C - Management Alternatives

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SECTION C – MANAGEMENT ALTERNATIVES

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C 1.0 OPPORTUNITIES AND CONSTRAINTS

C 1.1 Introduction

In the previous Section, we completed a comprehensive study of the Forbes Creek subwatershed and the expanded study area. The detailed study has given us insight into the physical and biological characteristics of this subwatershed and related environmental issues. The subwatershed plan is being completed in order to satisfy Provincial, Regional and municipal government policies regarding land development. Urban development is anticipated to occur on designated lands south of Blackbridge Road and east of Guelph Avenue.

To facilitate our understanding of the relationship between development and the environment and ultimately to determine the final extent and form of development within the subwatershed, we must first come to an understanding of the various constraints and opportunities that exist in the Forbes Creek subwatershed. Our research has allowed us to identify these constraints and opportunities. Constraints are those existing subwatershed characteristics that impose a limit on proposed development while opportunities are those subwatershed characteristics, which typically would allow some enhancement of the environmental feature but can also be an opportunity for development to build on environmental strengths. This careful examination of constraints and opportunities allows the subwatershed forms and functions to be carefully examined, in a coordinated fashion, prior to and considering future development.

We initially have examined the Natural Heritage component (wetlands and aquatic policies and issues). The various constraints and opportunities are summarized in tabular form as this facilitates cross-disciplinary evaluations and presentation (Section C 1.0).

Once the full range of constraints and opportunities are stated in a multi-disciplinary, environmental perspective, possible development scenarios are examined (Section C 2.0). Ultimately, the form of development is evaluated against the goals and objectives of the subwatershed study to ensure that the development concept meets these goals and objectives (Section C 3.0).

C 1.2 Natural Heritage Issues

Terrestrial Policy Issues

In conjunction with the biotic constraints identified as part of the subwatershed inventory, policy-related constraints were identified based on Provincial, Regional and City environmental policies.

This subwatershed study is a Comprehensive Environmental Impact Statement and has determined the general thresholds which will form the limits to development in different areas of the subwatershed, based on the preferred environmental management alternative.

The majority of the Natural Heritage System in the subwatershed was previously identified as a Locally Significant Natural Area (LSNA) as shown on Map 9 in the City of Cambridge Official Plan (Corporation of the City of Cambridge, 1999). Section 6.1.4 of the Official Plan indicates that it is the policy of the City to preserve, protect and enhance all LSNAs, and any permitted development within or adjacent to an LSNA must have regard for the preservation and enhancement of the LSNA. Figure C 1.2.1 illustrates existing areas currently recognized as LSNA by the City as well as proposed LSNA areas. The proposed LSNA areas would act to maintain the terrestrial corridor between the Forbes Creek wetlands and the Mill

Pond/Speed River. More specifically, they would include the lower parts of the Provincially Significant Forbes Creek Wetland Complex, as well as the smaller online pond and adjacent upland plantation. The proposed LSNA area satisfies the following five criteria listed on page 40 and 41 (Section 6.1.4.2) of the City of Cambridge Official Plan (Corporation of the City of Cambridge, 1999):

a) be identified by the *Province* as a *Locally Significant Wetland*

b) iii) contains "woodland: interior species" or habitats suitable for them

b) vi) contains uncommon, rare, threatened or endangered communities and species or habitats suitable for them

b) vii) provides a connection or acts a buffer to other natural areas, thus increasing ecological interaction between communities, and is important for ecosystem integrity

b) viii) performs a vital *ecological function*

It should be noted however, that if these lands were recognized as an LSNA, it would not change the degree of protection they currently receive through the Official Plan because the proposed LSNA area is within the existing Class 1 (Significant Natural Features) Open Space designation, which protects "Significant Natural Features". All Class 1 (Significant Natural Features) Open Space areas found in the Forbes Creek subwatershed are illustrated on Map 15 of the Cambridge Official Plan (Corporation of the City of Cambridge, 1999). Identification as a LSNA would require that an EIS be conducted before any proposed development is allowed to proceed that is adjacent or 'contiguous' to an existing LSNA area. In short, the identification of this area as a proposed LSNA serves to reinforce the validity of the existing Class 1 (Significant Natural Features) Open Space designation in this area. It is noted that the Cambridge Natural Areas Inventory conducted in 1995 did not examine areas already designated Class 1(Significant Natural Features) Open Space. Consequently, this area was not previously identified as a LSNA.

Although the Region has not designated an Environmentally Sensitive Policy Area (ESPA) within the subwatershed to date, the present study has identified features and attributes that could lead to such a designation. The areas shown on Figure C 1.2.1 are being proposed as a ESPA, "Forbes Creek Headwaters". A detailed analysis of the natural heritage features under consideration is outlined in **Appendix J8**. The Region's most recent position on the designation of an ESPA can be found in **Appendix J9**. If an ESPA is designated, the boundaries of the current Class 1 (Significant Natural Features) Open Space designation on Map 15 of the Cambridge Official Plan may have to be adjusted slightly. The majority of these lands are already so designated, reflecting the "no development" of ESPA provisions in the Cambridge Official Plan.

Provincial, Regional and local policy areas have been shown on Figure C 1.2.1.

Vegetation and Wildlife Constraints

As part of subwatershed characterization, a constraint analysis of existing vegetation and wildlife resources was undertaken. In the analysis, a variety of ecological attributes were assessed for each identified vegetation community, based on air photo interpretation and field inventories. The specific methodologies used to identify constraints are described in Appendices J3 (Vegetation Constraint Assessment Methodology) and J6 (Wildlife Constraint Assessment Methodology). The application of these methodologies led to the creation of constraint rankings for both the vegetation and wildlife resources. Results of this analysis are contained in **Appendix J4** (Vegetation Community Attributes and Constraint Rankings) and summarized along with other constraints on Figure B 8.3.2, Terrestrial Conservation Areas.

Linkages

Linkages of habitats within the subwatershed, and extending to natural features outside the subwatershed boundary were determined based on background information (particularly deer yarding data from MNR), field observations of species usage and signs of movement, and interpretation of contour mapping and aerial photographs. **Appendices J10** and **J11** and Figure C 1.2.2 (Conceptual Habitat Linkages) illustrate the conclusions on existing linkages. It should be recognized that establishing the use of particular linkages for a broad array of plant and animal species involves intensive research spanning several years. Therefore this analysis should be viewed as conceptual, and subject to detailed confirmation as part of subsequent design and subwatershed work, including that for adjoining subwatersheds such as the Chilligo Creek (Ellis Creek) system.

The identified habitat linkages represent both potential constraints, as well as some opportunities for enhanced connectivity in the landscape. Linkages which may be tenuous or apparently redundant in an agricultural landscape that is reasonably "porous' to the movement of wildlife species, will become critical to maintaining gene flow of sensitive species after development occurs in the vicinity. In general the principles of maximizing connections (redundancy) and providing sufficient and diverse habitat cover along linkages to maintain the three levels of normal corridor usage (passage, foraging and breeding), are key to any effective linkage network. Enhancement of linkages, such as improved access under Regional Road #24, will have particular benefits for smaller species, including amphibians and reptiles that are particularly prone to roadkill during seasonal migration periods. Regional Road #24 represents a major constraint to wildlife movement, which will become more acute as urban development occurs. Provision of an enhanced valley connection along the main branch of Forbes Creek is considered very important to the future functioning of the natural heritage system in the subwatershed. Functional linkages also exist between ground and surfacewater hydrology and the wetland in this subwatershed. The combination of subcatchment area, local topography, vegetative cover and soil texture represent a complex hydrologic system that sustains a mosaic of wetland communities. This regime is considered highly sensitive to land use changes which, by affecting any one of the components parameters, could reduce the complexity and quality of the existing community mosaic.

Sections C 3.3.2 and C 3.3.3 provide a detailed description of buffers and habitat enhancements, in conjunction with the consideration of subwatershed management alternatives, to address these linkage constraints.

Buffers and Habitat Enhancements

Buffers and habitat enhancement provide an opportunity to avoid impacts, improve habitat representation, and sustain linkage functions. Potential enhancement areas should be identified on the basis of indicators of local sensitivity (e.g. slopes, drainage or overhanging tree cover) and where habitat cover is currently considered deficient along the corridor. This is discussed further in Section C 3.3.3.

Fish Habitat Policy Issues

Within the legislative and policy framework identified in Section A, fish habitat within the Forbes Creek subwatershed and in the Speed River (to the extent that it can be affected by activities in the Forbes Creek subwatershed) poses both constraints and opportunities. Existing fish habitat is a constraint in that it cannot be harmfully altered, disrupted or disturbed without authorization under the Fisheries Act. There are, however, also opportunities to enhance fish habitat in the subwatershed.

Fish Habitat

Vegetated buffers along stream banks provide a variety of benefits including shading the stream, providing cover for fish, increasing bank stability, and filtering out sediment that may be carried in surface flow to the streams. The Ministry of Natural Resources usually require vegetated and unmown buffers that are, at a minimum, 15 metres wide on each side of a warmwater stream and 30 metres wide on each side of a coldwater stream. The City of Waterloo, in the Laurel Creek Watershed Plan stipulates that there be 15 metre buffers for intermittent streams and 30 metre buffers for permanent flowing streams. The MNR aquatic standards have been applied to the Forbes Creek system. The final width of the buffer should be established during the scoped site EIS process. Figure C 1.2.3 details a 15 and 30 metre buffer option on the Forbes Creek system.

C 1.3 Natural Hazard Issues

The key natural hazard issue within the Forbes Creek subwatershed area is the presence of the Regulatory Floodplain. This floodplain has been discussed in Section B 3.0 and detailed on Figure B 3.2.1. A related hazard issue is the presence of shallow water tables and associated wetland habitats throughout the subwatershed. These linked systems have achieved a relatively stable balance with existing land uses, which will be affected as portions of the subwatershed are urbanized. The use of buffers, setbacks and scoped studies of site-specific hydrology in the planning of land use changes will be key to avoiding impacts to these hazard features.

Another significant natural hazard issue is steep slopes. The location of steep slopes is generally along the Speed River valley, particularly in the expanded study area. Confirmation of the presence of steep slopes would be conducted at the site-specific EIS stage. Steep slopes have been identified on a preliminary basis on Figure C 1.3.1.

Steep slope criteria used in this study is according to the Grand River Conservation Authority whereby any slopes with a horizontal to vertical ratio steeper than 6:1 should be considered a steep slope. In such cases, a minimum top-of-bank setback of ten metres has been established. Where slopes are less than a 3:1 horizontal to vertical ratio, the ten-metre setback applies, beginning at the top of the slope. Where slopes are steeper than 3:1, the setback begins where a 3:1 angle, starting from the base of the steep slope, intersects with the ground level at the top of the slope. This results in a setback greater than ten metres from top-of-bank for slopes steeper than 3:1.

C 1.4 Summary of Opportunities and Constraints

A discussion on the numerous opportunities and constraints that relate to the study area has been summarized on **Table C 1.4.1**. The table has been organized into the following sections:

- Aquatic Systems (creeks and ponds)
- Water Management Systems
- Natural Heritage Systems
- Agricultural Systems

Various plans have also been prepared to convey the potential constraints and opportunities with the Forbes Creek subwatershed. The following figures are applicable to a final Opportunities and Constraints Plan:

- B 3.2.1 Regulatory Floodlines
- B 8.3.2 Terrestrial Constraint Areas
- C 1.2.1 Policy Areas
- C 1.2.2 Subwatershed Linkages
- C 1.2.3 Aquatic Buffers
- C 1.3.1 Areas of Steep Slopes

C 2.0 LAND USE SCENARIOS

C 2.1 Introduction

There is a very defined line between that area of the subwatershed that could be considered for development under existing planning policy framework and that area of the subwatershed study area that would require amendments to the policy framework as a prerequisite to any form of development. Blackbridge Road and Regional Road #24 serve as the boundary between what is defined as the CITY URBAN AREA and the AGRICULTURAL RESOURCE AREA Boundary in the Regional Official Policies Plan and the City of Cambridge Official Plan. These same two roads also define the boundary between the Class 1 (Urban) Residential District designation and the Class 1 (Prime) Agricultural Resource District on Map 15 - General Land Use Plan of the City of Cambridge Official Plan.

The Regional Official Policies Plan permits a broad range of urban land uses. The Class 1 (Urban) Residential District designation in the City of Cambridge Official Plan permits: municipal uses; limited commercial uses; mixed residential-commercial uses; and residential uses ranging from a minimum net residential density of 22 units per hectare, to a maximum net residential density of 75 units per hectare. These density limitations may be adjusted where warranted by natural features, environmental issues, impact on existing neighbourhood and cost of servicing. The information provided by the Forbes Creek Subwatershed Study will identify the physical and environmental constraints that may serve to determine appropriate density standards.

The study area may be divided into three distinct areas: the Existing Built Community; the area South of Blackbridge Road East of Guelph Avenue and the Built up Area; and the area North of Blackbridge Road.

Existing Built Community

The existing built community is the area bounded by the westerly and southerly limits of the study area, west of Guelph Avenue and south of Regional Road #24. This area also includes the existing residential development east of Guelph Avenue along Henry Villa Drive.

Based on air photo analysis the 'existing built community' is fully developed except for minor infilling opportunities on existing vacant parcels.

South of Blackbridge Road, east of Guelph Avenue and Built Up Area

An expanded study area is in the area bounded by Guelph Avenue to the west, Blackbridge Road to the north, the railway line to the east and the southerly limits of the study area. This area is undeveloped, except for a limited number of existing residential lots along the easterly limit of Guelph Avenue, and two farm houses with access to Blackbridge Road. The Forbes Estate and associated waterfowl sanctuary and agricultural lands are located within this area of the watershed.

Table C 1.4.1 Summary of Opportunities and Constraints					
Factor	**Importance**	**General Issues**	**Constraints**	**Opportunities**	**Relational Impacts**
AQUATIC SYSTEMS (CREEKS AND PONDS)					
Aquatic System	**Definition of Component** The aquatic system includes fish habitat and fish communities, as well as benthic invertebrate communities. The biological communities are largely determined by the physical environments that are present and by water quality and temperature. Important factors include base flow, stream morphology and riparian and aquatic vegetation. The aquatic communities contribute to biodiversity in the subwatershed, contribute to fish productive capacity within the sub-watershed and potentially in the adjacent reach of the Speed River. There are also linkages to the terrestrial communities (i.e. fish eating birds). **How have we assessed this area:** Background information has been assembled from documents and files with the City, Conservation Authority, Ministry of Natural Resources, and Region. This has been helpful in the characterization of specific stream habitats and of the fish communities associated with specific features. Aerial photographs have been used to delineate the extent of stream habitat types that were identified during field investigations. Field studies have been conducted in 2000 and 2001 to: ➢ Verify extent of stream habitat types ➢ Determine fish communities associated with various habitat	**General** Constraints upon fisheries within the study area are associated with: • Baseflow (permanence of flow has major impacts upon fish community). • Channel form/size • Barriers to fish migration. • Water quality/temperature **Specifics** 1. Flow in Forbes Creek is intermittent except in the reaches closest to the Speed River. Thus fish use upstream from that point is seasonal at most, except in those ponds that do not go dry. 2. The small size of the creek channel, particularly its shallow form, limits the size and amount of fish that it can support. 3. Barriers to fish migration at several points along the creek prevent fish from taking advantage of seasonal habitats or re-colonizing after periodic harsh conditions. Water temperature and quality can influence aquatic biota, but in the case of Forbes Creek are probably overshadowed by the lack of base flow.	1. Base flow is present only in the lower reaches of the creek, and a significant portion of this is emitted from a storm sewer. Permanence of flow is important for fish and invertebrate communities. Groundwater is also important in maintaining water levels in the ponds. 2. Barriers to fish migration prevent fish from the Speed River from accessing Forbes Creek and prevent movement of fish within Forbes Creek. 3. Maintenance of good water quality and suitable water temperatures is necessary for healthy fish and invertebrate communities.	1. Ensure that groundwater recharge is maintained at current levels or enhanced in order to maintain/increase base flow and pond levels. 2. Removal of barriers will allow fish movement, with the largest benefits arising from eliminating the barrier that prevents fish from the Speed River from moving into the creek. 3. Elimination of barriers within the creek system allows fish to make optimal use of available habitats. 4. Elimination of the dams that create/maintain the permanent ponds could reduce fish productive capacity if the ponds were eliminated too. Maximizing infiltration will maintain quality and amount of cool base flow. Treatment of storm water will minimize impacts on water quality.	Groundwater can also influence terrestrial vegetation communities. Removal of barriers affects stream morphology and can, in the case of dams, affect hydrology. Removal of dams could lower water levels, affecting vegetation. Removal of barriers may result in loss of wetlands.

Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
	types and individual stream reaches. ➢ Examine benthic invertebrate communities				
Base Flow	**Definition of the Component:** Base flow is that amount of water that sustains the creek system during periods of no rainfall. It is derived from groundwater discharge and is representative of groundwater conditions. Base flow is important in that it provides volume of water for channel maintenance and is vital for aquatic habitat. Base flow also is generally a source of cool water necessary for fish and other aquatic species. **How we have assessed this area:** Base flow has been assessed through direct measurement of flow during summer periods, with measurements taken at least 2 days after a rain event. Base flow is also assessed using the hydrological record and the model results, which are based on a long-term period. This reduces the impact of extended dry periods on results.	**General** There are a number of factors which contribute to alteration of base flow regimes in a subwatershed, including: 1. Loss of base flow due to extensive withdrawals of local wells 2. Addition to base flow caused by leaking infrastructure These can affect other analyses of subwatershed conditions by providing false readings which impact management decisions.	1. Reduced recharge to groundwater due to increased imperviousness of development 2. Change in existing groundwater flow directions 3. Surface water taking from streams (particularly critical during low flow periods) 4. Lack of quantity could result in increased groundwater temperatures. 5. Thermal impacts of stormwater management facilities 6. Loss of riparian shading.	1. Provide for extended detention of stormwater runoff to Increase base flow in creeks 2. Reducing or eliminating water well withdrawals may result in increased baseflow. 3. Enhance or Increase riparian vegetation to increase shading. 4. Shading of stormwater management facilities or other means or reducing thermal impacts. 5. Using discharge from stormwater facilities as source of cool water.	Base flow is critical for fish habitat and fish passage. Base flow is also critical for maintenance of channel form and function, even though it does not generally have channel-altering erosive power. Fish species depend upon the maintenance of cool water temperatures. Enhancement may occur if baseflow is increased or water temperature are lowered. Regional Environmentally Significant Discharge Areas are coincident with riparian areas and will provide base flow to stream systems. Their protection is required.
Maintenance/ restoration of natural channel form	**Definition of Component:** Restoration of natural fluvial processes is essential for the continued health of the aquatic system. These processes are impacted by changes in stream channel form, so it is necessary to assess existing channel form for potential to alter process. **How have we assessed this area:**	A stream which is not in equilibrium in terms of channel form is not in equilibrium with respect to instream processes. In other words, the channel is undergoing slow changes to form in order to accommodate existing flow regimes. Development in the area has the potential to alter this rate of readjustment and force the system into a state of flux which can	1. Development may directly eliminate natural channel form. 2. Development may alter the hydrograph, resulting in the alteration of channel form. 3. Excessive sediment loading during development may alter channel form. 4. Maintain existing natural channel form in streams which support	1. Restoration of altered channels on Main Branch and tributaries. 2. Erosion and sediment controls during construction phases of activity	Degraded systems will simplify fish populations. Degradation of form will result in long-term instability with erosion and sedimentation potential remaining relatively high in the lower reaches. This may impact the community plan if a trail system is planned for the lower reaches.

