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 Hespeler West subwatersheds. The detailed study has given us insight into the physical and biological characteristics of these subwatersheds and related environmental issues. This plan is being completed in order to satisfy Provincial, Regional and municipal government policies regarding land development as urban development is anticipated to occur on designated lands south of Maple Grove Road.

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 subwatersheds, we must first come to an understanding of the various constraints and opportunities that exist in the Hespeler West subwatersheds. 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 1.2).

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 in part a Comprehensive Environmental Impact Statement and therefore will determine the general thresholds which will form the limits to development in different areas of the subwatersheds, based on the preferred environmental management alternative.

The Natural Heritage System within the three subwatersheds includes:

- a portion of the Provincially Significant Speed River Wetland Complex;
- the Provincially Significant Maple Grove Road Wetland Complex (status revised in this study), and
- the Locally Significant West Creek Wetland Complex (newly evaluated in this study).

Portions of the Maple Grove Wetland Complex, associated upland habitats, and a natural feature on the Arriscraft lands, were previously identified as Locally Significant Natural Area (LSNA) 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 A 2.2.4 illustrates existing areas currently recognized as LSNA by the City. Based on the outcome of the terrestrial studies for the subwatersheds, the West Creek Wetland Complex would satisfy LSNA criteria. The majority of remaining habitats are included within the two Provincially Significant wetland complexes.

An overriding aspect from the standpoint of a linked natural heritage system is provided by 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 Hespeler West subwatershed are illustrated on Map 15 of the Cambridge Official Plan (Corporation of the City of Cambridge, 1999), presented as Figure A 2.2.4 in the present report. Identification as a LSNA requires 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.

The Regional Municipality of Waterloo has not designated Environmentally Sensitive Policy Areas (ESPAs) within the Hespeler West subwatersheds to date. An analysis of the natural heritage features observed according to ESPA criteria is provided in **Table C 1.2.1**. Based on this analysis, there are adequate grounds to consider ESPA designation of at least some of the habitat features in the East and Middle Creek subwatersheds. In particular, the headwater areas north of Maple Grove Road are relatively large and extensive, meeting several primary and likely two or more secondary ESPA criteria. Interpretation of secondary criteria must be based on an overview of the entire ESPA system, and Regional staff and the Region’s Ecological and Environmental Advisory Committee (EEAC) will therefore assess whether ESPA designation is appropriate. If one or more 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. Such a designation would limit development opportunities within the identified ESPA. However, Provincially Significant Wetland status has been recommended elsewhere in this report for most areas likely to be included in ESPA.

Existing Provincial, Regional and local policy areas are summarized on Figures A 2.2.3 and A 2.2.4.

Table C 1.2.1 Criteria Met for Environmentally Sensitive Policy Areas (from ROPP Policy 4.3.2, RM Waterloo, 1998)

ESPA Criteria		East Creek	Middle Creek	West Creek	Comments
Primary Criteria (section 4.3.2b):					
i)	comprise ecological communities deemed unusual, of outstanding quality or particularly representative regionally, provincially or nationally;	Poss	Poss	No	East and Middle Creeks SWS contain extensive communities: headwater swamp, upland forest, marsh, spring-fed swamp, floodplain swamp, shallow bedrock along the Speed River corridor
ii)	contain critical habitats which are uncommon or remnants of once extensive habitats such as old growth forest, forest interior habitat, Carolinian forest, prairie-savanna, bogs, fens, marl meadows, and cold water streams;	Yes	Yes	Yes	All 3 SWS contain habitat blocks with forest interior conditions, and support associated forest interior bird species. The largest blocks occur in East and Middle SWS north of Maple Grove Road.
iii)	provide a large area of natural habitat of at least twenty hectares which affords habitat to species intolerant of human intrusion; or	Yes	Yes	No	The portions of East and Middle Creeks SWS north of Maple Grove Road each contain contiguous blocks of habitat exceeding 20 ha
iv)	provide habitat for organisms indigenous to the Region recognized as nationally, provincially, or regionally significant; or	Yes	Yes	Yes	Plants – 21 species considered significant by Region; 3 considered rare in Province (subject to further verification) Wildlife – 34 species considered significant by Region
Secondary Criteria (4.3.2c):					
i)	contain an unusual diversity of native life forms due to varied topography, contain microclimates, soils, and/or drainage regimes;	Poss	Poss	Poss	All 3 SWS contain diverse native habitats over the varied soil, topographic and drainage regimes present from the headwaters down to the Speed River floodplain. Wetlands are better represented than uplands; the headwater area of East Creek contains the most diverse upland forests.
ii)	perform a vital ecological function such as maintaining the hydrological balance over a widespread area by acting as a natural water storage discharge or recharge area;	Yes	Yes	Yes	Extensive headwater wetlands provide major natural storage on East and Middle Creeks. Discharge systems exist in middle and/or lower reaches of all 3 Creeks. The upper East Creek SWS recharges aquifers that sustain the Chiligo Creek.
iii)	provide a linking system of relatively undisturbed forest or other natural habitat for the movement of wildlife over a considerable distance;	No	Poss	No	The Middle Creek habitat block north of Maple Grove Road is over 2 km in length, with one rural road crossing (Middle Block Road).
iv)	serve as major migratory stop-overs; or	No	No	No	
v)	contain landforms deemed unusual or particularly representative at the regional scale.	Poss	Poss	No	The East and Middle Creeks systems display a full range of soil and topographic extremes, from lacustrine and outwash sands in the headwaters, tills in the middle reaches, and shallow shale and dolomite bedrock along the Speed River.

Interpretation: **Yes** – criterion clearly met; **No** – criterion clearly not met;
Poss – criterion possibly met, subject to interpretation by Regional staff & EEAC.

