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Carp River Watershed/ Subwatershed Study Volume I - Main Report

Prepared For:



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1.0 INTRODUCTION

1.1 General

The City of Ottawa in partnership with the Mississippi Valley Conservation (MVC) is undertaking the Carp River Watershed/Subwatershed Study. The Ministry of Natural Resources (MNR), Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and Ministry of the Environment (MOE) are partners on the study as well.

Historically, a number of studies have been carried out within the watershed. Representative studies, which have been completed, include the Upper Poole Creek Subwatershed Study, Master Drainage Studies for Stittsville and Carp, numerous Stormwater Management Studies, the Carp River Environmental Review (MVC), the Kanata North Urban Expansion Planning Study and the Natural Environment System Strategy (NESS). Section 2 provides a more detailed summary.

These studies were generally completed independently and did not provide either a complete assessment of environmental conditions or an assessment of the potential impact of land use changes on the watershed as a whole. Due to the lack of environmental understanding and the degraded condition of the Carp River, the City of Ottawa authorized this study.

Watershed/Subwatershed planning is a cooperative effort of stakeholders, municipalities and government agencies to create a long-term management plan for resources within the watershed. Community input and support is critical to the success of the plan.

The process of Watershed and Subwatershed Planning has evolved over the last 15 years. The typical Subwatershed Plan of the early 1980's, which was commonly termed Master Drainage Plan, was primarily concerned with two issues; flooding and erosion. In the latter part of the 1980s the plan evolved and typically dealt with the above issues as well as water quality and occasionally aquatic resources.

Presently, watershed and subwatershed Plans deal with a number of issues including:

- Streamflow
- Surface water quality
- Water budget (i.e., groundwater, base flow and peak flows);
- Aquatic habitat;
- Stream morphology
- Terrestrial habitat including woodlands and wetlands;
- Areas of Natural and Scientific Interest;
- Environmentally Sensitive Areas;
- Aesthetics; and
- Recreation.

Furthermore, the plans are ecosystem based, with the potential interaction between each of the environmental features being strongly considered.

Integration of the Land Use Planning Process with Water Resource Management Planning has also evolved over the last 15 years. Whereas the common practice in the early to mid eighties involved the development of Official, Secondary and Draft Plans with nominal consideration of environmental consequences; present practice considers the two planning processes in unison. Watershed and Subwatershed Plans, in this manner, become an integral part of the overall planning process, and if successfully completed should provide a



solid foundation such that the environmental features will be protected, enhanced or restored under present conditions, and as land use changes occur. Information derived from the Watershed/Subwatershed Plans will ultimately be incorporated into planning documents as the basis of environmentally conscious land use designations and development policies.

1.2 Background

The Carp River Watershed is located in the northwest portion of the City of Ottawa in the former municipalities of West Carleton, Kanata and Goulbourn (see **Figure 1.1.1**).

Carp River drains an area of approximately 306 km² and discharges to the Ottawa River at Fitzroy Harbour. The Carp River has four major tributaries draining into it. These include Corkery Creek, Huntley Creek, Feedmill Creek and Poole Creek. Land use is predominately urban in the headwaters with the remainder of the watershed in a rural state. Rural villages and settlement areas located within the watershed include Carp, Kinburn, Fitzroy Harbour, Corkery, Huntley, Marathon and Smith's Corners.

1.3 Study Rationale

A number of initial environmental concerns have been identified as a result of the completion of previous studies. These concerns, which were confirmed in this study include: degraded fish habitat, release of deleterious substances, natural area protection and connectivity, lack of a riparian zone along streams, maintenance of base flow, erosion and sedimentation, groundwater use and surface flooding.

Development of a long-term environmental management strategy is necessary in order to protect, enhance or restore environmental quality in light of current and future demands on the resources. At the present time there is no mechanism for evaluating the cumulative effects of land uses on water resources and environmental quality on a watershed basis. . This situation largely exists because responsibility for land use and water resource planning falls within the mandate of a number of public authorities, each with varying levels of interest and differing management objectives.

Completion of the Watershed and Subwatershed Plans will provide an environmentally sound framework within which those involved in planning and decision-making can evaluate the consequences of current land use and future development scenarios in the context of the entire watershed.

1.4 Study Definition and Scope

Watershed planning is an integrated (ecosystem-based) approach to land use planning using the perimeter of a watershed as boundaries. The watershed drainage area provides the natural boundary for managing human uses of the river and connected wetlands, woodlands, valley lands and floodplains. It attempts to balance environmental protection, conservation and restoration with development and land use to ensure long-term ecological sustainability of the watershed and its important resources.

A watershed plan is a high level-planning document (similar in scale to an Official plan) that guides the long-term management of land and water interactions to protect the health of the watershed ecosystem. A subwatershed plan reflects the goals of the watershed plan but is tailored to meet the needs and issues relating to a smaller catchment area of the watershed. It reflects the scale of a Secondary Plan or Official Plan Amendment.



In this study the subwatershed area will include lands upstream of Richardson Side Road (**Figure 1.1.2**). The primary focus will be on lands contained within Feedmill Creek, a small portion of Huntley Creek, Poole Creek downstream of Main Street and the Carp River from Richardson Side Road to the Glen Cairn Stormwater Management Facility. Within the subwatershed area (see **Figure 1.1.2**) are lands referred to as the Planning Area lands. These lands include existing urban areas (e.g. Stittsville) together with other lands that are currently being considered for re-designation of land uses.

1.5 Report Outline

The key steps that are involved in preparing a watershed and subwatershed plan are shown in **Figure 1.1.3**. The steps as illustrated may be generally grouped into the following four phases.

Phase I: Existing Conditions (Watershed Report Card)

- Review background information
- Undertake field investigations and technical analysis
- Establish current health and functions of the natural system
- Determine interrelationships among environmental features together with opportunities and constraints

Phase II: Watershed Goals and Objectives

Prepare watershed/subwatershed goals and objectives

Phase III: Development of Watershed and Subwatershed Plans

Establish and evaluate alternative watershed/subwatershed management strategies.
 Select the preferred strategy (or Recommended Plan)

Phase IV: Implementation Plan

- Develop an implementation plan including funding, phasing, policy implications and implementing agencies
- Develop a monitoring strategy to establish a basis for evaluation the success of the proposed plans.

1.6 Public Consultation

Watershed planning and management is a cooperative effort by stakeholders, municipalities, and government agencies to create a long-term management plan for the natural resources within the watershed. One of the key components in developing a watershed plan is an effective public consultation and communication program.

Public consultation is an integral part of any environmental study. The consultation process used in this study recognizes the Planning and Design Process of the Municipal Class Environmental Assessment (MEA, June 2000). This Class Environmental Assessment document reflects the following five key principles of successful planning under the Environmental Assessment Act:



- Consultation with affected parties early on, such that the planning process is a cooperative venture.
- Consideration of a reasonable range of alternatives.
- Identification and consideration of the effects of each alternative on all aspects of the environment.
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects.
- Provision of clear and complete documentation of the planning process followed, to allow "traceability" of decision-making with respect to the project.

The Master Planning Process outlined in the MEA Municipal Class Environmental Assessment document was followed for the study as an overall stormwater management system for the urbanizing portion of the subwatershed area was to be identified. The subwatershed plan outlines a framework for planning stormwater management for the urbanizing portion of the study area as well as stream restoration measures. As such, Phases 1 (Identification of Problem or Opportunity) and 2 (Alternative Solutions) of the Municipal Class EA process were incorporated into the overall study process.

A Communications Plan (**Appendix F**) was developed at the onset of the study to ensure public consultation was an integral part of the study throughout its four phases and meet the key principles of the Class EA process. The intent of the Communications Plan is to achieve the following objectives:

- Traceable i.e., satisfy regulatory requirements e.g., EA process;
- Solicit input on issues, data, information accuracy, goals/objectives, etc.;
- Inform/educate the public as to problems and solutions;
- Develop common goals/objectives that represent true public views, not simply agency perspectives; and
- Build support for implementation.

A variety of different tools/techniques were used to deliver the public consultation program which includes the following:

- Steering Committee;
- Public Advisory Committee;
- Newsletters;
- Community Survey;
- Watershed Tour;
- Public Open Houses;
- Web Site;
- Landowner Contact;
- Individual/group interviews; and
- Workshops

1.6.1 Steering Committee & Public Advisory Committee

The project is being lead by the Department of Planning and Growth Management, Planning, Environment and Infrastructure Policy branch. A Steering Committee and Public Advisory Committees were established in the early stages of the study to allow for technical and community input throughout the development of the watershed/subwatershed plan. Both committees are advisory in nature providing guidance and advice throughout the study to the project team.



The Steering Committee includes representatives from the following City departments and provincial agencies:

- Environmental Management, Planning and Growth Management
- Community Planning and Design Division, Planning and Growth Management
- Infrastructure Policy, Planning and Growth Management
- Development and Infrastructure Approvals, Planning and Growth Management
- Water Environment Protection, Public Works and Services
- Mississippi Valley Conservation Authority (MVC)
- Ministry of the Environment (MOE)
- Ministry of Natural Resources (MNR)
- Ministry of Agriculture, Food and Rural Affairs (OMAFRA)

The Public Advisory Committee (PAC) is a volunteer advisory group that works in tandem with the Steering Committee to provide valuable input at key decision-making points in the study. The composition of the group attempts to be balanced in terms of both geographic location and key interest area. Key stakeholders representing environmental interest groups, resource users, agricultural and aggregate resource sectors, community associations, aggregate sector, recreational associations, rural residents and the general public from throughout the watershed were targeted.

A list of potential candidates was developed through advice from Ward Councillors and the Steering Committee members. These groups/individuals were contacted directly by the project manager to be a member of the committee. Additional vacancies were solicited through the first public open house and newsletter. We were successful in obtaining membership from throughout the watershed with representation from various sectors of the community including environmental interest group, farmers, local business and interested individuals.

The roles and responsibilities of both Committees were to:

- Review interim and draft reports from the study team;
- Attend all scheduled meetings;
- Provide advice to the study team;
- Participate in the public consultation process;
- Liaise with their respective department/organization; and,
- Work towards achieving consensus on technical issues.

1.6.2 Newsletters

Newsletters were one of the main tools used to update the watershed residents on study progress as well as to advertise public events. There were a total of four newsletters circulated over the course of the study. The newsletters were distributed to the study's master contact list, which is comprised of the following groups:

- Households in the entire watershed
- Commercial businesses within the watershed
- Ward Councillors
- Members of the Steering Committee and the PAC
- Local Media
- Land holdings in the subwatershed area (focusing on the Kanata West area),
- Applicable community contacts listed in the City's Master Contact List



The circulation of the newsletters corresponded with the public open house events listed below.

1.6.3 Public Open Houses

A total of four open houses were held over the course of the study. Provided below is a summary of the timeline, location and purpose of the open houses:

Open House #	Date(s)	Location	Торіс		
1	May 23, 2001	Kinburn Client Service Centre 5670 Carp Road, Kinburn	Existing Conditions, watershed		
	May 24, 2001	Glen Cairn Community Centre 186 Morrena Road, Kanata	Existing Conditions, subwatershed		
2	Nov. 14, 2001	Agriculture Society Building Carp Fairgrounds, 3790 Carp Road	Interim Watershed Report Card Goals and Objectives		
3	April 14, 2002	Kinburn Client Service Centre 5670 Carp Road, Kinburn	Opportunities and Constraints, Best Management Practices		
4	June 29, 2002	Corel Centre, Kanata	Recommended Measures		

Detailed documentation of the communications plan, newsletters, community survey, and public open houses is provided in Appendix F. Further details on the open houses are provided in the corresponding sections of this report.

1.7 Technical Terms

Considerable effort has been taken to write this document in a manner that is easy to understand. In order to facilitate this process a glossary of technical terms that are used in the report has been prepared (**Appendix A**).



2.0 BACKGROUND INFORMATION

2.1 General

A number of key studies have been completed for the Carp River Watershed. Several of these studies dealt solely with the Carp Watershed while others dealt with the Carp in a regional context. These background information sources assisted in characterizing the existing watershed condition as well as to define the fieldwork program where gaps in information or data were identified.

Summarized below are the findings from several key studies. These findings are discussed in more detail as they relate to the Carp Watershed in Section 3.

2.2 Relevant Background Documents

2.2.1 Upper Poole Creek Subwatershed Study

In the spring of 2000, a subwatershed study was completed for the portion of Poole Creek located upstream of Main Street in Stittsville (Marshall Macklin Monahan Limited, May 2000). This study was undertaken in recognition of the significance of the upper portion of Poole Creek as a cool-water stream, and the provincially Significant Wetland Complex that forms its headwaters. The goals of the subwatershed plan are:

- Maintain a cold to cool water aquatic habitat
- Extend existing pathways to create a pedestrian connection between Poole Creek and the upstream provincially significant wetlands

To achieve these goals, the subwatershed plan provides an overall strategy, development guidelines, and a monitoring strategy. Actions recommended in the subwatershed study include development guidelines, aquatic and terrestrial strategies, monitoring of fish and benthic communities, chemical and temperature monitoring, and administrative measures.

Recommendations contained in the subwatershed plan are significant for the watershed and in particular the subwatershed component of the Carp River Study. Recommendations of the Upper Poole Creek Subwatershed Plan were reviewed in the larger context of the entire Poole Creek basin and may be relevant to other parts of the study area.

2.2.2 Poole Creek, Feedmill Creek Master Drainage Study

In 1984, a Master Drainage Plan (MDP) of Poole Creek and Feedmill Creek was completed for MVC (Novatech Engineering Consultants Limited, December, 1984). The purpose of this study was to:

- Determine and assess existing drainage patterns and problems related to stormwater runoff quality and quantity
- Identify significant groundwater recharge/discharge zones
- Develop and assess stormwater management alternatives to alleviate existing and potential problems
- Prepare preliminary design and costing of the SWM alternatives
- Identify and evaluate current urban drainage policies and design practices
- Prepare flood and fill line mapping



The study concluded that no specific SWM measures were required to reduce flows. It also recommended that a control structure and gauge be installed on Poole Creek. This structure was constructed upstream of Hazeldean Road and was used to collect flow data. However, this structure does present a barrier for migrating fish and its continued presence will have to be evaluated.

2.2.3 Stittsville Master Drainage Plan

In 1994, an MDP was completed for the Village of Stittsville (Robinson Consultants Inc., July 1994). The MDP covered six drainage areas; five of these areas drain to the Carp River (Poole Creek, Feedmill Creek, and three small, unnamed, watercourses).

The MDP provides an analysis of existing and future flows and recommendations to mitigate the impact of ongoing development on downstream reaches of Poole Creek, Feedmill Creek, and the Carp River. The MDP does not make specific recommendations regarding the implementation of water quality and other environmental controls but does recommend that "Best Management Practices (BMP) should be utilized, where applicable, to mitigate development impact on water quality and quantity". It defers to the Regional Municipality, MNR and Conservation Authorities to determine where BMPs are required.

The main recommendations of the Stittsville MDP include guidelines for the construction of SWM facilities, the use of BMPs, and the protection of wetlands. The MDP has been the basis for SWM design in Stittsville since 1994.

2.2.4 Carp Master Drainage Plan

In 1996, an MDP was completed for the Village of Carp (Robinson Consultants Inc., May 1996). The Village of Carp represents the only significant development area outside the limits of the subwatershed plan. The MDP was developed based on a set of guidelines established by MNR ("General Guidelines for Development", MNR, 1992).

Since runoff from Carp discharges directly to the Carp River, quantity control was only considered based on outlet restrictions within the village and not on the basis of strict preand post-development peak flow matching. Appropriate Stormwater Management Practices (SWMPs) were recommended based on the design guidelines contained in MOE's "Stormwater Management Practices Planning and Design Manual" (Marshall Macklin Monaghan Limited, 1994).

The main recommendations of the Carp MDP include:

- Site level SWMPs in all future development areas. Most appropriate SWMPs are vegetative buffers and natural infiltration, reduced lot grading, and discharge of rainwater leaders to grassed surfaces
- Construction of a 3,200 m3 in-line pond in area 2
- Pervious pipe system SWMP in area 3A
- Construction of a 5,400 m3 extended detention facility in the ravine between Donald
 B. Munro Drive and Langstaff Avenue. This facility will serve areas 3A and 3B
- Construction of biofilter strips in areas 4 and 5 as temporary SWMPs. Determine ultimate SWM requirements once development in these areas is considered
- Undertake such additional ecological and geotechnical investigations as are required
- Implement post-construction monitoring programs to the satisfaction of approving agencies



With the exception of development in area 1, the cost of constructing SWM facilities is borne by the development served.

2.2.5 Floodplain Mapping Study of the Mississippi Valley Conservation

Floodplain mapping of the Carp River basin including Poole Creek, was completed in 1983 as part of a floodplain-mapping project that also included the Mississippi River and Watts Creek (Cumming Cockburn, December, 1983). Flood flows were analysed by means of a Station Frequency analysis of the gauge at Kinburn, a regional frequency Equation, the B.P. Sangal and R.W. Kallio Equation, and the HYMO computer model. Results indicated good correlation between the Station Frequency Analysis and the regional Equation on the one hand and the B.P. Sangal and R.W. Kallio Equation, and the HYMO computer model on the other. The report concludes that for the upper reaches, peak flow is generated by rainfall, while snowmelt dominates in the lower reaches.

The hydraulic analyses associated with the design flows were undertaken using the HEC2 computer model. A starting water level at the Ottawa River, an elevation of 59.3 m was used for all return periods. Backwater profiles were computed for the 5, 10, 25, 50, and 100 year return periods.

A spill zone was identified on the Carp River at Glen Cairn at the Castlefrank Road crossing (100 year flow condition only).

In February, 1992, Paul Wisner and Associates carried out an analysis of the reach between Highway 417 (Queensway) and Maple Grove Road. This resulted in a slight reduction of the 100-year flood elevation from Section 42+180 to Section 45+170.

The extent of the Carp River and Poole Creek floodplains is shown in **Figure 2.2.1** and **2.2.2** respectively.

2.2.6 Site Specific Stormwater Management Studies

A number of site-specific stormwater management reports exist on which individual SWM facilities have been designed and constructed. Many of these facilities were designed to attenuate peak flow only, although a number of quality control facilities have been constructed in recent years and more will undoubtedly be constructed as development in the subwatershed area continues. By far the largest existing pond is the so-called Glen Cairn pond. This facility is located along Terry Fox Drive just south of Hazeldean Road and is owned by the Mississippi Valley Conservation. This pond provides attenuation for an approximately 453 ha urban area of Kanata. A further 106 ha of NCC Green Belt also drains to this pond. The pond has a surface area of 6.07 ha and a storage capacity of 10.9 ha.m. The Glen Pond is significant not only because of its size but also because it forms the headwater of the Carp River and its visual impact on the immediate area.

Other stormwater management facilities that have been identified within the watershed are located in Stittsville, Kanata, and Carp and illustrated in **Figure 1.1.2**. A summary of existing facilities and those currently under construction is provided in **Table 2.2.1**.



No.	Munic.	Name	Туре	Control Quality	Quantity	Receiving Water	Engineer	Comments
1	Kanata	Walter Baker Park	Wet pond	Yes	Yes	Carp River	Robinson Cons.	Drains a portion of area east of Terry Fox Dr. Pond is part of park landscaping. Drains to fish habitat area (constructed as compensation for Terry Fox Drive extension) along Carp River
2	Kanata	Glen Cairn Pond	Wet pond	No	Yes	Carp River	Cumming Cockburn	Pond is probably undersized and has not been maintained for many years
3	Kanata	Corel Centre SWM Facility	On site BMPs, wet pond, and fish habitat compensation area	Yes	Yes	Carp River	J.L. Richards	
4	Kanata	Terry Fox Business Park	On site BMPs	Yes	Yes	Carp River		Developments other than Home Depot and Nortel have on site BMPs. Cardish lands covered by separate SWMP
4a	Kanata	Nortel	Dry/wet pond	Yes	Yes	Carp River	J.L. Richards	
4b	Kanata	Home Depot	On site BMPs	Yes	No	Carp River		
5	Kanata	West Creek Meadows	On site BMPs and Biofilter	Yes	Yes	Carp River	Novatech Eng. Cons.	
6	Kanata	Campeau Drive Business Park	Wet pond	Yes	No	Carp River		
7	Kanata	Signature Ridge	Dry pond	Yes	Yes	Carp River	Cumming Cockburn	Pond is under construction
8	Goulbourn	Fringewood Ind. Park	Dry pond	No	Yes	Minor Tributary to Carp River	Spencer Assoc.	Pond to be replaced by a new facility that will also service the new residential area to the west (Simmering Assoc.)
9	Goulbourn	Stittsville R.C. High School		No	Yes	Lower Poole Creek	Robinson Cons.	Quantity only, quality control through the existing Amberwood Pond (requires some modifications)
10	Goulbourn	Forest Creek	Wet pond	Yes	Yes	Lower Poole Creek	Novatech Eng. Cons.	

Table 2.2.1Existing Stormwater Management Facilities



No.	Munic.	Name	Туре	Control Quality	Quantity	Receiving Water	Engineer	Comments
11	Goulbourn	Amberwood	Wet pond	No	Yes	Lower Poole Creek	Robinson Cons.	Large wet pond. Originally not specifically designed for quality control but functions as quality pond
12	Goulbourn	Riverbank Court	Wet pond	Yes	Yes	Lower Poole Creek	Novatech Eng. Cons.	Very small facility
13	Goulbourn	Amberlakes	Wet pond	Yes	No	Lower Poole Creek	DMcManus/PSR Group	Quality control pond for commercial/residential development. In design stage
14	Goulbourn	Cypress Gardens South	Dry pond	No	Yes	Upper Poole Creek	Oliver Mangione McCalla	
15	Goulbourn	Cypress Gardens North	infiltration/dry pond	Yes	Yes	Upper Poole Creek	Robinson Cons.	Infiltration (perv. Catchbasins) for minor flows. Major flows are attenuated in backyard storage areas
16	Goulbourn	Westwood	Infiltration/dry pond	Yes	Yes	Upper Poole Creek	Oliver Mangione McCalla	Etobicoke filtration system for minor flows in combination with dry ponds. Phases 1 and 2 under construction, phase 3 in design
17	Goulbourn	West Ridge	Wet pond	Yes	Yes	Upper Poole Creek	Novatech Eng. Cons.	
18	Goulbourn	Timbermere	Wet pond	Yes	Yes	Feedmill Creek	Oliver MangioneMcCalla	Pond has not yet been constructed
19	Goulbourn	Eco Woods	Wet pond	Yes	Yes	Feedmill Creek	Novatech Eng. Cons.	Located downstream of Timbermere. Pond has been constructed but no outlet controls yet.
20	Goulbourn	Wyldewood	Dry pond	No	Yes	Lower Poole Creek	Ainley Graham	Small facility constructed in 1983. No record of maintenance
21	West Carleton	Rockwood Hills	Dry pond	No	Yes	Carp River	Novatech Eng. Cons.	Pond serves part of the subdivision. Design parameters not available for control structure at Langstaff Avenue

Table 2.2.1 cont'dExisting Stormwater Management Facilities



2.2.7 Preliminary Evaluation of Relative Aquifer Vulnerability (April 2001)

Waterloo Geohydrogeologic and CH2MHill Canada Limited completed this study for the City of Ottawa. The purpose of the study was to assess the relative vulnerability of aquifers to contamination. The tool used was the DRASTIC model, which employs seven hydrogeologic characteristics, including depth to water, aquifer media, soils media, topography and hydraulic conductivity. The model is primarily intended for groundwater resource allocation and land use planning.

The results of the DRASTIC model suggest that the western portion of the Carp Watershed, characterized by shallow Paleozoic bedrock and shallow water table, represents an area of high vulnerability. Other areas of vulnerability are areas where sand and gravel deposits provide a greater potential recharge to the aquifers.

2.2.8 Private Individual Services in the Rural Area (1992)

Geo Analysis Inc. and J.L. Richards & Associates completed this study. The purpose of the study was to recommend policies that would ensure appropriate development on private, individual services for the former Regional Municipality of Ottawa-Carleton. The study employed the Ministry of the Environment water well database and subdivision hydrogeological reports to outline overburden and to define areas constraints where Class IV septic systems could be used. Recommendations included minimum thickness of soils, mounding assessment on clay soils, dispersion calculations on permeable sand, minimum lot sizes and methodology to assess cumulative impacts of private services on groundwater.

2.2.9 Eastern Ontario Water Resources Management Study (March 2001)

CH2M HILL Canada Limited completed the Eastern Ontario Water Resources Study (EOWRMS) in March 2001 for the United Counties of Prescott and Russell (P&R), the United Counties of Stormont, Dundas and Glengarry (SD&G), and the City of Ottawa. The EOWRMS involved an extensive compilation and evaluation of regional water resources and servicing infrastructure in the South Nation River and Raisin Region watersheds. Although the Carp River Watershed/Subwatershed study area is not included the EWORMS study area, it was used as a data source for this study as it is in very close proximity. The results of this study were grouped into ten areas: (1) database compilation, (2) regional water budget, (3) surface water analysis, (4) groundwater analysis, (5) land use analysis - agriculture (6) servicing infrastructure, (7) public consultation (8) demonstration projects, (9) action plans and implementation and (10) recommendations.

2.10 Renfrew County – Mississippi – Rideau Groundwater Study (September 2003)

Golder Associates Ltd. completed the Renfrew County – Mississippi – Rideau Groundwater Study in September 2003 for the Mississippi Valley Conservation Authority Study Group. This study area includes all the lands within the Rideau and Mississippi Valley watersheds, plus Renfrew County. The study goals included, mapping of regional groundwater systems together with their susceptibility to contamination, and the characterization of quantity and quality of groundwater on a regional basis. The results of the groundwater study were grouped into eight areas: (1) database compilation, (2) regional water budget, (3) aquifer characterization, (4) surface water quality, (5) groundwater use, (6) aquifer vulnerability, (7) contaminant inventory and (8) agricultural impacts.



2.11 City of Ottawa Rural Wastewater Study (March 2004)

R.J. Burnside & Associates Limited completed the City of Ottawa Rural Wastewater Study in March 2004. This study was completed focused on the use and management of private septic systems within the City of Ottawa. Phase I included data collection, practices review and technology review, Phase II included public and industry consultation, risk model, village servicing approaches, and Phase III included management model development and implementation.

2.12 City of Ottawa Groundwater Management Strategy (May 2003)

In May 2003, Ottawa City Council approved a Committee Report outlining a two-phased City of Ottawa Groundwater Management Strategy. The first phase is to continue the types of activities which have been completed in the past, such as public education programs and groundwater characterization studies. A second phase is to develop a framework in which to identify, prioritize, and complete groundwater management activities once Provincial policies and regulations on source protection are finalized.

2.2 Carp River Environmental Review Report (1998)

Mississippi Valley Conservation completed this study. The study is a synthesis of the water quality-sampling database used in the current study (years 1993 - 1996 only). The study noted that phosphorus and bacteria exceeded Provincial Water Quality Objectives (PWQO) on most of the Carp River and tributary stations.

The study recommends continued monitoring by the Region (now City of Ottawa), as well as collecting dissolved oxygen readings and benthic invertebrates for the Carp River and its tributaries. Remedial actions are proposed, including re-vegetation of the river corridor, limiting cattle access, "Natural Channel Design" or future restoration projects, education and stewardship.

2.2.1 Natural Environment Systems Strategy (NESS)

This comprehensive study completed in 1995-96 examined natural areas within the Region of Ottawa-Carleton as input into the Official Plan. The NESS utilized a combination of existing studies, GIS/remote sensing analyses and selected detailed inventories to identify and prioritize existing natural features into a network of natural areas with a set of policies and programs to ensure their long-term sustainability. This strategy made extensive use of GIS technology to categorize vegetation, landform/soils, and surface water features into ecological units: identifiable areas with common ecological functions. Ground level inventories were then completed on selected sites to confirm ecological functions, identify important habitats/special status species and identify evidence of human impact and/or special ecological significance. The product of this exercise was the classification of all natural features in the region into areas of high, moderate or low significance for input into the Official plan. A number of GIS linked databases of this information were also prepared, providing detailed information on natural areas for future reference and use.

2.2.2 Terry Fox Drive Extension Environmental Study Report (Dillon et. al. 2000)

This report describes environmental conditions in the vicinity of the section of Terry Fox Drive between Eagleson and March Road and describes mitigation measures to offset road construction impacts.



2.2.3 Geomorphic Reports

Existing reports, maps and figures were collected as part of the background review process. Reports having geomorphic components include:

- Aquafor Beech Ltd (1995). "Ottawa Palladium Feedmill Creek Fish Habitat Compensation Plan: Natural Channel Design Component," Report prepared for McCormick Rankin Limited.
- MVC (1993). "Carp River Environmental Review Report", Report prepared by Mississippi Valley Conservation Authority.
- Fletcher, B. (1995). "How to Prevent Carp River Erosion", Rick Sgabellone. The Carp Valley Press, Carp, Ontario.
- Garrity, C, Ramseier, R. O., Dean, S., and Rooke, R. G. (2000). "Carp River Environmental Summary Report," A Report Prepared by the Fiends of the Carp River and the Regional Municipality of Ottawa-Carleton.

These reports were reviewed for content dealing with channel Form, Function and Linkage. The definition of these terms is provided below.

Aquafor Beech Ltd (1995) collected baseline geomorphic data on Feedmill Creek in the vicinity of the interchange for the Ottawa Palladium (now referred to as the Corel Centre). The geomorphic data included descriptions of microscale through macroscale features. Unfortunately the surveyed reach was diverted to accommodate the interchange. Consequently, the channel attributes cannot be resurveyed to determine changes to the morphology of the system. However, 'natural' channel design principles were used to design the diversion channel and the fisheries habitat compensation reach. Consequently, an examination of the reconstructed channel and comparison with the original survey data can be used to assess the success of "Natural" channel design measures. The success of the "Natural" channel design approach has a bearing on the types of restoration-stabilization measures that may be considered appropriate for this study. The study did not deal with Function or Linkages.

MVC (1993) dealt primarily with water quality and aesthetic issues. However, MVC (1993) noted that these issues were related to degraded streambanks associated with direct cattle access, streambank erosion and the absence of riparian vegetation buffer strips. Channel Form was not measured, however, a streambank inventory was accomplished by inspection of the banks from a canoe. The inspection noted riparian and aquatic vegetation characteristics, bank stability, and adjacent land use among other factors in an attempt to establish Function and Linkages.

The paper by Fletcher (1995) is referenced in MVC (1993); however, a specific citation could not be found in the later report. The original paper was not located for review and inclusion in this report.

Garrity et al, (2000) deals primarily with water quality and quality issues, as they pertain to efforts to improve water quality in the Carp River. The portion of the report dealing with channel morphology references the results of the MVC (1993) mapping of the streambanks. The main contribution of the Garrity et. al., (2000) report with respect to channel morphology is the compilation of an aerial photo data base documenting the linkage between areas of streambank erosion with direct cattle access and the lack of riparian vegetation buffer.



2.3 Public Consultation – Existing Conditions

The first newsletter was sent out on May 16th 2001, watershed wide using a bulk mail service through Canada Post. The newsletter introduced the study, stakeholders and advertised the first Open House events. It also contained the Community Survey that was prepared by the City (Appendix F). The community survey consisted of three sections:

- Part I: Who Are You
- Part II: Watershed Issues and Goals
- Part III: Community Involvement

The intent of the survey was to collect public opinion concerning the environmental issues facing the watershed and long-term environmental goals. It allowed the respondents to prioritise/rank issues and goals that were important to them. It also provided information regarding the types of conservation methods and recreational activities that are engaged by the watershed residents.

A total of 995 surveys were completed by watershed residents representing about 13% of the households. A detailed report has been prepared which describes the formulation and findings of the survey (City of Ottawa, October 2001). A summary of the community survey findings is provided below.

2.4 Survey Findings

The Carp River Watershed has several communities within its boundaries including West Carleton, Stittsville and Kanata. The communities that responded to the survey are displayed below:



Community Respondents



The watershed is home to a wide variety of people making it quite diverse. Each segment of the population responded to the survey, which is shown below:



Landowner Composition

The survey asked the respondents to assess to overall environmental health of the Carp River Watershed. The majority of respondents felt that the health of the Carp River watershed was in a degraded state. This is graphically displayed below



Respondents Assessment of the Environmental Health of the Carp River Watershed



The respondents were asked to rank each environmental issue and goal statement in order of importance. This lead to the following priority list of issues from the public's perspective:



Prioritized Watershed Issues

Prioritized Watershed Goals





It is interesting to note that the Top Three Issues are the same as the Top Three Goals. This illustrates the public's understanding of ecological processes found in the Carp River Watershed.

The Community Involvement section of the survey asked the respondents to check off any conservation practices undertaken on their property. It was broken down into urban and rural methods. The majority of respondents (97%) are protecting the environment by practicing one or more conservation methods. The response to this question is shown graphically below:



Watershed Residents Who Practice One Or More Conservation Method

Urban and Rural Conservation Methods





The graph below displays the results from the Rural Conservation Methods. Please note that about 39% of the respondents were from the rural area (33% rural residents, 3% hobby farmers and 3% farmers).



Rural Conservation Methods

Respondents were asked to indicate their recreational activity of choice within the watershed boundaries. 90% of the respondents actively pursue many of the recreational activities that the Watershed offers. Bird watching, hiking and cycling were the most common recreational activities.

Percentage of Watershed Residents who Practice One or More Recreational Activity







Preferred Recreational Activity of Watershed Residents

The last question of the survey pertained to public consultation. We wanted to find out what type of public consultation methods the public would tend to participate in as part of the study. This assisted the study team in planning and implementing future public consultation events. The results of this section supported the circulation of Newsletters and Notices, with 63% of respondents preferring this method.



Respondents Preferred Method of Public Consultation

2.5 First Public Open House

The first Open House was held on Wednesday, May 23, 2001, at the Kinburn Client Service Centre and on Thursday, May 24, 2001 at the Glen Cairn Community Centre in Kanata. Both open houses took place from 4:00 p.m. to 8:00 p.m. The event was advertised in the Carp Valley Press, the West Carleton Review, Stittsville News, Stittsville Signal, and the Kanata Courier a week to ten days before the event. The open house was also advertised in Ward Councillor and the Mississippi Valley Conservation Authority's columns in local newspapers. The West Carleton Review had an article in the May 16, 2001, edition about the watershed/subwatershed study, the community survey and the first open house schedule.



The purpose of the open house was to introduce the study and present findings based on existing reports and data. A total of eighteen (18) people attended the May 23rd open house in West Carleton. The general public, Steering Committee and PAC members made up this list of attendees. Two people at the event requested copies of the interim report and six comment sheets were filled out. The comments pertained to potential pollutant sources in both the rural and urban area. The open house in Kanata attracted sixteen (16) people. No comment sheets were filled out.

At each of these events, display boards were used to present the current understanding of the form and function of the Carp River system (based on existing information sources). A Geographical Information Systems database has been developed for the study and the map outputs (as seen in this report) were used to display most of the environmental information. The following information boards were displayed for the public to review, ask questions and provide comments:

- Purpose of the Study
- Study Process Chart
- Study Area
- General Watershed Characteristics
- Hydrogeology
- Surface Water Resources
- Aquatic Communities
- Terrestrial Resources
- Watershed Land Use
- Field Work Program
- Public Consultation

Based on the results of the community survey, it was decided that there would only be one central location for the remaining Public Open House events. Only 19% of respondents indicated an interest in attending open houses.



3.0 EXISTING WATERSHED/SUBWATERSHED CHARACTERISTICS

3.1 General

This chapter describes the existing watershed conditions. A watershed, i.e., the lands and waters drained by a river and its tributaries, is best described as an ecosystem unit, in that its physical, biological and even cultural features are connected by a complex, integrated network of environmental functions and linkages. Because of these interconnecting functions and linkages, changes to any individual feature usually result in changes to other features often in ways that are difficult to predict.

The **form** of a feature is its biophysical characteristics: size, shape, dominant vegetation type/age/health, species composition (diversity, abundance, rarity, special significance), uniqueness or representativeness and spatial distribution.

The **function** of a feature is its role as part of a larger system: as habitat for plants, fish, birds, other animals; as part of the hydrologic cycle - groundwater recharge, aquifer/ surface water supply, drainage network; as part of the food web/chain - predators, prey, primary producers, decomposers; as buffers between competing/conflicting uses - old fields, parklands, rights-of-way, forest edges; as contributing to biosphere functions - creating microclimates, contributing to biomass/nutrients/air quality, adding biodiversity; and adding quality of life to human experiences - economics (maple syrup, wood products, property values), nature appreciation, passive recreation.

The **linkage** of a feature is its connections to or between other features: as migration corridors for fish and wildlife, as an attenuator of surface water runoff quantity/quality to streams; as a recharge or discharge area linking surface water runoff to groundwater storage areas to stream spawning areas.

For example, four such features are a hardwood forest, a recharge area (where sandy loams promote infiltration of rainfall into the groundwater system), a coldwater stream and a brook trout population. The hardwood forest helps prevent rainfall from running off the land surface and improves the quality and amount of water recharging the groundwater system. In turn, the groundwater provides a constant source of cold, clean baseflow to the stream. This cold water, which upwells through the streambed provides spawning habitats for brook trout and prevents the stream temperature from becoming too warm for these fish. The replacement of forest with agricultural row crops or urban development causes rainfall to run off the land rather than percolating into the ground. This reduces the supply of water to the groundwater system, lowering the water table and reducing or eliminating the supply of cold, clear, upwelling baseflow to the stream. At the same time, the amount of warm, runoff water to the stream increases, causing rapidly increasing water temperatures. As a consequence, brook trout habitat is lost and these fish disappear from this part of the stream.

The changes illustrated by the example above are not necessarily negative or irreversible. Changes occur naturally and affect the features in a watershed. All ecosystems, because of their complexity, are resilient or have the ability to resist or recover from a certain amount of change whether natural or human. While it may be difficult to predict whether a change will negatively affect a watershed ecosystem, it is often quite feasible to identify indicators or early warning signs that a watershed is beginning to undergo permanent change and whether that change is positive or negative based on the features in the watershed considered most valuable or desirable.



Changes resulting from human activity that remain within the watershed's natural resiliency or capacity to resist or reverse change are often called sustainable development. Activities causing a permanent or irreversible change in a watershed are examples of non-sustainable development.

The following sections describe the watershed and subwatershed features in terms of their form, function and linkage, identify trends and indicators (early warning signs) of irreversible or non-sustainable changes. In addition, examples of positive or sustainable changes are highlighted where they occur in relation to historic conditions. At the beginning of each section, examples of the form, function and linkage of the feature is highlighted.

3.2 Climate

Form:

- Weather patterns and phenomena (storms, drought, etc.)
- Temperature
- Precipitation
- Evapotranspiration

Function/Linkages:

- Thermal regime
- Streamflow
- Groundwater supply
- Plant and animal community types and distribution
- Erosion (water/wind) processes
- Atmospheric transport (dust, nutrients, contaminants)
- Channel form

Warm summers, relatively cold winters, a moderate growing season, and usually reliable rainfall characterize the climate of eastern Ontario. The climate varies throughout eastern Ontario from location to location and from year to year. These locational or spatial variations are caused by topography, exposure to prevailing wind/weather patterns, which are modified by the Ottawa River Valley, and microclimate effects such as vegetation.

Figures 3.2.1 to 3.2.3 show monthly precipitation and temperature as measured at the Ottawa International Airport, and stream flow measured at Kinburn. These data suggest:

- Precipitation is fairly evenly distributed through the year, with slightly higher precipitation between May and September
- The mean monthly temperatures through the summer months (June, July, August) is above 18 °C, while mean monthly temperatures below freezing occur from December through March
- Peak runoff is a result of snowmelt

The following are pertinent climatic characteristics:

- Annual precipitation: 950 mm (25% as snow);
- Mean annual evapotranspiration: 550 mm;
- Growing season: 118 days (142 days frost-free);
- Mean annual temperature (at Ottawa): 5.9°C (-11°C in January; 20°C in July); and
- Frozen ground conditions exist between mid-November and late March.



The above description provides a general picture of annual climatic conditions for the watershed in terms of temperature, and precipitation. There are, however, longer- and shorter-term "cycles" or trends in these climate features, which may have important consequences within the watershed, as described below.

Key short-term trends (less than one year) include the daily range of temperature fluctuation, which typically is about 10 to 15°C and isolated temperature and precipitation events, for example, hot-dry periods, thunderstorms which occur over a period of hours or days. These short-term events can exert greater influence on other watershed characteristics than the longer-term "monthly average" conditions. Perhaps their greatest influence is on streamflow (floods and baseflow flows), stream morphology and aquatic life.

Finally, there are also longer-term climatic trends which influence watershed characteristics. These trends are only evident over a period of years or decades, and often are the result of large-scale or global events, for example, climate change, El Nino and volcanic eruptions to name a few.

Some scientists claim that there is a global climate change occurring, and that a possible result may be more extreme weather events. Climate change predictions suggest that the first indicators of change will be a slight increase in mean temperatures and an increase in the recurrence of extreme events. Possible examples could be unusually cold summers or mild winters, and more frequent storms and drought periods.

Synthesis

Climatic conditions in the watershed, moderate winters, warm summers, summer moisture deficits, frozen ground in winter, spring/fall runoff events and long growing seasons are most suited to Great Lakes-St. Lawrence Forest communities. Moisture deficit conditions through the summer increase the dependency of streams on groundwater supplies and riparian vegetation to provide sustained cool baseflows for coldwater fish. Mid-summer temperature extremes have the potential to increase stream temperatures above the required range for coldwater fish communities. These communities are found in Huntley Creek, Poole Creek Feedmill Creek, and Carp tributary (west of the Village) but not in the Carp River itself.

The growing season is sufficiently long for intensive crop production (e.g., corn, soy beans); however, topographic and soil (moisture/type) constraints limit cultivation and have protected wetlands/streams from extensive drainage practices. An increase in degree days from climate change phenomena could increase pressure on aquatic systems.

The soils of the watershed are primarily clay or rock-land, with very low surface slope. Infiltration throughout the watershed will be severely limited by the low porosity of the underlying soils. The low surface slope, while normally encouraging infiltration, has contributed to the installation of tile drains. These drains have the effect of decreasing the baseflow by quickly reducing the soil water content.

Peak flows from precipitation events are generally low and drawn out due to the low surface slope of the watershed. Meltwater events, however, due to their longer duration, are less affected by the shallow land slope, and contribute to very high flows for several days each year. These annual spring floods have the ability to cause significant erosion, particularly in areas that are otherwise already prone to erosion, such as where the soil is disturbed, vegetation is removed, or where the channel is constrained.



The river channel is identified throughout most of its length as an 'Eroded Channel', with steep narrow banks, indicative of significant long term channel erosion. The soils of the channel are typically sandy to clayey loam, to clay, all with fairly high erosion potential. Much of the native riparian vegetation has been removed due to agriculture and land development, with the associated increase in erosion potential.

3.3 Land Forming Processes

3.3.1 Bedrock Geology

Bedrock in the Carp Watershed comprises two types. A prominent ridge of Precambrian metamorphic rock forms the Carp Ridge along the east boundary of the watershed, extending across the watershed north of Kinburn.

The south third of the watershed is underlain by broad flat-topped ridge (mesa) of younger Paleozoic sedimentary rocks (Ordovician age, approximately 500 million years in age). These rocks consist of limestone, dolostones, sandstones and shales.

The contact between the Precambrian metamorphic rocks and the Paleozoic rocks is marked by an ancient southeast-northwest trending fault (the Hazeldean Fault) whose position lies along the present-day course of the Carp River. Slippage along the Hazeldean Fault and other parallel faults caused the younger Paleozoic rocks to drop in a series of steps, decreasing in depth to the south. These fault-bounded steps of Paleozoic rock underlie the Carp Valley.

Both these fault-controlled rock types form prominent ridges which exercise a dominant control on the topography within the watershed.

Synthesis

The Paleozoic bedrock exhibits a gentle northeast slope (interpreted as a series of faultbounded steps) extending as far west as Pakenham. This indicates that the groundwater catchment area extends considerably beyond the boundary of the Carp Watershed. Flatlying Paleozoic rocks, by virtue of their bedding planes and fracturing, are known to be a shallower and more reliable source of groundwater than the Precambrian rocks.

It will be demonstrated that, in addition to topography, the bedrock types exert a significant influence on the surficial (glacial) geology, landforms and soil-forming processes (Section 3.3.2), groundwater recharge (infiltration, Section 3.4.3) and some influence on water quality in the Carp River and its tributaries (Section 3.4.2).

3.3.2 Physiography, Surficial Geology and Soils

The faulting that formed the Carp Valley occurred millions of years before the last period of glaciation, which ended some 10,000 years ago. The Carp Valley provided a pathway for a lobe of ice that eroded the valley. The ice scraped the north Precambrian ridge clean and deposited a veneer of till on the flat-lying Paleozoic rocks to the south.

As the ice retreated up the Carp Valley, flowing water deposited sand and gravel along the valley floor. The valley, and much of southeastern Ontario, was flooded by a lake which deposited fine-grained clay and silt in the Carp Valley. The tills on the Paleozoic bedrock ridge and overlapping fine-grained lake sediments on the flank re-worked by wave action or deposited by streams to form sand and gravel deposits, many of which are less than 1 metre thick. The influence of the bedrock on the surficial geology can be seen in **Figure 3.3.1** -



Surficial Geology. Remnants of till are preserved on the bedrock ridges whereas the sand plains flank the ridges. The Precambrian ridge to the north remains essentially exposed within the watershed.

The landforms resulting from the post-glacial period (**Figure 3.3.2** - Landforms) mimic the surficial geology. The soils developed on the overburden and the bedrock is illustrated in **Figure 3.3.3** - Soils. The Carp Valley floor is dominated by clay loam and silty clay loam (North Gower Series) that are described by Chapman and Putnam as being the most fertile soils within the entire Ottawa Valley. They have traditionally been used for agriculture and dairy cattle. There are several sand plains on the valley floor, consisting of thin (40 - 100 cm) sandy loam overlying clay (Castor and Osgoode Series).

The flanks of the Paleozoic bedrock ridge are draped with fine sands and sandy loams. Coarse sand and gravel are occasionally present (Mile Isle and Kars Series). These sandy loam soils have been traditionally used as pasture. Organic soils and wetlands on the bedrock ridges appear to be underlain by dense, relatively impermeable tills.

The clay soils in the Carp Valley (North Gower and Dalhousie Series) are poorly-drained. Agricultural use of these fertile soils requires supplementary drainage and tile drains. These, in turn, will likely have impacts on surface water quality.

Synthesis

The Paleozoic bedrock ridge provides a combination of topography, fractured Paleozoic bedrock aquifers, coarse surficial sands, and wetlands. These conditions minimize runoff, erosion and flooding, while increasing infiltration (recharge) to the bedrock aquifer and prolonging the travel times of water in the shallow bedrock for subsequent discharge to streams on the flanks of the bedrock ridges. Many of the wetlands on these shallow bedrock features appear to be underlain by impermeable tills.

Precambrain metamorphic rock forms the Carp Ridge along the east boundary of the watershed, extending across the watershed north of Kinburn. The Precambrian ridge to the north remains essentially exposed with the watershed. Generally, because of the unfractured nature of this bedrock type, this area does not respresent a particularly good source of water supply, and does not provide recharge.

3.4 Surface Water System

Form

- Recorded stream flows
- Event hydrographs
- Precipitation records
- Water chemistry (dry- and wet-weather)
- Water temperature and dissolved oxygen levels
- Sediment transport
- Point sources and non-point sources (NPS) of pollutants
- Pollutant loadings
- Spatial and temporal trends in pollutant concentration



Functions and Linkages

- Maintenance of groundwater resources for all uses
- Maintenance of baseflows in streams to protect plant and animal life
- Habitats for aquatic life
- Erosion, transport and deposition of sediment
- Ultimate receptor of human and agricultural wastes
- Groundwater surface water interactions (recharge/discharge)
- Assimilation of pollutants
- Recreation (swimming, fishing, aesthetics)

3.4.1 Hydrologic Cycle

The hydrologic cycle is the process of evaporation of water from the earth's surface (mainly from the oceans around the equator), subsequent condensation to form clouds, precipitation in the form or rain or snow, and the runoff from the land back to the oceans.

The cycle begins with rain or snow (precipitation) falling to the ground. The amount and rate of precipitation actually reaching the ground depends on prevailing weather systems and local influences such as topography and vegetation. This process is often erratic in both time and area. As a result, streamflow cannot be predicted with accuracy but must be estimated based on measurement of past events or historical precipitation data. Precipitation is the source of both streamflow and groundwater.

When precipitation hits the ground, it runs across the ground surface and enters the stream network directly (runoff), infiltrates into the ground to supply the groundwater network (recharge), or is re-introduced back into the atmosphere by evapotranspiration. The proportion of total precipitation that appears as runoff, recharge and evapotranspiration varies from area to area and depends on the amount/intensity of precipitation, soil type (e.g., clay, silt, sand, gravel), topography (e.g., level, sloping, flat, hilly), land cover (e.g., forests, pasture, pavement) and ground surface condition (e.g., frozen, saturated, dry). In some areas, most precipitation appears as runoff, for example, paved surfaces in urban areas or when the ground is frozen, while in others most of the precipitation infiltrates or evaporates, for example, on hummocky terrain. The term water budget is used to describe the apportioning of the precipitation into runoff, infiltration and evapotranspiration. Maintenance of the natural water budget as land use changes occur is essential to maintaining the natural functions of the hydrologic cycle.

Runoff water collects in stream channels that lead to larger channels, wetlands and lakes. As surface water travels through this stream network, it may also infiltrate through the stream/ wetland/lake bed into the groundwater system or evaporate. As water flows, it modifies its channel and adjacent floodplain supplying sediment to the stream and by causing erosion and deposition along its course. For the most part, streamflows are contained within the stream channel. However, in response to major precipitation or snowmelt events, water periodically overtops the channel banks and floods adjacent lands (floodplain).

Water that infiltrates into the groundwater network is not static, but moves through the ground in a similar but much slower way that water flows across the land surface. Groundwater storage areas or aquifers are typically gravel or fractured bedrock deposits capable of holding large quantities of water within them. This water moves gradually downward or horizontally based on water pressure gradients until it meets an impermeable barrier (aquitard), usually solid bedrock or silt/clay material. Where stream channels have eroded downward into the overburden or underlying bedrock, groundwater discharge or upwelling into the stream can occur. Because groundwater flow is much slower than surface



water flow, groundwater discharge to streams occurs over a prolonged period, often continuously, thus maintaining a sustained baseflow in the stream. Streams lacking such areas of groundwater discharge are typically intermittent.

It is important to understand that the source of water stored in aquifers may be from two sources:

- A renewable supply from infiltration of precipitation; and
- A non-renewable supply which was stored in the aquifer during post-glacial periods

3.4.2 Streamflow Characteristics

Long-term continuous monitoring of streamflow has occurred on the Carp River near Kinburn since 1972. The distribution of streamflow throughout the year, based on the last 5 years of data (1997-2002), is shown in **Figure 3.4.1**. About 59% of the total annual streamflow occurs in March and April, and about 2.7% occurs in September and October. These results are typical of rural watersheds in Eastern Ontario that have shallow slopes and low porosity.

The Carp river watershed is unique, however, in that only the upper reaches are significantly urbanized, with the lower reaches comprising farmland and natural vegetation. This is the reverse of most watersheds in Ontario, due to typical settlement practices. This unique nature is a result of the pattern of growth of Kanata and Stittsville as satellite communities of Ottawa.

The streamflow in a river with an urbanized watershed would typically show much higher and faster peaks from rainfall and meltwater events than a rural watershed. Due to the shallow gradients and distance from the urbanized area, the expected severe responses are not detectable by the time the flow reaches the gauge at Kinburn. This does not diminish the risks to the river ecosystem that are the result of urban runoff but suggests that the impact to major flows does not extend downstream to the lower reaches of the river. Urbanization typically produces high salt loading in the spring, nutrient, trace contaminant and sediment loading though the year, faster and more severe responses to rainfall events, and a reduced diversity of species in the river.

As can be seen in **Figure 3.4.2**, the low flows in the summer and early fall is typically unresponsive to rainfall events. Only sustained, high volume rainfall events produce a significant response in the streamflow. Daily flow rates are less than 0.6 m³/s for 75 days through 5 months in the summer and early fall compared with the annual average flow rate of 2.9 m³/s. The land has little capacity to store peak events, and as a result, the baseflow which supports the aquatic ecosystems during dry periods, is very low. In 1996, for example, the lowest daily flow was 0.03 m³/s, about 1% of the average annual flow rate. The peak rate for that same year was 29.1 m³/s. The lowest flows measured in each of the last 5 years have been below 0.1 m³/s, and have been as low as 0.02 m³/s. A baseflow of 0.1 m³/s is about 3% of mean annual flow, which is generally insufficient to support sensitive warm and coldwater fish communities.

A comparison of streamflow between the Carp River and three other basins with similar landuse, shows how soil and topography affect both peak and base flows. Both the Eramosa and Credit Rivers (sandy soils) show a peak monthly flow of approximately 20% of the total annual runoff and a minimum base flow of about 4% of the total annual runoff, while the Carp and West Humber Rivers have a peak monthly flow of between 35 and 40% of the total annual runoff and minimum base flows that are 1% or less of the total annual runoff. Streamflow characteristics of these rivers are shown in **Figures 3.4.3** and **3.4.4**.


The flood flows in the lower Carp River are snowmelt related and occur, therefore, in the spring, usually at the end of March or early April. Based on the streamflow records from the gauge at Kinburn, it appears that runoff has decreased over time. The maximum-recorded daily discharge was 85.0 m³/s on April 18, 1972 and the lowest recorded peak flow was 22.7 m³/s on February 28, 2000. The 2000 peak flow was also unusual because it took place in February, approximately one month before the normal freshet period. As seen in **Table 3.4.1**, the last 15 years shows a trend of lower total runoff and lower peak discharge as compared to the previous 15 years. Changes in weather patterns do play a role in this trend but increased urbanization in the upper watershed has undoubtedly reduced the volume of the snowpack that is largely responsible for the spring freshet. This phenomenon is also illustrated by the reduction in total annual flow. Although the total annual flow shows some reduction over the 1972-2000 period, this reduction is relatively smaller and appears to be influenced by the high volume in 1972 and low volume 2000 respectively. Without the extreme high and low values, the total annual flow shows only a small decline during this period. The maximum daily discharge and total annual flow volumes are shown graphically in Figures 3.4.5 and 3.4.6 respectively.

Year	Maximum Daily Discharge (m ³ /s)	Total Annual Flow (ha.m)	Year	Maximum Daily Discharge (m ³ /s)	Total Annual Flow (ha.m)
1972	85.0	12,700	1987	48.7	7,980
1973	50.4	11,400	1988	27.8	6,760
1974	51.0	9,980	1989	45.4	6,840
1975	72.2	7,900	1990	31.8	8,970
1976	56.9	11,000	1991	42.2	8,480
1977	51.0	8,210	1992	39.3	9,580
1978	64.6	9,790	1993	55.7	9,960
1979	55.8	9,140	1994	26.0	8,530
1980	61.0	6,930	1995	37.3	9,300
1981	57.2	10,900	1996	29.1	11,650
1982	41.9	7,930	1997	66.8	9,950
1983	35.0	8,960	1998	76.1	9,040
1984	59.1	11,100	1999	69.7	8,080
1985	32.4	8,360	2000	22.7	6,230
1986	39.8	10,900	2001	49.1	N.A.

Table 3.4.1	
Annual Maximum Daily Discharge and Total Annual Flo	w

The river channel is identified throughout most of its length as an 'Eroded Channel', with steep narrow banks, indicative of significant long term channel erosion. The soils of the channel are typically Sandy to Clayey loam, to Clay, all with fairly high erosion potential. Much of the native riparian vegetation has been removed due to agriculture and land development, with the associated increase in erosion potential.

Flow Estimates Watershed

Estimates of peak flows, critical flows for erosion, and low flows, can be generated by means of a statistical analysis of the flow record (station frequency analysis). Flow estimates at other locations in the basin can be derived from the estimate at the gauging station by prorating the flow at the gauge based on the ratio of drainage areas and an empirical constant (K).



The value of 'K' can vary considerably; typical values are between 0.75 and 1.5. To accurately determine the value of 'K' for a basin, at least two gauging stations are required. A temporary gauge was established on Galetta Side Road crossing near Fitzroy Harbour to measure the 2001 freshet. Because the spring freshet did not produce a sufficiently high flow to accurately estimate the peak flow at the temporary gauge, a hydrologic model was used to generate flow rates. The QUALHYMO model was used to simulate runoff over a period of 26 years. The model was calibrated using the flow record of the Kinburn gauge. Results of the modelling are used to evaluate:

- Peak instantaneous flow estimates at the gauge
- Erosive flows
- Low flows

The watershed discretization for the QUALHYMO model can be found in **Figure 3.4.7**.

Flow Estimates Subwatershed

In the urban portion of the basin, peak flows are mostly caused by rainfall events. The urban area was modelled using the QUALHYMO continuous simulation model. Because QUALHYMO uses both precipitation and temperature as input, both snowmelt and rainfall events are simulated. Existing stormwater management facilities, shown in **Table 2.2.1** and **Figure 1.1.2**, and other significant control structures were included in the model. Model discretization for the subwatershed area is shown in **Figure 3.4.8**.

2001 Spring/Summer Field Program

To provide model validation and calibration, a gauge was established at a control section in Poole Creek, just upstream of Maple Grove Road. This gauge is operated during the summer and fall of 2001 (approximately 30 weeks). Monitoring results showed inconsistent flows at this location and could not be used for calibration purposes.

The gauge at Kinburn, the temporary gauges at the Galetta Side Road, and the precipitation at the March Road Pumping Station are shown in **Figure 3.4.7**.

Once the model was adjusted to simulate flows at the Kinburn gauge, 2, 5, 10, 20, 50, and 100 year peak flows at key locations were estimated by means of frequency analysis. The impact of future development (e.g. the Corel Area) was evaluated to determine potentially detrimental impacts of development on flood flows. Results indicate that quantity control is not required for future development areas. Peak flow estimates are presented in Section 9.3.1.1.

3.4.3 Surface Water Quality

Water quality is a general term that defines the chemical characteristics of water and their impacts on the environment. Impacts can be positive, such as when water is cold, clear and saturated with oxygen. Impacts can also be negative when the water is warm, turbid, anoxic (depleted in oxygen) or when it contains impurities. Surface water that is polluted by human impacts may include one or more of the following pollutants:

- Suspended sediment (from erosion and runoff);
- Bacteria, including E. Coli;
- Nutrients, such as nitrogen and phosphorus compounds;
- Pesticides and herbicides;
- Petroleum hydrocarbons, such as fuels and oils;



- Trace metals, such as copper, lead, zinc, chromium; and,
- Organic compounds, such as solvents or PCBs.

Water quality is a key component for aquatic habitat and also determines the suitability of water for drinking, swimming, fishing, wildlife and general aesthetics. Aquatic and plant life require trace amounts of impurities, although the presence of excessive amounts of nutrients, metals and organic compounds may be toxic to aquatic life and render the water unfit for human uses, including recreation and general aesthetics.

The concentrations of impurities and pollutants in surface water vary as a result of many factors, such as the geology of the watershed, the buffering capacity of soils, climate, topography and vegetation in the watershed, the action of wetlands, interaction with groundwater, and land uses. On a local scale, significant amounts of pollutants enter water as a result of human activities. These activities may include stormwater drainage, runoff from roads, fertilizers, pesticides and animal wastes from agriculture, accidental spills, leaking septic systems or illicit dumping.

Temporary imbalances in the concentrations of nutrients, bacteria or metals can be lethal to aquatic organisms. Some imbalances cause nuisance or reduce recreational opportunities, such as when habitat is lost, certain animal species disappear or when unsightly algal blooms appear. Consequences can be more serious, such as incidences of bacterial infections in children who play in the water or the appearance of fish kills.

Sediment load in streams is a special case for several reasons:

- Excessive sediment may smother fish eggs and bottom-dwelling organisms and kill fish by clogging their gill structures;
- Many trace metals, nutrient and organic compounds are attached (adsorbed) onto fine sediment and are carried into streams by runoff following storms and spring snowmelt;
- Increased sediment loads from developed areas can destabilize streams, causing erosion and bank failure, resulting in further degradation (infilling of stream pools, loss of streambank vegetation and warmer water); and,
- Increased sediment loads often contain high levels of nutrients, which cause algae growth and depletion of oxygen (eutrophication). Dead plant material settles to the bottom, causing further loss of oxygen until the stream becomes anoxic and ceases to support life.

3.4.4 Surface Water Quality Observations

Surface water quality is generally described in terms of one of more of the following sets of parameters: general chemistry (e.g. pH, conductivity, harness, chloride), bacteria (E. Coli), nutrients (nitrogen and phosphorus), trace metals, pesticides and herbicides, and organic compounds (e.g. fuels, solvents, PCBs).

Within the Carp River Watershed, a total of 995 individual water quality analyses were provided by the City of Ottawa, spanning the years 1993 - 1999 from 25 sample stations. Ten (10) sample stations are located on the Carp River from Hazeldean Road to Fitzroy Harbour and fifteen stations are situated on tributaries (3 on Poole Creek, 2 on Huntley and Corkery Creeks) and one each on 8 smaller tributaries. The data were assessed on an Excel spreadsheet. Geometric means of selected parameters were calculated and sampling locations were sub-divided among the Carp River itself and its tributary streams.



The water quality database was examined for spatial trends (Carp River versus tributaries), temporal trends (annual means) and under dry- and wet-weather conditions. Dry and wet conditions were divided on the basis of precipitation data at Kinburn and daily flow patterns in the Carp River at the Kinburn gauge.

Preliminary observations from the database are:

- Fifty-nine percent (59%) of water samples reflect dry-weather conditions. Forty-one percent (41%) reflect wet-weather conditions, including high winter and spring flows;
- Many of the 25 water quality stations exhibit long-term mean concentrations of parameters in excess of Provincial Water Quality Objectives (PWQO) for the protection of aquatic life. These include total phosphorus (22 of 25 stations), bacteria (22 of 25 stations), iron (18 of 25 stations), aluminium (24 of 25 stations) and total ammonia (1 of 25 stations);
- The mean concentrations of the trace metals (copper, zinc, nickel and lead) are below PWQO;
- Mean concentrations of parameters are lower in the Carp River compared to its tributaries;
- Mean concentrations of parameters from stations on the Carp River remain relatively constant, or exhibit decreases downstream from Hazeldean Road to Fitzroy Harbour.

3.4.4.1 Spatial Trends in Surface Water Quality

The degradation of surface water quality was assessed by a combination of ten key parameters that have known impacts on water quality, principally for aquatic habitats in streams. Many parameters have direct impacts on aquatic habitats due to high sediment loads (TSS) or oxygen depletion resulting from algae growth (elevated nutrients). Other impacts are long-term and cumulative, due to metals entrained with suspended sediment, bacteria from sanitary effluent and animal waste, trace metals from predominantly urban sources (copper, zinc) or chloride washed off from salted road networks or excessive use of water softeners. The selected parameters are:

- Total phosphorus (TP);
- Bacteria (Eschericia Coli)
- Total suspended sediment (TSS)
- Nitrogen species (as un-ionized ammonia and nitrate);
- Iron and Aluminium
- Copper and zinc; and,
- Chloride

These ten parameters were combined as a "Water Degradation Index" (WDI), which is described in **Table 3.4.2**. The WDI is a combination of parameters that have both acute and chronic impacts on the ecological health of streams, particularly on fisheries.

The WDI is defined as the sum of ratios (geometric means of individual parameters divided by a recognized criteria for the protection of aquatic life, which, in most cases in the Provincial Water Quality Objectives or PWQO), multiplied by an Effects Factor. The inclusion of a multiplier is used to reinforce the effects of parameters, which are keys to the protection and enhancement of fisheries.



Total phosphorus (TP) has a multiplier of 5 because its impact on oxygen depletion is much more significant than other measures of oxygen depletion in water, such as BOD5 or COD. The concentration of un-ionized ammonia is also assigned a multiplier of 5 because the elevated levels of un-ionized ammonia are lethal to fish. The concentration of un-ionized ammonia (as a fraction of total ammonia) is directly proportional to both pH and temperature of water. Copper is also assigned a multiplier of 5, since dissolved copper is the trace metal that is most toxic to fish. The other parameters are assigned Effect Factors of 1, as they represent cumulative, chronic and often correlated stressors on fish habitat.

Parameter	Units	Criteria (Denominator)	Source of Criteria	Effects Factor
Total Phosphorus	mg/litre	0.030	PWQO	5
Un-ionized Ammonia	mg/litre	0.020	PWQO	5
Copper	mg/litre	0.005	PWQO	5
TSS	Mg/litre	5	Dry-weather	1
Nitrates	mg/litre	10	ODWS	1
Iron	mg/litre	0.300	PWQO	1
Aluminum	mg/litre	0.075	PWQO	1
Chloride	mg/litre	250	ODWS	1
Zinc	mg/litre	0.020	PWQO	1
E. Coli	CFU/100 ml	100	PWQO	1
Total Score				Sum

Table 3.4.2Calculation of the Water Degradation Index (WDI)

A preliminary classification is proposed:

"Background" levels are considered representative of, or expected for, current conditions within the watershed. A WDI of 30 or less is considered background, although it must be emphasized that "background" does not necessarily imply the acceptable.