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Table C 1.4.1 Summary of Opportunities and Constraints					
Factor	**Importance**	**General Issues**	**Constraints**	**Opportunities**	**Relational Impacts**
	Field investigations and surveys of existing channel profile in both the downstream and cross-stream direction have been used to determine what form the channel currently takes. This form is then assessed against known principles of fluvial geomorphology and decisions are made as to the appropriateness of the existing condition, the potential for rehabilitation, and the probable success of that rehabilitation.	result in uncontrolled erosion or sedimentation. If this occurs there are definite implications for aquatic habitat. By rehabilitating existing problem areas in a stream system we are able to make the system resilient (flexible) so that any short-term impacts of development can be absorbed by the system, and once the impacts are lessened, the system will remain in a state of equilibrium. The fluvial assessment has indicated that the lower reaches of the Forbes Creek system are not in stable form, and will certainly undergo some alteration with development. A priority then is to rehabilitate the channel in the lower reaches so that it can absorb short-term changes in the basin.	healthy fish communities.		
Maintenance/Restoration of Riparian Buffers	**Definition of Component:** Riparian buffers are essential in the maintenance of water temperature, the stability of channel farm (i.e., erosion), and in the provision for food and habitat of certain terrestrial and aquatic species. **How have we assessed this area:** Field investigations and surveys by various team members provide an inventory of existence and an assessment of condition. These factors have implications on all aspects of system health.	Alteration (especially minimization) of riparian buffers alters stream function and has contributed to increased erosion of banks, resulting in sedimentation at other location in the channel. It is important from a fluvial functioning perspective that riparian buffers around streams be maintained and where not currently in existence be implemented as part of the overall management plan.	1. Development may reduce or degrade the existing riparian buffers along streams	1. There are opportunities to restore or enhance the riparian zones along streams 2. Application of provincial buffer standards 3. Provide additional system-related buffers	Degradation of riparian zones can potentially increase siltation, affect channel form, increase water temperatures, promote macrophyte growth, and expose fish to predators.

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Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
Channel Bank Erosion	**Definition of the component:** Bank erosion is part of a naturally occurring cycle of stream processes, and is expected to occur in all systems to some extent. Issues arise when bank erosion is excessive at particular locations, which is indicative of disequilibrium in stream process and requiring of attention. **How have we assessed this area:** Bank erosion was assessed directly in the field through the use of erosion pins in banks which appeared to be undergoing change as well as in banks which appeared stable (which were used as control sites). Repeated measurements of the exposure of the pins indicates the rate of bank retreat, which can be correlated to flows and the hydrological modeling.	Alteration to flow hydrographs with development can accelerate erosion at sensitive sites. Improper placement of instream structures (i.e. SWM outputs) can cause local erosion and can alter flow patterns which may impact erosion sites. Any naturalization or rehabilitation of stream form must consider bank erosion as an integral part of the design and management programme. Preventing bank erosion by hardening banks to the point where erosion is impossible results in increased erosion at other locations, either the bed at the hardened site or at another bank farther downstream.	1. Development may affect natural channel form. 2. Development may alter hydrology and change channel form. 3. Sediment from development may alter channel form. 4. Development may require lower creek invert for servicing, altering channel dynamics. 5. Straightened creeks and improved rural drainage may result in unstable downstream creek system. 6. Uncontrolled access of livestock to streams may result in loss of riparian vegetation and loss of streambank integrity increasing channel erosion 7. Straightened channel increase gradient, resulting in loss of natural channel and its functions (attenuation of flows, sediment supply-transport, aquatic habitat). This should be avoided.	1. Enhancements can be realized through City by replacing concrete channels, or enhancing these structures to mimic natural forms. 2. Naturalize straightened sections (not concrete) of channel. 3. Stable and diverse creek sections should be maintained. 4. Complete erosion control work at sites demonstrating excessive erosion. Further erosion control work should be minimized to ensure that erosion and sediment supply is not eliminated. 5. Minimize the amount of lowering and the extent of the lowering, based on detailed assessments. 6. Provide ample corridor to enable the channel to adjust naturally to any alteration. 7. Restoration of sections of Forbes Creek and its tributaries to the north. 8. Restriction of livestock access to streams.	Will provide greater access for fisheries in addition to providing more diverse aquatic habitat. Benefits could also be realized in the stream water quality. Monitor the sites, assess the physical processes and where appropriate control the erosion using "natural" techniques materials. Lowering the creek to support servicing options has a negative impact on aquatic habituate, although lowering may contact more shallow groundwater. Fluvial improvements will improve fisheries and water quality.

Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
Stream Morphology	**Definition of Component:** Stream morphology assesses the shape and form of watercourses as well as the operative processes within the channel. The application of this discipline offers several benefits including, establishing cause-effect relationships, which provides an understanding of the existing channel system and for evaluating the potential effects of future land use change. Further, this discipline identifies stream functions that pertain to the movement and storage of water and sediment through the subwatershed. **How have we assessed this area:** Background information was reviewed and consisted of previous reports and any data pertaining to channel flow and sediment transport. Mapping and aerial photographs were used to delineate basin and reach characteristics which permitted a preliminary identification of channel function and migration/alteration that has occurred over time. Field studies have been conducted in 2000 to 2001 to: • Confirm mapping –air photos findings as well as completing a rapid assessment of most reaches. • Detailed geomorphic field work at seven reaches located at representative areas Monitoring of high flow conditions, including sampling of sediment transport.	**General** Constraints upon stream morphology within the study area are associated with: • Physical controls on channel form (geology and climate) with geology being more variable • Modifying controls which included riparian vegetation and surrounding land use. • Alteration to the channels which included hardening and straightening. • Regulation of flow and natural runoff processes. • Alteration of interruption of natural sediment supply to channels. **Specifics** • Stream profiles and stream energy environment. • The effect of urbanization has resulted in more flow being conveyed through downstream channels, which has resulted in channel adjustments and bank erosion. • The area with concrete channels has reduced sediment supply and increased flow energy. • Some channels in rural areas have been straightened and riparian vegetation removed, increasing their sensitivity.	Stream morphology is indicative of equilibrium and therefore is used in tandem with other fluvial indicators to assess overall channel stability. Any naturalization or rehabilitation must incorporate the geometries of stream morphology of the Forbes Creek system in order to ensure success—process dictates that if the rehabilitated channel morphology does not match the exiting morphology geometrically, then the rehabilitated channel will fail. This results in erosion and sedimentation and causes potential risk to structures and aquatic habitat.	The lower reaches of the Forbes Creek system are not stable, and therefore we can utilize geometries of the upstream channel and other streams in the area of similar size and drainage area to rehabilitate the stream channel. These opportunities ensure success if all other design criteria (sediment size, etc) are fundamentally correct.	Proper morphology results in proper stream function. This is important for stable aquatic habitat as well as insurance that any structures built in the system will not be at risk.

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Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
WATER MANAGEMENT SYSTEMS					
HYDROLOGY	**Definition of Component:** The study of how water quality and quantity interacts on the surface of the earth (in the sky, at the surface, and in the ground). **How have we assessed this area:** We have created a computer model of the Forbes Creek subwatershed to reflect the hydrological processes that are taking place. The model uses the precipitation and streamflow data that we have collected to predict what flow rates could be expected in Forbes Creek during various storms. Once the model was calibrated to our data, we revised the model to reflect the type of development that could potentially occur. That allows us to see the potential changes and develop strategies to ensure the protection of the natural features in the Forbes Creek subwatershed.	General development results in land use changes. Increased development results in increased asphalt or imperviousness. This leads to: • Lower infiltration rates • Reduced baseflow • More frequent runoff • Increased stream erosion • Increased flooding The fluvial assessment has determined that excessive runoff could erode the channel or any future channel reconstruction. Water quantity control is required.	• Increased peak flow rates would increase flood damage potential in downstream reaches of the watercourse systems • Increased peak flow rates and volumes would increase erosion potential, particularly in downstream reaches of the watercourse systems	1. Provide stormwater quantity storage facilities to attenuate stormwater runoff prior to discharge to receiving watercourses. 2. Maximize infiltration at source to reduce runoff volumes.	Increased peak flow rates and volumes may effect riparian habitats along watercourse systems through altering timing, frequency and duration of flood occurrences which may in turn impact on stream morphology. Increased peak flow rates and volumes may effect stream bank stability and stream morphology which would impact riparian habitats along watercourse systems. Erosion control storage (extended detention) provided within stormwater management facilities would augment stream flow during the 1-3 days following storm events.

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Table C 1.4.1 Summary of Opportunities and Constraints					
Factor	**Importance**	**General Issues**	**Constraints**	**Opportunities**	**Relational Impacts**
HYDRAULICS	**Definition of Component:** Hydraulics is the study of the mechanics of storm flow in open watercourse systems. **How have we assessed this area:** The runoff rates associated with various land uses are used as input to models of the existing valley and watercourse systems. The hydraulic models provide details on flow velocities and depths.	The floodplain constraints are generally determined by: • Flow rate (hydrology) • Channel slope • Topography (i.e. depth of valley/floodplain systems) • Channel and floodplain characteristics (i.e. vegetation/substrate) Hydraulic effects of bridges, culverts and encroachments (i.e. alteration of floodplain topography)	1. Low channel gradients and lack of defined valley/floodplain systems within local tributary watercourses increases the sensitivity of these areas to changes in local hydrology and flood potential, thereby increasing the level of constraint in these areas. 2. Downstream areas are better defined.	1. Flood control structures will reduce peak flows to pre-development levels 2. The ultimate channel design will control the extent of potential flooding 3. Protection of Natural features keeps floodplain in natural state.	Fish passage must be accounted for.
WATER QUALITY	**Definition of Component:** Maintaining or improving water quality is vital to the health of the system and to the plants and animals that utilize the water for their existence. Maintaining or improving water quality also allows better aesthetics and recreational opportunities. **How is this factor being studied?** Background information has been assembled form documents and files with the City, Conservation Authority, Ministry of Natural Resources and Region. This has been helpful in the characterization of historical as well as current water quality conditions. Existing benthic invertebrate (good indicators of water quality) data was analyzed to help spatially characterize water quality. Field studies have been	Water quality constraints in the Forbes Creek Subwatershed are: • Groundwater availability (contributes to baseflow and lower water temperatures). • Changes in land use (i.e. urbanization) would effect the type and amount of non point source contaminant loads from the Subwatershed areas • The concrete channel impacts water temperatures	1. Increased pollutant loading from developing areas could degrade instream quality 2. Increased pollutant concentrations during storm event may impact aquatic resources 3. Increased water temperatures could reduce dissolved oxygen concentrations. 4. Agricultural nutrient loading could result in deterioration of water quality. 5. Increased pollutant concentrations could negatively effect aquatic species. 6. Application of road salts.	1. Provide stormwater quality treatment facilities (wet ponds wetlands) prior to discharge to receiving watercourses. 2. Maximize infiltration to reduce wash off and transport of pollutants. 3. Changes in land use and stormwater management could reduce nutrient loading 4. Increased shading from riparian vegetation could reduce plan growth, reducing diurnal oxygen fluctuations. 5. Reduction in water temperatures could increase dissolved oxygen solubility. 6. Increase baseflow to stream 7. Stormwater treatment could reduce the loadings or concentrations of certain contaminants 8. Reduction or elimination of loadings from agricultural practices	Water quality can be a limiting factor for certain fish species. Nutrient/contaminant loadings could create additional negative impacts on the Hespeler Mill Pond. Nutrient loading impacts plant growth, and fish habitat Excessive plant growth impacts dissolved oxygen levels and may limit certain fish species. Contaminants could limit or directly impact certain ecosystem components.

Table C 1.4.1 Summary of Opportunities and Constraints					
Factor	**Importance**	**General Issues**	**Constraints**	**Opportunities**	**Relational Impacts**
	conducted in 2000 and 2001.				

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Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
TERRESTRIAL RESOURCES					
NATURAL HERITAGE SYSTEM **TERRESTRIAL RESOURCES**	**Definition of Component** Terrestrial resources include vegetation and wildlife species and their communities. Together with their physical environments, they form terrestrial ecosystems. Terrestrial communities help regulate microclimate, retain moisture, prevent erosion, and provide habitat structure that sustains biodiversity (the complexity of life) within the subwatershed. **What was Done** Existing information was assembled from documents and files obtained from the City of Cambridge, Ministry of Natural Resources, Grand River Conservation Authority, and the Regional Municipality of Waterloo. This has been helpful in identifying known areas of wildlife concentration, and classified wetlands. Local residents and naturalists have provided important information on the seasonal occurrence of wildlife. Recent aerial photographs (spring 2000) were used to identify existing areas of forest, swamp, marsh, open water, agricultural fields, hedgerows, and cultural communities such as old fields, thickets and plantations. Field studies spanned all 4 seasons in 2000-2001to: • Verify and revise boundaries of natural features, including evaluated wetlands.	Terrestrial features with constraints include those associated with: • Sensitive canopy structure or habitat complexity • Steep slopes, poorly drained soils, or habitats reliant on groundwater regimes • Specialized habitats, such as wetlands, large blocks of habitat, or those containing special characteristics (such as old growth or forest interior) • Rare or significant plant and animal species and their habitats • Areas of high diversity of amphibians and reptiles • Existing habitat or areas of potential habitat that help link larger 'core' natural habitats • Habitats or functions that are particularly intolerant of human proximity • Core and corridor areas which are key for the protection and integration of habitats and functions. Collectively, these constraints support the policy designation of the natural habitats and linkages in the subwatershed as classified wetlands, or Environmentally Sensitive Policy Areas	1. The wetlands in the subwatershed were previously evaluated as a locally significant wetland (Forbes Creek Wetland Complex). In the present study, the wetland was upgraded to Provincially Significant Wetland (PSW) based on significant species present. The Provincial Policy Statement restricts development within and adjacent to PSWs. 2. Given the diverse habitats, proximity to the Speed River corridor, and predominantly rural character of the subwatershed, the existing Natural Heritage System is well-linked and contributes significantly to the ecological functions of adjoining subwatersheds. Further urbanization of the lower subwatershed will significantly reduce the habitat linkage provided by agricultural uses, as urban cover prevents movements of sensitive species. 3. Forest cover (*i.e.* forests, treed-swamps & plantation) represents 14.96% of the land base in the subwatershed. Wetlands (*i.e.* marsh, open water & thicket & treed swamps) comprise 13.12%. Although relatively well linked, the overall forest cover in the subwatershed is deficient in comparison to targets recommended by Environment Canada (1998): 30% forest cover. The amount of wetland	1. Work towards an eventual cover target of 30% natural forest cover for the subwatershed. This figure represents Environment Canada (1998) guidelines & could be accomplished by: • Protecting remaining forest and successional cover, including cultural woodlands and plantations. • Restoring degraded natural and cultural woodland features, and naturalizing future open space • Conducting forest management and stewardship practices for existing woodlots • Initiating Stewardship programs to reduce urban impacts • Using buffers to protect existing and future forested lands throughout the subwatershed • Ensuring that Regional and City Policies (O.P.'s, Secondary Plans, Subdivision Plans) reflect the Provincial Policy Statement through planning, design and construction. 2. Maintain an effective open space corridor from 200 to 400 m wide through the future urban area, composed of natural habitat, buffers, enhancement areas, and complementary land uses.	1. Sensitive wetland habitats immediately adjacent to the Creek may constrain placement of stormwater facilities. Outlets and infiltration facilities that may affect quantity, quality and seasonal flow characteristics (surface and shallow groundwater) should be outletted downstream of sensitive wetlands. 2. Road crossings act as barriers to movement to both wildlife & plants and will fragment adjacent biological communities. Rates of mortality will increase as a result of vehicular roadkills. The presence of roads lowers the quality of adjacent lands by increasing disturbance (*i.e.* noise), salt contamination, and access to invasive plant species. The numbers of impacts rise with the number of road crossings, number of lanes of traffic, and traffic speed. 3. Buffers sufficient to protect wetland habitat cover may be inadequate to maintain existing levels of wildlife movement, or presence of sensitive wildlife species. 4. Some commonly-planted species may affect forest habitat quality and promote erosion (*e.g.* Norway maple).

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Table C 1.4.1 Summary of Opportunities and Constraints

Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
	• Classify species and habitat structure, local drainage and topography • Prepare a checklist of vegetative and wildlife species for individual features • Identify potential Environmentally Sensitive Policy Areas (ESPAs) and Locally significant Natural Areas (LSNAs). • Identify existing and potential terrestrial linkages that occur both within and across subwatershed boundaries. • Identify areas for potential habitat rehabilitation or enhancement.		cover currently exceeds similar targets set by Environment Canada for wetland cover: 6% wetland cover for subwatersheds and 10% for major watersheds. 4. The subwatershed contains successional meadows, and supports breeding of regionally-significant meadow bird species (north of Highway 24). 5. Existing human encroachment into natural habitats (*e.g.* trampling, tree cutting, understorey removal, informal trails, garbage and debris dumping, vandalism) is limited. Further urbanization in the subwatershed will likely result in greater impacts on the existing system, including the further spread of introduced plant species such as Common Buckthorn and Garlic Mustard. 6. The quality, quantity, and seasonal flow of future urban runoff may detrimentally impact the habitat quality and species diversity of wetlands in the Forbes Creek Wetland Complex. Effects on shallow groundwater flows, and contamination with nutrients or road salt are of particular concern. 7. Urban wildlife issues include predation of wildlife by pets, and replacement of rural wildlife with “urban-adapted” species such as raccoons, skunks, gray squirrels, house sparrows, European starlings etc. 8. Microclimate (temperature, wind and humidity) will be altered by urban “heat island” effects and limited vegetation cover.	3. Enhance the corridor connection between the Speed River and the upper subwatershed north of Blackbridge Road by maintaining the agricultural lands and providing wildlife crossings at existing/future Highway 24. 4. Integrate and enhance Natural Heritage links to features outside the sub-watershed. 5. Develop stewardship programs to encourage farmers and other landowners to incorporate principles of habitat management for remaining woodlands and successional habitats and consolidate smaller fragments into large habitat blocks. 6. Provide open space planning for remnant habitats in existing and new urban areas, including a trail hierarchy to direct pedestrian movements and meet residents’ recreational needs. 7. Utilize locally-adapted native species in all public plantings (streetscapes, parks, open spaces). Develop stewardship programs to locate and eradicate problem species in key natural areas. 8. Provide public education and improved controls over cats and dogs within the urban boundary (by-laws)	

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Factor	Importance	General Issues	Constraints	Opportunities	Relational Impacts
AGRICULTURAL SYSTEMS					
AGRICULTURAL SYSTEMS	Definition of Component: Agricultural resources include a biophysical component which has subcomponents such as soils, climate and water. As well, agriculture includes social and economic components. The three interdependent components provide raw materials and skills together with a delivery system for food and other products. How have we assessed this component: Background information has been assembled from documents and files with the City, OMAF, Conservation Authority, Region of Waterloo and other published literature. This information together with aerial photographs and field studies (conducted in 2001) were used to: • Verify agricultural soils and soil	General issues associated agriculture include: 1. Preservation of prime agricultural land 2. Maintenance of agricultural infrastructure 3. Loss of agricultural expertise and experience, that is, fewer farmers 4. High risk associated with farm markets 5. Unknowns associated with land areas that are urbanizing Agricultural issues also relate to ecological subject matters discussed and/or proposed within the Subwatershed. 1. The presence PSWs as designated by the Ministry of Natural Resources or ESPAs have the potential to affect farm management and farm overhead costs	1. Farm economics make the application of best management practices difficult if farmers are required to apply, construct and maintain the practice(s) without subsidy 2. Agricultural land has been fragmented and agricultural infrastructure lost within the subwatershed. This fragmentation and loss is greatest south and east of Regional Road #24. 3. Agricultural land ownership tends to be greatest in the area north and west of Regional Road #24. Application of programs related to best management practices are likely to be more difficult in agricultural areas where land is owned by non-farmers. 4. Woodlands need to be available for grazing and/or logging. 5. Establishment of setbacks and buffers around natural features	1. Maximize use of existing subsidy programs and create new programs in areas of greatest need. 2. Protect remaining agricultural lands (as per PPS, 1997). 3. Ensure that Regional and City Policies (O.P.'s, Secondary Plans) reflect the Provincial Policy Statement. 4. Encourage the implementation of existing stewardship programs which include the application of best management practices and are available through the GRCA. 5. Encourage the use of existing programs available through OMAF such as environmental farm plans and manure management systems. 6. Develop stewardship programs to promote reforestation and wetland creation, to encourage farmers and other landowners to incorporate principles of habitat	Lack of natural cover may contribute to erosion and surface water quality problems which affect farm and farmer health. Impacts to features associated with streams and ponds may affect slope stability and water quality which affect quality of the agricultural resource.