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 **J7** (Wildlife Constraint Assessment Methodology). The application of these methodologies determines overall constraint rankings for both the vegetation and wildlife resources. Results of this analysis are summarized in **Appendix J6** and illustrated on Figure B 8.3.3.

A number of small features which were initially assigned with medium to high constraints on the basis of drainage or canopy age, were downgraded to medium or low constraint where it was determined that a) they represent features which were human-created and b) they are separated from core features by intensive land uses, to the extent to preclude significant contribution to overall functions of the natural heritage system. Examples include wet pockets along Highway 401, or minor drainage features without strategic connective value, and groupings of mature shade trees from former farmyards. Original constraint rankings are noted in brackets in the constraint Rating column in **Appendix J6**, along with their recognized constraint status.

Linkages

Linkages of habitats within the subwatersheds, and extending to natural features outside the subwatershed boundaries were determined based on background information (including deer yarding data from MNR), multi-season field observations of species usage and signs of movement, interpretation of contour mapping and aerial photographs, and review of preliminary regional habitat mapping of the Speed River, prepared by the Speed River Land Trust.

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 will be subject to detailed confirmation as part of subsequent design and subwatershed work, including that for adjoining subwatersheds.

Habitat linkages represent potential constraints, as well as 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 if 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 along tributaries to the Speed River Wetland Complex, will have particular benefits for a wide range of species, including large mammals such as deer and coyote, and amphibians and reptiles that are affiliated with wetland and riparian cover. Highway 401 represents a major constraint to wildlife movement from the West Creek to the Speed River. However, there is a potential linkage between West Creek and points eastward north of the Highway 401 through the Speed River corridor, connecting via the relatively large span bridge over the Speed River at Regional Road #24 to riverside habitats located well east of the subwatersheds. Provision of enhanced valley connections to the Speed River along the East and Middle Creeks is considered important to the future functioning of the natural heritage system in the subwatersheds. Enhanced habitat cover, hedgerows and rural countryside in the upper subwatershed areas would optimize connections with the nearby Chilligo Creek and Hespeler West subwatersheds, and can potentially provide part of a substantial natural heritage corridor between the Grand and Speed Rivers.

Functional linkages also exist between ground and surfacewater hydrology, and wetlands within the subwatersheds. The combination of subcatchment area, local topography, vegetative cover and soil texture represent a complex hydrologic system that sustains a mosaic of wetland communities as discussed in Section B of this report.

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.

A conceptual linkage and enhancement plan is presented in Figure C 1.2.1.

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 Hespeler West subwatersheds and in the Speed River (to the extent that it can be affected by activities in the Hespeler West subwatersheds) 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 Hespeler West system. The final width of the buffer should be established during the scoped site EIS process. Figure C 3.3.1 details a 15 metre buffer option on the Hespeler West creek systems.

C 1.3 Natural Hazard Issues

C 1.3.1 Flooding

The key natural hazard issue within the Hespeler West 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.

C 1.3.2 Steep Slopes

Steep slopes are another important natural hazard feature in the subwatersheds, particularly in areas of potential development. Steep slope areas exist along the Speed River and on the lower reaches of the three tributary creeks.

Steep slopes in the study area can generally be described as three main regions:

a). An area east of Beaverdale Road and next to Regional Road #24 near the Chilligo Creek subwatershed boundary. Top-of-bank is to the north in an area currently used for agriculture.

b). Several areas exist in the area southwest of the intersection of Beaverdale Road and Old Maple Grove Road along the lower section of the East and Middle Creek channels. Much of this area is developed into residential subdivisions.

c). Areas near the Arriscraft operations along Speedsville Road (excluding slopes related to the active pit operation).

d). Further west, an area on the east side of Boxwood Drive next to West Creek and steep slopes between Royal Oak Road and Highway 401 exist.

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.

Most of these areas identified above are contained in the High Constraint area shown on Figure B 8.3.3. Natural Heritage Constraints. Only three small areas of steep slope are omitted from this High Constraint designation and were considered too small to map. They are described as:

1) An area in East Creek subwatershed opposite Ratcliffe Drive and located between Regional Road #24 and Beaverdale Road (area = 80 x 200 metres and presently agricultural field).
2) An area in Middle Creek subwatershed located immediately west of the farm pond (M6 shown on Figure A.1.1.2) with an area = 150 x 50 metres and presently part of a farm yard, north of a barn.
3) An area in West Creek subwatershed located immediately north of Highway 401 and south of the row of houses fronting onto Cherry Blossom Road (area = 80 x 300 metres and presently the rear portion of residential lots).

These areas specifically will therefore need to be considered in any development or redevelopment activity planned. Areas of steep slopes and their required setbacks should be addressed in the Community Plan and in subsequent Scoped Environmental Impact Statements and Plans of Subdivision or Site Plan Approval.

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 Hespeler West subwatershed. The following figures are applicable to a final Opportunities and Constraints Plan:

- B 3.2.1 Regulatory Floodlines
- B 8.3.2 Evaluated Wetlands
- B 8.3.3 Natural Heritage Constraints
- C 1.2.1 Conceptual Subwatershed Linkages & Enhancement Areas

C 2.0 LAND USE SCENARIOS

C 2.1 Introduction

The existing planning designations are described in Section A 2.2 - City of Cambridge Official Plan and A 2.3 - City of Cambridge Zoning By-law. These designations are shown on Figures A 2.2.1 and A 2.2.2 and the zones are identified on Figure A 2.3.1.

C 2.2 Land Use

The subwatershed contains a mix of land use designations that can generally be described as "agricultural" north of Maple Grove Road and east of Middle Creek with a "urban" designation to the south and west of these features. The area designated agricultural is approximately 460 ha in size and would require amendments to the planning policies to permit urban development.