"Slightly degraded" conditions are defined where the WDI levels are between 30 and 50. WDI levels in this range are a warning that streams are under considerable stress.

"Severely degraded" conditions are defined where the WDI score is in excess of 50. These levels indicate a severe impact in the capability of water to support an aquatic habitat.

The WDI values for the Carp River and its tributaries, as a function of distance downstream from the headwater of the Carp River are presented in **Figure 3.4.9**. The locations of the tributaries are taken at the confluence with the Carp River.

The resulting pattern of WDI values and land use is illustrated on the map in **Figure 3.4.10** – Generalized Land Use.

The major observation is that Poole, Huntley and Corkery Creeks have low WDIs, whereas all but one of the smaller tributaries exhibit WDI indicative of slight to severe degradation. From **Figure 3.4.9**, it is apparent that all the degraded tributaries drain agricultural lands.



3.4.4.2 Temporal Trends in Surface Water Quality

Geometric mean concentrations of key water quality parameters for the 25 water quality stations were calculated on a yearly basis (1993 – 2000) to determine systematic increases on a year-to-year basis for the entire watershed. Data from Poole Creek is provided as representative of urban land use conditions, while data from Carp River is typical ofrural land use conditions.

Total phosphorus (TP) is the parameter, which exhibits the most consistent exceedance over PWQO. The yearly trend for TP and suspended sediment (TSS) are reproduced in **Figure 3.4.11**. The annual means for TP in Poole Creek and Carp River suggests a slight decrease, whereas TSS does not exhibit a consistent trend. It is of note that TP and TSS do not appear to demonstrate any recognizable correlation, at least on an annual basis. The only consistent trend observed was for chloride. Chloride increases from 50 mg/litre (1993) to approximately 100 mg/litre in 1999 – 2000. Chloride is a good surrogate ("early-warning") indicator parameter to gauge increasing degradation trends in water quality, because it is not naturally produced, it is soluble and is not removed from water by any natural processes. The main sources of chloride in the environment are from road salt and, to a lesser extent, water softeners and septic systems. Mean annual chloride concentrations are shown in **Figure 3.4.12**. For the period 1994 – 1996, there appears to be a declining trend in chloride concentrations in Poole Creek, while the corresponding trend in the Carp River gradually increases. The reason for this is not clear.

3.4.4.3 Surface Water Quality under Dry- and Wet-Weather Flow Conditions

Dry-weather and wet-weather flows from urban environments generally display distinct elemental signatures. Dry-weather flows often contain elevated metals (e.g. from washing vehicles and hosing down driveways), elevated nutrients and pesticides (e.g. from lawn watering over-spray) and elevated levels of bacteria.

More than half the total phosphorus (TP) in urban environments is bound (adsorbed) onto particulate matter and, as such, a correlation between TP and TSS is expected. This does not appear to be the case for the Carp River and its tributaries (see **Figure 3.4.13**). This has several implications:

- Phosphorus concentrations are similar for dry- and wet-weather conditions;
- Phosphorus concentrations display only a weak correlation (R² = 0.116) with TSS for wet-weather conditions, indicating that the availability of phosphorus is not controlled by suspended sediment;
- Phosphorus concentrations within the Carp River at sites near the Kinburn gauge display no correlation to flows (flow between <0.1 to >40 cubic metres/second); and,
- In water samples where phosphorus was analysed both a dissolved orthophosphate (PO₄²⁻ P) and total phosphorus (organic, inorganic, particulate and colloidal forms), it was noted that 2/3 of the phosphorus is present as dissolved orthophosphate. This dissolved form of phosphorus is the most prevalent form in sources such as fertilizers, septic effluent and oxidized animal waste.



3.4.4.4 Surface Water Quality as a Function of Source Areas

Groundwater from the Paleozoic Bedrock Aquifer is characterized by elevated hardness (due to dissolved calcium and magnesium ions). The Ministry of the Environment data indicates a mean value of 321 mg/litre. A compilation of bedrock and overburden water quality in the vicinity of the West Carleton landfill (WESA 1989, 1998) indicate geometric mean hardness of groundwater from the Paleozoic Bedrock Aquifer of 308 mg/litre and 325 mg/litre for water extracted from overburden aquifers. In contrast, hardness of water from peatland (wetlands) is considerably lower. The average hardness range of peatland waters in southeastern Ontario varies between 10 mg/litre in bogs and 100 mg/litre in fens (MNR, 1994). Given the inferred importance of wetlands in providing baseflow to creeks, hardness levels may be a gross indicator of the contribution of wetlands to tributary baseflow.

This hypothesis is examined in **Figure 3.4.14**, which shows the mean hardness of waters from the Carp River and its tributaries and a function of distance downstream. The lowest hardness levels are in Corkery and Huntley Creeks. Portions of Poole Creek and the northernmost tributary ("Smith Corners" Creek draining from wetlands on Precambrian rock) also show low hardness.

This observation, however crude, is consistent with the inferred role of wetlands in providing baseflow to the larger tributary streams flowing into the Carp River.

A second pattern emerges in plots of iron and aluminium versus TSS, where an almost linear correlation is apparent (**Figure 3.4.15**). This correlation indicates that suspended sediment is mainly derived from clay minerals (iron- and aluminium silicates). This is a general indication that the sources of TSS are predominantly linked to the surficial soils and the finer grained particles that contribute to TSS loadings.

Surface Water Synthesis

On a *watershed scale*, several inferences can be made from the above:

Spatial Trends:

- Surface water quality of tributaries sampled near the north flank of the shallow Paleozoic bedrock ridge is at background levels. Four examples (from north to south) are the upper reach of Corkery Creek (Station R0-10-21), the upper reach of a tributary at Thomas Argue Road west of the Carp Airport (Station R0-10-31), the upper reach of Huntley Creek (Station R0-10-19) and the headwater of Poole Creek (Station R0-10-32);
- Where multiple sample locations are present on tributaries, surface water quality becomes more degraded as the tributaries approach the Carp River;
- Surface water quality, based on the parameters selected for the Water Degradation Index (WDI), is most severely degraded on small tributaries that lie within the Carp Valley on agricultural lands. It is not possible to determine whether this degradation represents point sources or non-point sources, although the 2001 field program identified significant shoreline degradation and livestock access on several tributaries identified as "severely degraded";
- It is likely that the "severely degraded" water quality in small tributaries is aggravated by conditions of little or no flow, principally due to shallow gradients, low baseflow, altered (ditched) courses, or a combination of these. Little or no flow was observed in these tributaries during field work in June through September 2001;



- Due to the observed conditions of little or no flow, the cumulative impacts of the "severely-degraded" tributaries on overall water quality in the Carp River will be difficult to quantify;
- Hardness of water is lowest in tributaries that have wetlands at their headwaters, suggesting that wetlands provide a measurable contribution to baseflow;

Temporal Trends

- The poor correlation between total phosphorus (TP) and TSS in the dry-weather and wet-weather water data suggests that phosphorus inputs are similar under dry-weather conditions and wet-weather conditions (when high TSS levels would be anticipated with runoff). Furthermore, since the levels of phosphorus are relatively constant in both dry- and wet-weather conditions, it is likely that the source of phosphorus is both non-point and chronic. The source is possibly due to long-term inputs from manure (livestock access) and from fertilizers.
- An examination of the distribution of sampling sites characterized as "severely degraded" points to several major causes of degradation. In order of severity, these are phosphorus, nitrogen (as TKN and/or ammonia) and bacteria (E. Coli). Elevated iron and aluminium are well correlated with TSS. In contrast, "severely degraded" tributaries have the lowest levels of chloride of any tributaries. This combination of parameters is indicative of non-urban and agriculture non-point sources.

Source Trends

- Low levels of hardness in water from tributaries with headwater wetlands is consistent with a measurable contribution of baseflow from wetlands;
- Iron and aluminium levels exhibit very good correlations with suspended sediment (TSS), suggesting that most of the TSS is due to erosion of clay minerals (dominantly composed of iron-aluminium-magnesium silicates);
- High levels of phosphorus in surface water are dominantly in the form of dissolved orthophosphate or "reactive phosphorus" (PO₄²⁻ - P), suggesting inputs from fertilizers and possibly animal wastes.

On the *subwatershed scale*, the surface water quality is classified as background (see **Figure 3.4.9**). Although the subwatershed area is significantly more urbanized than the watershed, it is encouraging to note that the concentrations of chloride do not show a consistent increase with time (see **Figure 3.4.12**).

3.5 Groundwater Resources

Form

- Identification of aquifers
- Water table elevations
- Groundwater flow patterns
- Geologic cross-sections
- Baseflow contribution to streams
- Water budget



Function and Linkage

- Sustainable water supplies for domestic, municipal and irrigation
- Regional versus local groundwater supplies
- Maintenance of aquatic habitat through baseflow

Groundwater is the only source of drinking water in all rural areas and villages within the Carp Watershed. There are more than 1,638 water wells within the watershed. Private wells supply the Villages of Kinburn and Fitzroy Harbour. The Village of Carp has a communal well system maintained by the City of Ottawa. All rural areas and villages, with the exception of Carp, have private septic systems. Sanitary sewage from Carp is directed east to the City of Ottawa municipal sanitary system.

Bedrock and surficial geology maps were integrated with the Ontario Ministry of the Environment water well database to identify the principal aquifers within the watershed. Four distinct aquifers are ranked below from most prolific to least prolific:

- Paleozoic Bedrock Aquifer limestone, dolomite, sandstone and minor shale. This aquifer supplies more than 90% of the water wells in the watershed;
- Lower Overburden Aquifer gravel and sand layers at the bedrock interface, overlain by more than 10 metres of clay. This aquifer supplies <5% of wells, including the communal wells in the Village of Carp
- Precambrian Bedrock Aquifer sourced in massive metamorphic rock along the east margin of the watershed. This aquifer supplies <5% of wells;
- Upper Overburden Aquifer shallow wells tap thin and discontinuous sand and gravel lenses within the clay plain. This is generally an unreliable source of water and there is only one well within the watershed that taps this aquifer.

The water table characteristics were constructed from a compilation of the static water depth in water wells and elevation of the wells. The result is shown in **Figure 3.5.1**. Three cross-sections have been prepared to illustrate the water table and geology of the watershed. The cross-sections were taken along Hazeldean Road (**Figure 3.5.2**), Regional Road 49 (March Road) in **Figure 3.5.3** and Regional Road 20 (Kinburn Side Road) in **Figure 3.5.4**.

The water table appears to be under dominant topographic control, and has an overall 0.38% slope to the north across the watershed. The "bulge" of the water table mimics the Paleozoic bedrock ridge and extends along the southwest watershed boundary. This elevation of the water table suggests that the area of groundwater recharge to the bedrock aquifer extends beyond the watershed boundary to the southwest. The cross-sections illustrate that the Lower Overburden Aquifer (gravel layer at the bedrock interface) is not always present and that the Paleozoic Bedrock Aquifer represents a more reliable source of water. In order to protect and enhance the groundwater in the watershed (quantity and quality), it is important to recognized where groundwater is being replenished.

The combination of shallow fractured Paleozoic bedrock on topographic highs, coarsegrained sand and gravel associated with the overburden aquifers, and wetlands on areas of shallow bedrock perform important functions in retaining precipitation. These geological feature's condition minimize runoff, erosion and flooding, while increasing infiltration (recharge) to the bedrock aquifer and prolonging the travel times of water in the shallow bedrock for subsequent discharge to streams on the flanks of the bedrock ridges.



The water budget for the Carp watershed (Section 3.5.1) indicates that a surplus of 112.5 mm/year is available for storage as groundwater and in wetlands. Recharge potentials (in mm/year) were assigned to different geological materials in **Table 3.5.3**. The infiltration potentials are reasonable given the known hydraulic conductivities of different materials and their associated landforms. The values are consistent with those used by CH2M Hill and Waterloo Hydrogeologic (2001). The recharge value for sand (230 mm/year) is similar to the 3-D computer model input used by Golder Associates (2003) for the wellhead protection study of the Carp communal wells, namely 300 mm/year. The recharge values for clay (100 mm/year) are higher than Golder's value of 10 mm/year.

From inspection of **Table 3.5.3**, it is apparent that the sand deposits and shallow Paleozoic bedrock, representing less than 30% of the watershed, provide more than 50% of the groundwater recharge potential.

Although not strictly a groundwater recharge landform, wetlands provide an essential ecological function in storing water. This is especially important in the Carp watershed because the wetlands are situated on impermeable till layers overlying bedrock. As such, they intercept precipitation and snowmelt that would otherwise be lost as runoff. The wetlands are classified as "headwater wetlands" to emphasise the essential ecological function in maintaining baseflow for several important streams, particularly to Huntley and Corkery Creeks.

The groundwater recharge potential areas and the wetland headwater areas are summarized in **Table 3.5.3**.

Groundwater discharge areas were identified in the field (June 25 - 30) under dry-weather conditions and were inferred from geological observations of the surficial geology. It was observed that the bulk of flow in Huntley and Corkery Creeks originates from the headwaters, and emanates from wetland headwaters.

The upper reaches of Huntley Creek are rock bottom channels. Further downstream, within the sand deposits, alternate zones of seepage and diminished flow were observed. It appears that Huntley Creek alternately gains flow from groundwater discharge (gaining stream) or loses flow that infiltrates into the sand (losing stream). Given the similar geological setting, a similar situation is likely.

Groundwater discharge to streams are noted along geological contacts, such as the sand deposits that flank the Paleozoic bedrock ridge, where the groundwater gradients are locally steepened and intersect stream valleys. Other areas were noted where lenses of permeable sands pinch out in bedrock depressions or inter-finger with the more impermeable clays on the flanks of the bedrock ridge, nearing the valley floor.

The resulting map of groundwater recharge and discharge potential is presented as **Figure 3.5.6**.



3.5.1 The Water Budget

A water budget is a tool to determine how precipitation is distributed between surface runoff, infiltration into the ground and evaporation and transpiration by plants (evapotranspiration). In its simplest form, the relationship is:

Р	=	RO + ET + INF + Δ S, where
Р	=	Precipitation falling within the watershed
RO	=	Surface water runoff leaving the watershed
ET	=	Evapotranspiration (evaporation and plant transpiration)
INF	=	Water infiltrating to recharge groundwater
ΔS	=	Change in storage within the ground or in surface reservoir

All of these terms may be considered in units of volume / time and can be expressed in units of m³/day, m³/year or mm/year (if expressed over a given watershed area). The conventional units of measure are in mm/year. The area of the Carp watershed is calculated as 309.98 square kilometres. The area drained at the Kinburn gauge is 252 square kilometres (or 81% of the watershed area).

The water budget for the Carp Watershed is summarized in **Table 3.5.1**. Evapotranspiration values were taken from the Eastern Ontario Water Resources Management Study (EOWRMS, 2001). The values as functions of land cover are summarized in **Table 3.5.2**.

Water	mm/year	m³/year	Data Source
Precipitation	910.5	281,963,640	Ottawa International Airport (1938-1990)
Runoff	353.9	109,595,752	Carp River at Kinburn (1973-2000) average, (watershed area upstream of Kinburn = 252 km ²)
Evapotranspiration	444.9	137,776,632	EOWRMS (2000) - see Table 3.5.2
Groundwater pumping	0.7	226,787	Actual quarry de-watering (1993-2000)
Change in storage	0	0	Negligible when average over decades
Infiltration into ground	112.28	34,825,334	By difference Table 3.5.3

Table 3.5.1Annual Water Budget for the Carp Watershed

The Water takings in **Table 3.5.4** are incorporated in the water balance since the two quarries (Lot 22, Con IV and the Clark Quarry) discharge into the Carp River and Poole Creek, respectively. The de-watering contribution of the Clark Quarry shows up as "Runoff". Once operational the Stittsville and Henderson Quarry de-watering volumes will be directed into the Jock River and will essentially "lost" from the watershed. The groundwater pumping values are based on actual records rather than approved amounts in the Water Taking Permits.



Land Cover Type	ET (mm/year)	Area (km²)	Area percent	ET (mm/year)
Urban	150	15.11	4.87	7.31
Agricultural (med)	390	139.23	44.9	175
Open/sparse forest	335	21.99	7.09	23.7
Rock outcrop/barren	335	1.30	0.419	1.40
Forest – conifer	445	40.54	13.1	58.2
Forest - mixed (incl. greenbelts)	541	19.98	6.45	34.9
Forest-unclassified	577	3.24	1.05	6.03
Forest – deciduous	638	36.39	11.7	74.9
Meadows	577	15.78	5.09	29.4
Water and wetland	640	16.42	5.30	33.9
Totals		309.98	1.000	444.9

 Table 3.5.2

 Evapotranspiration by Land Classes (EOMRMS 2000 data)

The water balance indicates that 112.28 mm/year is infiltrated into the ground, which represents 34.6 million cubic metres per year over the entire watershed. Although this represents a huge volume of water, it is less than one-third of the entire flow of the Carp River, as recorded at the Kinburn gauge.

Groundwater does not infiltrate evenly into the ground. Some soil types, such as sand, readily transmit water to depth whereas other soil types (silt and clay) infiltrate water more slowly. Infiltration into bedrock is controlled by the degree of fracturing, which provides a network of channelway for water to percolate into bedrock.

The importance of different soil and rock types are considered in terms of their potential to infiltrate water to depth. The potential infiltration values are reasonable approximations for different soil types. Infiltration potentials for bedrock are extremely variable and site-specific - the numbers used in the table are thus "best-guesses", derived from values of hydraulic conductivity from published sources. Infiltration into bedrock is enhanced by abundant vegetation, such as mature forests even if these are on thin soils. The results are summarized in **Table 3.5.3**.

Soil Type	Infiltration Potential (mm/year)	Area (km²)	Area percent	Infiltration (mm/year)
Sand	230	40.78	13.2	30.3
Silt	125	8.86	2.85	3.57
Clay	100	99.94	32.2	32.2
Till	75	16.77	5.41	4.06
Paleozoic bedrock	125	69.93	22.6	28.2
Precambrian bedrock	50	33.88	10.9	5.46
Urban areas	75	20.75	6.69	5.02
Wetlands	50	16.66	5.37	2.69
Unclassified	100	2.41	0.777	0.777
Totals		309.98	1.000	112.28

 Table 3.5.3

 Annual Infiltration Rates by Soil and Rock Types for the Carp Watershed



3.5.2 Groundwater Uses

Groundwater supplies all the potable water requirements within the Carp Watershed (with the exception of Stittsville and Kanata urban areas). A total of 1,638 water wells lie within the watershed boundary, supplying water for domestic, livestock watering and irrigation. Water is supplied to the Village of Carp from a municipal communal well. Approximate water usage in the watershed is shown in **Table 3.5.4**

Activity	Source of Water	Maximum	m ³ /year (est)	Data Source
Private wells	1638 wells	58m ³ /capita	285,000	MOE, EOWRMS
Carp well	Communal well	1999	82,800	City of Ottawa
Pit/quarry	Lot 22, Con. IV	4,900 m ³ /day	358,000	MOE PTTW
Pit/quarry	Henderson Quarry	7,844 m ³ /day	550,000*	MOE PTTW
Pit/quarry	Stittsville Quarry	7,776 m ³ /day	550,000*	MOE PTTW
Pit/quarry	Clark Quarry	2,618 m ³ /day	184,500	City of Ottawa
Pit/quarry	Lot 21, Con. VIII	17,651 m ³ /day	1,288,600	MOE PTTW
Golf Courses	50% groundwater	172,000 m ³ /yr	86,000	EOWRMS
Landfill	Groundwater purging	Oct/97-Aug/98	45,000	WESA
Total			3,245,400	

Table 3.5.4
Groundwater Taking in the Carp Watershed

* These quarries are not operational as on September 2001

Groundwater use for drinking water within the watershed (**Table 3.5.4**) amounts to an estimated 360,000 cubic metres/year, which is approximately 1% of the total groundwater infiltration potential. Other known forms of groundwater extraction (e.g. pit or quarry dewatering, golf course irrigation and landfill purging) raises the total close to 10%. The total volume of groundwater withdrawal is based on available information from Permits to Take Water (PTTW – required for all groundwater or surface water withdrawals in excess of 50,000 litres/day). Other activities (e.g. livestock watering) and non-permitted irrigation withdrawals may raise the figure to >10%.

An inventory of groundwater and surface water withdrawals is necessary to assess the impacts, particularly to streams. This will be addressed as part of recommended implementation measures within the context of the City of Ottawa Groundwater Management Strategy.

3.5.3 Groundwater Quality

Groundwater quality information is sparse. The main sources of information include: "Private Individual Services in the Rural Area" (Geo-Analysis Inc. and J. L. Richards & Associates Ltd., 1992), "The Hydrogeology of Southern Ontario" (Ontario Ministry of the Environment, 1996) and the "Renfrew County – Mississippi – Rideau Groundwater Study", hereafter referred to as the RMR report (Golder Associates and others, 2003.

In 2003, the Renfrew County – Mississippi – Rideau Groundwater Study was completed. This study identified groundwater conditions in the region, mapped groundwater resources and identified sources of groundwater contamination and areas of groundwater susceptibility to contamination. The study identified a variety of recommendations under 9 program areas to ensure that groundwater resources and uses are properly managed. Reports are available through the Mississippi Valley Conservation Authority.



Please refer to Appendix C of the Renfrew County – Mississippi – Rideau Groundwater Study for a complete hydrogeological and aquifer analysis of the Carp River Watershed/Subwatershed study area.

The major portion of the Carp Watershed is underlain by Paleozoic carbonate rocks of Lower Ordovician age, divided into two regional formations. These are the lower March Formation (dolomitic limestone and sandstone) and the upper Oxford Formation (dolomitic limestone).

Water quality derived from these aquifers has been summarized in several publications. Groundwater from the limestone aquifers is generally of good quality, although it is characterized by elevated hardness and total dissolved solids (TDS). Iron, chloride and sulphate concentrations are usually very low. The available information is summarized below:

Parameter	Units	ODWS	Hydrogeology of Southern Ontario (1996)			R-M-F St	R Groundwater udy (2003)
			mean*	min	max	mean**	comment
Iron	mg/L	0.3	1.32	<0.05	15.0	0.12	28% >0.30 mg/L
Alkalinity	mg/L	30 - 500	264	121	695	-	-
Hardness	mg/L	80 - 100	321	92	870	261	74% >200 mg/L
Conductivity	µS/cm	-	701	310	2150	-	-
Total dissolved solids	mg/L	500	468	268	1380	300	19% >500 mg/L
рН	-	6.5 - 8.5	7.43	7.00	8.4	-	-
Nitrate	mg/L	0.10	4.40	<0.02	40.0	0.1	1% >0.10 mg/L
Sodium	mg/L	20	21.9	<1	138	20	50% >20 mg/L
Chloride	mg/L	250	41	3	272	21	7% >250 mg/L
Sulphate	mg/L	500	55.7	15	180	-	1% >500 mg/L

Table 3.5.5R-M-R Groundwater Study Summary

ODWS Ontario Drinking Water Standard

* Mean of 33 samples

** Means of 403 to 490 samples (depending on parameter measured)

On a regional scale, groundwater quality is acceptable in the Carp River Watershed. Most of the parameters (TDS, hardness, iron, chloride and sulphate) are below the (non health-related) Ontario Drinking Water Standards. These parameters are a reflection of the nature of the bedrock material, which is dominated by calcium carbonate (limestone), containing minor amounts of sulphate and iron. Chloride may be due to deep formation water (salty) or from human activities (see below).



Other parameters reflect human (anthropogenic) activities, principally nitrate, bacteria and chloride. As discussed in the RMR report (Appendix C), high levels of nitrate, bacteria and chloride often occur as a "package", due to infiltration from nearby septic systems. Such impacts are localized, generally detected in one or more wells close to the groundwater table. They do not (as yet) lead to any recognizable regional-scale groundwater impact.

3.5.4 Subwatershed Level Groundwater Resources

The subwatershed area was examined in more detail, by means of three cross-sections using available water well information (Cross-Sections D, E and F – **Figures 3.5.7 to 9**), geological maps, soils information and the geological setting of the West Carleton Landfill (WESA, 1989).

The purpose of this compilation was to assess infiltration potentials within the subwatershed. An understanding of the infiltration potential is essential to determine the appropriate stormwater management techniques for this developing area.

Current and future groundwater withdrawals within the subwatershed area are dominated by several operations, summarized in **Table 3.5.6**.

Activity	Source of water	Maximum	m ³ /year (est)	Discharge Point
Private wells	Approx. 100 wells	58m ³ /capita	17,400	N/A
Pit/quarry	Henderson Quarry	7,844 m ³ /day	550,000*	Jock River
Pit/quarry	Stittsville Quarry	7,776 m ³ /day	550,000*	Jock River
Pit/quarry	Clark Quarry	2,618 m ³ /day	184,500	Feedmill Creek
Golf Courses	50% groundwater	172,000 m ³ /yr	86,000 (50%)	Poole Creek
Landfill	Groundwater purging	N/A	45,000	ROPEC
	Total		1,432,900	

Table 3.5.6Groundwater Taking in the Subwatershed

* These quarries are not operational as on September 2001:

The geology of the subwatershed area can best be summarized as a smaller-scale reproduction of the Carp Watershed. A ridge of Paleozoic bedrock extends in a northeast – southwest direction along the west margin of the subwatershed area. This bedrock ridge is overlain, and flanked to the east, by a layer of sand and gravel. The thickness of the overburden ranges between 1 and 17 metres. The mean depth of overburden along the bedrock ridge in the vicinity of Carp Road is 8.6 metres, compiled from10 water wells and 84 boreholes on the West Carleton landfill (WESA 1998). The sand and gravel is, in turn, underlain by a till horizon, generally less than 2 metres thick in the vicinity of the West Carleton Landfill. The east half of the subwatershed areas is overlain by clay. The sand and gravel layer is present under the clay in the north half of the subwatershed area (equivalent to the Lower Overburden Aquifer), and reaches a maximum thickness of 12 metres under Huntmar Road. South of Maple Grove Road, the bedrock is generally quite shallow (often less than 3 metres below ground surface).

The infiltration potential within the subwatershed area (**Figure 3.5.10**) has been classified from a stormwater management perspective, based on the characteristics outlined in **Table 3.5.7**.



Geology/Soils	Hydraulic Conductivity	Parameter	Suitability
Sand	High	Thickness > 3 metres	Yes
		Infiltration >15 mm/min	
Till	Low	Thickness < 3 metres	Questionable
		Infiltration <15 mm/min	
Bedrock	Moderate	Infiltration <15 mm/min	No
Clay	Low	infiltration <15 mm/min	No

 Table 3.5.7

 Stormwater Infiltration Potentials – Subwatershed Area

Groundwater Synthesis – Watershed Scale

- Groundwater is the sole source of drinking water for rural areas within the Carp Watershed; Groundwater use for drinking water amounts to less than 1% of the annual recharge to groundwater aquifers. Other forms of groundwater withdrawal (e.g. quarry de-watering, irrigation, livestock watering) raises this figure to perhaps 10%;
- Four aquifer systems have been identified, the most important of which are the Paleozoic Bedrock Aquifer (supplying 90% of drinking water and the Lower Overburden Aquifer, supplying almost 10% of drinking water)
- The most important geological features contributing to replenishment of groundwater supplies (recharge) are the areas of shallow Paleozoic bedrock on topographic highs and the sand and gravel deposits on and flanking the bedrock. These features are present over less than 30% of the watershed area, but contribute more than 50% of the recharge to groundwater;
- Headwater wetlands, though not strictly groundwater recharge areas, nonetheless perform an important function. The wetlands lie on impermeable till layers and are able to store precipitation and snowmelt that would otherwise run off. Stored water in these wetlands is released gradually, providing a significant augmentation of baseflow to Huntley and Corkery Creeks;
- Baseflow augmentation from headwater wetlands also serves a function in groundwater recharge and discharge. It is likely that streams fed from wetlands can become "losing" streams as they traverse areas underlain by sand and gravel deposits. The same streams will become "gaining streams" when they intercept groundwater table where the sand and gravel layers "pinch out" or inter-finger with more impermeable clay or till;
- Because the headwater wetlands provide two important functions, namely baseflow augmentation to several tributaries and as a source of groundwater recharge further downstream, it is important that these be protected. The zone of protection would include the drainage areas of the headwater wetlands.



Groundwater Synthesis – Subwatershed Scale

- The subwatershed area has a similar geological setting as the watershed, with a bedrock ridge, flanking sand deposits, a clay plain and wetlands underlain by till. The groundwater surface water interactions appear to be a smaller-scale. The headwaters of Upper Poole Creek are described as having a shallow overburden cover (generally <3 metres), augmented by wetlands overlying till. Previous studies conclude that groundwater recharge and discharge potential to Poole Creek from overburden is low, but that there may be a component of groundwater discharge from bedrock, at least during the spring season;</p>
- Groundwater withdrawals from the subwatershed area represent almost 50% of the total estimated groundwater withdrawal for the entire watershed. The consequences of removing these volumes and their subsequent discharge points (especially for quarry de-watering) must be assessed.

3.6 Erosion and Stream Morphology

Fluvial geomorphology deals with the study of the effects of water on the landscape. The earth surface is intermittently, but on an ongoing basis, modified by rainwater and the concentration of these waters into rivulets and swales. These flows transport sediments eroded from the landscape to creeks and rivers. Some sediment is temporarily deposited on the floodplain where they are eventually remobilized by the channel and conveyed downstream. Consequently, the basic function of a watercourse is the transfer of sediment and water from the landscape to an ultimate receiver such as a lake or ocean.

The channel system adjusts its form to match the sediment load and quantity of water generated off the landscape such that the channel can maintain its function. A disruption in the sediment yields or flow characteristics upsets this balance resulting in adjustment of the channel form. A change in land use, land use activity or direct alteration of the channel can cause a disruption in channel form resulting in instability and channel adjustment. The purpose of this component of the study is to examine the relationship between channel form and function and land use type and land use practices.

Many insects, fish and other wildlife also rely on the channel for their habitat. Consequently, bio-geomorphic linkages also form a key component of this study.

Form: Biophysical Characteristics

- Microscale features (scale of local fluctuations or perturbations in the flow field)
- Dunes and ripples
- Form roughness
- Particle size distribution of the bed and bank materials
- Bank stratigraphy
- Bed armour
- Imbricate structures
- Sediment transport characteristics
- Secondary currents and eddies
- Root zone depth, root density, and diameter
- Instantaneous and critical boundary shear stress at a point about the boundary.
- Mesoscale features (scale of the width of the active channel)
- Hydraulic geometry variables (bankfull depth, width, cross-sectional area, velocity, dominant discharge)
- Average boundary shear stress



- Coefficient for determination of the transverse distribution of average boundary shear stress based on channel shape
- Riffle lines (particle size distribution, key stone diameter),
- Large Organic Debris, debris jams.
- Macroscale features (scale of the width of the floodplain)
- Longitudinal channel slope
- Bar form type (transverse, longitudinal, medial, point), dimension (width, length) and composition (particle size distribution)
- Riffle-pool dimensions (length, width, depth, slope, particle size distribution)
- Meander geometry (wavelength, radius of curvature, amplitude)
- Belt width
- Chutes
- Islands,
- Cut off channels
- Reaches of "like" morphology
- Channel classification
- Coefficient for determination of the transverse distribution of average boundary shear stress based on flow geometry.

Function: Role As Part Of A Larger System

The primary functions include:

- Conveyance of flow and sediment generated from the landscape to an ultimate receiver or deposition zone
- Storage of sediment
- Conveyance of rare flood flow events
- Habitat for insects, fish and wildlife
- Water supply
- Aesthetic and recreational opportunities.

Linkage: Connection To Or Between Other Features

- Groundwater or subsurface flow exfiltration/infiltration
- Exfiltration zones also create cold-water areas and provide a sediment sorting function leading to the formation of gravel pockets and spawning habitat
- Land use and the prevailing sediment-flow regime
- Surficial geology and longitudinal gradient
- Surficial geology and boundary material resistance to scour

Introduction

A stable channel form is one in which the forces tending to dislodge the boundary materials is balanced by the resistance of these materials such that the channel is just able to move its sediment load. Lane (1955) describe the balance as a function of the form,

 $Q_{S} f_{50} \propto QS$,.....[3.1]

in which QS represents the sediment load, ϕ 50 is the mean particle size, Q is the dominant discharge and S represents the longitudinal gradient (slope) of the channel. Equation 3.1 indicates that an increase in flow (Q) or a decrease in channel gradient due to channel straightening, must be balanced by an increase in sediment load conveyed by the River or the median particle size of the sediment being transported. The reverse also holds, that is



an increase in sediment yield must be offset by an increase in the ability of the River to transport material. If the increase in sediment loading exceeds the transport capacity of the channel aggrading conditions will dominate. Similarly, if the ability of the channel to transport sediments exceeds supply, degradation will dominate. Both conditions represent an unstable channel condition.

The geomorphic assessment of the Carp River and its tributaries examines the relationship between the factors controlling channel form and the linkage between channel form and aquatic habitat. This is done through a review of existing reports, maps and aerial photographs and secondly through the assessment of data collected as part of the field component of this study.

Current State of the Channel and Causative Factors Identified in Previous Reports

MVC (1993) classified the stream banks into one of three categories: "natural" state (relatively untouched shoreline with good width of buffer strip); "altered" shoreline (natural vegetation has been removed, good stewardship of adjacent land, possibly some restoration occurring but not back to natural state); and, "degraded" (area in an unnatural state with other parameters having a negative effect on the river). These categories are illustrated in **Figure 3.7.2**. From this figure, it can be seen that "degraded" shorelines constitute the single largest category ("degraded" = 46% by length), while shorelines in a "natural" state comprise only 30.3 % of the total stream length. Channel banks considered to be in an "altered" state make the balance at 23.7% of the total stream length. Consequently, the length of channel in an "altered" or "degraded" state constitutes almost 70% of the total length of the main channel of the Carp River.

The report identifies re-establishment of a vegetative corridor along the Carp River as a "first" priority in restoring the Carp River. The benefits of such action were identified as: increased infiltration and a reduction in soil erosion, sedimentation and nutrient loading to the channel. The establishment of a riparian zone would have to address the issue of cattle access. The report also recommends the adoption of "Natural" channel design principles for application to all future channel restoration projects.

The above reports deal primarily with the linkage between riparian vegetation management and limitations to direct cattle access as the primary restoration measures. Tree planting programs and discussions with beef and dairy farmers regarding the control of cattle access to the channel have been initiated. However, MVC (1993), quoting Harris (1993) notes that other factors may also be contributing channel instability,

"With settlement came the clearing of forested areas for agriculture. Field tile drainage and ditches were installed for increased agricultural potential. Meanders were eliminated, channels made uniform, and structure removed to aid the rapid flow of water after a storm. Eventually, the Carp itself was 'ditched' in many areas, accounting for the arrow-straight nature of the much of the river today."

Referring to Eqn. (3.1), these impacts would have a dramatic affect on channel form. Harris (1993) also conjures an image of the River prior to clearing of the lands (beginning in 1837) as a channel, "...continually meandering through tight turns, featuring undercut banks, sandbars, pools riffles and backwater wetland areas."



In addition to the increase in runoff and sediment loadings associated with clearing of the land for agricultural, straightening and removal of woody vegetation, the increase in urban land areas (Glen Cairn (Kanata), Stittsville (Goulbourn), Carp, Kilburn and Fitzroy Harbour) may also have impacted channel form. Although this source of impact is not explicitly addressed in the above reports, Total Basin Imperviousness (TIMP) within the Carp River watershed is estimated to be between 4 and 5% at the confluence with the Ottawa River. However, the majority of urban development is located in Glen Cairn and Stittsville, which are located in the headwaters of the River system. Consequently, basin imperviousness increases as a percentage of the watershed from the River mouth to its headwaters upstream of Hazeldean Road as illustrated in **Figure 3.6.1**.

Recent studies have shown that channel systems are more sensitive to alteration in the sediment-flow regime than previously thought. Channel microscale features (sediment forms, riffle lines, etc.), which impact benthic macro-invertebrate community health, begin to adjust when Total Basin Imperviousness reaches 3 to 5%. Mesoscale parameters (channel width, depth and cross-sectional area) begin to adjust when Total Basin Imperviousness reaches 7 to 10%.

Referring to **Figure 3.6.1** it can be seen that urban development may have an impact on mesoscale channel form upstream of March Road. Urbanization may impact microscale features along the entire length of the main stem of the Carp River. These impacts would be superimposed on agricultural impacts. However, impacts from urban development may be the dominant cause of morphological adjustment in the River upstream of the Queensway and perhaps upstream of Richardson Side Road.

Findings From Technical Studies Completed To Date

With the exception of Aquafor Beech Ltd (1995), studies of channel morphology conducted to date have been qualitative and not suitable for the quantitative assessment of management programs. Further, the Aquafor Beech Ltd (1995) study is limited to Feedmill Creek upstream of Huntmar Road. In order to assist in the quantitative evaluation of management options a more rigorous description of the channel system is required. A field program is outlined below for synoptic and diagnostic geomorphic surveys.

In conjunction with the geomorphic surveys the assessment of the response of the channel to various management strategies will require the development of relationships between the factors controlling and modifying channel form and parameters characterizing channel form. The primary factors controlling and modifying channel form include the sediment-flow regime, valley gradient, boundary material characteristics and riparian vegetation type, density and distribution. Valley gradient and the nature of the boundary materials are determined by the surficial geology and physiography of the region. Soil characteristics and climate are critical variables in the determination of riparian vegetation. However, riparian vegetation is controlled to a large extent by anthropogenic factors. Similarly, the sediment-flow regime is related to surficial material characteristics as well as land use type and land use practices. In agricultural areas, the primary issues relating to channel form and function involve sediment delivery to the channel, riparian vegetation management practices and direct cattle access. Channel adjustment due to straightening and dredging is also a major issue.



Mitigative strategies will depend on the goals and objectives established for the main stem of the Carp River and its tributaries. Restoration of the main stem of the Carp River has been proposed by MVC (1993). The restoration measures focus on riparian vegetation planting programs and restriction of cattle access to the channel. However, the proposed remedial strategy does not address the overall stability of the channel and the primary mode of adjustment. The development of a mitigation plan requires prediction of the ultimate stable channel form under the existing sediment-flow regime. Secondly, the ultimate stable channel form must be predicted under future land use conditions (and the associated sediment-flow regime). These forms must be assessed relative to project goals and objectives in order to establish if the ultimate stable channel form is acceptable or if intervention is warranted. Mitigation strategies are then formulated involving the management of the sediment-flow regime and the application of instream measures. The resulting channel form is predicted and assessed relative to project goals and objectives is predicted and assessed relative to project goals and objectives. A preferred mitigation strategy is then selected and formulated into an implementation plan.

In the urban areas, including the main channel of the Carp River upstream of Richardson Side Road and Feedmill and Poole Creeks, the primary issues are the modification of the sediment-flow regime associated with urban land use and drainage practices and the channel response to instream works. As noted above the ultimate, stable channel form will be predicted under existing and future land use scenarios and assessed relative to project goals and objectives in order to establish the need for intervention. Various mitigation strategies will then be developed and the ultimate, stable channel form assessed relative to the project goals and objectives established for this reach of the River. The control of instream erosion potential associated with existing and proposed SWM facilities will be investigated to determine if retrofit opportunities exist. Instream measures will be outlined in conjunction with possible SWM measures. A preferred mitigation strategy will be selected and an implementation plan developed.

Watershed Component

Rationale

A cursory level assessment was conducted on the larger tributaries of the Carp River including Huntley, Corkery and Marathon Creeks. Feedmill and Poole Creeks are dealt with separately within the "Subwatershed Level Investigation" component of the study. The purpose of this aspect of the study is to assess the geomorphic attributes of the tributary channel system from a watershed perspective in order to identify opportunities and constraints for rehabilitation of the channel system. This undertaking required the development of an inventory of the existing state of the channel system. The basis for this inventory was a classification (**Figure 3.6.2**) taken from an MVC Report (1993) that shows existing streambank conditions along the main channel and NESS data that classified tributaries as natural, disturbed/altered or unclassed.

The original inventory was summarized in a map that was constructed from data derived through air photo interpretation. In rendering **Figure 3.6.2**, the channel was classified into "natural" altered and degraded categories. Of these categories the "degraded" " classification constituted the largest single grouping on both the main channel and the tributary systems. Concerning the tributaries the smaller systems showed greater disturbance than the larger channel systems. One of the primary steps in this investigation was focused on the field calibration of the aerial photography.



Methodology

Given the scale of the watershed and the number and length of the tributaries involved it was determined that a drive-by-survey would be conducted to collect biological and geomorphic data to field proof the aerial photographs. Two field crews were assigned to this task. The crews consisted of a fluvial geomorphologist, forester, biologists with fish and benthic macro invertebrate specializations, a subwatershed planner and geologic engineer. To help standardize data collection the two field crews worked together for Huntley and Corkery Creeks before separating to survey the smaller tributaries to the east. Furthermore, a field survey form (**Figure 3.6.3**) was developed to standardize the observations.

Field observation consisted of a combination of quantitative and qualitative measurements. Quantitative geomorphic data included measurement of the low-flow and bankfull channel widths and depths. Qualitative geomorphic data included estimates of the channel stability, mode-of-adjustment degree of entrenchment, bed material particle size, flow, longitudinal gradient, slope, plan form, land use, floodplain characteristics, and observations of general condition. Biological data was recorded qualitatively and included types of flora and fauna in the stream and in the riparian zone. Survey locations are indicated **Figure 3.6.2**. Oblique photographs were taken up and downstream of each station to provide visual record of the Site.

The field observations were used to interpret forms and features observed on the air photos in the known area of coverage of the survey site. This procedure provided a semiquantitative calibration of the aerial photographs. The remaining lengths of channel were then classified from the aerial photographs as "natural", "altered" or "degraded" to be consistent with the previous study.

Findings

A total of 18 road crossings were surveyed up and downstream of the channel crossing providing 36 sets of observations. Eight of the 18 sites were located on Huntley and Corkery Creeks. These two creeks are the largest tributaries to the Carp River outside of the Subwatershed study area. They also appear to offer the greatest potential for rehabilitation. The results of the field survey are summarized in **Table 3.6.1**.

In **Table 3.6.1** hollow circles characterize low or no impact; half solid circles indicate moderate impact; and, solid circles represent high impact. Based on the findings summarized in **Table 3.6.1**, a total of 29 of 36 sites or 80% were classified as impacted. This compares to 70% of the total length of the main channel that is designated as impacted according to the MVC (1993) study.

Channel incision, aggradation, straightening and widening were commonly observed morphological impacts. Aggradation was observed at 83% of the sites, channel incision (disconnection from the floodplain) was noted at 61% of the sites while channel straightening was reported at 53% of the sites. These morphological impacts could be attributed to a number of causative factors. Those factors examined here included channelization (straightening, dredging, widening), riparian vegetation management strategies (removal of woody species from the riparian zone and loss of vegetative buffer), livestock access, agricultural (horticultural) practices, and urbanization and transportation corridor impacts. Of these factors horticultural practices resulting in elevated sediment yield to the channel was considered to be a significant factor in 89% of the survey locations. This compares with 58.3% for channelization, 50% for riparian vegetation management, 17% for cattle access and less than 10% for urban and transportation corridors.

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Oite	Channel	Morphologic	Otability .		Mo	de of		Floodplain	Oissussitu		Hydraulic	Geometry	/	Dry	Bed	01	Rij	parian			Causativ	e Factors		
Site	Туре	Class	Stability	AF		stment WF	PF	/ (Width)	Sinuosity	Surf	lath (m) Bfl	Deptn (Surf	m) Bfl	Flow	Sediment	Siope	Veg Woodv	Herbaceous	*Channelized	**RVM	Livestock	Aariculture	Urban	Transportation
HUN01- u/s	AL	MPR	?	?		?		? (W)	н	3-3.5	5.5-6	0.1-	1.0	?	Si (Co)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?		?		? (M)	н	2-2.5	6	0.1-	#1.0	?	Si (Co)	L	?	?	?	?	?	?	?	?
HUN05-	AL	MPR	?	?				? (W)	М	5.8	13	.52	.7	?	Si (Co)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (M)	Н	7.2	10	.55	.7	?	Si (Co)	L	?	?	?	?	?	?	?	?
HUN02- u/s	AL	MPR	?	?		?		? (M)	L	8.4	>8.4	>0.6	n/a	?	Si (Co)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?					? (M)	М	5.2	6.2	0.15	0.7	?	Co (Si)	М	?	?	?	?	?	?	?	?
HUN03- u/s	AL	MPR	?	?				? (M)	М	3-5	10-30	0.35- .4	n/a	?	Co (Si)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (N)	М	2.14	12.5	0.2	0.45	?	Co (Si)	L	?	?	?	?	?	?	?	?
HUN06- u/s	RB	MPR	?					? (M)	L	4.6	6	0.2	0.42	?	Bedrock	М	?	?	?	?	?	?	?	?
-d/s	RB	MPR	?					? (M)	L	3.1	9.2	0.13	0.52	?	Bedrock	L	?	?	?	?	?	?	?	?
COR01 - u/s	AL	ANA	?					? (W)	н	n/a	n/a	n/a	n/a	?	Muck	L	?	?	?	?	?	?	?	?
-d/s	AL	ANA	?					? (W)	Н	n/a	n/a	n/a	n/a	?	Muck	L	?	?	?	?	?	?	?	?
COR02 - u/s	AL	MPR	?	?				? (M)	L	2.6	7.1	0.26	0.56	?	Co (Bo)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (M)	L	2.4	3.4	0.12	0.28	?	SaGr (Co)	М	?	?	?	?	?	?	?	?
COR03 - u/s	AL	MPR	?	?				? (M)	н	7.8	9.3	0.82	1.27	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (M)	Н	6	8	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
MAR - u/s	AL	MPR	?	?		?		? (N)	М	1.88	6.58	0.09	0.92	?	CI	М	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (N)	М	1.5	6.4	0.08	0.9	?	Cl (Gr)	М	?	?	?	?	?	?	?	?
u/s	AL	ANA	?	?				? (M)	L	1.6	n/a	0.1	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	ANA	?	?				? (W)	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
CM2 - u/s	AL	ANA	?	?				? (W)	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (W)	М	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
BG1 - u/s	AL	MPR	?	?		?		? (M)	Н	1	2	0.1	0.3	?	Si	М	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (M)	Н	n/a	n/a	n/a	n/a	?	Si	М	?	?	?	?	?	?	?	?
u/s	AL	ANA	?	?				? (M)	L	2	n/a	4	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (W)	Н	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
BG4 - u/s	AL	MPR	?	?				? (N)	L	0.4	n/a	0.07	n/a	?	Si Cl (Co)	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (N)	L	n/a	n/a	n/a	n/a	?	Si Cl (Co)	L	?	?	?	?	?	?	?	?
u/s	AL	ANA	?	?				? (N)	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	ANA	?	?				? (N)	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
u/s	AL	MPR	?	?				? (W)	L	n/a	n/a	n/a	n/a	?	n/a	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? (N)	L	n/a	n/a	n/a	n/a	?	n/a	L	?	?	?	?	?	?	?	?
BG7 - u/s	AL	MPR	?	?				? (M)	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				n/a	L	n/a	n/a	n/a	n/a	?	Si Cl	L	?	?	?	n/a	?	?	?	?
u/s	AL	MPR	?	?				? n/a	L	0.5	n/a	0.05	n/a	?	Si	L	?	?	?	?	?	?	?	?
-d/s	AL	MPR	?	?				? n/a	L	0.34	n/a	n/a	n/a	?	Si	L	?	?	?	?	?	?	?	?
			Symbol		Stability	у	Mode Adjustr	of Flood	plain ctivity F	Dry -low	Ve	Riparia	n Jensitv		Causative	Effect			Influences					

Symbol	Stability	Mode of Adjustment	Floodplain Connectivity	Dry Flow	Ripa Vegetatio	Kiparian Vegetation Density				Influences					
					Woody	Woody Herbaceous C		RVM	Livestock	Agriculture	Urban	Transportation			
?	Stable		Connected	Flowing	High	High	No	None	Not Present	None	None	None			
?					Moderate	Moderate		Moderate		Moderate	Moderate	Moderate			
?	Unstable	Present	Incised	No Flow	Low	Low	Yes	High	Present	High	High	High			

Channel Type	Morphologic Class	Mode of Adjustment	Floodplain Connectivity and Width	Sinuosity	Bed S	ediment	Slope
AL – Alluvial	MPR – Meander Pool Riffle	AF – Aggradation	(W) – Wide - Wflp>20 WBfl	H – High	Cl – Clay	Si – Silt	H–High ->1.2%
RB – Rock Bed	ANA – Anastomosing	DF – Degradation	(M) – Moderate - 2#Wflp#20	M – Moderate	Sa – Sand	Gr – Gravel	M – Moderate - 0.2 – 1.2%
		WF – Widening	(N) – Narrow - Wflp∃2Wbfl	L – Low	Co – Cobble	Bo - Boulder	L – Low - < 0.2%
		PF – Planform Change					

** RVM – Riparian Vegetation Management includes cutting, clearing, mowing and allowing any activity that impedes natural vegetation growth

able 3.6.1 – Watershed Level Geomorphic Inventory



Figure 3.6.4 (Photo) at HUN06 and **Figure 3.6.5** (Photo) at COR03 is an example of adjacent landowners who have channelized the creek and removed riparian vegetation by mowing up to the edge of the stream. **Figure 3.6.6** (Photo) at HUN02 shows an over widened channel as a result of dredging. Although livestock access was noted in only 17% of the sites visited, they appear to have a significant impact on erosion and sedimentation. **Figure 3.6.7** (Photo) at HUN01 looking upstream past the fence shows eroded banks associated with cattle access. Similar, **Figure 3.6.8** (Photo) at BG4 provides an example of bank erosion and disturbance of the channel bed causing increased sedimentation due to cattle access. In both cases riparian vegetation is very limited by cattle grazing and bank erosion.

Other factors also contributed to channel instability. At site MAR (Marathon Tributary) evidence of extensive bank failure was observed from approximately 100 m upstream of the intersection with Donald B. Munro and John Shaw Road to the Creek crossing at Thomas A. Dolan Parkway. The instability is believed to be associated with the failure of a debris or ice jam in association with a high flow event (extreme thunderstorm or spring freshet). Evidence of bank oversteepening, undercutting and the exposure of many tree roots are depicted in **Figure 3.6.9** (Photo). **Figure 3.6.10** (Photo) shows evidence of cut lines on the banks associated with impounded water. Visual observation, upstream of Thomas A. Dolan Parkway noted the presence of a large amount of debris in contrast to the low incidence of woody debris in the downstream reach. Similarly, the channel upstream of Thomas A. Dolan Parkway was enlarged and showed evidence of geomorphic stress while the channel downstream channel consisted of a stable, narrow and sinuous channel.

In general the revised maps of channel state agreed with the original MVC (1993) mapping with some sections being downgraded from natural to disturbed. This occurred mainly in the larger tributaries of Corkery and Huntley Creeks involving small sections of channelization (**Figure 3.6.4** and **3.6.5**), and cattle access impacts (**Figure 3.6.7** and **3.6.8**). The section at COR03 was reclassified by visual observation and reviewing the aerial photography, which indicated the cattle impacts further downstream and upstream of the survey site.

The potential impact from urban land use (rural subdivisions) and transportation corridors was limited primarily to Huntley and Corkery Creeks. Rural villages and country lot estate developments constitute a small portion of the predominantly agricultural or wooded land uses within the watershed. Consequently, morphological impacts associated with urban land use are restricted primarily Feedmill and Poole Creeks within the subwatershed area.

Mitigative Strategies

Once the causative factors have been identified the next step is to quantify the magnitude of the morphological impacts and develop appropriate mitigative strategies. The quantification of the morphological impacts will be addressed in the next phase of this study. However, it is possible to examine mitigative strategies in at a broad-brush level at this time.

Mitigative measures may be divided into:

Watershed or "Production Zone" based controls that focus on management of the sedimentflow regime, e.g. the reduction of sediment loadings to the receiving channel.

Instream controls that may be carried out at the:

- Site Level;
- Reach Level;



- Multiple Reach Level; or,
- Watershed Level.

Controls in the "Production Zone" typically involve Hazard Land, Stormwater Management and Top Soil management measures. Although specific measures may differ between agricultural, forest and urban land use types, the general concepts and goals are consistent from one land use type to another. The goal typically being to control flow and sediment yield from the landscape to minimize deleterious impacts on the morphological features characterizing the receiving channel or to restore-rehabilitate the channel system.

Within agricultural landscapes, flow rate, volume and sediment yield increase over forested conditions. For example, flow volume may double or triple while sediment yield increases by 20 times forested levels. Although both sediment and flow yields increase, the substantially greater increase in sediment yield may result in a net depositional environment. This is particularly true in the lower gradient reaches in the valley bottomlands as indicated by sediment cores taken in Feedmill and Poole Creeks as part of the "Subwatershed Level Investigations". Consequently, the focus of management measures in agricultural areas is on the reduction of sediment production and delivery to the receiving channel.

In the urban landscape sediment yields decline from agricultural conditions to within a factor of 3 of yields representing forested conditions. This estimate excludes the active construction phase where sediment yield may exceed 66 times forested levels for short periods assuming "Top Soil" controls are not implemented. In contrast peak flow rate and runoff volumes increase significantly after stabilization of the urban surface. The increase in runoff rates and volumes is non-linear with rates increasing by 20 times agricultural rates for the 1:0.5 year event 3.5 times for the 1:2 year event and 1.2 times for the 1:100 year event. Runoff volumes increase in a similar manner with the 1:2 year event increasing by 3 to 4 times the predevelopment level. The results are an erosion-dominated environment. As such, the focus of management measures in urban landscapes is on flow rate and volume control.

The development and assessment of control measures within urban environments is dealt with in the "Subwatershed Level Investigations". Given the significance of agricultural impacts at the watershed level it is appropriate that these controls be discussed here. It should be noted however, that at this stage of the investigations and in keeping with a watershed level study, the discussion on management strategies is at a general level.

Tables 3.6.2 and **3.6.3** provide a list of generic mitigation strategies and how they may apply to the tributaries of the Carp River as represented by the interpretation of findings from the field survey. **Table 3.6.2** deals with watershed wide or "Production Zone" measures while **Table 3.6.3** is focused on probable Site Level through Watershed Level instream measures.

For each reach assessed the range of mitigation strategies is narrowed to include several alternatives that would be appropriate based on more detailed assessment and consideration of landowner needs. Within each broad category, there may be several different mitigation measures that could successfully address the problem, either at a site scale or at a reach or larger scale. In some cases, for example HUN06 and COR01, the assessed sites did not require specific mitigative measures. The category "Restore Riparian Zone" refers to replanting the riparian zone with native shrub and tree species to restore riparian functions. The category "Restore Vegetated Buffer Zone" refers to planting a continuous cover crop, such as hay, that would perform some of the functions of a natural riparian zone.

Table 3.6.2 – Prescription of Mitigative Measures – Watershed Wide or "Production Zone Measures"

Reserving Reserving infiltration Description Description Mading mem Modify magement Reserving magement Procession Proc	Site		Stormwater Management			Sedim	ent Management	
At Site -ramspiration At Site -rait larversing -rind informance Find of Pripe -ronds -resultance Stripe Disc. Inter HUN01-uis -rand informance -rand informance		Retention Based Controls e.g. source controls -infiltration	De	tention Based Controls	Modify Crop Management	Modify Tillage Practices	Closure of Sediment Pathways e.g. Maintained Vegetated Buffer	
-transpiration -initial transpiration -ponds -initial transpiration -ponds -init		-evaporation	At Site	End of Pipe			Strips	Disco
- - - - Internationage -		-transpiration	- rain harvesting	- ponds				
Image Image <th< td=""><td></td><td></td><td>- filtration basins</td><td>- wetlands</td><td></td><td></td><td></td><td>Interr</td></th<>			- filtration basins	- wetlands				Interr
non-oss - d/s \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet HUN02-us \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet HUN02-us \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet \bullet \bullet d/s \bullet \bullet \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet \bullet \bullet \bullet \bullet \bullet \bullet \bullet HUN05-us \bullet d/s \bullet \bullet \bullet \bullet \bullet \bullet <td></td> <td></td> <td>- rural drainage</td> <td></td> <td></td> <td></td> <td>•</td> <td></td>			- rural drainage				•	
HUNG-ds \bullet \bullet \bullet \bullet -ds \bullet \bullet \bullet \bullet \bullet \bullet -ds \bullet \bullet \bullet \bullet \bullet \bullet -ds \bullet \bullet \bullet \bullet \bullet \bullet \bullet -ds \bullet \bullet \bullet \bullet \bullet \bullet \bullet -ds \bullet \bullet \bullet \bullet \bullet \bullet \bullet \bullet <td>HUN01-u/s</td> <td></td> <td>•</td> <td></td> <td></td> <td></td> <td>•</td> <td></td>	HUN01-u/s		•				•	
MCMON $MCMONMCM$	-u/s HUN05-u/s		•				•	
HUN02-uš • • • -ds • • • HUN03-uš • • • -ds • • • HUN05-uš • • • -ds • • • • • -ds • <td< td=""><td>-d/s</td><td></td><td>•</td><td></td><td></td><td></td><td>•</td><td></td></td<>	-d/s		•				•	
dis \bullet \bullet \bullet \bullet HUN03-u's \bullet \bullet \bullet \bullet \bullet dis \bullet \bullet \bullet \bullet \bullet \bullet dis \bullet \bullet \bullet \bullet \bullet \bullet dis \bullet \bullet \bullet \bullet \bullet \bullet dis <td>HUN02-u/s</td> <td></td> <td>•</td> <td></td> <td></td> <td></td> <td>•</td> <td></td>	HUN02-u/s		•				•	
HUN03-u/s • • • • • ·	-d/s		•					
-dís •	HUN03-u/s		•				•	
HUNGeuis Image: Constraint of the second secon	-d/s		•				•	
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Table 3.6.3 – Prescription of Mitigative Measures – Instream Measures and "Naturalize Channel"

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Since elevated sediment yields represent the primary causative factor impacting the morphology of tributaries within the Carp River systems, it follows that an essential component of any mitigative strategy would be the management of sediment from the "Production Zone" (**Table 3.6.2**). This objective encompasses aspects of Stormwater Management, Sediment Management and Hazard Land Management. Stormwater Management in agricultural areas is concerned with the management of surface drainage off cultivated fields in a manner that minimizes entrainment and transport of soil particles. It also deals with the balance between the detention of surface drainage for irrigation and livestock watering and the construction of extensive tile drainage systems and agricultural ditches implemented to increase the amount of arable land. Fortunately, discharge from tile drainage networks is typically at a rate that does not significantly impact channel morphology.

Sediment Management practices for the reduction in sediment yield are well established and documented in the literature. Various techniques focus on the "Modification of Crop Management" and "Tillage Practices" along with the "Closure of Sediment Pathways" to the receiving channel (**Table 3.6.2**). "Hazard Land Management" refers to discontinuation of tillage or grazing in intermittent swales and steep gradient areas where the potential for erosion and delivery of soil to the receiving channel is high.

The above measures are "Production Zone" oriented. Instream measures may also be used to stabilize the channel and reduce sediment loadings ("Instream Measures – Natural Channel Design", **Table 3.6.3**). This management scheme applies to:

"Site Level"; "Reach Level" control measures; "Multiple Reach Level"; and, "Watershed Level" measures.

The type of control measure is selected based on the spatial scale of the causative factors. For example, "Site Level" measures involve the stabilization of specific features such as knick points, scour holes at bridge piers, culverts or storm sewer outlets or bank erosion at floodplain-active channel contact points where infrastructure, homes or business are a risk. These measures typically apply over short lengths of channel, one to several channel widths, because the causative factors are limited in aerial extent. "Reach Level" controls apply over one to several meander wavelengths. Typical "Reach Level" measures include reconstitution of a meander-pool-riffle form in a previously meandering channel system that has been straightened due to channelization.

The removal of weirs, dams or drop structures is an example of a multiple reach stabilizationrestoration measures involving stabilization-rehabilitation of the reaches upstream and downstream of the structure.

Stabilization-rehabilitation measures implemented on a system wide basis due to watershed scale alteration of land use, e.g. forest to agriculture or agriculture to urban, are examples of "Watershed Level" programs. These programs may also include the programs identified at the previous levels. The difference between the approach applied to the "Site Level", "Reach Level" or "Multiple-Reach Level" programs and the "Watershed Level" programs is the incorporation of changes in the causative factors controlling channel form at the scale of the watershed and the coordination of these changes into a comprehensive management plan.



Subwatershed Level Investigations

The primary objective of this task is to characterize the existing condition of two tributaries, which may impact by development; namely Poole Creek and Feedmill Creek. This information will be used as a basis to define existing baseline conditions. The information will also be fed into the QUALHYMO computer model in order to predict stream conditions for future land use conditions using a number of different stormwater management measures, which will protect, enhance or restore the tributaries. A summary of the field program is provided below. Details of the program are provided in **Appendix B**.

Diagnostic level geomorphic surveys were conducted at selected locations on Poole and Feedmill Creeks (**Figure 3.6.11** Subwatershed Geomorphic survey locations) to collect data for the:

- Assessment of channel type, stability, mode-of-adjustment;
- Characterization of boundary material sensitivity to scour; and,
- Determine the cross-section and plan form dimensions of the channel.

These data were subsequently used to develop regime relationships between various measures of channel form (width, depth, area, etc.,) and the dominant discharge. These data and associated relationships are pertinent to the assessment of the impacts of development and the performance of Stormwater Management (SWM) measures put forward to reduce or minimize morphological impacts to the receiving channel. The diagnostic surveys resulted in Poole Creek and Feedmill Creek being divided into reaches of like morphology, flow, land use, vegetation, channel gradient, boundary material composition and physiography.

Poole Creek was divided into 8 'like' reaches while Feedmill was divided into 5 reaches.

Three of the reaches within Poole Creek and one within Feedmill were assessed further to determine the stability of the channel and mode of adjustment. The RGA (rapid geomorphic assessment) protocol involves the determination of a Stability Index (SI) value using a semi-quantitative assessment of four Factors (**Table 3.6.4**). The Factors are Evidence of Aggradation (AF), Evidence of Degradation (DF), Evidence of Widening (WF) and Evidence of Plan Form Adjustment (PF). Each Factor is characterized using between 7 and 10 indices for which a "present" (Value =1), "absent" (Value=1) or "not applicable" (Value=0) response is assigned. The responses are summed and the total number of "present" responses is divided by the sum of the number of "present" and "absent" responses to arrive at a Stability Index value ranging from 0.0≤SI≤1.0. The basis for interpretation of the SI values is provided in **Table 3.6.5**.



					RGA Re	sults		St	ream Power C	riteria
SECNO	TYPE	AF	FAC DF	TORS WF	PF	SI Value	Stability Class	Specific Stream Power (Watts/m ²)	Channel Form	Satisfaction of Meander-Pool- Riffle Energy- Form Criteria
POL01-1	RB	0	0.5	0.5	0.14	0.29	Stable	34.5	Meander- pool-riffle	Satisfies Criteria
POL01-2	RB(Ar)							14.2	Meander- pool-riffle	Satisfies Criteria
POL02-1	AL(Ar)	0.25	0.8	1	0.5	0.64	In-Adjustment	28.5	Meander- pool-riffle	Satisfies Criteria
POL02-2	AL(Ar)							53.3	Cascade- pool	Violates Criteria
POL02-3	AL(Ar)							20.3	Meander- pool-riffle	Satisfies Criteria
POL02-4	AL(Ar)							10.7	Meander- pool-riffle	Satisfies Criteria
POL03-1	AL							24.5	Meander- pool-riffle	Satisfies Criteria
POL03-2	AL	0.6	0.5	0.8	0.29	0.55	In-Adjustment	5.4	Meander- pool-riffle	Satisfies Criteria
POL03-4	AL							3.7	Meander- pool-riffle	Satisfies Criteria
POL03-5	AL							19.0	Meander- pool-riffle	Satisfies Criteria

Table 3.6.4 Summary of Stability Analysis

Table 3.6.5Interpretation of RGA Score Values

SI Value	Classification	Description
S⊵0.24	Stable	The value for parameters characterizing channel hydraulic and plan form geometry and the rate of change in these parameters are within one standard deviation of the mean value representing a similar "stable" channel system.
0.24 <sl⊴0.4< td=""><td>Unstable and In Transition</td><td>The value for parameters characterizing channel hydraulic and plan form geometry are within one standard deviation of the mean value representing a similar "stable" channel system. However, there is evidence of excessive stress and the rate of change in these parameters may exceed that anticipated for a "stable" channel system.</td></sl⊴0.4<>	Unstable and In Transition	The value for parameters characterizing channel hydraulic and plan form geometry are within one standard deviation of the mean value representing a similar "stable" channel system. However, there is evidence of excessive stress and the rate of change in these parameters may exceed that anticipated for a "stable" channel system.
0.4 <sl≤1.0< td=""><td>Unstable and In Adjustment</td><td>The value for one or more of the parameters characterizing channel hydraulic and plan form geometry and the rate of change in these parameters exceeds one standard deviation of the mean value representing a similar "stable" channel system.</td></sl≤1.0<>	Unstable and In Adjustment	The value for one or more of the parameters characterizing channel hydraulic and plan form geometry and the rate of change in these parameters exceeds one standard deviation of the mean value representing a similar "stable" channel system.

