runoff, and rural residential development with onsite sewage disposal systems have the potential to discharge nutrients and bacteria to the watercourses. To achieve the objectives of the Subwatershed Plan and improve the aquatic ecosystems of the stream systems, recommendations have been provided for both rural and urban land uses, which will result in improved water quality in Pottersburg Creek and the Crumlin Drain.

With the implementation of storm water quality facilities to coincide with urban development along with the reduction of sediment, phosphorus and bacterial loadings within the rural community, the health of benthic communities will improve in both the Pottersburg Creek and Crumlin Drain subwatersheds. In addition, increased recreational opportunities and overall Creek aesthetics will be added benefits.

D2.2.7 Summary

In the Recommended Plan measures are proposed to:

- Significantly enhance terrestrial and aquatic ecology;
- Reduce erosion indices, bankfull frequencies and flow duration;
- Control flooding;
- Maintain infiltration; and
- Improve water quality and flow characteristics in the existing agricultural and development areas.
D3.0  THE RECOMMENDED PLAN

D3.1  Introduction

The recommended Pottersburg Creek and Crumlin Drain Subwatershed Plan consists of a series of management actions, which when applied together will provide a holistic strategy for meeting the Goals and Objectives and the environmental targets. The recommended Subwatershed Plan will protect and enhance the natural resources of the subwatersheds and reduce the impacts of existing land uses, while ensuring that future development proceeds in a manner which does not impair the key functions of the physical and biological systems which support the watershed integrity. The complex task of providing this protection requires the use of many types of management actions. The recommended actions are grouped under the following headings:

- Designation of Constraint Areas;
- Development Criteria;
- Conservation and Management Practices; and
- Specific Projects and Programs.

D3.1.1  Constraint Areas

The designation of a system of natural areas of biological or physical importance is fundamental to the implementation of the Subwatershed Plan. These areas are termed "constraint areas" because restrictions are placed on development or land use change, either prohibiting development entirely or requiring additional studies to determine if they can be developed, while preserving the important features and functions of the area. The restriction of land use in these areas performs one or more of the following functions:

- Prevents encroachment and direct physical damage to key natural systems;
- Enhances two or more natural areas by providing a physical connection between them; and/or
- Prevents land use change at a scale and in a manner which would exceed the capacity of the subwatershed to sustain both human use and natural systems and functions.

Two types of constraint areas are provided for in the Subwatershed Plan. No development would be permitted in the following types of areas:

- Provincially significant wetlands;
- ANSIs;
- Candidate ESAs (subject to City adoption as ESAs);
- Lands within the Regulatory floodline or fill line, as appropriate;
- Other designated stream corridors*; and
- Riparian vegetation areas contiguous to designated watercourses.

* No buffer or corridor widths are specified for the stream corridors. Corridor widths are to be determined at the Area Plan level.

Utility crossing and roadways would only be permitted after completion of an Environmental Assessment.
It is not the intent that Category 1 be interpreted as being entirely consistent with the Comprehensive Set of Policy Statements (CSPS) associated with Bill 163 at this stage. Refinements to ensure appropriate consistency will occur as the Official Plan is formulated. At this time, the strict definition of development used by the CSPS, which includes grading and the placement of fill, is to be applied only in provincial significant wetlands, ANSIs, Candidate ESAs (subject to City adoption as ESAs). Development within the Regulatory floodline and outside of provincially significant areas, ANSIs and ESAs is regulated by the floodplain management policies. For other Category 1 areas within the fill lines, it is possible that new parks or other recreational Open Space uses may be appropriate. It is intended that these types of uses be permitted in such areas if any Environmental Impact Study (EIS) is completed and shows that there would not be a significant loss of features or function.

In addition to the Category 1 areas, a second group of areas (Category 2) would be protected, subject to more detailed studies such as an Environmental Impact Study (EIS-specific type dependent upon Natural Heritage category), Area Plans or hydrogeologic study. The detailed studies could result in a reduction of the area to be protected, specification of special development criteria, replacement or other compensation, or an upgrade of a specific area to a "no development" status. The types of areas included in this category would include:

- All remaining vegetation patches > 4 ha;
- Riparian vegetation contiguous to a non-designated watercourse;
- Anti-fragmentation zones varying from more vegetated areas which cluster existing patches to high priority erosion areas or sediment producing areas which may be included within the anti-fragmentation area (See Table D.2 for justification of the selection of the anti-fragmentation areas);
- Corridors and buffers outside of the Category 1 areas; and
- Significant recharge/discharge areas.

The protection of these areas would be achieved through their designation in the City's Official Plan, with its attendant policies. The Constraint Areas recommended in the plans are shown in Map D1 and summarized in Table D.3. The system of Constraint Areas constitutes the physical structure of a Natural Heritage Strategy for the subwatersheds.

D3.1.2 Development Criteria

This group of management actions refers to the requirements and standards that new urban development and re-development will be expected to meet, as a condition of development approval. In general, the cost of these options to be borne by the proponent. The actions seek to mitigate the impacts of land use change and in some cases to improve upon the degraded conditions which have resulted from past land use practices.

Examples of the management actions under this category include various storm water controls: for flood protection, erosion prevention, water quality treatment, flow augmentation; infiltration requirements, and additional studies such as extension of floodline mapping. In general, where specified in the Subwatershed Plan, these controls are a requirement for development to proceed and specific design criteria are provided.
<table>
<thead>
<tr>
<th>TABLE D.2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pottersburg Creek and Crumlin Drain Subwatershed Studies</td>
<td>Rationale for Anti-Fragmentation Areas</td>
</tr>
<tr>
<td>Around Patches 4033 and 4034</td>
<td>▶ Protects and enhances habitat for Acadian Flycatcher</td>
</tr>
<tr>
<td></td>
<td>▶ Improves woodlot shapes</td>
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<td></td>
<td>▶ Increases woodlot size</td>
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<tr>
<td></td>
<td>▶ Greatly increases amount of forest-interior</td>
</tr>
<tr>
<td></td>
<td>▶ Buffer to Pottersburg Creek and Waubuno Creek</td>
</tr>
<tr>
<td></td>
<td>▶ In an area of medium potential sediment delivery</td>
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<tr>
<td></td>
<td>▶ Linkage to natural corridors along Waubuno Creek</td>
</tr>
<tr>
<td>Beside Patch 4037</td>
<td>▶ Improves woodlot shapes</td>
</tr>
<tr>
<td></td>
<td>▶ Increases woodlot size</td>
</tr>
<tr>
<td></td>
<td>▶ Greatly increases amount of forest-interior</td>
</tr>
<tr>
<td></td>
<td>▶ Potential to provide habitat for forest-interior species that require coniferous cover</td>
</tr>
<tr>
<td></td>
<td>▶ In an area of medium potential sediment delivery</td>
</tr>
<tr>
<td></td>
<td>▶ Public land</td>
</tr>
<tr>
<td>Around Patches 4042 to 4045</td>
<td>▶ Joins four smaller patches</td>
</tr>
<tr>
<td></td>
<td>▶ Improves overall woodlot shape</td>
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<td></td>
<td>▶ Increases woodlot size</td>
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<tr>
<td></td>
<td>▶ Creates forest-interior habitat</td>
</tr>
<tr>
<td></td>
<td>▶ In an area of medium potential sediment delivery</td>
</tr>
<tr>
<td>Around Patches 4046 to 4049</td>
<td>▶ Joins four smaller patches</td>
</tr>
<tr>
<td></td>
<td>▶ Improves overall woodlot shape</td>
</tr>
<tr>
<td></td>
<td>▶ Greatly increases forest-interior</td>
</tr>
<tr>
<td></td>
<td>▶ Increased buffer along Pottersburg Creek</td>
</tr>
<tr>
<td></td>
<td>▶ In an area of medium potential sediment delivery</td>
</tr>
<tr>
<td>Around Patches 4051 to 4055</td>
<td>▶ Joins five smaller patches</td>
</tr>
<tr>
<td></td>
<td>▶ Improves overall woodlot shape</td>
</tr>
<tr>
<td></td>
<td>▶ Increases woodlot size</td>
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<tr>
<td></td>
<td>▶ Creates forest-interior habitat</td>
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<tr>
<td></td>
<td>▶ In an area of medium potential sediment delivery</td>
</tr>
<tr>
<td>Around Patches 4061 and 4064</td>
<td>▶ Joins five smaller patches</td>
</tr>
<tr>
<td></td>
<td>▶ Improves overall woodlot shape</td>
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<td></td>
<td>▶ Increases woodlot size</td>
</tr>
<tr>
<td></td>
<td>▶ Creates forest-interior habitat</td>
</tr>
<tr>
<td></td>
<td>▶ Buffer along two headwater tributaries</td>
</tr>
</tbody>
</table>
### TABLE D.3
Recommended Subwatershed Plan Management Actions