The urban area south and west of the above described line contains both general industrial and surburban residential uses. The industrial uses include the Toyota vehicle manufacturing plant, Loblaws grocery distribution facility, Seaforth Creamery and Arriscraft International sand and gravel extraction. A small portion of the Arriscraft property to the east has been rehabilitated and developed into a residential subdivision (known as Idylwild). An adjacent residential area along Royal Oak Drive, Briardean Road and Speedsville Road completes the residential use within the subwatersheds. Proposals for development within the currently designated urban areas would be evaluated on the basis of existing policies and the requirements of the subwatershed study applicable to the proposed uses.

The extent of future development will be influenced by the outcome and implementation of the Regional Municipality of Waterloo's "Smart Growth Initiative" and the City of Cambridge "Country Side Line" (see Figure C 2.1.1 and discussion in Section B 7.3.1).

The City of Cambridge will implement the recommendations of the Hespeler West Subwatersheds Study where appropriate, through amendments to the Official Plan and a Community Plan. This includes designating natural heritage areas through the Greenspace Management Strategy. The information gathered through this 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 MANAGEMENT ALTERNATIVES

C 3.1. Aquatic Systems

C 3.1.1 Rehabilitation Background

The Hespeler West creek systems all have three main reach segments: an upper plateau in the headwater area, for the most part significantly altered in each case with the possible exception of East Creek upstream of Maple Grove Road; a transitional area which is characterized by steeper gradients and active erosion, however buffered for the most part by some riparian vegetation and containing structures in channel (such as ponds and drop structures); and lower reaches characterized as depositional zones which have also been altered to a great degree, with the possible exception of Middle Creek downstream of Hunt Club Road.

Each of these reach segments has specific fluvial process properties. The upper plateau reaches tend to contain wetland features that play a significant role in storage of large volumes of flow, assisting in slow release of water during periods of high input. This assists the lower reaches of the creeks by buffering some of the high potential energy as flow enters the steeper transitional areas. In these steeper areas, flow is somewhat more concentrated into a proper channel form, and we see evidence of channel wandering as meandering becomes more developed. The addition of flow energy to these reaches also assists in creating a diversity of channel components: riffles and pools are formed which are not homogeneous in nature with one another, providing high potential for diverse aquatic habitat. Within the depositional reaches we note that riparian buffers decrease in extent and the channels become less diverse, and in the case of West and East Creeks this section is highly altered and while able to deliver flow through the reaches, are essentially non-functioning from a fluvial perspective.

Instability is the main issue with regard to these creeks. As noted in the Impact Sensitivity Map in Section B4.3.7, the only reaches that are considered stable are those that have been channelized and protected or those in unaffected wetland complexes. As a result of the diversity of process properties in each of the channel areas (plateau, transitional and depositional), management strategies for these creeks must be site-specific if they are going to be effective. In other words, it would be unwise to adopt a single management strategy and methodology for all Hespeler West creek systems and apply it across all process boundaries. Specific treatments must be identified for each section.

C 3.1.2 Aquatic Options

Having considered the entirety of the fluvial assessment of these creeks, a number of management alternatives options present themselves.

System-Wide Options:

Considering the three creeks as a system, there are a number of system-wide options that present themselves:

1. Leave the systems as they are.
2. Establish naturally vegetated riparian buffers in all areas where none currently exist.
3. Protect and enhance existing buffers.
4. Remove the on-line ponds.
5. Remove or modify culverts that are barriers to upstream fish migration.
6. Conduct site-specific remediation strategies for immediate problem areas.

Leaving the systems as they currently exist would be a very cost effective strategy for the time being, as there would be no capital outlay initially. However, as time progresses there will be increasing capital costs to deal with ongoing maintenance issues as the systems continue to degrade.

Establishing riparian buffers is essential to proper functioning of the creek systems, and has wildlife and aquatic habitat benefits as well.

Removing the on-line ponds would result in a high initial cost, would require a series of significant interventions to the channel, and may cause some social or cultural impacts as some of the ponds have been in place for decades and have historical value. On the positive side, removal of the ponds would improve sediment transport and water flow, thereby increasing water quality.

Conducting site-specific remediation strategies for immediate problem areas would deal with the potential rapid decline in quality of segments of these creeks, and being targeted would provide maximum return on investment. One potential disadvantage of this option is it requires the attention of a fluvial geomorphologist to assist in the decision-making process for all strategies, from prioritizing works to designing and construction supervision of these works. While not a severe disadvantage, there would be associated costs with this strategy.

East Creek Options:

Based on the information available at this time, East Creek is a warmwater stream containing common stream fishes. A natural waterfall blocks upstream fish migration approximately 500 metres upstream from the Speed River. There are two more barriers created by culverts further upstream. There are no on-line ponds. Some reaches have been ditched/channelized in the past, and some reaches are bordered by manicured lawns, with some indication that this treatment will increase.

Management activities could be considered, alone or in various combinations, include the following:

1. Rehabilitate the lower section (previously channelized) of the creek from the start of the Regional Road #24 alteration to the Speed River.
2. Rehabilitate the entire lower section downstream of Beaverdale Road (including establishing a formal riparian buffer downstream of Beaverdale Road within the residential property).
3. Modify stream so that waterfall is no longer migration barrier.
4. Rehabilitate the section downstream of Maple Grove Road adjacent to the sod farm operation.
5. Keep development away from the headwater areas upstream of Maple Grove Road.