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Table C 1.4.1 Summary of Opportunities and Constraints					
Factor	**Importance**	**General Issues**	**Constraints**	**Opportunities**	**Relational Impacts**
	capability • Identify agricultural land use • Identify agricultural infrastructure such as farm buildings • Observe current farm management practices • Characterize property size and ownership	2. Planning for the provision of linkages between remnant natural systems will result in loss of land available for agricultural production 3. Any increase in wetlands once common in the Subwatershed, has the potential to affect farm drainage and reduce crop yields 4. Plans which affect farm management practices and which result in improved water quality will benefit farm wells and other surface waters used for water taking on the farm	may result in loss of agricultural land. 6. Application of best management practices has the potential to result in limited negative outcomes. In other words, a management practice may be good for one thing but negative for something else. 7. Human encroachment onto natural habitats on farms as well as on to farm fields has the potential to result in trampling, tree cutting, understorey removal, informal trails, garbage and debris dumping, vandalism. 8. Introduction or reestablishment of some plant species has the potential to increase costs associated with crop production associated with plant competition. 9. Provision of habitat for wildlife may result in increases in wildlife populations and predation on farms.	management for remaining woodlands and successional habitats and consolidate smaller fragments into large habitat blocks. 7. Create a hierarchy of public objectives associated the Subwatershed in order that best management practices can be chosen and applied in a way that matches that hierarchy. 8. Develop new public education and stewardship programs to reduce impacts and provide remediation of identified problems if existing programs are not effective or are discontinued. 9. Apply farm-related programs in areas most likely to remain in agriculture the longest - most likely those areas north and west of Regional Road #24. 10. Continue programs informing the public about the problems associated with trespassing on agricultural land. 11. Continue programs which pay farmers for losses associated with wildlife.	

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This area is currently designated for future urban development

North of Blackbridge Road:

Lands north of Blackbridge Road are identified as AGRICULTURAL RESOURCE AREAS in the Regional and City Official Plans, and are primarily used for agricultural purposes. The headwaters of the Forbes Creek and existing and future alignments of Regional Road #24 are located within this area. Except for uses that are permitted pursuant to current zoning regulations, there are no opportunities for development i.e. new lot creation, based on existing official plan policies. Any development within this area prior to 2016 could only be considered on the basis of amendments to the applicable planning documents supported by justification for inclusion of additional development lands within the City Urban Area.

C 2.2 Land Use-Designated Area

The area of the subwatershed south of Blackbridge Road is located within the Residential and Open Space Districts in the City of Cambridge Official Plan. The recommendations of this subwatershed study will be utilized in the formation of a community plan to define and implement appropriate official plan land use designations and broad development policies for the areas south of Blackbridge Road designated as Class 1 (Urban) Residential District and Class 1 (Significant Natural Features) Open Space District.

There are no land use options or scenarios to be considered for lands south of Blackbridge Road, as the Official Plan has determined that urban uses may be developed subject to the specific requirements of Section 14 of the Official Plan and other applicable development policies. The Official Plan does permit and encourages a mix of housing types and densities, and some limited convenience commercial uses, as well as institutional uses (i.e. schools), subject to specific location criteria. Development of any uses other that what is currently permitted by the Official Plan would require an amendment to the Official Plan.

There are approximately 95.6 hectares of land south of Blackbridge Road within the Class 1 (Urban) Residential District and the Class 1 (Significant Natural Features) Open Space District designations. Within the area south of Blackbridge Road, approximately 50.5 hectares have been identified by this study (as illustrated on Figure C 2.2.1) as Developable Area. Developable Area includes land area requirements for residential and other permitted land uses, plus roads and any other services that are not appropriate within the Non-Developable Area.

The remaining area south of Blackbridge Road, comprising approximately 45.1 hectares, has been identified by the subwatershed study as wetlands, marsh, slopes and associated 30 metre buffers. The limits of the Class 1 (Significant Natural Features) Open Space District

designation on Map 15 - General Land Use Plan of the Official Plan generally represents the locations of these features, except for the marsh and slope areas west of the railway in Catchment Area 901, which are currently within the Class 1 (Urban) Residential District designation.

Table C 2.2.1 Land Use-Designated Area				
Area	**Existing Land Use**	**Total Area**	**Potential Land Use**	**Potential Development Area**
Existing Community	Residential, Institutional	59.3 ha	Existing	0 ha
Forbes Creek South of Blackbridge Road	Agriculture, Water Course, Ponds, Limited Residential	95.7 ha	Residential, other permitted uses, and roads	50.5 ha
			Open Space	45.1 ha

The City of Cambridge will implement the recommendations of the Forbes Creek Subwatershed Study where appropriate through amendments to the official plan or a community plan. The information gathered through the Forbes Creek Subwatershed Study will be considered in identifying development areas, appropriate types and locations for permitted land uses, as well as the compatibility requirements for these land uses with regard to the environmental information and recommendations of the subwatershed study.

C 3.0 DEVELOPING AND ANALYZING MANAGEMENT ALTERNATIVES

The results of the Community Workshops, public responses and our investigations have concluded that maintaining the Forbes Creek pond and stream system is key to any management strategy. Accordingly, the Aquatic System (creeks and ponds) is regarded as the primary focus of the management strategy, subject to the resolution of safety and maintenance issues. Other systems, while ensuring that environmental conditions are maintained or exceeded, should also ensure that the Aquatic System is enhanced. Key components of a rehabilitation/enhancement plan are the removal of barrier structures and the improvement of fisheries habitat.

C 3.1 Aquatic System (Creeks and Ponds)

C 3.1.1 Fluvial Impacts and Issues

Forbes Creek operates unlike what would be expected from a stream system of this size, and from what would be expected from the data collected. This is because of the amount of flow regulation on the system: wetlands and online ponds alter local base levels and have an impact on energy budgets and sediment transport capabilities. Therefore, sediment which the data suggests must be in transport is clearly found not to be mobile, and in fact the stream component of the subwatershed is quite stable. Having said this, stability in no means indicates health, and there needs to be some consideration to the rehabilitation of the lower reaches (at the very least) in order to establish a channel which flows unregulated (while there is flow in the system) and can be utilized as habitat for fish and aquatic organisms.

The Forbes Creek system is highly altered and is in need of rehabilitation downstream of the two main ponds and all the way to the Hespeler Mill Pond on the Speed River. This work is required to create a naturally functioning fluvial system which has the resilience to accommodate potential development in the upstream reaches, and which has the potential to increase fish habitat potential.

There are several barriers to fish migration along Forbes Creek. Their removal would allow upstream migration but, as indicated previously, only the lower portion of the watercourse has permanent flow. It is possible that some species living in the Speed River could use Forbes Creek for spawning if barriers to migration were removed. White sucker might utilize the rocky areas in the lower reaches and northern pike might use the ephemeral reaches where vegetation is flooded in the spring. In the case of northern pike, the shallowness of the stream through its lower reaches might prevent or inhibit upstream migrations. Some of the barriers help to maintain the ponds in the subwatershed and some of the larger ponds contain fish. Removal of the ponds, although potentially benefiting migratory species, would reduce the habitat available for the fish in the ponds. The ponds also will provide some improvement in water quality when the upper portions of the creek are flowing.

The first two barriers to migration do not maintain ponds and thus their removal would appear to only enhance fish habitat by facilitating migration. For those barriers that maintain ponds there are fish habitat trade-offs to be considered when contemplating their removal.

The first barrier is located at the property line just upstream from the railway, and consists of a metal grate/weir. This effectively blocks all upstream fish migration from the Speed River and probably explains the low number of species present in the permanently flowing portion of Forbes Creek upstream from that point. Removal of this barrier would allow fish to move between the Speed River and the portion of Forbes Creek between this barrier and the next dam. This barrier does not create a pond or otherwise enhance fish habitat, so there should be no harmful alteration to fish habitat due to its removal, provided that it is done in a careful manner.

The next barrier is a concrete dam that, at one time, created an on-line pond. The dam no longer holds water and the pond is reduced to an area of watercress and other vegetation but the dam is still a barrier to migration. Once again, no harmful effect on fish habitat is anticipated if it is carefully removed.

Upstream barriers are dams associated with the larger upstream ponds (Ponds A, D and G). From a fish habitat perspective, the benefit of removing these structures and providing fish with access further upstream, or of creating a completely new channel, must be weighed against the fish habitat that the ponds provide, and their effect on downstream water quality and temperature. Although these ponds must increase water temperatures during the summers, when the creek is flowing, this portion of the stream was dry in the summers of 2000 and 2001, and may be dry during most summers. In these circumstances, water temperature is of less concern. Furthermore, in summers when the creek ceases to flow there would be little or no fish production from these reaches if the ponds were removed. Leaving these ponds in place and routing the stream around them in a new channel, or reconfiguring the stream in a way that allows the ponds to remain and fish to move into and through them from downstream would probably be the most beneficial management alternative from the standpoint of maximizing fish productive capacity.

The fish habitat benefits to be gained through channel reconfiguration further upstream from the ponds are, we believe, likely to be negligible given the absence of base flow and the stability of the existing condition.

C 3.1.2 Aquatic Options

Having examined the previous arguments, ten aquatic system alternatives were examined as follows:

1. Leave the system “as is”
2. Rehab lower portion only to Pond A
3. Rehabilitate lower portion of Creek to Pond D
4. Rehabilitate lower portion and upper portion (above Pond G to Blackbridge Road)
5. Take Ponds D and G off-line and create new creek adjacent to ponds

6. Removal of Ponds D and G and rehabilitate creek from Blackbridge Road to Pond A
7. Rehabilitate entire existing creek system including areas above Regional Road #24
8. Rehabilitate entire existing creek system including areas above Regional Road #24 and pond removal
9. Complete natural channel design for system south of Blackbridge Road
10. Complete natural channel design for entire system

All options which leave Ponds D and G in place also incorporate additional aquatic enhancement options which are discussed in Section C. All options also include the removal of Ponds B and C as they are redundant, purely aesthetic features and have a detrimental impact to stream habitat and water quality.

Option 1: Leave the system "as is"

This option requires little or no intervention other than to monitor the creek system as other works are undertaken. This alternative is the least intrusive to the channel from an intervention perspective, and would require little or no initial cost outlay. However, the system as it stands would remain in a degraded state, possible becoming more degraded over time. While there are little or no costs to this alternative over the short-term, over the long-term there would be maintenance costs related to bank stabilization and sediment removal.

Option 2: Rehabilitate lower portion only to Pond A

This option would rehabilitate the lower reaches of the creek system, up to and including Pond A. This would require removal of all concrete structures that currently act as barriers to sediment movement and also impair fish migration. While there are numerous opportunities to do major creek rehabilitation works in this section of the Forbes Creek system, there are locations in the current system where the channel is operating about as well as can be expected, given the size of the drainage basin. This option would require rehabilitating only those sections of the Forbes Creek system, which are currently exhibiting poor function. Pond A would have to be removed and a new channel created, and the locations where the flow goes underground would have to be brought back to the surface. Those sections of Forbes Creek which are operating properly will not require rehabilitation.

The value in this option is that it will rehabilitate the segments of the Creek which have water flowing in them for the majority of the year, which then makes that portion of the Creek accessible to fish moving upstream from the Speed River. From a geomorphological perspective, this portion of Forbes Creek, having permanent flow, has the highest potential for becoming a fully operational, functioning, Creek system.

Option 3: Rehabilitate lower portion of Creek to Pond D

This option would rehabilitate the entire Creek system downstream of Pond D. As with Option 2, only those sections of the Creek which are not functioning properly will be rehabilitated, however given the fact that the Creek system upstream of Pond A and Pond D has no real form to it, there can be extensive creek rehabilitation activity (and therefore costs) associated with this option. This option requires Pond A, as mentioned in Option 1, to be rehabilitated.

The value associated with this option is that it removes all concrete structures below Pond D, which then would allow unhindered movement of sediment in the downstream direction. This option also allows fish migration upstream to Pond D, and thereby increases the fish habitat potential. While the upper portion of the creek, i.e. above Pond D. did not have flow in it this summer, creating a formal structure to the creek would allow for stabilization during periods when flow is active at this location. Since there is already a semblance of a creek system in the location upstream of Pond A, the costs of rehabilitating this section will be relatively low, with a major expenditure being removal of the concrete bed and step immediately upstream of the lower pond.

Option 4: Rehabilitate lower portion and upper portion (above Pond G to Blackbridge Road)

This option includes the work outlined in Option 2. The rehabilitation of the upper portions of Forbes Creek from Pond G to Blackbridge Road would require a considerable amount of work, as there is no real creek system in operation in this location. Currently flow follows a swale into the upper ponds which, while historically it may have had a better fluvial form, has become overgrown to the point where no proper form exists. While there are a couple of sections where a bank and channel form have been found, they are few and far between and of little advantage. Therefore an entire creek design would be required at considerable cost.

The advantage of this alternative would be lessened in that this section of the creek does not have flow during dry periods and while the creation of form would help renaturalize the area, with little flow at times it would fall prey to filling in with vegetation as it currently exists.

Option 5: Take Ponds D and G off-line and create new creek adjacent to Ponds D and G

This option requires taking Ponds D and G offline and creating an entirely new creek channel adjacent to the ponds. This new section of creek would require a detailed design with sensitive issues surrounding tie-ins to the upstream and downstream creek system. The logic of this alternative is found in the fact that the on-line ponds act as barriers to sediment movement and would, in time, be subject to sedimentation. The ponds could, by accumulating sediment, cause erosion issues downstream. Taking the ponds off-line would alter the delivery of flow to the ponds, and may impact their ability to maintain volume. In addition, the Public Meetings and Workshops have indicated a desire to retain the ponds on-line, so there are social issues surrounding this option which must be considered.

Option 6: Pond removal and rehabilitate creek from Blackbridge Road to Pond A

This option requires all ponds to be removed and a detailed channel design be undertaken for the pond areas and the areas upstream where there is little or no creek form at present. This option is an ambitious one, given the desire to keep the ponds, as they are habitat assemblages, and given the fact that there is insufficient flow to maintain a creek system downstream of Blackbridge Road. It is, however a viable option if the ponds were to be removed altogether.

Option 7: Rehabilitate entire existing creek system including areas above Regional Road #24

This option requires a detailed comprehensive rehabilitation of the creek system from the headwater areas of the two branches upstream of Regional Road #24 to the Speed River. Given that there are few formal creek stretches upstream of Pond G, this option is limited in its utility, as rehabilitating a creek form which is not accessed by water except in Spring or during heavy rains would result in a reversion to the existing condition (heavily vegetated with no formal creek form being retained).

Option 8: Rehabilitate entire existing creek system including areas above Regional Road #24 and pond removal

This option is similar to Option 7 with the addition of Pond removal and subsequent design and construction of a creek where the ponds currently exist. Given the desire to retain the ponds and their value as habitat assemblages this is not a viable option.

Option 9: Complete natural channel design for system south of Blackbridge Road

This is an opportunity to create a new channel south of Blackbridge Road which conforms to the current flows and would therefore be to a degree self-sustaining. The option would require considerable effort in time and money, however would result in a system which, from a fluvial geomorphology perspective, would be properly functioning. This option would require not only creation of the creek system but also the establishment of a riparian zone to maintain the system, which currently does not exist to the proper buffer width at locations upstream of Ponds D and G. Countering this would be the lack of flow in the upper reaches. This lack of flow would over time result in the creek reverting back to its existing condition, being covered in with vegetation.

Option 10: Complete natural channel design for entire system

This option is similar to Option 9 but includes the portion of the system upstream of Blackbridge Road. The opportunities and constraints are similar to Option 9 with the exception that the overall cost would be significantly higher as a larger section of stream length would require attention. This renders this option impractical.

C 3.1.3 Fluvial Options Summary

Flow duration curves established from the post-development scenarios were utilized in the stream rehabilitation options.

Of the 10 options presented from the fluvial perspective, a number can be dismissed as not viable for different reasons. First, the removal of Ponds D and G and the flow into the ponds is impractical. Input from citizens through the public process clearly indicated that the ponds are important socially, and in fact they are habitat assemblages which should not be removed altogether. This eliminates Options 5, 6 and 8.

Given that there are no permanent flows upstream of Pond G during dry years, and given the fact that historically there was a channel in this location which has completely lost its form due to water quantity issues, any rehabilitation work or natural channel designs upstream of the Main Ponds is impractical. Add to this the fact that the system upstream of Pond G is stable and can accommodate the higher flows of spring and during heavy rains, and the cost of work in a stable area outweighs the benefits of the work, Options 4, 7, 9 and 10 are impractical and should be eliminated.

This leaves Options 1, 2 and 3 as the only realistic viable options from a fluvial perspective, though Option 9 has potential to be included if the proponents and other study components agree that a natural channel solution is warranted. Advantages and disadvantages of these three options are presented in **Appendix F**, **Table F1**.

C 3.1.4 Pond Options Summary:

Alteration of the existing on-line ponds (A, D and G) presents a range of management options. There are a number of factors that must be taken into consideration including fisheries, wildlife, wetland and public safety.

Maintenance of the permanent ponds is probably desirable for a number of reasons, including the maintenance of the fish habitat that they provide. The ponds probably also convey some water quality benefits when the stream is flowing, so their on-line status is beneficial in that regard. In coldwater streams, on-line ponds are often a concern because they increase water temperature but Forbes

Creek is primarily a warm water system (except downstream of the storm sewer outlet) so this is not a major concern.

Allowing fish to pass through the ponds by altering the outlet structures would permit seasonal fish access to areas upstream. This is always desirable, but the magnitude of benefits in this case are tempered by the intermittent nature of the creek. Nonetheless, if other considerations, including public safety, could be addressed, a new outlet configuration that permitted movement could provide modest benefits.

Enhancement of the ponds for fish habitat could also be undertaken, but once again the benefits are limited. The basic habitat limitations on species that can use the ponds will remain. With intermittent flow in this reach, there is little concern with this reach. It might be possible to maintain the ponds and still provide fish passage, but if the decision is for one or the other then in our opinion the benefits of the ponds probably outweigh the potential benefit of providing fish to this area from downstream.

Feasible actions, from a fisheries perspective are presented below.

Pond A

Pond A was completely dry during the summer of 2001. Its presence is of little or no benefit from a fisheries perspective and its elimination would be part of a natural channel restoration through this portion of the creek, if this were undertaken.