<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
</table>
| • Provincial Significant Wetlands  
  + None exist | • N/A | • N/A | • N/A | N/A | N/A | N/A | N/A |
| • ANSIs  
  + None exist | • N/A | • N/A | • N/A | N/A | N/A | N/A | N/A |
| • Candidate ESAs  
  + None exist | • N/A | • N/A | • N/A | N/A | N/A | N/A | N/A |
| • Lands within Regulatory Flood or Fill Line  
  + Protected through zoning  
  + Fill line mapping to be completed | • Protected through zoning  
  + Fill line mapping to be completed | • Natural heritage core area  
  + Backbone for linkages  
  + Hydrological balance  
  + Aquatic habitat protection  
  + Terrestrial corridors and habitats  
  + Reduces flood risk | • 253 ha of land designated as regulatory floodplain  
  + Fill line extensions will constrain additional lands | N/A | Current Policy | Yes | High |
| • Designated Stream Corridors and Setbacks  
  + To be utilized where floodlines do not exist  
  + Protected through zoning | • To be determined  
  + Protected through zoning | • Promotes natural stream valleys | • To be determined | N/A | Supported | Yes | Medium |
| • Riparian Vegetation Continuous to a Designated Watercourse  
  + Protected through zoning | • Protected through zoning | • Protects terrestrial habitat and its related function to the stream corridor | • Land will be undevelopable  
  + 61.4 ha of contiguous or floodplain woodlots identified | N/A | Supported | Yes | High |
<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Recharge/Discharge Areas</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>None existing</td>
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<tr>
<td>Other Terrestrial Patches &gt; 4 ha and not in</td>
<td>to be evaluated during</td>
<td>watershed aesthetics</td>
<td>258 ha of remaining</td>
<td>N/A</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
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<td>Category 1</td>
<td>the preparation of an EIS</td>
<td>terrestrial habitat</td>
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<td></td>
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<td>bio-diversity</td>
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<td></td>
<td></td>
<td></td>
<td>32 ha of other terrestrial</td>
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<td>patches are within the</td>
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<td>Regulatory Floodline</td>
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<td>Anti-Fragmentation Areas for Terrestrial</td>
<td>to be evaluated during an</td>
<td>enters interior forest</td>
<td>155 ha identified as anti-</td>
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<td>None existing or proposed</td>
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<tr>
<td>Peak Flow Attenuation Storage for Development</td>
<td>detention ponds to be</td>
<td>flood control</td>
<td>land must be set aside for</td>
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<td>Water Quality Storage Requirements for</td>
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<td>reduces suspended solids,</td>
<td>land must be set aside for</td>
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<td>Supported</td>
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<td>metals and nutrient</td>
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<td>$25/m³ of SWM</td>
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<td>inspection)</td>
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<tr>
<td>Erosion/Stream Morphology Extended Detention</td>
<td>extended detention</td>
<td>minimizes stress on</td>
<td>land must be set aside for</td>
<td>N/A</td>
<td>Supported</td>
<td>Yes</td>
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<td>Storage Requirements</td>
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<td>existing erosion sites</td>
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<td>prevents further</td>
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<td>$25/m³ of SWM</td>
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<td>(proponents cost)</td>
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D.14
<table>
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<tr>
<th>Practices</th>
<th>Technical Considerations</th>
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<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
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<tbody>
<tr>
<td>Development Criteria</td>
<td></td>
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</tr>
<tr>
<td>Erosion Control During Construction</td>
<td>• use of silt fencing, sedimentation basins and check dams during construction</td>
<td>• reduces sediment load to stream</td>
<td>• temporary basins may be required as construction proceeds</td>
<td>• by proponent</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
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<tr>
<td>Construction Inspection</td>
<td>• staff will be required to inspect the appropriateness of erosion control measures</td>
<td>• ensures that management practices are constructed as per specification</td>
<td>• None</td>
<td>• N/A</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Environmentally Sensitive Site Planning Techniques</td>
<td>• minimizes grading, tree preservation, innovative SWM techniques</td>
<td>• maintains hydrologic balance, provides community amenity, provides terrestrial habitat, reduces sediment and pollutant loading</td>
<td>• N/A</td>
<td>• development dependent</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
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<tr>
<td>Conservation and Management Practices</td>
<td></td>
<td></td>
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<tr>
<td>Manure Management and Feedlot Runoff Controls</td>
<td>• need to enforce OMAF guidelines for manure spreading, general problems of over-spreading of manure, however no priority farms were identified, feedlot operations will need to control storm water runoff, 7 operations have potential for runoff occurrence</td>
<td>• reduces bacterial and nutrient loadings</td>
<td>• None</td>
<td>• High</td>
<td>Supported</td>
<td>Variable owner support</td>
<td>Low</td>
</tr>
<tr>
<td>Control Livestock Access to Stream</td>
<td>• restricted access pertaining to livestock along stream courses will be required, 5 access locations identified, 2 locations generate up to 71 percent of coliform input</td>
<td>• reduces stream bank erosion, reduces bacterial and nutrient loadings</td>
<td>• Reduces available agricultural land</td>
<td>• $4,000/farm Estimated: $2,000</td>
<td>Supported</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>
# TABLE D.3