The first two options require extensive channel interventions to reestablish proper creek functioning in the lower reaches and should be seen as a priority for the health of this system, especially with regard to aquatic habitat. While the creek aesthetically looks fine immediately downstream of Beaverdale Road, the data indicates it is in a high state of flux and needs to be buffered. The third option would require less intervention overall as there are sections of the creek in this area which function well, this option would simply be more proactive to retain resilience in the creek. The fifth option is essential to maintain flood storage.

Middle Creek Options:

Based on the information available at this time, Middle Creek is a warmwater stream containing common stream fishes. There are several barriers to upstream fish migration through the middle reaches and three on-stream ponds in total. There are several sections of the stream where the channel has been straightened and otherwise modified. Through the middle and lower portions of the creek there appears to be a considerable amount of groundwater discharge, which suggest that it might be possible to create a coldwater (trout) stream. Further information with respect to temperatures and fish communities will assist in determining if this is feasible.

Management activities could be considered, alone or in various combinations, include the following:

1. Rehabilitate the section of creek upstream of Hunt Club Road to the on-line pond (previously gabion lined).
2. Remove on-line ponds.
3. Conduct site-specific treatments upstream of the on-line pond in the straight section between the path and Briardean Road (including removal of the culvert beneath the path and reestablishing a meandering pattern to the creek upstream).
4. Reestablish a natural pattern to the creek along the Maple Grove Road channelization.
5. Rehabilitate and properly size the channel upstream of Maple Grove Road to the headwaters area.

Again, option 1 and 2 would be very costly and considering the channel downstream is in good shape, might not need serious consideration as long as maintenance of these sections is ongoing. Clearly the most important option to consider immediately is the third one, as this segment of the creek is at the highest risk for further degradation. It is expected that while options 4 and 5 need addressing, they will not form a part of any management strategy for the time being due to high costs and transportation/development infrastructure issues.

West Creek Options:

Based on the information available at this time, West Creek is a warmwater stream containing common stream fishes. The headwaters of this system have been eliminated, so its source is now a storm sewer, which is the outlet of a stormwater management pond. It is possible that this has created a source of cool base flow. There is one dam that is a barrier to upstream migration, and a naturally steep section that will impair upstream movement. The lower reach has been channelized.

Management activities could be considered, alone or in various combinations, include the following:

1. Rehabilitate the lower portion of the creek in Riverside Park.
2. Remove the dam and drop structure at Royal Oak Drive.
3. Develop and implement a monitoring programme for the reaches upstream of Royal Oak Drive to assess ongoing channel adjustments to loss of upstream catchment area.

Option two would be the least cost-effective of the West Creek options, and option one would likely not be a priority as the creek is stable through this reach, though minor adjustments are taking place. Given the likelihood of significant channel adjustment due to loss of catchment area, option three should be given priority.

C 3.1.3 Aquatic Options Summary

Attempting to deal with stream management options across three systems can be a daunting task, with potential confusion surrounding which options to tackle in what order in an attempt to get the maximum benefit from funds. Therefore, a priority listing has been developed which puts these three creeks into perspective given the existing conditions as determined from the fluvial data and considering costs and likelihood of implementation. In order from high priority to low, the ranking is as follows:

1. East option 1.
2. East option 2.
3. West option 3.
4. Middle option 3.
5. East option 3.
6. East option 4.
7. Middle option 1.
8. West option 1.
9. East option 5.
10. Middle option 5.
11. Middle option 4.
12. West option 2.
13. Middle option 2.

The ranking has been based on an assessment of various evaluation criteria including:

- state of degradation;
- ease of implementation;
- ranking based on erosion sensitivity;
- degree of human impact;
- environmental benefit;
- resiliency to perturbation; and
- cost and availability of funding.

From a system-wide perspective, not considering the creeks as separate entities but the entire Hespeler West subwatersheds as a whole, the order of priority would be:

1. System Wide Option 3.
2. System Wide Option 2 and 6.
3. System Wide Option 5.
4. System Wide Option 4.

It is not recommended that System-wide Option 1 be seriously considered as these systems are, as indicated in Section B 4.3.7, at risk of rapid degradation.

Following this priority listing would provide the best management strategy to maintain the existing conditions of the creeks while increasing resilience to future development or other land-use pressures and improving degraded areas. These options and their rankings are summarized on Figure C 3.1.3 - Aquatic Strategy Rehabilitation.

Final designs of any option would be required. The design process would require extensive public, and agency consultation prior to this final approval and implementation.

C 3.2 Water Management Alternatives

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

1. Do-nothing;
2. Full water quality and quantity in new development ponds;
3. Water quality control only (additional flows directed to the Speed River);
4. Water quantity control only (no quality control);
5. 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 and 4. Option 3 was eliminated, as it was determined that the existing creeks were not able to accommodate the additional flows. Option 5 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 2.

C 3.2.1 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 (Interim Development) represents an assumed condition for areas already committed or proposed for residential and industrial development as far north as the countryside line. Scenario 3 (Ultimate Development) assumes complete development of all developable areas in all three subwatersheds. Scenario 3 is conceptual in nature as areas north of the countryside line have currently not been committed for development. However, Scenario 3 is necessary in order to fully understand how future conditions may impact the Hespeler West subwatershed, to determine ultimate Regulatory floodlines and to allow the current study to make any necessary allowances.

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.

The new urban areas in Scenarios 2 and 3 were assumed to be a combination of residential and industrial development. Future residential development was assumed for subcatchments where new or additional residential areas are proposed, or where the existing land use is predominantly residential. Industrial development was assumed for all other areas. Imperviousness values of 55% for residential development, and 88% for industrial development, were assigned in the revised impervious area calculations. These values were based on detailed analysis of the impervious coverage of developed areas recently undertaken by the City of Kitchener.