The implications of the RGA assessment on Poole Creek, particularly with respect to stormwater management measures that may be implemented is that:

A) The channel does not have the capacity to absorb any increase in instream erosion potential. The channel through Reach RCH-02 is more robust and may be able to accept some increase in instream erosion potential, however, SWM criteria must be developed to ensure that the Reaches most susceptible to erosion are duly protected. This approach follows the "weak link in the armour" concept; and,



B) RCH-07 Segment POL02 is unstable and will likely adjust its plan form despite previous attempts to stabilize the channel.

The reach within Feedmill Creek, which was assessed (see **Table 3.6.6**), was also found to be unstable in transition. The results suggest that an increase in sediment loading to the channel has produced an aggrading environment that has resulted in channel widening and plan form adjustment.

		R	GA Fact	ors		Brookes (1992) Criteria						
Channel Segment- Site	AF	DF	WF	PF	SI Value	Specific Stream Power (Watts/m ²)	Channel Type	Stability Class				
FED01-1				0.42		65.79	Cascade-pool	Unstable				
FED01-2	0.4	0.2	1.0		0.42	0.04	Anastomosing	Unstable				
FED01-3	0.4	0.2	1.0	0.43	0.43	7.13	Meander-pool-rifle	Stable				
FED01-4						0.30	Anastomosing	Unstable				
SECNO1	NI/A	NI/A	NI/A	NI/A	NI/A	16.48	Meander-pool-riffle	Stable				
SECNO2	IN/A	IN/A	IN/A	IN/A	IN/A	7.63	Meander-pool-riffle	Stable				

Table 3.6.6Results From the Rapid Geomorphic Assessment: Feedmill Creek

Dominant Discharges

Estimates of the dominant discharge (the discharge that has the most influence on the stream) were made using geomorphic-biotic indicators as well as regime relations developed for non-urban streams. The dominant discharge values are used as a basis to define hydraulic geometry parameters and channel cross sectional area flow relationships. This data, in turn, is used to assess stormwater management measures for the control of instream erosion potential and for design purposes in channel restoration approaches. Details are provided in **Appendix E**.

Erosion and Morphology Synthesis

The findings suggest that the channel through the lower part of Poole Creek is in an aggrading state and is declining in system energy. A further decline in energy may result in the transformation of a meander-pool-riffle form to an anastomosing morphology. Anastomosing systems are typically composed of multiple, interlacing channels producing a network or braided pattern. The channels either lack the competence¹ or capacity² to move the sediment load. If the sediments are near but within the competence of the channel but exceed conveyance capacity the result is a channel pattern that shifts with each major flow event. A further reduction in energy within the channel system results in a riverine wetland environment.

¹ Competence refers to the largest particle the stream can transport.

² Capacity refers to the total mass of sediment of all particle size fractions that the stream can transport.



The transition from meander-pool-riffle to anastomosing to riverine wetland has occurred in the main Carp River through the Subwatershed study area. This transition is believed to be associated with the accumulation of sediments in the floodplain and channel associated with sediments derived from erosion of agricultural lands. At the time of the field investigation a hand held auger with a 1.35 m extension failed to penetrate the alluvial deposits to the underlying intact clay till. This was observed at both the Feedmill and Poole Creek sites within the Clay Till Plain physiographic region adjoining the Carp River. As part of the rehabilitation program, it is necessary that the potential transformation of the lower portion of Poole Creek be addressed. The first option is to allow Poole Creek to evolve into an anastomosing channel system and subsequently a riverine wetland. The second option is to maintain the channel in its meander-pool-riffle form. In the later case the energyform characteristics for the channel cannot be allowed to approach the transition zone between anastomosing and meander-pool-riffle systems. This may be achieved by either a decrease in sediment loading to the channel system or an increase in channel competence and capacity within well-defined limits. Since both the Feedmill and Poole Creek systems are relatively sediment starved, the management strategy should focus on the increase in sediment transport characteristics. The increase in flow energy must not cause the channel to shift into a degradational mode.

Given the apparent build up of sediments in the downstream segments of Feedmill and Poole Creeks it is likely that these systems have and will continue to evolve toward a lower energy form such as an anastomosing channel system. As the energy environment declines the channel will have a tendency to straighten. Given that the existing channel has a highly sinuous plan form pattern, straightening of the channel will likely result in cut-off channels at meander bends. The meander bends may eventually from oxbow lakes or wetland areas providing habitat opportunities for a variety of species.

While the presence of an aggrading environment seems likely based on the above findings these results should be confirmed through placement of erosion pins or an equivalent monitoring program for both Feedmill and Poole Creeks. Another option is to tie the surveys to a benchmark and resurvey the same reach periodically. By overlaying the cross-sections it is possible to determine the change in cross-section parameters. Similarly, an overlay of the channel plan form allows for the assessment of the change in plan form features.

Another unknown at this time is the effect of further development on fluvial processes within the two watersheds. Urban development has a tendency to increase runoff yield as well as peak flow rates. Stormwater Management measures have proven to be effective at controlling flow rate, however, the control over runoff yield has been a more difficult challenge. In fluvial systems composed of fine-grained boundary materials the threshold for movement of loose sediments is relatively low. The increase in runoff duration associated with the truncation of stormwater runoff events, even at relatively low rates may be more important then previously thought. Similarly, the small but very frequent runoff events may also be more important for channels formed in fine-grained materials then previously considered.

The impact from alteration of the sediment regime is also an unknown at this time. Both Feedmill and Poole Creeks have a history of agricultural land use and relatively high loadings of fine-grained material to the channel. Urban development and stormwater management ponds have a tendency to reduce sediment yield to near forested conditions. The reduction in sediment yield coupled with an increase in runoff energy may result in a net degraded environment. These issues will be addressed in the recommended plan.



3.7 Terrestrial and Aquatic Resources

The landscape of the Carp River Watershed is a mosaic of landforms, plant and animal communities (forests, wetlands, waterbodies) and human settlement patterns which together serve to characterize the watershed. The plant and animal communities which once dominated the landscape now represent a much smaller proportion of the watershed. Where deciduous and coniferous forests and wetlands were once the most extensive vegetation community, these communities are now among the least represented in the watershed. Wetlands and grasslands/old field communities are now the dominant natural community type. While these changes have affected the abundance, type and distribution of plant and animal communities in the watershed, the remaining communities are still capable of serving some of the functions they once did, including supporting some very unique habitats and species.

In addition to supporting these natural ecosystem functions, these resources are vital to the human quality of life as well. Obvious benefits include recreation, nature interpretation and economics (e.g. forest products), however these systems also enhance groundwater recharge, create cool microclimates (for coldwater streams) and improve water quality.

The description of the plant and animal communities in the watershed typically focuses on two areas:

- aquatic communities particularly fish (streams and lakes), and
- terrestrial communities, particularly vegetation communities (forests, grasslands, wetlands).

The following sections describe the plant and animal communities of the watershed under these headings.

3.7.1 Aquatic Communities

Form:

- fish species lists and distribution
- benthic invertebrate species lists and distribution
- Biological Indices ranks of stream condition based on species ecology
- Aquatic Habitats flows, in-stream habitat, water quality, streamside vegetation indicator/target species/communities

Function/Linkage:

- Cold and cool water communities indicate tributaries with good baseflow (groundwater discharge), extensive streamside woody vegetation (riparian zone), stable flow and sediment regime, good water quality.
- Trout spawning sites indicate groundwater discharge (upwellings).
- Abundance of floodplain spawners, eg. northern pike reflect the interconnection (or lack thereof) of the floodplain with its channel
- Benthic invertebrates reflect local water quality conditions and indicate relative water quality and pollution concerns: lack of dissolved oxygen, nutrient enrichment, contamination by trace metals/synthetic organic components.
- Fish and benthic invertebrates indicate different temperature regimes (cold, cool, warm water) and flow conditions (intermittent, permanent, unstable or flashy, stable or dampened).



- Introduced fish species and presence of diseased fish indicate water quality and habitat degradation.
- Changes in fish/benthic invertebrate communities and aquatic habitats of stream reaches reflect changes in land use/land use practices within floodplains (stream alteration, vegetation changes) and on tablelands (forest, agriculture, urban) upstream of the reach.
- In-stream habitats (substrate types, cover, aquatic vegetation, large wood debris) reflect changes in the stream's morphology and stream bank condition (vegetation, erosion). Poor habitat indicates unstable morphology and streambanks.

The diversity and abundance of fish and aquatic invertebrates (aquatic insects, worms, clams and snails), and the habitats upon which they depend have long been recognized as "indicators" of conditions within the watershed through which the stream flows. Biological Indices, which are methods of ranking the condition of a stream based on its biological community, are also used to separate healthy streams from streams, which have been negatively affected, by land use changes and sources of contamination.

Aquatic habitats generally can be described according to the following components:

- Flow, particularly baseflow or lack of low;
- Water quality, including temperature and dissolved oxygen;
- In-stream habitats: substrates (boulders, cobbles, gravel, sands, etc.), in-stream cover (large woody debris, overhanging streambanks, boulders), aquatic plants, pool/riffle sequences, width/depth; and
- Riparian vegetation: extent and type of streamside vegetation.

Different aquatic communities have differing habitat preferences, which influence their abundance and distribution. When these habitats change as a result of activities such as channel and floodplain alterations, streambank vegetation clearing or water quality degradation, corresponding changes in the abundance and distribution of aquatic communities results. This change may be subtle (i.e., a change in the abundance of some species of a community type) or substantial (i.e., the disappearance of a species or replacement of one community type with another).

Communities

Background: A comprehensive inventory of fish communities at 9 stations, including 6 river locations and 3 tributaries, was completed in 1975 (MNR, 1975). A total of 23 species were found within the main river segments and major tributaries. More selective surveys have been completed since then as follows:

- MNR (1993) sampled 6 stations including two tributaries.
- TCPL (1992) sampled three tributaries along the gas right of way
- Dillon et. al (2000) sampled four locations, tributary to the Carp River for the Terry Fox Drive Class EA
- MMM et. al. (2000) sampled four locations in upper Poole Creek for the Upper Poole Subwatershed Study
- Ecotek (2000) sampled Poole Creek and Carp River at Hazeldean Road as well as two small drainage features

Results of these studies are presented in Table 3.7.1.

Table 3.7	. 1
Fish Capture Records	(various sources)

			MNR o	data (19	975)	75)						TCPL data (1992				MMM Data (2000)			
						ые	ır	eve											
	Carp at Fitzroy	Carp at Galetta	Carp at Kinburn	Carp at Craig	Carp at Carp	Carp at Maple Gro	Huntley at Huntma	Poole at Maple Gr	Poole at Abbott		Corkery Creek	Carp Trib	Huntley Creek		Poole Stn 1	Poole Stn 2	Poole Stn3	Poole Stn 4	
	2	3	4	5	6	7	8	9	10										
Creek Chub					1			1	3				3		р	р	р	р	
Golden Shiner			98	8	8											- 1			
Common Shiner			22	3	140		7	6	1		2	1	5		?				
Blackchin Shiner			8	3				-			_								
Blacknose Shiner			5	1							4								
Mimic Shiner			3	10	5						•								
Bluntnose Minnow			14	5	200		4					2			n	n	n	n	
Eathead Minnow			14		200				1		٩	6			р р	P n	P D	P D	
Rosvface Shiner		25													P	P	P	Р	
Redhelly Dace		25						9			3		2		n	n	n	n	
Longnose Dace	5							3			5		2		2 2	P	P	Ρ	
Common Carp	0					*									•				
Goldfish																	n		
Einsocalo Daco															2		P		
Podeido Dace															2				
Reuside Dace															: 2				
Emorald Shipar	-														p s	n		p	
Ellielaiu Sililiel Blocknoso Doco	-														р 2	Ρ		ρ	
Mathita Suckar	-				00						Б	2	2		؛ ۲		n	5	
Nille Sucker	-				00		1				5	3	2		Ρ		Ρ	ρ	
Rednorse Sucker spp	0			04	*		1	*							2				
ROCK Bass	2		32	21			13								?				
Bluegili	-		-	+	+		-	+									р	р	
Pumpkinseed			/			1	1									р	р	р	
Smallmouth Bass	4		2?																
Brown Bullhead								1											
Logperch	-		3	~	8											р			
Rainbow Darter																	р		
Fantal Darter						*												р	
Johnny Darter	11				4	^	3	3								р	р	р	
Tesselated Darter	2																		
Banded killifish															?				
Northern Hogsucker	-										_							р	
Central Mudminnow						1		*	11		3				р	р	р	р	
Brown Trout															?				
Mottled Sculpin																р	р	р	
Slimy Sculpin																	р		
Yellow Perch		*																	
Yellow Walleye	*	*																	
Northern Pike		*						*							?				
Brook Stickleback						*			4		8	1			р	р	р	р	

p - present
? - recorded in previous MMM study
* - recorded in Ecotek (2000) or MNR (1993) studies



Fifteen additional species were captured in these studies, bringing the total species for the Carp watershed to 38 species. The majority of these were captured in the upper Poole Creek. It is reasonable to expect that walleye and several species of redhorse sucker also frequent the lower Carp River at least seasonally.

Based on these studies, the fish community of the Carp River and its tributaries is dominated by minnow species (19 species), including both sensitive and tolerant types that are adapted to a variety of warm water habitats typical of low gradient, slow flowing rivers with many backwater and streamside wetland features and broad, flat floodplains. Game fish, including northern pike, walleye, yellow perch, smallmouth bass, rock bass and pumpkinseed were uncommon and mostly found in the lower river (downstream of the village of Carp). Brown trout occur in Upper Poole Creek in low numbers as a result of a stocking program. Only two species of darter, logperch and johnny darter (including the tesselated darter, which is a subspecies) were generally found throughout the main river and in the Poole Creek. Poole Creek has two other darter species as well as two sculpin species. Sculpin are typically found in cold-water environments, typical of brook trout habitat. Suckers (white, redhorse) are also uncommon in the watershed.

At most sampling locations, 4 – 7 species were present in the catches. This was the case for all tributaries (except Poole Creek) and the main river stations generally upstream of the village of Carp. Stations in the lower Carp (downstream of the village of Carp) generally had 7 - 10 species, and all stations in the Upper Poole Creek had 10 – 14 species. Some minor tributaries that were sampled contained less than 4 species and were generally considered to be intermittent or highly degraded.

2001 Studies: A total of 20 stations were inventoried to collect habitat information, sample fish communities and sample benthic invertebrate communities. Fish species captured, relative numbers, density and biomass at each station is presented in **Table 3.7.2**. A total of 32 species of fish were recorded during the survey, similar to the historic record. Most species were recaptured, and three additional species: pearl dace, iowa darter and river chub were new additions to the total record for the Carp River.

In general, the number of species captured was greater in the current inventory compared to the 1975 MNR inventory (although methods differed), which is evidence to suggest that the aquatic habitats supporting fish have not changed substantially in the past 25 years. Most stations had fish communities of 6 - 10 species, the lower Carp had communities of 10 - 13 species, and some tributary stations such as Poole, Feedmill, Corkery had 13 or more species.

Based on historic and current fish community records, the fish communities of the Carp River and its tributaries can be grouped into 5 general types (Figure 3.7.1):

 Tolerant coldwater fish community: This community includes cold/cool water species such as brown trout, sculpin, hogsucker (Photos 1- 4, Appendix C) as well as some intolerant warmwater species such as rock bass, fantail/rainbow darter. This community occurs in Poole Creek, Feedmill Creek, Huntley Creek and a tributary that discharges to the Carp River across from the village of Carp – "Carp Creek".
		-			1			1		1		<u> </u>								1	1	1			1				1 1									<u> </u>	<u> </u>
Station	1	2	2	2a	3		4		4a		5		6		7		8		9		10		11a		12	13		14	15		16		17		18		9	20	
																																		NC	O FISH				
Stream Order	4	4	1	4	4		3		4		2		2		2		2		2		2		1		2	3		3	3		3		3		2		3	3	
Area (sq. km)	290	24	40	260	120		40		76		10		18		13.5		9		5		4		1.5		9	36		20	24		16		22		12	2	.4	18	
Effort (fishing sec)	800	13	00		1000				750		980		633		843		387		650		625		650		200	500	7	710	850	4	555		740			8	0	500)
Area Fished (sq m)	320	56	60		480				300		500		300		350		250		120		120		90		50	700	4	440	400		80		640			2	.0	120)
Diseased Fish (%)																																							
Species	No. V	Vtg. N	o. Wtg.	No. Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	No.	Wtg.	. No.	Wtg.	. No. Wtg.	. No.	Wtg.	No. Wtg	. No. V	Vtg.	No. V	Vtg.	No.	Wtg.	No. V	Vtg. N	o. Wt.	-g. No	. Wtg.
Mottled Sculpin													3	18.1			17	134.6	51	120	48	82.5				1	5.6	12 20.1	4	10.4									_
Pike	1	450							1	240																													_
Brown Bullhead																																	3	120					
Brook Stickleback											12	7.6	9	11.03	2	1.6	139	157.6	28	45.87	14	12.9	147	154.8	24 22.11			49 33.39	27	16.4	34	50						23	14.1
Killifish											7	16.3																											_
Silver Redhorse	1 '	1750																																					_
White Sucker	2	100 1	9 506.7		7	310			2	340			26	317.8	2	3.8			3	30	1	17.7	1	22.6		13	100	17 184.2	2 40 3	353.7			36	310		-	6 70) 17	260
Mudminnow					1	15.2			13	64.7			10	183.3	1	4.5	116	198.2	13	31.85	11	23.4	13	75.3	3 6	1	4.7	13 20.22	2		7	25				54	.81 86	.6 14	46.67
Common Shiner		5	3 487.6										32	170.7					3	30	1	17.5				6	50	85 255	17	81.7	10	30	10	25				9	16
Golden Shiner									5	23			4	14.53									2	4		3	5.7						1	5.6		2	5 44	4	_
Unid. Shiner																										2	3.8		1	3.4								4	11.6
Mimic Shiner													1	6.3	1	7.5																							
Smallmouth Bass	18	37.2 9	61.8																																				
Rock Bass	23	1330 6	6 240		9	380			16	550			10	472.2	39	920										30	480						5 :	22.68			4.	9	
Pumkinseed					5	100			4	70			8	227.2	2	8										14	260						1	15.68					
Johnny Darter	3	5.7 6	6 4.3										37	22.2	1	2.3			1	2	-	-				5	5.9		36 2	26.29			24	24.6			2 1.8	ô7	_
Iowa Darter									2	4.1													1	1.4		2	2.36										6.5	33	
Logperch	8	60 6	1 457.5										2	11.5												3	25		5	20.4			7 :	29.68					
Emerald/Rosyface																																							
Shiner		12	20 254.8										43	56.95	1	1.2																							
Blackchin Shiner													2	8																									_
Blacknose Shiner	1	2 4	11.94		-				2	3.5			10	40	10	16.67	5	20.45	2	2.7	3	3.1	10	10.55		11	20.37	4 7.4	2	8.12	1	2.8	4 '	12.73			2 1.	7 1	1
Bluntnose Minnow	1	2.5 1	7 50.76		3	6.6					2	2	45	180	41	68.33	44	180	2	3			41	43.26	; 	43	79.63	4 7.4	8 3	32.48			18 /	57.27			<u>+ 3.</u>	4 2	3.9
Brassy Minnow			2.3											_																							2 3.9	<u>) 2</u>	8.6
Fathead Minnow											1	4	4	5			3	8	4	5.3	4	4.8	25	44				2 5					1	4.6				2	6.4
River Chub?													1	7.647	10-	1070						100		074.0															
Creek Chub			8.4		2	7.2			1	3.6	12	70	54	412.9	105	1070			14	40	25	460	47	271.6	4 25.14	1 35	220	53 320.5	0 73 3	331.8	158 3	363.4	21	110		i i	9 12	0 30	384
Longnose Dace	10 2	21.28 1	0 55.56										6	20	1	3.1			5	9.972	5	19.77	/		6 14.12	2 3	7.062	24 37.86	5 2 5	5.317								2	2.7
Blacknose Dace	37 7	78.72 4	4 244.4										28	93.33	2	7			18	35.9	10	39.53	3		25 58.85	5 10	23.54	95 149.9	0 10 2	26.58								4	5
																				~ ~ ~																			
Redbelly/Finescale Dace											8	13.2		-			163	94.04	82	68.76	28	30	50	87.5	9 9			/6 55.//	′ 10	9.4	205 9	3.48	2	2		23	2.4 131	2	_
Pearl Dace																			1	1.994	8	33.8	1	38							29 6	52.64							_
T the last					_				_						10		_												1.0		_								_
Total Species	11	1	3	0	6		0		9		6		20		13		/		14		12		11		6	16		12	13		1		13		0		1	12	_
Total Fish	105	35	01	U	27	040	0		46	4000	42	446.1	335	0070	208		487	700.0	227	407 -	158		344	7-0	/1	182	400.1	434	235		444		133	700.0	0	38	<u>5.2</u>	110	/ ===
Total Biomass		3837	2386	0		819		0	0.400	1299	1.000	113.1	50.00	2279	04.07	2114	105.6	792.9	04.00	427.4	05.00	745	50.00	/53	135.2		1294	1097	07.05	926	6	527.3		/39.8		0	474	<u>,.1</u>	760
Fishing Effort (100sec)	13.13	2	/		2.7				6.133		4.286		52.92		24.67		125.8		34.92		25.28		52.92		35.5	36.4	6	1.13	27.65		80	1	17.97			48	1.5	22	
Density (100 sq m)	32.81	62	68		5.625	170.0			15.33	400	8.4	00.00	111.7	750.0	59.43	0044	194.8	047.0	189.2	050 1	131.7	000.0	382.2	000.0	142	26	9	8.64	58.75	104 5	555	2	20.78	115.0		19	26	91.6	/
biomass (100 sq m)		1199	426.1			170.6				433		22.62		759.6		604.1		317.2		356.1		620.8	5	836.6	270.5)	184.8	249.2	2	231.5	7	84.2		115.6			237	/0	633.3

Table 3.7.2 - Fish Inventory Summary Carp Watershed July 2001



- Diverse, moderately tolerant cool/warm water fish community (Photos 5- 8, Appendix C): This community includes rock bass, smallmouth bass, northern pike, walleye (seasonally), redhorse sucker species, a number of sensitive minnow species such as blackchin shiner, blacknose shiner, rosyface shiner, mimic shiner. This community appears to be restricted to the lower Carp River, downstream of Kinburn as well as lower Corkery Creek, lower "Smiths Corners Creek" and the mid reaches of Poole Creek.
- Tolerant warmwater fish community (Photos 9 10, Appendix C): this community includes long nose dace, creek chub, white sucker, common shiner, pumpkinseed, central mud minnow, johnny darter. This community is generally distributed throughout the main river between the Village of Kinburn and Richardson Side Road, "Glen Cairn Creek" and the upper portions of Feedmill, Huntley and Corkery Creeks
- Degraded warmwater fish community (Photos 11- 12, Appendix C): this community includes fathead minnow, bluntnose minnow, brook stickleback. This community occurs in the headwaters of Huntley Creek, west of Highway 417, and the upper Carp (upstream of Richardson Side Road)
- Intermittent streams (Photo 13, Appendix C): All remaining tributaries were observed to be intermittent and are considered to provide either very limited fish habitat or only to contribute surface runoff, nutrients and contaminants to fish habitats located downstream

Habitat Assessment

Background

There is little habitat information available on the Carp River and its tributaries, except for a detailed assessment in the Upper Poole Subwatershed Study (MMM et. al. 2000), some air photo interpreted information on channel condition (NESS 1996) and an assessment of streamside conditions on the main river (MVC 1993). The MVC study classified the streamside environment as follows:

- Natural relatively untouched shoreline/stream banks with good width of vegetated buffer strip (Photo 14, Appendix C)
- Altered natural streamside vegetation removed, but generally good stewardship of the land adjacent to the river and possibly some restoration occurring (Photo 15, Appendix C)
- Degraded one or more of the following evident; direct cattle access, bank erosion, excessive nutrients/abundant aquatic plant growth, no vegetated buffer (Photo 16-17, Appendix C)

Only the main Carp River was assessed leading to the following results (**Figure 3.7.2** Streamside Environment):

Natural	12.7 km
Altered	11.9 km
Degraded	20.7 km

The most degraded portion of the river occurs between Kinburn and a point about 2 km upstream of the March Road crossing of the Carp River. This river segment is about 90% degraded and 10% natural. The lower Carp (downstream of Kinburn) and the upper Carp (upstream of the March Road bridge) are both about 50% natural and 50% altered.



A combination of air photo review and "windshield" survey confirmed that the streamside environment data from MVC was still accurate. The NESS database of terrestrial communities, excluding "meadow communities" was then overlain on the tributaries of the Carp River to highlight natural versus disturbed streamside environments on these tributaries (**Figure 3.7.2**). This assessment indicated the following distribution of streamside environments for the tributaries:

Natural	253 km
Degraded	258 km

These results generally confirmed that the majority of tributaries without riparian/streamside vegetation occur east and north of Highway 417 and west of the Carp River. Intermittent tributaries have the largest proportion of their total length without riparian vegetation, and generally smaller proportions of Corkery, "Carp", Huntley, and "Smiths Corners" Creeks are without riparian vegetation (**Figure 3.7.2**). The mid-reaches of the Carp River have the most degraded streamside environments of the main river, followed by the upper reaches.

The NESS database includes an aquatic habitat component that identifies stream channels as natural or disturbed, based on interpretation of air photos. This information, which includes the Carp River as well as the tributaries is illustrated on **Figure 3.6.2** and can be summarized as follows:

Unclassified	110 km
Natural	173 km
Disturbed	229 km

Disturbed reaches correspond to channels that appear to have been straightened by municipal drainage practices or channelization (**Photo 13, Appendix C**). Most of the unclassified streams appear to be headwater tributaries, wetland features and stream segments that lack a connection to a tributary or the main river.

These results suggest that the upper and lower segments of the Carp, as described above are somewhat more altered than the MVC study indicated and that the middle segment is less altered/degraded in terms of the stream channel. These results also indicate that most of the larger tributaries have substantial lengths of natural channels, with the smaller tributaries being mostly altered.

In contrast to other segments and tributaries to the Carp, habitats in the Upper Poole Creek exhibit higher gradients, pool: riffle morphology, coarse substrates and cool/cold water temperatures. Baseflows and spawning habitats for brown trout are considered marginal and limiting habitats. The Upper Poole Subwatershed Study recommended a number of enhancements to reduce these limitations.

A combination of air photo review and "windshield" survey confirmed that the tributary NESS data on natural versus channelized/altered tributaries was still accurate as shown in **Figure 3.6.2**. This same technique was also applied to the main Carp with natural segments being characterized as segments that appeared to have remained unaltered or channelized reaches that were exhibiting some evidence of natural recovery. The portion of the Carp River falling into these categories is as follows:

Natural20 km (Photo 18)Disturbed25 km



These data confirmed that stream channels in the upper reaches of the Carp (upstream of Carp village) are most altered/disturbed, with the reaches downstream of this point being about 60% natural and 40% disturbed. Altered reaches of tributaries are located primarily along intermittent streams. The lower portions of Corkery, "Smiths Corners", "Carp", and Huntley Creeks contain relatively extensive reaches of natural channels/reaches.

Two indicators of aquatic habitat conditions were used to classify stream health in the Carp River and its tributaries:

- The Index of Biotic Integrity: this is an index based on the characteristics of the fish community that uses the aquatic habitat. It is based on fish abundance, species diversity, and occurrence of unique species, sensitive species and tolerant species, and representation of fish species with different reproductive/feeding preferences. Higher scores indicate better stream health, in terms of riparian habitat, flow, water quality and instream habitats.
- 2) Benthic Invertebrate Community Analyses/indices: the benthic invertebrate community (aquatic insects, crayfish, clams, snails and worms) is also sensitive to the aquatic environment in which these organisms live. A number of indices, particularly, the number of species present, the EPT index (the proportion of the community made up of sensitive mayflies, stoneflies and caddisflies) and the WQI or BIOMAP Water Quality Index (a ranking of the sensitivity of each invertebrate species to water quality and aquatic habitat degradation), were calculated based on collections of benthic invertebrates at all of the fish sampling stations.

These various indices were calculated and are presented in **Table 3.7.3** and **Figure 3.7.1**. The IBI scores ranged from 19 to 37 (except for station 18 which had no fish) and fell into 4 categories as follows:

- Good Quality Habitat: Two stations on Poole Creek (east of Main Street) and stations at the mouths of Huntley and Corkery Creeks exhibit good quality habitat (2 ranking).
- Fair Quality Habitat: The Carp River downstream of its confluence with Huntley Creek, "Carp", "Glen Cairn", "Smiths Corners" and upper Huntley Creeks exhibit fair quality habitat (3 ranking).
- Poor Quality Habitat: the Carp River upstream of its confluence with Huntley Creek, Upper Poole Creek, Upper Corkery Creek and a tributary of Huntley Creek exhibit poor habitat quality (4 ranking).
- Very Poor Quality Habitat: an intermittent tributary (station 18) exhibits poor quality habitat since no fish were captured (0 ranking).

No locations scored sufficiently high to fall into an Excellent Quality Habitat category.

Locations with Good Quality habitat were generally considered to represent the best habitat in the watershed; in other words, the fish community reflects good water quality, stream flow, riparian and instream habitats. Locations with Fair Quality habitat may have habitat limitations in terms of baseflow and dissolved oxygen/nutrient concentrations. Locations with Poor Quality habitat generally appear to more severely limited by base flow and dissolved oxygen/nutrient conditions as well as poor instream/riparian habitat. Upper Corkery Creek (station 16) may be partially inaccessible to fish from the lower creek, because of barriers and/or sections of the stream that are "losing" streams (flows discharge into the streambed).

 Table 3.7.3

 Summary of Fish and Benthic Invertebrate Community Assessment

Station	Sculpin	Basses	Darters	No. Speicies	Density (100 sq m)	Biomass (100 sq m)	IBI Score	IBI Rank	Fish Community Type	Abundance (rel)	No. Species	EPT Index	WQI Index	EPT Rank	WQI Rank	Comboined Rank	Overall Water Quality Rank
4						4000	0.1	0		4400	07	10			0		
1		X	X	11	33	1200	31	3	4a	1100	37	13	8.6	1	3	1	1
2				10	60	400	20	2	10	1100	29	1.5	3.9	3	5	2	3
2a 2		X	X	13	63	420	29	3	4a 4b	 500	24	2	4.4	0	6	4	4
3		X		0	0	170	21	3	40	 500	24	2	4.4	0 F	0	4	4
4		×	×	0	15	420	27	2	4b	650	10	U	0.0	5	I	3	4
4a 5'		~	~	9	15	430	10	3	40	1700	20	0.5	2.4	Б	7	2	4
5 6	×	×	×	30	112	430	19	2	1	1600	29	0.5	5.4	5	5	2	4
7	~	×	×	13	60	600	33	4	1	1650	38	13.5	0.0	0	2	1	3
7 8	v	^	^	7	105	315	21	4	3	2700	23	5.5	9.5	7	2	3	3
0 0'	×		×	14	195	356	20	4	3	135	18	5.5	57	1	2	1	2
3 10	×		^	14	130	620	23	3	3	1900	20	10	12.2	1	<u>ک</u> 1	1	1
10	^			12	152	020	51	3	5	1300	23	0	16	5	9	3	1
119			×	11	382	836	31	3	Λ	130	0	0	1.0	5	3	5	4
12			~	6	142	280	25	2	5	 550	23	55	87	7	3	3	3
13'	×	x	x	16	26	185	37	4	2	1200	37	2	3.8	2	6	2	3
10	x	~	~	12	99	249	27	3	3	550	34	11	8.3	3	3	2	2
15	x		x	13	59	231	31	3	3	4500	29	9	7.4	5	4	2	2
16	X		X	7	555	784	19	2	5	750	36	19	9	1	2	1	1
17'		x	x	13	21	115	37	4	4	 700	25	2	4.1	2	4	2	3
18'		~	~	10	- 1	110	01		5	275	21	1	3.2	4	8	3	4
19'		x	х	11	1926	2370	27	3	4	550	23	2	4.5	2	3	2	3
20				12	92	633	27	3	4	150	12	1	3.9	8	7	4	4
-								-				-		-	-	-	-

Note: Benthic Stations marked with ' were sampled using a ponar; remaining stations were sampled using a surber



The benthic invertebrate results are shown in **Table 3.7.3** and **Figure 3.7.1**. EPT scores ranged from 0 - 13.5, WQI scores ranged from 1.6 - 12.2 and the number of species present ranged from 8 - 38. A composite water quality score was calculated by ranking and combining EPT and WQI scores for stations that were sampled using surber and ponar samplers, and these scores are presented in **Table 3.7.3** and **Figure 3.7.1**. Because the sampling locations were standardized in terms of habitat type, and since benthic invertebrates are considered to be more sensitive to water quality changes than fish, the benthic score is considered to be a water quality indicator. A number of water quality trends are suggested by this data (**Figure 3.7.1**) as follows:

- Water quality conditions in the main Carp River show gradual improvement from the Carp upstream of the confluence with Corkery Creek (very poor water quality), to the Carp between the Corkery Creek confluence and the Carp at Carp Road near Kinburn (Poor Water Quality) to the lower Carp downstream of this point (Good Water Quality).
- Good Water Quality conditions occurred in the upper Corkery, upper Feedmill and middle Poole Creek stations. The benthic communities at these locations indicate slight water quality impairment probably from nutrient enrichment
- Fair Water Quality conditions occurred in the middle reaches of Huntley Creek, lower Feedmill Creek, and "Carp" Creek. The benthic communities at these locations indicate moderate water quality impairment probably from nutrient enrichment.
- Poor Water Quality conditions occurred in the lower reaches of "Smiths Corners", Corkery, Huntley and Poole Creeks, as well as the upper reaches of Poole Creek. The benthic communities at these locations indicate substantial impairment of water quality, probably nearing eutrophic conditions, with the possibility of some form of sediment contamination or substrate disturbance.
- Very Poor Water Quality conditions occurred in upper Huntley Creek, an intermittent tributary near Kinburn (station 18) and an urban tributary at the northern limit of Terry Fox Drive (station 11). The benthic community at these locations indicate eutrophic conditions, some sediment contamination and perhaps high sedimentation/substrate disturbance.
- These benthic indicators of water quality are generally similar to the summary of water quality results provided in Section 3.3. Water quality results indicated better water quality in the headwaters of tributaries and in the Carp River than is predicted by the benthic results.
- At each fish sampling station, a habitat assessment form was completed and results of this qualitative assessment are shown in **Table 3.7.4**. The assessment considered 10 habitat criteria and provided a ranking of these criteria from "optimal" (score 16 20) to "poor" (score 0 5). These habitat criteria showed no particular trends across the range of stations sampled, nor did they appear to show any relationship to the fish community IBI scores. The data reflect the fact that stations were selected that represented the best conditions available in that particular stream or stream segment and thus are not necessarily representative of the "average" habitat condition of any stream or stream reach. Nevertheless the habitat scoring sheet shows promise as a monitoring tool for future habitat monitoring.

Table 3.7.4

Habitat Characteristics

station	IBI Score	Habitat Score	Epitaunal Substrate/Cover	Pool Substrate Characterization	Pool Variability	Sediment Deposition	Channel Flow Status (standing water)	Channel Alteration	Channel Sinuousity	Bank Stability (Left)	Bank Stability (Right)	Vegetation Protection (Left)	Vegetation Protection (Right)	Riparian Vegetation Zone (Left)	Riparian Vegetation Zone (Right)
1	31	197	12	17	10	16	12	17	9	16	16	20	20	16	16
2a	29	221	16	16	9	18	13	20	17	18	18	20	20	18	18
3	27	175	13	13	12	8	18	15	8	16	16	14	14	14	14
4a	27	169	13	16	10	13	13	13	3	18	18	16	16	16	4
5	19	163	2	12	2	2	15	8	2	20	20	20	20	20	20
6	35	159	7	12	14	8	12	14	8	14	14	14	14	14	14
7	37	215	18	18	19	19	14	19	16	18	18	16	16	12	12
8	21	185	9	12	14	8	9	12	13	18	18	20	20	16	16
9	29	215	9	14	15	18	14	19	14	16	16	20	20	20	20
10	31	219	19	10	15	20	15	19	17	16	16	16	16	20	20
11a	31	143	13	16	6	3	13	8	4	18	18	14	14	8	8
12	25	189	18	16	10	15	5	16	13	18	18	16	16	14	14
13	37	129	13	15	16	8	8	14	13	8	8	8	8	4	6
14	27	205	18	18	17	17	18	13	12	14	14	16	16	16	16
15	31	196	17	18	13	13	16	13	14	16	16	16	16	14	14
16	19	174	12	5	9	13	8	13	14	18	18	16	16	16	16
17	37	147	11	11	9	11	7	16	10	10	10	14	14	12	12
18	0														
19	27	195	13	13	8	13	13	13	10	18	18	20	20	18	18
20	27	197	13	13	14	13	17	14	13	18	18	16	16	16	16



Stream Temperatures

Some continuous temperature monitoring was conducted at a number of locations throughout the watershed, and records from several locations are presented in **Figures 3.7.3** and **3.7.4**. These results can be summarized as follows:

- There is a substantial daily fluctuation in stream temperature. This fluctuation is in the order of 2-3 C in Poole Creek and 5-8 C in Carp River
- Temperatures in Poole Creek are generally 3-5 C lower than temperatures in the Carp River in June/July, however temperatures in the Carp River gradually fall to similar levels as Poole through August.
- Temperatures in Poole Creek remain within the range of temperatures suitable for coldwater species, while Carp River temperatures exceed these temperatures in July.

3.7.2 Terrestrial Communities

Form:

- Vegetation, mammal, bird, reptile and amphibian species lists
- Vegetation community types by dominant species/vegetation form (forest, grassland, wetland)
- Specially designated features: habitat for rare, threatened, endangered species, ESAs, ANSIs, wetlands
- Distribution of indicator species, e.g., large mammals, forest interior birds representing high quality conditions, or in other cases poor quality/disturbed conditions (e.g., garlic mustard, cowbird, buckhorn)

Function/Linkage:

- Habitats to support other plants and animals
- Concentrate snowfall and retard snowmelt and runoff encouraging recharge and preventing floods
- Maintain cool microclimates for stream shading
- Reduce overland sediment transport to streams
- "Trapping" flood waters in the floodplain and delaying its return to the stream channel providing spawning habitat for fish and waterfowl staging habitat
- "Global" scale functions such as storing carbon, replenishing atmospheric gases through transpiration, etc.
- Stabilizing streambanks
- Providing a source of habitat, large woody debris and nutrients to streams
- Improving the quality of water infiltrating into the ground and discharging to streams
- Providing corridors for movement of animals and dispersion of plants

Background studies such as the former Region's NESS, the MNR's Site 6E-12 ANSI assessment and smaller scale investigations of subwatersheds and individual development properties have provided a good framework for our understanding of the features and ecological functions of the Carp River Watershed. This is a large and complex area, however, and only a fraction of the landscape has received direct scrutiny. This is particularly the case in the upper portions of the watershed (e.g. the Subwatershed planning area including Lower Poole, Upper Carp, Feedmill and Huntley subwatersheds).



Recent field studies were designed to produce a finer level of information on natural environment features/ functions and boundaries. This provides needed additional ecological input into the on-going planning program to effectively and appropriately guide future land use and development along the watershed.

Eighteen NESS areas as well as several other landscapes units and stream corridors were directly examined during the 2001 field inventory program (**Figure 3.7.8a**). In addition to classifying each unit in terms of dominant canopy, subcanopy and ground cover vegetation, the following information was collected where possible:

- Maturity of dominant species;
- Identification of significant conservation species;
- Community diversity;
- Habitat potential (interior forest, core/corridor potential, old growth);
- Presence of wildlife;
- Extent of disturbance/ fragmentation;
- Functions/ linkages (wildlife corridor, riparian function, etc.).

Where landowner access approval had been granted, reconnaissance surveys were conducted directly within the boundaries of particular properties. The edges of other properties were evaluated from public Right-of-Ways or from adjacent sites. Between one and ten properties were examined for each of the NESS and associated areas in the July to September 2001 field period. Extrapolation from these site examinations has permitted a more accurate assessment of the natural environment significance of each area. The assessment includes the preparation of significance mapping for each natural landscape unit.

Site assessment summaries for individual properties are documented separately (**Appendix D**). Following completion of the analysis of field data, the results of individual property assessments are being directly communicated to access-granting landowners.

Vegetation Communities

The watershed lies in the Great Lakes-St. Lawrence Forest Region, which represents a transition between more southerly deciduous forests and the predominantly coniferous forests of the boreal forest to the north. Sugar Maple, American Beech, Red Oak and Eastern Hemlock characterize well-drained sites, while moister sites, such as valleys and swamps, support White Cedar, Yellow Birch, White Elm, Black Ash, Silver Maple and Red Maple. Boreal species, such as Balsam Fir, White Spruce, Black Spruce, Balsam, Poplar and White Birch, are intermixed with other species.

Although the landscape is dominated by human settlement patterns (72% of the watershed in unforested), extensive vegetation features remain in the watershed. Key characteristics, which contribute to the overall nature of the Carp River watershed landscape, are as follows:

- Five Earth and Life Science candidate ANSIs exist in or adjacent to the watershed, representing 1771 ha or 5.8% of the watershed; **Figure 3.7.5**.
- Eleven significant wetlands/wetland complexes exist in the watershed representing 1150 ha or 3.8% of the watershed; Figure 3.7.6.



- Forested vegetation communities comprised about 27.6% of the watershed area, and natural/ naturalized areas represent about 12,000 ha or 40% of the watershed;
- Grassland/old field communities represent about 5% of the watershed and include some large tracts of land.

The distribution and representation of the major vegetation community types is shown in **Figure 3.7.7** and illustrated below:

	Area (ha)	% of Watershed
Coniferous forests (including	4013	13.1
forested wetlands, plantation)		
Deciduous forest (including forested	2610	8.5
wetlands, plantation)		
Mixed forest	1850	6.0
Meadow	1551	5.0
Scrub	2021	6.6
Wetland (open water)	169	0.6
Total	12214	40

Natural Environment System Strategy (NESS)

The former Region between 1993 and 1997 undertook the most comprehensive review of natural areas within the City of Ottawa. This ambitious program was initiated to provide information necessary for the production of the revised 1999 former Region's Official Plan. That critical document is the blueprint describing the relative values and priorities we place on landscapes within the city, and the limitations we must place on development in order to protect and enhance those values for the benefit of all Ottawa citizens. Providing substantial and defendable ecological data and analyses upon which planning and development decisions could be made for all areas of the City, then, was as important as it was ambitious. Largely through remote sources (primarily aerial photography), the NESS program classified all natural and near-natural landscapes larger than 2 ha in the City of Ottawa. From the thousands of individual classifications and analyses, which have been permanently entered into the City's Geographic Information System (GIS) database, patterns of significance were identified. An extensive ground-truthing exercise involving four field teams working throughout the 1996 spring/ summer/ fall field season provided further clarification of these analyses. The completed NESS provides analytical data on over 200 natural areas within the City of Ottawa. Each area was evaluated for a number of well-established ecological criteria, measured as follows:

- Landscape Attributes the degree of forest cover adjacent to or near the area;
- Vegetation Representation the presence of major examples of common vegetation types;
- Vegetation Significance rare vegetation representation as determined by GIS analysis;
- Rare Species numbers of exceptional species and their level of significance (Endangered or Threatened, Provincially or Regionally Rare);
- Vegetation Diversity richness of the natural variation within the area;
- Wildlife Concentration location and size of seasonal gathering (feeding, shelter, staging) areas for resident or migratory animal species;
- Hydrology inventory of hydrological assets (springs, creeks, etc.);
- Natural Area Condition measurement of floristic ecological integrity of natural vegetation.



The end result is a fairly coarse but uniquely objective assessment of the relative significance and conservation priorities of all landscapes in the City of Ottawa. This contributed directly to the identification and delineation of substantial conservation areas (Natural Environment Areas) within the Official Plan as well as the clarification of boundary and land management issues throughout the City. These areas were further classified into categories of High, Moderate or Low based on their relative score under the above categories. These are shown on **Figure 3.7.7** and **Figure 3.7.7A** and are represented by the following areas:

Significance	Areas (ha)
High	6467.24
Moderate	2892.01
Low	1673.08

All together they represent 36% of the total watershed area of 30,560 ha.

Areas of Natural and Scientific Study (ANSIs)

Natural areas that represent particularly good examples of the landform-vegetation complexes within the various ecological subdivisions of Ontario (called Site Districts) are identified as Areas of Natural and Scientific Study (ANS Is). Identifying these special natural areas has been an Ontario government program managed by the Ministry of Natural Resources. The best examples of particular landform-vegetation complex are typically designated Provincially Significant ANSIs, with less superlative examples being noted as Regionally Significant.

ANSI designation can be on public or private land. This places no zoning restriction upon landowners or managers but serves Ontario government protection objectives by identifying landscapes that have important conservation values on a province-wide scale. Provincially Significant candidate ANSIs are designated as Natural Environment Area designation within the City's Official Plan. Generally Regionally Significant candidate ANSIs are found largely within the Natural Environment Area and Rural Natural Features designations City's Official Plan. Each environmental category requires specialized evaluation of the natural values within these important natural landscapes before development approvals can be considered.

Portions of candidate Provincially Significant ANSIs are located within the Carp River Watershed study area. These candidates were identified in the 1992/1995 ANSI study of Site District 6E-12. The proposed ANSIs include: the Stony Swamp (Nepean/Kanata), Carp Barrens (Kanata/ West Carleton), Marathon Forest, South March Highlands and Carp Hills (Kanata/ West Carleton) candidate ANSIs. Some small earth science (geological) candidate ANSIs are also included within the watershed and several other ANSIs are adjacent to the watershed (eg. Mississippi Snye Wetland and Manion Corners).



The earth and life science candidate ANSIs (**Figure 3.7.5**) in and adjacent to the Carp River Watershed make up the following areas:

ANSI Area	Total Areas (ha)	Area Within Carp Watershed (ha)
Mississippi Snye Wetland	668.27	0
Carp Hills	2285.42	704.64
Carp Barrens	1294.82	215.83
Marathon Forest	944.53	617.21
Manion Corners	1183.06	0
South March Highlands	894.09	94.76
Stony Swamp	1490.34	137.75

Wetland Classification

Wetlands are recognized as providing economically and socially important assets within Ontario, one of the world's greatest depositories of fresh water. The condition of such areas are particularly important to the maintenance of public health and economic development in populated southern Ontario by prescribing the quantity and form of development which is sustainable in a given area without jeopardizing such values as drinking water quality, the provision of a consistent, year-round supply of water to industrial, agricultural and residential users, etc.

An important mechanism for determining the relative significance of particular wetland areas in Ontario is the Wetland Classification system. Four major values areas - hydrology, economic factors, social factors and biological assets - are measured in a prescribed, quantified manner which place each wetland within one of over half a dozen categories. Their resulting numerical score determines if a particular wetland area is considered Provincially Significant (Classes 1, 2 and 3). Ontario provincial policy requires that these special landscapes receive protection under policies in an Official Plan. New development and environmental impacts in and adjacent to such critical areas are prohibited or constrained, the prescriptions for these being determined by specialized professional studies reviewed by various municipal and provincial authorities.

Provincially Significant Wetlands - PSWs - form important components of the landscape in the Carp River Watershed, particularly in its headwaters and in central West Carleton. The significant wetlands are shown on **Figure 3.7.6** and occupy the following areas in and adjacent to the watershed:

Name	Total Area (ha)	Within Carp Watershed (ha)
Kilmaurs	77.65	77.65
Carp Hills Wetland Complex	39.71	0.86
Panmure	94.67	0
Corkery Creek	345.84	345.84
Scott Wetland Complex	187.3	187.3
Huntley	294.86	165.54
North Goulbourn	240.82	168.74
West Queensway	52.35	52.35
Stittsville Wetland Complex	78.7	78.7
Rothburn	25.05	25.05
Upper Poole Creek Wetland Complex	47.16	47.16



2001 Study - Ecological Significance:

The ecological significance of terrestrial natural environment values was assessed for the entire watershed as well as for selected subwatersheds within the Carp River system. A rating of terrestrial natural environment significance (High, Medium, Low) **Figure 3.7.8** has been assigned to portions of natural/ near-natural subunits within the Carp River watershed (e.g. individual NESS areas). These levels are defined as follows:

Low Level Significance

- Little or no representation in GIS vegetation analysis (woodland size and age; vegetation rarity and representative values);
- No Regionally significant special features values known from NESS studies or subsequently;
- Ecological integrity of the landscape minimal (canopy fragmentation advanced; few if any indicators for habitat renewal/ succession (natural debris, seed sources, etc.) present; high level of non-native plant infestation).

Moderate Level Significance

- Some representation in GIS vegetation analysis (woodland size and age; vegetation rarity and representative values);
- Some Regionally significant special features values known from NESS studies or subsequently;
- Ecological integrity of the landscape reasonable (level of non-native plant infestation not severe; canopy approximately intact; indicators for habitat renewal/ succession (natural debris, seed sources, etc.) present).

High Level Significance

- Substantial representation in GIS vegetation analysis (woodland size and age; vegetation rarity and representative values);
- Provincially significant and/ or several Regionally significant special features values known from NESS studies or subsequently;
- Ecological integrity of the landscape good (minimal canopy disturbance; low level of non-native plant infestation; indicators for habitat renewal/ succession (natural debris, seed sources, etc.) frequent).

The boundaries for these significance designations are based on consideration of 1) GIS analysis of vegetation data, 2) aerial photographic interpretation, and 3) on-site examinations. These designations and their boundaries are approximate, reflecting our incomplete knowledge of the natural environment assets of the land base, but are sufficient to provide general indications of the relative significance of particular portions of the natural/ near-natural areas within the Carp River watershed. The significance mapping for NESS Natural Area 409(Corkery) illustrates the application of this rating scheme (Figure 3.5.8). Such area assessments enhance our understanding of the overall ecological importance of the larger subwatershed/ watershed area.



Carp River Watershed

Although possessing enhanced habitat diversity, the majority of the vegetation within the Carp River watershed has developed upon sedimentary lowlands (limestone bedrock plains commonly buried beneath marine clay deposits). Shield-based habitats occur as well but are restricted to the Carp Hills area along the eastern side of the watershed, with localized outcropping in the Fitzroy Harbour area towards the mouth of the system. These erosion-resistant, largely acidic bedrock outcropping areas have discouraged agricultural development, resulting in an extensive more or less continuous woodland of upland deciduous and mixed forest habitat in thin soil on the highlands northeast of the river. White Pine and Eastern Hemlock were formerly more important components of more mesic, deeper soil areas dominated by Sugar Maple forest. The conifers were selectively removed in early settlement days, with only the former remain a common forest element (albeit, with reduced size).

The clay-based lowlands centred along the Carp River main channel constitute the agricultural heartland of the watershed and are predominantly deforested, as clearly indicated in Agricultural Use mapping (**Figure 3.8.1**). Natural habitats remnants are scattered and fragmentary, often confined to hedgerow-like growth of deciduous or mixed forest along stream channels. In recent years, rapidly expanding residential and commercial development in the southern Kanata-Stittsville area has consumed both agricultural and natural/ near-natural lands.

Woodland predominate southwest of Highway 417, with extensive deciduous and mixed swamp forests dominating the headwaters of several Carp River tributaries. Shallow soil over the extensive limestone bedrock plain encourages the development of scrubby forests of early successional deciduous and mixed forests on drier sites, with Trembling Aspen, White Cedar, White Spruce, White Birch, White Ash and White Pine being important in various combinations. Sugar Maple dominated forest is localized throughout in relatively less common areas of more mature forest habitats.

The long history of disturbance in the watershed, particularly in the immediate vicinity of the Carp River and in the increasingly urbanized southern section, has significantly reduced the ecological integrity of terrestrial habitats. Infestation of moist woodland edges and wetland swamps by the non-native Glossy Buckthorn has been unusually severe in the southern half of the watershed, especially so west of Highway 417. This has dramatically reduced natural biodiversity (vegetation, flora, and fauna) in younger woodlands. The closely related Black Buckthorn has had a similar effect on woodland edges of upland woodlands, invading and seriously infesting forest areas with disturbed canopies and open margins. Exceptionally high

White-tailed Deer populations since the mid 1990s has also dramatically impacted forest vegetation, with distinct browse lines, heavy shrub pruning from intensive feeding activities and deeply impacting deer trails being evident throughout the watershed.

The reduced level of ecological integrity in many portions of the watershed is indicated by the relative rarity of interior forest habitat (*viz.*, woodlands which are relatively unaffected by edge impacts and/ or by fragmentation). This is illustrated in **Figure 3.7.9**. Such areas with at least 200 m of continuous forest canopy represent only 59% of the woodland cover of watershed and 5010 ha or 16% of the Carp River watershed. A small portion of the westerly boundary of the South March Highlands (shown in Figure 3.5.5) is located just inside of the Carp Watershed boundary between March and Richardson Side Road and is also classed as a Centre for Ecological Significance. This significance feature, extends into the adjacent Shirley's and Watt's Brook Watersheds and is a major linkage between terrestrial features in the Carp watershed and natural features along the Ottawa River.



An important function of many areas within the watershed is the provision of ecological linkages between natural habitats within and beyond its limits, thus supporting Regional natural biodiversity, ecological integrity and natural restoration. Natural and near-natural vegetation along tributaries of the Carp River such as Poole and Huntley Creeks, continuous woodland along the western flank of the Carp Hills and extensive woodlands in drier uplands in the southwest, offer important linkages within the watershed and with areas beyond to the east, north and southwest.

Compilation of both remotely and field-generated ecological data, including the delineation of older, more natural woodlands, rare vegetation occurrences, extensive interior habitats, and special features concentrations, indicate natural core areas and linkages of particular ecological importance in the Carp River watershed (**Figure 3.7.11**). These features were called Centres of Ecological Significance and are predominately located in the vicinity of tributary headwaters of the Carp River, with a secondary concentration downstream along the main river course. These natural core and linkage areas include wetland complexes in the vicinity of Stittsville, an extensive upland forest complex associated with the Huntley Wetland, the Corkery wetland area, the Marathon Forest, the Carp Ridge, the Kinburn outcrop area, the Kilmaurs wetland complex and the Fitzroy area (**Figure 3.7.11**). These Centres of Ecological Significance represent 5284 ha or 17% of the watershed (**Photo 19**, **Appendix C**).

Strikingly, except towards its mouth at Fitzroy Harbour where the river crosses the Carp Ridges, few key natural areas have been identified along the main river course. This underscores the importance of the ecological contribution of tributary headwater areas to the overall natural function and significance of the watershed. It also emphasizes the need for upland habitat restoration along Carp River tributaries in order to enhance both the natural quality and ecological integrity of downstream systems and assets.

Subwatershed Planning Area

The upper reaches of the watershed include several locally important subwatersheds or portions of subwatersheds in which the potential impacts of active and anticipated urbanization are particularly in need of consideration (**Photo 20, Appendix C**). This includes Feedmill Creek, a small portion of Huntley Creek, Poole Creek downstream of Main Street, and the Carp River from Richardson Side Road to the Glen Cairn stormwater management facility.

Reflecting the urbanization pressures in the area, upland natural landscape in this portion of the Carp River watershed is frequently fragmented by new residential and commercial development or by established, more dispersed residential and agricultural development.

This pattern is also indicated by the relatively small proportion of natural/ near-natural vegetation in this area exhibiting interior habitat (i.e. with at least 200 m of continuous forest canopy) (**Figure 3.7.10**), despite relatively extensive representation of older woodland vegetation (**Figure 3.7.12**).

Wetland in the subwatershed reflect their headwaters location, typically consisting of shallow, partially ephemeral swamp forest, swamp thicket and marsh habitats with associated uplands of young to submature deciduous and mixed woodlands. Surface water flow control by beaver activity is widespread. Extensive areas of such wetland habitat were very low or completely dry during the historically dry summer of 2001. Remnant natural/ near-natural forest and scrub vegetation in creek corridors is frequently composed of a mixture of native and non-native dominants, such as Green Ash, Bur Oak, Manitoba Maple, White Cedar, Crack Willow, etc. The severe White-tailed Deer population impacts noted as affecting many



portions of the watershed (distinct browse lines in conifer forests, heavy shrub pruning from intensive feeding activities, deeply impacting deer trails) are particularly conspicuous in this subwatershed area.

The main course of the Carp River is more degraded in this uppermost section than in any other reach within the watershed. From the constructed Glen Cairn Stormwater Facility to downstream of Highway 417 the river is reduced essentially to a channelized ditch with no natural/ near-natural vegetation along its banks. The constructed wetland at the Palladium Drive crossing, however, provides a small oasis of open marsh, swamp thicket and deciduous swamp forest habitat along the otherwise artificially transformed corridor.

Large natural areas in the subwatershed planning area are predominantly confined to several extensive wetlands, including PSWs such as the Huntley Wetland, the Goulbourn Wetland Complex, the Upper Poole Creek Wetland Complex, the West Queensway Wetland (**Photo 20, Appendix C**). Upland mixed and coniferous forest areas where limestone bedrock outcrops extensively and thus historically were of reduced development interest, occur commonly in association with these shallow wetland, particularly west of Stittsville.

Over and above the watershed-scale contribution of the core natural areas located in the subwatershed planning area, locally important ecological contributions are evident in the natural/ near-natural landscape remnants here. Natural/ near-natural vegetation along creek corridors, such as the narrow deciduous forest riparian borders along Poole Creek and Hazeldean Creek in and about Stittsville and sections of Feedmill Creek north of Highway 417, for example, provide watercourse buffering as well as supporting populations of locally and Regionally significant flora and fauna. They also present a foundation from which much-needed habitat restoration can proceed to enlarge and enhance natural linkage functions to the presently degraded Carp River main course and within the upper areas of the Carp River watershed.

Synthesis

Aquatic Community

A total of 40 species of fish occur within the Carp watershed, which include both stream resident fish and fish that migrate from the Ottawa River on a seasonal basis.

Based on current and historic inventories, the fish communities of the Carp River and its tributaries can be grouped into 4 general types:

1. **Tolerant Coldwater Fish Community**

This community includes cold/cool water species such as brown trout, sculpin, hogsucker, as well as some intolerant warmwater species such as rock bass, fantail/rainbow darter. This community occurs in Poole Creek, Feedmill Creek, Huntley Creek and a tributary that discharges to the Carp River across from the village of Carp – "Carp Creek".



2. Diverse, Moderately Tolerant Cool/Warm Water Fish Community

This community includes rock bass, smallmouth bass, northern pike, walleye (seasonally), redhorse sucker species, a number of sensitive minnow species such as blackchin shiner, blacknose shiner, rosyface shiner, mimic shiner. This community appears to be restricted to the lower Carp River, downstream of Kinburn as well as lower Corkery Creek, lower "Smiths Corners Creek" and the mid reaches of Poole Creek.

3. **Tolerant Warmwater Fish Community**

This community includes longnose dace, creek chub, white sucker, common shiner, pumpkinseed, central mudminnow, johnny darter. This community is generally distributed throughout the main river between the Village of Kinburn and Richardson Side Road, "Glen Cairn Creek" and the upper portions of Feedmill, Huntley and Corkery Creeks

4. Degraded Warmwater Fish Community

This community includes fathead minnow, bluntnose minnow, brook stickleback. This community occurs in the headwaters of Huntley Creek, west of Highway 417, and the upper Carp (upstream of Richardson Side Road)

5. Intermittent Streams

All remaining tributaries were observed to be intermittent and are considered to provide either very limited fish habitat or only to contribute surface runoff, nutrients and contaminants to fish habitats located downstream

Stream channels in the upper reaches of the Carp (upstream of Carp village) are most altered/disturbed, with the reaches downstream of this point being about 60% natural and 40% disturbed. Altered reaches of tributaries are located primarily along intermittent streams and upper reaches of major tributaries. The lower portions of Corkery, "Smiths Corners", "Carp" and Huntley Creeks contain relatively extensive reaches of natural channels/reaches.

The majority of tributaries without riparian/streamside vegetation occur east and north of Highway 417 and west of the Carp River. Intermittent tributaries have the largest proportion of their total length without riparian vegetation, and generally smaller proportions of Corkery, "Carp" Huntley and "Smiths Corners" Creeks are without riparian vegetation (**Figure 3.6.2**). The midreaches of the Carp River have the most degraded streamside environments of the main river, followed by the upper reaches.

A number of water quality trends are suggested by the benthic invertebrate community indices (EPT and WQI) as follows:

- Water quality conditions in the main Carp River show gradual improvement from the Carp upstream of the confluence with Corkery Creek (very poor water quality), to the Carp between the Corkery Creek confluence and the Carp at Carp Road near Kinburn (Poor Water Quality) to the lower Carp downstream of this point (Good Water Quality).
- Good Water Quality conditions occurred in the upper Corkery, upper Feedmill and middle Poole Creek stations. The benthic communities at these locations indicate slight water quality impairment probably from nutrient enrichment.



- Fair Water Quality conditions occurred in the middle reaches of Huntley Creek, lower Feedmill Creek, and "Carp" Creek. The benthic communities at these locations indicate moderate water quality impairment probably from nutrient enrichment.
- Poor Water Quality conditions occurred in the lower reaches of "Smiths Corners", Corkery, Huntley and Poole Creeks, as well as the upper reaches of Poole Creek. The benthic communities at these locations indicate substantial impairment of water quality, probably nearing eutrophic conditions, with the possibility of some form of sediment contamination or substrate disturbance.
- Very Poor Water Quality conditions occurred in upper Huntley Creek, an intermittent tributary near Kinburn (station 18) and an urban tributary at the northern limit of Terry Fox Drive (station 11). The benthic community at these locations indicate eutrophic conditions, some sediment contamination and perhaps high sedimentation/substrate disturbance.

The lower Carp River, and parts of Poole, Feedmill, Huntley, Corkery, "Smiths Corners" and "Carp" Creeks support the greatest diversity of species and best habitat conditions. Limiting factors include baseflow, stream temperatures, lack of riparian cover and to a lesser extent, stream instability and sedimentation

Substantial portions of the above tributaries and the middle reaches of the Carp are more seriously impacted as a result of extensive stream alterations, poor riparian canopy, lack of baseflow, nutrient/sediment loading and degradation of pool:riffle habitat.

The upper reaches of the Carp and the intermittent tributaries are highly degraded as a result of lack of base flow, nutrient/sediment loading, lack of riparian vegetation and lack of instream habitats. Dredging has also enlarged the upper Carp, which has altered stream morphology and reduced the function of the riparian wetland features that form its banks.

Terrestrial Communities Synthesis

Although the landscape is dominated by human settlement patterns, some extensive vegetation features remain in the watershed. Key characteristics, which attribute to the uniqueness of the plant communities here are as follows:

- A total of five earth and life science candidate ANSIs exist in or adjacent to the watershed (**Figure 3.7.5**) representing 1771 ha or 5.8% of the watershed;
- Eleven significant wetlands/wetland complexes exist in the watershed (Figure 3.7.6) representing 1150 ha or 3.8% of the watershed;
- Sheltered habitats of several of these wetland and ANSI areas adjacent to productive farmlands are ideal as winter deeryards, and the watershed contains a number of deeryards and high concentrations of deer relative to adjacent areas;

A comprehensive assessment and ranking of natural areas was completed in the NESS study which ranked areas of the natural landscape as High, Medium or Low based on ecological characteristics and terrestrial functions. These areas represent 36% of the total watershed area.

Forested vegetation communities comprised about 27.6% of the watershed area, and natural/naturalized areas represent about 12,000 ha or 40% of the watershed; and Grassland/old field communities represent about 5% of the watershed and include some large tracts of land.



The primary limitation is the loss of connectivity between individual features; either between individual wetlands or ANSIs (eg. Carp Hills) and the general lack of floodplain/riparian vegetation. Restoring these connections would increase ecological biodiversity and add to the size of individual features while providing corridors to facilitate the dispersal of plant and animal communities between major vegetation features. The potential for enhancement of hydrologic functions within floodplain and riparian areas also exists.

Compilation of both remotely and field-generated ecological data, including the delineation of older, more natural woodlands, rare vegetation occurrences, extensive interior habitats, and special features concentrations, indicate natural core areas and linkages of particular ecological importance in the Carp River watershed. These are predominately located in the vicinity of tributary headwaters of the Carp River, with a secondary concentration downstream along the main river course near Fitzroy Harbour. These natural core and linkage areas include wetland complexes in the vicinity of Stittsville, an extensive upland forest complex associated with the Huntley Wetland, the Corkery wetland area, the Marathon Forest, the Carp Ridge, the Kinburn outcrop area, the Kilmaurs wetland complex and the Fitzroy area (**Figure 3.7.11**).

Over and above the watershed-scale contribution of the core natural areas located in the subwatershed planning area, locally important ecological contributions are evident in the natural/ near-natural landscape remnants here. Natural/ near-natural vegetation along creek corridors, such as the narrow deciduous forest riparian borders along Poole Creek and Hazeldean Creek in and about Stittsville and sections of Feedmill Creek north of Highway 417, for example, provide watercourse buffering as well as supporting populations of locally and Regionally significant flora and fauna. They also present a foundation from which much-needed habitat restoration can proceed to enlarge and enhance natural linkage functions to the presently degraded Carp River main course and within the upper areas of the Carp River watershed.