Recommended Subwatershed Plan Management Actions

<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septic System Effluent</td>
<td>• existing septic systems need to be surveyed to identify problem systems</td>
<td>• reduces bacterial and nutrient loading</td>
<td>• Nil</td>
<td>• $5,000 to $15,000 if replaced required</td>
<td>Supported</td>
<td>Variable owner support</td>
<td>Medium</td>
</tr>
<tr>
<td>Conservation Tillage</td>
<td>• farmers to modify tillage practices in high and medium erosion potential areas</td>
<td>• reduces soil loss, sediment and phosphorus loading</td>
<td>• Nil</td>
<td>• $8,000 to $11,000 per farm</td>
<td>Supported</td>
<td>Variable owner support</td>
<td>Medium</td>
</tr>
<tr>
<td>Grassed Waterways</td>
<td>• streams in the upper reaches can be left grassed instead of ploughed</td>
<td>• reduces stream erosion, flow modification</td>
<td>• 3.0 km of grassed waterways proposed</td>
<td>• site specific</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Vegetated Buffer Strips</td>
<td>• buffer strip and setback requirement should be identified in rural areas</td>
<td>• reduces soil loss, sediment and phosphorus loading</td>
<td>• 2.0 km of vegetated buffer strips proposed</td>
<td>• dependent on existing adjacent land use</td>
<td>Supported</td>
<td>Varied</td>
<td>Medium</td>
</tr>
<tr>
<td>Natural Channel Succession</td>
<td>• modified agricultural drain clean out practices</td>
<td>• improves aquatic habitat</td>
<td>• Nil</td>
<td>• to be determined based on effort required</td>
<td>Varied</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Municipal De-Icing Programs</td>
<td>• de-icing compounds (salt) can be replaced with sand in areas adjacent to streams may require increased frequency of street sweeping and catchbasin clean-out</td>
<td>• reduces chloride load to stream</td>
<td>• Nil</td>
<td>• cost to replace salt with another de-icing agent</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Top Soil Preservation</td>
<td>• enforcement as development proceeds • applicable within City boundary</td>
<td>• reduces soil loss and sediment loading</td>
<td>• Nil</td>
<td>• cost for administration of program</td>
<td>Supported</td>
<td>Varied</td>
<td>Medium</td>
</tr>
<tr>
<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
<td>Ranking</td>
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<tr>
<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Erosion Monitoring</td>
<td>monitoring program needs to be implemented under conservation authority jurisdiction</td>
<td>provides feedback on success of erosion control measures</td>
<td>None</td>
<td>N/A</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Disconnect Roof Leaders from Storm Sewers</td>
<td>program to be carried out by City in existing urban areas</td>
<td>augment infiltration and flow moderation</td>
<td>Nil</td>
<td>$200/property</td>
<td>Supported</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Plant Riparian Vegetation in Urban Areas</td>
<td>program carried out by City Parks and Recreation Department and interest groups</td>
<td>reduces stream erosion, improves aquatic habitat, filters runoff</td>
<td>6.1 km of riparian vegetation to be planted</td>
<td>15 m buffer - $4,500/km</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Natural Channel Rehabilitation Techniques Including Pools and Riffles with Stone Weirs</td>
<td>improves aquatic habitat, improves fluvial geomorphology</td>
<td>creates aquatic habitat</td>
<td>2.5 km of improvements proposed</td>
<td>$7,500/km</td>
<td>Supported</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Remediation of Significant Erosion Areas</td>
<td>2 to 3 m high exposed banks experiencing intermittent failures due to entrenched channel</td>
<td>reduces sediment loading to stream</td>
<td>9000 m²</td>
<td>$300,000</td>
<td>Supported</td>
<td>Potential Landowner Opposition</td>
<td>Low</td>
</tr>
<tr>
<td>Pottersburg Creek, upstream of airport (See Plate 1)</td>
<td>most high exposed banks experiencing intermittent failures due to entrenched channel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Practices</td>
<td>Technical Considerations</td>
<td>Environmental Benefits</td>
<td>Land Requirements/Impacts</td>
<td>Costs</td>
<td>Agency Acceptance</td>
<td>Public Acceptance</td>
<td>Ranking</td>
</tr>
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</tr>
</tbody>
</table>
| • Remediation of Significant Erosion Area  
  • Potterburg Creek upstream of Gore Road Bridge (See Plate 2) | • 4 to 5 m high bank on west side has experienced consistent failures due to lack of vegetation and effects of mid-channel bar  
  • approximately 60 m of channel bank should be regraded to a stable slope  
  • base of slope should be protected with rip-rap and mid-channel bar to be removed | • reduces sediment loading to watercourse  
  • improves aquatic habitat | 1200 m² | $75,000 | Supported | Yes | High |
| • Remediation of Minor Erosion Area  
  • Potterburg Creek south of CN rail, south of Oxford Street near Second Street (See Plate 3) | • creek is too close to rail line. Banks are steep with little vegetation  
  • stabilization required through application of rip-rap | • reduces sediment loading to watercourses  
  • improves aquatic habitat | not available | less than $25,000 | Supported | Land owner negotiations required | Low |
| • Remediation of Minor Erosion Area  
  • Cramlin Drain north and south of Gore Road culvert (See Plate 4) | • bank erosion which may lead to failure of culvert | • reduces sediment loading to watercourses  
  • improves aquatic habitat | not available | less than $25,000 | Supported | Yes | Low |
| • Public Awareness Program | • general public, landowners and agricultural community to be the focus | • builds support for ecosystem protection and enhancement  
  • reduces human impact on natural areas | N/A | Program dependent | Supported | Yes | High |
<table>
<thead>
<tr>
<th>Practices</th>
<th>Technical Considerations</th>
<th>Environmental Benefits</th>
<th>Land Requirements/Impacts</th>
<th>Costs</th>
<th>Agency Acceptance</th>
<th>Public Acceptance</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specific Projects and Programs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• Oxford Street - Highway 100 Floodplain Management Assessment</td>
<td>• Landowners in this area have completed hydraulic studies to investigate recovery of floodplain land</td>
<td>• an opportunity exists for proponent involvement in naturalizing a significant reach of Pottermburg Creek</td>
<td>• subject to detailed study</td>
<td>• approximately $100,000 of additional study is required to address the hydrological impacts and to develop a naturalizing program</td>
<td>Reserved pending study</td>
<td>Dependent on outcome of study</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>• further study is necessary to assess the hydrological impacts of lost floodplain storage</td>
<td>• improves riparian vegetation</td>
<td>• impacts of lost floodplain storage must be evaluated downstream to confluence with Thames River</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• further evaluation of this area of interest should consider improvements to the fluvial geomorphological characteristics of the channel, terrestrial, riparian enhancement and aquatic habitat improvements</td>
<td>• improves aquatic habitat</td>
<td></td>
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<td></td>
<td>• studies to-date have only addressed the hydraulic aspects, and there is a need to balance the loss of floodplain storage with potential ecological improvements</td>
<td></td>
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</tr>
<tr>
<td>• Projects Within Airport Lands</td>
<td>• variable</td>
<td>• Verifies</td>
<td>• Verifies</td>
<td>• Unknown</td>
<td>Supported</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>• strongly encourage adherence to Pottermburg Creek recommendations</td>
<td></td>
<td></td>
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</tbody>
</table>
In addition to these requirements, this category may include management options which are not mandatory but which may be in the best interests of both the proponent and the natural environment. Such options may include replacement and restoration of a degraded stream corridor or creation of a stable channel which will avoid future erosion problems. Where specific SWM volume requirements on a per hectare basis are provided, these are to be taken as cumulative volumes. In addition, erosion monitoring will be required and it should involve a program overseen by the Conservation Authority.