Ponds D and G

Ponds D and G contained water throughout 2001 and would therefore be expected to contain water under most if not all circumstances. These ponds contain fish and support wildlife including fish eating birds. They could be enhanced for fisheries and wildlife use by increasing the diversity of habitats and amount of cover available in and around them. Management options include:

1. Removing the barrier between the two ponds and joining them with a deepened channel would permit fish in pond D to move into pond G when conditions were more favorable there and vice versa (Optional).
2. To ensure safety, liability and maintenance issues are addressed; any control structure should be replaced or removed, as current structures are unsuitable public or even private Open Space areas.
3. Deepening a portion of Pond D near the outlet would provide a deeper refuge which would stay cooler than the shallow areas during the summer. Deeper water also provides a refuge from fish eating birds. A deeper outlet at the inlet would provide sediment control and refugia as well.
4. Providing cover along portions of the shoreline in the form of stumps or logs provides cover for fish as well as spawning substrates for some species such as fathead minnows which build nests on the undersides of logs and stones.
5. Tree planting around the ponds where the perimeter is now lawn will create shade, which reduces summer water temperatures and provides cover for fish, as well as discourages use by Canada geese.

C 3.1.5 Recommended Stream and Pond Management Plan

The preferred alternative from an aquatic and fluvial perspective is the rehabilitation of Forbes Creek from the Hespeler Mill Pond to Pond D, the enhancement of Ponds

D and G and the use of buffers to provide additional riparian habitat and protection.

Figures C 3.1.1 and C 3.1.2 provide details of the proposed stream and pond works respectively. Final designs, including an assessment of all engineering, biological (aquatic and terrestrial) and fluvial issues should be prepared as part of the implementation of the Greenspace Master Plan. Further discussions on channel design targets are presented in Section C 3.2.5. The basis for the design should be that a rehabilitated channel must be similar in nature to portions of the existing channel. As a result, the design should ultimately reflect characteristics of Site 2 or 3.

C 3.2 Water Management

C 3.2.1 Stormwater Management Alternatives

The following management alternatives have been considered for the Water Management system:

1. Do-nothing
2. Full water quality and quantity in existing ponds (adjust controls to achieve)
3. Full water quality and quantity in new development ponds
4. Water quality in development ponds and water quantity in existing ponds (adjust controls to achieve)
5. Water quality control only (can quantity make it to the Speed without impacts)
6. Water quantity control only (will ponds provide adequate water quality control with no impact to system)
7. Over-control in areas to allow under-control in other areas
8. Infiltration of stormwater runoff

An evaluation of the various alternatives in light of existing environmental conditions, governing policies, municipal and Conservation Authority guidelines eliminated Options 1, 2, and 6. Option 4 was eliminated as it was determined that the existing ponds were not able to accommodate the additional water fluctuations. Option 5 was eliminated as the existing (or any potentially rehabilitated channel) would not be able to accommodate the additional flows. Option 7 requires additional knowledge of development patterns and should be determined through additional modelling at the Draft Plan of Subdivision or Community Plan stage. Option 8 is required to ensure that baseflow is maintained and would be applicable to effectively all the previous Options. The result is that the preferred Management Alternative is Option 3.

C 3.2.2 Hydrologic Impact Analysis

Having determined that water quality and quantity controls are necessary, an evaluation of the ultimate extent of the impact of future development is required for a robust analysis.

As detailed in **Appendix D**, the existing conditions hydrologic model (Scenario 1) was modified to account for two future scenarios. Scenario 2 (proposed development) represents an assumed condition for areas already committed or proposed for development (e.g. new residential areas in subcatchments 115, 116, 117, 120 to 124 and 901). Scenario 3 (Potential Development) assumes full development upstream of Blackbridge Road. Scenario 3 also includes the proposed new alignment for Regional Road #24. Scenario 3 is conceptual in nature as this area has currently not been committed for any development. However, a Scenario 3 is necessary in order to fully understand how future conditions may impact the Forbes Creek subwatershed, to determine ultimate Regulatory floodlines and to allow the current study to make any necessary allowances. For modeling purposes Scenarios 2 and 7 assumed a 30 m setback from all natural features as shown on Figure C 2.2.1. This is a conservative estimate of flood flows as it utilizes a 30 m setback rather than the 50 m buffer recommended in this study (subject to future scoped EISs, see Section C 3.3).

Post-development conditions are represented in the hydrological model primarily through changes to the following input variables.

- Increased imperviousness, with a corresponding decrease in pervious area (no changes were made to existing wetlands and forest areas). The methodology for estimating impervious areas is outlined in **Appendix D**.
- Changes to the drainage network (represented by different flow cross-sections, and subcatchment length and width) to reflect post-development conditions. In past applications, this has included modifications to channel routing reaches representing future 'channelization' efforts, but with recent trends in 'natural' approaches in subwatershed management, the existing channel routing reaches remain unaltered.

For Scenarios 2, and 3, modifications to the subcatchments were primarily made as increases to impervious areas (e.g. Response Unit 1), with corresponding reductions in the 'open' area or 'low vegetative' cover response units (e.g. RUs 2, 3, 4 and 5). In cases where the revised impervious values were greater than 10%, adjustments were made to the overland flow routing parameters (e.g. decrease in main and off-channel travel times, decrease in overland lag). **Appendix D** outlines the differences between urban and rural subcatchment elements, in terms of timing or routing parameters.

Since all the new urban areas in Scenarios 2 and 3 were assumed to be residential development, an imperviousness of 50% was assigned in the revised impervious area calculations, the value used in the existing development in catchments 119 and 125.

Flood flow estimates were made using revised GAWSER subwatershed files for Scenario 2. The results are presented in **Table C 3.2.1**. The corresponding mean annual water balance summaries resulting from the 39 year continuous simulation for Scenario 2 are given in **Table C 3.2.2**. Flow duration curves showing the results for each scenario are given in Figure C 3.2.1 for Forbes Creek at the Speed River locations.

Table C 3.2.1 Summary of Flood Flow Estimates Scenario 2 Conditions with SWM Controls

No.	Point of Interest	Km^2	25 mm	1:2 yr	1:5	1:10	1:25	1:50	1:100	Reg 1.00
203	East Branch Wetland 203	0.693	0.246	0.326	0.645	1.140	1.780	2.420	4.290	5.900
603	East Branch at Regional Road #24	0.839	0.292	0.409	0.822	1.490	2.150	2.770	4.940	6.280
605	East Branch at Blackbridge Rd	1.183	0.281	0.415	1.230	2.320	3.350	4.060	6.130	9.050
607	Outlet of East Branch	1.340	0.293	0.448	1.620	3.070	4.420	5.400	8.080	10.600
209	West Branch at Regional Road #24	1.027	0.102	0.143	0.280	0.466	0.825	1.070	1.560	4.000
612	West Branch at Blackbridge Rd	1.056	0.238	0.340	0.623	0.937	1.060	1.340	1.830	4.090
615	Outlet of West Branch	1.235	1.100	1.370	2.300	3.490	4.410	5.250	7.130	4.690
617	Confl. East & West Branches	2.575	1.190	1.540	3.330	5.420	7.220	8.700	12.600	15.200
211	Forbes Creek at Pond G	2.720	0.485	0.768	2.170	4.160	6.150	7.470	11.200	16.300
213	Forbes Creek at GaugeNo.1 (Pond D)	2.963	0.402	0.698	2.330	4.560	6.900	8.410	13.200	18.700
215	Forbes Creek at Pond A	3.036	0.406	0.610	2.630	4.960	7.270	8.510	13.800	19.200
15	Sewer Outlet at GaugeNo.2	0.463	3.250	3.910	5.780	8.090	10.100	12.600	17.500	6.460
625	Forbes Creek outlet at Speed River	3.499	3.290	3.950	5.820	8.180	10.200	12.800	17.900	23.800
911	Area East, Part 1	0.038	0.003	0.138	0.465	0.643	0.776	0.922	1.230	0.533
912	Area East, Part 2	0.059	0.005	0.147	0.501	0.776	0.952	1.110	1.510	0.808
913	Area East, Part 3	0.066	0.006	0.129	0.344	0.576	0.771	0.930	1.300	0.873
914	Area East, Part 4	0.127	0.007	0.191	0.639	1.160	1.600	1.990	2.840	1.700
915	Area East, Part 5	0.111	0.047	0.120	0.374	0.719	1.010	1.250	1.820	1.290

Table C 3.2.2 Water Balance Summary Scenario 2 Without SWM Controls

			Water Balance Quantities (mm)					
Number	Location	Drainage Area (km^2)	Precip	ET/SUB	Runoff	Baseflow	Losses	Flow
603	East Branch at Regional Road #24	0.839	882.1	579.5	44.4	147.9	110.2	192.3
209	West Branch at Regional Road #24	1.027	882.1	576.6	55.0	109.2	141.2	164.2
617	Confluence: East and West Br.	2.575	882.1	560.1	71.7	224.3	26.0	296.0
619	Forbes Creek Inflow to Pond G	2.720	882.1	555.0	68.6	216.0	42.5	284.6
213	Forbes Creek at GaugeNo.1 (Pond D)	2.963	882.1	547.5	69.8	209.8	55.0	279.5
15	Sewer Outlet at GaugeNo.2	0.463	882.1	445.0	302.9	186.1	-51.9	489.0
625	Forbes Creek at Speed Outlet	3.499	882.1	533.3	100.3	221.3	27.2	321.6
913	Area East, Part 3	0.066	882.1	85.5	187.4	306.8	2.4	494.2

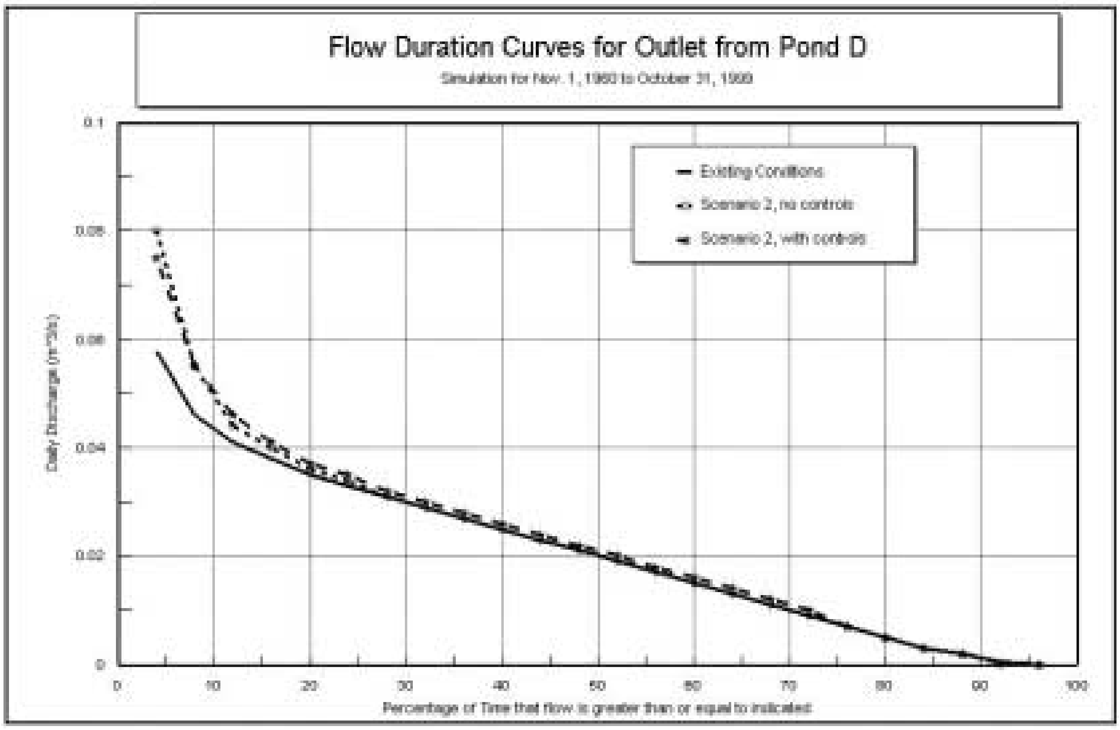


Figure C 3.2.1 Flow Duration Curves Forbes Creek at the Speed River

From examination of **Tables C 3.2.3, C 3.2.4**, and **C 3.2.5**

and Figure C 3.2.1 the following general trends can be seen:

1. The greatest changes in hydrologic response occurred in catchments with the greatest urban development.
2. Catchment 125 contributes the most significant amount of runoff, even in the ultimate scenario.

To get some idea of the magnitude of the Stormwater Management volumes required in each subwatershed, the Scenario 2 hydrology model was modified by inserting detention pond elements at the outlet of subcatchments 115, 116, 117, 120, 123, 124, 127, 911, 912, 913 and 914. These detention ponds were sized for both extended detention (water quality purposes, and with 48 hour drawdown providing Level 1 control as per MOEE '94) and for controlling the peak flows from the 2 year to 100 year return period 3 hour Chicago Storm using the City of Cambridge IDF (Intensity Duration Frequency) information. **Tables C 3.2.3** and **C 3.2.4** show the volumes required for stormwater control.*

Table C 3.2.3 Summary of Extended Detention Volumes for Scenario 2

Subcatchment	Extended Detention Volume (m^3)	48 hour Drawdown Rate (L/s)	Volume/area (m^3/ha)	Volume/Impervious Area (m^3/ha)
115	407	2.4	83.1	277
116	94	0.5	62.7	249
117	1410	8.2	99.4	239
120	1090	6.3	102	344
123	2020	11.7	101	279
124	423	2.4	96.2	291
127	390	2.2	53.4	284
911	473	2.7	123	1320
912	826	4.8	140	584
913	917	5.3	139	275
914	925	5.4	72.8	260

* **Table C 3.2.5** summarizes the peak outflows from the subcatchments with stormwater controls for the 2 year through 100 year events.

Table C 3.2.4 Summary of Required Storm Volumes for Scenario 2				
Subcatchment	**100 Year Detention Volume (m^3)**	**Peak Outflow (m^3/s)**	**Volume/area (m^3/ha)**	**Volume/ Impervious Area (m^3/ha)**
115	1220	1.22	249	830
116	388	0.451	259	1030
117	5350	2.02	377	906
120	4880	1.08	456	1540
123	7930	2.65	398	1100
124	1570	0.736	357	1080
127	1500	1.37	205	1090
911	760	1.23	200	2150
912	1580	1.51	268	1120
913	2510	1.30	380	752
914	3350	2.83	264	943

Table C 3.2.5 Summary of Peak Subcatchment Outflows									
Node No.	**Outflow Location**	**Area (km^2)**	**Peak Flows (m^3/s)**						
			1:2 yr	**1:5**	**1:10**	**1:25**	**1:50**	**1:100**	**REG**
115	Subcatchment 115	0.049	0.100	0.309	0.531	0.708	0.869	1.220	0.674
116	Subcatchment 116	0.015	0.030	0.101	0.182	0.246	0.313	0.451	0.203
117	Subcatchment 117	0.142	0.136	0.413	0.777	1.090	1.360	2.020	1.600
120	Subcatchment 120	0.107	0.121	0.260	0.453	0.625	0.758	1.080	1.030
123	Subcatchment 123	0.199	0.204	0.559	1.040	1.460	1.810	2.650	2.190
124	Subcatchment 124	0.044	0.051	0.167	0.297	0.411	0.510	0.736	0.536
127	Subcatchment 127	0.073	0.091	0.331	0.551	0.731	0.894	1.370	0.879
911	Subcatchment 911	0.038	0.003	0.138	0.465	0.643	0.776	0.922	1.230
912	Subcatchment 912	0.059	0.005	0.147	0.501	0.776	0.952	1.110	1.510
913	Subcatchment 913	0.066	0.006	0.129	0.344	0.576	0.771	0.930	1.300
914	Subcatchment 914	0.127	0.007	0.191	0.639	1.160	1.600	1.990	2.840

C 3.2.3 Evaluation of Stormwater Practices

The Ministry of the Environment and Energy (MOEE) published the "Stormwater Management Practices Planning and Design Manual" in 1994. This manual provides guidelines for the design of SWMPs (stormwater management practices) to address the management of stormwater quality and quantity. The selection of SWMPs should take into primary consideration the preservation of the hydrologic cycle, that is, to maintain infiltration, evapotranspiration and runoff characteristics as close as possible to existing conditions. Based on this goal, the MOEE have grouped SWMPs into three categories based on their form and function i.e. Lot level controls, conveyance controls and end-of-pipe controls. SWMPs were screened as discussed below with the most desirable form of SWMP listed first. **Table C 3.2.6** provides a summary of the different SWMPs and an indication of which SWMPs will be given further consideration.

Table C 3.2.6 Stormwater Management Practice

SWMP	Water Quality	Flooding	Erosion	Recharge	Other			Long Term Effectiveness ***	Recommended for Further Consideration
					Temp.	Spills	Bacteria		
LOT LEVEL CONTROLS									
Lot Grading	⊠	⊠	⊠	■	⊠		⊠	7	Yes
Rear Yard Ponding	⊠	⊠	⊠	■	⊠		■	7	No
Roof Leader Soakaway Pits	⊠	⊠	⊠	■	■		■	6	Yes
Oil/Grit Separator (offline or bypass)	⊠					■		4	Yes
CONVEYANCE CONTROLS									
Pervious Pipes	■*	⊠	⊠	■	■	*	⊠	4	Yes
Pervious Catchbasins	■*	⊠	⊠	■	■	*	⊠	3	No
Grassed Swales	⊠		⊠	⊠				7	Yes
Infiltration Trench	⊠**	⊠	⊠	■	■	*	■	4	Yes
Water Quality Trench	■	⊠	⊠	■	■	*	■	N/A	No
END OF PIPE CONTROLS									
Wet Pond	■	■	■		*	■	⊠	10	Yes
Dry Pond with Forebay	■	■	■			■		7	Yes
Wetland with Forebay	■	■	■		*	■	⊠	9	Yes
Sand Filter	■	⊠	⊠			⊠	⊠	8	Yes
Infiltration Basin	⊠**	⊠	⊠	■	■	*	■	2	No
Vegetated Filter Strip	■		⊠	⊠	⊠			5	Yes
UV Disinfection							■	7	Yes

■ highly effective (primary control)
⊠ limited effectiveness (secondary control)
not effective
* may have adverse effects
** effective pollutant removal (TSS, nutrients, metals, bacteria) but suspended solids removal reduces their longevity and effectiveness
*** 1 not reliable; 10 very reliable
N/A Unknown

ADAPTED from the Stormwater Management Practices Planning and Design Manual, MOEE, 1994.

C 3.2.3.1 Lot Level Controls

Lot Level Control can consist of the following techniques:

- rear yard ponding or ponding in swales;
- subsurface soakaway pits which accept runoff from rear yards and/or rooftops; and
- foundation drain sump pumps to soak away pits instead of to the storm sewer.

Ponding in the rear yards will reduce the volume and erosion potential of runoff. Water ponds until it infiltrates or evaporates. Ponding in rear yards may be considered a nuisance since it may take 24 to 48 hours for the water to disappear.

Infiltration should be promoted on public lands to the greatest extent possible as this will ensure that the facility remains in place while also allowing for long-term maintenance issues to be addressed. However, infiltration facilities are not to be place in road rights-of-way as this may lead to the deterioration of the road bed. Buffer zones and parkland areas are preferred places for the infiltration of storm runoff.

However, private infiltration facilities may also be acceptable. Roof leader discharge to soakaway pits provides benefits for mitigating the flooding and erosion potential of stormwater runoff. In addition, the soakaway pits allow direct infiltration of stormwater runoff from rooftops and recharge to the groundwater table (i.e., no evaporation losses). Soakaway pits have been implemented in numerous areas (e.g., Toronto, Waterloo and Maryland) and have proven successful. The advantage of the soakaway pit is that it causes less inconvenience to the homeowner than surface ponding and there are no evaporation losses. The potential for clogging is reduced compared to end-of-pipe infiltration techniques since it only accepts relatively clean roof drainage. Detailed design of these facilities should incorporate a filter or screen to prevent debris from entering the infiltration facility.