3.8 Land Use

3.8.1 Rural Land Use

The watershed is predominately rural with only about 10% in urban land uses, primarily in the former City of Kanata and in Stittsville in the former Township of Goulbourn. Rural settlements include small communities such as Carp, Kinburn, Fitzroy Harbour, Marathon Village and limited linear development along Donald B. Munro Drive Some limited residential growth is occurring within the rural areas of the watershed, particularly on the periphery of the Village of Carp and Fitzroy Harbour. Most of this residential development is in the form of rural estate subdivisions. Several subdivisions have been approved for many years but have not been developed, due to market conditions. As well, several applications have received draft plan approval but have not received subdivision registration. The amount of development that is either registered and draft plan approved in the rural areas could provide a steady supply of residential lots for many years.

An agricultural land use map was prepared as shown in **Figure 3.8.1**, based on data available from the City of Ottawa's. The data represent rural land use characteristics some 15 years ago, based on inventories completed by the OMAFRA and are summarized by area below:



Agricultural Area	Total Area (ha)
Abandoned Farmland	1417
Scrubland	851
Built-up	1205
Corn System	5257
Extraction (Sand & Gravel)	239
Extraction (Top Soil)	74
Grazing System	4531
Hay System	1503
Specialty Agriculture	6
Mixed System	1473
Monoculture System	2382
Recreation	196
Sod Farms	0
Swamp / Marsh	116
Woodland	15293

The agricultural land uses represent 14,272 ha or 48% of the lands inventoried and 56% of the total watershed area. Corn and grazing crops were the most common land use followed by hay, mixed crops, monoculture (likely corn, hay, grains and soybeans) and monoculture crops (likely grain or soybeans).

The high percentage of grazing, monoculture, mixed crops and corn is indicative of a livestock farming area. Both beef and dairy operations are common in this area and livestock densities appear to be relatively high based on the farmstead density and evidence of livestock impacts on the watercourses. A survey completed by MVC indicated that livestock access, livestock watering and farm field runoff were the major agricultural concerns with respect to surface water quality.

2001 Studies

A windshield survey was completed to update the agricultural land use mapping and correct the historical land use data shown in **Figure 3.8.1**. In general, agricultural land use changes were relatively minor, but reflected some intensification of cropping practices, with more lands devoted to corn and soybeans rather than mixed crops and hay.

In addition, agricultural lands within the Huntley Creek subwatershed, east of Highway 417 appear to be in a transitional state, with agricultural uses declining and urban uses increasing.

The majority of intensively farmed lands within the Carp Watershed are located on the flat valley and along the Carp River and the lower portions of its tributaries, between the more topographically diverse "hills" along the east and west margins of the watershed (**Photo 21**, **Appendix C**). As noted in Section 3.5, the main Carp and its tributaries generally lack riparian or streamside vegetation and are therefore poorly buffered from the effects of runoff containing sediment and nutrients from agricultural cropping practices. Thus, topography (slope) and streamside buffering capacity are considered to represent minor factors in affecting the transport and delivery of non-point sources of nutrients and sediment on agricultural lands. Intensity of cropping practices is then the primary factor controlling the erosion and transport of sediment and nutrients to streams.



Figure 3.8.2 targets priority areas for sediment/nutrient management on agricultural lands based on cropping practices. Priority One areas represent lands in intensive crop production and Priority Two areas represent lands in pasture and less intensive crop use. Priority One areas would likely be most significant in terms of sediment and nutrient delivery to streams, whereas a Priority Two area may represent sources of manure runoff or potential stream access points for livestock. These areas are represented in the watershed as follows:

Priority One:9113 ha (29% of watershed)Priority Two:6040 ha (19.5% of watershed)

A windshield survey was also completed within the watershed to identify possible point source pollution problems on agricultural lands. The following areas were identified, where they were evident from the road network:

Evidence of livestock access to streams representing slight (<100 m of stream impacted), moderate (100 – 500 m of stream impacted) and severe (> 500 m of stream impacted) potential for contaminated runoff from farmsteads to impact a stream (the presence of farm buildings, barnyards and manure storage areas in close proximity to a drainage feature) was noted.

A dry weather survey of stream flows was completed to prioritize watercourses based on their baseflow contribution to the Carp River (see Section 3.3). Survey results were used to prioritize streams with point sources in terms of their contribution of nutrients/contamination to the Carp River during dry weather. **Figure 3.8.3** illustrates priority stream reaches for non-point source pollution control from agricultural activities. Priority One reaches are streams with point sources that may impact the Carp River during dry conditions and Priority Two reaches are streams which have substantial point source problem areas but may only contribute nutrients/contaminants during wet weather events. Other streams were considered to have the potential to impact the Carp River during severe wet weather events, such as spring melt.

Priority One:Streams included: 66 km of channelsPriority Two:Streams included: 16 km of channels

There is not a direct relationship between Priority 1 and 2 streams and Priority 1 and 2 areas, as the first addresses point source pollutant loadings, while the second address non-point source pollutant loadings. In general, however, the Priority 1 and 2 streams represent the larger tributaries to the river, and also those with the best aquatic habitat, based on the presence of baseflow. It would be reasonable, therefore, to focus efforts on non-point source nutrient management (Priority 1 and 2 areas) that are found within drainage areas of Priority 1 and 2 streams.

3.8.2 Planned Urban Land Use

Development plans are proceeding for large areas of vacant urban land within the Poole Creek Subwatershed and the Feedmill Creek Subwatershed as well as upper reaches of the Carp River. Development of these lands over the next 20 years will dramatically change the character of these subwatersheds. In addition, pressures for additional urban development within the watershed are expected to continue, due to the watershed's location adjacent to existing urban areas.



In 2003 Ottawa Council approved a concept plan to guide development within Kanata West, about 710 ha of vacant urban land in the vicinity of the Corel Centre (**Figure 3.8.4**). The concept plan envisions a mixed-use community that provides residential development, employment and community facilities. The community is also intended to be transit supportive in its design and intensity of uses. The Kanata West Concept Plan was closely integrated with the initial recommendations of the Carp River Watershed/Subwatershed study.

One site within Kanata West was under construction in 2004. This site, the Palladium AutoPark, is planned to accommodate up to 12 auto dealerships, associated office space, two restaurants and a farmers market. Development applications for other sites within Kanata West were filed in 2004.

Other urban development includes a proposed subdivision application for a vacant, 57-ha parcel in Stittsville north of Hazeldean Road, where Taggart Development Ltd. has proposed residential development.

Through the late 1990s and early 2000s, applications to amend official plans to permit urban development were filed for two sites within the watershed and several sites to the south and west of the watershed. In 2003 Ottawa City Council refused four applications to amend the urban boundary in the 1997 Regional Official Plan in or near the watershed and adopted a new Official Plan for the city. Owners of land within and adjacent to the watershed have appealed the Council refusal of their applications, or their designation within the 2003 Official Plan, or both. An Ontario Municipal Board (OMB) hearing on several appeals has been scheduled for 2005.

The sites within the watershed subject to appeal include:

- A 50 ha site directly south of Highway 417, east of Carp Road, owned by Metcalfe Realty, the Mion family and other parties, designated as Rural Natural Feature and General Rural Area
- A 95 ha parcel owned by Del Corporation, directly south of Hazledean Road and east of Stittsville, designated as Agriculture Resource Area.

Appeals to the OMB are also outstanding for the following parcels near the watershed:

- A 232-ha parcel east of Shea Road and north of Fernbank Road, designated Agriculture Resource Area and General Rural. Applications from Brookfield Homes for this site have been prepared jointly with the applications for the Del property.
- A 125-ha site north of Fernbank Road and adjacent to the current urban boundary of Kanata, designated Agriculture Resource, is the subject of an application from West Park Estates.
- A 110 ha parcel north of Fernbank, east of Stittsville, designated General Rural and owned by Tartan Land.

Other appeals have also been filed south of Fernbank Road and west of Stittsville. In addition to these private appeals, City Council has requested a study of the land use designations and location of the urban boundary for a Special Study Area east of the Carp River adjacent to the proposed alignment of Terry Fox Drive. The report and a Council decision on its recommendations are scheduled for the fall of 2004.



Urban development has been approved in principle for large areas of now-vacant land within the subwatersheds and the next 20 years will see considerable change as these lands are urbanized. Although the 2003 Ottawa Official Plan maintains the current boundary of the urban area, this plan and its designations are under appeal and potentially, more land may become urbanized within the watershed.

3.8.3 Recreational Opportunities and Linkages

The City's Official Plan sets out policies for a continuous public path system along the Carp River in the Kanata urban areas and in the villages. This provides the authority for the City to use the development approval process, public works programs and projects, and master concept plan processes to implement this policy.

The Carp River flood plain, as mapped by the Conservation Authority, and as designated in the official plan, provides the setting for this pathway and other recreational opportunities. The flood plain also has the capability, based on the modified floodplain approach described above, for either private or public recreational facilities in the flood fringe zone and it also can serve as part of the landscape setting for developments outside of and adjacent to the floodplain.

As the Carp River proceeds northwest from the Kanata urban area, the change from urban to rural planning policy areas creates a disconnection of the recreational pathway system and urban open spaces from the river and floodplain. There is an opportunity to connect the urban recreational pathway system to existing, planned and potential systems in the rural area. The proposed trail system expands on some of the existing scenic routes that are already designated on Schedule "J" of the City's Official Plan, such as Carp Road and Galetta Side Road.

In the urban area and in the rural-urban fringe areas between Kanata and Stittsville, the Carp River floodplain provides the setting for a variety of recreational opportunities. This is demonstrated by the facilities at the Walter Baker Centre, which has an arena, a live performance theatre and an array of outdoor sports facilities that border on the east side of the Carp River. The Kanata/Glen Cairn stormwater management facilities at the "headwaters" of the Carp River and a similar facility on the east edge of the Corel Centre property are examples of infrastructure that is evolving into a natural appearing state while serving drainage control functions. These facilities offer settings for natural areas and informal trails along the Carp River. The southern edge of the Carp River subwatershed is marked by a section of the Trans-Canada Trail, which follows a former rail right of way between Kanata and Stittsville. With this important trailhead at the southern terminus, a continuous recreational path system is possible up to Hazeldean Road. This system can be connected to a trail and public park that is planned for the Monahan Drain, that flow in a south-easterly direction through future development in the Kanata South Business Park.

The reconstruction of Hazeldean Road, as envisioned in recent studies undertaken for the Environmental Assessment, presents an opportunity to provide a connection under the roadway by ensuring that bridge and culvert structures are raised sufficiently to allow pedestrian and cycling passage. North of Hazeldean Road the system connects to the Walter Baker Centre on the east and future recreational and public areas for the south-eastern section of the Kanata West area.

Highway 417 is a major barrier and a path system will have to rely on the local roads and Terry Fox Drive to cross the highway until an alternative becomes available. This could take the form of another pedestrian bridge, such as the one in the Kanata Town Centre or by raising future bridge and culvert structures of Highway 417 to enable passage underneath.



An example of this is the paved path on the east side of the Rideau River, by the Hurdman Bridge.

As noted above, the area north of Highway 417 makes a transition from urban to rural as the Carp River with the area in the west forming part of the Kanata West area while Terry Fox Drive and the Kanata Lakes community are located to the east. Terry Fox Drive, as noted above is proposed for construction on the east side of the Carp River, along the edge of the floodplain. This presents an important opportunity to provide a pathway linkage along the east side of the river. This area is also the confluence of Feedmill Creek from the west and the conceptual location of major stormwater facilities that will serve the Kanata West area that will collectively contribute to the setting of a recreational pathway system that will transition from the river and floodplain to other systems and the local road network.

A conceptual plan showing the potential for a trail system from the urban area through the rural area is presented on **Figure 3.8.5**. In the short term, this system could use the local roads in the vicinity of the Carp River and provide a variety of landscapes and views along the route, ranging from farm settings to rugged Canadian Shield character areas. This would be punctuated by arrival at the villages along the Carp River. The focus of the route could be along roads such as Carp Road, Old Coach Road and Diamond View Road with side routes leading to Kinburn, in closer proximity to the river. This could also serve as looping route that would terminate in the village of Fitzroy Harbour and connect to the provincial park nearby.

The trail connects the urban Recreational Pathways that extend northwest from urban Kanata along the roads that frame the Carp River Valley. The proposed route was set out with the following considerations in mind:

- Views to the Carp River in a variety of settings that range from village and agricultural to rugged Canadian shield terrain
- Views to the differing landscapes that frame the Carp River Valley and provide the settings described above
- Variety of experience and exposure to the rural character and heritage of this part of Ottawa
- Safety for pedestrians and cyclists is better away from busy roads, such as Carp Road, that have a highway character
- Connectivity of the urban community to the rural villages, and hamlets such as Carp, Marathon, Kinburn and Fitzroy Harbour
- Opportunities to either take shorter routes within the system or take side routes
- Maximum accessibility for users with minimal acquisition cost to the City
- Use of existing historic routes and available resources

These considerations have been applied in the proposed route that is presented on **Figure 3.8.5**. The proposed trail presents excellent panoramic views of the Cap River and its setting along various points, with examples such as Old Carp Road just north of the railway underpass, along Diamondview Road and along Galetta Side Road. These views can be enjoyed either briefly in a car or, with the proposed trial route, by cyclists and pedestrians.

The rural sections could be implemented relatively early and with a minimum cost that would be put toward maps, signage and interpretive structures that can provide cultural, historical and environmental information along the route. It will be essential to provide clear signage along the parts of the trial that use local roads to communicate the route and to educate motorists to use caution when approaching trail users. Given the length and character of the roads, the most probably users will be cyclists.



Land Use Synthesis

The key land planning issues for the Carp River subwatershed can be summarized by the following considerations.

The Carp River proceeds through three major settings; a fully urbanized area that is undergoing development, a rural/urban transitional area and a fully rural area that is punctuated by villages. These settings influence the approach that is to be taken on infrastructure, (e.g. stormwater facilities), public access and pathways and the natural environment along the river's course.

The Carp River is connected with several significant planning policies related to floodplain protection, unstable slopes, setbacks, public pathways and subwatershed planning. Subwatershed planning is the first step in planning for development in and around the river. The Carp River has a number of different functions, including drainage, a natural environment habitat, a water source for irrigation, a natural and aesthetic amenity, a land use separator, and an edge that marks the boundary between urban and rural areas.

Public access to the river and public pathways along the river in urban areas and village are a significant planning policy. Pathways are not required in rural areas along the river. The pathways that are or will be provided along the Carp River should connect to the wider system of trails and pathways in the western part of Ottawa.



4.0 OPPORTUNITIES AND CONSTRAINTS

An assessment of existing environmental conditions in the watershed has identified the current state of the watershed's environmental health. Based on this assessment, there are a number of limitations, or constraints, that are currently preventing a healthy environmental state from being achieved. On the other hand, there are also a number of factors, or opportunities, that if implemented could protect, enhance and/or restore the watershed to a healthy state. Section 4.1 provides a summary of the key findings described in Section 3.0. It also highlights the current constraints and potential opportunities associated with each resource area. Section 4.2, Integrated Findings, provides a synthesis of the interrelationships occurring between the natural resources demonstrating the vital functions that need to be maintained to achieve a healthy watershed.

4.1 Summary of Existing Conditions

Bedrock Geology & Soils

Bedrock in the Carp Watershed comprises of two types: 1) a prominent ridge of Precambrian metamorphic road forms the Carp Ridge along the eastern boundary of the watershed; 2) Paleozoic sedimentary rocks situated along the southern third of the watershed.

The groundwater catchment area extends considerably beyond the boundary of the Carp Watershed (extending out along the Paleozic bedrock).

The Carp Valley floor is dominated by clay loam and silty clay loam that are described as being the most fertile soils within the entire Ottawa Valley.

Stream Flow Characteristics

Daily and annual stream flows have decreased in recent years and this is particularly evident during the summer low flow period. These observations indicate that baseflows may be declining in the watershed.

Historical records show that the highest flows in the river occur in March and April when the snow melts and runs into the river (Almost 60% of the yearly volume of flow occurs in these two months). The lowest period is in August and September (5% of the yearly totals).

The soils of the watershed are primarily clay or rock-land, with very low surface slope. Infiltration throughout the watershed will be severely limited by the low porosity of the underlying soils. The land has little capacity to store peak events (rainfall), and as a result, the baseflow which supports aquatic ecosystems during dry periods is very low.

The floodplain along the main channel of the Carp River is quite wide, generally in excess of 500 m. As a result of channelization and removal of streamside vegetation, the floodplain has lost some of its natural functions and connectivity with the stream channel. Flooding also impacts agricultural lands, bridges and some structures.



Surface Water Quality

Where multiple sample locations are present on tributaries, water quality becomes more degraded as the tributaries approach the Carp River. Water quality, based on the parameters selected for the Water degradation Index (WDI), is most severely degraded on small tributaries that lie within the Carp Valley on agricultural lands. It is not possible to determine whether this degradation represents point sources or non-point sources, although the 2001 field program identified significant shoreline degradation and livestock access on several tributaries identified as "severely degraded". Hardness of water is lowest in tributaries that have wetlands at their headwaters, suggesting that wetlands provide a measurable contribution to baseflow;

An examination of the distribution of sampling sites characterized as "severely degraded" points to several major causes of degradation. In order of severity, these are phosphorus, nitrogen (as TKN and/or ammonia) and bacteria (E. Coli). Elevated iron and aluminium are well correlated with TSS. In contrast, "severely degraded" tributaries have the lowest levels of chloride of any tributaries. This combination of parameters is indicative of non-urban and agriculture non-point sources.

High levels of phosphorus in surface water are dominantly in the form of dissolved orthophosphate or "reactive phosphorus" ($PO_4^{2^2} - P$), suggesting inputs from fertilizers and possibly animal wastes.

Hydrogeology

Four aquifers are reported for the watershed: two within the overburden, which serve very few wells and two in the underlying bedrock, on of which (the Paleozoic) supplies 90% of the area wells.

Groundwater use for drinking water amounts to less than 1% of the annual recharge to aquifers. When all other uses are added (quarry de-watering, golf course irrigation, landfill purging), this figure increases to about 10%.

Permitted groundwater withdrawals from the subwatershed represent almost 50% of the total estimated groundwater withdrawal for the entire watershed. The majority of the permitted withdrawals in the subwatershed are from quarry de-watering. It must be emphasised that actual quarry pumping volumes (on an annual basis) are much lower than permitted volumes (expressed as a daily maximum). In one case, the total annual pump volume is only 20% of the permitted volume.

Significant recharge potential exists on the southerly watershed margin over the Paleozoic bedrock formation, in the headwaters of several permanent tributaries. The edge of this ridge, which parallels the Carp Valley on the southwest side, has alluvial deposits and provides groundwater discharge to tributaries here, such as Poole, Feedmill, Corkery and Huntley. The shallow bedrock, sands and gravels that typify recharge areas associated with this feature are present over less than 30% of the watershed, but account for over 50% of the recharge.

Headwater wetlands occurring on both margins of the watershed, though not strictly groundwater recharge areas nonetheless perform an important function. The wetlands lie on impermeable till layers and are able to store precipitation and snowmelt that would otherwise run off. Stored water in these wetlands is released gradually, providing a significant proportion of baseflow to Huntley, Corkery, Feedmill and Poole Creeks.



Erosion and Stream Morphology

Approximately 80% of the stream reaches within the Carp River and its tributaries have been significantly altered by urban and rural land use activities which include channelization, dredging, removal riparian vegetation, livestock access, agricultural practices, urbanization and transportation corridor impacts

The lower Carp River downstream of Kinburn to the mouth at Fitzroy Harbour is predominantly in a natural state and provides good habitat for both the aquatic and terrestrial communities. This reach is considered to be the most stable within the system as the evidence of erosion appears to be limited to natural processes including scouring the outer bends of meanders.

The middle and upper reaches of the Carp and its major tributaries (excluding Poole and Feedmill Creeks) have been significantly impacted/altered. The shallow gradients of these streams and limited baseflow results in a general lack of morphological diversity and uniform, fine substrates. These streams have generally been enlarged relative to their natural condition and are unable to transport their sediment load causing aggraded conditions (sediment build up).

Aquatic Resources

A total of 40 species of fish occur within the Carp watershed which include both stream resident fish and fish that migrate from the Ottawa River on a seasonal basis.

The lower Carp River, Poole Creek, Feedmill Creek and Huntley Creek, as well as the mouths of Corkery, "Carp" and "Smiths Corners" Creeks support the greatest diversity of species and best habitat conditions. Limiting factors include baseflow, stream temperatures, lack of riparian cover and to a lesser extent, stream instability and sedimentation. Poole, Feedmill, Huntley and "Carp" Creeks support a tolerant cold water fish community and a diverse warm water fishery, while the lower Carp supports a diverse, warm water fish community.

Other reaches of the permanent tributaries (eg. Huntley, Corkery, Feedmill) and the middle reaches of the Carp generally support a tolerant warm water fish community as a result of extensive stream alterations, poor riparian canopy, lack of baseflow and degradation of pool: riffle habitat.

The upper reaches of the Carp and the intermittent tributaries are highly degraded as a result of lack of base flow, nutrient/sediment loading, lack of riparian vegetation and poor instream habitats. The upper Carp has also been enlarged by dredging which has altered stream morphology and reduced the function of the riparian wetland features that form its banks.

Terrestrial Resources

The terrestrial features, which presently exist, include:

- Five candidate earth and life science Areas of Natural and Scientific Interest (ANSIs, 5.8%))
- Eleven provincially significant wetlands (3.8%)
- Forests and wetlands representing over 30% of the watershed area
- Grassland/old field habitat representing 5% of the watershed area



Compilation of both remotely and field-generated ecological data identified Centres of Ecological Significance which represent natural core areas and linkages of particular ecological importance in the Carp River watershed. These Centres include delineation of older, more natural woodlands, rare vegetation occurrences, extensive interior habitats, and special features concentrations. These are predominately located in the vicinity of tributary headwaters of the Carp River, with a secondary concentration downstream along the main river course near Fitzroy Harbour. These natural core and linkage areas include wetland complexes in the vicinity of Stittsville, an extensive upland forest complex associated with the Huntley Wetland, the Corkery wetland area, the Marathon Forest, the Carp Ridge, the Kinburn outcrop area, the Kilmaurs wetland complex and the Fitzroy area (Figure 3.5.11).

The primary terrestrial limitation in the watershed is the loss of connectivity between individual features; core areas and creek/river corridors which generally lack floodplain/riparian vegetation. Restoring these connections would increase ecological biodiversity and add to the size of individual features while providing corridors to facilitate the dispersal of plant and animal communities between major vegetation features. The potential for enhancement of hydrologic functions within floodplain and riparian areas also exists.

The wetlands appear to be underlain by clay deposits and therefore do not appear to provide a significant recharge function, however many of the upland features overlying the Precambrian and Paleozoic bedrock features provides recharge to the deeper aquifers. In the subwatershed planning area, over and above the watershed-scale contribution of the core natural areas, locally important ecological contributions are evident in the natural/ near-natural landscape remnants areas. Natural/ near-natural vegetation along creek corridors, such as the narrow deciduous forest riparian borders along Poole Creek and Hazeldean Creek in and about Stittsville and sections of Feedmill Creek north of Highway 417, for example, provide watercourse buffering as well as supporting populations of locally and Regionally significant flora and fauna. They also present a foundation from which much-needed habitat restoration can proceed to enlarge and enhance natural linkage functions to the presently degraded Carp River main course and within the upper areas of the Carp River watershed.

Land Use

Rural

The watershed is predominately rural with only about 10% in urban land uses, the majority of which occur in the urban area (Kanata, Stittsville). Development in the rural area is concentrated in the small village communities of Carp, Kinburn, Fitzroy Harbour, and Marathon with limited linear development along Donald B. Munro Drive. There is also some limited residential growth on the periphery of the Village of Carp and Fitzroy Harbour. Most of this residential development is in the form of rural estate subdivisions.

There are a number of rural estate subdivisions that have been approved for many years, but due to market conditions for this type of residential development, have not been developed. The amount of development that is either registered and draft plan approved in the rural areas could provide a steady supply of residential lots for many years.

The agricultural land uses represent 14,272 ha or 47% of the total watershed area. Pasture and hay crops were the most common agricultural land use type. The high percentage of pasture, hay, mixed crops and corn is indicative of a livestock farming area. Both beef and dairy operations are common in the area and livestock densities appear to be relatively high based on the farmstead density and evidence of livestock impacts on the watercourses.



The majority of intensively farmed lands within the Carp Watershed are located on the flat valley land along the Carp River and the lower portions of its tributaries. The main Carp and its tributaries generally lack riparian or streamside vegetation and are therefore poorly buffered from the effects of runoff containing sediment and nutrients from agricultural cropping practices. Priority areas for sediment/nutrient management on agricultural land were identified based on land use, topography, and stream buffering. Priority One areas represent lands in intensive crop production and Priority Two areas represent lands in pasture and less intensive crop use. Priority One areas would likely be most significant in terms of sediment and nutrient delivery to streams, whereas a Priority Two area may represent sources of manure runoff or potential stream access points for livestock. These areas are represented in the watershed as follows:

Priority One: 9113 ha (29% of watershed) Priority Two: 6040 ha (19.5% of watershed)

Possible point sources pollution problems on agricultural lands were identified based on current and previous studies. Priority stream reaches for point source pollution control from agricultural activities were identified. Priority One reaches are streams with point sources that may impact the Carp River during dry conditions and Priority Two reaches are streams which have substantial point source problem areas but may only contribute nutrients/contaminants during wet weather events. Other streams were considered to have the potential to impact the Carp River during severe wet weather events, such as spring melt.

Priority One:Streams included 66 km of channelsPriority Two:Streams included 16 km of channels

Urban

The majority of future residential development within the watershed is proposed within the urban area in the communities of Kanata West, Stittsville and Kanata Lakes neighbourhood. The major new growth area is the Kanata West development which encompasses about 1,500 acres of land surrounding the Corel Centre. The concept plan envisions a mixed use community that provides residential development, employment and community facilities. Recreational Pathway

The City's Official Plan sets out policies for a continuous public path system along the Carp River in the Kanata urban areas and in the villages. The Carp River flood plain, as mapped by the Conservation Authority, and as designated in the official plan, provides the setting for this pathway and other recreational opportunities. As the Carp River proceeds northwest from the Kanata urban area, the change from urban to rural planning policy areas creates a disconnection of the recreational pathway system and urban open spaces from the river and floodplain. There is an opportunity to connect the urban recreational pathway system to existing, planned and potential systems in the rural area. The proposed trail system expands on some of the existing scenic routes that are already designated on Schedule "J" of the City's Official Plan, such as Carp Road and Galetta Side Road.



4.2 Integrated Findings

4.2.1 Wetlands, Recharge, Fish Communities and Core Natural Features

One of the key limitations within the watersheds is the lack of baseflow to the Carp River and its tributaries. The majority of tributaries are intermittent in nature and only a few including "Smiths Corners", "Carp", Corkery, Huntley, Feedmill and Poole Creeks are considered to be permanently flowing. During a dry weather survey, these tributaries accounted for 132 l/s or about 50% of the total Carp River flow at Kinburn (252 l/s). The remainder of the flow was from direct discharge of groundwater to the Carp River. The inter-relationship between wetlands, groundwater recharge, fish communites and natural features is illustrated in **Figure 4.1.1**.

The headwaters of these tributaries extend to the margins of the watershed and each includes extensive wetland areas, most of which are provincially significant wetlands. These headwater areas also are underlain by surficial deposits of sands, gravels and shallow bedrock that have high recharge potential. It is interesting to note however, that not all of the wetland features in these headwater areas provide a direct recharge functions as many of them are underlain by impermeable materials such as muck and clay. These wetlands do however serve several key functions that serve to maintain stream baseflows as follows:

 Wetlands that directly overlay recharge areas serve to recharge the shallow and deep aquifer systems that supply drinking water for the majority of rural and rural community residents.

Wetlands that directly overlay recharge areas serve to recharge the shallow and deep aquifer systems that baseflow to local tributaries as well as the Carp River.

Wetlands that are underlain by impervious materials still serve an important hydrologic function to local tributaries by capturing the runoff from their upstream drainage areas and acting as a "sponge" to reduce peak discharges to these creeks and provide extended release of this surface runoff to the creeks thus maintaining baseflows.

Several wetlands in the headwaters of Corkery and Huntley Creeks serve an indirect recharge function by gradually releasing runoff downstream to portions of these streams that are underlain by sands and shallow bedrock. These streams then recharge the groundwater system and are called "losing" streams, because their flow diminishes through these reaches.

The tributaries with headwater wetlands are the only tributaries in the watershed that support either coldwater fish communities or diverse warmwater fish communities, which represent the best quality and most sensitive fish communities in the watershed. The only other area where diverse warmwater fish communities occur is in the lower Carp, downstream of Kinburn. These fish communities require a dependable supply of baseflow to maintain critical spawning and nursery habitats and to regulate stream temperatures.

Finally, the headwaters of these tributaries, because of their unique combination of topography (relief), surficial geology and soils, and waterbodies (mostly as wetlands) have given rise to some of the best quality woodlands (over 50 years old), most extensive natural areas (represented by interior forest habitat), and areas of high biodiversity (represented by rare species habitats and extensive areas of common vegetation). These extensive areas of upland/swamp forests, wetlands and successional communities represent the most important core natural areas within the watershed in terms of vegetation and wildlife habitat (**Figure 3.7.11**). The importance is even more significant by virtue of the fact that they protect much



of the important recharge areas and wetland drainage areas within the watershed. These natural features provide both a water quality and quantity function in relation to groundwater recharge and stream discharge by:

- Slowing rates of runoff and snowmelt to tributaries;
- Providing a cool microclimate that delays snowmelt reducing runoff and promoting recharge;
- Attenuating nutrients and contaminants in surface water as it either infiltrates into the groundwater system or runoffs off into streams thus improving water quality; and,
- Moderating stream temperatures important to sustaining fish communities.

It is probable that the supply of cool, clean base flows from the headwater areas of these tributaries in part offsets the degrading impacts of rural and urban land use practices that impact these watercourses as they cross the Carp valley and discharge in the main river.

4.2.2 Aquatic Habitats, Morphology, Riparian Vegetation and Sediment Management

A large percentage of stream sections examined for evidence of morphological impacts leading to instability indicated that stream channels and the adjacent riparian areas have been altered. This includes some extensive reaches of the main Carp River. One of the more serious problems appears to be aggradation, which was observed at over 80% of the sites examined. This is particularly evident in the rural tributaries and in the upper Carp (upstream of the village of Carp). In fact the depth of sediment in the Carp riverbed in the upper section is probably in the order of metres of sediment and the same is true of some of the tributary mouth areas. Because of the watershed hydrology and the extensive sediment loading from rural and in some cases urban land uses (e.g. construction), most tributaries and the Upper Carp River have insufficient stream power to transport sediment out of the reach, resulting in aggradation and sediment buildup.

The impact of this sediment buildup is to precipitate a series of channel adjustments in the stream, such as widening (through bank erosion),headcutting (erosion of the streambed in an upstream direction) and straightening (loss of natural meander pattern). These adjustments have the general effect of causing further aggradation and loss of stream power, because the channel is becoming over-widened relative to its natural width. This creates problems with municipal drains (the channel aggrades above the level of the drain outlet) and livestock watering (water is too shallow and the streambed is too soft to provide access). This leads to the need for costly and often ineffective drain maintenance activities.

Furthermore, the accumulated sediment in streams creates a degraded environment for fish and other aquatic life, by smothering sensitive habitats, fostering excessive plant growth that uses valuable and scarce oxygen supplies and reduces pool and riffle depths making such areas unusable as fish habitat. For example, the upper Carp River supports only a degraded warmwater fish community. Conditions are made worse, since nutrients and contaminants are carried by sediments into the stream where they cause water quality deterioration and can accumulate in the streambed sediments. The benthic invertebrate community is a sensitive indicator of nutrient-rich sediments and the community that exists in the upper Carp reflects very poor water (and sediment) quality.



Water quality conditions in the intermittent tributaries also indicate severely degraded conditions with among the highest concentrations of nutrients in the watershed. These tributaries, however may only contribute to water quality impairment in the Carp River during periods of high flow, when water quality impairment is less of a concern. Unfortunately when the sediments carrying nutrients from these tributaries settle on the Carp riverbed, they can accumulate and create eutrophic conditions leading to excessive plant growth.

The source for much of this sediment is from intensive cropping practices, primarily corn and soybean crops. Without some form of conservation tillage or winter protection on these croplands, soil erosion and transport to nearby streams can be substantial. This situation is made more severe when streamside vegetation is lacking provides no buffering of runoff to the stream. Large reaches of the Carp River and most tributaries lack streamside vegetation to serve this purpose. As indicated above, this loading of sediment leads to adjustments in stream morphology that further increase sediment loading. Livestock access areas also can be a source of sediment to the stream as a result of trampling of stream banks. Portions of the main Carp, as well as portions of the permanently flowing tributaries are targeted for management of point and non-point rural pollution of this type.



5.0 STUDY GOALS AND OBJECTIVES

5.1 General

Goals and objectives are broad statement of intent, that when applied to a watershed, address the local management issues and needs. Generally, goals and objectives are developed for natural resources or aspects of the watershed that are desired values or, threats to desired values (MOEE, 1993a). For this watershed study goals and objectives have been developed for surface water, groundwater, aquatic and terrestrial resources:

The identification of goals and objectives for the Carp River watershed is important because they deal with the key concerns and issues related to the management of the natural resources within the watershed.

The study goal statement defines what the stakeholders expect the watershed to be like in the future and is important as it guides the work that needs to be undertaken and helps to set priorities. The following study goal statement has been developed for the Carp River Watershed/Subwatershed:

Study Goal

To develop and implement appropriate strategies in order to protect, enhance and restore the natural resources of the Carp Watershed under present conditions and as land use changes occur.

Principles

- 1. Protection, enhancement, restoration of healthy natural resources are essential to the social and economic well being of Carp Watershed residents.
- 2. Stewardship of natural resources on public and private lands is the cornerstone for achieving healthy natural environment
- 3. Urban growth must protect existing natural resources and provide an opportunity to rehabilitate upgraded environments to a healthy state.
- 4. Public awareness and support for stewardship and natural area protection programs should be encouraged through the provision of passive recreation and natural interpretive opportunities
- 5. To follow the Class Environmental Assessment process which provides for a balance of economic, environmental and social considerations.

5.2 Environmental Goals/Objectives

The following presents the goals and objectives for the watershed/subwatershed plan. It is expected that many of these objectives can only be achieved over the long term.

Goal #1 – Surface/Ground Water Quantity

Ensure that the hydrologic regime (surface drainage to wetlands, ponds and watercourses, as well as flows in the groundwater system) of the watershed is suitable to:



Objectives

- Minimize flood risk to existing residents;
- Restrict future development from flood-prone areas;
- Protect groundwater supplies, including recharge and discharge areas which provide drinking water and stream base flows;
- Maintain natural channel stability in all watercourses;
- Provide a flow regime suitable for the maintenance of healthy aquatic and terrestrial communities; and
- Manage surface water withdrawals to protect stream base flows.

Goal #2 – Surface/Ground Water Quality

Protect the quality of surface waters in wetlands, ponds and streams to:

Objectives

- Support reasonable human uses, including irrigation, livestock watering, aesthetics;
- Prevent eutrophication, stagnation and excessive algal growth;
- Prevent contamination of groundwater which provides a source of drinking water and which supports local aquatic and terrestrial communities; and
- Maintain healthy aquatic and terrestrial communities.

Goal #3 – Aquatic Resources

• Establish a healthy aquatic ecosystem, which supports resident, coldwater and warmwater fish populations by:

Objectives

- Protecting critical reaches with healthy fish communities;
- Protecting/restoring natural streamside vegetation;
- Protecting/restoring the natural morphology, sediment transport and flow characteristics of streams;
- Restoring the quality of surface waters necessary to support healthy aquatic communities;
- Enhancing the microhabitats, such as pools and riffles, important to aquatic life;
- Maintaining opportunities to provide for unrestricted movement of fish; and,
- Protecting groundwater baseflow.

Goal #4 – Terrestrial Resources

Establish a healthy terrestrial ecosystem by:

Objectives

- Protecting and restoring "valued" terrestrial features, ANSIs, wetlands and core natural areas, as well as wetlands, stream corridors and woodlots;
- Providing habitats suitable for native plan and animal communities; and
- Enhancing terrestrial features that perform related ecosystem functions such as wildlife corridors, water storage and groundwater recharge/discharge.



5.3 Public Input to Goals and Objectives

Meetings took place with the Steering and Public Advisory Committees to discuss the draft Watershed Report Card as well as to introduce the draft study goals and objectives. A Public Open House was held at the Agricultural Society Building, Carp Fairgrounds, 3790 Carp Road, on Wednesday, November 14, 2001, between 4:00 and 8:00 pm. The purpose of the open house was to report on the progress of the study and to obtain the public's opinion regarding the data collection, initial findings, and present the draft Study Goals and Objectives.

The open house featured a number of display boards that outlined the project scope and results of the field work. The consultant team provided a PowerPoint presentation summarizing the study results. This was followed by a question and answer session. The presentation dealt with the following issues:

- Community Survey
- Historical Land Use Practices and Associated Impacts
- Aquatic Resources
- Terrestrial Resources
- Stream Morphology
- Hydrogeology
- Water Quality
- Recreation
- Hydrology
- Urban Land Use
- Rural Land Use
- Integrated Findings and Analysis
- Next Steps

A total of 33 participants were registered although the actual number of attendants was much greater, probably in the order of 50 people. Questionnaires were handed out to gauge the public's response to the material presented. Four completed questionnaires were received and the input was as follows:

- 75% agreed with the material that was presented, 25% did not respond
- Additional comments included:
 - Some methodological problems with data collection, e.g. water intake by quarrie and golf courses not included. This may weaken the results.
 - Very impressed with the displays
- 75% had no additional questions or comments on the draft study goals, 25% did not respond
- 50% had no issues or additional information to be added to the study, 50% did not respond
- 25% found the open house very useful, 50% found it useful, 25 % did not respond
- 50% found out about the open house through newspaper ads, 25% through the newsletter, and 25% through the Kanata West Concept Plan process.
- 50% were landowners in the study area, 25% were residents, 25% were 'other'.


 Additional comments included reference to the Kanata West Concept Plan and March Highland Housing projects as the most significant potential pollution threats.

Documentation associated with the second Public Open House is presented in **Appendix F**. The third Public Open House (Section 7.3) describes additional consultation on the final Study Goals and Objectives as presented in this section.



6.0 ALTERNATIVE BEST MANAGEMENT PRACTICES

6.1 General

This chapter will describe the different types of Best Management Practices (BMPs) that may be implemented in order to protect, enhance or restore the environment. As there are many BMPs that could be considered for any given area, not all will be described in detail. **Table 6.1** provides a list of BMPs.

Section	BMP Alternative	Land Type
No.		
6.3.1	Municipal Source Control Practices	Urban
6.3.2	Infiltration Facilities	Urban
6.3.3	Water Quality/Quantity Facilities	Urban
6.3.4	Urban Retrofitting	Urban
6.4.1	Buffer Zones	Urban/Rural
6.4.2	Aquatic Habitat Restoration	Urban/Rural
6.4.3	Stream Restoration/Natural Channel Design	Urban/Rural
6.4.4	Terrestrial Habitat Restoration/Reforestation	Urban/Rural
6.4.5	Wetland Creation	Urban/Rural
6.4.6	Public Education	Urban/Rural
6.4.7	Erosion and Sediment Control During Construction	Urban/Rural
6.4.8	Groundwater Recharge and Baseflow Protection	Urban/Rural
6.4.9	Source Protection Plans	Urban/Rural
6.5.1	Livestock Access Control	Rural
6.5.2	Fertilizer/Manure Management – On-Field Measures	Rural
6.5.3	Fertilizer/Manure Management – Streamside Measures	Rural
6.5.4	Manure/Feedlot Storage and Handling – Structural and Non-	Rural
	Structural	
6.5.5	Fragile Land Management	Rural
6.5.6	Road Side Ditch and Drain Maintenance using Natural Channel	Rural
	Design Principles	
6.5.7	Milkhouse Waste Management	Rural
6.5.7	Pesticide Storage and Management	Rural
6.5.7	Irrigation Management	Rural
6.5.7	Replace Faulty Septic Systems	Rural

Table 6.1
Listing of Alternative BMPs

The chapter has been divided into three sections; urban, urban/rural and rural, as both types of land uses can significantly impact present environmental conditions within the Carp Watershed.



6.2 General Types of Best Management Practices

Prior to presenting the various BMPs, the general categories by which most BMPs will fall are described. Each of the BMPs presented may be included in one of the following four categories:

- Environmental protection or prevention
- Environmental control;
- Regulatory control; and
- Habitat protection, restoration or enhancement

6.2.1 Environmental Protection or Prevention

Environmental protection or prevention is an umbrella term for a wide range of pollution reduction activities which are carried out at the source of where the pollutant originates. These may include:

- Public education eg. Educate urban consumers on household hazardous wastes and lawn management practices; educate farmers on conservation land management.
- Source control eg. sewer use bylaw enforcement, spill prevention and management at source control of urban runoff; manure/feedlot storage and handling.
- Inspection eg. regulatory inspection of erosion/sediment control devices.
- Alternative substance/material usage eg. replacing or substituting hazardous for non- hazardous materials in processes.

6.2.2 Environmental Control

Environmental control generally involves the implementation of technical solutions to reduce/minimize/eliminate the impact of a given contaminant. Prime examples include the upgrading of a water pollution control plant to treat combined sewer overflows or the installation of a stormwater management facility to reduce water quality contaminants associated with stormwater runoff. Rural examples include: livestock access control, conservation tillage practices and fertilizer management.

6.2.3 Regulatory Control

Regulatory control may be applied in one of many ways. For example, the Ministry of the Environment has various programs (eg. Municipal Industrial Strategy for Abatement of Pollution (MISA)) which set standards for the discharge of pollutants from various municipal and industrial plants. Regulatory control may also be used to protect environmental features (eg. through the Wetlands Policy or Fisheries Act). Lastly, regulatory control may be applied in conjunction with environmental control alternatives. This approach was used in the City of Ottawa where proposed stormwater management facilities which discharge flows to the Rideau River must have effluent levels of faecal coliform less than 100 E coli/100 ml. The New Nutrient Management Act regulations require nutrient management plans to be developed and identify minimum buffer widths along watercourses.



6.2.4 Habitat Protection, Restoration or Enhancement

The protection, restoration or enhancement of habitat is generally used to improve conditions for aquatic species, waterfowl or wildlife. Improving habitat also has ancillary benefits with respect to baseflow and groundwater resources (as increased vegetation generally increases infiltration to the soils). Also, habitat enhancement may have multiple benefits in situations where the stability of streams is improved. Typical habitat restoration includes streamside vegetation planting, stream channel restoration and naturalizing/planting abandoned agricultural lands.

Prior to describing the BMPs, several points should be noted. These are summarized below:

- 1. Several of the BMPs, such as pubic education or source control, should be implemented in all cases, while others such as infiltration facilities are feasible only in specific areas.
- 2. For several of the BMPs, it is relatively straightforward to quantity the impact. For others, it will not be because of the type of BMP (eg. buffer strips) or because of the benefit of the BMP is not yet quantified.
- 3. Several alternatives, ie. Reforestation, habitat restoration, buffer zones, natural channel design may be applied in both urban and rural settings.

The following sections outlined the alternative BMPs. The urban BMPs are presented in Section 6.3, while the rural BMPs are presented in Section 6.4. For several of the alternatives, a brief description is provided as is a listing of potential constraints which may limit the feasibility of applying the given BMP. A statement as to whether the given BMP should always be applied (ie. If there are no technical considerations such as is the case for public education) is also given.

At the beginning of each section a summary table defining the general types of BMPs and the potential benefit on different environmental resources is provided. For further information regarding urban BMPs the reader is directed to the Ontario Ministry of the Environment Stormwater Management Planning and Design Manual (MOE 2002).

6.3 Urban Best Management Practices

A listing of available urban BMPs is provided in **Table 6.2**. The table identifies the environmental resource that is benefited by the individual measure.



Table 6.2 Urban BMPs

Environmental Benefit	Municipal Source Control Practices	Infiltration Facilities	Water Quality/ Quantity Facilities	Urban Retrofitting
Surface/Groundwater Quantity				
reduce runoff	х	х	х	х
increase infiltration	x	x		
reduce flooding			х	х
reduce streambank erosion	x	х	х	х
maintain/enhance natural hydrologic regime	x	x	x	x
Surface/Groundwater Quality				
reduce sediment loading	x	x	x	x
reduce pollutants in runoff/sediment	x	x	x	х
reduce groundwater contamination				
reduce instream sediment deposition		х	х	х
reduce instream contaminants	x	x	х	х
Aquatic Ecosystem				
maintain/enhance baseflows	x	х	х	х
maintain/enhance natural channel morphology		x	х	х
maintain/enhance riparian vegetation				
moderate stream temperatures	х	х	х	х
protect/enhance instream habitats		х	х	х
Terrestrial Ecosystem				
protect/enhance forests and wetlands				
protect habitats for special status species				
protect/enhance wildlife corridors				

6.3.1 Municipal Source Control Practices

The primary philosophy behind using source control measures is to stop the problem at the source, thereby, reducing the downstream impacts. There are various source control measures which are frequently used by municipalities and homeowners. These include:

- Street sweeping
- Catchbasin cleaning
- Installation of spill control devices
- Management of hazardous household wastes
- Pet litter and general litter control
- Sediment/erosion control during construction

Other measures, such as using sumpless catchbasins (where the soils are permeable) or filter bags within catchbasins, have been used in several municipalities.

Source control practices are quickly gaining favour over control alternatives and should therefore be implemented wherever possible.



Various measures may be carried out on-site to reduce the impact of urbanization from the individual residential, commercial or industrial sites. In general, all the alternatives are based on one of two principles, ie.:

- Reduce the volume of runoff from the site
- Filter the runoff prior to discharge from the site

Several activities which should be considered include:

- Discharging of roof leader flows to grassed areas, soakaway pits or rain barrels as illustrated in Figure 6.3.1 and Figure 6.3.2 (Photos)
- Filtering runoff from impervious areas by conveying flows across grassed areas
- Replacing impervious materials with alternatives such as interlocking stone, crushed stone or porous pavement which promote infiltration
- Grading sites, where the soils permit, to promote infiltration (ie. Provide depressions to store runoff) or reuse as an amenity
- Minimizing alternations to original grades

The above alternations may, for the most part, be implemented within new developments or incorporated into redevelopments. They are therefore not subject to any technical limitations.

6.3.2 Infiltration Facilities

One of the key impacts urbanization has on the environment is the change of the hydrologic cycle.

Infiltration at all levels (eg. on-site and on a centralized basis) will assist in reducing the impact by: (see **Figures 6.3.3 thru Figures 6.3.7** (Photos).

- Reducing the rate and volume of water and pollutant loading reaching the local streams and rivers by overland routes
- Replenishing the groundwater supply
- Augmenting the baseflow to the local streams and rivers
- Potentially reducing the water temperature to the receiving body of water

Methods of promoting infiltration on an on-site basis are described in Section 7.3.3. On a centralized basis, infiltration may be carried out by constructing:

- Infiltration trenches or
- Infiltration basins

Several factors must be considered when designing and constructing infiltration facilities. These include:

- Soil type
- Depth to watertable
- Depth to bedrock



Any infiltration device will be susceptible to clogging. Therefore, erosion/sediment control during construction should be strictly enforced and grassed buffers, sediment traps or special inlets should be constructed upstream of the trench to reduce long-term sediment loadings.

One potential risk of infiltrating stormwater is the possibility of contaminating the local groundwater drinking source. This risk must be assessed prior to the selection of this BMP.

6.3.3 Water Quality/Quantity Control Facilities

Water quality/quantity control facilities, as a group, include detention (dry) ponds, extended retention (wet) ponds and hybrid wetponds/wetlands. Dry ponds have historically been constructed in order to reduce the impacts of urbanization on flooding and erosion as shown in **Figure 6.3.8** (Photo). Dry ponds have a minimal impact on reducing water quality pollutants.

Wet ponds as illustrated in **Figure 6.3.9** (Photo) are generally constructed in order to remove pollutants from stormwater runoff, and have been found to be efficient in reducing particulate matter, including suspended solids, organic nutrients, heavy metals and BOD. Biological processes may also be used to reduce soluble nutrients. Reduction of peak flows to reduce downstream erosion or flooding may also be incorporated into a wet pond; however, the design must ensure that resuspension of settled material during severe events does not occur. Wet ponds may also be used to augment baseflow during low flow conditions.

Hybrid wetponds/wetlands combine the features and benefits of a pond and wetland. The plants located in the wetland component assist in reducing nutrients, provide a natural setting and may provide limited habitat value.

A majority of the facilities presently being constructed are wetponds or hybrid wetponds/wetlands.

Several items should be considered when designing a water quality/quantity control facility.

These include:

- Water quality target
- Water quantity target
- Safety
- Liability
- Integration into the surrounding area
- Operation and maintenance

There are several constraints which must be considered prior to selecting water quality/quantity facilities as a potential BMP. These include:

- Space requirements
- Minimum upstream drainage area (for water quality facilities)
- Soils (facilities constructed in areas containing sands and loams may wash out during severe events)
- Safety
- Existing aquatic resources (existing or potential aquatic resources precludes the use of an in-line facility as the facility will create a barrier to migration).



Further details with respect to benefits, constraints, and design considerations are provided in the MOE manual (MOE 2003) previously referenced.

6.3.4 Urban Retrofitting

Redevelopment within urban areas will provide an opportunity to improve upon existing conditions and ultimately be more environmentally conscious. Whenever possible, methods which promote infiltration, improve both water quality and quantity and are cognizant of the potential impact of spills should be promoted.

In general, there are three categories where retrofitting could occur. Retrofitting (or restoration) may occur:

- At source
- Within existing BMPs (eg. retrofitting a dry pond to provide water quality benefits) and urban infrastructure
- Within the urbanized streams and rivers

Source retrofitting is particularly applicable to individual commercial sites or industrial sites as they are redeveloped. Retrofitting of the municipal infrastructure will, in the long term provide benefits as the existing infrastructure is replaced. Restoration of existing streams and rivers is detailed in other sections (natural channel design, reforestation, aquatic habitat protection).

Urban retrofitting, depending upon the application, will generally be dependent upon the same considerations as outlined for a proposed application for new developments. The applicable constraints have been outlined in various sections.



6.4 Urban/Rural Best Management Practices

A listing of BMPs that can be applied in both the urban and rural areas is providing in **Table 6.3** below.

Table 6.3 Urban/Rural BMPs

Environmental Benefit	Buffer Zones	Aquatic Habitat Restoration	Stream Restoration (Natural Channel Design)	Terrestrial Habitat Restoration/Reforestation	Wetland Creation	Public Education	Sediment/Erosion Control During Construction	Groundwater Recharge and Baseflow Protection	Source Protection Plans
Surface/Groundwater Quantity									
reduce runoff	х			х	х	х		х	х
increase infiltration					х			х	х
reduce flooding					х				
reduce streambank erosion	х		х	х		х	х		
maintain/enhance natural hydrologic regime	x	x	x	x	x			x	x
Surface/Groundwater Quality									
reduce sediment loading			х		х	х	х	х	х
reduce pollutants in runoff/sediment	х			х	х	х	х		
reduce groundwater contamination	х			х	х	х	х	х	х
reduce instream sediment deposition			х		х	х	х		
reduce instream contaminants	х	?	х	х	х	х	х	х	х
Aquatic Ecosystem									
maintain/enhance baseflows	х			х	х			х	х
maintain/enhance natural channel morphology	x	x	x	x					
maintain/enhance riparian vegetation	х	x	x	x	x	x			
moderate stream temperatures	х	х	х	х				х	х
protect/enhance instream habitats	х	х	х	х		х	х		
Terrestrial Ecosystem									
protect/enhance forests and wetlands	х	х	х	х	х	х	х	х	х
protect habitats for special status species	x	x		х	x				
protect/enhance wildlife corridors	х	х	х	х	х	х			



6.4.1 Buffer Zones

Buffer zones are areas of permanent self-sustaining indigenous vegetation communities located between development sites or agricultural lands and sensitive features.

Buffer zones should be considered along stream banks and valley tops, and around wetlands, woodlots, and sensitive areas which require control of human and/or livestock intrusion. Riparian planting techniques include seeding, sodding, stake, wattles, transplants and nursery stock. Key functions of buffer zones include:

- Wind control
- Sediment control
- Reduction of runoff and control of input of dissolved and particulate contaminants to watercourses
- Provision of terrestrial/aquatic habitat and food sources
- Stream shading
- Bank stabilization
- Greenspace/passive recreational opportunities/aesthetics
- Sign and noise barriers

Current MNR specifications require riparian buffer zones, 15 m wide along each bank of warmwater streams, 30 m wide along each bank of coldwater streams, and 9 m wide buffer zones along the top of steep slopes. For other locations, a typical guideline is that the width of the buffer zone from the water's edge should be 20 m plus 1.5 times the slope gradient (ie. for a 10% slope, add 15 m). Under the Nutrient Management Act, a buffer width of 3 m on either side of the watercourse is recommended on active agricultural lands.

Provision of buffer zones along non-regulated features usually requires dedication of land that might otherwise be developed. Site preparation is critical to the success of riparian plantings, and the degree of preparation will vary with the techniques used and the soils present. Machinery may be required in some instances. Adams and Whyte (1990) provide advice and details on riparian planting methods.

6.4.2 Aquatic Habitat Restoration

A number of methods are available for restoration of physical aquatic habitat. The two primary alternatives relate to streambank stabilization and creation of in-stream structures. Other BMPs, such as buffer strips and wetland creations or enhancement can also contribute to habitat improvement and it is recommended that wherever possible, these methods be used in conjunction with the habitat restoration methods described below.

A number of techniques are available for streambank stabilization. The use of any one technique will be dependent on factors such as bank size, erosion potential and cost. Several techniques that should be considered include:

- Placement of rock rip rap or other inert materials such as log walls, timber cribs and tree revetments
- Bioengineering approaches (commonly referred to as biotechnical bank stabilization), such as soft gabions and live crib walls composed of dogwood, willow and alder;
- Streambank fences and crossings to prevent livestock or human intrusion in sensitive areas – fences should be set back from the top of bank to allow establishment of the riparian zone and lateral stream movement



As for streambank stabilization, there is a wide selection of techniques used to provide instream cover for fish. These techniques involve the installation of rocks and/or wooden structures within the stream channel. Examples are weirs, ramps, deflectors, boulder groups, large organic debris, submerged half logs and log bank cover structures. In some instances, it is possible to create spawning beds or channels. Summaries of these techniques are provided in several documents (OMNR, 1984; Alberta Environment, 1986; Adams and Whyte, 1990). The selection of a particular technique depends on site-specific features such as the species or aquatic community objectives, stream size and gradient, and peak flows.

Installation of bankside and in-stream structures requires that they be able to withstand hydraulic forces. Such structures must be adequately secured, and proper installation is essential. Improper installation may result in overall habitat loss if the structure is dislodged, and may cause further damage downstream. The durability, maintenance requirements, and installation costs of available techniques is highly variable, however, it is strongly recommended that the reach in which these structures are installed be stable.

6.4.3 Stream Restoration (Natural Channel Design)

One means by which the impact of land use activities including development, agriculture land use practices and municipal drainage practices, on a watercourse may be mitigated is through the preservation of existing channels, and the design of natural channels for degraded stream reaches. In fact, existing channels are often in the process of adjusting to an altered hydrologic/sediment regime as a result of existing land uses. Consequently, the channel may continue to degrade even if appropriate controls are placed on new development or even if the conservation tillage practices are implemented. This requires that planners and drainage engineers rethink drainage practices. Traditional techniques of straightening and channelizing drainage swales, and lining watercourses with manmade materials (eg. concrete), need to be abandoned. Rather, the principles of fluvial geomorphology need to be incorporated into urban drainage designs. These principles, called natural channel design principles, stress that natural watercourses normally have three distinct channels for flow conveyance, and that each of these channels plays an important role in establishing and maintaining the ecosystem in and adjacent to a watercourse.

These channels include:

- A low flow channel for baseflow and flow conveyance of typical (eg. weekly) runoff events
- A bankfull channel to convey runoff from less frequent (eg. 1 to 2 year) runoff events
- A floodplain to convey flows which exceed the bankfull capacity of the watercourse

Fish habitat is most frequently found in the low flow channels. Similarly, the floodplain normally contains habitat for wildlife, and this habitat requires flooding to preserve its distinct characteristics. In addition, each watercourse has a natural sinuosity at which it functions best, and which should remain undisturbed to preserve its velocity characteristics and sediment carrying capacity. An example of a natural channel design is shown in **Figure 6.4.1 and Figure 6.4.2** (Photos).

Although these principles differ substantially from current practices, they should be incorporated into existing and future developments to help limit the impact of land use activities on a watercourse and its ecosystem.



Furthermore, in areas where alteration of the channels are required, techniques which promote the use of natural materials should be used to ensure that both they hydraulic and environmental capacity are optimized.

There are no technical constraints to applying natural channel design using the principles of fluvial geomorphology. The successful adaptation of this approach will, however, require rethinking and education of the designers to ensure that the proposed designs are appropriate.

6.4.4 Terrestrial Habitat Restoration/Reforestation

For reforestation and wetland restoration emphasis should be placed on use of native plant materials and avoidance of monoculture plantations. Re-establishments of floodplain connections and maintenance of flood frequency and depths on riparian areas are key measures to improve terrestrial habitat. Opportunities exist to enhance terrestrial habitats through natural landscaping around stormwater management ponds, particularly if the pond is located adjacent to a woodlot, thus diversifying habitat. On a micro scale, habitat enhancement may include provision of nest boxes, brush piles for cover and islands within wetlands to provide shelter from predators and establishment of temporary wetland features as habitat for amphibians and reptiles.

Reforestation is an alternative that has recently been proposed in many regions within Canada. If applied on a wide-scale basis, reforestation may be used to offset the impact on the hydrologic cycle due to urbanization. The programs are especially effective in upland areas where the impact on the smaller streams due to land use changes may be more pronounced.

Reforestation of the valley lands also provides many benefits including:

- Improvement of the riparian stream buffer zone
- Reduction in streambank erosion
- Improvement to wildlife habitat
- Improvement of riparian canopy
- Provision of a continuous wildlife corridor

The Town of Markham has recently undertaken an extensive reforestation program for several of the reasons described above.

There are no technical constraints to carrying out reforestation programs. Large scale programs will require innovation with respect to implementation of the program and acquisition of funding.

6.4.5 Wetland Creation

Artificial wetlands have been used in many parts of the United States and Europe for treatment of many types of effluent including acid mine drainage, sewage treatment and food processing effluent. They are gaining increasing popularity as a means of controlling downstream effects of urban runoff, and for reducing suspended solid, nutrient and trace contaminant concentrations. In rural areas, artificial wetlands re also being constructed to manage runoff from feedlots and manure storage facilities.



Contaminants are removed from the water column through sedimentation and through anaerobic chemical and microbial-mediated reactions. Vegetation, substrates and microbial populations are key components of the system. Such systems can have the additional benefit of attracting wildlife, and adding wetlands to areas where existing wetlands have been destroyed by draining or developing. Four types of systems are currently in use:

- 1. Densely vegetated overland flow
- 2. Subsurface flow through a crushed rock bed
- 3. Pond/island wetlands
- 4. Channel wetlands with floating vegetation

Sites suitable for construction of artificial wetlands must be depressions, have a gently sloping downstream gradient, adequate water supply and an ability to retain water at required levels. Good knowledge of the water budget, including groundwater discharge is required. This pre-construction monitoring of surface and subsurface flows for at least one full hydroperiod.

Depending on design requirements, such as retention period and removal efficiency, such systems may require large land areas.

Removal efficiencies for contaminants which are achieved through temperature-sensitive reactions (eg. nutrients) are much lower during the winter months, and the system may require special maintenance during ice-covered periods.

6.4.6 Public Education

In recent years, considerably more effort has been spent on educating the public as to the potential impacts of urban and rural land use practices and defining ways in which they can assist in reducing the impact.

Several measures which may be carried out by the public include:

- Water conservation
- Reducing use of toxic/hazardous chemicals
- Composting
- Increasing the reuse, recycling and reduction of non-renewable resources
- Minimizing use of fertilizers
- Controlling pets
- Use of rural BMP's, particularly buffer plantings and conservation tillage practices
- Replacement of faulty septic systems

There are no technical constraints to implementing a public education or public awareness program. Indeed, many municipalities are actively trying to educate the public as to how they can be environmental stewards. The Upper Thames River Conservation Authority (UTRCA) has used public education as a key component for two proposed stream restoration projects (Hall Creek and Avon River).



6.4.7 Erosion and Sediment Control During Construction

The use of erosion and sediment controls during construction can significantly reduce the potential for sediments entering the receiving body of water. All construction activities whether they include stream crossing work, projects within floodplain lands or some distance away, must consider the potential for sediment transport to receiving waters. The principles of control are based on preventing or minimizing erosion of soil and trapping of suspended soil particles during wet weather conditions.

The use of a well prepared erosion and sediment control plan will ensue the maximum benefits are obtained. The plan should consider:

- The prioritisation of erosion controls over sediment controls
- Construction schedule
- Areas of sheet and concentrated flow

Commons types of controls include:

- Rock check dams
- Temporary sediment basins
- Soil covers (mulches, seeding, sodding, etc)
- Locating and stabilization of soil stock piles
- Cofferdams
- Gabion and slope sediment traps
- Catchbasins and sewer outfall capping
- Buffer zones

There are no technical constraints to implementing the above works. Many municipalities within Ontario have recently passed Top Soil By-Laws to ensure that the works as shown on the design drawings are carried out.

6.4.8 Groundwater Recharge and Baseflow Protection

Cold baseflow in streams is maintained during the hottest days of the summer time if cold groundwater discharges to augment baseflow and if overhanging riparian canopy shields the surface of the stream water from the hot sun. The amount of groundwater which discharges as baseflow is protected if several factors are maintained in their present state, including present groundwater levels and the amount of water recharging the aquifer.

The quantity and quality of water which recharges into the aquifer is a key variable. The principle concerns include ensuring that an equivalent volume of water of suitable quality infiltrates into the ground after urbanization, as before urbanization occurs. This can be accomplished by infiltration BMPs and maintaining key recharge areas in a pervious state.

Recharge areas, maintained in a pervious state can be used for a variety of other uses, including:

- Wetlands
- Wooded areas
- Recreation uses (eg. soccer fields)
- Walking corridors



Protection of the recharge areas may require dedication of the land to public ownership. Maintenance of the quality of infiltrating water may preclude certain land uses where specific types of chemicals (eg. herbicides, spills of petroleum products) pose a risk to groundwater quality.

6.4.9 Source Protection Plans

Watershed-based source protection plans (SPP)³ are meant to protect and enhance all surface and groundwater for all current and future water uses⁴. The watershed is the most logical unit upon which a SPP is to be developed, as it provides an ecosystem-based linkage between all living things and both surface water and groundwater. The first 17 recommendations presented in Chapter 4 of the Walkerton Inquiry concentrate on source protection.

From a municipal perspective, Official Plans must be consistent with or have regard for SPP. The main deliverables of SPP are summarized in **Table 6.4**, many of which can and will be eventually be incorporated into municipal Official Plans.

Deliverable	Components
Groundwater Protection	Groundwater vulnerability for wellhead protection, sensitive sites and aquifers at risk. Designate areas subject to municipal land use restrictions. Nutrient management and farm water protection. Biosolids disposal master plans. Wastewater management and rural septic systems. Decommissioning abandoned wells and excavations.
Water Quantity Management	Water budgets. Groundwater recharge Identification of hydrologically sensitive areas. Water needs (population growth and agricultural intensification). Updated municipal water supply master plans. Water allocation guidelines between competing users. Drought (low -water) contingency plans. Water conservation measures. Remedial work to increase water capacity.
Water Quality Management	Identification of contaminant sources. Nutrient loading (farm and non-farm). Allocation of assimilative capacity between users. Updated municipal wastewater management. Updated sewer use by-laws. Urban stormwater management. Rural and farm water quality improvement. Preservation & restoration of buffers and wetlands. Operational limits for Certificates of Approval.

 Table 6.4

 Components for Watershed-Based Source Protection Plans

³ "Protecting Ontario's Drinking Water: Toward a Watershed-Based Source Protection Planning Framework", Advisory Committee on Watershed-Based Source Protection Planning, Conservation Ontario and Ministry of the Environment (April 2003).

⁴ "Conservation Ontario Perspective on Implementing Watershed Based Source Protection Planning", Draft issued November 21, 2002.



Watershed-based SPP require inter-jurisdictional co-operation, consistency and continuity, because they cross municipal boundaries. They incorporate components under provincial jurisdiction (e.g. groundwater), federal jurisdiction (Fisheries Act) or international agreements (e.g. the Great Lakes Basin). SPPs must be flexible (as no two watersheds are identical), have popular support, and have mechanisms for implementation (including monitoring requirements), measurable milestones and defensibility to challenges.

6.5 Rural Best Management Practices

Table 6.5 lists a range of possible BMPs that can be applied in the rural area. This list was derived from the Best Management Practices publications issued by the Ontario Ministry of Agriculture and Rural Affairs.