To develop an understanding of the Stormwater Management criteria and targets required in each subwatershed, the Scenario 3 hydrology model was modified by inserting detention pond elements at the outlet of developed subcatchments. These detention ponds were sized for both extended detention (water quality purposes with 48 hour drawdown providing Level 1 control as per MOEE 1994) 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 3.2.1** and **C 3.2.2** show the volumes required for stormwater control. **Table C 3.2.3** summarizes the peak outflows from the subcatchments with stormwater controls for the 2 year through 100 year events.

Flood flow estimates were made using revised GAWSER subwatershed files for Scenario 3. The results are presented in **Table C 3.2.4**. The corresponding mean annual water balance summaries resulting from the 39-year continuous simulation for Scenario 3 are given in **Table C 3.2.5**. Flow duration curves showing the results for existing conditions, Scenario 3, and Scenario 3 with controls, are given in **Appendix D, Figures 3.6.1 to 3.6.9** for East, Middle and West Creeks respectively.

Table C 3.2.1 Summary of Extended Detention Volumes for Scenario 3

Creek	Subcatchment	Extended Detention Volume (m^3)	48 hour Drawdown Rate (m^3/s)	Volume/area (m^3/ha)	Volume/Impervious Area (m^3/ha)
East Creek	1101	636	0.0037	100	178
	1103	1660	0.0096	100	130
	1110	749	0.0043	100	130
	1115	1180	0.0068	100	130
	1117	1900	0.0110	100	141
	1125	671	0.0039	100	294
	1130	1030	0.0060	100	131
Middle Creek	2101	1170	0.0068	100	113
	2110	2520	0.0146	100	154
	2115	3850	0.0223	100	333
	2125	5100	0.0295	100	192
	2130	2330	0.0135	100	141
	2135	2040	0.0118	100	125
	2136	777	0.0045	100	185
	2139	401	0.0230	100	213
	2140	577	0.0033	100	122
	2150	2700	0.0156	100	222
	2155	2840	0.0164	100	161
	2160	2210	0.0128	100	264
	2170	2820	0.0163	100	204
	2172	1180	0.0068	100	128
	2173	1280	0.0074	100	213
	2175	1060	0.0061	100	217
	2180	676	0.0039	100	323
West Creek	3103	479	0.0028	100	114
	3104	2120	0.0123	100	167
	3110	482	0.0028	100	151
	3115	242	0.0014	100	454
	3120	399	0.0023	100	114
	3125	549	0.0032	100	137
	3135	1170	0.0068	100	113
	3145	241	0.0014	100	238
	3150	696	0.0040	100	114

Table C 3.2.2 Summary of Required Storm Volumes for Scenario 3

Creek	Subcatchment	100 Year Detention Volume (m^3)	Peak Outflow (m^3/s)	Volume/area (m^3/ha)	Volume/Impervious Area (m^3/ha)
East Creek	1101	2641	0.28	415	741
	1103	6439	0.99	387	502
	1110	2497	0.61	333	433
	1115	4947	0.74	420	545
	1117	7312	0.05	386	543
	1125	1202	0.48	179	527
	1130	4160	0.53	402	529
Middle Creek	2101	5506	0.56	470	534
	2110	10452	0.93	415	638
	2115	10923	0.45	284	945
	2125	21069	1.01	413	795
	2130	9110	1.27	391	550
	2135	8491	1.11	417	522
	2136	2154	0.59	277	513
	2139	950	0.25	237	504
	2140	2298	0.38	398	486
	2150	8098	1.19	300	666
	2155	10719	1.53	377	608
	2160	5654	0.55	256	675
	2170	9478	1.30	336	685
	2172	4029	1.02	341	437
	2173	1499	2.60	117	250
	2175	1309	2.30	123	268
	2180	1684	0.71	249	804
West Creek	3103	1913	0.34	400	454
	3104	8148	1.24	385	641
	3110	1279	0.44	265	402
	3115	363	0.10	150	681
	3120	1245	0.42	312	355
	3125	1654	0.50	301	413
	3135	4530	0.77	386	438
	3145	274	0.43	113	270
	3150	2515	0.59	362	411