Roof Leader Soakaway Pits are to be entirely located on individual lots and not to straddle lot lines. In general they should be constructed to MOEE '94 standards however, in general, the City of Cambridge prefers that the facilities be located 5 metres from structures, 4' below grade for frost protection, above the water table and below the footing. An overflow outlet is required to grade. This complex set of criteria should be reviewed at the detailed design stage to see if all the conditions are met and if not, the report should address how the variation is to be mitigated. The Guelph system, consisting of an infiltration trench with an overflow to the storm sewer system, is a recommended control technique. This system is also applicable to conveyance and end-of-pipe systems. In addition, a water budget analysis is necessary to warrant development strategies. However, due to the limitations of site-specific water budgets, infiltration targets for various soils and subcatchments have been provided in **Table B 1.5.3**.

Homeowners should be provided with education material explaining the theory, practice and benefits of soakaway pits as they will ultimately be responsible for maintenance of the structures. The homeowner should also be made aware of location of the facility, maintenance requirements (eg debris), potential impacts due to building renovation, fence and pool construction and the potential requirement to relocate the facility. The City of Cambridge Building Department currently does not monitor the installation or certify the completion of private infiltration facilities. The City currently relies on the private consultant to ensure that the facility is correctly installed and operational.

Reduced lot grading from the standard 2% to 0.5% will increase the depression storage on lots and therefore mitigate the flooding and erosion potential of stormwater runoff. It is recommended that the 2% grading be maintained at least 4 m from the building. This technique can be easily implemented in areas where the land is naturally flat. However, for hilly areas this technique may not be feasible. Ponding on lots may be considered a nuisance since it may take 24 to 48 hours for the water to disappear.

Sump pumping of foundation drains to soakaway pits instead of directly to the storm sewer will be beneficial for mitigating flooding and erosion concerns and enhancing infiltration/recharge. Foundation drainage is relatively clean water and removal from the storm sewer system will reduce the volume of water which will require treatment.

Oil/grit separators may be implemented on the lot level for commercial/institutional developments. The oil/grit separators provide primary treatment of low flows from the site to remove oils and sediment and could be located on public property to allow access for City staff to perform regular maintenance.

It is anticipated that a combination of several of the measures will be required to meet water quality and water quantity targets. Roof leader soakaway pits will be implemented for all development areas. Localized infiltration of runoff in park blocks and buffers is also required. The following management targets will be addressed:

- volume of runoff (flood and erosion control);
- infiltration (groundwater recharge); and
- water quality (temperature, phosphorous, bacteria).

For additional utilization of the stormwater resource, rain barrels are recommended.

C 3.2.3.2 Conveyance Controls

Conveyance controls can consist of the following techniques:

- perforated pipe systems (such as a modified Etobicoke exfiltration/filtration system);
- grassed swales;
- pervious catchbasins;
- infiltration trenches;
- water quality trench;
- oil/grit separators ; and
- sand filters.

Perforated pipe systems will mitigate the flooding and erosion potential of stormwater runoff. They will also increase the recharge rate to the groundwater table. A perforated pipe system requires some form of pre-treatment of stormwater runoff to remove sediment to reduce clogging potential. Pre-treatment may be achieved via a grassed boulevard. Historically, perforated pipe systems have been unreliable in terms of long term performance. In addition, the exfiltration of road drainage without pretreatment has the potential of contaminating the regional aquifer since stormwater runoff may contain elevated levels of metals, oil/grease and chlorides.

Grassed swales provide benefits by filtering and attenuating stormwater runoff if designed properly. Basically, the swales should be designed with wide, flat bottoms and a grade of 1% or less. Check dams may be incorporated into the swale to enhance their performance.

Pervious catchbasins are normal catchbasins with a larger sump and are physically connected to exfiltration storage media beside the catchbasin. The sump allows for pre-treatment of the stormwater runoff. Pervious catchbasins have not been extensively implemented and their performance is still being assessed. As with perforated pipe systems, there is the potential of contaminating the regional aquifer since road drainage may contain elevated levels of metals, oil/grease and chlorides.

Infiltration trenches may be incorporated into a swale system where water is allowed to percolate into an infiltration gallery. They should be implemented for small drainage areas with pre-treatment of the runoff provided. Historically infiltration trenches have not been reliable mainly because a large amount of water is expected to infiltrate into a small area and they are susceptible to clogging due to sediment in the water. The City of Cambridge will not accept infiltration facilities within the right-of-way due to complications with the road bed and services. Open Space areas may present an opportunity to provide additional infiltration should other methods be inadequate or unable.

Water quality trenches were not evaluated in the SWMP Planning and Design Manual, however, they have been proposed by several developments within the Region of Waterloo. The water quality trenches would be constructed beneath roadside ditches throughout the development. Road runoff would be temporarily ponded in the ditch by check dams placed at catchbasin locations. The ponded water will in turn percolate through the topsoil layer (average depth of 0.15 m) into the water quality trench. At a depth of 0.3 m, ponded water will overflow the crest of the ditch inlet catchbasin and enter the storm sewer system. Stormwater runoff which has percolated through the trench will pass through a gravel and sand layer and be filtered and cooled. A portion of the percolated water will infiltrate into the native soils. A discharge pipe near the bottom of the trench will ensure that the trench drains in a reasonable period of time in anticipation of the next storm.

This design will not allow the prevention of runoff entering the infiltration trench, therefore, there is the potential that contaminants entering the system may enter the groundwater. Therefore, this infiltration system will not be utilized within the Forbes Creek subwatershed due to potential impacts to the regional aquifer.

It is anticipated that a combination of several of the measures will be required to meet water quality and water quantity targets. Grassed swales will be implemented where practical (to be determined at the site development stage). The following management targets will be addressed:

- reduction in peak flows (flooding and erosion); and
- water quality (sediment).

Some form of perforated pipe/infiltration trench system may be implemented where possible in order to promote additional infiltration across the subwatershed. The system could be the Guelph infiltration system or a modified form of the successful Etobicoke exfiltration system where clean water passes through a perforated pipe into a stone trench and infiltrates to recharge the groundwater aquifer. If the system will be accepting road runoff or other potentially contaminated water, then pre-treatment will be required. The following management targets will be addressed:

- volume of runoff and peak flow (flooding and erosion);
- infiltration (groundwater recharge); and
- water quality (temperature, sediment).

Three measures are recommended for pre-treatment of road runoff before it is allowed to enter an infiltration trench: sand filters, manhole oil/grit separators and wetlands. These measures could be used in isolation or combined to provide the required level of pre-treatment. The design of the measures would include manual shut-off valves to the infiltration trenches to prevent stormwater from entering in the event of a spill. An alternate outlet from the pre-treatment facility would allow for removal and/or treatment of any contaminated water. **Table C 3.2.7** provides a summary of the advantages and disadvantages of the three pre-treatment measures. The appropriateness of pre-treatment measures will be reviewed at the Draft Plan stage in order to address any site specific issues including the potential effects on Locally or Regionally Environmentally Significant Discharge Areas (RESDAs). Infiltration in Open Space areas may also be investigated at this time.

Table C 3.2.7 Advantages and Disadvantages of Pre-Treatment Measures for Road Runoff

Pre-Treatment Measure	Advantages	Disadvantages
Sand Filter	Because stormwater must infiltrate through layers of soil, sand and gravel there is a significant delay from when stormwater enters the system to when it enters the infiltration trenches. Therefore, closure of the shut-off valves could be completed before any "contaminated" stormwater enters the trenches. All sediment will be filtered out of the stormwater runoff. Heavy metals and hydrocarbons will also be filtered out since they tend to associate with sediment particles. Will address erosion (reduction in peak flows and volumes) and water quality (sediment, phosphorus, bacteria, hydrocarbons) management targets.	The maintenance requirements of a sand filter are high. Removal of sediment and litter will be required once or twice every year. The sod and sand layer may require regular replacement to ensure that infiltration through the filter is maintained. The frequency of this type of maintenance is unknown since sand filters have not been used extensively in Canada. It is anticipated that if sand filters are used in isolation (i.e., no pre-treatment of runoff before it enters the sand filter) more frequent maintenance will be required.
Manhole Oil/Grit Separator	During low flow events hydrocarbons and large sediment particles will be removed. Maintenance is easily carried out by vacuuming. System can be readily maintained for scheduled maintenance. Will address water quality (sediment, hydrocarbons) management targets.	Smaller sediment particles will be directed to the infiltration trenches. Proper equipment is required for maintenance and disposal of sediment. During storm events there would be only a short delay from when "contaminated" stormwater enters the system to when it is directed to the infiltration trench. Therefore some "contaminated" stormwater may enter the trenches before the valves are closed.
Constructed Wetland	Because the design of the wetland includes a restricted outlet there would be a delay from when "contaminated" stormwater enters the system to when it is directed to the infiltration trench. Therefore, closure of the shut-off valves could be completed before a significant amount of "contaminated" stormwater enters the trench. Removal of accumulated sediment is only required once every five years. Will address erosion (reduction in peak flows and volumes) and water quality (sediment, phosphorus, bacteria, hydrocarbons) management targets.	The facility will not remove all sediment from runoff, therefore, the finer particles may clog the trench over time. The facility will not remove hydrocarbons except that which remains associated with sediment particles.

C 3.2.3.3 End-of-Pipe Controls

Public end-of-pipe controls can consist of the following techniques:

- wet ponds;
- wetlands;
- dry ponds;
- infiltration basins;
- filter strips;
- sand filters;
- oil/grit separators; and
- UV disinfection.

Wet ponds and wetlands are the most reliable form of stormwater management facility. Both the wet pond and the wetland incorporate a permanent pool into their design which prevents the re-suspension of sediment and provides extended settling. Aquatic plants assist in the removal of pollutants. Environmental impacts include potentially increasing the downstream water temperature. These facilities are recommended for further consideration in the development of a management plan.

Dry ponds have no permanent pool and therefore, the removal of contaminants is purely a function of the drawdown time. Resuspension of the accumulated sediments with each subsequent storm is also a concern because there is no permanent pool. Overall, dry ponds are less effective than wet ponds for sediment removal. However, dry ponds may be more desirable if downstream water temperature is a concern.

Infiltration basins are above ground pond systems which are constructed in highly pervious soils. Water infiltrates into the basin and either recharges the groundwater system or is collected by an underground pipe network leading to a downstream outlet. Historically, infiltration basins have not had long-term reliability. One of the main problems is that runoff from a large drainage area is expected to infiltrate into a small area and they are susceptible to clogging, due to sediments in the water. Infiltration basins will not be considered in the development of the management plan.

Filter strips consist of a level spreader and a variety of vegetative plantings which filter the sediment from stormwater and encourage infiltration. Filter strips can be effective for small drainage areas (less than 2 ha) and should be used in combination with other management practices.

Sand filters can be implemented above ground or below ground as part of a storm sewer infrastructure. Generally they are intended for drainage areas less than 5 ha. Sand filters consist of a sand layer within a minimum depth of 0.5 metres. A layer of sod (0.15 metres to 0.3 metres) may be placed above the sand layer to enhance the appearance of the sand filter. Below the sand layer is a layer of gravel 0.15 metres to 0.3 metres in depth. Within the gravel layer are perforated pipes which convey filtered stormwater to an outlet. The trench may be encased in an impermeable liner to prevent stormwater from infiltrating into the native soils.

Oil/grit separators as an end-of-pipe treatment are generally ineffective as stand alone water quality enhancement. They are most effective for low flow spill conditions. Oil/grit separators as an end-of-pipe treatment will not be considered in the development of a management plan, but may be considered as part of a treatment train within the storm sewer infrastructure.

UV disinfection can be very effective in reducing bacteria levels, particularly where body contact activities (e.g. swimming) are planned in downstream reaches. However, there are several drawbacks. UV disinfection is generally only effective during low flow periods and its effectiveness is reduced by the turbidity of the water. The decision about whether to use UV disinfection or not will be based on detailed design of the facility and on-going monitoring.

It is anticipated that a combination of several of the measures will be required to meet water quality and water quantity targets.

Wetlands will be implemented when required, based on the level of upstream control. The following management targets will be addressed:

- flooding (reduction in peak flows);
- erosion (reduction in peak flows); and
- water quality (sediment, phosphorous, bacteria).

Design of the wetlands must consider impacts to the receiving water bodies such as temperature and dissolved oxygen levels. Techniques such as shading of the facilities, bottom draw outlets and underground gravel outlets will be considered at the draft plan level for the individual residential, commercial, or institutional developments. If preferred that wetlands are non-fenced and located outside of any Provincially Significant Wetland.

Vegetated filter strips will be considered as tertiary treatment to other stormwater management practices. The practicality of implementing them will be determined at the site development stage. The following management targets will be addressed:

- peak flows (flooding and erosion); and
- water quality (sediment).

It is recommended that the preceding stormwater management practices be implemented before UV disinfection is considered for the subwatershed. Extended detention facilities, such as wet ponds and wetlands, are capable of reducing bacteria levels. Their effectiveness should be evaluated through a monitoring program. If it is determined that the number of excedences over a year are unacceptable, then implementation of UV disinfection should be considered at the stormwater management pond locations.

C 3.2.3.4 Screened Stormwater Management Practices

Based on the preceding analysis, Development Scenario 2 may be implemented within the subwatershed and the expanded study area with restrictions to land use, as discussed in Section C2.0. Future development must implement the necessary stormwater management practices and the preceding sections have provided a summary of the stormwater management practices which will need to be implemented in the subwatershed in order that management targets will be met.

The facilities required to provide the water quality and quantity controls noted in **Table C 3.2.3** and **C 3.2.4** are shown on Figure C 3.2.1. In addition, facilities discharging directly to the Speed River will require volume control to ensure that the Speed River PSW is not impacted. A scoped EIS will be required to address micro drainage issues.

C 3.2.3.5 Environmental Issues

To assist in augmenting the erosion control measures, Forbes Creek should be renaturalized and a buffer established and maintained as development proceeds. Measures outlined in Sections C3.2 and C3.4 will help to stabilize the existing erosion. Bioengineering techniques will also be necessary along some sections of the creek (to be determined at the site development stage). Other areas of naturalization include the revegetation of the natural riparian corridor. Final discharge points, wetland microdrainage issues and infiltration techniques are to be addressed in a scoped site EIS at time of development. (As per **Table E 2.5.1**).

Based on the 39 year simulations and in consultation with the project hydrogeologist, **Table C 1.5.3** provides estimates of the mean annual infiltration requirements (or targets) for a selected number of subcatchments.

Finally, the placement and functional design of stormwater management facilities in the lower subwatershed has important implications for natural habitats. Current literature (e.g. Azous and Horner, 2001, and others) indicates that natural wetlands are highly vulnerable to damage from alteration of water quantity and quality following urbanization of watersheds. Inadequate "functional buffering" of these systems from urban runoff typically results in reduced vegetation biodiversity (i.e. conversion to monocultures), and elimination of suitable breeding habitat for key wildlife (especially amphibians). The stormwater management strategy should address the avoidance of these impacts through a) adequate understanding of existing predevelopment quantity/quality conditions; b) placement of facility outlets downstream of hydrologically sensitive wetland areas; and c) provision of adequate buffers between development and wetlands.

C 3.2.4 Rehabilitation of Existing Storm Sewer System

The storm sewer system that services the existing residential development in Forbes Creek has been in place for many years. Development generally occurred without the benefit of water quality or quantity controls (other than a surcharge pond located adjacent to Regional Road #24).

The storm sewer system contributes relatively cool baseflows to the downstream portion of Forbes Creek. There are normal water quality issues (water quality is typical of urban catchments) and water quantity issues are minimal since the discharge point is located at the end of Forbes Creek.

Our study has identified several options for the rehabilitation of the existing storm sewer system as follows:

Incorporating additional water quality control in upstream areas through the placement of ponds or oil-grit separators;

1 Placement of a water quality facility at the downstream end of the pipe system;
2 Overcompensate for water quality and quantity in the remainder of Forbes Creek;
3 Additional lot-level, at-source controls (infiltration pits, etc); and
4 Do nothing.

Water quality and quantity controls have not been identified as required measures. It would be prudent to review and analyze their requirements but ultimately, rehabilitation is not legislated nor is it necessary other than to marginally improve the existing system.

In addition, upstream areas have limited opportunities for the placement of new surface control features such as stormwater management ponds. Oil-grit separators are expensive and can only service a limited area (less than 1 or 2 hectares generally). There may be an opportunity to improve the performance of the existing surcharge pond but this would only serve a small area, provide only peak control and does not provide water quality improvements.

Overcompensation in other areas of the Forbes Creek subwatershed would have minimal benefits considering:

1 the limited need and
2 the fact that overcompensation does not reduce the loadings from the point source but only

services to marginally lower the total loadings on the Mill Pond.

Additional controls in upstream areas would be expensive and ineffective.

The most practical and viable alternative would be to investigate the possibility of providing additional controls at the downstream end of the existing pipe system. The pipe could be shortened and a wetland treatment facility could be constructed at the new terminus. The design could be integrated into the fluvial rehabilitation proposed for the stream reach from Pond D to the Hespeler Mill Pond.

It is recommended that the final Stream Rehabilitation Plan include the possibility of incorporating water quality controls for the existing storm sewer system.

C 3.2.5 Channel Design Considerations

The flow exceedance tables for Scenarios 1 and 2 (with controls) is presented in **Table C 3.2.8** and **C 3.2.9** respectively. Critical flows in the upper areas were computed to be 0.001 cms while the critical flow is 0.02 cms at the outlet. The latter value will be used for design purposes so that the channel will be approximately equal to that of a naturally occurring channel in existing conditions (see Site 2 in **Table B 4.4.4**).

The tables show that in-stream erosion targets have been met for post-development controls, i.e. the flow-duration in Scenario 2 (with controls) is similar to, or less than, existing conditions. As a result, the proposed facilities provide appropriate levels of flow control.