D3.1.3 Conservation and Management Practices

Conservation and management practices provide a means of preventing or mitigating the impacts of certain land uses or practices at-source. This category of management action seeks to prevent problems from occurring, or to reduce the impacts resulting from existing land use practices.

There are many sound environmental management practices which are generally applicable to urban environments. Recycling programs, household hazardous waste collection, industrial site management programs, public education and many other such programs are all important to an urban centre. These programs address the general needs of the community however, and are not specific to a particular subwatershed and so they are not discussed in detail in the Plan. Conservation and management programs which have a direct applicability to the subwatershed include:

- Flood and Fill Lines and Flood Policy;
- Agricultural Practices such as conservation tillage, stream buffers, virtually eliminating livestock access;
- Septic Systems Control Practices;
- Erosion and Sediment Control during construction;
- Use of De-icing Chemicals; and
- Public Awareness Programs.

Many of the conservation and management options involve both agency assistance and cooperation and participation by landowners. The relative success of many conservation and management programs is dependent upon agency staff resources to promote the program, as well as the level of financial assistance available to the landowner.

D3.1.4 Specific Projects and Programs

Specific projects and programs are recommended as part of the Subwatershed Plan in order to correct existing problems which have occurred as a result of past land use practices. Specific projects are targeted at individual stream reaches or flood damage centres. Examples of projects include reconstruction of a natural, stable channel in an area experiencing severe on-going erosion problems, or protective berming to prevent potential flood damage. Programs are more general in their application than projects and may include stream bank revegetation or stream habitat rehabilitation along fairly long reaches of watercourse. Plates 1, 2, 3 and 4 are photographs of areas requiring specific projects in the Pottersburg Creek and Crumlin Drain subwatersheds.

Projects and programs are normally publicly funded, whether through Municipal or Conservation Authority resources, or through Provincial grants to public organizations. As such, their implementation is dependent upon approvals of budgets.
The plan suggests that a specific detailed hydrologic and ecological study be completed for the lands in the vicinity of Oxford Street and Highway 100 to address the proposed highway realignment, floodplain storage and ecological enhancement. In addition, implementation of the Pottersburg Creek Recommended Plan is strongly encouraged for projects within the London Airport lands.

D3.2 Subwatershed Plan Components

The components of the Pottersburg Creek and Crumlin Drain Subwatershed Plan are shown in Table D.3. The evaluation criteria are provided to substantiate the selection of the components. As well, a ranking is provided. Plan components are given a rank of high, medium or low, which is intended to prioritize the implementation of the components. Plan components with the ranking of high should be implemented as development proceeds or should be implemented as soon as possible, as these plan components will lead to a direct improvement in the ecological health of the Pottersburg Creek and Crumlin Drain subwatershed system. Components with the ranking of medium should be implemented over time. Components with the rank of low will provide some ecological improvement, however, may be implemented as funds and programs become available.

Map D1 illustrates the recommended Subwatershed Plan and selected management actions for Pottersburg Creek and Crumlin Drain. The map shows the various recommended constraint areas within the Pottersburg Creek and Crumlin Drain system. It also identifies locations within the watercourse where natural channel design projects are recommended.

D3.3 Fact Sheets

In an effort to clarify the goals and objectives, targets and overall management strategy for the Pottersburg Creek and Crumlin Drain system, fact sheets have been prepared on a reach-by-reach basis that summarize pertinent information with respect to:

- Resources (including water resources, aquatic resources, stream morphology, and terrestrial resources);
- Proposed Best Management Practices (including SWM);
- Proposed studies; and
- Environmental targets (for flows, water quality, aquatic community and terrestrial).

The Fact Sheets and accompanying reference map are provided in Appendix 1 of this document and are also included in the Technical Appendix.

D3.4 Greenspace Planning

D3.4.1 General

A Comprehensive Open Space Plan is a necessary element in the planning of any municipality, in order to meet current trends and objectives for the provision of open space, recreation and leisure planning, and healthy communities. At the subwatershed study level, the development of a greenspace plan identifies opportunities for the integration of environmental planning criteria with open space planning, as a first step toward the development of a city-wide network of linked green spaces.
The subwatershed greenspace plan identifies the broad structuring elements based on the natural systems and principles of sustainability. Further refinement of an open space plan should be undertaken at both the city-wide level and through the secondary plan process. Municipal parks, school sites, storm water management areas and other public open space lands should be planned and located with objectives of ecological protection and restoration, the establishment or re-establishment of linkages between the natural systems, in addition to enhancing the landscape quality and passive recreation opportunities throughout the city. The development and management of the municipal open space system represents one of the greatest opportunities for implementing ecological restoration proposals.

The following principles were used in the development of the conceptual greenspace plan:

- Identify a system of interconnected natural corridors and green spaces that will provide for the integration of passive recreation opportunities with the maintenance of ecosystem functions and protection of natural areas;

- Establish the broad greenspace framework that can be used to structure community open space planning;

- Provide the structure for a looped (where possible) system of trails for inter-regional, city-wide and local community uses;

- Integrate existing and potential recreation areas based on natural and cultural heritage features as special features or destinations within the greenspace system; and

- Encourage management practices within the greenspace system that will enhance recreation opportunities in addition to the restoration of the natural systems.

D3.4.2 Greenspace Plan Components

The subwatershed greenspace system comprises of the following components which are based on the environmental planning criteria established within the earlier phases of the subwatershed study. The proposed greenspace plan for the Pottersburg Creek and Crumlin Drain subwatershed is illustrated on Map D2 and includes potential connections into adjacent subwatersheds, and the surrounding townships.

Corridors

The natural corridors are the structuring framework of the greenspace system. The following classifications have been developed to assist in the development of a city-wide plan, that can be implemented as land uses change. Other corridors, not specifically identified at this level of study, which should be considered for incorporation into a city-wide open space plan, include hydro or other utility corridors, unopened road allowances or rights-of-way, and hedgerows.
Urban Greenways

The creek valleylands and tributaries of the subwatershed within the urban boundaries are the primary open space corridors and include all lands within the Regulatory floodlines or fill lines (See Figure D1). The greenways will establish connections between key recreation areas, natural environment areas or points of interest throughout the city or surrounding region, and would support a city-wide/regional trail system consisting of bikeways and/or hiking trails that link into the existing trail system. Trails through undeveloped areas may begin as hiking trails and be upgraded to bikeways as adjacent communities are developed.