Environmental Benefit	Manure Storage/Handling A) Nonstructural Measures	Manure storage/Handling B) Structural Measures	Livestock Access Control	Fertilizer/Manure Management A)On Field Measures	Fertilizer/Manure Management B) Streamside Measures	Fragile Land Management A) Management Actions	Fragile Land Management B) Retirement of Lands	Road Side Ditch Maintenance	Reducing Drain Maintenance Impacts	Milkhouse Waste Management	Pesticide Storage and Management	Ilrrigation Management	Replace Faulty Septic Systems
Surface/Groundwater Quantity													
reduce runoff	х	х		х	х		х						
increase infiltration			<u> </u>	х		<u> </u>	х						
reduce flooding													
reduce streambank erosion			х	<u> </u>	х	<u> </u>			х				
maintain/enhance natural hydrologic regime				x		x			x				
Surface/Groundwater Quality			<u> </u>	<u> </u>		<u> </u>							
reduce sediment loading			х	х	х	х	х						
reduce pollutants in runoff/sediment	х	х	х	х	х					х	х		
reduce groundwater contamination	х	Х		х						х	х		х
reduce instream sediment deposition			х	х	х	х			Х				
reduce instream contaminants	х	х	х	х	х				Х	х	х		х
Aquatic Ecosystem													
maintain/enhance baseflow s			<u> </u>	х		<u> </u>						х	
maintain/enhance natural channel morphology			x	x	x				х				
maintain/enhance riparian vegetation			х		х	х	х						
moderate stream temperatures					х	х	х		Х				
protect/enhance instream habitats	х	х	х	х	х				Х				
Terrestrial Ecosystem													
protect/enhance forests and wetlands			x		x	x	x						
protect habitats for special status species			x		x	x	x						
protect/enhance wildlife corridors			х		х	х	х						

Table 6.5 - Rural BMPs



Rural BMPs are measures or techniques that can be implemented in order to eliminate, reduce or minimize the effects of agricultural land use practices on aquatic and terrestrial animals and their habitats, particularly lakes, streams and wetlands. Most of these BMPs are targeted at keeping soils, nutrients (including manure) and pesticides on the land to optimize crop production and away from waterbodies where they cause pollution and habitat losses. They are also targeted at keeping nutrients and waste products generated by livestock pasturing and livestock operations contained where these products can be reused or properly disposed of. Thus implementing BMPs at the individual farm level benefits the environment and improves farm productivity.

Rural BMPs can be grouped according to whether they address point or non-point source agricultural impacts to waterbodies.

Point source impacts occur when sediment, nutrients, bacteria and/or pesticides enter waterbodies via a channel or pipe or overland within a short reach of stream. Examples include:

- runoff from a manure pile,
- roadside ditches,
- milkhouse wastes discharging through a tile drain or
- an unrestricted livestock watering or stream crossing site.

Non-Point Source impacts occur when sediment, nutrients, bacteria and/or pesticides are carried overland by sheet runoff and enter an un-buffered watercourse along its entire length. Examples include:

- runoff from croplands,
- pastured lands and other actively tilled lands
- streambank erosion,
- wind erosion
- erosion of steep slopes; and,
- erosion-prone soils.

In some cases rural BMPs can include either structural or non-structural measures. These generally refer to BMPs that address rural point source problems. Non-structural BMPs generally include common sense measures, for example installing barn eavestroughing to route clean runoff away from feed and manure storage areas to reduce contamination. Structural measures include facilities such as liquid manure storage systems or covered storage facilities that are expensive and require specialist expertise to construct.

6.5.1 Manure/Feedlot Storage and Handling – Point Source Control

Runoff from manure storage areas, feedlots and barnyards can directly enter streams causing water quality degradation, algal blooms, fish kills, streambed sediment contamination and degrading aquatic habitats. Accumulation of organic material on the streambed can alter stream morphology and increase streambank erosion.

Structural Measures for addressing manure/feedlot storage and handling problems include solid and liquid storage facilities, covered storage facilities, and runoff storage facilities. These structural measures replace conventional storage measures such as unconfined solid manure piles. Handling includes spreading equipment such as box spreaders, tankers, hoppers and injectors.



Non-structural measures include eavestroughing and berming to keep clean runoff from becoming contaminated by manure/feedlot storage areas, berming adjacent to waterbodies to keep contaminated runoff away from the stream and siting of storage/handling facilities and feedlots away from waterbodies.

While non-structural measures (such as diverting clean runoff away from manure storage areas and berming to contain contaminated runoff) are less expensive, structural measures are often needed where manure storage requirements are high. Constructing liquid or solid storage facilities eliminates transport of contaminated runoff to streams. Covering these facilities also eliminates entry of clean water to the facility, reducing storage volumes. Storage volume is based on expected annual manure volume and manure application rates. Proper storage, handling and application of manure can also lead to improved soil fertility and better crop yields.

Reducing or eliminating contaminated runoff to streams improves water quality, eliminates algal blooms and fish kills, and improves aquatic habitat conditions. The reduce volume of organic material entering the stream enhancing stream morphology. Eliminating contaminated runoff from manure storage areas also can prevent the transmission of water borne diseases, bacteria and parasites.

6.5.2 Livestock Access Control – Point/Non-Point Source Control

When livestock are permitted unrestricted access to watercourses, they can degrade the quality of water and aquatic habitats by trampling and introducing nutrients and bacteria through their waste products. They also can aggravate streambank erosion by trampling and reduce buffering of streamside vegetation by over-grazing. Unrestricted access can also lead to the transfer of disease, bacteria and parasites among livestock leading to reduced livestock health and even mortality. Similar impacts can occur when livestock have unrestricted access to wetlands and woodlots.

Livestock Access Control includes a variety of measures to prevent or limit livestock from entering watercourses. These include streamside fencing, constructed watercourse crossings and streamside watering facilities.

The most effective solution is to fence watercourses to eliminate opportunities for livestock access. Ideally, the lands adjacent to the watercourse should be planted with trees and shrubs to protect the stream, however a crop such as hay or grain would also be effective. Streamside watering facilities, powered by solar energy, can replace lost access to streams. Alternatively, a small portion of the stream can be left unfenced and stabilized with coarse material to allow limited access. A fenced livestock stream crossing, stabilized with coarse material also reduces livestock impacts.

The introduction of livestock wastes, containing nutrients and bacteria to the stream system is reduced or eliminated. Sediment loading from trampling of the bed, banks and streamside environment is reduced. Water quality and instream habitats are improved for fish and aquatic life and risk of disease in livestock is reduced.

6.5.3 Fertilizer/Manure Management – On Field Measures – Non-Point Source Control

Traditional cropping practices and indiscriminate manure/fertilizers application can lead to erosion and transport of soils and nutrients overland to streams. Over-application can also lead to groundwater contamination and direct release of nutrients to watercourses through tile drainage networks. Nutrient and sediment loading to streams causes water quality impairment, algal blooms, degradation of aquatic habitats and, in some cases, fish kills.



On-field measures for fertilizer/manure management include tillage practices, cropping practices designed to reduce loss of sediments and nutrients from croplands. Measures also include management of application rates/timing, crop rotation/strip cropping, cover crops, and conservation tillage. Measures can also include avoiding application adjacent to waterbodies.

The use of on-field measures is often preferred by farmers, compared to streamside measures (grassed waterways and streamside buffers) because less land is taken out of production. The most effective on-field measures begin with first tailoring the rate and timing of applications of fertilizers/manure to nutrient requires of the soils and of the crop planted. This is combined with use of a cover crop or conservation tillage practice to reduce exposure of soils to erosion. Conservation tillage practices can vary from simple measures such as crop rotation/strip cropping, to contour ploughing, to low-till or no-till practices. The effectiveness of various practices depends on the type of soils, topography and crop.

Reduced soil erosion and nutrient runoff from farm fields improves stream water quality and enhances stream aquatic habitats. Reducing stream sediment loads also protects natural stream morphology and reduces sediment deposition on the streambed which can smother aquatic life and lead to increased bank erosion. Water quality improvement results in reduced occurrence of algal blooms, oxygen depletion and fish kills. Improved management of application rates and timing of application can also reduce groundwater contamination.

6.5.4 Fertilizer/Manure Management – Streamside Measures (grassed waterways and streamside buffers) – Non-Point Source Control

Traditional cropping practices and indiscriminate manure/fertilizers application can lead to erosion and transport of soils and nutrients overland to streams. Over-application can also lead to groundwater contamination and direct release of nutrients to watercourses through tile drainage networks. Nutrient and sediment loading to streams causes water quality impairment, algal blooms, degradation of aquatic habitats and, in some cases, fish kills.

Streamside measures include plantings along waterbodies (wetlands, lakes, streams), as well as swales between crops (grassed waterways) that function to trap sediments, nutrients and contaminants and prevent them from entering waterbodies. Measures can also include windbreaks to reduce the impacts of wind erosion.

Plantings of native vegetation (grasses, shrubs and trees) adjacent to waterbodies or along swales (that may overly tile drains) retards the rate of runoff and causes sediment, nutrients, bacteria and other contaminants to deposit here instead of entering the waterbody. Alternatively, hay crops can also serve as vegetated cover in place of native vegetation, thus providing a harvestable crop in these areas. The use of native vegetation enhances these lands as wildlife habitat. The effectiveness of the buffer or grassed waterway is related to the land slope, width of the buffer, type of vegetation and infiltration capability of the underlying soils.

Reduced soil erosion and nutrient runoff from farm fields improves stream water quality and enhances stream aquatic habitats. Reducing stream sediment loads also protects natural stream morphology and reduces sediment deposition on the streambed which can smother aquatic life and lead to increased bank erosion. Water quality improvement results in reduced occurrence of algal blooms, oxygen depletion and fish kills. Improved management of application rates and timing of application can also reduce groundwater contamination.



6.5.5 Fragile Land Management – Retirement of Lands

Fragile lands are lands that are easily damaged by traditional farming practices and include steep slopes, knolls, floodplains, and riparian areas. Marginal lands are not profitable to the farm and include steep, dry, shallow, extremely stony or very poorly drained soils, and wetlands. Farm woodlots are also included in this category, because of the important natural functions they perform (protect recharge areas, reduce runoff, provide wildlife habitat, protect streams and wetlands). When these lands are damaged by conventional farming practices, erosion of sediments and nutrients occurs leading to degraded stream water quality, sedimentation of aquatic habitats and disturbance of natural stream morphology. Draining of wetlands and poor woodlot management practices can destroy important habitats for plant and animal communities and alter the natural surface and groundwater runoff patterns, leading to increased stream erosion and reduced baseflow

Retirement of lands that are uneconomic to farmers may be taken out of traditional farming activities. These lands may be allowed to succeed naturally to a native vegetation community or they may be actively managed for conservation purposes. Actively managed practices include wetland protection, woodlot management and reforestation. Other activities such as changing cropping and tillage practices, windbreaks, shelterbelts, natural fencerows, plantations and silvipasture are classed as Fragile Land Management – Management Actions.

Fencing of the perimeter of woodlots and wetlands to exclude livestock allows natural regeneration of the undergrowth to occur and eliminates damage to trees. Silviculture and woodlot management that focuses on selective harvesting and wildlife management can improve woodlot productivity. Steep slopes, sandy soils and stony lands can be stabilized with a cover crop of grasses and fenced to preclude livestock grazing. These areas can often ultimately be restored to forested condition.

One of the key environmental benefits of retiring these fragile or marginal lands is to enhance habitats for native plant and animal communities. Other important benefits include soil stabilization, reducing sediment loading to watercourses, improving the quality of water infiltrating to groundwater, reducing snowmelt runoff and reducing nutrient loading to watercourses.

6.5.6 Stream Restoration, Roadside Ditch and Drain Maintenance With Natural Channel Design Principles

Historical rural drainage management practices have resulted in substantial alternations to natural drainage systems in order to improve crop productions, maintain roadside drainage, and accommodate farm operations and cropping practices. Many watercourses and drainage features have been straightened, widened and deepened to provide conveyance of tile drainage networks. While this has provided an efficient means of moving surface water off fields and promoting early elrying of soils, it has also resulted in increased bank erosion and increased soils losses. Because the altered drainage network is oversized relative to the typical annual runoff regime, stream and drain networks lack sufficient energy to move the volume of sediment entering the system. This results in loss of conveyance capacity and leads to a reoccurring requirement for maintenance dredging of these features. The impacts on the aquatic environment from these channel alternations and drainage maintenance activities are:



- degradation and loss of fish habitats
- increased stress and mortality of fish, particularly sensitive life stages such as eggs, juveniles and sensitive species such as darters, sculpins, basses, trout
- water quality deterioration particularly from nutrient/sediment environment and reduced dissolved oxygen levels

These negative aquatic impacts occur, not only in the altered stream, roadside ditch and drainage networks, but also further downstream in larger tributaries and the main river where sediment and nutrient loads ultimately accumulate on the riverbed causing the same aquatic effects.

These negative effects of stream and drain alternations and maintenance activities are further exacerbated when drainage networks are further altered to accommodate roadside ditches and road runoffs. Similar, but often more frequent maintenance of roadside ditches are required and road runoff also contributes additional sediment and contaminants such as road salt, metals and oils that arise from road maintenance/surface treatments and tire wear.

In order to reverse these negative impacts and to prevent losses of soil from fields and streambanks from agricultural streams and drainage networks, the principles of natural channel design can be applied. Natural channel design recreates the natural stream processes that maintain a balance between the stream channels physical characteristics (gradient width, depth, substrates, meandering pattern, floodplain) and the annual variation in sediment beds and surface runoff to which it is exposed. Natural channel design combines the sciences of fluvial geomorphology (the study of stream and stream evolution processes), biology and engineering to design stream/drain sections that are more self-sustaining resulting in reduced long term maintenance costs, a healthier aquatic environment and reduced soil loss.

Stream restoration and drain maintenance using natural channel design principles are often required even after stream side and onfield sediment control practices are implemented to reduce sediment loads because historic impacts have degraded the stream/drain to the point where it cannot recover naturally. Costs for stream restoration and drain maintenance using natural channel design are moderately high and can be in the order of \$300/m for a medium sized stream.

Roadside ditch maintenance can be treated similarly to municipal drain maintenance, by using natural channel design principles. In addition, the application of salt, and other materials used to maintain the road can be managed in an environmentally responsible manner.

6.5.7 Rural BMPs for Specialized Operations

A number of other BMPs are used to address specific rural problems. Measures include:

- Milkhouse Waste Management separate storage facilities, combined facilities (with manure storage)
- Pesticide Storage, Handling, Application Management
- Irrigation Management controlled withdrawals, off-line ponds
- Faulty Septic System Replacement



7.0 SELECTION OF THE PREFERRED MANAGEMENT STRATEGY

7.1 General

As stated previously, the Carp Watershed/Subwatershed Study is a hybrid study addressing primarily rural land use issues at a watershed scale and addressing urban and urbanizing issues at the subwatershed scale in Feedmill and Poole Creeks, and the Carp headwaters. Clearly, the resulting plan requires an integrated set of management actions or strategies that together restore the watershed resources to a healthy state while meeting the economic goals of landowners and the City. However, the mechanisms by which these integrate strategies are implemented differ in rural areas versus urban/urbanizing areas.

In rural areas, implementation will be achieved based on the willingness and commitment of landowners to undertake the recommended management measures on their lands. To encourage this effort, the City, the MVCA, other agencies and interest groups need to promote stewardship education and incentive programs to assist these landowners in meeting their resource management responsibilities.

In urban/urbanizing areas, the implementation of management strategies will be achieved through the land use planning process using regulatory, legislative and planning mechanisms to ensure that protection and restoration of natural features is achieved. Implementation within existing urban areas will also require efforts on the part of the City to identify opportunities to retrofit and restore natural areas and functions that have been historically damaged by development. This will not only require the implementation of capital works programs, but also building partnerships with community groups, interest groups, and even corporations to rehabilitate these areas.

The development of a preferred management plan or strategy for the Carp Watershed and the subwatershed resulted from a combination of technical studies, input from public agencies and a Public Advisory Committee and a focused public consultation process with measurable opinions at each state of plan development.

Section 8.2 describes the selection process for the preferred strategy. Section 8.3 summarizes input from the public based on rural workshop, open houses and questionnaires regarding the public's preferences for rural and urban BMPs that could be implemented to address the protection, restoration and enhancement of the watershed resources. In addition, the public's feedback on the various BMPs assisted in the prioritizing the list of management actions to be included in the preferred strategy.

7.2 Selection of Preferred Strategy

The selection of the preferred management strategy for the Subwatershed and watershed placed considerable weight on public and agency views and also on measures required to achieve the level of ecological enhancement identified in the study goals and objectives. The development of the strategy focused on selecting the most cost effective and publicly acceptable actions rather than on a more traditional approach of comparing alternative plans.

The preferred plan was based on the following steps:

1. Completion of a background review and technical studies to describe the current state of the natural resources of the Carp Watershed and the list of opportunities and constraints (see Chapter 4) that have enhanced or degraded these features to their current state of health.



- 2. The development of a set of goals and objectives to protect/restore/enhance the natural resources in the watershed to a healthy state that were endorsed and supported by agencies, the PAC and the general public. These goals and objectives were considered to set ambitious, yet realistic, long term targets for the healthy ecosystem, based on a good understanding of existing conditions.
- 3. The development and prioritisation of a series of Best Management Practices, Policies and Programs that when implemented would achieve the stated goals and objectives. These management actions/strategies were prioritized based on the following:
 - i. Ability to meet the stated goals and objectives
 - ii. Technical feasibility
 - iii. Cost
 - iv. Ease of implementation
 - v. Public acceptability

These management actions/strategies were ranked/prioritized by the agencies/PAC and also by the public.

- 4. The long list of prioritized management actions/strategies evaluated in Step 3 was reduced to a short list of priority management actions that represents the minimum/optimum set of actions necessary to meet the goals and objectives: the preferred management plan (Section 8).
- 5. The implementation strategy for the plan was developed which identifies short and long term costs, implementation responsibilities, opportunities for funding and partnering, and monitoring requirements. Implementation of the plan is considered to be a long-term requirement, with progress dependent on the ability of the implementing parties to secure the necessary funding and resources to implement the individual management actions (Section 9).

The final preferred strategy is presented in Chapter 8 and is broken down into rural and urban areas. The preferred strategy is defined as the Recommended Plan.

7.3 Public Participation

7.3.1 Rural Best Management Workshop

On March 6, 2002, a Rural Best Management workshop was held at the Kinburn Client Service Centre to discuss rural Best Management Practices. Attendees included members of the Steering Committee, PAC, Ward Councillor, City of Ottawa staff, individuals from the farming community/organizations, and staff from the Rural Clean Water Program and Wetland Habitat Fund. The workshop provided a forum for municipal staff, provincial agencies, environmental groups, stewardship organizations and the farming community to discuss the various BMP alternatives and gain an understanding of their practicality in the watershed.

There was a presentation of the best management practices made by the consultant team, which provided background information on the following:

- 1. Livestock Access Control
- 2. Fertilizer/Manure Management: (a) On-field (b) Streamside
- 3. Manure Storage Handling: (a) Non-structural (b) Structural



- 4. Fragile Land Management: (a) Management Actions (b) Retirement of Lands
- 5. Milkhouse Waste Management
- 6. Reducing Drain Impacts
- 7. Pesticide Storage and Management
- 8. Irrigation Management
- 9. Replace Faulty Septic Systems

The group was then broken down into smaller working groups and investigated the environmental benefits, cost benefits, and success rates of each best management practice (See Appendix F Workshop Notes). The group also had an opportunity to review all documents that were to be distributed at the third Open House Event. In general, non-structural and on-field measures were preferred to structural and streamside measures. Incentives were viewed as the best means to encourage implementation.

7.3.2 Third Public Open Houses

The final public open houses were held on Tuesday June 18, 2002, at the Kinburn Client Service Centre, and on Wednesday, June 19, 2002, from 6:00 to 9:00 pm, at the Corel Centre in Kanata.

The third open house at the Kinburn CSC focused on presentation of a variety of agricultural/rural BMPs that could be implemented to address point and non-point sources of pollution and habitat effects associated with rural lands use practices (see Chapter 6 for list of rural BMPs). A total of 51 people attended the rural open house. A questionnaire was handed out which ask the public's opinion on the study goals, objectives and list of Best Management Practices. About 80% of the attendees represented farmers and rural residents. Generally, the respondents agreed (70%) with the study goal statement and objectives. Overall, water quality was felt to be the most important issue. The major impediment to implementing the various BMPs was money and incentive programs. In addition, lack of information/assistance was also cited as an implementation impediment. Overall, measures that have the potential to protect/maintain/enhance the environment (best environment benefit) is the most important evaluation criteria.

The urban open house meeting in Kanata was scheduled in conjunction with a public meeting for the Kanata West Concept Plan study. The focus of the Carp River Watershed/Subwatershed portion of the meeting was to present and discuss environmental protection, restoration and enhancement measures and guidelines for the active and urbanizing portions of the watershed. These areas include:

- Village of Carp
- Village of Stittsville
- Corel Centre Area (Kanata West Concept Plan Area)
- Glen Cairn Community of Kanata

Proposed measures consist of:

Surface Water Component

- Protect hydrologic function of woodlands and wetlands
- Protect natural sediment/flow processes in watercourses
- Maintain natural drainage areas to Poole Creek and Feedmill Creek
- Provide adequate corridor widths along watercourses (70-100 m)



- Implement urban BMPs for erosion control and to protect baseflow, water quality
- Implement 2-zone floodplain policy for Carp River
- Restoration of Carp River and lower Poole/Feedmill Creeks

Groundwater Component

- Protect hydrogeologic function of woodlands and wetlands
- Maintain groundwater recharge
- Implement urban BMPs to maintain recharge characteristics of the lands and seasonal discharges to streams

Environmental Component

- Protect function necessary to support resident fishery, riparian cover, baseflow, temperature, habitat
- Provide adequate corridor widths based on aquatic/morphologic criteria
- Protect remaining woodland/wetland features to maintain natural heritage system
- Focus naturalization efforts on Centres of Ecological Significance and other habitat blocks (reduce fragmentation, increase size, improve linkage, increase biodiversity)
- Protect/restore upland woodlots

A questionnaire was provided. The questions focussed on the respondent's background, study goals and environmental objectives, best management practices, and evaluation of the proposed measures. Only three responses were received. Respondents agreed with the objectives and proposed measures but were divided about the ease of implementation and public acceptance.



8.0 RECOMMENDED PLAN

8.1 Overview

Chapter 3 describes the natural environmental resources that at present exist within the watershed. Environmental opportunities and constraints were described in Chapter 4. Chapters 5, 6 and 7 outlined the goals and objectives, alternative BMPs and rationalization for selecting a preferred strategy. As stated, the preferred strategy for the rural areas is based on an assessment of a number of alternatives together with input received from stakeholders who attended the public open house. A stewardship program will be the focus for implementing the proposed restoration/rehabilitation measures.

For the urbanizing area (the subwatershed), the primary focus of the preferred strategy will be to provide further direction for subsequent studies which will be carried out at the Secondary, Draft or Site Plan stage. In this regard, the preferred strategy will also incorporate, where appropriate, findings from studies that have already been undertaken (eg: Kanata West). Furthermore, the preferred strategy will incorporate findings from other relevant studies, such as the Upper Poole Subwatershed Study, where appropriate. The recommended rural and urban plans are presented in Section 8.2 and 8.3 respectively. These plans have been developed based on the key integrated findings which are reiterated here for easy reference.

Groundwater, Wetlands, Forested Areas and Aquatic Resources

- One of the key limitations within the watershed is the lack of baseflow to the Carp River and its tributaries. The majority of tributaries are intermittent and only a few including Corkery, Huntley, Feedmill and Poole Creeks are considered permanently flowing.
- During a dry weather survey, these tributaries were found to account for 50% of the total Carp River flow at Kinburn. The remainder of the flow was direct discharge to the river from groundwater.
- Flowing streams support coolwater or diverse warmwater fish communities.
- Tributaries with baseflow have wetlands in the headwaters. These wetlands serve several key functions that serve to maintain stream baseflows and recharge aquifers. The headwaters of these tributaries also give rise to the best quality woodlands and areas of highest biodiversity.
- Water taking accounts for 10% of groundwater serving local communities and rural residents.
- The remaining 90% discharges to tributaries or feeds Regional Aquifers.
- A total of 50% of groundwater recharge is provided by 30% of lands which are located in the southern part of the watershed.

Aquatic Habitats, Morphology, Riparian Vegetation & Sediment Management

- One of the more serious problems observed within the Carp River and some of its tributaries is aggradation (ie. the streams cannot push sediment through the system) resulting in sediment build-up. Over 80% of the Carp River is experiencing this condition.
- This is particularly evident in the rural tributaries and the Carp River upstream (south) of the Village of Carp.
- Historical and current land use practices have caused aggradation and sediment build-up.



- The stream channel will adjust to this condition by widening (through bank erosion), headcutting (erosion of the streambed in an upstream direction) and straightening (loss of natural meander pattern). These adjustments make the problem worse.
- Accumulated sediment and these channel adjustments contribute to degraded water quality and degraded fish habitat.
- Accumulated sediment and these channel adjustments contribute to degraded water quality and degraded fish habitat.
- Sources of increased sediment include cropping and municipal drainage practices, removal of streamside vegetation, livestock access and urban construction practices.
- The situation is aggravated when streamside vegetation is lacking, as runoff to streams is not buffered and streambanks are exposed to erosion.

Land Use and Community

- The majority of the watershed is and will likely remain in agricultural uses. There is some evidence that marginal lands are being taken out of production. There appears to be a growing interest among farmers to support stewardship programs if financial incentives and technical support are provided.
- Rapid urban growth is occurring in the headwaters within Kanata West and Stittsville. Some large urban development areas provide an opportunity for natural resource protection, enhancement and restoration.
- There is a well-organized community of volunteers and organizations interested in carrying out projects in the watershed.
- There are numerous incentive programs and other in-kind support at all levels of government for environmental conservation initiatives.
- The community, in particular, rural landowners, have a strong interest in stewardship of their natural resources.

A series of measures that are deemed necessary to achieve the stated goals and objectives for the rural areas of the watershed are shown in **Table 8.1** and highlighted in **Figure 8.1**. **Table 8.2** and **Figure 8.5** concentrate on the urban areas (**Figures 8.2, 8.3**, and **8.4** describe components of the preferred plan for the subwatershed urban area). For both the rural and urban areas, these recommended measures are described under the following components:

Surface Water Management Plan, which describes protection, enhancement and restoration measures to sustain streams in a stable natural state, to manage flood and erosion risks and to remediate water quality problems.

Groundwater Management Plan, which identifies key measures necessary to enhance recharge, protect baseflow and to protect groundwater quality.

Greenlands Plan, which describes the aquatic and terrestrial systems and outlines required protection, enhancement and restoration measures.

The recommended plan for the protection, enhancement and restoration of the natural resources of the Carp River Watershed, as presented in the above referenced tables and figures, is realistic, yet ambitious plan. It is based on what can realistically be achieved given the physical characteristics of the watershed, using best available science and technology. The following sections in Chapter 8 describe the Rural Watershed and Subwatershed Plans. Chapter 9 identifies an implementation strategy aimed at achieving the measures identified in the recommended plan, recognizing that some of the necessary implementation actions

CRITERIA				
Recommendation	Technical Consideration	Environmental Benefits	Implementation Considerations	Cost
SURFACE WATER MANAGEMENT PLAN - FLOOD CONTROL				
Program emphasis on reducing flooding impacts on agricultural lands through stream restoration, wetland/forest protection measures as described below	See measures under Surface Water Management Plan and Greenland Plan		NA	
Wetland Restoration and Reforestation of non-productive farmland (Section 9.2.1.1)	Type and size of plant material % of woody vegetation versus non-woody Success rate/ optimum planting time Wildlife control Monitoring/replacement of dead vegetation Control of non-native/invasive species	control downstream sediment supply increase flood storage retard the rate of runoff reaching the Carp River enhances surface water quality	Some agricultural land taken out of production Landowner cooperation	Approximately \$250/ha for seedlings
SURFACE WATER MANAGEMENT PLAN – EROSION AND SEDIME	INT CONTROL			
Stream restoration using natural channel design and engineered natural channel measures along 15.4 km of priority 1 stream reaches in the tributaries and 13 km of priority 1 stream reaches along the Carp River	Need to develop cost effective, practical design templates for landowners to implement requires specialist expertise to properly design stream works requires a "reach-level" assessment and design approach rather than a "piecemeal" approach	control downstream sediment supply restores aquatic habitat restores long term stream stability link aquatic communities in the upper and lower reaches remove excess sediments improve channel stability using natural channel design increase flood storage in stream channel and floodplain retard the rate of runoff reaching the Carp River	Some agricultural land taken out of production (5- 10 ha per stream km) Design Details Phasing Funding Mechanisms Landowner cooperation	(28.4 km @ \$250/m) = \$7,000,000 (assumes inkind support
Control livestock access restrictions and installation of alternate watering sources on livestock operations in priority 1 stream reaches in the tributaries and along priority 1 Carp River segments	Fencing – ice jams may damage fencing riparian plantings- see considerations below alternative livestock water supply Solar powered devices or battery operated may present technical/maintenance challenges	reduces channel erosion and excess sediment supply provides long term channel stability enhances surface water quality protects existing aquatic community	Stewardship/landowner consent Funding mechanisms	(28.4 km @ \$12/m) = #340,000
Riparian zone plantings along 24.2 km of priority 1 stream reaches in the tributaries and 9 km of priority 1 Carp River segments	Riparian planting plan Type and size of plant material Width of planting zone % of woody vegetation versus non-woody Success rate/ optimum planting time Wildlife control Monitoring/replacement of dead vegetation Control of non-native/invasive species	restores aquatic habitat restores long term stream stability improve stream bank stability provide stream shading, reduce nutrient and bacteria loading reduce sedimentation	Some agricultural land taken out of production (10 ha per stream km assuming 5 m width along each side of watercourse) Stewardship/landowner consent	(33.2 km @ \$2,500/km) = \$83,000
Riparian zone plantings along 18.2km of priority 2 stream reaches in the tributaries	Riparian planting plan Type and size of plant material Width of planting zone % of woody vegetation versus non-woody Success rate/ optimum planting time Wildlife control Monitoring/replacement of dead vegetation Control of non-native/invasive species	restores ("Net Gain") in fish habitat restores aquatic habitat restores long term stream stability improve stream bank stability provide stream shading, reduce nutrient and bacteria loading reduce sedimentation	Some agricultural land taken out of production (10 ha per stream km) Stewardship/landowner consent	(18.2 km @ \$2500/km) =\$45,500
Implement conservation land management practices on about 4500 ha of priority 1 and about 2500 ha of priority 2 agricultural lands in priority 1 subwatersheds to reduce soil erosion	reduce soil erosion and overland transport improve crop production reduce nutrient losses may affect growing season if planting is delayed by slow warming/drying of soil because of conservation tillage practice may require landowner to adjust fertilizer application rates requires adjustment in timing of crop management activities such as cultivation	restores aquatic habitat restores long term stream stability link aquatic communities in the upper and lower reaches reduce soil erosion and overland transport reduce nutrient loading to streams	Short term reduction in productivity	Equipment purchase: about \$30,000-\$50,000 shared among several farmers (1 set of equipment/5 farms)
Reconstruction of roadside ditch systems to address erosion and sedimentation problems	Improve channel stability reduce sedimentation reduce road maintenance costs	reduces downstream sediment supply restores aquatic habitat restores long term stream stability	May cause some nuisance flooding on adjacent lands	(\$600/m) – incorporate into municipal road O&M costs

CRITERIA				
Recommendation	Technical Consideration	Environmental Benefits	Implementation Considerations	Cost
Site specific erosion control measures (livestock access control, instream/roadside grade controls, streambank stabilization) in priority 2 streams in the tributaries	need to develop cost effective, practical design templates for landowners to implement requires specialist expertise to properly design stream works requires a "reach-level" assessment and design approach rather than a "piece-meal" approach	restores ("Net Gain") in fish habitat remove excess sediments improve channel stability using natural channel design increase flood storage in stream channel and floodplain retard the rate of runoff reaching the Carp River	Some agricultural lands taken out of production	Stream works (\$250/m) Fencing (\$12/m) (assumes inkind support and use of existing programs)
SURFACE WATER MANAGEMENT PLAN – SURFACE WATER QUA	LITY			
Implement non–structural BMP's on all farmsteads on priority 1 and 2 agricultural lands, beginning with those operations contributing directly to priority 1 and 2 stream reaches in the tributaries and priority 1 Carp River segments (approximately 50 farms)	Complete Environmental Farm Planto identify solutions Need for technical expertise to properly design facilities, address drainage problems May require adjustments to farming operations and type of equipment used (equipment purchase)	enhances fish access potential to alternate habitat enhances aquatic community habitat conditions through a reduction in maximum water temperatures and improved surface water quality enhances the quality of the terrestrial community and improves neighbourhood aesthetics remove excess sediments improve stream bank stability reduce nutrient and bacteria loading	Measures have no land use impact	\$3,000 per farm = \$150,000
Implement structural BMP's on all farmsteads contributing directly to priority 1 stream reaches in the tributaries and priority 1 Carp River segments (approximately 20 farms)	Complete Environmental Farm Planto identify solutions Need for technical expertise to properly design facilities May require adjustments to farming operations and type of equipment used (equipment purchase)	enhances downstream aquatic community habitat conditions through a reduction in maximum water temperatures integrates pond for an enhanced terrestrial community restores fish access to alternate habitat remove excess sediments improve stream bank stability reduce nutrient and bacteria loading	Structures/facilities may increase farmstead "footprint" causing minor effect on agricultural land	\$20,000 - \$40,000 per farm = \$800,000
GROUNDWATER MANAGEMENT PLAN				
Integrate groundwater management recommendations into the City's Groundwater Management Strategy (2003)	City staff to integrate findings into City-wide strategy and identify priorities and timelines	Maintain/enhance natural hydrologic regime Increase infiltration Reduce runoff Maintain/enhance baseflows		
Initiate a septic system inspection program and repair/replace faulty systems	Requires training of municipal staff resources for inspections	Reduces groundwater contamination Eliminates potential for surface water contamination	Requires allocation of municipal staff resources for inspections May require development of by-law Rural Clean Water Program funding	
Implement Rural BMP's on agricultural lands in high/moderate recharge (priority 1 and 2 agricultural areas)	Complete Environmental Farm Planto identify solutions Need for technical expertise to properly design facilities, address drainage problems May require adjustments to farming operations and type of equipment used (equipment purchase)	restores aquatic habitat, restores long term stream stability, link aquatic communities in the upper and lower reaches, enhances fish access potential to alternate habitat ,enhances aquatic community habitat conditions through a reduction in maximum water temperatures and improved surface water quality enhances the quality of the terrestrial community and improves neighbourhood aesthetics reduce soil erosion and overland transport improve crop production reduce nutrient losses remove excess sediments improve stream bank stability reduce nutrient and bacteria loading	Short term reduction in productivity Structures/facilities may increase farmstead "footprint" causing minor effect on agricultural land	Equipment purchase: about \$30,000-\$50,000 shared among several farmers (1 set of equipment/5 farms) \$3,000 per farm = \$150,000 \$20,000 - \$40,000 per farm = \$800,000 (duplicated under conservation tillage and rural BMP measures above)

Table 8.1 Recommended Watershed Plan

CRITERIA				
Recommendation	Technical Consideration	Environmental Benefits	Implementation Considerations	Cost
Develop a more detailed record of actual water takings from surface and groundwater supplies	Provide more accurate accounting of withdrawals	Ensure sustainability of water supplies Protect stream baseflows	none	May be small incremental cost to existing programs
Require hydrogeological investigations for land development proposals (MOE Guideline D5-5)	Identify groundwater flow patterns, recharge discharge characteristics, water table elevation Maintain existing groundwater quality	Protection of groundwater and surface water supplies, sensitive features	Development specific	\$3,000 - \$50,000 per development (small scale developments)
GREENLAND PLAN - TERRESTRIAL		•	•	
Protect all Category 1 features – Centres of Ecological Significance, Candidate ANSI's, woodlands and wetlands in high recharge areas, riparian corridors (see detailed description in 9.2.3.2) Include centres of ecological significant in City Acquisition Plan.	Review Official Plan designations and other land use planning policy to identify areas not currently protected to ensure the following functions are maintained protect unique species/habitats protect areas serving as core habitat for plants and animals, maintain hydrologic/water quality function increase linkages between natural areas for plant/animal	increases biodiversity (# of species/communities) increases integrity of terrestrial system (linkages, functions) provides recharge/water quality function	Some marginal agricultural lands taken out of production Landowners lose some revenue from woodlot production	Increased development/lot costs Cost dependent of feature to be acquired.
Conduct EIS on all Category 2 features (see detailed description in 9.2.3.2) - woodlands contiguous with Level 1/2 riparian corridors, features in low/moderate recharge, adjacent lands (30 or 120 m setbacks) – applies only to development applications	dispersion evaluate function of feature w.r.t. habitat for plants / animals, unique species, wetland and stream function	adds to overall terrestrial habitat, source of seeds/plant material to replace lost biodiversity or cores and corridors may have stream/wetland function	Potential loss of development area (lower lot density)	Some lost revenues
Undertake a stewardship/education program to promote protection and regeneration of Category 1 areas to a natural state (see detailed description of Category 3 areas in 9.2.3.2)	evaluate current state of Category 1areas to determine degree to which regeneration has occurred Prioritize areas for rehabilitation Develop planting schemes, native species lists for use	adds to overall terrestrial system - increased habitat particularly in core areas increased width of corridors allows use by more sensitive species, increases habitat value	Potential loss of development area (lower lot density)	Some lost revenues
Undertake a stewardship/education program to promote protection and regeneration of Centres of Ecological Significance	Develop list of potential grant programs Outreach program to private landowners/environmental organizations	maintain aesthetic and habitat value of trees on public and private urban lands	Potential loss of development area (lower lot density)	Some lost revenues
GREENLANDS PLAN - STREAM AND VALLEY CORRIDOR SYSTEM	1	•	•	•
protect valley and stream corridors adjacent to all classified streams including intermittent watercourses through Official Plan Policies, Conservation Authority Act, Fisheries Act and other tools to ensure their protection as land use change occurs	protect critical aquatic habitats, spawning areas, discharge areas provide space to allow natural morphological processes to continue unrestricted maintain natural floodplain characteristics protect intermittent watercourses that provide seasonal fish habitat or have well vegetated riparian areas	protect critical spawning habitats, discharge areas protect floodplain functions: - fish spawning habitat - amphibian habitat - discharge - sediment control - flood conveyance - flood production maintain natural morphological/channel forming processes	When development occurs, lands adjacent to stream protected 30m buffer = 30 ha/stream km 60m buffer = 60 ha/stream km	Lands deeded to City
Implement a stewardship program to encourage buffer plantings adjacent to all classified streams to reduce sediment loadings to streams	define minimum criteria for channel/floodplain width width based on conveyance of flows, sediment control and water quality considerations	conveyance of flows maintenance of water quality sediment control aquatic food production	Some agricultural lands taken out of production 10 ha/stream km	N/A
GREENLANDS PLAN - RECREATION				
Develop Recreational trail system plan and implementation strategy for the Carp River Corridor and connections	identify appropriate routes identify sensitive natural areas to be avoided	recreational amenity link communities/neighbourhoods control access to sensitive features provide education/interpretive opportunities	combination of public/private lands	NA

Table 8.1 Recommended Watershed Plan

CRITERIA				
Recommendation	Technical Consideration	Environmental Benefits	Implementation Considerations	Cost
SURFACE WATER MANAGEMENT PLAN - FLOOD CONTROL			·	
Implement modified floodplain policy along the upper Carp from Glen Cairn pond to Richardson Side Road	Requires detailed hydraulic analysis for the entire reach to ensure no negative impacts on flood levels and erosion	Protects vulnerable lands along Carp River and Poole Creek/Feedmill Creek corridors	Allows partial development within existing floodplain contingent on implementation of Carp River Restoration Plan	\$ 10,000
Undertake Floodplain Mapping for Carp River, Poole Creek, and Feedmill Creek downstream of Highway 417	Requires updated mapping Requires detailed hydrologic/hydraulic analyses	Prevents development within floodprone areas	May affect existing floodplain limits and creek corridor setback requirements	Carp River \$ 550,000 Poole Ck/Feedmill Ck \$ 200,000
SURFACE WATER MANAGEMENT PLAN - EROSION AND SEDIMEN	IT CONTROL			
Carp River Corridor Plan: Restore upper Carp river to riverine wetland with floodplain features and recreational trail system (approx. 5000 m)	Requires detailed design plan integrating updated floodplain mapping and hydraulic analysis with environmental restoration measures	reduces downstream sediment supply reduce sedimentation remove excess sediments restores aquatic habitat restores long term stream stability improve stream bank stability	Landowners to implement restoration plan and dedicate Carp River Corridor to the City as public open space	(5 km @ \$800/m) = \$4,000,000
Protect stream corridors along Carp (100 m), Poole (80 m) (downstream of Hazeldean Road) and Feedmill (70 m) downstream of Queensway	Updated floodplain mapping required to confirm creek corridor setback requirements	Protect aquatic features and functions Provides terrestrial and recreational linkage function Protect floodplain control downstream sediment supply Protects stream channel form and function link aquatic communities in the upper and lower reaches	Development to provide specified creek corridor to the City as public open space as part of the development approval process	Land value based on hazard land/ constraint use
SURFACE WATER MANAGEMENT PLAN – EROSION AND SEDIMEN	IT CONTROL			
Implement riparian planting along 2000 m of Feedmill Creek and 5000 m of Poole Creek as per riparian corridor targets (75% of the corridor vegetated with woody species)	Detailed planting plan in coordination with restoration plan for creek systems	restores aquatic habitat maintain thermal regime improve stream bank stability improve water quality reduction in sediment inputs	Developer to implement through development review process	Cost per linear metre dependent on size of plant material \$100 - \$200 / linear metre (60 m width)
Implement natural channel design restoration for designated reaches of Poole and Feedmill (approximately 1000 m)	Detailed design plan required for designated reaches	reduces channel erosion and excess sediment supply provides long term channel stability enhances surface water quality increase flood storage in stream channel and floodplain improve stream bank stability restore aquatic habitat	Developer to restore channel as part of the development approval process	(1 km @ \$600/m) = \$600,000
Implement GREE design restoration for designated reaches of Poole (approximately 800 m)	Detailed design plan required for designated reaches	restores aquatic habitat restores long term stream stability enhances surface water quality	Restoration in existing development. Cooperation with adjacent landowners. No additional lands required	(1 km @ \$600/m) = \$600,000
Restore lower reaches of Poole and Feedmill Creek to riparian wetland systems contiguous with Carp River Corridor plan (approximately 1000 m)	Detailed design plan required for designated reaches	restores aquatic habitat restores long term stream stability link aquatic communities in the upper and lower reaches remove excess sediments improve stream bank stability provide stream shading reduce nutrient and bacteria loading	Incorporate into the Carp River Restoration detailed design study Landowners to implement restoration plan and dedicate creek corridor to the City as public open space	\$800/m \$640,000

Table 8.2 - Recommended Subwatershed Plan

		CRITERIA	
Recommendation	Technical Consideration	Environmental Benefits	Implementation Cor
Implement Source Control Measures	Selection of Source Controls dependent on surficial soils, geology,	restores ("Net Gain") in fish habitat	Dependent on measure
	groundwater table, subdivision design, operation and maintenance,	Maintain baseflow/water budget	
		Maintain thermal regime of aquatic systems	
		Reduce peak flow rate	
SURFACE WATER MANAGEMENT PLAN – SURFACE WATER QUAL	TY		
Centralized SWM facilities within Kanata West (Options 1 or 2) must	Technical considerations and study		Developers within catchment area of
meet water quality and runoff targets	requirements outlined in	remove excess sediments	construction of the centralized facility
	Factsheets in Section 10	improve stream bank stability	Land required for the stormwater mar
		reduce nutrient and bacteria loading	Facilities can be situated in the floodp
			implemented
GROUNDWATER MANAGEMENT PLAN			
Prepare a groundwater characterization study on a subwatershed wide	Hydrogeological study	Preserve baseflow (groundwater	NA
basis to determine groundwater gradients and divides, to preserve	Geotechnical study (soils,	discharge)	
groundwater discharge (baseflow), to access feasibility of infiltration-	bedrock depth)	Preserve infiltration (groundwater	
based stormwater management of BMPs and to maintain a pre-	Hydraulic conductivity	recharge)	
development water balance.	Monitor wells	Preserve thermal regime within stream	
	Streambed piezometers	courses	
	Map upwelling in streams	Protect quality of infiltrating water	
GREENLAND PLAN - TERRESTRIAL			
Protect all Category 1 features (see detailed description in Section	Review Official Plan designations	increases biodiversity (# of species/communities)	Category 1 areas in private ownersh
9.4.3) – Centres of Ecological Significance, Candidate ANSI's,	and other land use planning	increases integrity of terrestrial system (linkages,	environmental policy
woodlands and wetlands in high recharge areas, riparian corridors	policy to identify areas not currently	provides recharge/water quality function	
Include centres of ecological significance in City Acquisition Program	protected to ensure following	provides recharge/water quality function	
	functions are maintained:		
	protect unique species/habitats		
	protect areas serving as core nabitat for plants and animals, maintain		
	increase linkages between natural areas for plant/animal		
GREENLAND PLAN - TERRESTRIAL			
Conduct EIS on all Category 2 areas (see detailed description in	evaluate function of feature w r t	adds to overall terrestrial babitat and biodiversity	EIS requirement not currently trigger
Section 84.3 – natural features continuous with Category 1 areas	habitat for plants/animals unique	source of seed sources for revegetation efforts	Lie requirement not ourrently trigger
features in low/moderate recharge, adjacent lands (30 or 120 m trigger)	species, wetland and stream function	cores and corridors may have stream/wetland function	
A stewardship/education program to promote protection and	evaluate current state of Category1	adds to overall terrestrial system –	Link with other stewardship and gran
regeneration of Category 3 areas (see detailed description in Section	and2 areas to determine degree to	increased habitat	
8.4.3) to a natural state	which regeneration has occurred	particularly in core areas	
A stewardship/education program to promote protection and habitat	develop planting schemes, native species lists for use	increased width of corridors allows	
ennancement within Category 1 areas		use by more sensitive	
		species, increases nabilal value	

Table 8.2 - Recommended Subwatershed Plan

siderations	Cost
the pond pay for design and	\$10,000 - \$20,000 / impervious ha
e en	
agement ponds facilities	
nain ir restoration plan	
	\$10,000 - \$100,000 per development
	depending on scale and complexity
ip not currently protected by	Dependent on feature
	Could be cost prohibitive
ad for some grass	
eu ior some areas	
t programa	
r programs	

	CRITERIA			
Recommendation	Technical Consideration	Environmental Benefits	Implementation Cons	
GREENLANDS PLAN - STREAM AND VALLEY CORRIDOR SYSTEM				
Protect valley and stream corridors along upper Carp, Poole and Feedmill Creeks (See Section 9.4.2) Dedicate stream corridors in public ownership through the development review process	protect critical aquatic habitats, spawning areas, discharge areas provide space to allow natural morphological processes to continue unrestricted maintain natural floodplain characteristics provide pathway linkages and public accessibility	protect critical spawning habitats, discharge areas protect floodplain functions: - fish spawning habitat - amphibian habitat - discharge - sediment control - flood conveyance - flood production maintain natural morphological/channel forming processes	Dependent on width of corridor	
GREENLANDS PLAN - STREAM AND VALLEY CORRIDOR SYSTEM				
Review current aggregate operations in Feedmill headwaters and review opportunities to augment baseflows in both Feedmill and Poole. Confirm that rehabilitation plan devotes restoring significant lands to natural state	Assess impacts on local water table, groundwater flow patterns and discharge areas	Enhancement of baseflows in Poole and Feedmill Creeks		
Maintain key functions of valley and stream corridors in Hazeldean and unnamed Tributaries	define minimum criteria for channel/floodplain width width based on conveyance of flows, sediment control and water	flow conveyance maintenance of water quality sediment control aquatic food production	N/A	
GREENLANDS PLAN - RECREATION				
Recreational trail system	identify appropriate routes identify sensitive natural areas to be avoided	recreational amenity link communities/neighbourhoods control access to sensitive features provide education/interpretive opportunities	combination of public/private lands	

Table 8.2 - Recommended Subwatershed Plan

nsiderations	Cost		
	N/A		
	N/A		
	Not listed		



may require changes to municipal, provincial and federal legislation and policies and/or an increased level of environmental stewardship by landowners and communities. As a result, it is recognized that the implementation strategy will require many years to implement. Chapter 10 focuses on the integration of the recommendations into the development review process.

While each recommendation is presented under one component plan for ease of reading, it is important to recognize that most recommendations represent integrated solutions to problems that address each of the component systems: greenlands, groundwater and surface water. For example, restoration of an unstable stream will reduce excessive sediment supplies which, in turn, will protect sensitive spawning areas, protect stream morphology (e.g., pool/riffle habitat), improve water quality and protect sensitive plant species in wetlands which are susceptible to turbid waters.

Similarly, reforestation not only improves habitat for plant and animal life thereby increasing plant and animal abundance and species diversity, but also filters water entering streams or the groundwater system. Furthermore, reforestation may also augment existing groundwater supplies and help shade streams thereby keeping water cool for aquatic life.

The recommended plan represents a long-range environmental management plan for the watershed which, of necessity, looks well beyond typical municipal planning horizons, i.e., 30 to 50 years, instead of 5 to 20 years. This is realistic because:

- it approximates the timeframe for an ecosystem or its functions to recover;
- it recognizes that a number of implementation actions may require extended timeframes to change legislation and policy;
- it recognizes that a number of implementation actions may require a substantial change in the attitudes of agencies, communities and landowners towards environmental stewardship; and
- it recognizes that the costs involved are large, requiring implementation to be spread out over many years.

8.2 Rural Watershed Plan

8.2.1 Surface Water Management Plan Component

The surface water management plan component of the Watershed Plan addresses issues of flooding, erosion and sedimentation, and surface water quality. Urban development measures are addressed in the subwatershed plan and should also be applied for urban development in the rural watershed. The surface water management plan consists of a number of the preferred rural Best Management Practices discussed and assessed in Chapters 6& 7. Primarily, the plan consists of the following measures:

- a. Stream Restoration using natural channel design and engineered natural channel measures.
- b. Riparian Zone plantings.
- c. Conservation Land Management Practices such as tillage practices, cropping practices, management of fertilizer/manure application rates/timing, crop rotation/strip cropping, cover crops and conservation tillage.
- d. Control livestock access and installation of alternate watering sources for livestock operations.
- e. Reconstruction/Maintenance of roadside ditch system



- f. Non- structural Manure/Feedlot Storage and Handling BMPs such as:
 - Eavestroughing and berming to keep clean runoff from becoming contaminated by manure/feedlot storage areas
 - Berming adjacent to waterbodies to keep contaminated runoff away from the stream
 - Siting of storage/handling facilities and feedlots away from waterbodies
- g. Structural Manure/Feedlot Storage and Handling BMPs such as:
 - Covered storage facilities solid and liquid storage facilities
 - Runoff storage facilities
- h. Site specific erosion control measures such as livestock access control, instream/roadside grade controls, streambank stabilization.
- i. Septic system inspection program

8.2.1.1 Flooding

Outside of the subwatershed area, there are no flood vulnerable dwellings and few flood vulnerable roads. Because of the broad, flat floodplain of the Carp River, the extensive drainage improvements that have been made to the river and the lower reaches of most tributaries and backwater effects from a number of bridge structures, flood waters cover extensive areas of farmland each spring. Field studies reported that 70% of the river channel and 80% of tributaries and their riparian zones have been altered primarily to promote drainage. This results in extensive flooding of agricultural lands along the river each spring. This flooding is considered by farmers to cause a number of problems affecting productivity including:

- delays in planting due to slow drying, cool soils;
- reduced use/productivity of pasture lands along the river;
- concentrations of migrating waterfowl that cause crop damage;
- flooding and ice movement that destroy farmland, fences and erodes streambanks;
- flooding and ice movement that impacts bridges, river crossings, roads and roadside ditches; and,
- erosion and sedimentation of drains and the river reducing conveyance capacity, (for recreation and livestock watering) limiting water access, and increasing drain maintenance requirements.

Further development in the urbanizing subwatershed as well as along the ridges of the watershed in the tributary headwaters has the potential to reduce the capacity of headwater forest and wetland features to provide flood storage and could aggravate these flooding issues. Continuing traditional municipal drainage practices will also contribute to ongoing flooding by maintaining a tributary drainage network that transports flows and sediments to the main Carp that is beyond the river channel's handling capacity. The result is more extensive flooding, sedimentation and bank erosion. The combination of bank erosion and field soil loss is also a source of lost farm productivity.

The solution is to restore the river, its floodplain and its tributaries to a more natural state accompanied by on-field measures to reduce soil erosion. This restoration process, in effect, will restore the capacity of the tributaries to store flood waters by reconnecting them with their floodplains. The impact on farmers will be a short-term loss in productivity for lands adjacent to the river and tributaries, offset by a long term increase in productivity on other farmlands through soil conservation and improved land stewardship. These measures are discussed in more detail in the erosion and sediment control and water quality sections which follow. Briefly, measures to reduce rural flooding problems include:



- stream restoration using natural channel design and engineered natural channel measures along 15.4 km of Priority 1 tributaries and 13 km of the Priority 1 Carp River segments. These priority areas are shown in Figure 8.1 as disturbed reaches.
- wetland restoration and reforestation of non-productive farmlands

8.2.1.2 Erosion and Sediment Control

As noted above, 70% of the Carp River segments and 80% of tributary reaches in the watershed have been altered. In addition, agricultural land use representing 50% of the total watershed area is concentrated along the Carp River floodplain and the lower portions of all tributaries, primarily east of Highway 417. While municipal drainage practices have increased the conveyance capacity of the tributaries to carry flood flows, they have also increased the volume and rate of sediment transport to the Carp River and to the tributary mouths. Since the Carp River lacks sufficient energy to move this sediment, it deposits on the riverbed, reducing its capacity and causing the river to widen by eroding its banks, contributing more sediment to the river. Continued maintenance dredging of tributary drains, many of which also form roadside ditches, creates gullies that are no longer connected to their floodplains. Floodwaters that would normally spill over the banks on these gullies are now contained within them causing accelerated streambank and stream bed erosion that undermines road culverts, causes road slumps and loss of farmland adjacent to streams.

This process of onfield and instream erosion, transport and aggradation (deposition) has proceeded to the point in many tributaries that control-at-source of soil erosion through conservation land management practices will not correct the problem on its own. To address the erosion and sedimentation problem, tributaries and segments of the Carp River need to be reconnected with their floodplains, in part, by increasing the elevation of the streambeds and in part by restoring their natural meandering flow pattern. In addition, stream banks need to be stabilized through a combination of woody, riparian plantings and engineered natural channel measures.⁵

River systems can be described in terms of their hydrologic functions and their erosion and sediment regime. From an erosion and sediment regime perspective, a river system can be divided into three sediment regimes:

- an erosion regime, where water running off the land picks up a supply of sediment
- a transport regime, where sediment carried to a stream is actively transported in a network of channels, and tributaries
- a deposition regime, where the river deposits its sediment load generally in a large river, lake or other water body

Where these river zones are in balance (dynamic equilibrium), the river, its riparian zone and floodplain generally remain in a stable condition where changes occur gradually over decades or even centuries. When this dynamic equilibrium is upset, for example when land use changes from forested to agriculture to urban, these changes may be accelerated resulting in annual or more frequent changes.

⁵ Engineered natural channel measures are a combination of natural channel design principles, native materials and engineered structures use to create "naturalized" streams not mimic natural stream processes, but provide additional structural stability where constraints limit full restoration of the channel to a natural state.


If these changes are addressed as the land use change occurs it may be sufficient to apply corrective or innovative measures only at source allowing the remainder of the river system to adjust naturally. If such changes are not addressed until long after the land use change has occurred, corrective measures need to be applied in all river zones. The Carp River and its tributaries fall into this latter category.

An erosion and sediment control strategy is proposed to address each component of the river systems sediment regime:

Source Control:

Aimed at managing productive soils at the field level to minimize soil erosion from water and wind (e.g. conservation land management practices)

Tributary Measures:

A combination of steam buffer plantings and instream measures to reverse the current trend of downcutting and widening of stream channels in the tributaries (e.g. stream restoration measures).

River Measures:

A combination of stream riparian and floodplain measures in Carp River segments and at tributary mouths to re-establish floodplain and riparian functions and re-create riparian wetlands (e.g. stream restoration, riparian planting, wetland creation).

Recommended Measures

These measures are prioritized based on the flow and aquatic characteristics of the tributaries and the Carp River. Priority 1 tributary reaches and Carp River segments and their associated drainage are permanently flowing while Priority 2 tributary reaches are intermittent. Erosion and sediment control measures to be applied in Priority 1 agricultural areas are as follows:

- Stream restoration using natural channel design and engineered natural channel measures along 15.4 km of Priority 1 tributaries and 13 km of Priority 1 Carp River segments. These priority areas are shown in Figure 8.1 as disturbed reaches.
- Riparian zone plantings along 24.2 km of Priority 1 tributaries and 9 km of Priority 1 Carp River segments. These priority areas are shown in Figure 8.1 as non-vegetated reaches.
- Conservation land management practices on 4500 ha of Priority 1 and 2500 ha of Priority 2 agricultural lands to reduce soil erosion.
- Livestock access restrictions and installation of alternative water sources on livestock operations in Priority 1 agricultural lands and along Priority 1 Carp River segments.
- Reconstruction of roadside ditch systems using natural channel design principles to address erosion and sedimentation problems.



In the drainage areas of Priority 2 tributary reaches (see also Figure 3.4.7 for drainage areas), the emphasis will be on at-source controls with application of conservation land management practices on Priority 1 agricultural lands, plus the following:

- site specific erosion control measures including livestock access control, instream and roadside grade controls, streambank stabilization
- riparian plantings along 18.2 km of stream. These priority areas are shown in Figure 9.1 as non-vegetated reaches.

8.2.1.3 Surface Water Quality

At the subwatershed level, a series of measures is proposed to address water quality impacts from urban development. These measures will also be applied in other urbanizing areas of the watershed. Agricultural land use practices also contribute to water quality problems in the watershed, primarily nutrient enrichments (phosphorus, nitrogen compounds), bacteria and sediment. These loadings are compounded by lack of stream flow and high stream temperatures due to lack of shading. This leads to stagnant water, eutrophic conditions and reduced oxygen levels in tributaries and the Carp River.

Although some farmers feel that their current practices have improved relative to historic practices, the river and its tributaries still exhibit the effects of current and historic land use practices and additional measures are still necessary before historic/current trends can be reversed. It was also identified that wildlife populations are contributors to nutrient and bacterial loadings to the river and that wildlife populations have increased in recent years. For example, it has only been in the last decade that resident populations of Canada geese have become established in the Ottawa area.

Improvements in water quality, particularly from excessive loadings of nutrients, bacteria and sediment can result from implementing two types of measures:

- land based controls or source controls: including measures that reduce or eliminate nutrients, bacteria, sediments before they enter the stream system
- instream controls: including measures that increase the streams capacity to utilize/convert the nutrients, bacteria, sediments into biologically available forms

Land-based or source control measures address both point and non-point sources of these contaminants. Most non-point sources of pollutants on agricultural lands arise from soil erosion that also carries nutrients, sediment and bacteria. This may arise from1) over-applied fertilizer or manure; 2) fertilizer or manure applied at the wrong time of year (e.g. frozen ground); or 3) over-pastured. Conservation land management practices to address these sources have already been discussed. Point sources include livestock access, as well as a variety of contaminants that arise from farmsteads and are carried in runoff to the nearest watercourse. Feedlot and barnyard runoff, runoff from manure, feed and fertilizer storage areas, milkhouse wastes are examples of point sources of these contaminants. A group of rural BMPs are recommended to address these point sources. Priorities for implementation are as follows:

- implement non-structural BMPs on all farmsteads on Priority 1 and 2 agricultural lands, beginning with those operations contributing directly to Priority 1 and 2 stream reaches.
- implement structural BMPs on all farmsteads contributing directly to Priority 1 stream reaches.
- initiate a septic system inspection program and repair/replace faulty systems (covered under groundwater program).



8.2.2 Groundwater Plan Components

The purpose of this section is to link the key groundwater components identified in this study to the City of Ottawa's Groundwater Management Strategy that was approved by City Council in February, 2003. The City has developed a two-phased Groundwater Management Strategy. The first phase involves organizing current groundwater management activities into eight separate 'elements', while the second phase will be completed once the provincial source water protection legislation in complete.

The eight elements are listed and described below:

	Element	Description
1	Public Consultation, Awareness, Involvement	Develop and implement programs to inform the community about groundwater management issues and to involve the community in making decisions regarding these issues.
2	Groundwater Resource Definition	Investigate and evaluate the extent and characteristics of the groundwater resources.
3	Identification of Potential Contaminant Sources	Identify and evaluate potential sources of groundwater contamination. These sources arise from a variety of land use practices and industrial activities, both present and historic, that either use compounds or produce waste products that can contaminate the groundwater resource
4	Groundwater Use Assessment	Conduct scientific estimates of water budget using four main components of the hydrogeologic cycle (precipitation, evapotranspiration, surface water and groundwater) in specific areas or groundwatersheds. This element could also address the management of large groundwater takings.
5	Groundwater Quality and Level Monitoring	Collect and evaluate water quality and water level data, to identify trends. It is essential that these data be collected on a broad basis, at regular intervals, and in a structured organized fashion.
6	Data Management	Develop and maintain a database system which will provide fast easy access to, and manipulation of, groundwater data, including geological, hydrogeological, and water quality information.
7	Emergency Preparedness, Response and Contingency Plan	Develop and/or maintain contingency plans: a) for responding to emergencies which might threaten groundwater; and b) for emergency water supply in the event that major supply sources must be shut-down because of contamination.
8	Best Management Practices, Protection Policies and Legislation	Identify existing and/or develop new best management practices, protection policies and legislation for groundwater management.

In terms of priorities within the Carp River watershed, specific concerns are:

- Agriculture impacts on groundwater and surface water (point and non-point sources)
- Protection of recharge/discharge areas
- Reducing impacts from septic systems
- Suitability of current provincial guidelines for hydrogeological investigations



Agricultural Impacts

A review of the water quality information indicates that several tributaries of the Carp River are degraded. Parameters contributing degradation are nutrients (phosphorus and nitrogen), bacteria and elevated levels of suspended sediment. Analysis of the data indicates that tributaries with multiple sampling sites become more degraded as they traverse agricultural lands bordering the Carp River. This suggests non-point sources related to agriculture (fertilizer use and manure, cattle access to streams) may be significant.

On the positive side, most of the degraded surface water sites are separated from the areas identified as significant groundwater recharge zones or classified as having low aquifer vulnerability, using the DRASTIC method (CH2M Hill, 2001) or the MOE ISI method (Golder Associates and others, 2003).

Several key regional-scale observations may points are:

- The impact of nutrients and bacteria on surface water will be reflected, albeit on a longer time frame, in groundwater. Some municipal wells in Eastern Ontario have been identified as being under the direct influence of surface water (GUDI) and several have been taken off-line due to bacterial contamination.
- The 2003 RMR study (**Appendix H**) found that there is no direct link between agriculture and nitrate concentrations in groundwater, although the study cautions that the combined impact of excess agricultural nutrients and pesticides may impact several areas of high aquiver vulnerability, including an area between Panmure Road and March Road, within the Carp Watershed.

It is evident that measures designed to protect and improve surface water quality (Section 8.3.1.3) will provide benefits to groundwater. Protection of surface water quality in areas of groundwater recharge should be added to the City of Ottawa Groundwater Management Strategy under Element 8 (Best Management Practices).

The City of Ottawa has a Rural Clean Water Program with committed funding of \$750,000 over 3 years (1999-2001) as cost-share grants to projects and best management practices (BMPs) that protect surface water quality. This program should be maintained and expanded to include the rehabilitation, protection of water supply wells and assist with proper abandonment to unused wells. In this regard, **Figure 8.1** shows areas of high and moderate recharge in relation to Priority 1 and 2 agricultural lands. Rural BMP's should be applied on a priority basis on agricultural lands overlying these areas of high and moderate recharge.

Groundwater Recharge and Discharge Areas

Important groundwater recharge and discharge areas were identified in the watershed study and are shown in Figure 8.1. Protection of these features is achieved, in part, through the Greenlands Plan by protection of Category 1 and 2 features and protection of watercourses and riparian areas. In addition, some of these recharge areas are also protected where they coincide with Priority 1 and 2 Rural Management areas, where implementation of conservation tillage practices is recommended.



Some additional important recharge/discharge areas may still be vulnerable to impacts from land use activities. These areas may be addressed through recommendations from a number of initiatives, including:

- The Regional Groundwater Study
- The City of Ottawa's Groundwater Management Strategy
- Future Source Water Protection Plan that may be completed

Septic Systems

Sub-standard and failing septic systems are recognized as a significant threat to groundwater in a 1992 study for the former Regional Municipality of Ottawa-Carleton (Geo-Analysis 1992), the recent Eastern Ontario Water Management Study (EOWRMS, 2001) and the Renfrew County – Mississippi – Rideau Groundwater Study (Golder Associates and others, 2003). These studies recommend several approaches, such as minimum lots sizes, encouraging communal well systems for hamlets, restrictions on multiple severances, inspection of septic systems as conditions of transfer and setting guidelines for hydrogeological investigations for development applications on private services.