Table C 3.2.8 Stream Discharge Exceedance Summary – Scenario 1 (Existing Conditions)

	Location: Confluence: East and West Br.				Location: Confluence: Forbes Creek at Speed Outlet			
	Period: 1960/11/ 1 to 1999/10/31				Period: 1960/11/ 1 to 1999/10/31			
	Threshold 1				Threshold 2			
Month	**Total Hours**	**Flow**	**Hours**	**PCT**	**Total Hours**	**Flow**	**Hours**	**PCT**
JAN	29016.	0.001	28913.	99.6	29016.	0.020	23207.	80.0
FEB	26424.	0.001	26424.	100.0	26424.	0.020	18008.	68.2
MAR	29016.	0.001	29016.	100.0	29016.	0.020	24774.	85.4
APR	28080.	0.001	28080.	100.0	28080.	0.020	28078.	100.0
MAY	29016.	0.001	29016.	100.0	29016.	0.020	27777.	95.7
JUN	28080.	0.001	28080.	100.0	28080.	0.020	15032.	53.5
JUL	29016.	0.001	29016.	100.0	29016.	0.020	5693.	19.6
AUG	29016.	0.001	28596.	98.6	29016	0.020	4962.	17.1
SEP	28080.	0.001	24453.	87.1	28080	0.020	4968.	17.7
OCT	29016.	0.001	22737.	78.4	29016	0.020	8315.	28.7
NOV	28080.	0.001	25694.	91.5	28080	0.020	14794.	52.7
DEC	29016.	0.001	28141.	97.0	29016	0.020	21132.	72.8
Total	**341856.**	**0.001**	**328166.**	**96.0**	**341856**	**0.020**	**196740.**	**57.6**

Table C 3.2.9 Stream Discharge Exceedance Summary – Scenario 2 (with controls)

	Location: Confluence: East and West Br.				Location: Confluence: Forbes Creek at Speed Outlet			
	Period: 1960/11/ 1 to 1999/10/31				Period: 1960/11/ 1 to 1999/10/31			
	Threshold 1				Threshold 2			
Month	**Total Hours**	**Flow**	**Hours**	**PCT**	**Total Hours**	**Flow**	**Hours**	**PCT**
JAN	29016.	0.001	28857.	99.5	29016.	0.020	21793.	75.1
FEB	26424.	0.001	26424.	100.0	26424.	0.020	17198.	65.1
MAR	29016.	0.001	29016.	100.0	29016.	0.020	24278.	83.7
APR	28080.	0.001	28080.	100.0	28080.	0.020	28077.	100.0
MAY	29016.	0.001	29016.	100.0	29016.	0.020	27252.	93.9
JUN	28080.	0.001	28080.	100.0	28080.	0.020	14176.	50.5
JUL	29016.	0.001	29016.	100.0	29016.	0.020	6839.	23.6
AUG	29016.	0.001	28511.	98.3	29016.	0.020	6351.	21.9
SEP	28080.	0.001	24177.	86.1	28080.	0.020	6149.	21.9
OCT	29016.	0.001	22565.	77.8	29016.	0.020	9101.	31.4

Table C 3.2.9 Stream Discharge Exceedance Summary – Scenario 2 (with controls)

Location: Confluence: East and West Br.					Location: Confluence: Forbes Creek at Speed Outlet			
Period: 1960/11/ 1 to 1999/10/31					Period: 1960/11/ 1 to 1999/10/31			
Threshold 1					Threshold 2			
Month	**Total Hours**	**Flow**	**Hours**	**PCT**	**Total Hours**	**Flow**	**Hours**	**PCT**
NOV	28080.	0.001	25677.	91.4	28080.	0.020	14953.	53.3
DEC	29016.	0.001	28106.	96.9	29016.	0.020	20630.	71.1
Total	341856.	0.001	327525.	**95.8**	**341856**	**0.020**	**196797**	**57.6**

C 3.3 Natural Heritage And Greenspace Systems

As described in Section C 1.0 of this report, relevant Provincial, Regional and City policies form the basis for the determination of the natural heritage system to be protected within the subwatershed. The following sections present considerations of the form and content of this system.

C 3.3.1 Existing Functions, Attributes and Linkages

As discussed in Sections A and B, the wetland, riparian and upland habitat features in the subwatershed contain attributes including plant and animal species organized into ecological communities. These features are reliant upon and affected by a) physical functions related to ground and surface water, soils, nutrients, and local microclimate, by b) biological functions related to habitat structure (e.g. type of cover, age and extent of habitats, migration between habitats within and beyond the subwatershed), proximity to other biotic or abiotic features, and by c) the various effects of human presence in the subwatershed. Existing land uses in the subwatershed have a very important bearing on the current composition, quality and functions of the ecosystem.

The predominantly agricultural character:

- provides significant functional benefits, allowing many wildlife species to move relatively freely between habitats
- constrains the movement of some species (such as forest interior plants)
- favours plant and animal species, that are generally tolerant of, or benefit from agricultural practices (e.g. agricultural weeds and exotics; White-tailed Deer, Raccoons and Canada Goose feeding on corn; Red Fox and Coyote reliant on field mice and voles)
- inhibits the development of more extensive habitats that could sustain a richer flora and fauna (such as marsh-dwelling birds or a wider range of forest interior species)
- is associated with regular landscape disturbances, which may degrade natural habitat quality due to erosion, use of chemicals, or impacts from livestock.

Existing residential uses also affect plants, wildlife and habitat quality, by:

- deterring the successful breeding of forest interior birds (see Friesen, 1995)

- causing road kills, or preventing the migration of certain amphibians between seasonal habitats
- favoring wildlife adapted to human settlements (Raccoons, Red Fox, Striped Skunks, European Starlings, Blue Jays, etc.)
- exposing wildlife to predation or disturbance by domestic pets
- exposing habitats and species to the negative impacts of noise, light, elevated runoff, and contaminants
- introducing plant species that are potentially invasive (Norway maple, periwinkle etc.)
- creating impacts on remnant habitats (trampling, informal trail development, garbage and debris, microclimate alteration).

Regional Road #24 traverses the subwatershed, which:

- contributes to roadkill of wildlife species, particularly terrestrial species
- restricts wildlife movements due to habitats fragmented by road embankments
- introduces road salt and other contaminants into the landscape, affecting habitat quality and reducing species composition
- creates road noise which is known to affect use of habitats by the avian community when noise levels consistently exceed 50 decibels (Forman and Hersperger, 1996).

C 3.3.2 Management Alternatives

The management alternatives for the Natural Heritage and Greenspace System in the subwatershed consist of increasingly stringent measures to maintain and enhance natural features and functions as areas within the subwatershed undergo changes in land use. A brief overview of available strategies which can be included in alternatives is presented below and in **Table C 3.3.1**.

Environmental Impact Studies

Completion of Environmental Impact Studies or Statements (EIS) prior to development is a standard requirement under Provincial, Regional and City policies, and is intended to guide careful development, ongoing management, and monitoring in the vicinity of wetlands and other significant natural features. This Subwatershed Study comprises a Comprehensive EIS that will set the standards for future development, as prescribed for the Preferred Alternative. Under some alternatives, a site specific EIS may be undertaken if further refinement of buffer requirements is deemed to be necessary. Section E of this report includes guidelines for scoped EISs in key areas of the subwatershed under the preferred management alternative.

Buffers

Buffers are spatial separators, barriers (e.g woody plantings, fences), and/or areas with special zoning, intended to help ecological systems a) adapt to physical changes associated with development, and b) maintain their ecological integrity in the longer term under altered land uses. Buffers may be beneficial in urban, agricultural or rural residential settings. Buffers ideally should be determined on a site specific basis, informed by available science. Sometimes buffers are combined with trail corridors, or stormwater management facilities; however, the impacts of placement of these facilities on adjoining features and the overall corridor functions must be carefully examined.

Small private or public spatial buffers (3-10 m) may be used to protect simple situations such as vegetated edges with no associated sensitivity issues (e.g. wet soils, closed canopy, tall trees, specialized habitats). Larger buffers (15 to 100+ m) in public ownership may be used to protect features that are reliant on sensitive hydrological conditions, that support vulnerable habitats and species (e.g. forest interior or area-sensitive wildlife; habitats vulnerable to noise, nutrient or road salt impacts), or that currently form part of functional wildlife corridors. Corridors composed of natural habitats plus buffers may have to be quite large to sustain residency by some species (e.g. 0.6 km wide to support resident White-tailed Deer - Harrison, 1992). Buffers require regular monitoring and management, to ensure that they are not rendered less effective by urban impacts.

Buffers are an effective tool which will likely be utilized to a varying extent throughout the subwatershed. Specific recommendations for buffer dimensions are discussed under Natural Heritage System Alternatives in Section C 3.3.3. The following discussion provides the rationale for the application of buffer and enhancement standards within the subwatershed.

Available groundwater information from the present study indicates that the wetlands located downstream of Blackbridge Road are reliant on a shallow water table which is perched on finer textured soils, and fed by shallow groundwater flows (interflow) from the surrounding agricultural lands, and by seasonal flows originating from upstream. Wetland conditions (i.e. hydric soils, seasonally high water table, and hydric vegetation) are evident in a continuous habitat belt along Forbes Creek, ranging in width from approximately 90 m at the lower end, to 300 m at Regional Road #24/Blackbridge Road. This belt is generally coincident with the Regional Floodline, which exceeds the width of the wetland in most areas.

The wetland boundary is generally indicative of a historic limit beyond which active agricultural use of the land was impractical due to wet soils. Distinctive patterning of wet soils in the agricultural fields beyond the wetland limits is evident on aerial photos taken under springtime conditions. Given the types of wetland communities that are prevalent, and the identified presence of a perched system, shallow storage around the wetland contributes in varying degrees to sustenance of moisture levels within the wetland through the year.

Based on averaged soil condition, a 50 m buffer 'threshold' would accommodate the majority of shallow groundwater functions (i.e. storage, water quality buffering and shallow flows) that sustain key habitats in the wetlands south of Blackbridge Road. This threshold is based on the assumption that urban uses will predominate in the vicinity. The buffer could potentially be reduced (minimum of 30 m recommended) in some areas subject to site-specific studies of shallow groundwater and affected biological resources. Requirements for subsequent studies as part of scoped Environmental Impact Studies are presented in Section E. However such reductions would further constrain corridor functions in an urban context.

The 50/30 m minimum buffer is considered adequate to mitigate the protection of treed areas within the wetland and to provide filtration of sediments and nutrients assuming that the buffer is maintained in meadow or early shrub succession. A chain link fence without gates is recommended on public land, and access to the wetland should be limited to formal public trails. However, a 50/30 m is considered inadequate to sustain the movement of wildlife through narrower sections of the stream/wetland corridor, or to sustain breeding populations of migratory amphibians such as Spring Peeper which pass most of their lives in upland woodlands outside the spring breeding season.

A minimum 30 m buffer around wetland features in the rural areas of the subwatershed is considered generally adequate based on the observation that the wetlands in the upper watershed do not exhibit the same reliance on shallow groundwater storage in the immediate periphery of the features. Rather, they are primarily kettle features fed by runoff and sustained due to perching on deeper fine-textured layers. It is assumed that development in the rural area will consist of isolated residences, septic systems, and occasional barns and outbuildings. In this case, a scoped EIS is recommended when any development occurs within 30 m of a wetland or upland woods to ensure that grading or changes to runoff do not affect the feature. If more concentrated development is to occur such as groups of buildings or larger-scale livestock barns, site-specific buffer needs should be reviewed in a scoped EIS whether or not the development is proposed within 30 m of any natural feature.

Linkages

Natural heritage systems in southern Ontario are typically composed of three components, namely: core natural areas such as large woodlands or wetlands, corridors that form major connections between core areas, and linkages which are secondary connections that enhance overall functions. While core natural areas provide the primary habitat for plants and animals to prosper and sustain regional populations, corridors and linkages allow them to sporadically or regularly intermingle and exchange genetic material. This exchange is critical to the long-term viability of most species resident to those areas, by strengthening a population's ability to survive catastrophic events such as predation or disease. Linkages allow populations to be recolonized should they suffer such a local extinction event. In general terms, the larger and more numerous linkages are the more likely populations are able to survive over extended periods of time. However, it should be noted that corridors and linkages are not always advantageous; they may expose certain species to excessive levels of predation during migration.

The need for connectivity applies equally at all geographical scales, from local site level linkages, to regional or provincial scale corridors (based on physiographic and/or topographic features) such as river systems, (e.g. Speed and Grand Rivers) the Niagara Escarpment or Oak Ridges Moraine. Recognizing this fact, two main types of corridors and linkages were identified as part of this study; those that that help connect existing natural heritage features contained *within* the subwatershed and linkages that connect up to broader natural heritage systems *outside but adjacent* to the Forbes Creek subwatershed.

While most wildlife species prefer to use the shelter and relative security provided by vegetated systems such as hedgerows and tributary corridors when moving between core areas, agricultural fields and other open spaces also either support adjoining linkages or serve as important terrestrial linkages in their own right. Since these seasonally unvegetated areas are typically the first to be developed, this places even greater importance on the protection and enhancement of existing vegetated linkages from both an ecological and planning perspective.

If linkages and/or corridors are to be truly effective, special attention must also be placed on mitigating the negative effects of existing barriers, the most significant of which are major roadways. The larger the roadway (i.e., number of lanes), the higher the traffic volumes, and the greater the vehicle speeds, the greater the barrier to species trying to cross them. In addition to the most obvious impacts of roads, roadkill, roads fragment and isolate populations.

The other main barriers to movement (for some species) are areas that simply lack natural cover. In the Forbes Creek subwatershed, they are typically agricultural fields. While they provide far greater opportunities for dispersal than do developed urban environments, enhancement or rehabilitation may be required to make linkages that straddle these areas more viable to a greater diversity of species. Linkages and corridors need to satisfy the life history requirements of all the species that intended to utilize them. Examples range from simple naturalization, to selected plantings, to the creation of specific habitats such as small ponds, or even wildlife-friendly underpasses (culverts).

Linkages of a functional nature also occur between physical resource characteristics (catchment area, topography, soil texture, nutrients in runoff) and biological systems (plant communities and reliant species, reliant wildlife species). In the Forbes Creek subwatershed, wetland cover is strongly reliant on discrete surface and groundwater conditions within individual subcatchments. The maintenance of these linkages between the physical and biological systems is critical to the protection of these habitats. The primary tools to protect these linkages include a) adequate buffers around features to ensure that existing hydrological relationships are maintained; and b) the planning of infrastructure to avoid any major change to hydrology and water quality as it is concentrated for discharge into receiving watercourses.

Habitat Enhancement and Rehabilitation

Natural habitats may be enhanced in area, diversity, connection or function to make them more sustainable within an overall natural heritage system. Former agricultural uses may have encroached into areas that, because of slopes, drainage or overhanging tree cover, are considered too sensitive to support urban uses. More extensive habitat cover may be necessary to maintain existing species (e.g. area sensitive wildlife) or to maintain functions (e.g. shallow groundwater movement, and dispersal or seasonal migration of wildlife species) in an otherwise urban context. Habitat enhancement may extend into the urban landscape, represented by native plantings along secondary trail linkages, in naturalized open spaces, and in streetscapes to improve urban habitat, maintain beneficial seed sources, and reduce ongoing maintenance.

Habitat rehabilitation may be desirable where past development has removed or degraded existing habitats. In some cases rehabilitation may include removal of aggressive or weedy species that have overtaken habitats and reduced diversity. In the case of man-made ponds or altered stream channels, restructuring or conversion to other types of habitat, may yield positive benefits and reduce long-term management requirements.

Figure C 3.3.1 (Enhancement Areas) identifies those areas within the subwatershed that would benefit most from enhancement activities. Habitat enhancement would have immediate benefits if undertaken along Forbes Creek south of Blackbridge Road, and along the Regional Road #24 corridor. Longer-term enhancements in the upper subwatershed could increase the size of core habitat areas, improve the range of available habitats, and improve linkages between habitats within and beyond the subwatershed boundary. In fact, the area located along the northern boundary of the subwatershed (vegetation communities 4.13, 4.14, & 4.15) is considered a potentially important node that links up three different subwatersheds, Forbes Creek subwatershed, Chilligo Creek (Ellis Creek) subwatershed (to the west) and Glenchristie subwatershed (to the east). Rehabilitation opportunities include the removal or reconfiguring of the constructed ponds, restoration of channels to natural form and flood functions, improvement of riparian connections across Regional Road #24, and control of invasive plant species (e.g. purple loosestrife, European buckthorn, Norway maple, garlic mustard).

Complementary Land Uses

The placement of certain land uses in the vicinity of natural habitats may enhance connectivity under urbanized conditions. Parkland, seasonally-used playing fields, lands associated with places of worship; community centres or cemeteries can supplement buffer and enhancement strategies. Stormwater management facilities may be placed within the complementary or enhancement land use area if a) there are no direct impacts on hydrology or water quality of adjoining wetland units, and b) they do not constrain the corridor functions of the enhancement area. The use of low-traffic local streets to define the transition between residential and open space uses is generally preferable to backing lots directly onto buffers around sensitive open space areas. This assumes that the buffer is encouraged to regenerate to successional cover over time, and that unregulated pedestrian access is discouraged.

Stewardship Programs

Stewardship programs involve cooperative activities by residents and farmers to expand habitats in deficient areas, pick up garbage and debris, detect and control undesirable uses, and provide ongoing monitoring. The Forbes Creek subwatershed is probably well suited to stewardship programs due to the presence of an existing residential community, farmers, and knowledgeable naturalists.

Table C 3.3.1 Natural Heritage and Greenspace System Management Strategies

Measure	Advantages	Disadvantages
Buffers	• Public buffers help define land use transition (ecotone) from urban to natural uses, thereby reducing encroachment and aesthetic conflicts • Public buffers facilitate monitoring and maintenance • Buffers may supplement habitat diversity • Buffers help increase breeding bird success • Buffers help reduce adjacent disturbance-related impacts on wildlife • Buffers can reduce invasions by introduced weedy plants that spread vegetatively • Buffers are favorable for trail development • Adequate buffers can effectively reduce impacts of runoff quality (sediments & nutrients)	• Buffers may reduce developable land • Buffers on private residential lots are problematic to monitor, and subject to illegal encroachments • Buffers require commitments to maintenance and monitoring in order to remain effective over time • Buffers cannot reduce the impact of invasive plants spread by birds and other wildlife • Buffers can only partially mitigate development impacts on runoff quantity • Buffers are usually inadequate to sustain existing corridor functions through new urban areas unless they are very substantial • Large buffers are required to attenuate noise, temperature and light impacts from urban areas.
Habitat Enhancements	• Habitats can be easily enhanced through naturalization and/or planting • Habitat enhancement within the regional floodline does not affect development land • Strategically located habitat enhancements will strengthen linkage function between core areas • Consistent corridor width will improve functions under urbanized conditions • Expansion of core habitat areas with naturalized cover would benefit habitats & species in subwatershed	• Enhancements may reduce developable land
Habitat Rehabilitation	• Physical changes to ponds and channels will improve wetland sustainability and potentially reduce longer term maintenance • Can strengthen linkage functions • Provides a focus for ongoing volunteer activities and sense of ownership • May help offset some impacts of surrounding development	• Changing context of surrounding lands (rural to urban) may limit potential benefits • Physical changes will be initially cost-intensive • Rehabilitated areas may reduce amount of developable land
Complementary Land Uses	• Minimizes the loss of development land • Allow transition from regular to intermittent and seasonal uses (e.g. playing fields) • Trail networks and other open space uses can be better integrated	• May be difficult to negotiate (e.g. location of schools and parks in neighbourhoods) • Certain uses may create perceived conflicts (e.g. fear of wooded areas becoming 'hangouts') • Placement of manicured areas close to natural areas or ponds may lead to water quality issues (concentration of Canada geese)
Stewardship Programs	• Involvement of local residents and farmers contributes to long term system health • Reduces management interventions and facilitates monitoring	• Stewardship needs commitment to ongoing coordination and involvement by the City, agencies, and private citizens/groups

C 3.3.3 Natural Heritage System Alternatives

Table C 3.3.2 summarizes three Natural Heritage System alternatives, as well as a 'do nothing' option. The following is a brief summary of issues and considerations in regard to each alternative.

Option 1 – No Buffers

This option would place development in direct proximity to natural features, and would have significant impacts on the composition, structure, hydrology and functions of the system over time. The lack of buffers would definitely result in immediate impacts during construction, and successive impacts over time. Option 1 would not meet the intent of the Provincial Policy Statement or relevant Regional, City and Grand River Conservation Authority policies.

Option 2 – 50/30 m Buffer (30 m north of Blackbridge Road)

As discussed in Section C 3.3.2, wetlands located downsteam of Blackbridge Road are reliant on a shallow water table which is perched on finer textured soils, and fed by shallow groundwater flows (interflow) from the surrounding agricultural lands, and by seasonal flows originating from upstream. Based on average soil conditions, a 50 m buffer "threshold" would accommodate the majority of shallow groundwater functions (i.e. storage, water quality buffering and shallow flows) that sustain key habitats in the wetland south of Blackbridge Road. The buffer could potentially be reduced (minimum of 30 m recommended) in some areas subject to site-specific studies of shallow groundwater and affected biological resources. However, such reductions would further constrain corridor functions in an urban context. Requirements for subsequent studies as part of scoped Environmental Impact Studies are presented in Section D.