Table C 3.2.3 Summary of Peak Subcatchment Outflows										
Creek	Node	Outflow Location	Area (ha)	Peak Flows (m^3/s) 1:2 yr	1:5	1:10	1:25	1:50	1:100	REG
East Creek	1101	Subcatchment 1101	6.4	0.024	0.033	0.066	0.114	0.161	0.193	0.282
	1103	Subcatchment 1102	16.6	0.047	0.081	0.205	0.381	0.549	0.671	0.991
	1110	Subcatchment 1110	7.5	0.019	0.041	0.122	0.233	0.338	0.416	0.612
	1115	Subcatchment 1115	11.8	0.016	0.042	0.136	0.272	0.399	0.493	0.735
	1117	Subcatchment 1117	19	0.023	0.060	0.193	0.384	0.566	0.700	1.050
	1125	Subcatchment 1125	6.7	0.039	0.055	0.110	0.186	0.255	0.306	0.482
	1130	Subcatchment 1130	10.3	0.009	0.027	0.094	0.190	0.282	0.350	0.532
	1135	Subcatchment 1135	12.4	0.477	0.583	0.919	1.340	1.690	2.010	2.690
	1140	Subcatchment 1140	13.2	0.244	0.336	0.633	1.020	1.330	1.620	2.350
	1145	Subcatchment 1145	11.8	0.515	0.615	0.929	1.320	1.650	1.950	2.590
	1150	Subcatchment 1150	12	0.103	0.132	0.233	0.372	0.506	0.596	0.843
	1155	Subcatchment 1155	2.7	0.110	0.132	0.197	0.281	0.351	0.412	0.546
	1160	Subcatchment 1160	1.1	0.019	0.022	0.034	0.050	0.065	0.075	0.102
Middle Creek	2101	Subcatchment 2101	11.7	0.027	0.046	0.115	0.214	0.312	0.380	0.563
	2110	Subcatchment 2110	25.2	0.071	0.101	0.211	0.369	0.528	0.635	0.935
	2115	Subcatchment 2115	38.5	0.019	0.031	0.081	0.154	0.231	0.284	0.449
	2120	Subcatchment 2120	21.9	0.699	0.882	1.460	2.200	2.820	3.370	4.580
	2125	Subcatchment 2125	51	0.134	0.165	0.274	0.431	0.598	0.696	1.010
	2130	Subcatchment 2130	23.3	0.081	0.124	0.280	0.503	0.718	0.870	1.270
	2135	Subcatchment 2135	20.4	0.043	0.081	0.221	0.419	0.610	0.748	1.110
	2136	Subcatchment 2136	7.8	0.012	0.034	0.112	0.221	0.324	0.401	0.593
	2139	Subcatchment 2139	4	0.010	0.019	0.051	0.096	0.138	0.169	0.250
	2140	Subcatchment 2140	5.8	0.006	0.020	0.069	0.138	0.204	0.253	0.378
	2141	Subcatchment 2141	27.7	0.029	0.061	0.180	0.353	0.527	0.650	0.986
	2143	Subcatchment 2143	27.8	0.029	0.057	0.162	0.316	0.471	0.581	0.890
	2150	Subcatchment 2150	27	0.054	0.094	0.239	0.446	0.649	0.792	1.190
	2155	Subcatchment 2155	28.4	0.176	0.227	0.408	0.660	0.908	1.070	1.530
	2160	Subcatchment 2160	22.1	0.023	0.040	0.102	0.193	0.284	0.348	0.550
	2165	Subcatchment 2165	7.8	0.094	0.118	0.203	0.317	0.423	0.496	0.689
	2170	Subcatchment 2170	28.2	0.094	0.137	0.291	0.510	0.725	0.872	1.300
	2172	Subcatchment 2172	11.8	0.156	0.192	0.314	0.479	0.634	0.738	1.020
	2173	Subcatchment 2173	12.8	0.364	0.469	0.801	1.220	1.580	1.890	2.600
	2175	Subcatchment 2175	10.6	0.405	0.496	0.781	1.140	1.440	1.710	2.300
	2180	Subcatchment 2180	6.8	0.133	0.158	0.241	0.351	0.455	0.524	0.706
	2182	Subcatchment 2182	20.6	0.058	0.076	0.145	0.247	0.350	0.419	0.639
	2185	Subcatchment 2185	22.5	0.107	0.135	0.236	0.379	0.523	0.615	0.881
	2190	Subcatchment 2190	11.5	0.047	0.056	0.089	0.135	0.182	0.210	0.291

Table C 3.2.3 Summary of Peak Subcatchment Outflows

Creek	Node	Outflow Location	Area (ha)	Peak Flows (m^3/s) 1:2 yr	1:5	1:10	1:25	1:50	1:100	REG
West Creek	3103	Subcatchment 3103	4.8	0.006	0.018	0.064	0.127	0.187	0.232	0.344
	3104	Subcatchment 3104	21.2	0.152	0.194	0.342	0.549	0.749	0.879	1.240
	3110	Subcatchment 3110	4.8	0.011	0.028	0.086	0.167	0.240	0.295	0.442
	3115	Subcatchment 3115	2.4	0.002	0.005	0.019	0.038	0.055	0.069	0.104
	3120	Subcatchment 3120	4	0.020	0.037	0.093	0.171	0.239	0.293	0.424
	3125	Subcatchment 3125	5.5	0.013	0.032	0.098	0.189	0.272	0.336	0.496
	3135	Subcatchment 3135	11.7	0.041	0.067	0.163	0.297	0.424	0.518	0.772
	3145	Subcatchment 3145	2.4	0.044	0.061	0.115	0.184	0.242	0.295	0.427
	3150	Subcatchment 3150	7	0.025	0.047	0.124	0.230	0.329	0.403	0.589
	3155	Subcatchment 3155	5.2	0.060	0.078	0.139	0.223	0.299	0.354	0.500
	3160	Subcatchment 3160	10.8	0.116	0.141	0.228	0.348	0.463	0.538	0.743
	3170	Subcatchment 3170	1.4	0.044	0.056	0.091	0.137	0.175	0.208	0.282
	3175	Subcatchment 3175	6.1	0.250	0.302	0.464	0.670	0.843	0.995	1.330

Table C 3.2.4 Comparison of Flood Flows for Scenario 1 (pre) and Scenario 3 With Controls (post)