In November 2003, an information package for the Rural Wastewater Management Study was presented (R.J. Burnside, 2003). The study notes state that there are some 30,000 septic systems in the rural City of Ottawa, with approximately 600 being added every year. The study developed a groundwater pollution potential risk model, which shows that six communities are classed as high risk / high priority, including Kinburn and Fitzroy Harbour Villages.

The study suggested a management program that incorporates seven components:

- A three-phase re-inspection program
- Septage management (in light of the ban on land application of septage under the Nutrient Management Act)
- Database management (all on-site septic systems)
- •
- Legal Issues ((City by-laws and Building Code)
- Education and Training
- Budgetary Considerations

To illustrate the cumulative impact of domestic septic systems, 30,000 private septic systems may add more than 400 metric tonnes of nitrogen (as nitrate) into the ground, equivalent to the amount of nitrate that would be expected to leach from fertilizer applied to 200 square kilometres of corn crops.

Faulty septic systems will also leach phosphorous and bacteria, resulting in surface water quality degradation and potential groundwater contamination.

It is recommended that a detailed investigation of septic systems be undertaken in the high risk communities, including Kinburn and Fitzroy Harbour. In addition, a targeted education/awareness program should be developed and implemented for other rural residents of the watershed, using the database developed as part of the newsletter/questionnaire circulation list developed for this study. Residents should also be made aware of the Rural Clean Water Program and the possibility of assistance available through this program.



Hydrogeological Investigations for Land Development Proposals

The MOE Guideline D-5-5 (Technical Requirements for Private Wells: Water Supply Assessment) was last revised in 1996. This procedure was applicable to individual and small developments, generally applied when 5 lots/units (or more), at a time when the Ministry of Environment approval was required.

Some municipalities have developed more stringent technical requirements for hydrogeological investigations for subdivisions. Examples include a requirement that wells be drilled on each proposed lot (Regional Municipality of Halton) or that areas of recharge and discharge be subject to more detailed hydrogeological studies and that groundwater contributions to baseflow be protected (Town of Caledon OPA 114 & 124, 1997).

The existing MOE Policy D-5-5 is considered a minimum requirement for developments consisting of 5 lots/units. It does not specifically exempt smaller developments (<5 lots/units), and some municipalities choose to require D-5-5 for severances.

Technical guidelines for hydrogeological investigations and terrain analysis are currently under development by the City of Ottawa. Until new guidelines are developed, it is good practice to require that any study based on Guideline D-5-5 must include elements of Guideline D-5-4 (Technical Guideline for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment), which requires that servicing proposal consider both site-specific and "cumulative" impacts in consultation with the municipality – and that this be based on existing and proposed municipal servicing plans and growth management objectives.

The cost of a proper Hydrogeological study may range from several thousand to several tens of thousands of dollars (excluding the cost of well drilling). The benefit will be more accurate understanding of the cumulative impact of private services, a refinement of aquifer vulnerability (water wells and observation wells will provide more accurate resolution of the intrinsic susceptibility (IS) of aquifers and groundwater quality data points).

It is recommended that guidelines or generic terms of reference be developed for hydrogeological studies that address the impacts of development, including servicing on local groundwater resources (quality and quantity) on the aquifer systems, including assessing potential cumulative effects and effects on sensitive environmental features, including wetland, woodlands and watercourses. As part of these studies, a detailed water budget should be developed that addresses water conservation, protection of recharge and discharge areas, maintenance of local groundwater table elevations and flow patterns.

8.2.3 Greenlands Plan Component

8.2.3.1 Aquatic System

The Carp Watershed consists of following 5 types of fish communities that reflect the current state of health of the aquatic system within the watershed (**Figure 3.7.1**):

- Tolerant coldwater fish community;
- Diverse, moderately tolerant cool/warm water fish;
- Tolerant warmwater fish community;
- Degraded warmwater fish community; and,
- Intermittent streams.



The priorities at the watershed scale for aquatic communities are as follows:

- protect and enhance base flows
- provide stream shading and riparian habitat benefits through woody riparian plantings
- reduce sediment and nutrient loadings to streams
- stabilize streams and re-establish connections between the Carp River, and its tributaries and adjacent floodplains

Measures to be implemented have already been presented under the Surface Water Quantity and Quality sections. Protection of recharge areas is also discussed under the Groundwater Plan component.

For each target community, there are also a series of biological and habitat targets that can be used to assess the extent to which stream reaches have been restored and to provide minimum targets to be achieved for any project activities, developments or discharges to receiving streams. These are presented in **Table 8.2.1** and **Table 8.2.2**. The target fish communities for all reaches of the Carp River and all tributaries within the Carp watershed are as follows:

- All reaches of the Carp River downstream of Kinburn Side Road: diverse warmwater/tolerant coldwater fish community – Type1 / 2
- All reaches of the Carp River between Kinburn and Richardson Side Road: diverse warmwater fish community – Type 2



Table 8.2.1 Representative Species For Different Fish Community Types

FISHERIES								
Type I Tolerant Coldwater Community	Type II Diverse Warmwater Community	T Modera Warmwa	ype III ately Tolerant ter Community	Type IV Tolerant Warmwater Community		Type Va Highly Tolerant Warmwater Community	Type Vb No Aquatic Community	
 Minimum of one of the following fish species: rainbow trout chinook/coho salmon brown trout 	Minimum of 14 fish species, including at least 4 of the following: northern hog sucker pike smallmouth bass lowa darter redside dace yellow perch walleye intolerant minnows ¹ stonecat	Minim um of including at following: rock bas largemo rainbow fantail da redhorse central s insectivo	10 fish species, least 2 of the s uth bass darter arter ss toneroller prous minnows ²	 community community pecies, of the Minimum of 4 fish species, including at least 1 of the following: pumpkinseed/bluegill black crappie white sucker gizzard shad johnny darter omnivorous minnows³ 		Minimum of 1 of the following fish species: • carp • goldfish • brown bullhead • brook stickleback • central mudminnow	No fish present	
MACROINVERTEBRATES								
Type I Stable Coldwater Community	Type II Stable Warmwater Comm	unity	Type III Unstable Warmwater Community		Ty Warm	pe IV Impaired water Community	Type V Severely Impaired Community	
WQI >13 EPT ≥15	WQI >12 EPT ≥10		WQI EPT	7 ≥5		WQI 5 EPT 3	WQI ≤5 EPT ≤3	
At least four of the following: Amphinemura Leuctra Haploperla Ectopria Heterotrissocladius Eukiefferiella Rhyacophila	At least five of the followi Acroneuria Isoperla Taeniopteryx Paraleptophlebia Serratella Chimarra Rhyacophila Diamesa Lumbriculus variega Turbellaria Eukiefferiella	ng: tus	At least six of th Turbellaria Baetis Caenis Stenacron Tricoythrodes Cheumatopsy Hydropsyche Neophylax Optioservus Stenelmis Micropsectra Simulidae	e following: /che	At least four o Sialis Berosus Cheumato Hydropsyc Dubiraphia Probezzia Cryptochiro Paratanyta Rheotanyta Chaetoclac Hemerodro	f the following: osyche he onomus rsus arsus lius omia	At least five of the following: Nais pardalis/bretscheri Limnodrilus offmeisteri L. claparedianus Tubifex tubifex Sparganophilus Berosus Probezzia Chironomus Physella	

¹ Blacknose shiner, sand shiner, rosyface shiner, river chub.
 ² Hornyhead chub, emerald shiner, common shiner, blacknose shiner, striped shiner, spottail shiner, rosyface shiner, spotfin shiner, sand shiner, redfin shiner, blacknose dace, longnose dace, mimic shiner.
 ³ Fathead minnow, northern redbelly dace, bluntnose minnow, goldfish, creek chub, brassy minnow, golden shiner.



Table 8.2.2 Aquatic Habitat Targets for "Type" Fish Communities

Indicators	Rational for Targets	Potential Targets (Bolded Values indicate primary targets for design a indicate secondary targets	and monitoring, Italized targets
1.1 Representative Aquatic Communities	 Fish and aquatic invertebrates are barometers of healthy waterbodies Type 4 and 3 fish communities include fish that are less tolerant of pollution and require more diverse habitats to survive 	Type 4 Fish Community – tolerant warmwater Type 3 Fish Community – moderately tolerant warmwater	Type 1/2 Fish Community- tolerant coldwater/diverse warmwater
1.2 Diversity of Aquatic Communities	Higher values of these fish and aquatic invertebrate indices (IBI, BioMap and EPT) indicate improved water quality, quantity and aquatic habitats	 IBI = 6 (@nin?BioMap = 5 (min)?, EPT = 3 (min) 4 fish species (min) IBI = 20 (@nin?BioMap = 7 (min)?, EPT = 5 (min) 8 fish species (min) 	 IBI = 36 (@nin?BioMap = 12 (min?, EPT = 10 (min) 14 fish species (min)
1.3 Abundance of Aquatic Communities	greater densities of fish indicate improved water quality and aquatic habitats	• density = $<150/100m^2$; biomass = $<2500g/100m^2$ • density = $300 - 400/100m^2$; biomass = $<2500g/100m^2$	 density = 150-300/100m²; biomass = 5000 g/100m²
1.4 Aquatic Community Health	 Target values as shown are required to support populations of the target fish community DO saturation levels need to be maintained or increased to support respiration and decomposition in aquatic ecosystems Maximum instream temperatures need to be reduced to support more sensitive aquatic communities TSS levels need to be reduced to minimize siltation of aquatic habitats and clogging fish gills Nutrients (TP & nitrogens) need to be lowered to avoid causing excessive algae growth that lowers DO levels through decomposition Chemical concentrations in waterbodies need to be reduced to minimize the potential for toxic / stressful conditions – dry target is chronic toxic level: wet target is acute toxic level Trace metal concentrations need to be reduced to minimize the potential for chronic toxic levels during dry conditions and acute toxic levels during periodic wet conditions 	 DO minimum: 4 mg/L and 50% saturation Temperature max.: 38.0 C (upper preferred = 38 C) TSS = 10 mg/l (dry); 100 mg/l (wet) - 25% of the time TP = .03 mg/l (dry); 0.1 mg/l (wet) - 25% of the time Nitrite+Nitrate = 0.3 mg/l (dry); 1.0 mg/l (wet) 25% of the time Copper = 0.005 mg/l (dry); 0.2 mg/l (wet) - 25% of the time Copper = 0.005 mg/l (dry); 0.2 mg/l (wet) 25% of the time Lead = 0.025 mg/l (dry); 0.5 mg/l (wet) 25% of the time Zinc = 0.02 mg/l (dry); 0.5 mg/l (wet) 25% of the time Zinc = 0.02 mg/l (dry); 0.5 mg/l (wet) 25% of the time 	 bissolved Oxygen: 6 mg/l and 80% saturation Temperature max.: 25 C (22 C – Type 2 upper preferred); 20 C (Type 1- 18 C upper preferred) TSS = 10 mg/l (dry); 100 mg/l (wet) 80%of the time TP = .03 mg/l (dry); 0.1 mg/l (wet) 80%of the time Nitrite+Nitrate = 0.3 mg/l (dry); 1.0 mg/l (wet) 80%of the time Copper = 0.005 mg/l (dry); 0.02 mg.l (wet) 80%of the time Lead = 0.025 mg/l (dry); 0.2 mg/l (wet) 80%of the time Zinc = 0.02 mg/l (dry); 0.5 mg/l (wet) 80%of the time



Table 8.2.2 Aquatic Habitat Targets for "Type" Fish Communities – cont'd

Indicators	Rational for Targets	Potential Targets (Bolded Values indicate primary targets for design and monitoring, Italized targets indicate secondary targets					
1.5 Habitat Integrity ¹	 Target values as shown are required to support populations of the target fish community Natural hydrology (water quantity) conditions and physical instream and streamside habitats need to be improved to support more sensitive aquatic life Groundwater contributions to total annual flow needs to be increase to reduce periods of intermittent stream flow and water stagnation Increasing woody riparian vegetation and instream woody debris increases stream shading and instream cover for aquatic life Increasing the percentage of pool and riffle habitat in streams provides spawning, nursery and refuge habitat for fish Increases oxygenation of water and increases food supplies 	 Flow time series = current conditions Average Recharge = x mm / year (maintain current rates) Groundwater = 8 % mean annual flow RGA = stable for >10% of reaches >10% natural streams with stable morphology 20% stream banks with woody riparian vegetation 10% instream cover by woody debris 20% stream with pool:riffle-3:1 20% riffles with <10 fines/embedding 30% of pools – Type 2 width:depth – min depth at riffle: 2 cm (low flow) Flow time series > 2x historic condition (< 25% urbanized) Average Recharge = x mm / year (maintain historic rates) Groundwater = 10% mean annual flow (min) RGA = stable for 50% of reaches S0% natural streams with stable morphology 50% stream banks with woody riparian vegetation 10% instream cover by woody debris 20% stream with pool:riffle - 3:1 50% stream with pool:riffle - 3:1 50% of pools - Type 2 width:depth – min depth at riffle: 2 cm (low flow) 	 Flow time series < 1.5x historic condition (<10% urbanized) Average Recharge = x mm / year (maintain historic rates) Groundwater = 25% mean annual flow (min) RGA = stable for 75% of reaches 75% natural streams with stable morphology 75% stream banks with woody riparian vegetation 10% instream cover by woody debris 75% stream with pool:riffle - 3:1 75% riffles with no fines/embedding 75% of pools - Type 1 (minimum 50 – 100 cm deep) width:depth – min depth at riffle: 10 cm (low flow) 				
1.6 Waterfront Aquatic Community Health	 The quality of stream water at the river mouths should be reduced to approach PWQO's to support downstream fish communities 	Meets PWQO - 25 %of the time Achieve PWQO- 50%of the time	Achieve PWQO- 80% of the time				

Targets for Habitat Integrity are appropriate for natural channels and GREE channels exhibiting pool:riffle characteristics; for riparian wetland communities the pool:riffle targets and riffle targets are not applicable.

For riparian wetland channels, add the following: minimum of 10% of channel should be free of rooted, emergent vegetation, floodplain pools should be a minimum of 1.5 m deep and connected to the river channel at ½ bankfull flows, 10% of pools should be over 1 m deep

1



- All reaches of the Carp River upstream of Richardson Side Road: tolerant warmwater fish community – Type 3
- Priority 1 and 2 tributaries: tolerant warmwater fish community Type 3 except as follows:
 - Huntley (south branch) and Corkery (north of Highway 417) Creeks: diverse warmwater fish community – Type 2
 - Carp Creek, Huntley (north branch), Feedmill and Poole Creeks: diverse warmwater fish community/tolerant coldwater fish community – Type 1 / 2
 - All other tributaries (including intermittent tributaries): water quality and quantity conditions to support downstream fish communities – Type 1, 2 or 3

Stream restoration and riparian plantings identified in the surface water component will be designed to achieve the target criteria for the appropriate fish community.

The riparian corridor restoration target for the Carp River and its tributaries is as follows based on the target communities outlined above (please note - this does not reflect creek corridor development setback requirement, only streamside vegetation target within the creek corridor. The actual development setback may be different.)

- Type 1 fish community: 30 metre setback on each side of the watercourse; revegetating up to 75% of the total stream length with native, woody, riparian vegetation (with woody vegetation representing 50% by area of the replanted area)
- Type 2 and 3 fish community: 15 metre setback on each side of the watercourse; revegating up to 50% of the total stream length with native, woody, riparian vegetation (with woody vegetation representing 50% by area of the replanted area)
- All other streams, including intermittent watercourses: 15 metre setback on each side of the watercourse; revegating up to 50% of the total stream length with native, woody, riparian vegetation (with woody vegetation representing 50% by area of the replanted area)

Intermittent watercourses include all drainage features with any of the following features:

- a defined channel and banks
- a drainage area great than 125 ha
- permanent stream flow or evidence of groundwater discharge (permanent watercourse)
- stream banks vegetated with native, woody species
- a channel occurring within a well defined valley feature

It is recognized that on lands under active cultivation, a narrower stream buffer may be acceptable when used in combination with conservation, tillage practices or livestock fencing. In this regard, a 3 m buffer on either side of the watercourse is recommended under the Nutrient Management Act.

8.2.3.2 Terrestrial System

The focus of the terrestrial system component of the watershed plan is on protection of forest and wetland features that currently cover about 30% of the watershed, but are restricted to the ridges along the northerly and southerly margins of the watershed. Secondly, the terrestrial system includes enhancement and restoration measures to re-establish forest and wetland habitat along the Carp River and its tributaries (Priority 1 and 2 tributaries) to provide aquatic benefits that serve as secondary wildlife corridors. This restoration would be initiated



through a stewardship program on agricultural lands, recognizing that current agricultural practices could continue. Should land use change, a stream corridor setback would be established based on floodplain, meander belt geometry and fisheries requirements as identified for Poole and Feedmill Creeks in the subwatershed plan.

The terrestrial system strategy is also aimed at protecting existing headwater features and restore riparian areas along Priority 1 and 2 stream reaches to a natural state. Components of the recommended terrestrial system were prioritized for implementation as follows:

Category 1: Protection Recommended

- the natural features occurring with the boundaries of Centres of Ecological Significance
- all high NESS areas, candidate ANSIs, Provincial Significant Wetlands and mature woodlands (see Figure 3.7.12), features containing interior habitat (see Figure 3.7.9)
- all riparian vegetation along the Carp River
- all priority 1 and 2 riparian (stream and valley) corridors
- all Moderate and Low NESS areas in high recharge areas

Category 1 areas are fundamental building blocks which provide core natural areas and contribute the most to the biodviersity and integrity of the area. These areas are identified to be protected. They may also have a significant hydrologic, specifically groundwater function. These areas perform important ecological processes and protect biological diversity and life-supporting systems that would be lost or degraded if such areas were permanently disturbed in any way.

Category 2: Protect Feature and Function (Environmental Impact Statement)

- all Moderate and Low NESS areas in moderate recharge areas
- locally significant wetlands (not captured by Category 1)
- all natural features contiguous with Category 1 features including Low NESS areas
- all lands within a 30 m adjacent lands (120 m for wetlands) from the boundary of Category 1 areas
- the riparian corridor along all other watercourses, including intermittent watercourses

Category 2 areas provide important secondary benefits in terms of wildlife habitat, linkages to the Category 1 areas, and act as seed sources or nuclei from which revegetation efforts can build upon. Category 2 areas should be protected through stewardship programs, however if land use change is proposed, these areas should be protected or replaced with equivalent features depending on the results of more detailed evaluation. These areas provide important ecological functions to the watershed and allow for creation of new ecological features such as vegetative buffers, wetlands and linkages between vegetated areas and watercourses. If land use changes are proposed, subject to detailed studies in the form of an Environmental Impact Statement (EIS), some level of development may be permitted to alter the size and physical form of a Category 2 area provided that the ecological functions including hydrologic and hydrogeologic functions are protected and maintained.

Category 3: Restoration/Enhancement Opportunities

- areas targeted for stewardship include the following:
 - any non-vegetated areas within the boundaries of Category 1 areas in particular within/adjacent to Centres of Ecological Significance that would enhance the function of the Category 1 area



- any Category 2 areas that would serve one of the following functions:
 provide a linkage function between Category 1 areas, if enhanced
 - increase the amount of interior habitat within a Category 1 area, if enhanced
 - protect a high or moderate recharge area, if enhanced
 - provide a riparian corridor along a watercourse, if enhanced

Category 3 areas represent opportunities to improve the overall form and function of the terrestrial system by either enhancing the form and function of portions of Category 1 areas that are not currently in a healthy state, or by restoring selected Category 2 areas to support the functions of Category 1 areas, such that these restored Category 2 features would then be protected as Category 1 areas.

Category 1 and 2 areas are shown in **Figure 8.1.** Category 3 areas are not shown, as additional studies or stewardship efforts would be required to identify where these opportunities may exist. The study area for this additional work would generally fall within the areas designated as Category 1 and 2 in Figure 8.1.

8.3 Recommended Subwatershed Plan for Urbanizing Areas

In the following sections the Recommended Subwatershed Plan for the Urbanizing Areas is presented. As stated in Section 8.1, the recommended measures are described under the following components:

Surface Water Management Plan (Figures 8.2 and **8.5**), which describes protection, enhancement and restoration measures to sustain streams in a stable natural state, manage flood and erosion risks and avoid/remediate water quality problems.

Groundwater Management Plan (Figures 8.3 and **8.5**), which identifies key measures necessary to enhance recharge, ensure baseflow contribution and protect groundwater quality as urban development proceeds.

Greenlands Plan (Figures 8.4 and 8.5) which describes the terrestrial and aquatic systems and outlines required protection, enhancement and restoration measures.

8.3.1 Urban Surface Water Management Plan

The surface water management plan describes protection, enhancement and restoration measures to manage flood and erosion risks, sustain streams in a stable natural state and maintain or improve existing water quality conditions. The surface water management plan is divided into three subsections, flood control management, stream erosion and water quality (see **Figure 8.5**).

8.3.1.1 Flood Control

Background

The Upper Carp River subwatershed extends from Richardson Side Road upstream and includes portions of the former city of Kanata, Stittsville, and the Kanata West development lands that form the largest area of future development within the watershed. Within the urbanizing subwatershed area are two major tributaries, Poole Creek and Feedmill Creek.



These tributaries contribute significantly to the base flow in the Carp River. Future development areas within the subwatershed are shown in Figure 3.6.4, Land Use Planning Areas.

The QUALHYMO hydrologic model was used to evaluate existing and future flow conditions in the entire watershed. The model was used to carry out the following analyses:

- Continuous simulation of precipitation/runoff over a 27 year period. A frequency analysis
 was then performed to generate return period flows at selected locations.
- In the subwatershed area, the impact of urbanization on the Carp River between the Glen Cairn pond and the reach downstream of Richardson Side Road was evaluated using discrete design events, ranging from a 25mm event to the 100 year storm.

Flood Control Measures

There are no current flood damage sites or flood susceptible areas located within the subwatershed area, with the exception of the Glen Cairn Community in Kanata. The Glen Cairn Community is the oldest urbanized area within the watershed. The area experienced significant flooding in 1996 and again in 2002. The flooding was due to the absence of an overland flow route in the Castlefrank Road area in combination with partially blocked culverts and/or undersized culverts. In September 2004, a 24-hour rainfall well in excess of the hundred year event did not result in any reported flooding and did not exceed the capacity of the Glen Cairn stormwater management facility.

As urbanization occurs, stormwater runoff rates and volumes will increase, this could increase the likelihood of flooding unless a comprehensive water management plan is adopted for the urbanizing areas.

Hydrologic Analyses

In order to determine the impact of urbanization on flood potential within the watershed / subwatershed area, a QUALHYMO model was constructed and peak flows were determined for existing and future development conditions (assuming no stormwater controls) at a number of locations within the watershed / subwatershed. Peak flows were determined for the 25mm, 1, 2, 5, 10, 25, 50, and 100-year events.

The QUALHYMO model of the Carp River watershed consists of a number of subcatchments representing homogeneous areas. Where the effects of channel routing was considered significant, the REACH routine was used, otherwise flow transfer between subcatchments was simulated by simple addition of hydrographs. Where reservoirs or culverts provide measurable attenuation of peak flows, the POND routine was used to REACH flows.

Design Events

Two types of analysis were undertaken: A station frequency analysis using precipitation and temperature records from the Ottawa MacDonald-Cartier International Airport and discrete design events using return period rainfall.

Hourly precipitation and temperature records from the Ottawa International Airport were used as model input. Hourly precipitation data from 1967 to 1993 was used.



Model Calibration

Since snowmelt related runoff events have historically caused the highest flows in the rural portion of the watershed (downstream of Richardson Side Road) a calibration procedure was carried out to match measured spring flows. Peak flows from the gauge at Kinburn were used for calibration.

Published snowmelt parameter values were used for SNOFAC, ALPHAA, XKL, BCOEF, XNCOEF, COEFD, and COEFE. For calibration, BASET (temperature at which melt starts) and PSTATE (temperature above which precipitation occurs as rain) were used as variables.

Initially, both BASET and PSTATE were set at 0°C. The U.S. Army Corps of Engineers Snow Laboratories have reported values for BASET varying from -2.8°C for open sites to 5.6°C for forested areas. Based on the geography of the Carp basin and through a comparison of measured vs. simulated flows, a BASET value of 0°C was used for urbanized subcatchments and 2.3 °C for rural ones.

Results show that the hourly peak flows generated by the QUALHYMO model are, on average, approximately 93% of the measured peak daily flows and 87% of the peak instantaneous flows. The model results indicate a wider range between high and low flows than is shown in the measured record. As a result, the more frequent events are somewhat under estimated and estimates of the extreme events are more conservative.

Results show good agreement between measured and modelled flows for some years and poor results for others. For the purpose of generating return period flows, the model appears adequate.

Peak Flows

A frequency analysis of the peak flows at key locations was carried out using the Environment Canada CFA88 program. This program produces design flows for runoff events with a frequency between 1 and 500 years. Results of this analysis indicate a 100 year peak flow at Kinburn of 139.0 m^3 /s. This compares with a design peak flow of 100.4 m^3 /s suggested in the 1983 floodplain mapping report.

In addition to continuous simulation of measured precipitation, synthetic design storms of 25mm, 1 hr, 3 hr, 6, hr, 12 hr, and 24 hr were used to estimate design flows within the subwatershed area (upstream of Richardson Side Road). The SCS distribution was selected as the most representative of longer duration storms (for short duration storms, rainfall distribution was not considered significant because the QUALHYMO model uses 1 hr timesteps. As such, the distribution of precipitation from storms of 6 hours and less does not have any real impact on peak flows).

To simulate the wet conditions that are normally assumed in single event models, the design storm was inserted in a historic precipitation pattern of a typical wet year (1986). The design event was inserted following a period of moderate rainfall but with only minimal precipitation (1.4 mm) in the 24 hour preceding the event (August 1).

Results indicate that the 12 hour storm best represents the peak flow conditions within the subwatershed area, although the duration of the storms that produce the peak flow rates vary somewhat. From Richardson Side Road downstream, the 24 hour storm produces slightly higher flows than the 12 hour event and upstream of Hazeldean Road, the 6 hour storm controls.



Routing Methods

Through the subwatershed area, the Carp River has low bedslope and generally a wide floodplain, typically in the order of 100-500 m. Under these conditions, overbank flows contribute significantly to the conveyance capacity of the river. Because of higher Manning 'n' values of overbank areas, floodplain storage and overbank conveyance capacity are expected to have a significant impact on peak flows. Peak flows may also be affected by the capacity of hydraulic structures such as bridges and culverts. To evaluate whether conveyance is controlled by the in-reach characteristics or hydraulic structures, two types of routing was carried out.

First, the river reaches were modelled using the REACH routine. Subsequently, the reaches between Hazeldean Road and Huntmar Road (this is the first crossing downstream of Richardson Side Road) were also modelled using the POND routine. This approach assumes that the reaches act as reservoirs during high flow conditions and that conveyance is controlled by the hydraulic structures. Storage estimates and stage-discharge relationships at bridges and culverts were obtained from the updated HEC2 model that has been prepared by the MVC.

The POND routine ignores routing time lag through the reach because outflow is controlled by the capacity of the downstream structure, while the ROUTE routine ignores any control by hydraulic structures. To determine which condition controls, peak flow estimates are compared. The lowest results are controlling. Results of both approaches are presented in **Table 8.3.1**.

		Flow, m³/s							
Location		Reach	Routing	Pond F	Routing				
		2 yr	100	2 yr	100				
			yr		yr				
C3	Hazeldean Rd.	7.0	16.2	7.0	16.2				
C4	Maple Grove Rd.	5.9	14.9	7.3	17.2				
C6	Hwy 417	12.0	33.0	15.9	40.5				
C8	Richardson Side Rd.	12.2	39.7	16.4	44.5				
C9	Huntmar Rd.	15.9	38.9	23.0	58.6				

Table 8.3.1Flow Comparison using Reach and Pond Routing

To evaluate which condition controls, the peak flows at each structure were compared. Reach routing produced the lowest peak flows at all location. To determine the controlling condition, the structure capacities at the depths produced by the reach routing were compared with the reach flows. It should be recognized that both the reach routing and the modelling as a pond provide only an approximation of the actual conditions. However, results are close enough that an assessment of the expected flows can be made. Based on the modelling results, the bridges at Hazeldean Road, Maple grove Road, Highway 417, and Richardson Side Road provide the controlling conditions. A summary of flows and water levels is presented in **Table 8.3.2** and **Table 8.3.2A**.



			100 year Event Existing Conditions							
Location		Routed	Elev.	Structure	Pond	Elev.	Structure	Road		
	LUCATION	Flow		Cap.	Flow		Cap.	Elev.		
		m³/s	m	m³/s	m³/s	m	m³/s	m		
C3	Hazeldean Road	16.2	93.9	16.2	16.2	93.9	16.2	95.45		
C4	Maple Grove Road	14.9	93.4	1.6	17.2	93.8	14.1	96.44		
C6	Highway 417	33.0	92.5	2.0	40.5	94.0	41.4	95.72		
C8	Richardson Side Rd.	33.3	92.4	6.1	44.5	93.4	34.7	94.04		
C9	Huntmar Road	38.9	91.0	5.8	58.6	93.0	56.3	93.42		
				100 year Ev	ent Future C	Condition	IS			
C3	Hazeldean Road	16.2	93.9	16.2	16.2	93.9	16.2	95.45		
C4	Maple Grove Road	14.9	93.4	1.6	17.2	93.8	14.1	96.44		
C6	Highway 417	33.3	92.5	2.0	39.3	94.0	40.6	95.72		
C8	Richardson Side Rd.	33.5	92.4	6.1	42.9	93.4	35.0	94.04		
C9	Huntmar Road	39.2	91.0	5.9	59.5	93.0	56.8	93.42		

 Table 8.3.2

 Controlling Flow Conditions - Existing Channel

Table 8.3.2ATable 8.3.2AControlling Flow Conditions – Modified Floodplain

Location				100 year Eve	ent Existing	Conditio	ns	
		Routed	Elev.	Structure	Pond	Elev.	Structure	Road
	LUCATION	Flow		Cap.	Flow		Cap.	Elev.
		m³/s	m	m³/s	m³/s	m	m³/s	m
C3	Hazeldean Road	16.2	93.9	7.7	16.2	93.9	7.7	95.5
C4	Maple Grove Road	15.2	93.0	1.8	17.9	94.0	19.6	96.4
C6	Highway 417	34.0	92.5	2.1	41.5	94.1	41.0	95.7
C8	Richardson Side Rd.	34.6	93.8	42.9	52.8	93.5	24.0	94.0
C9	Huntmar Road	38.9	91.0	5.7	63.1	93.3	57.5	93.4
				100 year Ev	ent Future (Condition	IS	
C3	Hazeldean Road	16.2	93.9	7.7	16.2	93.9	7.7	95.5
C4	Maple Grove Road	15.2	93.0	1.8	17.9	94.0	19.6	96.4
C6	Highway 417	34.1	92.5	2.1	40.8	94.1	40.7	95.7
C8	Richardson Side Rd.	34.8	93.8	43.5	50.4	93.4	24.5	94.0
C9	Huntmar Road	39.3	91.0	5.7	61.2	93.3	56.2	93.4

Peak flows at key locations under existing conditions are summarized in **Table 8.3.3**. The level of discretization for the watershed and subwatershed is shown in **Figures 3.3.2** and **3.3.3** respectively. A comparison of expected peak flows at the downstream boundary of the urban area (Richardson Side Road) is shown in **Table 8.3.4**. The detailed hydrologic analysis is presented in **Appendix F**.



Interpretation

Table 8.3.2, Table 8.3.2A and Table 8.3.3 shows modelling results under two conditions. Under the first condition, flow routing through the reaches, as modelled by QUALHYMO, is assumed. This means that the hydraulic effect of structures is ignored and the reaches are not connected so that water levels in each reach is independent of the upstream and downstream reaches. Under the second option, the reaches are assumed to act as reservoirs where peak flow is controlled by the capacity of the downstream structure. For both options, the structure capacities are obtained from a stage-discharge relationship that was generated through the HEC2 modelling.

Under real life conditions, flows and water levels are a function of both the channel shape and slope, and structure capacity. Under most circumstances, the channel tends to control the lower flows more than the structures under low flow conditions. During high flow events, the hydraulic characteristics of the structures normally control upstream water levels and discharge.

A comparison of **Table 8.3.2** and **Table 8.3.2A** indicate that differences in elevations under the 100 year event for the existing channel versus the modified floodplain channel, are negliable.

Controlling Condition

As an example the Maple Grove Road culvert is used. For the channel depth associated with a peak flow of 14.9 m^3 /s (100 year flow), the flow through the structure would only be 1.6 m^3 /s. This means that ponding would occur until the flow through the structure equals the flow in the channel. Using the pond characteristics only, a flow of 17.2 m^3 /s is expected. This would result in a water level of approximately 93.8 m. At this elevation, the structure capacity is 14.1 m^3 /s. Because ponding occurs upstream of the structure, peak flow will be reduced until the flow matches the capacity of the structure. Actual flow is, therefore, expected to be somewhere between 14.1 and 17.2 m^3 /s.

A review of the tables shows that the structure control dominates at Maple Grove Road, Highway 417, and Richardson Side Road. At Huntmar Road, the capacity associated with the ponding condition is about 45 % larger than the peak flow obtained through channel routing. Here, some ponding will occur but not to the same extend as in the upstream reaches.



	Location		F	low (m³/s		
	Location	25 mm	1 yr	2 yr	5 yr	100 yr
Poole	Creek					
P1	Main Street	3.8	4.1	5.3	7.1	12.8
P2	Hazeldean Road	4.9	5.8	7.8	10.5	17.9
P3	Maple Grove Road	5.0	6.3	8.6	11.9	21.1
P4	Confluence w Carp River	5.1	6.4	8.8	12.1	21.5
Feedm	ill Creek					
F1	Carp Road (RR#5)	0.5	0.5	0.7	0.8	2.7
F2	Highway 417	1.3	1.6	2.1	3.0	6.0
F3	Huntmar Road	1.9	2.2	3.0	4.2	7.8
F4	Confluence w Carp River	2.1	2.6	3.5	4.8	8.8
H1	Huntley Creek			10.2*	13.6*	23.9*
CC1	Corkery Creek			11.3*	15.5*	27.0*
Carp R	iver					
C1	Glen Cairn Pond @ Terry Fox	9.2	10.4	14.1	19.3	33.5
C2	Outlet Glen Cairn Pond	3.8	4.4	5.7	7.1	12.3
C3	Hazeldean Road	4.1	5.2	7.0	9.2	16.2
C4	Maple grove Road	3.0	4.2	5.9	7.9	14.9
C5	D/S of Poole Creek	6.5	9.2	12.8	18.1	34.1
C6	Highway 417	5.8	8.6	12.0	17.1	33.0
C7	D/S of Feedmill Creek Confluence	7.1	10.4	14.5	20.6	39.7
C8	Richardson Side Road	6.2	8.8	12.2	17.1	33.6
C9	Huntmar Road	9.7	12.0	15.9	21.8	38.9
C10	March Road			12.6*	17.7*	31.4*
C11	Carp Road			17.7*	25.5*	54.6*
C12	Confluence Corkery Creek					
C13	Panmure Road			36.5*	55.5*	121.0*
C14	Kinburn Gauge			37.3*	59.6*	139.0*
C14	From observed flows			52.7*	68.2*	99.2*
C15	Confluence w Ottawa River			55.7*	84.9*	197.0*
*) Flov	v estimates from station frequency a	nalysis				

Table 8.3.3Peak Flows at Key Locations



Return	Flow (m ³ /s)						
Period	Existing Conditions	Future Conditions					
25mm	6.2	6.7					
1 year	8.8	9.2					
2 year	12.2	12.5					
5 year	17.1	17.4					
100 year	39.7	33.5					
Flows are g	generated using design s	torms					

Table 8.3.4Flow Comparison at Richardson Side Road

The results do show some local increases in peak flow rates under future uncontrolled conditions. However, future flows will still be contained within the valley lands and the Carp River shows no significant increase in peak flows. Therefore, the implementation of flood control measures such as quantity control SWMPs is not recommended.

Runoff Volumes

As **Table 8.3.2, Table 8.3.2A, Table 8.3.3** indicates, the instantaneous peak flow rates in the Carp river are not significantly affected if no quantity control is implemented for future development. However, total runoff volumes will increase and this could affect the frequency of higher than normal flows in downstream reaches. The estimated increase in runoff volumes at key locations is presented in **Table 8.3.5**.

			Runoff Volume in ha.m								
	Location	3 hour event		% change	12 hou	ur event	% change				
		Exist.	Future		Exist.	Future					
P2	Hazeldean Road	53.3	53.3	0.0	68.6	68.6	0.0				
P3	Maple Grove	61.0	63.3	3.8	79.5	81.9	3.0				
P4	Confluence	62.9	65.8	4.6	82.1	85.2	3.8				
F2	Highway 417	32.4	33.2	2.5	44.7	45.5	1.8				
F3	Huntmar Road	41.4	43.0	3.7	57.0	58.8	3.2				
F4	Confluence	43.2	45.5	5.1	59.4	61.8	4.0				
	Hazeldean Road	45.5	45.5	0.0	60.8	60.8	0.0				
	Maple Grove Road	54.8	55.6	1.5	73.3	74.2	1.2				
	Highway 417	130.0	134.0	3.1	171.0	175.0	2.3				
	Richardson Side Rd.	196.0	200.0	2.0	259.0	262.0	1.2				
	Huntmar Road										

Table 8.3.5 Runoff Volumes



The results presented in **Table 8.3.5** indicate that there is some increase in total runoff volume associated with the expected development in the subwatershed. The predicted change in total runoff volume between existing and future conditions should be investigate as part of the functional design of the Carp River corridor plan.

Carp River Modified Floodplain Concept

Within the Subwatershed area (upstream of Richardson Side Road) the existing floodplain varies in width from less than 100m to almost 500m. Landuse within the area currently consists of residential (upstream of Hazeldean Road), business park, institutional (park) and rural. It is anticipated that the area will ultimately become fully urbanized.

Presently most of the Carp River flood plain is administered as a one-zone. Following the Provincial Policy Statement, development and site alterations are not permitted within the Regulatory (1:100 year) flood plain. Any development within the 100-year floodplain of the Carp River is controlled by floodplain regulations and land use designations. Development within the floodplain or filling (within the fill lines) requires a permit from Mississippi Valley Conservation (MVC). Other than the permit requirement, MVC does not restrict development in the area between the fill line and regulatory floodline but development within the floodline limits is generally not allowed.

The possibility of implementing a two-zone floodplain upstream of Richardson Side Road was investigated as an incentive mechanism to implement the Carp River restoration measures. Under this concept, the flood plain is divided into two zones: the floodway and the flood fringe. The floodway is the area that is required to convey the regulatory flood flows without impacting the originally established upstream or downstream flood elevations and velocities. Any area beyond the floodway, up to the regulatory flood level, is known as the flood fringe. Filling of the floodfringe lands, above the Regulatory flood level, would be allowed because this would not have a significant impact on flood levels and erosion. The floodway/flood fringe concept is shown schematically in **Figure 8.6**.

The analysis was undertaken to determine if a modified floodplain can be established contingent on the Carp River restoration plan being implemented. This policy would identify the floodway and flood fringe, and would consist of:

- Allowing the placement of fill within the flood fringe
- Allowing development in the flood fringe area

Filling of the floodplain may be allowed if upstream flood levels are not impacted and the travel time through the affected reach is not decreased. This generally means that that the filling must not result in increased headloss (e.g. through expansion/contraction and/or significant changes in velocity) and that floodplain storage must not decrease significantly as a result of the filling.

MVC (1993) has identified the re-establishment of a vegetative corridor (riparian zone) along the river as a "first" priority in restoring the Carp River. The benefits of such actions were identified as:

- Increased infiltration
- Reduced soil erosion, sedimentation, and nutrient loading
- The establishment of a riparian zone would have to address the issue of cattle access. The MVC report also recommends the adoption of "natural" channel design principles for application to all future channel restoration projects.



From the geomorphological and hydrologic / hydraulic analyses that have been undertaken as part of the watershed / subwatershed study, the following issues and solutions were identified (see **Figures 8.3a** and **8.3.4**).

- In the urbanized areas, including the channel within the subwatershed area (upstream of Richardson Side Road), the primary issues are the modification of the sediment-flow regime associated with urban land use and drainage practises, and the channel response to instream works. An ultimate stable channel form must be achieved under existing and future land use scenarios.
- Various mitigation strategies are available but the most feasible solution appears to be the establishment of a riverine wetland environment along most of the channel. To ensure that the mitigation strategy can be implemented, a protective corridor must be established along the river. The width of this corridor must be sufficient to accommodate the riverine wetland, a low flow channel, recreational pathways, and appropriate buffer zones.
- An initial estimate of the minimum required corridor width was made based on the existing rehabilitation works that are located in the vicinity of Palladium Drive. The width of the remedial habitat areas is approximately 85 m. To accommodate recreational pathways and buffer zones, an additional 10-15 m would be required for a minimum total corridor width of 100 m.
- To evaluate the impact of the modified floodplain approach on flood levels and velocities, the reaches between Richardson Side Road and the Glen Cairn Reservoir of the existing HEC2 model of the Carp River were modified to limit all conveyance within the 100m floodway area. It was assumed that the areas outside the 100 m floodway do not contribute to conveyance or storage. For the analysis, it was assumed that the cross-section characteristics within the floodway area are those of a riverine wetland with an average Manning 'n' of 0.045. A second analysis was carried out using the QUALHYMO model. For this analysis, the REACH routine was modified to contain all flow within a 100 metre corridor.
- The impact of the 100m floodway from Huntmar Road to the Glen Cairn Reservoir was evaluated. The results indicate that limiting the floodway to 100 m in the reach between Richardson Side Road and Highway 417 will only have a marginal effect on upstream flood levels and in-channel velocities. The most significant impact is immediately downstream of Highway 417. This is mainly due to the removal of the existing channel constriction north of Highway 417 that would be accomplished through the implementation of a 100m floodway. The results of the HEC2 analysis are summarized in **Table 8.3.6**, the QUALHYMO results in **Table 8.3.7**.



Table 8.3.6
HEC2 Results

SECN	Location	Q	Invert	Reg. Fl.	Existing 100 m Corridor		Change			
				Elev.						
		(m³/s)	(m)	(m)	Elev. (m)	Vel. (m/s)	Elev. (m)	Vel. (m/s)	Elev. (m)	Vel. (m/s)
31790	Carp Road	55.7	89.06	92.5	92.51	0.95	92.51	0.95	0.00	0.00
33310	March Road	56.2	89.67	92.7	92.61	1.10	92.61	1.10	0.00	0.00
37405	Huntmar Road	58.3	89.44	93.1	93.06	0.67	93.06	0.67	0.00	0.00
40110	Richardson Side Rd.	40.0	90.05	93.4	93.48	0.34	93.48	0.47	0.00	0.13
40860		40.0	90.23	93.5	93.51	0.32	93.59	0.60	0.08	0.28
41630		42.3	90.77	93.6	93.74	0.98	93.74	0.98	0.00	0.00
42060		42.3	91.16	93.9	93.87	2.03	93.99	1.68	0.12	-0.35
42180	Highway 417	42.3	91.34	94.0	94.14	0.51	94.19	0.44	0.05	-0.07
42410		41.3	91.56	94.2	94.14	0.51	94.21	0.55	0.07	0.04
42660		41.3	91.62	94.2	94.16	0.40	94.24	0.45	0.08	0.05
42885	Palladium Drive	41.3	91.68		94.17	0.38	94.25	0.51	0.08	0.13
43150	Poole Creek	42.4	91.73	94.4	94.21	0.64	94.30	0.82	0.09	0.18
43390	Maple Grove Rd	24.6	91.78	94.6	94.56	0.26	94.60	0.27	0.04	0.01
43775		24.6	92.09	94.6	94.57	0.16	94.61	0.28	0.04	0.12
44320	Hazeldean Rd.	24.6	92.31	95.2	95.24	0.19	95.29	0.21	-0.02	0.02
44915		7.6	92.66	95.2	95.24	0.06	95.30	0.12	0.06	0.06

Table 8.3.7 QUALHYMO Results – Channel Routing

Location		Future Flow (m ³ /s)					
		Existing	Channel	100m Corridor			
		5 yr	100 yr	5 yr	100 yr		
C3	Hazeldean Rd.	9.2	16.2	9.2	16.2		
C4	Maple Grove Rd.	8.0	14.9	7.8	15.2		
C6	Highway 417	17.8	32.9	17.5	34.0		
C8	Richardson Side Rd.	17.4	33.5	16.9	34.8		
C9	Huntmar Rd.	22.0	39.2	21.9	39.4		

The HEC2 analysis indicates that under existing 100 year flow conditions, restricting the floodplain to a 100 m corridor between Hazeldean Road and Richardson Side Road will have some impact on water levels and velocities. In general, water levels will be approximately 0.1 - 0.3 m higher and velocities about 10% lower than under existing conditions. Between Richardson Side Road and Huntmar Road, velocities will increase from approximately 0.7 m/s to 0.8 m/s due to the increase in hydraulic gradient in this reach. Water levels and velocities downstream of March Road are not affected.

The results presented in **Table 8.3.7** indicate that the impact of restricting the floodplain to a 100 m width has a minimal impact on peak flows. The table also shows that the flows used in previous analyses are more conservative than the QUALHYMO results.

A comparison of flow estimates obtained from the current modelling and the 1994 Stittsville MDP/1983 Floodplain Mapping Study is provided in **Table 8.3.8**.



Location	Stittsville I	MDP (1994)	QUALHYMO Model			
Location	5 year	100 year	5 year	100 year		
Poole Creek						
Main Street	16.8	32.9	8.6	15.3		
Hazeldean Road	18.9	9 29.4 10.5		16.4		
Maple Grove Rd.			11.9			
Carp River	14.4	24.6	12.1	16.9		
Feedmill Creek						
Carp Road	0.7	0.9	0.7	0.9		
Highway 417			3.0	3.1		
Huntmar Road			4.2			
Carp River	13.5	21.1	4.8	6.5		
Carp River Floodplain Mapping (1983)						
Outlet Glen Cairn Pond	2.6	7.6	7.1	12.3		
Hazeldean Road	8.0	24.6	9.2	16.2		
Maple Grove Road	8.0	24.6 7.9		14.9		
Highway 417	14.0	41.3	20.6	33.0		
Richardson Side Road	16.0	40.0	17.1	33.6		
Huntmar Road	35.4	58.3	21.8	38.9		
March Road	37.6	54.8	29.8	54.6		

Table 8.3.8Comparison of Peak Flow Estimates

Stormwater Attenuation

The need for quantity control within the subwatershed is based on the location of stormwater management facilities. In the Kanata West Planning Area, stormwater management requirements were identified as follows:

- Scenario1: the general arrangement of facilities presented in the Kanata West Servicing Study (Stantec 2002). Stormwater management facilities outlet directly to the Carp River
- Scenario 2: an alternate arrangement of facilities that preserves the natural drainage patterns within the planning area as much as possible and a number of facilities outlet to Poole Creek and Feedmill Creek

The drainage areas for each of these options are shown on **Figures 8.6 and 8.7**. Any facilities that do not outlet directly to the Carp River require 2 through 100 year post to pre control and 30% DRC control for erosion. Specific requirements for the areas identified in **Figure 8.7** are listed on the Environmental Fact sheets presented in Section 10.3.

Floodplain Mapping - Carp River

- Flood risk mapping for the Carp River from Fitzroy Harbour to Glen Cairn was prepared in 1983. The mapping produced at the time consisted of ortho-photo maps that show flood and fill lines and contours within the floodplain only. The mapping is available in hardcopy only.
- Downstream of Richardson Side Road, landuse has not changed significantly since 1983, although several bridges have been replaced. Upstream of Richardson Side Road, the river is within the City of Ottawa urban envelope where numerous changes have taken place over the past 20 years and more are anticipated in the near future.



• The hydrologic analysis for the 1983 mapping was based on 9 years of flow data at the Kinburn gauge. The QUALHYMO results are significantly different in some locations (as shown in **Table 8.3.9**).

Location	1983 Flood Plain Mapping Study			QUALHYMO Model			
	5 yr.	5 yr. 10 yr. 100 yr. 5 yr		5 yr.	10 yr.	100 yr.	
Highway 417	12.4	18.2	42.4	13.4	15.9	25.6	
Carp Road	44.5	48.1	65.9	25.5	31.5	54.6	
Kinburn	72.9	78.8	102.1	59.6	76.5	139.0	
Ottawa River	81.6	88.4	109.3	84.9	107.0	197.0	
Note: QUALHYMO flows are generated using station frequency analysis							

Table 8.3.9Peak Flow Estimates – Carp River

Based on the need to update mapping, the production of new flood risk mapping is recommended for the entire length of the Carp River. Hydrologic analysis for the mapping could be based on the QUALHYMO model developed for the watershed/subwatershed study. The model would have to be further calibrated and refined. The hydraulic analysis and resulting floodlines would make use of new topographic base mapping.

Floodplain Mapping - Poole Creek and Feedmill Creek

- There is no floodplain mapping for Feedmill Creek. Flood risk mapping for Poole Creek dates back to the early 1980s. Due to changes in land use, much of the existing mapping is now out of date. Also, the hydrology for the existing mapping is based on uncalibrated models and shows significant discrepancies with the current QUALHYMO modelling, as shown in **Table 8.3.9**.
- Ongoing urbanization within both the Poole and Feedmill Creek basins would make the availability of current flood risk mapping desirable. Based on these considerations, new flood risk mapping should be prepared for the Poole Creek basin and Feedmill Creek downstream of Highway 417. Upstream of Highway 417, the Feedmill Creek watershed is undergoing rapid changes. Instead of new mapping, a hydrologic/hydraulic analysis should be undertaken to establish existing return period water levels and associated storage in the reach between Regional Road No. 5 and Highway 417.

8.3.1.2 Erosion Control – Stream Restoration & Runoff Control

Section 3.4.8 provided an overview as to the existing conditions of the Carp River as well as the tributaries. Within the subwatershed area the following points should be noted:

- The section of the Carp River through the subwatershed area is considerably degraded. Furthermore, this section of the Carp has transformed from a river with meander pools and riffles to a riverine wetland. The river has been highly altered (straightened) and has a considerable amount of sediment build up in the bed (≥1.35m).
- The accumulated sediment build up in the Carp River is impacting the lower reaches of Feedmill Creek and Poole Creek which are two of 4 streams still providing coldwater habitat.



- Poole Creek upstream of Hazeldean Road is cut into bedrock. A majority of the sediment supply is therefore provided in the lower reaches. The management strategy should focus on the increase in sediment transport characteristics.
- Poole Creek is a relatively unstable stream. The channel does not have the capacity to absorb any increase in instream erosion potential.
- The lower portion of Poole Creek is in transition, partly as a result of the sediment build up in Carp River. This portion of the creek will either evolve into a riverine wetland or maintain its meander-pool-riffle form. The restoration plan should address this transition.
- A number of groundwater discharge points located downstream of Hazeldean Road in Poole Creek were noted during the field program.
- Feedmill Creek is a relatively stable stream. The stream, however, is sediment starved and the management strategy should focus on the increase in sediment transport characteristics. The increase in flow energy must, however, not cause the channel to shift into a degrational (erosion) mode.
- Feedmill, like Poole Creek is in transition as a result of the build up of sediment in Carp River. The restoration plan should address the transition. The restoration plan should also take into consideration that parts of the stream valley located in the lower reaches has been altered.
- A short section of Feedmill Creek, upstream of Huntmar Drive has been restored using natural channel techniques.
- Hazeldean tributary and the unnamed tributary do not provide habitat for aquatic resources. They should, however, provide equivalent water quality and hydraulic function when the area is urbanized. This can be achieved using natural channel and riparian wetland techniques.
- One additional tributary enters the Carp River downstream of Feedmill Creek, and the northern boundary of the subwatershed planning area. This tributary is intermittent in nature, however unlike the Hazeldean Tributary, it has a defined channel that extends from its confluence with the Carp River to a point just upstream of Huntmar Road. This tributary currently flows through agricultural lands and is in a relatively stable channel meandering through an ill-defined valley.
- Geomorphic investigations defined a total of 8 reaches in Poole Creek and 5 reaches in Feedmill Creek that could be addressed individually as part of an overall protection and restoration plan for the Carp Subwatershed. In addition, a number of problems were identified in the upper Carp River that could be addressed as part of a subwatershed scale surface water strategy.
- Stream stability, erosion and sedimentation in the tributary reaches and the segments of the upper Carp River can be addressed through a combination of instream measures (protection and restoration) and runoff controls (source controls, drainage area management and stormwater management facilities). These are discussed below.



Instream Measures (please refer to Figure 8.5)

Protect in Natural Condition: Reaches 1 (upper portion), 2, 4, 6, 7 and 8 of Poole Creek, and Reaches 2, 3 and 5 of Feedmill Creek are currently stable (as pool:riffle or wetland systems) or have been stabilized through previous instream works. With proper stormwater management or retrofitting of existing facilities, these reaches can be maintained by protection of the associated riparian and floodplain lands. No specific instream measures are required unless existing conditions change (e.g. future roadway crossings).

Riverine Wetland Restoration: Reaches 1 (lower portion)of Poole Creek and Reach 1 of Feedmill Creek are in transition and actively degrading from a pool:riffle morphology to an anastomosing, riverine wetland morphology. This is a result of lack of energy in these tributaries to move the accumulated sediment, and extensive buildup of sediments in the upper Carp River. The upper Carp River has been further degraded from a riparian wetland system through extensive dredging and channel widening, to the extent that extensive restoration is necessary to re-establish riparian wetland conditions (see Section 8.4.2). Restoration of these reaches of Poole and Feedmill Creeks can be achieved through the following measures:

- Modification of the stream cross section and plan form to create a linear riparian wetland feature, interspersed with deeper pools to provide refuge habitat for fish
- Creation of a meandering, "U" shaped low flow channel, interspersed with drowned riffle structures to encourage sediment transport and inhibit plant growth in a portion of the channel
- Diversion of drainage from some of the upper catchments of these tributaries to increase stream energy in these reaches

Geomorphic Referenced River Engineering (GREE) Restoration: Reaches 3 and 5 of the Poole Creek exhibit pool:riffle morphology, are currently unstable and will continue to degrade regardless of the implementation of runoff controls upstream. At the same time, there are a number of limitations and restrictions that make restoration using a natural channel design approach infeasible. GREE employs geomorphic principles to design a stable channel configuration complete with pools and riffles so that the channel looks and functions like a natural, meandering pool-riffle system. However, the channel plan form is fixed in place so that the meanders cannot move. The result is a stable, natural looking and functioning channel that cannot erode its bed or banks and therefore does not provide a risk to riparian structures, pipelines or adjacent lands.

Natural Channel Design Restoration: Reaches 1 (upper portion),4 and 5 (lower portion) of Feedmill Creek are currently in a natural state, however, there are a number of existing instabilities associated with reduced sediment supply, altered hydrology and upstream land use change will degrade these reaches further without a combination of restoration and runoff control. Natural Channel Design uses the natural morphological characteristics of the existing stream reach or those of a non-impacted reference stream, combined with the expected hydrologic and sediment regime to re-establish a naturally functioning system. In the case of these reaches, the natural channel exhibits pool: riffle morphology and a meandering pattern, interspersed with some shallow bedrock and wetland features. The existing channel, riparian and floodplain components are not restricted by adjacent land uses such that the channel has room to naturally evolve within its floodplain and can accommodate the changes in hydrology and sediment loading from the proposed land use changes (with appropriate runoff controls).



Runoff Control

Source Controls: Source controls are recommended for all new development within the subwatershed area. In addition, existing development in the Poole and Feedmill subwatersheds should be retrofitted with source controls wherever possible in an effort to reduce runoff and encourage groundwater infiltration from existing development to sensitive reaches of these tributaries.

Diversion and Overcontrol: These measures should be applied to Reaches 1 and 2 of Poole and Feedmill Creeks. Storage facilities for new urban developments tributary to the upper Segment will require Distributed Runoff Control (DRC) utilizing a high degree of overcontrol coupled with source control measures to reduce surface runoff rates and volumes. Diversion of pond flows to the lower Segment of the channel is also possible in combination with source controls. The diversion of storm runoff from the upper to lower Segment will reduce erosion in the upper Segment while increasing the ability of the lower Segment to transport its sediment load. These are both beneficial impacts. For all new developments, opportunities for groundwater infiltration should be examined on a site by site basis.

Distributed Runoff Control: These measures should be applied for all new development tributary to all other reaches, in order to prevent an increase in flow energy associated with urbanization that could destabilize the channel banks. DRC ponds with source controls are recommended for new developments such that the increase in instream erosion potential does not exceed 5% of the erosion potential under existing conditions. For all new developments, opportunities for groundwater infiltration should be examined on a site by site basis.

Distributed Runoff Control

To release water at a rate that is consistent with established erosion control targets, runoff control must be established. Runoff rates can be determined by means of the Distributed Runoff Control (DCR) method.

Under predevelopment conditions, the channel forming flow or bankfull flow corresponds to a flow with a return period of approximately 1.5-2.0 years. Smaller, mid-bankfull events are significant in terms of sediment transport but play a secondary role in channel formation. A result of development, there is an increase in the occurrence of mid-bankfull flows. These events then become more significant in determining channel form. The intent of the DCR approach is to control in-stream erosion potential for the range of flows that exceed the critical flow (the rate at which sediment transport of bed forms or intact boundary material begins) up to the bankfull stage, with the highest level of control focussed on the mid-bankfull range.

Flowrates below the critical flow are controlled for water quality purposes. Flows in excess of the bankfull stage are controlled for flood hazard reduction. For flows that fall between the critical flow and the bankfull flow, the DCR method is applied.

The DCR approach follows an overcontrol curve up to the mean annual flow rate. The overcontrol curve is determined as a multiple of the 2-year peak flow shaving curve. The degree of overcontrol is a function of the boundary material composition. The DCR method is described in Appendix D of the "Stormwater Management Planning and Design Manual" (MOE, 2003).



8.3.1.3 Urban Water Quality Control Plan

The existing water quality conditions within various tributaries in the Carp River were established based on an analysis of historical water chemistry data (Section 3.4.7) and by the benthic invertebrate results (Section 3.5.1). Generally, water quality conditions were similar in the rural and urban areas. The health of the stream at a given location tended to be more dependent upon the natural resources (eg. Wetlands, vegetated corridors, discharge locations) located upstream of the sampling location.

Water quality conditions within the Carp River could be protected or improved by requiring water quality control in new developments and/or retrofitting one or more of the existing stormwater management facilities located within the subwatershed (see **Figure 1.1.2**).

Consideration was given to retrofitting existing facilities, however, closer analysis showed that the discharge from several SWM facilities (e.g., Glen Cairn Pond) showed better water quality than the ambient water quality conditions noted as numerous sampling locations along the Carp River. Furthermore, recommendations have been made to improve other limiting conditions (e.g., habitat, baseflow) for streams located downstream of existing facilities. For these reasons, retrofitting of existing SWM facilities is not recommended.

Water quality control is required for new developments in order to limit the transport of contaminants to receiving watercourses. Typical contaminants in stormwater include: total suspended solids (TSS), nutrients (e.g. total phosphorous), heavy metals (e.g. copper, zinc, lead) and bacteria. Generally, a good portion of nutrients and heavy metals are attached to the total suspended solids in stormwater, so removing TSS tends to reduce the concentrations of most contaminants from urban areas.

Water Quality Targets

The minimum amount of water quality control required to support various aquatic environments is specified by the Ontario Ministry of the Environment. The required level of control is higher for sensitive aquatic species. Based on the MOE guidelines and the characterization of the urban creek systems, the following water quality targets are recommended:

Feedmill Creek and Poole Creek: Level 1 – Enhanced Protection

Both these stream systems support coldwater aquatic species as such, Level 1 is required in order to protect existing conditions. This level of water quality control requires that 80% of total suspended solids in the incoming stormwater be removed by stormwater Best Management Practices.

Carp River – Level 2 – Normal Protection

For facilities discharging to Carp River or any other tributaries within the subwatershed area, Level 2 control, suitable for warmwater species is required. This level of water quality control requires that 70% of total suspended solids in the incoming stormwater be removed by stormwater Best Management Practices.

The storage volumes that are required not only vary depending upon the type of fishery to be protected, but also based on the type of BMP that is selected to provide the control and the percent impervious of the catchment area. **Table 8.3.10** summarized the volume requirements for Levels 1 and 2 protection for a variety of different BMPs. This table has been taken directly from the MOE Stormwater Planning Design Manual.



Protection	SWMP Type	Storage Volume (m ³ /ha) for			
Level		lr	nperviou	s Level	
		35%	55%	70%	85%
Level 1	Wetlands	80	105	120	140
	Hybrid Wet Pond/Wetland	110	150	175	195
	Wet Pond	140	190	225	250
	Any Stormwater BMP capable of achieving Level 1 Control				
Level 2	Wetlands	60	70	80	90
	Hybrid Wet/Pond/Wetland	75	90	105	120
	Wet Pond	90	110	130	150
	Any Stormwater BMP capable of achieving Level 2 control				
Level 3	Wetlands	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80
	Wet Pond	60	75	85	95
	Dry Pond (Continuous Flow)	90	150	200	240

Table 8.3.10Water Quality Storage Requirements Based on Receiving Waters

*Hybrid Wetpond/Wetland systems have a minimum of 50% of their permanent pool volume in deeper portions of the facility (eg. forebay, wet pond)

For wetlands, wetponds and hybrids, all the storage, except for 40m³/hr in **Table 8.3.10** represents the permanent pool volume. The 40m³/hr represents extended detention storage.

In addition to the water quality control criteria outlined above, a key target for tributaries and the main Carp River is to augment low flow conditions during summer. This can be accomplished by including a low flow outlet in the design of dry ponds (continuous flow), extended detention ponds, wet ponds and wetlands (where feasible without compromising other pond design criteria) that will release a minimum flow of 10 l/s over a 7 day period. This typically approaches the average inter-event period during summer.

This study has identified two options as it relates to catchment areas within Kanata West. The first option presents the original KWCP proposal of 5 centralized stormwater management facilities all draining into the Carp River (**Figure 8.6**). The second option presents an alternate arrangement of facilities that preserves the natural drainage patterns within the planning area as much as possible. Option 2 presents 10 stormwater management facilities that drain to the tributaries as well as the Carp River (**Figure 8.7**). This option is presented to allow for more flexibility as it relates to phasing and ownership. The ultimate scenario for stormwater management could be a combination of both options depending on landowner agreement, phasing, servicing considerations and cost. Implementation considerations for each of these options are described in more detail in Sections 9 and 10.



Urban Surface Water Management Plan Summary

The subwatershed surface water management plan provides specific direction on studies and measures necessary to address flooding, erosion and water quality concerns in order for development to proceed. This includes stormwater management facility sizing and design criteria, floodplain mapping requirements, source control measures and stream restoration requirements. The plan, as recommended will also achieve fish community and aquatic habitat benefits through base flow augmentation, water quality management, stream channel and riparian zone stabilization.

In summary, the Carp River through the urban area should be restored as a priority. Restoration will result in improved water quality and habitat conditions, incorporation of recreational features that are important from a watershed basis. The restoration plan and modified floodplain approach also frees up approximately 60 ha of land for development. This area could be used as leverage to engage the development community in Kanata West to participate in the restoration of the Carp River. The modified floodplain approach is one mechanism to implement the Carp River restoration plan. However, the restoration of the Carp River corridor is required regardless of whether development proceeds in the flood fringe. The Carp River and its tributaries were identified in the Kanata West Concept Plan as the major defining features of the new area, providing continuous open space corridors and pedestrian and cycling facilities.

Feedmill and Poole Creeks should be protected and maintained as cool/cold water systems. The lower reaches of both stream systems have been impacted by sediment build up from the Carp together with the removal of streamside vegetation. Riverine wetland restoration is recommended for these sections of the streams. Sections of Feedmill Creek will require stream stabilization works using natural channel design as land use changes occur. The existing functions (water quality, hydraulic and buffering) of the Hazeldean and unnamed tributaries should also be protected/enhanced by using natural channel design techniques.

This study provided baseline information (eg. hydrology, hydraulics, stream characteristics) for which restoration of the Carp River and lower reaches of Feedmill and Poole Creeks can be undertaken. Further work will, however, have to be undertaken in order to better define the parameters for restoration and thus the detail design.

This study also provides the basis for defining existing conditions in Feedmill and Poole Creek together with design parameters (flow series, discharges, stream power and boundary shear stresses) that need to be met (see **Appendix B**), once urbanization occurs. Subsequent, work should ensure that the flow/sediment requires as described in this report are properly accounted for in order to protect these streams. In this regard the following direction is provided.

Existing sediment supplies in Feedmill and Poole Creeks should not be diminished. Discharge areas in Poole Creek downstream of Hazeldean Road should be protected. Existing drainage areas to Feedmill Creeks should not be altered unless it can be shown that adverse impacts will not result.