The 50/30 m minimum buffer is considered adequate to mitigate the protection of treed areas within the wetland, and to provide filtration of sediments and nutrients assuming that the buffer is maintained in a meadow or early shrub succession stage. Option 2 would limit direct urban impacts; indirect impacts such as noise, light, and disturbance of wildlife by pets would also be moderated. However, 50/30 m is considered inadequate to sustain the movement of wildlife through narrower sections of the stream/wetland corridor, or to sustain breeding populations of migratory amphibians such as Spring Peeper which pass most of their lives in upland woodland outside the spring breeding season.

Under Option 2, a minimum 30 m buffer would be applied around wetland features in the rural areas of the subwatershed is based on the observation that these features do not exhibit the same reliance on shallow groundwater storage in the immediate periphery of the features. In this case, a scoped EIS would be recommended when any development occurs within 30 m of a wetland of upland woods to ensure that grading or changes to runoff do not affect the feature. If more concentrated development is to occur, such as groups of buildings or larger-scale livestock barns, site-specific buffer needs should be reviewed in a scoped EIS whether or not the development is proposed within 30 m of any natural feature.

In our opinion, Option 2 would not meet the intent of the Provincial Policy Statement, or relevant Regional, City and GRCA policies, because of its inadequacy to mitigate the loss of existing agricultural matrix and corridor functions south of Blackbridge Road.

Option 3 – 50/30 m Buffer and Enhanced Corridor

This Option would supplement the provisions of Option 2 (i.e. 50/30 m buffers) with placement of enhancement areas and (where feasible) complementary land uses adjacent to the wetland/stream corridor south of Blackbridge Road. This would create a 250 to 300 m wide natural corridor, ultimately containing upland and successional cover as well as the ponds and wetland. This option would be most effective with respect to accommodating sensitive local hydrology, seasonal wildlife movements and breeding, and trail development following urbanization of the surrounding lands.

On other grounds, it is considered that minimum buffers of 30 to 50 m will not sustain current levels of landscape connectivity that exist in and adjacent to the Forbes Creek corridor downstream of Blackbridge Road, in an urban context. Common wildlife species such as White-tailed Deer and Coyotes may create nuisance issues with residential uses unless a viable wildlife corridor is created. In this respect Option 2 (30/50 m buffers) is considered inadequate. Human proximity effects including noise, light, and pets typically reduce habitat usage by neotropical forest birds unless buffers of at least 100 m are provided; buffers of up to 300 m may be required to sustain nesting by species such as Mallards (Norman, 2000). Direct human encroachment into natural woodlands may exceed 60 m (Matlack, 1993), and natural area encroachment behind residential lots is typically on the order of 80-90% in southern Ontario municipalities where this has been studied (e.g. Kitchener, Oakville, Mississauga). The provision of an enhanced corridor would largely offset these impacts, and sustain substantive deer movements and waterfowl usage that were indicated as key public concerns during the public consultation for the subwatershed study.

Although the impacts of landscape conversion from an agricultural to an urban matrix would not be fully mitigated under Option 3 (it is spatially impossible to replace the functions of the extensive agricultural matrix which facilitates wildlife movements through the lower subwatershed today), it would retrofit the stream and wetland corridor with substantial additional habitat and buffering to essentially offset the conversion of the surrounding agricultural matrix. If upland habitats are established effectively within the enhancement and buffer areas, there may be a gain in utilization by sensitive species requiring transitional habitats over a period of years. The creation of a more substantive 'critical mass' and diversity of habitat under Option 3 would more effectively offset the indirect impacts of urban proximity than buffers alone (i.e. as proposed under Option 2).

With respect to the wetland units (6.24 and 6.25) that are located in the expanded study area south of Blackbridge Road, it is recommended that these be provided with a 50 m buffer, subject to reduction to 30 m based on a scoped EIS. It is anticipated that these wetlands will be placed in the Speed River Wetland Complex by MNR.

For lands upstream of Blackbridge Road, Option 3 would include the Option 2 approach for minimum 30 m buffers for new rural development (see Option 2 discussion). However, enhancements of habitat cover as shown on Figure C 3.3.1 would be included under Option 3.

In our opinion, Option 3 would meet the intent of the Provincial Policy Statement, and relevant Regional, City and GRCA policies.

C 3.3.4 Recommended Natural Heritage and Greenspace Management System

Option 1 would not meet the intent of the Provincial Policy Statement or relevant Regional, City and Grand River Conservation Authority policies.

In our opinion, Option 2 would not meet the intent of the Provincial Policy Statement, or relevant Regional, City and GRCA policies, because of its inadequacy to mitigate the loss of existing agricultural matrix and corridor functions south of Blackbridge Road.

In our opinion, Option 3 would meet the intent of the Provincial Policy Statement, and relevant Regional, City and GRCA policies.

Figure C 3.3.2 presents the Greenspace Management Strategy.

C 3.4 Forbes Creek Trail Strategy

C 3.4.1 Introduction

Informal trail development has occurred within the Forbes Creek study area and along the north side of the Speed River. To assist with planning for formalized trails at the Community Plan stage, the subwatershed plan has identified general opportunities and constraints for trails based on environmental findings.

There are numerous opportunities within the study area to create trails and links to a wide assortment of destinations in the immediate area. Typical destinations are schoolyards, parks and connections to larger trail systems. Future trails for this area would be multi-use and to current City standards.

Figure C 3.4.1 shows "Existing Trails and Parks" in the vicinity of the Forbes Creek subwatershed while Figure C 3.4.2 shows a "Conceptual Trail Strategy" based on environmental findings of this Subwatershed Study. The trail system will be finalized at the Community Plan Stage and this document provides environmental design guidelines toward that end.

C 3.4.2 Previous Trail Study Findings, Directives and Recommendations

Potential trails for the Forbes Creek area are made reference to in the *1996 Cambridge City-Wide Multi-Use Trail Study,* as well as the *1993 Riverbank Long Range Concept Development Plans.*

The *Multi-Use Trail Study* refers to the Forbes Creek area as Section 42 and Section 43 in the overall study. The report refers to Section 42 as: *"A north-south route beginning at Guelph Ave. and following the existing Mill Pond trail along the north side of the Speed River. The trail continues through an area of future development to Blackbridge Road."* The study goes on to say, *"The configuration of this trail is subject to the Hespeler North subdivision plan. The routing of this trail should be designed so that the adjacent landowners are not impacted."* For section 43, Mill Pond to Blackbridge Road (parallel and south/east of CP Rail Line), the trail is described as: "*This trail begins at Mill Pond Park and continues north to Blackbridge Road."* and *"This trail is an existing footpath on private property. It provides a connection to the Speed River, which runs to Guelph and beyond. Long-term arrangements should be made with the landowner to ensure that this trail remains open."*

The 1993 Long Range Concept Riverbank Development Plans for the Preston and Hespeler Communities established a concept for an integrated and linked hikeway/bikeway system along the Grand and Speed Rivers, uniting the communities of Hespeler, Preston, Blair and Galt, within the City of Cambridge. It conceptually identifies trail routes and links at the railway/Blackbridge Road, along the ponds/creek and crossing the rail line to the Mill Pond, along the north/west side of the CP rail line, and around the Speed River Mill Pond, including a proposed crossing of the eastern end of the Mill

Pond/Speed River which would connect this area to Brewster Trail and the Hespeler East community.

C 3.4.3 Existing Trail Systems

The following is a list of various informal or formal footpaths and trails that are currently used, within and near the Forbes Creek Subwatershed Study area.

Forbes Park/Woodland Park Trail: This City trail meanders through residential areas on the south side of the Speed River, from the Hespeler Town Core to Winston Blvd. The trail is comprised of paved trail and beaten earth footpath, is extensively used and links several parkettes and woodlands to the downtown core. There is also a link to Hespeler Public School at the southern portion of the trail.

Mill Run Trail at Jacob's Landing: This popular hard surfaced and beaten earth City trail runs along the flood dike on the north/west side of the Hespeler Mill Pond from Jacob's Landing at Guelph Ave to the CP rail line and includes informal fishing areas, viewing platforms, and a portage/access to the Speed River at the Hespeler Mill Pond Dam. This City trail officially terminates at the rail bed – but an informal beaten footpath exists (Speed River Hiking Trail) and is used to a limited extent beyond that point following the CP Rail line to Blackbridge Rd, (the substantial portion of which is on privately owned and Railway property).

Speed River Hiking Trail: This informal beaten earth footpath, which is mostly on private property, is located along the southern/eastern edge of the CPR Rail line and at times in the Provincially Significant Wetland adjacent to the Speed River. It is not a public trail, encroaches at times on the railway lands and is subject to use by a private landowner. Portions of the trail toward Blackbridge Road are extremely rough and difficult to navigate. The south end approximately ties into the terminus of the Mill Run Trail at Jacob's Landing.

Mill Run Trail: This City stonedust trail runs along the Speed River ultimately connecting to Riverside Park in Preston and is a significant spine of the City's River Trail system. This trail is heavily used and has been upgraded several times in the past few years. It has a trailhead with parking at Sheffield St./Clemens Ave and connects to Jacob's Landing by using Sheffield Street and Guelph Avenue.

Brewster Trail: This is a fairly new asphalted and stonedust trail developed in the wooded valley between the new Hespeler East community and the older portion of Hespeler. The trail runs from Queen Street at the Speed River past Hillcrest Public School and the Our lady of Fatima Separate School to Hammett St and will eventually connect to Woodland Park Public School and the Hespeler Memorial Arena complex.

C 3.4.4 General Opportunities and Constraints

C3.4.4.1 Trail Planning Principles

The following general design principles have been prepared in discussions with Steering Committee members, city staff and the consultant team:

- To identify ecologically based trail system constraints which avoid or minimize intrusions and impacts on sensitive features taking into account ecological functions such as soil hydrology and wildlife movements;
- To identify localized community trail opportunities through and along natural areas between places of residence, work, recreation, and points of interest; and to identify linkage opportunities and

constraints to existing and potential open spaces and trail systems within and outside the study area

- To identify opportunities and constraints for on-road pedestrian and cycling connections
- To identify opportunities and constraints for Trail Loops. While trail loop options are possible throughout the site, trails that cross sensitive wetlands are discouraged and should be minimized. Trail loops should not isolate or fragment wetland areas nor should excessive trail looping systems be provided in natural areas. Trail loop opportunities exist along hedgerows that run north - south as well as east - west.
- To identify opportunities and constraints with respect to maintenance
- To identify interpretation and education opportunities

C 3.4.4.2 Environmental Considerations - Opportunities and Constraints

In addition, the following environmental opportunities and constraints should be noted:

- Trail routes should avoid or minimize impact on the creek and major wetland areas and areas of rare or sensitive plant and animal species. Some areas will be identified for no trail development while other areas will be identified for trail use subject to acceptable distance setbacks.
- Trail routes are preferably located along naturally occurring ecotones (changes in habitat). This way, the fragmentation of individual habitat types is kept to a minimum. There may be some disturbance to species that normally occur along edges but for the most part, they are common generalist species.
- Where possible, hedgerows will be used to separate trails from existing habitats and to provide a buffer to potentially more sensitive areas. In some cases, it may be prudent to create or enhance a natural buffer by planting native trees and shrubs.
- Minimize the disturbed area of trail routes recognizing the development and maintenance requirements of current City standards for trails.
- Minimize mowed edges of trails while recognizing trail development and maintenance requirements and guidelines for safety.
- Stonedust (limestone screenings) for trail surfacing is preferred over asphalt, recognizing that asphalt may be required where steep slopes, winter maintenance or other trail needs have been identified. Asphalt trails may have greater setback requirements and will be subject to Scoped Environmental Impact Statements.
- Trail route location should assist in controlling access to natural areas to minimize undesirable impacts.
- Lighting of trails in natural areas is discouraged.
- Where appropriate, servicing corridors may be used for trail routes recognizing initial construction and future servicing maintenance needs, and these opportunities should be explored as part of environmental study/review of such servicing corridors.

C 3.4.4.3 Environmental Interpretive Opportunities

Interpretive opportunities, which could present information on wildlife, the nature of the watercourse, local ecology, rehabilitation efforts, and groundwater issues, can be incorporated into trail routes in natural areas include:

- The trail adjacent to Forbes Creek presents opportunity to educate pedestrians about the interactions between Forbes Creek, groundwater conditions and fish habitat, particularly in the southern portion of the creek where restoration work is anticipated;
- Ecological enhancements to ponds and Forbes Creek allow for discussions on human intervention and fish habitat improvements;
- There is an opportunity (preferably in the northern portion of wetland area) to discuss municipal water supply issues and management strategies needed to supply water to Cambridge residents without interfering with the ecological processes of the Forbes Creek Subwatershed;
- Trails in the vicinity of the pine plantation at the southern end could explain plantation management (monoculture issues) and how we currently manage plantations through diversification and ecological improvements.

C 3.4.5 Viewing Opportunities for Trail Routing

During our on site investigation we observed many locations that offered interesting views and experiences in natural settings.

Wildlife observations, and bird watching in particular, can occur throughout all the natural areas. Bird watching is promoted by providing trails and views adjacent to or through a variety of habitats, including areas of open water for waterfowl, marshes supporting wetland species, or old fields and woodlands that contain songbirds.

Specific viewing areas or features along the trail should be limited and situated to minimize disturbance and impacts. For average trail users, placement of the trail through a range of successional edges will usually provide adequate viewing opportunities. Occasional views of the pond through openings among screen plantings will be less costly to develop and maintain and more effective at achieving wildlife views than construction of blinds, lookouts or other special features.

Interesting views have been documented as opportunities for a trail route. Parts of these views may be impacted by eventual development of the area but merit consideration when locating trails. These locations and the corresponding location numbers are shown on Figure C.3.4.2.

Viewing Opportunity Location 1 is an area at the north end of the site as Forbes Creek (West Branch) flows from wetland areas north of Regional Road # 24. The large wetland area makes this area impractical for trails and boardwalks but it does provide a pleasing viewshed over a large natural habitat area. Numerous animal trails were observed so the chance of seeing an animal is likely (see **Photograph C1**).

Viewing Opportunity Location 2 is a sensitive area where the stream corridor is at its narrowest point at the confluence of the east and west branch tributaries. There are also numerous animal trails on both sides of the watercourse at this location (see **Photograph C2**).

View Opportunity Location 3 is looking west, over the watercourse from the midpoint of the creek study area to the housing along Guelph Ave. A similar view exists from these houses east over the creek (see **Photograph C3**).

Viewing Opportunity Location 4 provides a very picturesque setting for bird watching and relaxing with appropriate provision of screening. The view is south over Pond G. The ponds on site are large enough to attract birds and other animals (see **Photograph C4**).

Viewing Opportunity Location 5 is between Ponds D and G, where a control structure maintains the water level in the upper pond (Pond G). The control structure will require structural, operational and safety upgrades and at that time the design should incorporate pedestrian access. This feature is considered as a potential trail crossing location. Its rustic character lends charm as well as a sense of discovery from the past. The photo is taken from the control structure looking north over Pond G. Proper screening would be required (see **Photograph C5**).

Viewing Opportunity Location 6 is a highlight of this area due to the variety of settings it provides. Within minutes the user could be alongside four different ecosystems and their corresponding habitat. This view is along Pond D, the most northerly pond on the west side. The east side by contrast has thick vegetation down to the water's edge, making the eastern edge of the pond virtually inaccessible (see **Photograph C6**).

Viewing Opportunity Location 7 is from the southeast corner of the site looking west over the ponds to the housing on the upper west side. The creek forms the lowest point throughout the study area. There are a number of views, which occur from East to West and North to South from the higher elevations along the outside edges of the creek area (see **Photograph C7**).

Viewing Opportunity Location 8 is at the southwest corner of the site where there is a high point that affords significant views both on site and off-site. This view is southwest to the historic village center of Hespeler (see **Photograph C8**).

Viewing Opportunity Location 9 This photo of the most southerly pond (Pond A), near the end of Shaw Ave. Aside from the two large ponds (Ponds D and G), there exist a number of smaller, scenic ponds in the study area. These are set into more dense vegetation and are therefore more intimate in scale and character (see **Photograph C9**).

Viewing Opportunity Location 10 is at the foot of Shaw Ave. This potential trail access point (which includes an abandoned asphalt path/lane that ends at this location, is a reasonably level area where access from Shaw Ave. is clear and asphalted. This view also looks across to the largest wooded block within the lower Forbes Creek corridor, a pine plantation (see **Photograph C10**).

C 3.4.6 Trail Opportunities and Constraints of Forbes Creek Study Area

North-South and East-West Axial Trail Spines

Based on discussions with staff from the Community Services Department, the conceptual trail routing would link through the study area and to surrounding areas by two axial trail spines: one north-south and one east-west. The central north-south spine would be defined by the watercourse and its associated floodplain and buffers and extends from the foot of Shaw Ave. north to the intersection of Guelph Ave. and Blackbridge Road.

Within the study area a number of trail loops may be possible along the central north-south spine should future studies determine that a road crossing would be required. However, in this study, road crossings of the Forbes PSW and Forbes Creek have not been recommended. Both ends of this spine have areas that are relatively flat and suitable as trail access points and would form a logical location for a larger loop.

The east-west axial trail spine is dependant on the location of a trail crossing of the creek, with the preferred location being at the Milton Avenue Extension. A span bridge of the rehabilitated creek is required. Other alternative trail creek crossing locations would be subject to a scoped EIS.

Trail System Connections to Adjacent Areas

Pedestrian and cycling linkages to off site destinations will be addressed at the Community Plan stage. These destinations include schools, parks, the Hespeler Town Centre and other trails both present and future. These pedestrian linkages may be off-road, on-road or more likely a combination of both. One tremendous opportunity that would offer greatest benefit for a future off-road and off-site trail link would occur if the railway line on the south/east side of the study area were removed. Although there are no current plans for such an abandonment of the rail line, consideration should be given for trail purposes if it becomes available.

Ecological Characteristics Influencing Trail Route Options

Any proposed trail routing should follow the high edge of the floodplain along and within the buffer of the creek. The site is generally flat from north to south within the floodplain. As one moves east and west the land slopes up to level agricultural lands on both sides of the floodplain.

Influence of Habitat on Trail Alignment

There are several ponds and wetlands (provincially significant) located along the watercourse. Waterfowl as well as deer and other smaller mammals utilize these ponds. Evidence of deer activity extends along the entire length of the watercourse. Therefore, the trail will be a minimum of 15 metres from the Forbes Creek Provincially Significant Wetland boundary to minimize disturbance.

Natural Corridor Access and Connections

To integrate future residential development with the major open space associated with the creek ponds and wetlands, trails should connect to this natural corridor at connection points along its perimeter. This could include the use of existing roads (such as Poplar Dr., Milton Ave. and Shaw Ave) as well as connections to existing trails along the adjacent river lands. Scott Road could be considered for future access as it is a connection to Silverheights Public School. Fisher Mills Road could also be considered a link as it is connects to Victoria Park.

Access to trails within the natural corridor should be functional but limited. Too much access, may lead to excessive trail density and to degradation of the wetland corridor. “Unofficial” trails may result from inappropriate trail placement/access locations.

Trail Types and Surfacing Materials

The preferred trail type in the natural corridor would be the city standard 2.5m wide stonedust (limestone screenings) trail.

Where deemed necessary at the Community Plan stage, asphalt trails can be provided in the natural corridor as main connections to schools or other features, where heavy use or winter maintenance is required. Asphalt trails may require a further set back from the wetland edge based on the findings of a scoped EIS which is required for asphalt trails. Ecologically, asphalt trails are not preferred within the buffer. Asphalt trails should be located in enhancement areas rather than the wetland buffer as they may affect shallow groundwater and surfacewater movements but also since asphalt trails imply a heavier usage and greater disturbance of the site. If an asphalt trail within the wetland buffer is determined to be required at the Community Planning Stage, then a scoped Environmental Impact Statement should be undertaken to determine its appropriate location.