No. Point of Interest	Km^2	25 mm Pre	25 mm Post	1:2 yr Pre	1:2 yr Post	1:5 Pre	1:5 Post	1:10 Pre	1:10 Post	1:25 Pre	1:25 Post	1:50 Pre	1:50 Post	1:100 Pre	1:100 Post	Reg. Pre	Reg. Post
1503 East Ck - Headwater Pond	0.309	0.04	0.04	0.08	0.06	0.24	0.29	0.46	0.53	0.70	0.78	0.85	0.93	1.31	1.37	1.84	2.86
1210 East Ck at Mohawk Road	0.384	0.04	0.05	0.09	0.07	0.27	0.36	0.55	0.70	0.85	1.05	1.05	1.25	1.69	1.89	2.44	3.54
1213 East Ck at Node 1213	0.502	0.04	0.05	0.09	0.07	0.27	0.36	0.55	0.70	0.85	1.05	1.05	1.25	1.69	1.89	3.42	4.71
1232 East Ck: Lower Wetland	1.279	0.72	0.04	0.92	0.27	1.55	1.30	2.39	2.29	3.13	3.24	3.72	3.64	5.04	5.05	7.49	9.24
1235 East Ck at Beaverdale Rd	1.332	0.72	0.04	0.91	0.22	1.55	1.19	2.40	2.27	3.13	3.13	3.75	3.58	5.04	5.07	7.85	9.57
1255 East Ck at Speed R outlet	1.607	1.21	0.09	1.52	0.30	2.56	1.63	3.96	3.40	5.22	4.98	6.14	5.54	8.34	8.20	10.3	12.2
2215 Middle Ck at Block Road	1.044	0.67	0.15	0.86	0.38	1.54	1.21	2.45	2.26	3.30	3.45	3.92	3.80	5.46	5.40	6.45	10.8
2228 Middle Ck at Station 11+25	2.069	0.24	0.11	0.35	0.36	0.73	0.86	1.30	1.52	1.92	2.17	2.34	2.59	3.55	3.18	6.43	12.0
2235 Middle Ck at Station 16+25	2.285	0.24	0.12	0.36	0.37	0.79	0.90	1.43	1.61	2.13	2.31	2.61	2.78	4.00	4.14	7.81	13.4
2240 Middle Ck at Node 2240	3.949	0.50	0.36	0.98	0.72	2.54	2.21	4.63	4.11	7.26	6.61	8.73	7.94	13.1	12.1	19.4	28.4
2245 Middle Ck at Maple Grove Rd	4.219	0.53	0.37	1.04	0.78	2.71	2.44	4.97	4.53	7.80	7.25	9.41	8.73	14.2	13.3	21.2	31.1
2260 Middle Ck at Briardean Rd	4.802	0.65	0.42	1.24	0.97	3.18	2.91	5.82	5.54	9.11	8.76	11.0	10.5	16.6	15.9	25.0	36.5
2265 Middle Ck - Inlet Farm Pond	5.330	0.75	0.47	1.40	1.15	3.59	3.41	6.58	6.49	10.4	10.3	12.5	12.3	19.1	18.6	28.6	40.9
2275 Middle Ck at Hunt Club Rd	5.504	1.04	0.48	1.44	1.13	3.68	3.47	6.79	6.66	11.0	10.7	13.2	12.9	19.3	19.6	31.0	42.3
2285 Middle Ck at Speed R Outlet	6.050	0.93	0.48	1.49	0.96	3.64	3.34	6.66	6.68	10.3	10.6	12.7	12.8	19.3	19.4	31.0	42.4

Table C 3.2.4 Comparison of Flood Flows for Scenario 1 (pre) and Scenario 3 With Controls (post)

No.	Point of Interest	Km^2	25 mm		1:2 yr		1:5		1:10		1:25		1:50		1:100		Reg.	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
3501	West Ck - Loblaws SWM Pond	0.151	0.06	0.06	0.08	0.08	0.22	0.22	0.44	0.44	0.69	0.69	0.82	0.82	1.21	1.21	1.47	1.47
3502	Outlet Seaforth SWM Pond	0.191	0.15	0.05	0.24	0.05	0.68	0.13	1.32	0.72	1.94	1.36	2.34	1.73	3.37	2.80	2.43	2.38
3204	West Ck Start Toyota Divers.	0.680	0.24	0.11	0.47	0.14	1.32	0.80	2.51	1.98	3.71	3.01	4.43	3.63	6.41	5.44	6.48	7.00
3210	West Ck u/s ATS Site	0.848	0.24	0.13	0.49	0.21	1.44	1.01	2.82	2.42	4.24	3.79	5.11	4.59	7.62	6.88	8.03	8.62
3505	Outlet ATS SWM Pond	0.114	0.04	0.04	0.05	0.05	0.12	0.12	0.46	0.46	0.84	0.84	1.07	1.07	1.70	1.70	1.43	1.43
3235	West Ck at Royal Oak Rd	1.222	0.30	0.20	0.56	0.35	1.63	1.34	3.51	3.25	5.46	5.18	6.63	6.28	10.20	9.61	11.40	12.30
3245	West Ck at Highway 401	1.382	0.36	0.21	0.59	0.34	1.63	1.27	3.41	3.18	5.33	5.19	6.45	6.28	10.00	9.63	12.50	13.40
3247	West Ck at Hal Rogers Drive	1.403	0.41	0.22	0.59	0.34	1.63	1.27	3.43	3.19	5.38	5.21	6.51	6.31	10.10	9.70	12.70	13.50
3255	West Ck at Speed R Outlet	1.477	0.66	0.23	0.71	0.35	1.65	1.28	3.37	3.16	5.34	5.19	6.51	6.32	10.20	9.77	13.00	13.80