There is an opportunity for the existing urban greenway along Pottersburg Creek (Kiwanis Park) to be continued as far north as the airport lands. Opportunities should be examined for the development of a linkage between Kiwanis Park and the South Thames River system, and at the north end to the North Thames River system and Fanshawe Conservation Area, both considered to be the core recreational areas in this area of the City.

Secondary Community Corridors

These corridors establish connections between the urban greenways, natural environment areas, and community areas throughout the city. The secondary community corridors would support local trails that create loops within the broader city-wide trails system and could include bikeways and/or walking trails. The limited extent of watercourse and natural areas restrict opportunities in the Pottersburg Creek subwatershed. Some opportunities may exist along the Crumlin Drain in conjunction with the proposed restoration of a vegetated buffer strip. A connection could potentially be made through the natural area at the south end of the airport to the greenway along Pottersburg Creek, and at the south end along Waubuno Creek to the Thames River.

Future Potential Corridors

Enhancement of water quality in rural areas is proposed through such management practices as grassed waterways and vegetation buffer strips along existing stream courses. If further expansion of the urban boundaries or land subdivision in rural areas were to take place, the natural stream corridors should form the potential framework for a future open space system. It is not intended at this time that the stream corridors through rural areas form part of the planned trail network (See Figure D2). However, there may be future interest and opportunities for regional trail connections through rural areas, along these stream corridors. Any proposed public access over private lands would have to be conducted with the full support and permission of land owners.

Potential Recreation Amenity Areas

Existing Natural Areas

The designation of a system of natural areas within the subwatershed included the identification of Constraint Areas, with restrictions placed on development or land use change, including provincially significant wetlands. These areas may have potential as recreation areas for low impact uses, if sensitively handled. Only one such vegetation patch exists for the Pottersburg Creek subwatershed on its extreme easterly boundary. The airport lands pose a major obstacle in the development of a continuous greenway along Pottersburg Creek to connect to this natural area. Any proposed land use change north of the airport should consider this.
Urban Corridor Cross - Section

**Riparian Edge Planting**
- indigenous riparian species
- deep, wide spreading root systems
- dense well balanced top growth
- high tolerance to flood and sediment inundations

**Low Maintenance Area**
- native shrubs and trees, grasses and wildflowers
- suited to soil, moisture and site conditions
- no intensive cutting, fertilizing, herbicide/pesticide treatments

**Pedestrian/Bicycle Pathway**

**Low Maintenance Area**

**Mowing Strip**

**Riparian Edge Planting**

**Stream Channel**

**Active Floodplain**

**Low Maintenance Area**

**Mowing Strip**

**Low Maintenance Area**
Rural Stream Channel Cross - Section

**Buffer Strip**
- indigenous riparian species
- deep, wide spreading root systems
- dense well balanced top growth
- high tolerance to flood and sediment inundations
Proposed improvements to the aquatic habitat through restoration and management practices will increase the fishing opportunities along Pottersburg Creek, and in a selected area just south of the airport.

Areas of Cultural/Natural Heritage Interest

This classification defines areas of interest from a cultural and natural heritage perspective, that have recreation potential and/or should be considered for special policies/guidelines to ensure that land use change respects the heritage integrity.

One such area was identified in the northern part of the Pottersburg Creek subwatershed, where there is a relatively intact settlement pattern of heritage farms and tree lined roadways. Other rural areas of the subwatershed would also benefit from the encouragement of practices that would enrich the landscape character and restore some of the area’s heritage features, as land uses change. Examples of restoration would include street tree and roadway planting and re-establishment of hedgerows, along with revegetation of watercourses.
PART E

CONCLUSIONS AND RECOMMENDATIONS
PART E CONCLUSIONS AND RECOMMENDATIONS

Completion of the Pottersburg Creek and Crumlin Drain Subwatershed Study involved undertaking detailed studies and analyses to develop an understanding of features, functions and linkages of their ecosystems, and to identify a Plan to sustain, and where possible, enhance existing conditions in the subwatershed. Through this process a number of key conclusions and recommendations have been made, which are summarized in the following subsections. Additional recommendations regarding the implementation of this study's recommended Subwatershed Plan are discussed in the Implementation Plan Report.

E1.1 Conclusions

The following conclusions have been organized with respect to the disciplines for which detailed studies have been undertaken, in addition to general conclusions on the Pottersburg Creek and Crumlin Drain subwatershed ecosystems.

E1.1.1 Land Use

1. Less than 25 percent of the Pottersburg Creek watershed area (including airport industrial lands) and 15 percent of the Crumlin Drain watershed area are currently designated as urban development areas. Future land use changes will result in almost 45 percent of the Pottersburg Creek watershed being designated as urban development, with the primary land use being industrial.

E1.1.2 Geology/Hydrogeology

1. The hydrogeological regime in the Pottersburg Creek and Crumlin Drain subwatershed can be divided into the regional and local groundwater flow systems. The regional system covers the northern Thames Basin with groundwater flow likely originating to the northeast of the Pottersburg Creek and Crumlin Drain subwatersheds, and flowing south-westerly to the South Thames River. The local groundwater flow system is controlled by subwatershed topography and drainage. The local groundwater flow occurs at shallow depths within the overburden sediments. Approximately two-thirds of recharge flows through the local groundwater flow system to Pottersburg Creek and Crumlin Drain, while the balance enters the regional system.

E1.1.3 Fluvial Geomorphology

1. The fluvial geomorphology classification of Pottersburg Creek indicates that most channel reaches are stable, except for the channelized reaches in the London Airport area which are in a degraded condition where the stream has been removed from its floodplain due to excessive down cutting and bank erosion. The upper reaches of Crumlin Drain are in a degraded state and are unstable, while its lower reaches are in a stable form with a low sensitivity to change.

2. Critical velocities for the movement of bed material were found to be lower than bankfull velocities at two of three locations in Pottersburg Creek and at both locations analyzed on Crumlin Drain, which indicates that some reaches in the subwatershed could be particularly sensitive to increases in flow rates or runoff volumes (that could result from future development).

3. Most erosion sites in the subwatershed are the result of channelization and relatively steep embankments with little riparian vegetation.
E1.1.4 Surface Water Hydrology

1. Flow measurements indicate that Pottersburg Creek is continuously flowing along the main channel, while some of its tributaries have intermittent flow. Flow in Crumlin Drain is generally intermittent, particularly during the summer period.

2. Peak runoff conditions in the Crumlin Drain are greatest from a combination of runoff and snowmelt events, while peak flow conditions in Pottersburg Creek are greatest during extreme rainfall events.

3. Future development in the Pottersburg Creek will moderately increase peak flows, and significantly increase peak flows in Crumlin Drain, if storm water management controls are not utilized.