Photograph C1
Location 1: Marsh area near Guelph Ave. and Blackbridge Road

Photograph C2
Location 2: Easterly view of wetland

Photograph C3
Location 3: Westerly views – mid section of creek

Photograph C4
Location 4: Southerly view of Pond G

Photograph C5
Location 5: Northerly view of Pond G

Photograph C6
Location 6:Trail along Pond D

Photograph C7
Location 7: Viewing location across Forbes Subwatershed

Photograph C8
Location 8: Southerly views across the Speed River

Photograph C9
<u>Location 9</u>: Pond A

Photograph C10
<u>Location 10</u>: Access point

C 3.4.7 Public Consultation Process

Using the opportunities and constraints present in the Forbes Creek subwatershed and agency objectives, a conceptual trail strategy was presented at the October 11, 2001 Community Workshop. Several verbal comments were received at the meeting and incorporated into the proposed strategy.

C 3.4.8 Conceptual Trail Framework

Based on public comments, site opportunities and constraints, agency concerns and trail design principles, a conceptual trail framework has been included in this study as described below and presented on Figure C 3.4.2.

North-South Axis: This major axis is the primary off-road trail within the subwatershed. The north-south route may eventually link this site to the Hespeler Mill Pond and the Hespeler Town Centre to the south. It can also link to future development to the north end of the site as well as to Silverheights Neighbourhood Park. The trail will run along both sides of the watercourse and be located within the buffer or enhancement area, setback 15 metres or more outside of the wetland boundary. Spur trails are not recommended as they are less used, subject to misuse and tend to develop other unauthorized footpath loops. Spur trails may be within 10 to 15 metres of a specific feature of concern, subject to a scoped EIS study at the Community Plan stage. Trails may be located within the Regulatory Floodline but are subject to the frequency of flooding, maintenance or standing water.

East-West Axis: The preferred trail routing would be along a future rail trail however; we have assumed that this is not likely to occur in the near future as the railway is currently utilized. A secondary opportunity for the east-west axis would be parallel and offset along the north/west side of the railway ultimately connecting to the existing Speed River hiking trail at Blackbridge Road. The east west trail creek crossing for the axis would be at the Milton St. extension as shown on Figure C 3.4.2.

Trail Access Points: There is an opportunity to provide access points to existing facilities and roads off the major north south axis on the west side at Shaw Avenue, Milton Avenue, Scott Avenue, and at Blackbridge Road. On the east side there are several opportunities along the existing fence line at the Forbes Estate, through the existing pine plantation, and at the existing trail leading to the sand pit shown as Location 8 on Figure C 3.4.2. An internal road system could potentially connect to Pond J. Access to the system and proper access for school traffic should be assessed at the Community Plan Stage.

Three offsite trail link opportunities are conceptually shown on Figure C 3.4.2 proceeding from south to north. The first is along the existing rail corridor to Sheffield Street linking up to Jacob's Landing and the Mill Run Trail. The second opportunity would be a trail link between at the Blackbridge Road area to the Silverheights Neighbourhood Park. The third opportunity would be a trail link to the Speed River trail.

Trail Construction: Within the PSW and creek buffer areas it is recommended that all trails be stonedust or natural material. Asphalt can be considered within these areas for conveying pedestrian traffic during winter months (which necessitates snow maintenance) subject to findings at the Community Plan Stage and a scoped EIS. This should be reviewed at the Community Plan stage when additional information is known about the nature and extent of development.

Future Speed River Trail Crossing: Previous trail planning studies proposed a trail crossing of the Speed River through the PSW. While not recommended, as it would be crossing sensitive wetland area, further study is required to evaluate such a concept.

A trail crossing over the Speed River may be undesirable, as it will introduce more human disturbance into the Speed River PSW and recognized deer wintering area. This low-lying area of floodplain does not presently attract much human traffic due to its relative inaccessibility. The number of local pets (unleashed dogs and free-roaming cats) gaining access to this sensitive area would reduce the quality of breeding and migratory habitat in the PSW and increase native species mortality due to predation.

Should a pedestrian bridge crossing over the Speed River be considered, it is recommended that it be located further upstream, away from the edge of the Mill Pond. The Mill Pond is regularly used by a wide variety of waterfowl species during migration. A highly visible trail located at the edge of the pond would substantially increase the level of disturbance and ultimately cause those species to abandon the eastern third of the pond. The marsh-pond interface is the most critical area for breeding waterfowl and gallinaceous fowl. A side trail leading off the main trail to a pond viewing area would have fewer negative impacts. Such a viewing area could be built as a blind rather than an open structure, which would result in less stress to wildlife.

Wetland Crossings and Boardwalks: Only one trail creek crossing has been identified on Figure C 3.4.2. Alternate trail creek/wetland crossings opportunities have not been shown and would require further study and evaluation through a scoped EIS at the Community Planning stage. Boardwalks are a possibility subject to a scoped EIS but are discouraged due to high construction and maintenance costs and impact on the wetlands.

Should the Community Plan determine that a road crossing is required, pedestrians and cyclists could use such a road crossing.

Future Environmental Impact Study Requirements: The conceptual trail framework has been identified as environmentally preferred. Trail location opportunities in the approximate location shown on Figure C 3.4.2 will ensure that there will be no adverse ecological impacts. The proposed trail should remain outside of the minimum 15-metre setback from the wetland boundary or creek system. Asphalted trails are not recommended within creek/wetland setback but may be allowed within the 50 m buffer subject to a scoped EIS.

Trail routing, as identified on Figure C 3.4.2, within the wetland buffer and natural areas, will not require any further study other than field evaluation of a final location.

The identification of additional crossings, asphalting of trails, or additional trails within the identified wetland and creek setbacks and buffer areas at the Community Plan stage will require a scoped EIS to be completed. The Scoped EIS will need to address:

- Site specific trail locations, taking into account sensitive flora and fauna as well as other integral biological and physical functions
- Mitigation opportunities (native planting as visual screens, etc.)
- Trail creek crossing coordination with the upgrade of the dam structure between Ponds D and G;
- Micro-drainage issues (i.e. culvert/bridging requirements, permeable trail base etc);
- Site specific buffer requirements;
- Trail surfacing material and construction (i.e. asphalt vs. stonedust);
- Trail access points from the urban fabric;
- Maintenance (snow removal, mowing of edges and verges, tree pruning, timing of activities with) in relation to critical ecological or wildlife functions; and,

- Construction methodology.

C 3.4.9 Conclusions

The conceptual trail framework is consistent with objectives of previous studies both in terms of location and character while addressing the environmental opportunities and constraints within the study area this trail framework would have minimal impact on the character of the Forbes Creek natural areas.

Figure C 3.4.2, "Conceptual Trail Framework", graphically portrays the following conclusions:

1. Further information from the Community Planning process will influence the final trail network.
2. Placing all trails outside of the 15 m wetland setback has placed a strong emphasis on environmental protection.
3. Providing a north-south trail on either side of the Forbes wetland will minimize stresses and minimize the possibility that people go off trail at sensitive locations and negatively impact identified vegetation and wildlife resources.
4. Trails have remained outside of sensitive areas and loop around wetlands. It is recommended that access be prohibited to the two small wetland pockets to the east of the main north-south wetland corridor south of Blackbridge Road (Units 7.12 and 7.14). These areas supported a much wider diversity of breeding reptiles and amphibians than Ponds D and G.
5. Only one creek trail crossing has been identified. Other opportunities have been shown but are discouraged and would be subject to a scoped Environmental Impact Statement
6. A potential trail crossing at the dam between Ponds D and G should only occur if the dam structure is upgraded.
7. The framework identifies future potential use of the existing railroad bed as a trail and this should be explored further at the Community Plan stage.
8. During planning and review of servicing options as part of the Community Plan and Environmental Assessment process, opportunities for incorporating trails as part of the initial construction and ongoing maintenance needs of such servicing corridors should be reviewed as part of a comprehensive assessment.
9. Access points and connections to roads and institutional/residential areas should be finalized at the Community Plan stage.
10. A potential pedestrian bridge over the Speed River was suggested in a long-range plan for this area. Further study is required to determine if this is appropriate given the sensitive nature of some aspects of the Speed River PSW.
11. The trail framework has avoided any private properties including the Forbes Estate.
12. The conceptual trail framework shown on Figure C 3.4.2 is environmentally sound.
13. A Scoped EIS will be required if additional trails, creek or wetland crossings, or asphalt trails are proposed in the wetland/creek natural areas. Details of the Scoped EIS requirements are noted in Section C 3.4.8 and in **Table E 2.5.1**.

14. Trails are to be designed, constructed and maintained to current City of Cambridge trail standards.
15. Development of the final trail plans at the Community Plan Stage is to be reviewed by the Cambridge Trails Advisory Committee prior to adoption.

C 3.5 Agricultural Management Systems

C 3.5.1 Biophysical Component

Much of the subwatershed has soil materials, which have a high amount of sand and silt. These materials are often relatively loose and structureless and, when found in combination with topographic differences, are prone to erosion by wind and water. In addition, the number of different soils found in combination with different slope classes result in a highly variable landscape. The variable landscape requires different agricultural best management practices within relatively small areas of the subwatershed. On a practical basis, this means that a number of different management practices would need to be applied within a single farm field. This complex management requirement would explain, in addition to the biophysical characteristics of the soils, the reason for a significant amount of soil erosion observed within the sloping areas of the subwatershed. The erosion is exacerbated because of the planting of corn crops.

C 3.5.2 Social Economic Component

The subwatershed is predominantly used for the production of common field crops which provide relatively low economic returns for farmers. The best economic returns are for those farmers who raise specialty crops and sell directly to the public. The northern tip of the subwatershed contains an operation that produces specialty crops and has direct public sales.

The subwatershed does not contain high value infrastructure such as greenhouse operations.

C 3.5.3 Recommendations

Recommendations for programs in the subwatershed can be grouped into four general categories as follows:

- Do nothing
- Initiate a general rural public education program
- Link programs to the GRCA Rural Water Quality Program
- Optimize results and dollars spent through site specific rehabilitation efforts

The "do nothing" recommendation would suggest that there are no significant problems related to agriculture and found within the subwatershed. Field observations indicate otherwise. Therefore, existing programs assisting farmers with information and with financial assistance/incentives for the application of best management practices (BMPs) could be encouraged extensively within the subwatershed. The application of assistance associated with BMPs would need to be applied in areas of greatest need. For example, application of incentives could be based within the areas where erosion is observed to be the greatest and where the results of the erosion are most likely to cause problems with water quality. The identification of areas with the greatest need would require additional study.

Changes in the Official Plan designation of agricultural lands within the subwatershed will require Official Plan Amendments with consideration for all respects of the PPS. However, if the Provincial Policy Status to be followed and agricultural policy is hypothetically considered to be more important than other policies, then the poorer agricultural lands which are adjacent to built-up areas would be developed first. As well, provincial policy differentiates between specialty croplands and prime agricultural lands and rates specialty croplands as more important. This policy-related sequence or hierarchical classification of agricultural land would suggest that the better agricultural lands, especially lands used for specialty crop production, within the subwatershed are likely to remain in agricultural use the longest. Thus, these better lands should be the ones considered when plans are initiated to improve management practices on agricultural land. This issue and other PPS issues would be considered during the OPA process. In addition, dialogue/discussions, which would provide information about the time frame estimated for urbanization, are recommended with farmers and farm groups. In this way, farmers could make more pragmatic cost-effective decisions about the timing, amount and location(s) associated with the application of best management practices.

Given the agricultural characteristics of the study area as well as land ownership, any proposals for the improvement of terrestrial ecosystems will need the acquiescence but preferably the "buy in" of farmers. Therefore, any proposals to improve ecosystem linkages, to improve habitat or to rehabilitate ponds or wetlands must consider the needs and wishes of the agricultural community (e.g., Waterloo Federation of Agriculture).

Existing stewardship programs aimed at the agricultural community can be grouped into three broad categories, which are:

- educational
- monetary incentives
- disincentives (generally monetary but may take another punitive forms)

All three categories are utilized in Ontario for environmental components of soil, air, water, forested land and wildlife. Educational approaches, or methods that have been called persuasion or moralsuation in the literature, are preferred when dealing with private agricultural lands. Education takes the form of free booklets such as those published by OMAF and listed in **Table I1** (**Appendix I**). Alternatively, there are demonstration sites on farms throughout the Province, including a number of locations in Waterloo Region. Demonstrations available in Waterloo and adjacent Counties as described in the South Western Ontario Land Stewardship Demonstration Areas Catalogue (Grand River Conservation Authority web site, 2001) include but are not limited to grass waterways, permanent streambank buffer strips, manure storage and handling facilities, milk house waste treatment, sensitive land retirement, erosion control, cattle fencing by streams, spill containment facilities and conservation tillage. In addition, methods for the preparation of environmental farm plans are available in a program administered by the Agricultural Adaptation Council and delivered locally by the Ontario Soils and Crop Improvement Association (OSCIA). http://www.gov.on.ca/OMAFRA/english/environment/efp/efp.htm - see **Table I1** (**Appendix I**) or are presented as part of workshops by OMAF.

Monetary incentives related to conservation programs change regularly depending on the budgets of municipal through to federal governments. Programs included or currently include opportunities for grants or for the supply of low cost loans to pay a portion of costs associated with the construction of approved manure storage facilities or for the implementation of environmental farm plans, for example. Currently, the Rural Water Quality Control Program administered by the GRCA is supplying funds for projects as diverse as treatment of milk house waste through to sensitive lands retirement. Another current program administered by OMAF is called Healthy Futures for

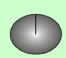
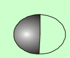
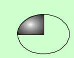
Ontario Agriculture and will pay up to 50 percent of the cost associated with projects that will maintain or improve water quality (see also **Table I2**, **Appendix I**).

Disincentives are described as part of legislation such as the proposed Nutrient Management Act (2001), the Environmental Protection Act at the provincial level as well as within the Federal Fisheries Act. The application of educational programs in addition to monetary incentives and disincentives are a function of government will, policies and budget. At the individual farm level, adoption of best management practices that will result in good water quality and quantity outcomes are a function of individual values, farm economics, interest and the number of people involved in decision-making. In the latter instance, for example, where tenants use farms, application of conservation programs has the potential to be more difficult because more people and different interests are involved in the application and maintenance of the conservation program. While some people are of the view that tenants are less likely to employ best management practices, scientific proof of such a relationship is difficult to find. Therefore, application of conservation programs on private lands that will improve water quality is likely to be more difficult with a number of people involved in the decision increases. In general terms, this problem is more likely to arise within the subwatershed in the area south and east of Regional Road #24, particularly in the area south of Blackbridge Road, because of the increased property fragmentation in that area.

Existing stewardship programs tend to be limited as well as discontinuous (temporally and geographically) depending on the funding available from different levels of government. Generally, the federal government makes money available for specific scientific studies associated with stewardship while government at the provincial and municipal levels (including the GRCA) tend to make some funds available for the application of a limited number of measures designed to meet specific objectives associated with stewardship. In other words, some programs deal with concepts while other programs deal with practical application at the individual farm level. Because the funding at the applied scale tends to be less than 100 percent, is also contingent on a set of rules, and, as mentioned previously, is discontinuous, the choice or recommendation of a program of application is most practically made at the time the funds are first made available. Therefore, no specific recommendations have been made as part of this report. On a practical basis, recommendations related to programs can best be made at the time of possible implementation based on the programs available at that time.

Agriculture consists of a number of components that can be described as biological, physical, social and/or economic. Which of these components is most important, that is, which component has the greatest or highest value, varies within communities. Thus, any management strategy associated with the subwatershed will need to consider a broad cross-section of different values. Therefore, it is recommended that public or private meetings for the farm community or individual farmers be held where these meetings have the specific objective of defining a preferred management strategy related to agriculture.

Table C 3.3.2 Evaluation of Alternative Natural Heritage System Options

Evaluation Factor	Option 1 (No Buffers)	Option 2 (50/30 m Buffer)	Option 3 (50/30 m Buffer, Enhanced Corridor)
Description	Development outside staked limits of natural features or regional floodline, whichever is greater, within the subwatershed	**South of Blackbridge Road: No urban development within 50 m buffer around wetland features, or within regional floodline, whichever is greater. Reduced buffer dimension may apply subject to site-specific hydrogeological assessment as part of a Scoped EIS; min 30 m**	**South of Blackbridge Road: No development other than trails within 50 m buffer around wetland features, or within regional floodline, whichever is greater. Enhancement areas to be naturalized to create overall corridorwidth of 250 to 300 m. Reduced buffer may apply subject to site-specific hydrogeological assessment; min 30 m. Permitted uses within Enhancement Areas include passive recreation and stormwater management facilities (subject to scoped EIS).**
		North of Blackbridge Road: No rural development within 30 m buffer around natural features, or within the regional floodline, whichever is greater. Scoped EIS required if development is proposed within 30 m buffer, or if major development is proposed (see text).	**North of Blackbridge Road: No rural development within 30 m buffer around natural features, or within the regional floodline, whichever is greater. Scoped EIS required if development is proposed within 30 m buffer, or if major development is proposed (see text). Enhancement Areas proposed.**
			Enhancement areas as shown on Greenspace Management Plan
Policy Compliance	Not fully compliant with Provincial, Regional, City and/or GRCA policies	Not fully compliant with Provincial, Regional, City and/or GRCA policies	Complies with Provincial, Regional, City and/or GRCA policies
Impacts to Vegetation	High impacts to edge vegetation, encroachment effects (*see text*), altered hydrology, altered water quality; likely loss of significant plant species	Low to moderate impacts to existing vegetation due to altered hydrology, potential loss of significant plant species, spread of invasive species.	Low to moderate impacts to existing vegetation due to altered hydrology, potential loss of significant plant species, spread of invasive species.
Impacts to Wildlife	High impacts to wildlife due to encroachment effects, loss of edge habitat, reduced landscape porosity; likely loss of wildlife diversity and breeding bird species	Moderate impacts to wildlife due to encroachment effects, loss of edge habitat, reduced landscape porosity; potential loss of wildlife diversity and breeding bird species	Low to moderate impacts to wildlife due to encroachment effects, loss of edge habitat, reduced landscape porosity; potential changes of wildlife diversity and breeding bird species; potential long term gain in diversity due to creation of upland habitats in Enhancement Area.
Impacts to Functions	High impacts to functions: groundwater, habitat diversity, connectivity, seasonal migration and dispersal	Moderate to high impacts to functions: groundwater, habitat diversity, connectivity, seasonal migration and dispersal	Moderate impacts to functions: connectivity, seasonal migration and dispersal; potential gain in function for some sensitive species that require transitional upland habitats.
Impacts to Future Land Use	No limitations beyond regulatory requirements	Loss of development opportunity	Loss of development opportunity; constraints on land uses in vicinity of wetland corridor, buffers and enhancement areas
Trail & Recreation Impacts	Trail location constrained by seasonally wet conditions; extensive boardwalks necessary.	Trail location within PSW subject to Scoped EIS, boardwalks required to cross creek.	Trail location within PSW subject to Scoped EIS, boardwalks required to cross creek.
	Trails will create moderate to high impacts on wildlife.	Trails will create low to moderate impacts on wildlife; subject to Scoped EIS.	Trails will create low to moderate impacts on wildlife; subject to Scoped EIS.
OVERALL EVALUATION			 ***PREFERRED ALTERNATIVE***