8.3.2 Urban Groundwater Management (Subwatershed Level)

The primary components of a groundwater management plan at the watershed level includes:

- Protection of aquifers
- Protection of areas of recharge and discharge



- Protection of headwater wetlands
- Wellhead protection
- Monitoring of groundwater withdrawals
- Control of past and future sources of contamination
- Management of land use
- Continued public education and promotion of stewardship

Within the subwatershed area the following points should be noted:

- There are both shallow and deep aquifers. The shallow aquifers contribute directly to streamflows (via discharge through the streambanks and bed) and recharge the deep aquifers.
- Headwater wetlands, though not strictly groundwater recharge areas, nonetheless, perform an importance function as these wetlands lie on impermeable till layers and are able to store precipitation and snowmelt that would otherwise runoff.
- Groundwater withdrawals within the subwatershed represent almost 50 percent of the total estimated water withdrawal for the entire watershed. In one case, the groundwater that is pumped from the quarry provides a considerable component of the baseflow in Feedmill Creek.

The primary components of the groundwater plan for the subwatershed area will therefore involve:

- Protection of the wetland features which provide baseflow
- Understanding the groundwater flow patterns (gradients)
- Protection of the recharge capabilities of the soils
- Protection of key baseflow sources (ie. Clark Quarry)

Figure 8.3 illustrates several of the key components of the groundwater system including:

- Seasonal discharge areas
- Moderate and high recharge areas
- Headwater wetlands which support baseflow
- Location of the Clark Quarry discharge to Feedmill Creek.

Protection of the headwater wetlands and the Clark Quarry discharge will be dealt with primarily through implementation. Protection/enhancement of seasonal discharge areas and moderate/high recharge areas will require the selection, design and construction of the proper suite of BMPs (see Chapter 6), together with an undertaking of a water budget to ascertain that infiltration is not decreased and surface water/groundwater flow patterns are maintained. Characterization of the discharge areas will require some detailed geotechnical investigations, including descriptions of soil stratigraphy, percolation or infiltration rates, monitor wells for hydraulic conductivity measurements, seasonal water table fluctuations and groundwater gradients.

The water budget analysis may be undertaken using continuous simulation using a number of computer models (eg. QUALHYMO, GAWSER) or by implementing the approach as outlined in the MOE Stormwater Planning and Design Manual.

Based on the analysis of the various components of the water budget (see Section 3.4.3) as defined for the Carp Watershed and the approach as defined in the MOE Stormwater Manual, a water budget for the different soils types and land use types for the Carp River subwatershed area was prepared (see **Table 8.3.11**).



8.3.2.1 Water Budgets for Urban Development Within the Subwatershed

Urban development causes significant changes to the water balance in the hydrologic cycle. For example, urbanization leads to land use modifications that result in decreased evapotranspiration (ET) along with concomitant increases in runoff (RO), including:

- increased impervious areas, such as building roofs, roadways or other hard surfaces;
- changes in land cover to shallow-rooted vegetation (e.g. grassed lawns);
- soil compaction in open spaces (soccer fields, golf courses, walkways, cycle paths);
- removal of loamy or organic topsoil for construction purposes; and,
- improvements in drainage of low-lying areas.

It is essential to understand how the opposing processes of ET and RO affect the water balance in both pre- and post-development scenarios. The calculation of site-specific and defensible values for ET and RO will define the fraction of annual precipitation that is available to infiltrate into the ground before and after urban development. It is appropriate at this stage to establish "target" values for infiltration.

A water balance was developed for the entire 310 km² watershed in Section 3.4.3. Climate normals (1961-1990) indicate a mean annual precipitation (P) of 910 mm/year, ET was determined from land cover (vegetation) types to be 445 mm/year and RO was calculated as 354 mm/year from flows in the Carp River upstream of Kinburn. Net infiltration⁶ that was available to replenish groundwater resources is 113 mm/year for the entire watershed.

The water balance on a smaller scale (site plan or Secondary Plan areas) within the subwatershed must be calculated in a manner that establishes a "target" value of predevelopment total infiltration.

Infiltration potential within the subwatershed, suitable for a preliminary assessment of the suitability of infiltration-based stormwater management, was sub-divided into 3 broad categories on the basis of surficial geology, soil types, depth to bedrock and landform (topography). These areas were classified as low, moderate and high infiltration potentials.

The Thornthwaite method is an empirical model that is commonly used to calculate the evapotranspiration component (ET) of the pre-development water balance and to establish "target" annual infiltration values within the subwatershed. The advantage of the Thornthwaite methods is that the data are readily available. An example calculation is presented below, using the following data:

- Monthly Precipitation (Ottawa International Airport Climate Normals for 1971-2000);
- Mean monthly temperatures (as above);
- Monthly Evapotranspiration (method of Thornthwaite & Mather method); and,
- Annual Total Infiltration (by difference).

Within the subwatershed, undeveloped land was modelled as former agricultural lands, comprising overgrown pasture, with deep-rooted grasses and scrub woods. This, along with soil types and their water retention capacities, constitute the input for the calculation of ET.

The following table (**Table 8.3.11**) is an example of the water balance calculation for the Carp River subwatershed.

⁶ Net Infiltration is total infiltration minus that portion which discharges back to streams as baseflow.



Table 8.3.11						
Water Balance Components - Carp River Subwatershed						

Infiltration Potential	Soil Type	Hydrologic Soil Group	Soil Moisture Retention (mm)	Precipn. (mm)	ET (mm)	Runoff (mm)	Equiv. Runoff coeff.	Infiltr. (mm/yr)
High	Fine sand	A	100	943	559	123	0.32	262
Moderate	Fine sand & silt or clay loam - shallow limestone bedrock	С	250	943	574	268	0.72	104
Low or Not Classified	clay and till - shallow Precambrian bedrock	D	200	943	579	292	0.80	73

Notes:

- Monthly precipitation (P) and temperatures from Canadian Climate Normals (1971-2000) for the Ottawa International Airport.
- Soil Types from published geology and soil survey mapping
- Hydrologic Soil Groups from SCS (U.S. Soil Conservation Service)
- Soil Moisture Retention for deeply-rooted vegetation (0.67 -1.25 metres) as defined by Thornthwaite & Mather.
- Evapotranspiration (ET) calculated by the Thornthwaite & Mather method.
- Runoff (RO) and runoff coefficients based, in part, on curve number (CN) in the SCS method.
- Infiltration calculated by difference) INF = P -ET RO), assuming changes in soil moisture are zero.
- The values shown in the above table should be used for defining existing (undeveloped) conditions.

At the implementation stage, groundwater discharge studies are essential in order to assess and to protect the degree of baseflow arising from such discharge, particularly in the vicinity of Poole and Feedmill Creeks. The characterization of discharge areas involves a combination of Hydrogeological and geotechnical studies, as discussed previously. The components of these studies include:

- Installation of streambank and streambed piezometer to determine vertical gradients (ie. gaining or losing streams).
- Field-mapping of areas of upwelling by means of temperature profiles, vegetation and nature of streambed (bedrock, clay/till, muck and alluvium) by means of hand augering;
- Dry-weather spot flow measurements upstream and downstream of suspected discharge areas;
- Boreholes and test pits to determine soil stratigraphy (aquifers and aquitards), classification of hydrologic soil groups (e.g. SCS method), curve numbers (CN) and depth to bedrock. Boreholes should extend to a minimum depth of 4 metres below anticipated finished grades (or to refusal);



- Installation of monitor wells to determine groundwater gradients and groundwater divides;
- Determination of seasonal water table fluctuations;
- Pump tests on selected wells to determine hydraulic conductivity of soils;
- Monitoring drawdown during pump tests in observation wells and streambank piezometers to determine transmissivity of soils, to determine the extent of cones of depression and to assess the potential for interferences;
- Infiltration or percolation tests of representative soils; and,
- Determine the pre- and post-development water budget with target infiltration rates.

The cost of implementing the recommended discharge study, if done in conjunction with a geotechnical borehole investigation, would likely be of the order of several thousand dollars.

8.4 Urban Greenlands

8.4.1 Greenlands Plan

The emphasis of the urban greenlands plan is on the urbanizing subwatersheds in the headwaters of the Carp watershed: Poole, Feedmill, Carp headwaters tributaries and portions of Huntley Creek subwatershed. However, the general recommendations also apply to small villages in the watershed including Carp, Kinburn, etc. The Greenlands Plan consists of three components:

The Greenlands or Natural Heritage Plan consists of three separate, yet integrated components:

- a stream and valley corridor system which protects important stream functions, habitats, fish and other aquatic life, and provides the backbone of the natural landscape system;
- a terrestrial system consisting of a mosaic of core natural areas with inter-linking, forested corridors which provide important functions necessary to support healthy, self sustaining communities of plants, birds and other animals in their native habitats; and
- a recreational trail system which provides a complementary network of recreational trails and passive recreation nodes to promote the value of these natural systems to the community.

Each of these components of the Greenlands Plan is described below, and highlighted in **Figure 8.2**.

8.4.2 Stream and Valley Corridor System

As presented in **Figure 3.7.1**, the fish communities currently represented in the subwatershed portion of the Carp River system is as follows:

- Feedmill Creek & Poole Creek (Reaches 1/2/3/8) Tolerant coldwater fish community: This community includes cold/cool water species such as brown trout, sculpin, hogsucker, as well as some intolerant warmwater species such as rock bass, fantail/rainbow darter.
- Poole Creek (Reaches 4/5/6/7) Diverse, moderately tolerant cool/warm water fish: This community includes rock bass, smallmouth bass, northern pike, walleye (seasonally), redhorse sucker species, a number of sensitive minnow species such as blackchin shiner, blacknose shiner, rosyface shiner, mimic shiner.



- Carp River Degraded warmwater fish community: this community includes fathead minnow, bluntnose minnow, brook stickleback.
- Intermittent tributaries (Hazeldean Creek) Intermittent streams that do not have year-round flows and extensive reaches of dry stream beds that provide a source of runoff and nutrients to downstream aquatic communities.

Although the Carp River is severely degraded in the subwatershed portion of the study area, the tributary areas support healthy fish communities. The Upper Poole Subwatershed Study used a target species approach of using the fish community as a barometer of stream health to set rehabilitation targets for the upper Poole Creek. The presence of mottled sculpin, a coldwater species that co-exists in streams with potential to support brown trout, was selected as an indicator of good habitat conditions in Upper Poole Creek.

Findings of this study indicate that this tolerant coldwater fish community is limited to Poole, Feedmill, Huntley and another tributary near the village of Carp. Target communities have been identified in the subwatersheds as shown in **Figure 8.4** as follows:

- Tolerant coldwater/diverse warmwater (Type 1 / 2): Feedmill, Poole,
- Diverse warmwater (Type 2): Glen Cairn Tributary
- Tolerant warmwater (Type 3): Carp River headwaters
- Intermittent Tributaries (quality and quantity targets to support downstream fish communities Type 1, 2 or 3): Hazeldean Tributary, Unnamed tributary (north of Feedmill Creek). These quality and quantity targets are shown in Table 8.2.2.

Biological and habitat requirements for these fish community types are provided in **Table 8.2.2** and include elements of stream flow, water quality, stream morphology, riparian habitat and instream habitats. For each target community, there are also a series of biological and habitat targets that can be used to assess the extent to which stream reaches have been restored and to provide minimum targets to be achieved for any project activities, developments or discharges to receiving streams. Figure 8.5 presents the stream restoration measures recommended for Poole Creek, Feedmill Creek and the Carp River as discussed in Section 8.3.1.2.

During a synoptic dry weather flow study in September 2001, the total tributary flow of 132 l/s (92% from the urban subwatersheds) represented 60% of the total stream flow of 191 l/s in the Carp River at March Road and 50% of the total stream flow of 252 l/s in the Carp River at Carp Road near Kinburn. This underlines the significance of baseflows in the subwatershed tributaries to the overall health of fish communities in the Carp watershed.

Of fundamental importance in meeting these requirements is the protection of an adequate riparian corridor to sustain the other aquatic functions, the protection of recharge areas and watertable elevations that ensure adequate stream baseflows and the protection of wetland features that provide both hydrologic and water quality support functions. The treatment of recharge areas and watertable maintenance is discussed in **Section 8.2.2** and wetlands are addressed in **Section 8.2.3**.


Riparian Corridor

The minimum width of the riparian corridor necessary to support stream functions is dependent on a number of different functions, such as:

- floodplain limits,
- valley wall/erosion setbacks,
- meanderbelt evolution allowances,
- aquatic buffers; and,
- terrestrial and wildlife habitat.

Floodplain Limit

As discussed in Section 8.3.1, there is no floodplain mapping for Feedmill Creek and out dated mapping for Poole Creek. Therefore, the floodplain limit for these two tributaries is not well defined at this time. New flood risk mapping should be prepared for the Poole Creek basin and Feedmill Creek downstream of Highway 417. Upstream of Highway 417, the Feedmill Creek watershed is undergoing rapid changes. Instead of new mapping, a hydrologic/hydraulic analysis should be undertaken to establish existing return period water levels and associated storage in the reach between Regional Road No. 5 and Highway 417. Updated floodplain mapping is also required for the Carp River which will produce new flood risk mapping along the entire length of river.

Meanderbelt Allowances

The tributaries in the subwatershed are generally characterized by an ill-defined valley and many reaches have been altered such that their original meanderbelt characteristics are no longer apparent. Bankfull width estimates for the lower reaches of Feedmill and Poole Creeks were determined, based on site-specific indicators to be about 2 m for Feedmill and 3 m for Poole Creek. Based on meander patterns of these, and other streams in the watershed, these watercourses were likely Rosgen Type C or E streams. Using the Rosgen classification system as a guide, this would suggest that meander belt widths for these lower reaches historically were in the order of 20 to 40 times the bankfull width or 60 to 120 m for Poole Creek and 40 to 80 m for Feedmill Creek, which may extend beyond the floodplain limits of these watercourses. Applying the meanderbelt corridor width calculation of Prent and Parish (2000) yields a corridor width about 70 m for Feedmill and 80 m for Poole Creek. Riparian corridor limits for Hazeldean and other intermittent tributaries should be 30 m using the MNR fisheries buffer. These limits should be considered minimum development setbacks, with additional allowances for other buffer requirements added, as required.

Aquatic Setback

Based on the discussion in Section 8.2.3.1, the riparian corridor width and restoration target for aquatic habitat protection in the subwatershed are as follows:

- Type 1 fish community Poole Creek & Feedmill Creek: 30 metre setback on each side of the watercourse; revegetating up to 75% of the total stream length with native, woody, riparian vegetation (representing 50% of the replanted area)
- Type 2 and 3 fish community Carp River and Glen Cairn Tributary: 15 metre setback on each side of the watercourse; revegating up to 50% of the total stream length with native, woody, riparian vegetation (representing 50% of the replanted area)
- Intermittent watercourses including Hazeldean tributary: 15 metre setback on each side of the watercourse; revegating up to 50% of the total stream length with native, woody, riparian vegetation (representing 50% of the replanted area)



The riparian corridor along much of the lower reaches of Poole and Feedmill Creeks (east of Carp Road) contains little woody riparian vegetation and as a result, some riparian functions, such as stream shading, a source of woody debris and litter, bank erosion protection and a cool microclimate, are lacking. To adequately support tolerant coldwater and diverse warmwater fish communities, approximately 75% of the riparian corridor should be vegetated with woody species. For intermittent tributaries, the target is reduced to 50%. This also creates urban wildlife habitat by providing a forest-like vertically-layered environment of canopy, subcanopy/understorey and ground cover communities that also contributes to the watershed's biodiversity. Riparian habitat along about 2000 m of Feedmill Creek and 4000 m of Poole Creek, would require planting. Currently, approximately 20% of this habitat is forested.

Currently there is an old weir structure in Poole Creek, upstream of Hazeldean Road, that is a migratory obstacle to fish. This weir maintains a small wetland feature upstream and has created a deep plunge pool on its downstream side. Removal of this feature is not warranted for fisheries purposes, since it is also supporting a wetland feature.

The headwaters of Poole and Feedmill Creeks contain extensive wetlands. Protection of these features is discussed in Section 8.4.3.

Carp River Corridor Restoration Plan

One of the key components of the recommended subwatershed plan for the urbanizing headwaters of the Carp River is the need to undertake restoration actions within the Carp River Corridor between Hazeldean Road and Richardson Side Road. The restoration plan has been proposed to address problems of water quality degradation, sedimentation and aquatic habitat degradation as a result of historic and current channelization and aggradation problems. The Carp River Restoration Plan has been proposed will:

- Allow a modified floodplain concept to manage floodplain issues
- Improve channel stability over the long term
- Improve fisheries and aquatic habitat
- Provide a recreational trail system on both sides of the river as conceptual illustrated in the City's Official Plan
- Enhance wildlife habitat for waterfowl and urban wildlife through vegetation plantings and riparian wetland development

Existing conditions are illustrated in **Photo 11** in Appendix C and the conceptual plan for the Carp River Corridor Restoration is illustrated in **Figure 8.3**.

The existing channel has been substantially altered through floodplain manipulations, channelization and sediment loading from historic and current land use activities to the extent that the current channel lacks sufficient energy (stream power) to move accumulated sediment downstream. Sediment accumulation is in excess of 1.5 m. The resulting stream channel is over-widened relative to both event-based and baseflows from the adjacent lands, creating a wide, very shallow channel that becomes stagnant for significant periods during the summer and winter. Aquatic plant and algal growth is excessive, because of stagnant conditions combined with a wide shallow channel exposed to sunlight. This plant growth also contributes to eutrophication of the stream by contributing a large biomass of decaying material each year.



Historically, the upper Carp River was likely a riverine wetland perhaps with some segments that exhibited pool:riffle morphology where the channel intersected with shallow bedrock. Sufficient base flow was present to maintain a weed-free meandering channel through the wetland with sufficient energy to move its sediment load.

An opportunity exists with development occurring in the upper Carp watershed, including Kanata West, to implement a river corridor restoration plan to re-establish a healthy aquatic ecosystem and provide aesthetic and recreational trail opportunities for the community.

The restoration plan for a 3 - 4 km (5000 m) river corridor will include the following components:

- Implementation of a modified floodplain concept to manage flood plain issues
- A minimum 100 m floodway along the river to facilitate a riverine wetland
- The establishment of a series of floodplain pools and deeper refuge pools along the river to provide spawning and nursery habitat for fish and wildlife and summer refuge for fish during periods of low flow
- The creation of a series of drowned riffles and strategic locations along the river to encourage channel scouring and help maintain an open channel form
- Placement of large woody debris in the channel to create habitat structure and promote channel scouring.
- Establishment of riparian tree plantings (currently less than 5% has forested cover)
- Re-contouring of the river bed to create a "U" shaped, weed-free, meandering low flow channel the physical dimensions sized to be self sustaining
- A stormwater management plan including some diversion of flows into the Carp River to increase base flows and bankfull flows, to increase stream power in the new channel
- Provision of a trail linkage along the corridor to link with other City trails and provide pedestrian access across the Queensway

The City will undertake a study to prepare an overall functional design plan for the Carp River Corridor Restoration Plan. This study will follow the Municipal Class Environmental Assessment Process for Schedule B undertaking. The functional design plan will include hydrologic modelling, restoration design drawings, corridor specification, modified floodplain strategy, servicing and stormwater management considerations, cost estimates, preferred cost sharing formula, phasing and an overall implementation plan. The implementation of the restoration plan will involve the City and the development community with assistance from the Mississippi Valley Conservation Authority.

8.4.3 Terrestrial System

Within the urbanizing subwatersheds of Feedmill and Poole Creeks and the Carp headwaters (upstream of Richardson Side Road) expanding development around historic Stittsville and the former municipality of Kanata have placed additional pressures on the riparian corridors as well as eliminating significant portions of headwater wetlands in the upper Poole and Feedmill Creeks. The Upper Poole Subwatershed study provided recommendations to protect some of these headwater wetland areas, but allow some encroachment on more isolated features to occur. Because of its focus on only a portion of the Carp watershed, the Upper Poole Study did not evaluate the significance of these wetlands in the context of the overall watershed. As stated previously, the Carp headwater tributaries contribute the majority of the baseflow to the Carp River and Feedmill, Poole and Huntley Creeks represent the only remnant coldwater streams in the upper watershed; streams that are on the verge of losing this capability because of baseflow limitations. As



discussed in Section 8.3, these wetlands serve an important hydrologic function by attenuating runoff, maintaining base flows and improving water quality in these stream systems. From a terrestrial system perspective, wetlands are concentrations of high biodiversity, because of they provide extensive land water interface areas that provide habitat for a variety of plants, animals, birds and amphibians.

There are several priorities for protection, enhancement and restoration of the terrestrial system within the subwatershed area, as shown in **Figure 8.4**. These priorities are as follows:

Category 1: Protection Recommended

- The natural features occurring within the boundaries of Centres of Ecological Significance (3 within the subwatershed area)
- all high NESS areas, candidate ANSIs (Stoney Swamp), wetland features and woodland features (swamp forests and woodlands with stands in excess of 50 years of age)
- the riparian corridor along the Carp River, Poole Creek and Feedmill Creek (protection and restoration of the Feedmill/Poole and Carp riparian zone (see Section 9.3) as an east-west and north-south linkage)
- all Moderate and Low NESS areas in high recharge areas (enhancement and restoration of natural features, high and moderate recharge areas and aggregate extraction lands located primarily within the Feedmill Creek subwatershed in an area bounded by Hazeldean Road, Carp Road, Richardson Side Road and the western boundary of the Kanata West Planning area).
- the riparian corridor along all other watercourses, including intermittent watercourses (see Aquatic section for definition of watercourses)

Category 2: Protect Feature and Function (Environmental Impact Statement)

- all Moderate and Low NESS areas in moderate recharge areas
- all natural features contiguous with Category 1 features including Low NESS areas
- all lands within a 30 m adjacent lands (120 m for wetlands) from the boundary of Category 1 areas (should land use change)

Category 3: Restoration/Enhancement

- areas targeted for stewardship include the following:
 - any non-vegetated areas within the boundaries of Category 1 areas in particular within/adjacent to Centres of Ecological Significance that would enhance the function of the Category 1 area
 - any Category 2 areas that would serve one of the following functions:
 - provide a linkage function between Category 1 areas, if enhanced
 - increase the amount of interior habitat within a Category 1 area, if enhanced
 - protect a high or moderate recharge area, if enhanced
 - provide a riparian corridor along a watercourse, if enhanced
 - Riparian corridors along Carp River, Poole Creek and Feedmill Creek

For further definition of Categories, please refer to Section 9.2.3.2.



The Kanata West EIS also made specific recommendations concerning the protection of terrestrial features, and these are restated here:

- Potential contributions and support for documented off-site natural features such as downstream Carp River features and functions and fisheries values, constitute the major ecological asset of the Kanata West Business Park study area;
- Existing and potential wildlife corridor values along Poole, Feedmill and Hazeldean Creeks and their contribution to the maintenance of ecological values in the Carp River, provide support for habitat restoration along these watercourses. A wooded riparian corridor along the main Carp and its tributaries represents the "skeleton" of the terrestrial system and enhances the aquatic – terrestrial interface which is typically an area of high biodiversity.
- Maintenance and protection of the locally significant White Pine grove and the large Eastern Hemlock tree in the south end of the study area would provide valuable aesthetic and landscaping assets to the community in and around for the Kanata West Business Park.
- Consider be given to establishing a location to re-establish a representative upland forest community, perhaps adjacent to existing stream corridors or remnant wetland features to demonstrate community commitment to natural area preservation (this could be achieved in exchange for existing landholdings of the City within the planning area).

8.4.4 Recreational Trail System

Within the subwatershed, a recreational trail system is proposed along both sides of the Carp River (**Figure 3.8.5**) consistent with the City's Official Plan. The proposed pathway follows the upper Carp River southerly from Richardson Side Road intersecting with the TransCanada Trail system at the southern watershed boundary, as well as a trail planned along the Monahan Drain through the South Kanata Business Park. Secondary trails would also follow Poole and Feedmill Creek valleys and Hazeldean tributary. North of Richardson Side Road, the trail would tend to follow the road network rather than the river because of access issues and because the primary trail use would likely be cycling. Several recreational nodes within the subwatershed would be created such as outdoor recreation facilities like the Walter Baker Centre. A major constraint currently is a pedestrian crossing of the Queensway in the vicinity of the Carp River Bridge. This could be overcome by means of a raised crossing over the highway.



9.0 IMPLEMENTATION

9.1 General

The study goal is defined as:

• To develop and implement appropriate strategies in order to protect, enhance and restore the natural resources of the Carp Watershed under present conditions and as land use changes occur.

Section 8.0 presented the technical components of the Recommended Watershed and Subwatershed Plans, which in this Section, are referred to as the "Recommended Plan". Collectively, the individual components (e.g., Surface Water, Groundwater and Greenlands) when applied together, provide a holistic management strategy that will meet the study goal and associated objectives.

This Chapter will describe the activities which must be undertaken if the Recommended Plan is to be successfully implemented. The Implementation Strategy must consider the following:

- It must consider issues associated with both urban (primarily Subwatershed) and rural (primarily Watershed) land uses;
- It must be consistent with the other components of the study, and recognize existing and approved land uses;
- It must be flexible, in that the approach to management issues may change overtime as a result of new technology, legislation, or as the knowledge base advances through further studies. An adaptive management approach needs to be adopted recognizing that the natural environment is not a static system;
- It must recognize that successes associated with implementing various steps will be strongly dependant upon the support of residents within the watershed. As such, stewardship and education are thus highlighted as key components to implementation;
- It should (assuming the requirements as outlined herein are met) streamline the review and approval process for submissions relating to land use change;
- It must recognize the various user groups of the document that include municipal staff and politicians, developers and consultants, technical review agencies, members of the public and special interest groups;
- It must be consistent with the City's and MVCA's overall implementation concept for Watershed Plans which include:
 - planning and policy;
 - stewardship and education;
 - rehabilitation and retrofitting;
 - environmental monitoring; and
 - research and development.

This Chapter has been divided into the following implementation components that are required to move the Recommended Plan from words to actions:

- Implementation Strategy
- Adoption and Integration of the Recommended Plan
- Watershed/Subwatershed Plan Administration
- Education/Stewardship Program



- Land Use Planning Mechanisms/Implementation Tools
- Environmental Monitoring
- Time Frame

Section 10 deals specifically with implementation as it relates to the development approval process. Please refer to Section 10 for direction as it applies to development applications within the watershed.

9.2 Implementation Strategy

The Implementation Strategy is presented in **Table 9.1** and **Table 9.2** for the watershed and subwatershed plans respectively. The Implementation Strategy consists of the following elements that capture the requirements and responsibilities for executing the Recommended Plan.

Plan Component:	component (e.g., surface water, groundwater or greenland) under which the action is described
Action:	a description of the proposed measure
Next Steps:	additional actions or studies required
Facilitator:	the agency or group that will coordinate efforts to implement the measure
Contributor:	the agency(ies) or group(s) that will assist in implementing the measure by providing support in any of a number of ways, e.g., funding, labour, materials, technical expertise
Policy Considerations:	policy considerations relating directly to the Official Plan and other strategic documents
Implementation Mechanisms	other applicable legislation or programs that will enable action
Time Frame:	three time frames; short (0-10 years), medium (11-20) years and long (21-30 years), which reflect general prioritization of the measures have been selected
Cost:	approximate cost of the measure assuming traditional funding sources (e.g., primarily municipal/provincial agency). It should be noted that the use of special interest groups and/or members of the public to implement the proposed measures and the pursuit of additional funding sources (e.g., special interest groups, environmental foundations) will reduce municipal/provincial/federal funding requirements.
Funding:	these include traditional sources such as through direct municipal and provincial funding as well as other sources such as special interest groups, corporation and endowments

Action	Next Steps	Facilitator / Contributor	Policy Considerations	Implementation Mechanisms	Timeframe	Costs	Funding Alternatives	Other Comments
SURFACE WATER MANAGEMENT PLAN - FLOOD CONTROL								
 Program emphasis on reducing flooding impacts on agricultural lands through stream restoration, wetland/forest protection measures as described below 	See Action Items 2, 4, 5, 16, and 17							
SURFACE WATER MANAGEMENT PLAN - EROSION AND SEDIMENT								
2 Stream restoration using natural channel design and engineered natural channel measures along 15.4 km of priority 1 tributaries and 13 km of priority 1 Carp River segments	Work with farmers to address potential Nutrient Management Act (NMA) issues Integrate as part of drain maintenance program under Drainage Act - Classify reaches for restoration and develop restoration templates for different stream types - Use in-kind support from public agencies, farmers, interest groups - equipment, labour, materials - Develop demonstration projects for funding unde Rural Clean Water Program	- City, MVC, Landowner, Special interest groups, OMAF, MNR, DFO r	 review opportunities to require natural channel design under Drainage Act; draft topsoil by-law; prepare fill regulation 	- stewardship - maintain and expand Rural Clean Water Program - use Drainage Act - provide education/training to Drainage Engineers on natural channel design	M-L	(28.4 km @ \$250/m) = \$7,000,000 (assumes in- kind support and use of existing programs)	Drain maintenance funding - Clean Water Program; Trillium Fund; Special Interest Group / Corporate Funding	; Stewardship emphasis
3 Control livestock access restrictions and installation of alternate watering sources on livestock operations in priority 1 subwatersheds and along priority 1 Carp River segments	Utilize Rural Clean Water Program and expand staff complement to implement program - Use in-kind support - equipment, labour, materials - Work with farmer to address potential NMA issues	City, MVC, Landowner, OMAF rs	- none	- stewardship - maintain and expand Rural Clean Water Program, MVCA programs, OMAF	S-M	(28.4 km @ \$12/m) = \$340,000	- Rural Clean Water Program; - OMAF; MVC programs	- City should coordinate efforts with OMAF and MOE in association with Nutrient Management Act implementation
4 Riparian zone plantings along 24.2 km of priority 1 tributaries and 9 km of priority 1 Carp River segments	Provide funding for staff complement to implement program - Use in-kind suppor - equipment, labour, materials - Work with farmers to address potential NMA issues	rf City, MVC,. Landowner, Special interest groups, OMAF, DFO, MNR	- City to consider a clearer Riparian/Floodplain designation in OP to include Carp River, Municipal Drains and Tributaries	- stewardship - maintain and expand Rural Clean Water Program - Utilize tree planting grant programs	S-M	(33.2 km @ \$2,500/km) = \$83,000	- Rural Clean Water Program; Green Acres - OMAF; MVC programs	- City could consider providing incentives for tree planting to meet overall objective of increasing forest cover
5 Riparian plantings along 18.2km of priority 2 streams	Provide funding for staff complement to implement program - Use in-kind suppor - equipment, labour, materials - Work with farmers to address potential NMA issues	rr City, MVC, Landowner, Special interest groups, OMAF, DFO, MNR	- City to consider a clearer Riparian/Floodplain designation in OP to include Carp River, Municipal Drains and Tributaries	- maintain and expand Rural Clean Water Program - Utilize tree planting grant programs	S-M	(18.2 km @ \$2500/km) =\$45,500	- Rural Clean Water Program; Green Acres - OMAF; MVC programs	- City could consider providing incentives for tree planting to meet overall objective of increasing forest cover
6 Implement conservation land management practices on about 4500 ha of priority 1 and about 2500 ha of priority 2 agricultural lands to reduce soil erosion	Expand grant program under Rural Clean Water Program to allow equipment purchase - Encourage sharing of equipment among farmers - Develop lease program	City, OMAF, MVC, landowners	- may be addressed through phase in of Nutrient Management Act	- consider purchase and lease program through Rural Clean Water program - audit Environmental Farm Plans; update Nutrient Management Plan	M-L	Equipment purchase: abou \$30,000-\$50,000 shared among several farmers (1 set of equipment/5 farms)	t - Rural Clean Water Program; - OMAF; MVC programs	
7 Maintenance of roadside ditch systems to address erosion and sedimentation problems	Prepare guidelines on best maintenance practices to reduce sediment contribution from roadside ditches	City	Implement as part of drain maintenance program under Drainage Act and/or ongoing O&M program for rural roadside ditches	 incorporate costs into regular operating and maintenance budget for roads 	S-M	(\$600/m) - incorporate into municipal road O&M costs	 incorporate costs into regular operating and maintenance budget for roads 	
8 Site specific erosion control measures (livestock access control, instream/roadside grade controls, streambank stabilization) in priority 2 streams	Identify priority stream reaches and specific erosion control measure. Provide / funding for staff complement to implement program - Use in-kind support - equipment, labour, materials - Work with farmers to address potential NMA issues - Develop demonstration projects	City, MVCA. Landowner, Special interest groups, OMAF	- City to consider a clearer Riparian/Floodplain designation in OP to include Carp River, Municipal Drains and Tributaries	- maintain and expand Rural Clean Water Program - use Drainage Act	M-L	Stream works (\$250/m) Fencing (\$12/m) (assumes in-kind support and use of existing programs)	- Rural Clean Water Program; - OMAF; MVC programs - Drainage Act; - City Roads Budgets	
SURFACE WATER MANAGEMENT PLAN - SURFACE WATER QUALITY								
9 Implement non -structural BMP's on all farmsteads on priority 1 and 2 agricultural lands, beginning with those operations contributing directly to priority 1 and 2 tributaries and priority 1 Carp River segments (approximately 50 farms)	Work with farmers to address potential NMA issues - Provide funding for staff complement to implement rural programs and provide technical support - Prioritize farms for work and help farmers develop remediation plans - Use in- kind support - equipment, labour, materials - Increase Rural Clean Water Program funding and grant structure	City, MVC, OMAF, Landowner	 may be addressed through phase in of Nutrient Management Act may use section of Drainage Act to prohibit discharge of pollutant to drains 	 stewardship - maintain and expand Rural Clean Water Program, MVC programs, OMAF programs OMAF may provide technical support to help farmers address problems before they are regulated under N.M. Act 	S-M	\$3,000 per farm = \$150,000) - Rural Clean Water Program; - OMAF; MVC programs	
10 Implement structural BMP's on all farmsteads contributing directly to priority 1 tributaries and priority 1 Carp River segments (approximately 20 farms)	Work with farmers to address potential NMA issues - Provide funding for staff complement to implement rural programs and provide technical support - Prioritize farms for work and help farmers develop remediation plans - Use in- kind support - equipment, labour, materials - Increase Rural Clean Water Program funding and grant structure	City, MVC, OMAF, Landowner	 may be addressed through phase in of Nutrient Management Act may use section of Drainage Act to prohibit discharge of pollutant to drains 	stewardship - maintain and expand Rural Clear Water Program, MVC programs, OMAF programs - OMAF may provide technical support to help farmers address problems before they are regulated under N.M. Act	M-L	\$20,000 - \$40,000 per farm = \$800,000	- Rural Clean Water Program; - OMAF; MVC programs	
GROUNDWATER MANAGEMENT PLAN								
11 Implement the eight elements of the City's Groundwater Managemen Strategy	Implement as part of provincial program on Source Water Protection	City/MVC	 City and CA to implement recommendation of regional studies 	s - City to implement recommendations of regional studies - update guidelines on Watershed / Subwatershed plans to include source protection plans	S-M	Not available	Provincial (MOE)	

Table 9.1 Watershed Plan Implementation Strategy

Action	Novi Stone	Escilitator / Contributor	Policy Considerations	Implementation Machanisms	Timoframo	Costs	Funding Altornativos	Other Commonts
12 Develop the groundwater management strategy to address notability	Kinhurn and Eitzrov Harbour are high priorition. Additional staff recourses more		- City has completed study identifying sites		S M	Sentic system ro inspection		other comments
contaminant sources and source protection.	be required for inspection		- Groundwater Management Strategy	inspections	3-101	may be self-financed (set		
				- need Program to target boundaries and		fee per		
				ensure works done - City		household).Contaminant		
				implementgroundwater management strategy		(2003)Landfill monitoring		
						<\$100,000 per site		
13 Implement Rural BMP's on agricultural lands in high/moderate	See rural BMP measures above		See Rural BMPs above (Action Items 6, 9	Stewardship/private land ower initiated	L	Equipment purchase: about	See Rural B.M.P. measures	
recharge (phony r and z agricultural aleas)						among several farmers (1		
						set of equipment/5		
						farms)\$3,000 per farm =		
						\$150,000\$20,000 - \$40,000		
						\$800,000(duplicated under		
						conservation tillage and		
						Turai Divir measures above)		
14 Develop a more detailed record of actual water takings from surface	Implement through existing programs	MOE, MVC	Permit to Take Water Program	- program currently under review	S-M	May be small incremental	MOE	
and groundwater supplies						cost to existing programs		
45 Demission budge and the line of a first factor of a land development	Providely a state of the state		Outileling to summarize lists	development and a second second	-	\$0.000 \$50.000 m m	la a davia a a	
15 Require hydrogeological investigations for land development proposals (MOE Guideline D5-5)	Prepare hydrological study guidelines as per MOE Guideline D5-5 and integrate groundwater characterization requirements	City, MVC, MOE	Guideline to support policies	development approval process	S	\$3,000 - \$50,000 per development (small scale	landowner	ongoing
						developments)		
GREENI AND PLAN - TERRESTRIAL								
16 Protect Category 1 Areas (see detailed description in Section 0.2.2.3)	City to include Centres of Ecological Significance in Official Plan policy and	City MVC MNP landowners	City to examine natural area policies in	-City to incorporate Category 1 features	SM	To be determined as part of	-City Acquisition Budget:	City to encourage
- Centres of Ecological Significance, candidate ANSI's, High NESS	acquisition budgets - Consider incentives to landowners who protect Category 1	interest groups, corporations,	Official Plan to ensure protection of all	particularly Centres of E.S. in OP, Greenspace	3-101	acquistion strategy	-private sector funding;	landowners to protect
Areas, natural features in high recharge areas, wetlands, riparian	areas - Develop stewardship program to work with landowners on feature		Category 1 features are captured (OPA one	Master Plan and Acquisition Budget;			-Trillium Fund, EcoGift	features
corridors.	protection		mechanism)	Encourage landowners to protect/rehabilitate				
				-City to undertake study to identify protection				
				approach for Category 1 Areas				
17 Conduct EIS on all Category 2 features (see detailed description in	Require EIS to be completed on all development applications in Category 2	City, MVC, developers,	City to review Official Plan policies and	- Develop OP mechanism for EIS requirement	S-M	about \$2,000 - \$7,000 per	EIS to be landowner funded	
Section 9.2.3.2) - woodlands contiguous with Level 1/2 riparian	areas	landowners	expand EIS requirement to include all	for development applications		EIS	as land use change occurs	
120 m setbacks) - applies only to development applications			Calegory 2 realures (OFA, MAF)					
18 Undertake a stewardship/education program to promote protection	to include Centres of Ecological Significance in Acquisition budgets - Consider		Environmental Strategy: Greenspace Master	City to expand Rural Stewardship Exhibit to all	9	\$1,500, annual per exhibit	City CA landowner MNR	
and regeneration of Category 1 areas to a natural state (see detailed	incentives to landowners who protect Category 1 areas - Develop stewardship	corporations, landowners	Plan	Client Service Centres	3	\$1,500, annuai per exhibit	City, CA, landowner, wink	
description of Category 3 areas in 9.2.3.2)	program to work with landowners on feature protection							
GREENLANDS PLAN - STREAM AND VALLEY CORRIDOR SYSTEM								
19 Identify and protect valley and stream corridors adjacent to all	Review OP to ensure all streams properly protected - improve definition of	City, MVC, MNR, interest groups,	Official Plan/Fisheries Act/ Conservation	-Official Plan Policy	S-M	- Lands deeded to City as	City, MVC, DFO, MNR	
classified streams in Municipal planning and/or zoning schedules to	watercourse in OP to ensure features protected	DFO, landowners	Authority Act/Infrastructure Master	-Greenspace Master Plan		public lands		
ensure their protection as land use change occurs			Plan/Comprehensive Zoning By-laws	Infrastructure Master Plan/Stormwater Master				
20 Implement a stewardship program to encourage buffer plantings	Provide funding for staff complement to implement program - Use in-kind suppo	ort City, MVC, MNR, interest groups,	Environmental Strategy; Greenspace Master	- maintain and expand Rural Clean Water	S-M		City, CA, landowner	
streams	issues	corporations, landowners	Plan	- Utilize tree planting grant programs				
21 Percentional trail system	Identify trail route	City MVC landowners interest	already identified in OR	work with landowner to allow use of private	MI	NI/A	City	
	with landowners to seek cooperation	groups		property	IVI-L	11/7	Ony	
	- Develop trail system master plan							
	Identify opportunities and constraints							
22 Environmental Monitoring Program	Agencies to review Carp recommendations and update monitoring programs as	City, MVC, MNR, MOE, DFO,	agencies to adopt "adaptive management"	-Agencies to ensure adequate resources	S-M	most Agencies need to	Agencies, landowners,	
	appropriate	landowners, interest groups	and build-in monitoring and reporting as tool	available for monitoring		expand monitoring budget	corporations, interest groups	
				-need to improve monitoring and auditing of				
				monitoring conditions on works				

Table 9.1 Watershed Plan Implementation Strategy

Item	Action	Next Steps	Facilitator / Contributor	Policy Considerations	Implementation Mechanisms	Timeframe	Costs	Funding Alternatives	Other Comments
	ACE WATER MANAGEMENT PLAN - FLOOD CONTROL							Alternatives	
1	Assess impacts of floodplain modifications resulting from stream restoration works along upper Carp from Glen Cairn pond to Richardson Side Road	City to coodinate as part of overall function design and environmental assessment for Carp River Corridor Restoration Plan	City, CA, landowners	may require 2 zone approach	include in the Carp River Corridor Plan project	S	\$10,000	City/CA	refer to Subwatershed fact sheets
2	Undertake Floodplain Mapping for Carp River, Poole Creek, and Feedmill Creek downstream of Highway 417	Studies to be lead by the City with developer/landowners participation	City, CA, landowners		include in the Carp River Corridor Plan project	S	Carp River \$50,000 Poole Ck/Feedmill Ck \$ 20,000	landowner	refer to Subwatershed fact sheets
SURF	ACE WATER MANAGEMENT PLAN - EROSION AND SEDIMENT CONTROL								
3	Carp River Corridor Plan: Restore upper Carp River to riverine wetland with floodplain features and recreational trail system (approximately 5000 m)	City to undertake functional design and environmental assessment with funding provided through a number of sources: benefiting landowners, all landowners in Kanata West planning area, entire drainage area	City/CA	may be EA requirement modify floodplain policy Kanata West Concept Plan	City to lead and coordinate study	S-M	(5 km @ \$800/m) = \$4,000,000	Investigate as part of the functional design	refer to Subwatershed fact sheets
4	Protect stream corridors along Carp (100 m), Poole (80 m) (downstream of old dam) and Feedmill (70 m) downstream of Queensway	Implement as part of development review and approval process Dedicate to the City as public open space	City/CA	Official Plan Policies Floodplain Policy Infrastructure Master Plan	Kanata West Concept Plan City to approve terms of reference for EMP studies	S	cost related to land priced as hazard constraint	landowner	refer to Subwatershed fact sheets
5	Implement natural channel design restoration for designated reaches of Poole and Feedmill (approximately 1000 m)	Functional design to be funded by developers/landowners	landowner	Official Plan Policies Environmental Strategy Infrastructure Master Plan	City to approve terms of reference for EMP studies	S-M	(1 km @ \$600/m) = \$600,000	landowner	refer to Subwatershed fact sheets
6	Implement GREE design restoration for designated reaches of Poole (approximately 800 m)	Functional design to be funded by developers/landowners	landowner	Official Plan Policies Environmental Strategy Infrastructure Master Plan	City to approve terms of reference for EMP studies	S-M	(1 km @ \$600/m) = \$600,000	City/CA/DFO Fishery Compensation	refer to Subwatershed fact sheets
7	Restore lower reaches of Poole and Feedmill Creek to riparian wetland systems contiguous with Carp River Corridor plan (approximately 1000 m)	City to coodinate as part of overall function design and environmental assessment for Carp River Corridor Restoration Plan	City/CA	may be EA requirement modify floodplain policy	City to coordinate study	S-M	\$600,000	Investigate as part of the functional design	fact sheets
8	Implement Source Control Measures as part of Stormwater Management system	City to approve terms of reference for detailed studies Developers/landowners to undertake functional design	landowners	MOE Stormwater Management & Design Guidelines Infrastructure Master Plan	EMP/development application City to approve terms of reference for EMP studies	S-M	dependent on type of BMP	landowner	refer to Subwatershed fact sheets
9	Require all new facilities to implement groundwater infiltration wherever feasible and to control post development erosion flows to within 5% of existing	City to approve terms of reference for detailed studies Developers/landowners to undertake functional design	landowners	Official Plan Policies MOE Stormwate Management & Design Guidelines	r EMP, City to approve terms of reference for EMP studies				refer to Subwatershed fact sheets
	ACE WATER MANAGEMENT PLAN - SURFACE WATER QUALITY								
10	New SWM facilities must meet the water quality and runoff targets specified for each watercourse	Prepare conceptual stormwater management system on a tributary basis demonstrating water quality targets will be met	landowners	Official Plan Policies MOE Stormwate Management & Design Guidelinesn	r EMP, review SWM options	S-M	Reflected in cost of stormwater management facility and source control BMPs	landowners within drainage area	refer to Subwatershed fact sheets
GROU	NDWATER MANAGEMENT PLAN								
11	Prepare a groundwater characterization study on a tributary drainage basis to determine groundwater gradients & divides, to preserve groundwater discharge (baseflow), to assess feasibility of infiltration-based stormwater management BMPs and to maintain a pre-development water balance.	City to approve terms of reference for detailed studies as part of the development review process	landowners	Official Plan policies Groundwater Management Strategy Infrastructure Master Plan	EMP plus groundwater studies	S-M		landowners within drainage area	refer to Subwatershed fact sheets
GREE	NLAND PLAN - TERRESTRIAL								
12	Protect Category 1 Areas (see detailed description in Section 9.4.3) - Centres of Ecological Significance, candidate ANSI's, High NESS Areas, natural features in high recharge areas, wetlands, riparian corridors.	Study required to identify candidate Natural Environment Areas. Changes to OP maybe necessary to ensure that Category 1 features are protected. List of Centres of Ecological Significance to be added to City's acquisition program	City	Official Plan Policies Greenspace Master Plan	use EMP to require EIS incorporate in City's Acquisition Plan	S-M-L	fair market appraisal based on land use/zoning/purchases of like land	City budget Ecogift Environmental Foundations	Figure 9.5 refer to Subwatershed fact sheets
13	Conduct EIS on all Category 2 features (see detailed description in Section 8.4.3) woodlands contiguous with Level 1/2 riparian corridors, features in low/moderate recharge, adjacent lands (30 or 120 m setbacks) - applies only to development applications	Require EIS to be completed on all development applications in Category 2 areas	City, MVCA, developers, landowners	City to review Official Plan policies and expand EIS requirement to include all Category 2 features (OPA)	 Develop OP mechanism for EIS requirement for development applications 	S-M	about \$2,000 - \$3,000 per EIS	EIS to be landowner funded as land use change occurs	Figure 9.5 refer to Subwatershed fact sheets
14	A stewardship/education program to promote protection and regeneration of Category 3 areas (see detailed description in Section 8.4.3) to a natural state. A stewardship/education program to promote protection and enhancement of Category 1 areas (see detailed description in Section 8.4.3)	Identify landowners and current protection status For publicly owned lands prepare management plan to guide activities and restoration	City, CA, MNR, landowners	Greenspace Master Plan	use Forest Management / Environment strategy as a guide good Forest Practices Bylaw	Μ		City budget, Grant programs, landowner resource centre	Figure 9.5 refer to Subwatershed fact sheets
15	Review current aggregate operations in Feedmill headwaters and review opportunities to augment baseflows in both Feedmill and Poole. Confirm that rehabilitation plan devotes restoring significant lands to natural state	City and MNR to initiate discussions with aggregate producer	City, MNR, MOE, CA	Source Protection Planning Regional Groundwater Study Water Taking Permit	assess groundwater / surface water impacts review rehab. plans and final land use designation	M-L		operator	refer to Subwatershed fact sheets
GREE	NLANDS PLAN - STREAM AND VALLEY CORRIDOR SYSTEM								
16	Protect valley and stream corridors along upper Carp, Poole and Feedmill Creeks (See Section 8.2)	corridors identified in subwatershed City to incorporate corridors in EMP's for individual installments	City, CA, landowner	Official Plan Policies Kanata West Concept Plan	EMP/development application	S-M	land dedication	landowner	refer to Subwatershed fact sheets
17	Maintain key functions of valley and stream corridors in Hazeldean and Unnamed Tributaries	corridors identified in subwatershed City to incorporate corridors in EMP's for individual installments	City, CA, landowner	Official Plan Policies Kanata West Concept Plan	EMP/development application	S-M	land dedication	landowner	refer to Subwatershed fact sheets
GREE	NLANDS PLAN - RECREATION								
18	Recreational trail system	Incorporate into the Carp River Corridor Plan functional design and the Poole Creek and Feedmill Creek restoration plans. Delineate pathway location through development review process.	City, landowners	Official Plan Policies Kanata West Concept Plan	coordinate with other development study requirements, particularly infrastructure	S-M	land dedication	City, landowner	refer to Subwatershed fact sheets

Table 9.2 Subwatershed Plan Implementation Strategy



Other Comments: any other information/considerations relevant to implementation

In general, there are two key factors which will determine the success of the implementation plan:

- a strong community-based commitment to stewardship with active participation by all government levels; and
- a strong will within the City and MVCA to accept responsibility for the protection, enhancement and restoration measures.

It is proposed that the City will be the facilitator of many of the proposed plan components. The MVCA has also been listed as the facilitator for components involving stewardship. Furthermore, the initiatives involving stewardship and naturalization will transcend the watershed boundary and are therefore best addressed by an agency with responsibilities on a watershed basis. Other agencies have been identified as contributors for specific plan components.

The overall time frame for implementing the plan has been selected to be 30 years; which reflects both budgetary considerations and the long term nature of several components (particularly naturalization plans). Three time periods have been selected. These are:

- Short Term 0 to 10 years: components to be implemented in this time frame are of high priority, may need to be implemented to protect existing natural resources, have reasonable costs associated with the construction/implementation and may not require additional policies to be written to implement the plan component;
- Medium Term 11 to 20 years: within this category, selected measures are of moderate priority, generally enhance/restore existing resources, have moderate costs associated with the works, and may require policy change; and
- Long Term 21 to 30 years: components in this category are lower priority, may be relatively costly and only address enhancement/restoration of a single natural environmental resource, require policy change, and may impact existing uses by a landowner (e.g., removal/restoration of a private pond).

It should be noted for some of the plan components, more than one time frame has been given. For example, under stream restoration, Priority 1 reaches where works are required to protect/enhance critical aquatic resources have been listed under the 0 to 10 year category; while works for Priority 2 reaches are under the 11 to 20 year category. With respect to the naturalization strategy, all components have been given a 0 to 30 year time frame as it is acknowledged that undertaking of these components is a long term commitment and that support and buy in by individual landowners is required. The proposed naturalization strategy was based on existing uses of the land and environmental considerations. However, until each landowner is contacted and support/buy in (see Section 10.6) is provided, prioritization cannot be provided.



9.3 Adoption and Integration of the Recommended Plan

9.3.1 General

Watershed and Subwatershed planning is one of the cornerstones of the City of Ottawa's Official Plan. Accordingly, City Council and MVCA's Board should (by resolution) endorse the Carp Watershed/ Subwatershed Plan as the technical basis for proceeding with future municipal planning initiatives, as well as in the development review process.

This approach is consistent with Policy 2.4.3 of the Official Plan which states that watershed and subwatershed plans are to be approved by City Council as a statement of City Council policy. It provides City staff with the authority and technical information for use when evaluating development applications or undertaking other initiated planning activities. The proposed approach to have a City Council Approved Watershed and Subwatershed Plan is thereby consistent with current practice and provides an appropriate level of recognition and authority.

Appendix I summarizes the various OP policies related to watershed/subwatershed planning. It is expected that the Carp River Watershed and Subwatershed Plans will serve as the authorized technical basis on the interpretation and study requirements to satisfy these relevant Official Plan policies. In order to make users aware of the study, it is recommended that a Plan showing the City Council approved Watershed and Subwatershed Study Areas be prepared and attached to the City of Ottawa Official Plan as an Annex. This will create a place for the recognition of Watershed and Subwatershed Plans as part of the information provided with the OP without an actual amendment of the OP. An example of this is Annex 3. Areas suspect to an approved Community Design Plan or Policy Plan approved by City of Ottawa Council. When development applications such as plans of subdivision, consents, condominiums and site plan control applications are submitted, the Carp River Watershed/Subwatershed Study will be consulted as a Council Approved reference document in the Annexes of the Official Plan. It is also recommended that the property identifiers in the City of Ottawa's database include a reference to the study, in the same way that the zoning history, and heritage designations are flagged on the property file. The policies of Section 4 of the OP will be applied during the review of development applications.

9.3.2 Integration with other Studies

The findings and recommendations of the Carp River Watershed/Subwatershed Plan will need to considered and integrated into the other City strategic planning initiatives such as:

- Greenspace Master Plan
- Groundwater Management Strategy
- Infrastructure Master Plan
- Stormwater Management Master Plan
- Forest Strategy

Over time, a variety of more project specific studies (e.g., land use planning, zoning, municipal servicing, transportation, parks and open space, environmental assessment), will be undertaken within the watershed. This study provides both baseline information relating to *existing* natural environmental resources as well as a framework for the protection, enhancement and restoration of valuable natural environmental resources.



9.4 Watershed/Subwatershed Plan Administration

The completion of the watershed study was a cooperative effort led by the City of Ottawa and MVCA, with support as required from provincial/federal agencies, special interest groups and representatives from the public. The recommendations as described in this Plan were discussed with the above noted groups and, as such, provide a framework for implementing the plan. An Implementation Committee will, however, be required to further define implementation mechanisms, ensure conformance with component strategies, assess the effectiveness of the plan and, in general, update and monitor plan implementation.

In terms of administration, it is recommended that an Implementation Committee be formed for the Watershed to oversee plan implementation. The composition of the Implementation Committee should include representation from the City, the Conservation Authority, provincial regulatory agencies, special interest groups and members of the public. Ultimately, the Implementation Committee may split into two or three subcommittees to deal with the following four topics:

- plan implementation;
- funding opportunities and partnership;
- stewardship;
- environmental monitoring; and
- restoration and retrofitting.

There is already a well organized and committed community of volunteers, interest groups and landowners that have undertaken many projects by providing various types of inkind support including labour, materials, equipment and supplies for implementation. The Implementation committee can make use of this network of support to assist in the implementation of the plan.

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

9.5 Education/Stewardship Program

A majority of the lands within the watershed are privately owned. Furthermore, many of the proposed measures outlined as part of the Recommended Plan would be undertaken on private lands. Success of this plan will therefore depend on the support and buy in of the individual landowners. This will involve an education process whereby the importance of the existing natural environmental resources on a landowners property are clearly explained as are the proposed benefits of undertaking a specific measure (e.g., reforestation) on their lands. It will also require targeted programs which involve private landowners in conservation through voluntary choice (i.e., stewardship).

Several stewardship programs (e.g., reforestation, stream restoration, habitat enhancement) have been undertaken within this watershed. It is recommended that a committee be established to oversee stewardship programs which will build on those already underway. In this regard, a stewardship committee should be formed. The committee should be comprised of agency staff, special interest groups and the public.



The objectives of the committee would be to:

- oversee the proposed stewardship program;
- develop guidelines (e.g., woodland conservation, valley land naturalization) for the protection, restoration and enhancement of the natural environmental resources on private property; and
- develop a stewardship manual.

Further discussion of each of the items is provided below.

Proposed Stewardship Program

The City, through its Rural Clean Water Program already has considerable experience in implementing an effective stewardship and education program. The program components include the following:

- a joint agency/community partnership in developing community support programs for encouraging private stewardship;
- education is important, i.e., most landowners are very interested in obtaining more information on their land to inform them why their land is important (i.e., presence of significant habitat, functions of woodlots) and how they might better manage their lands;
- straightforward, voluntary agreements with landowners are the easiest to obtain;
- acknowledgements of good stewardship efforts, through the issuance of plaques, certificates are beneficial;
- the importance of gaining landowner trust and using this opportunity to develop long term partnerships to improve land stewardship cannot be underestimated; and
- successful stewardship programs require "one-window" stewardship offices which serve as the contact point for local landowners (otherwise, landowners are more likely to become confused and disinterested).
- Grants range in value up to \$10,000, covering 50% of the costs of a wide range of Rural Best management practices to address impacts on surface and ground water resources. Grants cover a range of measures including livestock fencing, implementation of tillage practices, structural and non-structural manure management and storage facilities, streambank stabilization, erosion protection and septic system replacement. The City also can provide technical support and advice through available staff resources.

This program is an excellent example of one of the few stewardship programs available to farmers. With the recent passing of Nutrient Management legislation, the continuation of this program with its staff complement represents a key means of helping farmers address new legislation.

Guidelines

The Rural Clean Water committee has guidelines for the program, such as:

 a stewardship agreement, e.g., if reforestation of the property is undertaken, what type of agreement would be required to ensure that the lands remain in a natural state;



- policy related to private land ownership and stewardship, i.e., the development of woodlot conservation policy, naturalization guidelines; and
- land ownership, ensuring that the requirements/rights of the individual landowner and general public are met.

These guidelines can be used as a template to development similar guidelines for stewardship initiatives recommended in the Plan.

Stewardship Manual

A stewardship manual outlining actions which are typically the focus of a stewardship program should be undertaken. Typical measures include:

- rural Best Management Practices, in particular, practices which reduce overland sediment delivery to streams and which take environmentally sensitive lands out of production;
- reforestation programs to revegetate valley lands and streamsides, naturalize idle lands or provide linkages (terrestrial corridors) between natural areas;
- stream rehabilitation and aquatic habitat enhancement including creation of wetlands;
- other types of habitat creation or natural area planning; and
- recreational trail development.

The City already has a plan for funding stewardship programs. Additional funding/partnerships from the following sources should be considered:

- agencies (monetary, or services in kind);
- Ottawa Stewardship Council;
- endowments;
- special interest groups;
- corporations;
- environmental foundations; and
- other sources (e.g., reinvest funds that are currently collected for fishing licences).

9.6 Land Use Planning Mechanisms/ Implementation Tools

This section describes, with specific reference to the City of Ottawa, how Official Plan policy documents, and other related planning tools, are available that may assist in carrying forward the recommendations of the Carp River Recommended Plan. Because of the scope of its recommendations and the limitations to some types of planning requirements, a long list of implementation tools such as municipal by-law provisions, other regulatory acts, funding opportunities, have been identified for consideration.

9.6.1 Land Use Planning Mechanisms

Official Plan Amendments:

Figure 8.1 and **Figure 8.5** identify two (2) categories of natural environmental resources. Based on a review of the Official plan schedules, Schedules A and B apply to natural features; Schedule K identifies wellhead protection areas and floodplains. On Schedules A and B, the following designations are considered to be protected from adverse development:



- Urban Natural Features
- Natural Environment Areas
- Significant Wetlands
- Rural Natural Features Area

A comparison of the land use designations of Schedules A and B of the OP with the Category 1 and Category 2 Areas was undertaken for this Study. In most cases, the Category 1 Areas correspond with an environmental designation such as Natural Environment Area, Rural Natural Area, Urban Natural Areas and Significant Wetland Areas. However, Category 1 boundaries did extend outside of these land use designation for some areas. A review of the adequacy of the existing designation needs to undertaken. In addition, the areas extending beyond current designation limits requires further consideration and may represent candidates for re-designation in an Official Plan Amendment or future OP review.

Category 2 areas are generally not protected by the Official Plan designation. In addition, there is no requirement for an EIS study to be completed should development of these features be proposed. Only lands within 120 m of a Significant Wetland or 30 m of a Natural Environment Area or Urban Natural Feature are treated as Category 2.

In order to ensure that the Greenlands Plan of the Carp River Watershed/Subwatershed study is achieved, it is important that the Category 1 areas are designated for protection and that the Category 2 areas are appropriately assessed through an EIS study if land use changes are proposed. Further examination of the appropriate protection mechanisms needs to be undertaken which could potentially identify amendments to Schedule A and B of the Official Plan. This effort will be coordinated and integrated into the Greenspace Master Plan that is currently on-going.

The accuracy of the mapping of the boundaries of Category 1 and Category 2 lands reflects the scale at which the inventory/mapping of the Carp Watershed Recommended Plan was undertaken (ie. 1:10,000). Therefore, more detailed mapping is required to support any proposed change in designation in the Official Plan. Designation of the Category 1 lands as Natural Environment Area or Rural Natural Feature would ensure implementation of the Greenlands Plan, along with policies or designations to ensure that an EIS is completed where development is proposed in Category 2 areas.

Expansion of the Environmental Impact Statement Requirement

For any land use change proposed within 30 m of Category 1 areas (or 120 m of a wetland) or within any Category 2 areas, it is recommended that an Environmental Impact Statement (EIS) be prepared. Currently this requirement is limited to Natural Environment Areas, Rural Natural Features Areas and Urban Natural Ares in the OP. Thus the expansion of a requirement for an EIS for a development application should be pursued. In the interim, this could be achieved through a best effort basis, by referring to the recommendations of the Carp River Watershed/Subwatershed Study and Sections 2.4.3 (Watershed and Subwatershed Plans), 3.2 (Natural Environment) and 4.7 (Environment Protection) of the Official Plan.

City of Ottawa Comprehensive Zoning By-law

The Carp River Watershed/Subwatershed Study can also be implemented through the future comprehensive zoning by-law for the new City of Ottawa. This is preferable to amendments



to the existing zoning by-laws because it will be consistent with the new draft City of Ottawa Official Plan.

The minimum setback requirements from rivers/lakes and streams is 30 m from the normal high water mark and 15 m from the top of bank, as per Section 4.7.3.1 of the OP. This will likely be in the new zoning by-law. In cases where a specific minimum stream corridor is identified in this study, the future zoning by-law should take these into account if they are greater than the minimum standard as set out above.

The definitions for watercourses stated in the Recommended Plan are generally consistent with the MVCA/DFO watercourse definition and, as a minimum satisfy DFO's policy regarding fish habitat. Within the current Official Plan, the definition of watercourse is somewhat vague: "a naturally occurring drainage channel, which includes rivers, streams and creeks." The identification of watercourses to be protected, corridor widths and restoration requirements are established through the completion of watershed, subwatershed and/or Environmental Management Plans, as outlined in Section 2.4.3 of the OP. Once the study is endorsed by Council, the above definitions and the recommended plan, as illustrated in **Figure 8.1** and **Figure 8.5** that show these features, should be adopted.

A common method of indicating floodplains as constraints is to have a floodplain overlay on the zoning schedules with related provisions in the text of the by-law indicating the permitted uses within the floodplain and minimum performance standards, such as setbacks from the watercourse or the floodplains. The mapping of the floodplain is based on the approved mapping established by the Conservation Authority. This is also indicated in a general way, on the map schedule related to Environmental Constraints in the Official Plan (Schedule K).

The overlay would be presented as a shaded area over a general zoning category such as the RU – Rural or AG – Agricultural. The zoning by-laws of the former City of Nepean, City of Gloucester and City of Ottawa use this approach.

Zoning Amendments:

Natural environmental resources should be zoned in an open space, conservation or hazard lands zone category that protects the characteristics and/or functions of the feature by restricting the land uses to be permitted and imposing restrictions on buildings and structures (where permitted) and other standards for development. The boundaries of the Category 1 and 2 Areas identified in the Recommended Plan can be used as a general basis for establishing zone boundaries. However, subject to the cautionary observations noted above, these zone boundaries can be refined through a further study process, or in conjunction with the review of a specific development application.

In addition, the objectives of the Recommended Plan may also be addressed through restrictions on development adjacent to a particular natural resource. Accordingly, the City may wish to consider identifying specific setbacks for other zone categories where they abut an open space, conservation or hazard lands zone. For instance, a typical rear yard setback for a single-detached residential zone category may be 7.5 metres. However, where such a lot abutting an open space zone associated with a Category 1 or 2 Area, that rear yard may need to be increased to, for example, 12 metres with associated prohibitions on swimming pools or other accessory buildings/structures within a certain distance of the rear lot line.

Accordingly, zoning can implement the objectives and recommendations of the Recommended Plan not only by regulating the zoning of the natural environmental resources themselves, but also by regulating activities on immediately adjacent lands.



9.6.2 Other Implementation Tools

As discussed above, there are a number of land use planning mechanisms that may assist in the implementation of some actions contained in the Recommended Plan. This section describes other types of implementation tools that may assist in the protection of natural environmental resources through regulatory approvals processes and other planning initiatives/projects.

Development Charges:

Certain Ontario municipalities have included in their municipal Development Charges by-law, a cost factor associated with the acquisition of natural resources (such as woodlots) and stream restoration works, subject to Provincial limitations under the Development Charges Act. The factor establishes a specific price per acre for the land and enables the municipality to purchase (at this set price) the lands from a landowner. These charges can cover a variety of works including stormwater management facilities, stream restoration, facility retrofitting, etc. In the case of the Carp River Watershed/Subwatershed Study, environmental restoration and securement opportunities should be explored and amendment to the City of Ottawa Development Charges By-Law be considered.