E1.1.5 Rural Point and Non-Point Source Pollution

1. Current gross soil erosion rates are estimated to be about 10,000 tonnes/year in agricultural areas of the two subwatersheds. Recent changes in cropping systems and in the area of land base which they are performed have resulted in a very minor increase (about 1%) in annual soil loss.

2. Conservation tillage practices are currently in use at a number of areas in the subwatershed, but could be further extended to a number of key areas to realize a substantial reduction in actual sediment loading to surface waters.

3. Some headwater swales which are currently cultivated would benefit from the establishment of grassed waterways.

4. Livestock access contributes more than 90 percent of the raw fecal coliform input to the headwaters of Pottersburg Creek and Crumlin Drain.

5. Milkhouse waste may contribute over 95 percent of annual continuous phosphorus loading.

E1.1.6 Water Quality

1. The water quality monitoring program results indicated that median concentrations of the E. Coli Bacteria, total phosphorus, iron and copper (at 1 of 2 stations) in Pottersburg Creek exceeded provincial guidelines. In Crumlin Drain median concentrations of E. Coli Bacteria, total phosphorus, copper (at 2 of 3 stations) and lead (at 1 of 3 stations) exceeded provincial guidelines.

2. Median concentrations of suspended solids, ammonia, nitrate, potassium, lead, manganese, zinc and dissolved oxygen were within provincial guidelines.

3. Compared to other creeks in the London Subwatershed Studies, Pottersburg Creek and Crumlin Drain maintained lower than average water quality, for E. Coli bacteria, dissolved solids, nitrates, calculated hardness, sodium, beryllium and manganese. However, temperature and nitrate in Crumlin Drain were found to be of higher than average quality and in Pottersburg Creek, dissolved oxygen, temperature, phosphorus, aluminum and titanium were found to be of higher than average quality.
E1.1.7 Aquatic Resources

1. Water Quality Index ratings for reaches of Pottsburgh Creek and Crumlin Drain were generally found to be unstable or impaired, except for one location immediately upstream of the airport on Pottsburgh Creek which was found to be unimpaired.

2. Overall, all the quality of fish habitat in Pottsburgh Creek was found to be poor except for the headwater and north areas which were classified as fair. In Crumlin Drain, fish habitat was classified as poor to not supporting fish habitat.

3. Two provincially significant fish species were documented in Pottsburgh Creek and Crumlin Drain: central stoneroller and greenside darter.

E1.1.8 Terrestrial Resources

1. The combined area of natural vegetation in the Pottsburgh Creek and Crumlin Drain subwatersheds is approximately 372 ha, or about 7 percent of the total area, which is about one-half as Middlesex County (13.5%), in total.

2. The existing natural areas in the Pottsburgh Creek and Crumlin Drain subwatersheds are relatively isolated.

3. The majority of patches were found to be too small to support forest-interior species. Only one patch (4033) was found to have the potential to support some forest-interior bird species.

4. A provincially significant bird species, the Acadian Flycatcher, was found in Patch 4033.

5. One provincially significant and nationally rare plant species was found in the Pottsburgh Creek subwatershed.

E1.1.9 Archaeological Resources

1. Four registered and two unregistered archaeological sites were noted during this study.

2. Seventy locations of standing or extinct heritage buildings were noted in published and unpublished studies.

E1.1.10 Infrastructure

1. The developed area in the Pottsburgh Creek and Crumlin Drain subwatersheds (in the City of London) are serviced by an existing sanitary sewer system.

E1.1.11 Pottsburgh Creek and Crumlin Drain Subwatershed Ecosystems

1. Four distinct management areas in the Pottsburgh Creek subwatershed and management area for Crumlin Drain can be defined by physiographic, geologic, land use and environmental quality conditions. The management areas represent the rural upper area of Pottsburgh Creek (Management Unit 5, or MU5), the Airport Lands development area (MU7), the lower reaches in the existing development area (MU8), and the Crumlin Drain subwatershed (MU9).
2. Streams in MU5 are all first and second order, and almost all have been channelized to improve agricultural drainage. Streams in MU5 are impaired and support tolerant fish species. There is evidence of groundwater discharge in two areas which supports a Type III fisheries community, including the provincially significant central stoneroller. These areas are the highest quality fish habitat in Pottersburg Creek and Crumlin Drain. Streams in MU5 could be enhanced by removing barriers to fish movement and naturalizing the channel, but are unlikely to attain high quality.

3. MU6 consists of the 550 ha of the Pottersburg Creek subwatershed that drain the London Airport Lands. The reaches of Pottersburg Creek in this unit are severely degraded and support Type IV aquatic communities. Significant limitations include low baseflow, poor water quality, limited riparian vegetation, watercourse structures and storm water management facilities. There is little opportunity to enhance Pottersburg Creek in this area. Further degradation could result in the reaches of this area no longer supporting fish species.

4. MU7 represents the main area of future growth in the Pottersburg Creek subwatershed and where land use currently is largely industrial. All reaches, including the main creek are channelized in this area. The fisheries community is severely degraded, and the invertebrate community is impaired, being primarily Type IV and V communities. Extensive rehabilitation is required before this reach of Pottersburg Creek will support intolerant species of aquatic invertebrates and fish. Moderate improvements could result from increasing riparian and instream cover and by eliminating pollution sources.

5. MU8 is located in the lower reaches of Pottersburg Creek, where lands are largely developed. The main creek through this area is channelized, except for the mouth of the creek which is in a natural state. Most "tributaries" are enclosed in storm sewers. The invertebrate community is impaired and the fisheries community is Type IV, except for the mouth which supports a Type III community, where provincially significant central stonerollers have been found. Significant improvements in water quality and channel configuration are required to make noticeable improvements.

6. MU9 contains the entire Crumlin Drain subwatershed and the portion of the Waubuno Creek subwatershed downstream to the Thames River. Crumlin Drain contains only first and second order streams, all of which have been channelized. The fisheries communities in Crumlin Drain are all impaired or do not support fisheries. Aquatic invertebrate communities exhibit the lowest quality of all management units. In contrast, Waubuno Creek below the confluence with Crumlin Drain supports a diverse Type IIIB fish habitat. Because of its channelized nature and low baseflow, it is unlikely that Crumlin Drain can be significantly enhanced.
E2.0 RECOMMENDATIONS

The main recommendations resulting from the Pottersburg Creek and Crumlin Drain Subwatershed Study are presented in the Implementation Plan and in Table D.3 of this report. The recommendations of the Subwatershed Plan fall within four categories: Constraint Areas, Development Criteria, Conservation and Management Practices and Special Projects and Programs.

E2.1 Constraint Areas

1. It is recommended that the following constraint areas be classified as Category 1, in which development is prohibited.
   
i) Lands within Regulatory Flood or Fill Lines;
   ii) Designated streams and setbacks; and
   iii) Riparian Vegetation Contiguous to a Designated Watercourse.