Cash In Lieu/Water Rate Surcharges:

In some instances, a development may proceed without meeting certain stormwater management, hazard policies or environmental constraints by providing funds upfront to the City for use at a later time for such purposes for example infilling development or where proposed development precedes a larger development (of which it is a part) or where the City has identified specific restoration or naturalization targets for a subwatershed,. A surcharge on water and wastewater rates can also be used to offset infrastructure replacement and water management costs.

Fill Regulations/By-laws:

Regulations to prohibit the placing/dumping of fill on defined lands; regulating grading; requiring plans to be submitted; and, compelling approvals/permits (subject to conditions) to be secured can be achieved through the Conservation Authorities Act (within prescribed fill regulations areas), or through the Municipal Act (by by-law).

These regulations can have significant effect on the grading and/or site alterations that may affect the form or function of natural resources. Municipalities should consider the enactment of fill by-laws pursuant to the Municipal Act; particularly in the Environmental Constraint Areas as identified in the Recommended Plan. Such by-laws may only be imposed on lands not otherwise subject to Conservation Authority fill regulations. These regulations also apply to control the removal of organic soils and peat for commercial reasons.

These regulations, under Section 28 of the Conservation Authorities Act have recently been amended to allow for greater scope in protecting headwaters, headwater streams and wetlands. The Generic Regulation was passed in April, 2004 and is included in **Appendix H**.



Tree Preservation:

Tree preservation regulations may be secured by either by-laws enacted pursuant to the Trees Act, or the Municipal Act.

Under the Municipal Act, those local municipalities with populations greater than 10,000 persons, can enact by-laws to regulate the destruction of trees in defined areas and require permits (subject to conditions) to be issued to permit tree removal. The Act also identifies situations in which the by-law does not apply (for example, highway road allowances, lands where site plan/building permits have been issued, and Christmas tree farms) or to which it does apply (for example size, density, age, species of trees).

Under the Trees Act, municipalities may pass by-laws to restrict tree removal. Typically, such by-laws include a definition of the "areas" or "woodlots" to which the by-law would apply (ie. geographic size).

The City has developed a Good Forestry Practices in Environmentally Sensitive Areas By-Law as part of the comprehensive Urban Forestry Strategy, one of the strategic plans identified in the Official Plan. The by-law applies to lands designated in the following categories: Significant Wetlands, Natural Environment Areas and Urban Natural Features, as well as adjacent lands defined in the Official Plan.

The City also has general objectives for maintaining or increasing forest cover within its jurisdiction in the Official Plan. As part of the good forestry by-law, City staff are proposing an extension services program that would offer assistance to landowners to preserve woodlots and trees on private property and to address forest management on City property.

Topsoil By-law:

A topsoil by-law may be enacted pursuant to the Topsoil Preservation Act, which permits a municipality to regulate the removal of topsoil for defined areas; require the issuance of permit to allow topsoil removal; and, prescribe required rehabilitation measures.

An evaluation of its operational effectiveness should be undertaken so that all departments having responsibility in the development review process (and by-law enforcement) are aware of its standards. In addition, information regarding these regulations should be made available to the general public (through the other educational efforts associated with this Plan) and specifically, to landowners in planned development areas and development proponents.

The City has identified the need to control topsoil and peat removal in the Official Plan.

Development Guidelines:

Development proponents should be able, early in the development review and approvals process, to understand the more detailed implementation measures related to specific recommendations of the Carp Watershed/Subwatershed Recommended Plan (Chapter 9). A manual(s) containing standards or guidelines dealing with environmental issues should be available to residents, landowners and development proponents to assist in both the ongoing maintenance and management of lands, and to assist in the preparation of development proposals. For example, such guidelines may address specific environmental issues, such as water budget analysis, integration of stormwater management and creek restoration works, or woodland/forestry management.



The City and MVCA may jointly prepare such Development Guidelines in order to achieve consistent application throughout the City including the Carp Watershed area.

Development Bonusing:

Pursuant to the Planning Act, a municipality may provide for an increase in density or height of a development, in exchange for certain "facilities, services or other matters". In the context of the Recommended Plan, bonusing may be utilized as a means to encourage the retention and preservation of natural environmental resources. In order to utilize such provisions as an "incentive" to development proponents, a municipality must first have general policies in its Official Plan indicating its intent to use development bonusing and, specify in the zoning by-law which "facilities, services or other matters" are to be achieved in return for such bonusing.

Alternative Development/Engineering Standards:

Certain development standards for public infrastructure (for example, road rights-of-way, servicing easements, boulevard widths, sight triangles) are land extensive and require large areas to accommodate the facility. Where such infrastructure must be located within or adjacent to natural environmental resources, municipalities should consider reduced standards in order to minimize potential impacts on these areas/features.

In Chapter 6, a number of innovative BMPs were described that may require changes in standard engineering practice or municipal standards in order to be implemented (eg, wetland facilities, infiltration devices, third pipe systems). Approval agencies need to bestay abreast of best management practices to promote them within their jurisdictions and adjust standard practices where appropriate.

Land Acquisition:

Public ownership and management of significant natural heritage areas/features ensures their long-term preservation, management, security and accessibility to the public (where appropriate). Such public ownership can be vested in a municipality or a conservation authority. However, financial resources for acquisition are limited.

The City has an acquisition program for Natural Environment Areas designated in the Official Plan. It is recommended that this program be expanded to allow for the acquisition of other types of environmental lands where the value of such lands has been identified through a watershed study or other comprehensive study. Information from the Recommended Plan may be used to prioritise areas for acquisition and assist in developing a long-term financial budget for environmental land securement.

Parkland Dedication

The parkland dedication pursuant to the Planning Act permits a municipality to secure a specific percentage of land area for public park purposes. Traditionally, municipalities have sought to acquire tableland suitable for active recreational activities through the parkland dedication process. However, as an alternative, a municipality may consider acquisition of natural environmental resources through this statutory process.

The municipality should also consider a "credit" process, wherein the calculation of tableland parkland dedication requirements is based on a "net" developable land area (i.e., the net area remaining after the other natural resources to be preserved and perhaps, transferred to public ownership) have been deducted. In some circumstances, the amount of lands



deducted from the parkland calculation, provide a sufficient incentive to the development proponent while, at the same time, allowing the public to acquire a natural resource that would otherwise be unavailable.

A Greenspace Master Plan is being prepared for 2005 to identify, among other matters, the components of the City's greenspace system, targets for provision of greenspace and forest cover, and acquisition policies.

Agricultural Impacts and the Nutrient Management Act

The purpose of the Act is to provide for the management of materials containing nutrients in ways that will enhance protection of the natural environment and provide a sustainable future for agricultural operations and rural development.

The Nutrient Management Act was developed by the Ministry of Agriculture and Food (OMAF) and the Ministry of Environment and Energy (MOEE) using the recommendations of many private and public sector sources. It:

- sets out a comprehensive and integrated approach to all land-applied materials and the safe disposal of deadstock;
- ensures that all land-applied materials will be managed in a sustainable, beneficial manner which results in environmental and water quality protection;
- provides for clear, province-wide standards so that farmers can invest with confidence in their businesses; and
- increases public confidence in a sustainable future for agricultural and rural development.

The Nutrient Management Act provides the authority to develop and implement new, enforceable standards, supported by new inspection and compliance measures and new authority for remedial action and provincial enforcement. The Act provides a framework for the Ministry of Agriculture and Food and the Ministry of Environment and Energy to work with a broad range of stakeholders to develop the specific standards.

It provides authority for regulations governing several areas, including:

- establishing requirements for NMPs and NMSs, including record keeping and filing;
- enhancing regulations for the use, quality and application of land applied nutrients;
- establishing minimum distance separation requirements for land application and buildings to protect land and water;
- establishing categories of agricultural operations and standards relating to the management of materials containing nutrients;
- establishing requirements for the collection, storage, handling, use and transportation of materials containing nutrients;
- establishing qualifications, education, training and certification for farmers and others applying materials containing nutrients to land;
- providing for the use, establishment and access to a registry in which NMPs/NMSs would be recorded;
- using innovative technologies (e.g. composting) to manage materials containing nutrients; and
- locally mediating issues that are not related to enforcement, including establishing local advisory committees.



At this time, agencies are still consulting with the public, other agencies (including municipalities) and the agricultural industry on this legislation and are finalizing issues associated with phase in of the regulations and how the Act would be applied to different operations, based on size, type operation, etc.

Currently it does apply to biosolids application and to new agricultural operations, and OMAF is working on the development of training and education for farm operators.

Grant Programs

There are a variety of funding alternatives for implementing the recommendations of the Watershed Plan. Traditionally, funding for implementation was primarily through a combination of government funding and private landowner funding, with the municipality and conservation authority providing the main source of government funds. This traditional model has changed substantially with corporations, interest groups, community groups, now becoming significant contributors of funding and in-kind support to projects. Some examples of possible funding "partners" include:

- Trillium Fund
- Friends of Carp
- City Rural Clean Water Program, Natural Area Acquisition policy, Green Acres Program
- National Capital Commission acquisition/management of federal parklands
- OMAF incentive programs for farmers, training/education re: Nutrient Management Act, drain maintenance under the Drainage Act, Healthy Futures Program
- MVCA/MOE Source Area Protection Plans, Groundwater Plans
- MVCA Rural BMPs, grants, conservation plantings and plans
- MNR Community Fisheries Involvement and Community Wildlife Involvement Programs, Stewardship Councils
- Ducks Unlimited
- Ontario Soil and Crop Improvement Association Environmental Farm Plan, Regional Partners Fund
- Agriculture Adaptation Council
- Wetland Habitat fund

9.7 Environmental Monitoring

9.7.1 General

An environmental monitoring program is required to ensure that the study goal and environmental targets are achieved. Development of the program must be responsive to several items including:

- the environmental resources to be monitored;
- available funding;
- staffing;
- availability of volunteer groups;
- existing monitoring databases;
- proposed measures to be undertaken; and
- rate of change of development within the watershed.

The City of Ottawa has one of the most comprehensive environmental monitoring programs in the province. The program has grown from initially emphasizing water quality parameters to one that is more ecosystem based, including the following:



- Precipitation
- Stream flow
- Water quality
- Groundwater resources
- Fluvial geomorphology (stream morphology/erosion)
- Benthic invertebrates
- Fish communities and habitats

There are about 4 stations along the Carp River as well as several in tributaries including Poole and Feedmill Creeks. A number of additional recommendations for monitoring are provided in the following sections, that represent "value added" information to an existing program that already provides excellent, in depth monitoring and reporting of environmental conditions in the City's watersheds.

The primary objectives of the monitoring program are to:

- evaluate the effectiveness of the measures as described in Chapter 9 in order to protect, enhance and restore the natural environmental resources; and
- establish the impacts of potential land use changes and ensure that the environmental targets for each tributary and the watershed as a whole, are met.

In order to meet each of these objectives, a different type of monitoring program may be required. For example, monitoring the effectiveness of stream restoration works to restore a coldwater fishery may entail localized monitoring along the stream reach which was restored and may be focused primarily on indicators which impact aquatic resources. Conversely, monitoring the impact of proposed development would require that a range of indicators be selected and may require that different scales (e.g., local, tributary and subwatershed) be used.

The primary focus of the monitoring program will be to evaluate the effectiveness of the proposed measures which are proposed to protect, enhance and restore the natural environmental resources. The reasons for this focus are as follows:

- The premise of the study was to use existing and approved land uses as a basis. As such, it is not known whether land use changes will occur, or the extent and location, should changes occur.
- An approach which involves defining environmental resources, outlining future study requirements and setting of environmental targets has been provided. This approach, together with what has been provided below, could be used as a basis for establishing a monitoring program should land use changes occur.

As stated in Section 10.4, it is recommended that an Environmental Monitoring Committee be established to initiate and oversee the proposed monitoring program. The committee would be comprised of municipal staff, MVCA staff and members of the public. It is recommended that the City act as the facilitator as they currently have in-house staff to oversee the program and much of the monitoring will be carried throughout the watershed. The following recommendations should be compared to the current City-wide monitoring program to identify any components that may not be covered by the City's program.

It is recommended that, where possible, volunteer groups, individual landowners or local residents participate in the monitoring program. This is consistent with the stewardship



approach as outlined in Section 10.6 and will be cost effective. Training of individuals or groups will be necessary to ensure reliability of the results.

The proposed monitoring components are outlined below. For the purpose of discussing monitoring each of the natural environmental resources, the following components have been used:

- surface water quantity (Section 10.9.2);
- groundwater (Section 10.9.3);
- surface water quality (Section 10.9.4);
- fluvial geomorphology (Section 10.9.5);
- terrestrial resources (Section 10.9.6); and
- aquatic resources (Section 10.9.7).

Environmental monitoring generally requires defining baseline conditions from which change or effectiveness can be monitored.

9.7.2 Surface Water Quantity

The monitoring of the water budget (e.g., peak flows, flow volumes and baseflows) is an integral component of the program as many items (e.g., flooding, erosion, aquatics, terrestrial and surface water/groundwater interactions) rely on accurate assessments of flows being attained.

There is currently only one flow gauge (located near Kinburn) which provides continuous flow results. It is recommended that flow monitoring at two additional sites be undertaken. Information would be used as input to establishing baseline conditions and monitoring effectiveness of various measures as they are undertaken.

Initially, monitoring could be undertaken at Richardson Side Road and downstream of the Village of Carp. Monitoring at these sites could also be used to help assess potential impacts associated with pending developments in the headwaters of these two tributaries.

The estimated cost to purchase two level recorders and one portable velocity meter (to establish stage/flow curves) is approximately \$10,000. Monitoring could be undertaken by agency staff.

9.7.3 Groundwater

The major components of a groundwater monitoring program (Groundwater Management Strategy, Element 5) include:

- regular water level monitoring in the pumping wells, observation wells and streambed piezometers;
- pumping volumes in all municipal and communal wells;
- water quality monitoring in pumping wells, selected observation wells and selected low flow baseflow grab samples;
- Detailed studies of groundwater recharge to aquifers tapped by communal and municipal wells to determine the influence of surface water (GUDI) and to refine the delineation of wellhead protection areas (WHPA); and
- spot flow baseflow measurements in select reaches.



Some of the components of this monitoring program may overlap with the finalized surface water quantity and surface water quality monitoring program.

A limited water level monitoring program could be developed utilizing streambed piezometers. This monitoring program should be developed, to a greater extent, in conjunction with and utilizing instrumentation incorporated in the Groundwater Management Plan. A regular streambed piezometer monitoring program is limited by the susceptibility of a streambed piezometer to be destroyed. The frequency of all water level measurements, as a minimum, should be seasonal.

Water quality samples are currently being obtained from the pumping wells and should continue. Water quality analyses should include as a minimum, inorganic species, metal species and nitrogen species.

The location of spot flow baseflow measurements should be done in conjunction with the Groundwater Management Plan but, in the current absence of the Plan, strategic locations coincide with reaches that show substantive baseflow. Spot baseflow measurements should be taken during a low flow period (eg. June - September), no less than 2-3 days subsequent to a precipitation event. An attempt should be made to gather all data within a 2-3 day window. These same reaches could be sampled for water quality (inorganic species, metals, nitrogen species) at the same time as the spot flow measurements.

9.7.4 Surface Water Quality

The existing City monitoring program is adequate to define water quality conditions (parameters and benthos). As such, additional monitoring efforts under existing conditions are not required. Monitoring protocol and assessment would be required should land use changes occur, or if infrastructure changes occurred. Efforts should be made to correlate water quality results with flow information.

9.7.5 Fluvial Geomorphology

Stream morphology is dependent on the ability of the stream to convey the water and sediment inputs from upland regions. Changes in water discharge, sediment discharge bed and bank material may cause adjustments of width, depth slope, velocity and planform.

Periodic sampling of stream morphology should be conducted to detect improvements in the stream stability and diversity at the current City monitoring stations. This program has been initiated by the City. At-a-station information should be collected at the five detailed survey stations used to establish baseline conditions for this study. The data collected through these surveys should include:

- the longitudinal profile;
- cross-sectional profiles;
- the planform; and
- particle size distribution of substrate.

Volunteer groups could provide additional information. Downstream trends and the nature of the remediation project upstream of the survey sites can be collected using a video camera by interest groups. The purpose of this video survey is to document localized impacts not detectable at the five detailed monitoring sites. Analysis of the video tapes would require a qualitative assessment of changes in stream morphology to document localized impacts/improvements and downstream trends.



More frequent monitoring is appropriate when specific works are undertaken such as stream restoration, riparian plantings and pond retrofits. Morphological changes can occur more quickly after such measures are imposed and should be monitored after the spring freshet for the first two years and fifth year after the project is completed. A detailed survey site should be established at the site of the remedial measures such that changes in the stream morphological diversity can be monitored. Video footage of the project site and areas upstream and downstream where impacts/improvements are anticipated. Sampling frequencies can be lengthened to five years if the rate of change decreases. This monitoring would be completed by the proponent of the works.

9.7.6 Terrestrial Resources

Before a monitoring program to assess the effectiveness of watershed plan recommendations can be undertaken, a systematic inventory of the smaller remnant features and the regenerating lands is required. This inventory would focus on a community level assessment and an accurate identification of the boundaries of existing features in order to prepare an accurate baseline. Since this inventory could not be completed without landowner permission, this would be one of the first steps in the stewardship program. Monitoring of the terrestrial system will focus on collecting and interpreting information at two scales: the watershed/subwatershed scale and the plot or property level scale. The frequency of this monitoring effort should be, on average, every five years. At the watershed/subwatershed scale, there is an opportunity to take advantage of remote sensing satellite imagery which is readily available on an annual basis. Although resolution varies, the imagery can differentiate between areas in the order of 30 m x 30 m or 0.09 ha. With limited groundtruthing, major vegetation types and different land uses can be differentiated.

This information can be used in a GIS system to provide the following information:

- the total area covered by natural vegetation and plantations;
- the size distribution of individual features, e.g., number of features <3 ha, 3 to 10 ha, 10 to 40 ha, >40 ha;
- the proportion of vegetation in major community types, e.g., wetland, upland broadleaf forest, mixed/coniferous forest; and
- the number of features with interior forest conditions, e.g., features with an area of at least 40 ha and an edge to area ratio of less than 5:1.

Other subwatershed scale information to be collected could include:

- number of lands revegetated;
- number of lands retired from agricultural use; and
- number of landowners participating in stewardship programs.

At the plot or property level, volunteers (including landowners) could be used to undertake simplified terrestrial inventories of a number of vegetation features representing different community types. Community types might include:

- an old field/meadow community;
- a non-treed wetland;
- a treed wetland;
- a bottomland/slope forest;
- an upland forest; and
- a forest with forest interior habitat (>40 ha).



On a five-year interval, a standardized transect in each community type would be walked in each season, and the characteristics/species of vegetation and wildlife would be recorded. Information to be recorded could include:

- species lists of vegetation and wildlife;
- size/distribution of unique vegetation;
- presence of forest interior species;
- age/succession stage of vegetation;
- vertical structure development, e.g., coverage by canopy/understorey/ground cover;
- condition of soil/litter layer poorly/well developed; and
- presence of specialized habitats/habitat diversity, e.g., dead trees for hole dwellers, brush piles/fallen logs, etc.

Representative photographs and audio recording could also be taken as a permanent record of each site inventory.

9.7.7 Aquatic Resources

Fish and aquatic invertebrates are a product of the environment in which they live. In other words, the health, abundance and diversity of aquatic life in a stream is influenced by a number of factors, namely:

- streamflow characteristics, particularly baseflow;
- water quality conditions, particularly oxygen and temperature;
- riparian vegetation;
- stream morphology and sediment regime (i.e., stability);
- in-stream habitat diversity; and
- biological interactions.

Periodic sampling of fish and aquatic invertebrates can serve as an inexpensive indicator of the condition of streams and provide information on what specific components of habitat may be limiting or degrading the stream environment. They serve equally well as an indicator of improvements in the stream environment. Benthic invertebrates, because they are unable to move out of an area (like fish), are often better indicators of water quality degradation. On the other hand, fish are an indicator of a larger portion of the stream environment because individuals use more stream area than benthic invertebrates. Fish also are at the top of the aquatic food chain and thus reflect any potential contaminants which may become toxic through bioaccumulation or pose a threat to human health.

Monitoring of streams can also be undertaken at a subwatershed and a tributary scale. The frequency of monitoring should be in the order of five years; however, more frequent monitoring is appropriate when specific works are undertaken such as stream restoration, riparian plantings and pond retrofits. This program has been incorporated into the City wide monitoring program.

At the subwatershed scale, monitoring could include:

- number of metres of stream restoration;
- number of metres of riparian plantings;
- number of metres of streamside fencing to control livestock; and
- number of on-line ponds retrofitted.



In addition, a subwatershed-wide fish and benthic invertebrate survey should also be undertaken on a five-year basis (this is consistent with the City's program). This could be a cooperative effort and employ several crews of summer students to undertake surveys in several subwatersheds.

On a tributary basis, volunteers could undertake simple surveys on representative reaches on five-year intervals. Representative reaches would be about 100 to 150 m in length, and the following information would be collected in each of three seasons:

- stream temperature (particularly summer maximum temperature);
- observations of fish spawning sites (particularly brook trout);
- estimates of streamflow (particularly low flow);
- stream width and depth;
- number of riffles and condition (particle size, presence of silt/algae/aquatic plants);
- average particle size of substrate (pebble count);
- percent stream shaded by trees/shrubs;
- percent of in-stream cover (large boulders, logs, undercut banks); and
- observations of fish and benthic invertebrates (use of dipnet or minnow seine).

Photographs could be taken at reference locations to illustrate changes in stream condition.

The location of the representative reaches should coincide with stream morphology monitoring sites.

9.8 Time Frame

Tables 9.1 and **9.2** provide a time frame for the various actions contained in the Recommended Plan. A time frame for the other implementation components is provided below:

Short Term

Following the approval of the study by City Council the first actions to implement the study are:

- Prepare and add the Plan of City Council Approved Watershed and Subwatershed Study areas to the Annexes of the OP (currently on-going).
- Integrate findings into the City's Greenspace Master Plan (currently on-going).
- Undertaking studies necessary to support future OP amendments, for example studies of Category 1 Areas to identify candidate Natural Environment Areas.
- Incorporate study findings and recommendations into other strategic planning documents, as appropriate.
- Distribute copies of the approved study to all municipal, provincial and federal approval agencies.
- Provide briefing sessions to City staff on the findings of the study and the applicability of the study when reviewing applications or undertaking activities in the watershed areas.
- Distribute copies of the approved study to municipal offices and libraries and publicize the study and its findings through the City of Ottawa's web site/ planning database.
- Apply the findings of the study through the development application approval process by requiring the related technical reports as set out in Sections 2.0 and 4.0 of the Official Plan.



- Consult with the Rural Clean Water Program and the Ottawa Stewardship Council to promote stewardship related components of the Recommended Plan.
- Set up the Implementation Committee and Stewardship Program.

Medium Term

In the medium term the study findings can be implemented and monitored in the following ways:

- Incorporate the floodplain mapping and watercourse corridor mapping into the new zoning by-law of the City of Ottawa, with the related provisions regarding permitted uses, minimum setbacks and provisions for the modified floodplain approach. This can also apply to wellhead protection areas and recharge areas.
- Integrate the Environmental Monitoring Plan into existing City and Conservation Authority monitoring programs.
- Review and monitor the application of the study in the development approval process using environmental indicators.
- Implement medium term projects such as the recreation path and scenic route signage and interpretation area.
- Drafting amendments to the Official Plan, as appropriate, and complete the OPA process.
- Land acquisition by the City and/or a nature conservancy for protection and conservation of important material areas.

Long Term

In the long term the study can be implemented and updated in tandem with the required review of the City Official Plan. Other long term actions could include:

- Measure environmental change through execution of the Environmental Monitoring Plan.
- Continue to provide educational information and opportunities to promote environmental stewardship in the watershed.
- Implement and monitor stewardship activities promoted in the Watershed Plan.
- Development of separate recreational pathways from the road system and expansion of signage, interpretation and cultural heritage resource designations.



10.0 STUDY REQUIREMENTS AND DEVELOPMENT APPROVAL PROCESS

10.1 General

This section will discuss the study requirements and approval process should land use changes be proposed within the watershed. In the rural area, Subwatershed Plans may be required in the future for large development proposals involving multiple owners for urbanizing areas. This would be anticipated for large village type development. General requirements for subwatershed plans are addressed in the Official Plan in Section 2.4.3.

In the urban area, technical environmental studies will be completed for the Kanata West development on a catchment area basis (with the exception of the AUTOPARK lands where approval has already been received). The first developer to come forward with an application within a specific drainage area will be responsible for addressing the environmental issues represented within the catchment area. This will require cooperation and coordination with other landowners. These studies will generally be carried out concurrently with other studies which are necessary at this stage in the land use process, e.g., land use planning studies, parks and open space, transportation, and servicing studies. For all other lands, individual technical studies triggered through the development review process will be required. The types of technical studies that may be required to support a development proposal include:

- Hydrogeological and Terrain Analysis
- Integrated Environmental Review
- Environmental Impact Statement
- Stormwater Site Management Plans (conceptual and detailed)
- Groundwater Impact Assessment
- Tree Preservation and Protection Plan

The Carp River Watershed/Subwatershed Plan will be used as a guiding document in preparing these technical studies. The **Integrated Environmental Review Statement** (IER, Policy 4.7.1) will clearly demonstrate how the development has incorporated the watershed/subwatershed recommendations through the various technical studies. Overall the various technical studies need to include the following key deliverables:

- protection plan based on field assessments, as necessary, identifying and defining the features, functions, and linkages areas;
- a protection/restoration/enhancement strategy for the protection areas;
- location, sizing and preliminary design of all Best Management Practices;
- integration of the study findings and recommendations with other technical studies (e.g., stormwater management, aquatic, geomorphology, groundwater) as well as other planning studies that may be carried out concurrently (transportation, servicing); and
- framework for the compatible integration of land use, recreational and environmental requirements.

10.2 Technical Study Requirements For Development

The purpose of this section is to provide direction on future study requirements should land use changes be proposed. Outlined below is the general study requirements for each natural environment component that may be required as part an individual technical study. Each component may not necessarily be required for each tributary or development application depending on the existing site characteristics and scale of development. For



each component, the trigger mechanism, policy requirement and links to other technical studies are provided.

10.2.1 Surface Water Resources

Trigger:	Development applications involving drainage/stormwater management
Requirement	Stormwater Management System at tributary scale (Policy 2.4.3.11), Stormwater Site Management Plan (OP Policy 4.7.6) at subdivision/site scale
Study Links	Groundwater Impact Assessment, Stream Morphology, Aquatic Resources

The intent of this component is to complete the necessary hydrologic and hydraulic analyses, and conceptual and functional design of surface water management facilities on a tributary basis. The goal of this study is to define existing conditions, the potential impacts of land use change, and requirements for the management of the surface water resource to meet the goals, objectives and specific targets set for each tributary. Management of surface waters resources includes requirements for defining restricted land use areas or defined by flood plains, channel erosion/natural stream stability requirements, base flow and surface water quality. Presented below is a general description of the scope of work and deliverables to be completed by the study.

The scope of work and deliverables of the surface water resource study may include, but is not limited to the following:

- Calculation of peak flow rates under existing and future land uses conditions for the purpose of defining the existing Regulatory Storm flood plain, where suitable mapping is not available, and to determine the potential impacts of land use change on existing flood elevations.
- Preparation of approved flood plain mapping to identify development restrictions and requirements as defined by MVCA's flood plain policies. This would be required only for those tributaries and locations where suitable flood plain mapping is not currently available (ie. Feedmill Creek)
- The proposed approach to flood flow and erosion control, and the location and size of proposed flow control storage facilities to maintain existing peak flow conditions on a tributary and subwatershed basis.
- The proposed surface water management strategy for maintaining the existing surface water budget, baseflow conditions and surface water quality. This would include proposed site planning and design considerations, and locations and preliminary sizing of proposed stormwater management BMPs including source controls, conveyance systems and end of pipe facilities. Preliminary sizing of facilities should include retention (permanent pool) and detention/extended detention storage volumes to be used for infiltration, wetpond, wetland or other stormwater BMP facilities.
- The proposed approach for integrating surface water management facilities required for flood control, baseflow and water budget management, quality control and erosion control/channel stability management.



• The proposed approach for integrating the tributary surface water management strategy with other proposed works and environmental management components for the tributary and subwatershed.

10.2.2 Groundwater Resources

Trigger:	Development applications generally involving headwater areas, recharge/discharge areas, infiltration targets, baseflow contribution, stormwater management BMPs
Requirement	Groundwater Impact Assessment (OP Policy 4.7.5) at tributary or subdivsion/site scale
Study Links	Surface Water Analysis, Rural Servicing/Terrain Analysis, Aquatic Resources

As previously discussed in Chapter 8, a more detailed groundwater characterization of the recharge and discharge areas, and the linkage between them has to be carried out on the tributary and reach scale to assess potential impacts and assign appropriate BMPs for future land use changes.

The major purpose of the future studies would be to quantify in more detail, within the tributary catchment or subcatchment area, the following:

- (1) Groundwater recharge and infiltration capacity of soils;
- (2) Groundwater gradients and flow patterns;
- (3) Groundwater discharge to quantify and preserve baseflow contribution; and,
- (4) The water balance and target infiltration values.

The recharge component is the most significant hydrogeological function within the subwatershed when land use changes are assessed that do not include groundwater withdrawal. The groundwater flow system and its linkages will be maintained by preserving and (where feasible) enhancing the quality and quantity of infiltrating water.

A range of recharge values related to surficial geology / soil type was presented in Chapter 9. This range was used to provide a general subwatershed groundwater budget. Groundwater budget assessments would be carried out in more detail on the tributary catchment or subcatchment scale, utilizing a more detailed assessment of the areal distribution of surficial geology, soil type, vegetation, landform and depth to bedrock. As such, it must be recognized that the recharge values derived earlier illustrate the method and are not meant to be absolute targets.

The assessment of infiltration potential combined with the more detailed investigations of the groundwater flow system (eg locating local groundwater divides, perched water tables, fractured bedrock) will provide significant input into the type and location of stormwater BMPs. The identification of groundwater flow patterns will require combined geotechnical and hydrogeological investigations (e.g., boreholes, installation of monitor and observation wells, streambed and bank piezometers, pump tests, seasonal monitoring, streamflow measurements).

Such studies must include an assessment of infiltration potential, seasonal water level fluctuations and water quality, in order to assess potential impacts from stormwater infiltration facilities or septic systems on sensitive receptors.



Baseflow Contribution

A more detailed assessment of baseflow contribution is a necessary component to a full understanding of the tributary and reach groundwater flow system, particularly from the linkage perspective. This linkage is very significant for impact assessment in dealing with groundwater withdrawals and (to a lesser extent) for stormwater infiltration.

The baseflow component should include but not be limited to the following assessment:

- Detailed spot streamflow measurements representing baseflow, on 50 metre reaches to indicate localized contributions and identification of upwellings;
- Streambed temperature survey and spawning survey to assess potential upwellings; and,
- Installation of streambed piezometers to obtain water levels and vertical hydraulic gradients in areas of upwellings.

Headwater Tributary Assessment

When development is proposed on lands within headwaters, the conveyance of flows may be dealt with as a function of subdivision design without necessarily maintaining a natural channel. The natural channel should be maintained if it has any of the following characteristics:

- a continuous baseflow;
- a source of food production for aquatic resources;
- a well-defined valley;
- native woody or wetland vegetation; or
- fish spawning/nursery habitat (Level 1).

A site inventory of each drainage feature should be completed to identify whether the feature should be maintained, based on the above criteria, or allowed to be incorporated into development plans. In either case, the functions of the feature in contributing to the quality and quantity of downstream reaches will be maintained/enhanced/restored. Guidance for the protection of these features is also provided through the regional groundwater study and will also be part of the recent requirements for Source Protection Plans under the Safe Drinking Water Act (See Section 8.2.2 Groundwater Management).

10.2.3 Terrestrial Resources

Trigger:	Category 1 and 2 Areas, some of which include Urban Natural Features, Rural Natural Features, Natural Environment Areas (NEA) and Significant Wetlands/ Adjacent Lands to NEA, Significant Wetlands and Urban Natural Features
Requirement	Environmental Impact Statement (OP Policy 4.7.8), Integrated Environmental Review
Study Links	Aquatic Resources, SWM Best Management Practices, Groundwater Impact Assessment



An Environmental Impact Statement framework will be used to assess terrestrial resouces within the catchment area or site. The Environmental Impact Statement (EIS) will describe the physical form and function of the ecological features of the area, any functional relationships to adjacent Category 1 areas, and demonstrate how the proposed development will maintain or compensate for the area's existing ecological/hydrological functions. The EIS should include but not limited to:

- a description and rationale for the development proposal showing building envelopes, property boundaries, open spaces and utility corridors;
- maps illustrating the existing environmental features/communities within and adjacent to the study area, landownership, land use zoning and existing/approved landownership;
- Inventory of breeding birds, herpetiles and other wildlife;
- a description of the physical form (species, size, state of maturity) and ecological/hydrological function of the area's environmental features,
- a summary of the features/functions which may be affected by the development proposal in/adjacent to the area or downstream;
- a description of any development alternatives which would offset any impacts by maintaining/ enhancing/restoring the area's hydrological/ecological function;
- a comparative evalution of management alternatives based on environment merits, of each alternative, leading to a preferred alternative; and
- a summary of the expected impacts, recommended mitigative measures and suggested environmental monitoring.

The recommended plan identifies the need to prepare naturalization plans for Category 1 areas and areas targeted for stewardship plans (Riparian corridors and portions of Centres of Ecological Significance, in part). These naturalization plans represent a revegetation and natural area management plan for each ecological unit, which could be implemented on a property-by-property basis. A naturalization plan should include the following:

- a detailed inventory and map of existing natural features showing vegetation communities present, areas which are naturally regenerating, areas which are disturbed by existing land uses, forest management, agriculture or invasion of nonnative species;
- a map showing soil types, general terrain/topographic characteristics, drainage features, floodplains;
- a list of native species common to each vegetation community; and
- a vegetation management plan identifying areas to be replanted and appropriate species, areas which should be allowed to revegetate naturally, and areas which may require special actions in order to accomplish the following:
- maintain habitat for a unique species,
- remove/reduce non-native species, and
- encourage natural processes to be self-sustaining.

10.2.4 Aquatic Resources

Trigger:	Development application that includes/drains to streams
Requirement	Policy 4.7.3, Integrate into EIS or IER
Study Links	Terrestrial Resources, SWM Best Management Practices, Groundwater Impact Assessment, Stream Morphology



Delineation of Stream/Riparian Corridors

The stream setback requirements are specified in Section 8.4.2 for tributaries in the subwatershed area. The corridor setback requirements for streams in the rural watershed area require further examination. Currently agricultural land use activities such as pasturing livestock, crop production, application of fertilizers and manure spreading; are permitted uses within areas generally designated as stream/riparian corridors. Through stewardship efforts and under the Nutrient Management Act, efforts are being made to encourage farmers to implement measures within stream corridors to reduce impacts on the stream riparian area and on the stream channel. These measures include the following:

- restrictions on application of fertilizers and manure spreading near watercourses
- planting of buffer strips of native materials or a hay crop adjacent to watercourse
- fencing of livestock out of watercourse and adjacent riparian areas
- use of conservation tillage practices to reduce soil and nutrient losses and loading to watercourses
- use of structural and non-structural BMP's to address point sources of nutrient loading to watercourses

When agricultural lands are the subject of a rural development application, including a severence, an EIS should be undertaken to delineate the stream/riparian corridor. The following functions need to defined and delineated in order to establish an appropriate setback limit:

- Regulatory floodplain (if available);
- Meander belt width (determined through the stream morphology study);
- Riparian vegetation (extent and condition)
- Aquatic habitat conditions
- Fish community type (eg warm or cold water)
- Stable slope lines
- Terrestrial features and linkages

The stream/riparian corridor delineation should be incorporated into the EIS.

Stream Rehabilitation/Restoration

There are two general types of studies necessary for designated streams:

- the development of natural channel designs to restore stream stability as discussed in Section 10.5.2.5, and
- revegetation plans within the riparian zone along each streambank.

For the purposes of stream protection and habitat enhancement, the riparian zone should consist of about 50% woody species (trees and shrubs) to provide stream shading, a local cool microclimate, intercept precipitation and create wildlife habitat. The canopy created should be partly open, allowing a groundcover of grasses and forbes to develop which intercepts sediment in runoff and contributes terrestrial vegetation and insects to the stream. Where conditions (soil type and moisture) are suitable, species typical of coniferous or broadleaved swamps may also be suitable for planting. Creating a species mix with at least 50% woody species also will provide a supply of woody debris to the stream, an important fish habitat element.

Restoration work would typically be funded and completed by landowners as part of the development approval process.



The riparian corridor restoration target for the Carp River and its tributaries is as follows (except where wider corridors have been identified as part of the subwatershed study):

- Type 1 fish community: 30 metre setback on each side of the watercourse; revegetating up to 75% of the total stream length with native, woody, riparian vegetation(representing 50% of the replanted area)
- Type 2 and 3 fish community: 15 metre setback on each side of the watercourse; revegating up to 50% of the total stream length with native, woody, riparian vegetation (representing 50% of the replanted area)
- All other streams, including intermittent watercourses: 15 metre setback on each side of the watercourse; revegetating up to 50% of the total stream length with native, woody, riparian vegetation (representing 50% of the replanted area)

This study component would further define the stream features on site.

10.2.5 Stream and Valley Morphology Study

Trigger:	Development application that includes/drains to streams
Requirement	Official Plan Policy 4.7.3,
Study Links	Surface Water Resource Analysis, Aquatic Resources, Terrestrial Resources

The intent of this study component is complete the necessary investigations and analyses required to define development restrictions and measures required to maintain stable, natural channel systems and to protect properties from natural stream and valley erosion processes in areas where land use changes are proposed. In areas where land use changes have already occurred and stream stabilization works are recommended these studies may not require identification of development restrictions.

With respect to the stream corridors, the goal is to maintain, and in some locations restore and enhance, channel systems to either their existing or previous state of natural channel stability. With respect to valley systems, the goal is to restrict development to acceptable limits for the protection of private and public properties from the natural erosion of valley slopes and migration of channel systems.

Management requirements may include the definition of the top of bank (between valley and tableland), set backs or buffers from the top of bank, fill limits, floodplain widths, set-backs required for maintaining sufficient meander belt width allowances and channel migration in undefined valley systems, BMPs required to maintain channel stability, and the possible need for instream works.

The scope of work and deliverables of the steam morphology and valley studies may include but are not limited to the following:

- Completion of a supplementary geomorphic field survey which builds upon the base line information obtained in the Carp Watershed study. This includes assessments of both the channel and valley systems.
- Determination of the critical geomorphic threshold or the ability of a channel to absorb or resist change.


- Determination of the valley and stream corridor boundaries for defined and undefined valley systems, to maintain the dynamics of naturally stable streams and to protect against the natural erosion/widening of valleys. A method for determining Meander Belt corridor allowances is provided in Prent and Parish 2000.
- Selection of possible retention and/or detention BMP techniques to control channel stability to erosion targets, field surveys and technical analyses of the critical geomorphic threshold.
- Preliminary design of proposed instream works.

Subwatershed Planning Area

The subwatershed study involved a detailed morphologic assessment of the stream systems together will recommendations as to which reaches need to be restored. Appendix B presents the findings from the geomorphic assessments.

The intent of this component would be to undertake the conceptual and functional design of the stream reaches in the upper parts of Feedmill and Poole Creeks that need to be restored.

Appendix B provides a number of hydrologic and geomorphic parameters that were established for existing conditions. Further hydrologic information is provided from QUALHYMO model. The aquatic resources section above provided a variety of habitat targets that are appropriate for the target aquatic species. Lastly, **Figure 9.5** defines the target type of stream reach to be constructed. The alternatives include: riverine, wetland, natural channel design and Geomorphic Channels.

A description of each type of restoration is given in Section 8.3.1.2 of the report and provided below.

Riverine Wetland Restoration

The objective is to re-establish riparian wetland conditions in these reaches. Measures to be undertaken will include:

- Modification of the stream cross section and plan form to create a linear riparian wetland feature, interspersed with deeper pools to provide refuge habitat for fish.
- Creation of a meandering "U" shaped low flow channel, interspersed with drowned riffle structures to encourage sediment transport and inhibit plant growth in a portion of the channel.

For the Carp River together with the mouths of Feedmill and Poole Creeks which are impacted by sediment from Carp River, an Environmental Assessment lead by City staff followed by Functional Design of the Corridor Restoration Plan is proposed.

• Geomorphic Referenced River Engineering (GREE) Restoration

GREE restoration is proposed where physical limitations exclude the use of natural channel design approach. GREE employees geomorphic principles to design a stable channel configuration complete with pools and riffles so that the channel looks and functions like a natural, meandering pool-riffle system. However, the channel plan form is fixed in place so that the meanders cannot move. The result is a stable, natural looking and functioning



channel that cannot erode its bed or banks and therefore does not provide a risk to riparian structures, pipelines or adjacent lands.

Natural Channel Design Restoration

Natural Channel Design uses the natural morphologic characteristics of the existing stream reach or those of a non-impacted reference stream, combined with the expected hydrologic and sediment regime to re-establish a naturally functioning system. In the case of these reaches, the natural channel exhibits pool: riffle morphology and a meandering pattern, interspersed with some shallow bedrock and wetland features. The existing channel, riparian and floodplain components are not restricted by adjacent land uses such that the channel has room to naturally evolve within its floodplain and can accommodate the changes in hydrology and sediment loading from the proposed land use changes (with appropriate runoff controls).

At the EMP stage for reaches of Poole and Feedmill Creek which are not directly impacted by Carp River, a conceptual and functional design of the stream reaches to be restored will have to be undertaken. Completion of this work will require a team of specialists including a geomorphologist, biologist and engineer.

Several documents may be utilized for undertaking conceptual and functional design of degraded streams systems. These include: Ministry of Natural Resources Planning and Natural Channel Design Manual as well as the Ministry of Environment Stormwater Management Planning and Design Manual.

10.3 Fact Sheets

Fact sheets have been prepared on a tributary or catchment area basis for the subwatershed planning area as well as the Huntley Creek and Corkery Creek in the rural area. The fact sheets provides a summary of the recommended measures to be implemented within the applicable catchment area as described in Chapters 8 and 9 of the report. These Fact Sheets will assist in the preparation of individual technical studies at a tributary or site-specific scale that are required as part of the development review process.

Each Fact Sheet provides direction for completing the various technical studies under the following headings:

- **Environmental Priorities**: a description of the key items or issues that need to be addressed:
- **Existing Resources**: an outline of the current environmental conditions within the catchment area.
- Targets: a summary of the stormwater management and environmental management targets that have been established for the catchment area;
- **Studies**: a list of the studies that need to be completed at the subsequent, more detailed planning stage; the studies may include EMP's Environmental Impact Studies, Environmental Assessments or Functional Design of Restoration Works For the Kanata West Planning Area, fact sheets have been prepared on the basis of the following 2 generalized stormwater management plans:
 - Scenario1: the general arrangement of facilities presented in the Kanata West Servicing Study (Stantec 2002);
 - Scenario 2: an alternate arrangement of facilities that preserves the natural drainage patterns within the planning area as much as possible.



The drainage areas for each of these options are shown on Figures 8.6 and 8.7. These drainage area boundaries will also be overlain on the recommended subwatershed plan map (Map 8.5) that shows the location of key measures and features to be protected.

Also presented is a Fact Sheet for two large urban development areas located outside the Kanata West Planning Area in Stittsville (Area F5) and the Special Study Area in Kanata Lakes (Area C4). For these two areas only, one scenario has been presented.

10.3.1 Environmental Fact Sheets – Option 1

ENVIRONMENTAL FACT SHEET – OPTION 1 - AREA F5 Total Area – 268 ha

ENVIRONMENTAL PRIORITIES

- Protection of stable reaches and restoration of degraded reaches along Feedmill Creek
- Establishment of environmental corridor along Feedmill Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Undertake floodplain mapping for Feedmill Creek
- Implementation of water quantity controls
- Protection of wetland and undertake Site EIS
- Protection of groundwater discharge areas and flow patterns

EXISTING RESOURCES

Aquatic Resources

- tolerant coldwater fishery
- >60% of corridor length is naturally vegetated

Groundwater Resources

- 97 ha of high recharge area
- 129 ha of moderate recharge area
- 42 ha of low recharge area
- significant contribution to baseflow provided by quarry operation located upstream of subject area

Terrestrial Resources

- Category 1 areas 146 ha comprised of stream corridors, wetlands and high/moderate NESS
- Category 2 areas 202 ha of low NESS

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Feedmill

100% of stream length is channelized



TARGETS

Groundwater Resources

- 262 mm/yr infiltration for high recharge areas
- 104 mm/yr infiltration for moderate recharge areas
- 73 mm/yr infiltration for low recharge areas
- maintain groundwater discharge to Feedmill Creek

Surface Water Resources

- Enhanced (80% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- area F5 requires 2 through 100 year post to pre control for flooding and 30% DRC control for erosion

Stream Morphology

 Restoration of 1100 m of stream using natural channel design principles (see Appendix B for baseline conditions)

Aquatic Resources

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.1 for representative species and Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

 Protect Category 1 features located within Feedmill Creek Corridor and tableland woodlands/wetlands

Corridors

Provide a minimum 60 m corridor along Feedmill Creek.

- Restoration Plan and delineation of creek corridor widths for Feedmill Creek
- Floodplain mapping for Feedmill Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Groundwater study to identify flow patterns, recharge discharge characteristics/linkages
- Preparation of Site EIS Report in Category 1 and 2 areas
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET – OPTION 1 - AREA C4 Total Area – 266 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River
- Maintenance of infiltration rates .
- . Implementation of water quality controls
- Enhancement of baseflows
- Update Carp floodplain mapping
- Complete Site EIS for Category 1 and 2 lands

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated

Groundwater Resources

- 7 ha of medium recharge area
- 259 ha of low recharge area

Terrestrial Resources

- Category 1 areas 51 ha comprised of Carp River corridor, parts of Trillium Woods
- Category 2 areas 91 ha Low NESS areas .

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 104 mm/yr infiltration for moderate recharge areas
- 73 mm/yr infiltration for low recharge areas

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control .
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Restoration of 1000 m of Carp River as riverine wetland (see Appendix B for baseline conditions)

Aquatic Resources

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see **Table 9.2.2** for specific targets)
- Maximum stream temperature = 30 C .
 - Minimum Dissolved Oxygen = 4 mg/l



Terrestrial Resources

Protect/restore Category 1 features located within Carp Creek Corridor

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Site EIS for Category 1 areas
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET- OPTION 1- AREA 1 Total Area – 183 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Feedmill Creek
- Protection of stable reaches and restoration of degraded reaches along Feedmill Creek
- Establishment of environmental corridor along Feedmill Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Undertake floodplain mapping for Feedmill Creek and updating of Carp floodplain mapping

EXISTING RESOURCES Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Feedmill

- Feedmill tolerant coldwater fishery
- 60% of corridor length is naturally vegetated

Groundwater Resources

- 30 ha of moderate recharge area
- 153 ha of low recharge area
- significant contribution to baseflow provided by quarry operation located upstream of subject area

Terrestrial Resources

• Category 1 areas – 16.05 ha comprised of Feedmill Creek and Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Feedmill

- 30% of stream length is stable
- 50% of stream length is degraded
- 20% of mouth reach is impacted by sediment build up from Carp River

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas



Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Carp/Feedmill

 Restoration of 1000 m of Carp River as riverine wetland and restoration of 300 m of lower Feedmill Creek to riverine wetland (see Appendix B for baseline conditions)

Feedmill

 Restoration of 700 m of stream using natural channel design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Feedmill

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

Protect Category 1 features located within Feedmill Creek Corridor

Corridors

Provide a minimum 80 m corridor along Feedmill Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Feedmill Creek
- Restoration Plan and delineation of creek corridor widths for Feedmill Creek
- Floodplain mapping for Feedmill Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 1- AREA 2 Total Area – 36.8 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Feedmill Creek
- Protection of stable reaches and restoration of degraded reaches along Feedmill Creek
- Establishment of environmental corridor along Feedmill Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Undertake floodplain mapping for Feedmill Creek and updating of Carp floodplain mapping

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Feedmill

- Feedmill tolerant coldwater fishery
- 60% of corridor length is naturally vegetated

Groundwater Resources

- 36.8 ha of low recharge area
- significant contribution to baseflow provided by quarry operation located upstream of subject area

Terrestrial Resources

Category 1 areas – 4.21 ha comprised of Feedmill Creek and Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Feedmill

- 30% of stream length is stable
- 50% of stream length is degraded
- 20% of mouth reach is impacted by sediment build up from Carp River

Carp

100% of stream length is degraded from sediment build up and overwidening



TARGETS

Groundwater Resources

73 mm/yr infiltration for low recharge areas

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Carp/Feedmill

 Restoration of 200 m of Carp River as riverine wetland and restoration of 300 m of lower Feedmill Creek to riverine wetland (see Appendix B for baseline conditions)

Feedmill

 Restoration of 700 m of stream using natural channel design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Feedmill

- Maintain Tolerant Coldwater Fish Community Type 1(see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

Protect Category 1 features located within Feedmill Creek Corridor

Corridors

Provide a minimum 80 m corridor along Feedmill Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Feedmill Creek
- Restoration Plan and delineation of creek corridor widths for Feedmill Creek
- Floodplain mapping for Feedmill Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 1 - AREA 3 Total Area – 37.6 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Update Carp floodplain mapping

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Groundwater Resources

- 4.6 ha of medium recharge area
- 32.6 ha of low recharge area

Terrestrial Resources

Category 1 areas – 8.87 ha comprised of Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Restoration of 100 m of Carp River as riverine wetland (see Appendix B for baseline conditions)

Aquatic Resources

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Terrestrial Resources

Protect/restore Category 1 features located within Carp Creek Corridor



- Environmental Assessment and Functional Design Corridor restoration plan for Carp River
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 1- AREA 4 Total Area – 358 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Poole Creek
- Protection of stable reaches and restoration of degraded reaches along Poole Creek
- Establishment of environmental corridor along Poole Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Update floodplain mapping for Poole Creek and Carp River
- Protection of discharge to Poole Creek
- Findings from AutoPark Stormwater Management Study to be incorporated into EMP
- Existing development adjacent to Highway 417 to be taken into consideration in EMP

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Poole

- tolerant coldwater fishery
- 40% of corridor length is naturally vegetated

Groundwater Resources

- 1 ha of high recharge area
- 135 ha of moderate recharge area
- 224 ha of low recharge area
- groundwater discharge along upper creek

Terrestrial Resources

 Category 1 areas – 16.4 ha comprised of Poole Creek, Carp River corridor and tableland woodland (Pine Grove/Hemlock)

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Poole

- 50% of stream length is degraded
- 50% of mouth reach is impacted by sediment build up from Carp River

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 262 mm/yr infiltration for high recharge areas
- 104 mm/yr infiltration for moderate recharge areas



- 73 mm/yr infiltration for low recharge areas
- maintain groundwater discharge and flow patterns to Poole Creek

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Carp/Poole

 Restoration of 600 m of Carp River as riverine wetland and restoration of 500 m of lower Poole Creek to riverine wetland (see Appendix B for baseline conditions)

Poole

 Restoration of 500 m of stream using natural channel design and Geomorphic Engineered design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Poole

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terre strial Resources

 Protect Category 1 features located within Poole Creek Corridor and tableland woodlands (Pine Grove and Hemlock)

Corridors

Provide a minimum 90 m corridor along Poole Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Poole Creek
- Restoration Plan and delineation of creek corridor widths for Poole Creek
- Updated floodplain mapping for Poole Creek and Carp River
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Groundwater study to identify flow patterns, recharge discharge characteristics/linkages
- Preparation of Site EIS for Pine Grove and Hemlock
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 1 - AREA 5 Total Area – 90.7 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Poole Creek
- Protection of stable reaches and restoration of degraded reaches along Poole Creek
- Establishment of environmental corridor along Poole Creek and Hazeldean Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Update floodplain mapping for Poole Creek and Carp River

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Poole

- tolerant coldwater fishery
- 40% of corridor length is naturally vegetated

Hazeldean

conveyance of flows to support downstream fishery in Carp River

Groundwater Resources

- 90.7 ha of low recharge area
- groundwater discharge along upper creek

Terrestrial Resources

 Category 1 areas – 13.7 ha comprised of Poole Creek, Hazeldean Creek and Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Poole

- 50% of stream length is degraded
- 50% of mouth reach is impacted by sediment build up from Carp River

Hazeldean

100% of stream length is degraded

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- maintain groundwater discharge to Poole Creek



Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Carp/Poole

 Restoration of 600 m of Carp River as riverine wetland and restoration of 500 m of lower Poole Creek to riverine wetland (see Appendix B for baseline conditions)

Poole

 Restoration of 500 m of stream using natural channel design and Geomorphic Engineered design principles (see Appendix B for baseline conditions)

Hazeldean

Restoration of 600 m of stream using natural channel design principles

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Poole

- Maintain Tolerant Coldwater Fish Community Type 1(see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

 Protect Category 1 features located within Poole Creek Corridor and tableland woodlands (Pine Grove and Hemlock)

Corridors

Provide a minimum 90 m corridor along Poole Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Poole Creek
- Restoration Plan and delineation of creek corridor widths for Poole Creek
- Floodplain mapping for Poole Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Groundwater study to identify flow patterns, recharge discharge characteristics/linkages
- Development of an Environmental Monitoring Plan



10.3.2 Environmental Fact Sheets – Option 2

ENVIRONMENTAL FACT SHEET - OPTION 2 - AREAS F1, F2, F3 Total Area – 37.5, 98.4, 60.6 ha respectively

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Feedmill Creek
- Protection of stable reaches and restoration of degraded reaches along Feedmill Creek
- Establishment of environmental corridor along Feedmill Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Implementation of water quantity controls in Feedmill Creek
- Enhancement of baseflows
- Undertake floodplain mapping for Feedmill Creek and updating of Carp floodplain mapping
- Findings of AutoPark Stormwater management Study to be incorporated into EMP for Area F3
- Potential diversion of Area F3/P3/C3 to be taken into consideration

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Feedmill

- Feedmill tolerant coldwater fishery
- 60% of corridor length is naturally vegetated

Groundwater Resources

- 0.1 ha of high recharge area
- 70.1 ha of moderate recharge area
- 126 ha of low recharge area
- significant contribution to baseflow provided by quarry operation located upstream of subject area

Terrestrial Resources

Category 1 areas – 15.2 ha comprised of Feedmill Creek and Carp River corridor

Surface Water Resources

- •
- Applicant to confirm pre and post development flows based on acceptable modelling
- •

Stream Morphology

Feedmill

- 30% of stream length is stable
- 50% of stream length is degraded
- 20% of mouth reach is impacted by sediment build up from Carp River



Carp

.

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas
- 262 mm/yr infiltration for high recharge areas
- protect groundwater discharge areas along upper Feedmill Creek

Surface Water Resources

Carp

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Feedmill

- Enhanced (80% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- areas F2 and F3 require 2 through 100 year post to pre control for flooding and 30% DRC control for erosion
- area F1 requires water quality control only

Stream Morphology

Carp/Feedmill

 Restoration of 100 m of Carp River as riverine wetland and restoration of 300 m of lower Feedmill Creek to riverine wetland (see Appendix B for baseline conditions)

Feedmill

 Restoration of 700 m of stream using natural channel design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Feedmill

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

Protect Category 1 features located within Feedmill Creek Corridor



Corridors

Provide a minimum 70 m corridor along Feedmill Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Feedmill Creek
- Restoration Plan and delineation of creek corridor widths for Feedmill Creek
- Floodplain mapping for Feedmill Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 2 - AREAS C1 Total Area – 84.5 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Feedmill Creek
- Restoration of degraded reaches along Feedmill Creek
- Establishment of environmental corridor along Feedmill Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Undertake floodplain mapping for Feedmill Creek and updating of Carp floodplain mapping

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Feedmill

- Feedmill tolerant coldwater fishery
- 60% of corridor length is naturally vegetated

Groundwater Resources

- 86.4 ha of low recharge area
- significant contribution to baseflow provided by quarry operation located upstream of subject area

Terrestrial Resources

Category 1 areas – 10.6 ha comprised of Feedmill Creek and Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Feedmill

- 50% of stream length is degraded
- 50% of mouth reach is impacted by sediment build up from Carp River

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

73 mm/yr infiltration for low recharge areas



Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Carp/Feedmill

 Restoration of 900 m of Carp River as riverine wetland and restoration of 300 m of lower Feedmill Creek to riverine wetland (see Appendix B for baseline conditions)

Feedmill

 Restoration of 400 m of stream using natural channel design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Feedmill

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

Protect Category 1 features located within Feedmill Creek Corridor

Corridors

Provide a minimum 70 m corridor along Feedmill Creek (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Feedmill Creek
- Restoration Plan and delineation of creek corridor widths for Feedmill Creek
- Floodplain mapping for Feedmill Creek
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 2 - AREA C2 Total Area – 37.6 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Update Carp floodplain mapping

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Groundwater Resources

- 4.6 ha of medium recharge area
- 32.6 ha of low recharge area

Terrestrial Resources

Category 1 areas – 8.87 ha comprised of Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Stream Morphology

Restoration of 100 m of Carp River as riverine wetland (see Appendix B for baseline conditions)

Aquatic Resources

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l



Terrestrial Resources

Protect/restore Category 1 features located within Carp Creek Corridor

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 2 - AREAS P1, P2, P3 Total Area – 78.9, 59.1, 125.8 ha, respectively

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River and mouth of Poole Creek
- Protection of stable reaches and restoration of degraded reaches along Poole Creek
- Establishment of environmental corridor along Poole Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Update floodplain mapping for Poole Creek and Carp River
- Potential diversion of Area F3/P3/C3 to be taken into consideration

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Poole

- tolerant coldwater fishery
- 40% of corridor length is naturally vegetated

Groundwater Resources

- 72.26 ha of moderate recharge area
- 191.5 ha of low recharge area
- groundwater discharge along upper creek

Terrestrial Resources

 Category 1 areas – 23.9 ha comprised of Poole Creek, Carp River corridor and tableland woodland (Pine Grove/Hemlock)

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

STREAM MORPHOLOGY

Poole

- 50% of stream length is degraded
- 50% of mouth reach is impacted by sediment build up from Carp River

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

- 104 mm/yr infiltration for moderate recharge areas
- 73 mm/yr infiltration for low recharge areas
- maintain groundwater discharge to Poole Creek



Surface Water Resources

Carp

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required

Poole

- Enhanced (80% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- area P3 requires 2 through 100 year post to pre control for flooding and 30% DRC control for erosion
- areas P1 and P2 require water quality control only

Stream Morphology

Carp/Poole

 Restoration of 600 m of Carp River as riverine wetland and restoration of 500 m of lower Poole Creek to riverine wetland (see Appendix B for baseline conditions)

Poole

 Restoration of 500 m of stream using natural channel design and Geomorphic Engineered design principles (see Appendix B for baseline conditions)

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Poole

- Maintain Tolerant Coldwater Fish Community Type 1 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

 Protect Category 1 features located within Poole Creek Corridor and tableland woodlands (Pine Grove and Hemlock)

Corridors

Provide a minimum 90 m corridor along Poole Creek (see Section 9.4.2)



- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and mouth of Poole Creek
- Restoration Plan and delineation of creek corridor widths for Poole Creek
- Floodplain mapping for Poole Creek
- Site EIS for area P3 for protection of Pine Grove and Hemlock
- Conceptual and Functional design of stormwater management facilities
- Preparation of water budget for subject area
- Groundwater study to identify flow patterns, recharge discharge characteristics/linkages
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - OPTION 2 - AREA H1 Total Area – 48.6 ha

ENVIRONMENTAL PRIORITIES

- Implementation of corridor restoration plan for Carp River
- Relocation and restoration of Hazeldean Creek
- Maintenance of infiltration rates
- Implementation of water quality controls
- Enhancement of baseflows
- Consideration of alternative BMPs other than ponds for water quality control

EXISTING RESOURCES

Aquatic Resources

Carp

- Carp very tolerant warmwater fishery
- <10% of corridor length is naturally vegetated</p>

Hazeldean

conveyance of flows to support downstream fishery in Carp River

Groundwater Resources

48.6 ha of low recharge area

Terrestrial Resources

Category 1 areas – 5.1 ha comprised of Hazeldean and Carp River corridor

Surface Water Resources

Applicant to confirm pre and post development flows based on acceptable modelling

Stream Morphology

Hazeldean

100% of stream length is degraded

Carp

100% of stream length is degraded from sediment build up and overwidening

TARGETS

Groundwater Resources

73 mm/yr infiltration for low recharge areas

Surface Water Resources

- Normal (70% long term suspended sediment removal) level water quality control
- 10 l/s (over 7 day period) low flow augmentation from each stormwater management facility
- Flood and erosion control storage not required



Stream Morphology

Carp

Restoration of 1000 m of Carp River as riverine wetland (see Appendix B for baseline conditions)

Hazeldean

Restoration of 600 m of stream using natural channel design principles

Aquatic Resources

Carp

- Restore fish community to a moderately tolerant warmwater fish community Type 3 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 30 C
- Minimum Dissolved Oxygen = 4 mg/l

Terrestrial Resources

- Protect/Enhance Category 1 features located within Corridors
- Provide a minimum 30 m corridor along Hazeldean Tributary (see Section 9.4.2)

- Environmental Assessment and Functional Design Corridor restoration plan for Carp River and Hazeldean Tributary
- Conceptual and Functional design of stormwater management facilities or alternative BMPs
- Preparation of water budget for subject area
- Development of an Environmental Monitoring Plan



ENVIRONMENTAL FACT SHEET - HUNTLEY CREEK Total Area – 4900 ha

SUBWATERSHED PRIORITIES

- Implementation of corridor restoration plan for agricultural reaches (Priority 1 reaches)
- Protection of stable reaches
- Implementation of non-structural BMPs on Priority 1 and 2 agricultural lands
- Implementation of structural BMPs on farms adjacent to Priority 1 reaches
- Acquisition of Centres of Ecological Significance or development of stewardship plan
- Develop stewardship plan for Category 1 and 2 natural features

EXISTING RESOURCES

Aquatic Resources

- tolerant coldwater/diverse warmwater fishery
- <30% of corridor length is naturally vegetated

Groundwater Resoucres

- 1065 ha of high recharge area
- 2287 ha of moderate recharge area
- 1548 ha of low recharge area
- potential groundwater discharge in middle and upper reaches

Terrestrial Resources

- Category 1 areas 1769 ha
- Category 2 areas 1405 ha
- Centres of Ecological Significance 1000 ha

Surface Water Resources

- Existing 2 year flows = $10.3 \text{ m}^3/\text{s}^*$
- Existing 100 year flows = 30.6 m³/s*
- * Flows are based on single event rainfall modelling

Stream Morphology

- 50% of stream length is stable
- 50% of stream length is degraded

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas
- 262 mm/yr infiltration for high recharge areas

Surface Water Resources

Stream Morphology

 Restoration of 3000 m of Priority 1 stream using natural channel design principles (see Appendix B for baseline conditions)



Aquatic Resources

- Maintain and restore Tolerant Coldwater/Diverse warmwater Fish Community Type 1/2 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 25 C (coldwater); 28 C (warmwater)
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

- Protect Category 1 features
- Acquisition of Centres of Ecological Significance
- Stewardship plans for Category 1 and 2 features



ENVIRONMENTAL FACT SHEET - CORKERY CREEK Total Area – 2780 ha

SUBWATERSHED PRIORITIES

- Implementation of corridor restoration plan for agricultural reaches (Priority 1 reaches)
- Protection of stable reaches
- Implementation of non-structural BMPs on Priority 1 and 2 agricultural lands
- Implementation of structural BMPs on farms adjacent to Priority 1 reaches
- Acquisition of Centres of Ecological Significance or development of stewardship plan
- Develop stewardship plan for Category 1 and 2 natural features

EXISTING RESOURCES

Aquatic Resources

- Tolerant warmwater/diverse warmwater fishery
- 40% of corridor length is naturally vegetated

Groundwater Resources

- 754 ha of high recharge area
- 1026 ha of moderate recharge area
- 1000 ha of low recharge area
- potential groundwater discharge in middle and upper reaches

Terrestrial Resources

- Category 1 areas 1586 ha
- Category 2 areas 589 ha
- Centres of Ecological Significance 250 ha

Surface Water Resources

- Existing 2 year flows = 5.3 m³/s*
- Existing 100 year flows = 18.7 m³/s*
- * Flows are based on single event rainfall modelling

Stream Morphology

- 70% of stream length is stable
- 30% of stream length is degraded

TARGETS

Groundwater Resources

- 73 mm/yr infiltration for low recharge areas
- 104 mm/yr infiltration for moderate recharge areas
- 262 mm/yr infiltration for high recharge areas

Surface Water Resources

Stream Morphology

 Restoration of 4000 m of Priority 1 stream using natural channel design principles (see Appendix B for baseline conditions)



Aquatic Resources

- Protect and Restore Diverse Warmwater Fish Community Type 2 (see Table 9.2.2 for specific targets)
- Maximum stream temperature = 28 C (warmwater)
- Minimum Dissolved Oxygen = 6 mg/l

Terrestrial Resources

- Protect Category 1 features
- Acquisition of Centres of Ecological Significance
- Stewardship plans for Category 1 and 2 features