2. It is recommended that the following constraint areas be classified as Category 2, where the extent of permissible development must be determined through the completion of an Environmental Impact Study (EIS).
   
i) Other terrestrial patches > 4 ha and not in Category 1; and
   ii) Anti-fragmentation areas for terrestrial enhancement.

E2.2 Development Criteria

1. It is recommended that the following storm water management measures be required for urban development:
   
i) Peak flow attenuation;
   ii) Water quality control;
   iii) Extended detention for erosion/stream morphology constraints; and
   iv) Infiltration facilities where permeable soils exist.

2. It is recommended that environmentally sensitive site planning techniques be used in all developments to maintain the hydrologic balance, preserve trees and natural habitat areas and reduce impacts to water quality in the receiving watercourse.

3. It is recommended that erosion controls be required on all construction sites and that during the construction period, the measures are inspected and monitored.

E2.3 Conservation and Management Practices

1. It is recommended that the following practices be employed to control point-source pollution sources:
   
i) Manure management and feedlot runoff controls;
   ii) Control of livestock access to streams;
   iii) Milkhouse waste controls; and
   iv) Septic system effluent controls.
2. It is recommended that the following practices be employed to control non-point source pollution sources:

   i) Conservation tillage;
   ii) Grassed waterways;
   iii) Natural channel succession;
   iv) Municipal de-icing program optimization; and
   v) Top soil preservation.

E2.4 Specific Projects and Programs

1. It is recommended that the following programs be initiated to improve current subwatershed conditions:

   i) Disconnect roof leaders from storm sewers; and
   ii) Initiate a public awareness program.

2. It is recommended that the following projects be initiated to improve current subwatershed conditions:

   i) Plant riparian vegetation along stream corridor through built-up area;
   ii) Rehabilitate urban channelized reaches using natural channel design techniques;
   iii) Remediate significant erosion areas: Pottersburg Creek, upstream of the airport; Pottersburg upstream of Gore Road; and Crumlin Drain north of Gore Road; and
   iv) Remediate minor erosion areas: Pottersburg Creek south of CN rail line; and Crumlin Drain both the culvert upstream and downstream ends of the Gore Road culvert.

All of which is respectfully submitted,

PARAGON ENGINEERING LIMITED

Jack Gorrie, M.A.Sc., P. Eng.

JG/sc


Conservation Authorities Act. Sections 3 and 4 - Fill, Construction and Alterations to Waterways Regulations.


Delcan Delieuwcathe, Canada Ltd. 1994. *Pottersburg Creek Storm Water Management Study.* Prepared for UTRCA.


Department of Fisheries and Oceans. 1986. *Policy for the Management of Fish Habitat. Fish Habitat Management Branch.* Ottawa.

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Ministry of Natural Resources. 1994. *Fish Habitat Protection Guidelines for Developing Areas.*


APPENDIX 1

Pottersburg Creek and Crumlin Drain
Fact Sheets
POTTERSBURG CREEK
Tributary and Catchment Area Factsheet

AREA 1

RESOURCES

Water Resources

- 1800 ha drainage area
- 8.5 km first and second order watercourses

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- dominated by tolerant fish species (Type IV)
- highly tolerant macroinvertebrates (Type IV)

Stream Morphology

- mostly channelized streams

Terrestrial Resources

- Category 1:
  - woodlots contiguous to watercourse, 4036, 4034, part of 4033
- Category 2:
  - terrestrial patches, part of 4066, 4065, 4064, 4063, 4062, 4061, 4060, 4059, part of 4067, 4058, 4057, 4056, 4055, 4054, 4053, 4052, 4051, 4050, 4049, 4048, 4047, 4046, 4045, 4044, 4043, 4042, 4041, part of 4040
  - four anti-fragmentation areas

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- 7.5 km of stream requiring vegetated buffer strips
- 2.4 km of first order stream to be maintained as grassed waterways
- infiltration of 25 mm roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be defined
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
ENVIRONMENTAL TARGETS

Flows

- N/A (rural area)

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- 100 percent of the second order streams with vegetated buffer strips
- WQI score = 10-12, EPT Index = 8-10
- Type IV fishery

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- re-vegetated non-vegetated areas in Category 1
- use indigenous species
POTTERSBURG CREEK
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AREA 2

RESOURCES

Water Resources

- 267 ha drainage area
- 1.0 km of first order stream

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- dominated by tolerant fish species (Type IV)
- highly tolerant macroinvertebrates (Type IV)

Stream Morphology

- mostly channelized streams

Terrestrial Resources

- Category 2:
  - terrestrial patches, 4039, 4038, 4037
  - one anti-fragmentation area

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be defined
- scoped EIS for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms
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AREA 2 (continued)

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l (discharge target)
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- WQI score = 10-12, EPT Index = 8-10
- Type IV fishery

Terrestrial

- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
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AREA 3

RESOURCES

Water Resources

- 106 ha drainage area
- 1.0 km of second order stream

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- dominated by tolerant fish species (Type IV)
- highly tolerant macroinvertebrates (Type IV)

Stream Morphology

- mostly channelized streams

Terrestrial Resources

- Category 1:
  - lands within regulatory floodlines

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls).
- infiltration of 25 mm of roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms
POTTERSBURG CREEK

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AREA 3 (continued)

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- 450 m of watercourse with vegetated buffer strips
- WQI score = 10-12, EPT Index = 8-10
- Type IV fishery

Terrestrial

- protect all Category 1 Areas
- re-vegetate non-vegetated areas in Category 1
- use indigenous species
POTTERSBURG CREEK
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AREA 4

RESOURCES

Water Resources

- 583 ha drainage area
- 3.3 km of main stem Pottersburg Creek
- 3.0 km first and second order streams

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- fish populations are dominated by minnows, white sucker, and brook stickleback, Type IV community
- impaired invertebrates community, Type IV

Stream Morphology

- 325 m of enclosed watercourses (London Airport)
- remainder are all channelized

Terrestrial Resources

- Category 1:
  - woodlots contiguous to watercourse or within regulatory flood plain, 4031
  - lands within regulatory flood plain
- Category 2:
  - terrestrial patches, part of 4032, 4030

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist
- 500 m of first order stream established/maintained as grassed waterways
- remediation of one significant erosion area (upstream of the airport)
POTTERTON CREEK
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AREA 4 (continued)

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be defined in first order streams
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP ≤ 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- 500 m of grassed swales established
- WQI score = 10-12, EPT Index = 8-10
- Type IV fishery (Type V in the grassed swale)
- regrading of approximately 500 m of bank; extending side slopes up to 9 m on either side; bottom of banks to be protected by rip-rap and vegetation planted above rip-rap (Pottersburg Creek upstream of airport)

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- re-vegetate non-vegetated areas in Category 1
- use indigenous species
POTTERSBURG CREEK
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AREA 5

RESOURCES

Water Resources

- 415 ha drainage area
- no defined watercourses

Terrestrial Resources

- Category 2
  - terrestrial patches, part of 8023, 4025 and 4027

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP ≤ 0.03 mg/l
- SS ≤ 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Terrestrial

- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
POTTSBURG CREEK
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AREA 6

RESOURCES

Water Quality

- 463 ha drainage area
- 2.6 km main stem of Pottsburgh Creek
- 2.0 km first order streams

Aquatic Resources (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- fish populations are dominated by minnows, white suckers, and brook stickleback (Type IV)
- impaired invertebrate community (Type IV)

Stream Morphology

- mostly channelized

Terrestrial Resources

- Category 1:
  - woodlots contiguous to watercourse or within regulatory flood plain, 4024, 4021
  - lands within regulatory floodlines

- Category 2:
  - terrestrial patches, > 4 ha, part of 4030, 4023
  - other terrestrial patches, part of 4025, 4027, 4029, 4022

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist

PROPOSED STUDIES

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- regulatory floodlines to be extended
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
POTTERSBURG CREEK
Tributary and Catchment Area Factsheet

AREA 6 (continued)

ENVIRONMENTAL TARGETS

Flows
• match existing peak flows from the 2 through 100 year storms

Water Quality (instream targets)
• TP ≤ 0.03 mg/l
• SS ≤ 50 mg/l
• Nitrite < 0.03 mg/l
• Nitrate < 1.0 mg/l
• fecal coliform (counts per 100 ml) < 50

Aquatic Community
• riparian vegetation planted along 2.5 km reach
• stone weirs to create pools and riffles along 3.2 km reach
• WQI score = 10-12, EPT Index = 8-10
• Type IV fishery

Terrestrial
• protect all Category 1 Areas
• protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
• re-vegetate non-vegetated areas in Category 1
• use indigenous species
POTTERTSBURG CREEK
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AREA 7

RESOURCES

Water Resources

- 243 ha drainage area
- no well defined watercourses

Terrestrial Resources

- Category 2:
  - terrestrial patches > 4 ha, part of 9017
  - other terrestrial patches, 4012, 4013, 4011, 4010, 9010, 9011, 9051, 4009, 4008, 4007, 4006

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management facilities designed to satisfy the subwatershed development criteria (375 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget requirements
- scoped EIS for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- match existing peak flows from the 2 through 100 year return period storms

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Terrestrial

- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
POTTERTON CREEK
Tributary and Catchment Area Factsheet

AREA 8

RESOURCES

Water Resources
- 1125 ha drainage area
- 6.5 km main stem of Pottersburg Creek
- 1.7 km first order streams

Aquatic Resources  (refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)
- Type IV fish communities throughout the majority of the reach, except near the mouth at the Thames River, which supports a Type III community
- the invertebrate populations are typical of a Type IV impaired community, dominated by highly tolerant oligochaete species

Stream Morphology
- almost all of the reach is channelized
- tributaries of the main stem Pottersburg Creek are essentially all enclosed in storm sewers

Terrestrial Resources
- Category 1:
  - woodlots contiguous to watercourse or within regulatory flood plain, 4020, 4017, 4016, 4015, 4014, 4005, 4004, 4003, part of 4002
  - lands within the regulatory floodlines
  - lands within fill lines
- Category 2:
  - terrestrial patches > 4 ha, 4018

KEY BEST MANAGEMENT PRACTICES
(refer to Table D.1 and Map D1 for details)

Storm Water Management Practices
- storm water management facilities designed to satisfy the subwatershed development criteria (375 m³/ha for peak flow attenuation, 100 m³/ha for extended detention, and 100 m³/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist
- disconnect roof leaders from storm sewers
- riparian vegetation planting along 1.9 km watercourses in three areas
- significant (upstream of Gore Road Bridge) and minor (south of CN rail, south of Oxford Street near Second Street) erosion areas to be remediated
POTTERTSBURG CREEK
Tributary and Catchment Area Factsheet

AREA 8 (continued)

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas

ENVIRONMENTAL TARGETS

Flows

- N/A (existing developed area)

Water Quality (instream targets)

- TP < 0.03 mg/l
- SS < 50 mg/l
- Nitrite < 0.03 mg/l
- Nitrate < 1.0 mg/l
- Fecal Coliform (counts per 100 ml) < 50

Aquatic Community

- riparian vegetation to be planted along 1.9 km streams at three locations
- WQI score = 10-12, EPT Index = 5-10
- Type III fishery in the main branch, Type IV in tributaries

Terrestrial

- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- re-vegetate non-vegetated areas in Category 1
- use indigenous species
CRUMLIN DRAIN

Tributary and Catchment Area Factsheet

AREA 9

RESOURCES

Water Resources

- 609 ha drainage area
- 1.3 km of first and second order streams.

Aquatic Resources

(refer to Map C7 for location of aquatic communities and Section B7 for translation to habitat types)

- Type IV (impaired) fish communities, dominated by minnows and brook stickleback

Stream Morphology

- all are channelized

Terrestrial Resources

- Category 1:
  - woodlots contiguous to watercourse or within regulatory flood plain, 5010, 5005, 5002, part of 5001
  - lands within the regulatory floodlines
  - lands within fill lines

- Category 2:
  - terrestrial patches > 4 ha, 5006, 5004, part of 5003
  - other terrestrial patches, 5009, 5008, 5007

KEY BEST MANAGEMENT PRACTICES

(refer to Table D.3 and Map D1 for details)

Storm Water Management Practices

- storm water management practices designed to satisfy the subwatershed development criteria (375 m$^3$/ha for peak flow attenuation, 100 m$^3$/ha for extended detention, and 100 m$^3$/ha at-source controls)
- infiltration of 25 mm roof runoff where permeable soils exist
- remediation of one significant (north of Gore Road, south of confluence with main tributary) and one minor (south of Gore Road culvert) erosion areas

PROPOSED STUDIES

Water Resources

- storm water management study to confirm size and location of facilities, peak flow rates, water budget and channel conveyance requirements
- scoped EIS for areas within 50-100 m of Category 1 Areas and for all Category 2 Areas
CRUMLIN DRAIN
Tributary and Catchment Area Factsheet

AREA 9 (continued)

ENVIRONMENTAL TARGETS

**Flows**
- match existing peak flows from the 2 through 100 year return period storms

**Water Quality** (instream targets)
- $\text{TP} < 0.5 \text{ mg/l}$
- $\text{SS} \leq 50 \text{ mg/l}$
- Nitrite $< 0.03 \text{ mg/l}$
- Nitrate $< 1.0 \text{ mg/l}$
- Fecal Coliform (counts per 100 ml) $< 50$

**Aquatic Community**
- establish vegetated buffer strips along 1.7 km main stem of Crumlin Drain
- plant riparian vegetation along 1.4 km of the west tributary
- $\text{WQI score} = 6-10$, $\text{EPT index} = 2-5$
- Type IV fishery

**Terrestrial**
- protect all Category 1 Areas
- protect Category 2 Areas which are sensitive to development which are to be defined in an EIS
- re-vegetate non-vegetated areas in Category 1
- use indigenous species