Table C 3.2.5 Water Balance Summary Scenario 2 Without SWM Controls

Node	Location	Drainage Area (km^2)	Precip	Water Balance Quantities (mm)				
				ET/SUB	Runoff	Baseflow	Losses	Flow
1210	East Creek at Mohawk Road	0.384	882.1	290.7	369.8	43.8	177.8	413.6
1225	East Creek at Maple Grove Rd	1.023	882.1	318.2	189.6	32.9	341.4	222.5
1235	East Creek at Node 1235	1.332	882.1	534.5	70.5	268.6	8.5	339.1
1240	East Creek at Beaverdale Road	1.450	882.1	329.7	261.2	288	3.1	549.2
1255	East Creek at Speed R outlet	1.607	882.1	335.2	276.4	266.3	4.3	542.6
2504	Middle Ck at Middle Block Road	1.044	882.1	334	431.5	61.2	55.3	492.7
2228	Middle Ck at Node 2228	2.069	882.1	327.8	462.8	56.2	35.4	518.9
2245	Middle Ck at Maple Grove Road	4.019	882.1	323	460.3	52.7	46	513
2250	Middle Ck at Speedsville Road	4.303	882.1	323.6	461.5	53.6	43.3	515.1
2275	Middle Ck at Hunt Club Road	5.304	882.1	334.8	447.7	58.1	41.6	505.7
2285	Middle Ck at Speed R outlet	5.850	882.1	342	428.5	97.7	13.8	526.2
3501	West Creek: Loblaws SWM Pond	0.151	882.1	213	659.3	10.1	-0.3	669.4
3502	West Creek: Seaforth SWM Pond	0.191	882.1	591.4	162.8	102.9	25	265.7
3505	Outflow ATS Swm Pond	0.114	882.1	213.8	644.8	26	-2.5	670.8
3235	West Creek at Royal Oak Road	1.222	882.1	337.2	438.4	57.4	49.2	495.8
3245	West Creek u/s Highway 401	1.382	882.1	346.4	433.4	59.7	42.6	493.1
3250	West Creek at Hal Rogers Drive	1.417	882.1	343	439	94.5	5.6	533.5
3255	West Creek at Speed R outlet	1.477	882.1	345.1	438.3	92.8	6	531

From examination of **Table C 3.2.1** and Figures C 3.2.1, C 3.2.2, and C.3.2.3 it has been demonstrated that future development will require:

1. Extended detention of the 25 mm runoff volume for water quality control.
2. Water quantity control (post- to pre-) for return period storms up to the 100 year event.

Individual development applications are required to submit preliminary stormwater management reports detailing how these criteria have been implemented and how they adhere to the recommendations of the Hespeler West Subwatersheds Study.

C 3.2.2 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

Table C 3.2.6 Stormwater Management Practice

SWMP	Water Quality	Flooding	Erosion	Recharge	Other			Long Term Effectiveness ***	Recommended for Further Consideration
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 3.2.2.1 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 placed 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 1.5.5**.

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 (e.g., 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 metres 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 3.2.2.2 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 Regional Municipality 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 metres) into the water quality trench. At a depth of 0.3 metres 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 Hespeler West 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: sandfilters, wetlands and manhole oil/grit separators. 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 3.2.4** 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. Infiltration in Open Space areas may also be investigated at this time.

Table C 3.2.4 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.

Table C 3.2.4 Advantages and Disadvantages of Pre-Treatment Measures for Road Runoff

Pre-Treatment Measure	Advantages	Disadvantages
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 3.2.2.3 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. Re-suspension 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 that 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.

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 3.2.2.4 Screened Stormwater Management Practices

Based on the preceding analysis, Development Scenario 2 may be implemented within the subwatersheds with restrictions to land use, as discussed in Section C 2.0. Future development must implement the necessary stormwater management practices and the preceding sections have provided a summary of the stormwater management practices that will need to be implemented in the subwatershed in order that management targets will be met.

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 3.2.2.5 Environmental Issues

To assist in augmenting the erosion control measures, Hespeler West creeks should be re-naturalized and a buffer established and maintained as development proceeds.

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 D 2.5.1**).

Based on the 39 year simulations and in consultation with the project hydrogeologist, **Table B 1.5.5** 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 3.2.3 Hydrologic Impact on West Creek

Additional hydrological analysis was performed for West Creek to determine the effects of the 1986 development of the Toyota Manufacturing facility, which resulted in a large portion of the historic West Creek watershed being diverted to other drainage systems, including Middle Creek. The only parts of the West Creek drainage area that remain upstream of the Toyota site are the Loblaws and Seaforth Creamery industrial sites, which are routed around the Toyota property through a diversion system that outlets to West Creek at the eastern site boundary. As detailed in Appendix D, the existing conditions model was modified to represent the 'pre-existing' drainage area of West Creek (i.e., prior to the development of the Toyota Site). West Creek subcatchments 3101 and 3102 were enlarged and Middle Creek subcatchments 2125, 2130 and 2145 were reduced to account for the historic West Creek subwatershed area. **Table C 3.2.5** summarizes the changes to the existing conditions model. The flood flows generated by the model for pre-existing and existing conditions are compared in **Table C 3.2.6**.

Table C 3.2.5 Subcatchment Modifications for Pre-Existing Scenario

Creek	Subcatchment	Existing Conditions		Pre-Existing Conditions	
		Area (ha)	% Imp	Area (ha)	% Imp
West	3101	15.1	90	74.6	2
	3102	19.1	81.5	156.7	2
Middle	2125	51.0	5.7	0.0	-
	2130	23.3	6.4	20.7	2
	2145	65.7	90	51.1	2

Table C 3.2.6 Pre-Existing vs. Existing Flood Flows

Point of Interest	Area (km^2)		2 year		10 year		100 year		Regional	
	Pre-Exist.	Exist	Pre-Exist.	Exist	Pre-Exist.	Exist	Pre-Exist.	Exist	Pre-Exist.	Exist
3204 West Creek – Start Toyota Divers.	**2.655**	**0.680**	1.41	0.47	4.48	2.51	10.6	6.41	17.3	6.48
3210 West Creek – u/s of ATS site	**2.822**	**0.848**	1.42	0.49	4.77	2.82	11.4	7.62	18.6	8.03
3235 West Creek – Royal Oak Road	**3.196**	**1.222**	1.55	0.56	5.49	3.51	13.5	10.2	21.5	11.4
3245 West Creek – Highway 401	**3.356**	**1.382**	1.55	0.59	5.33	3.41	13.5	10.0	22.3	12.5
3255 West Creek – Speed River Outlet	**3.451**	**1.477**	1.56	0.71	5.32	3.37	13.6	10.2	22.6	13.0
2245 Middle Creek – Maple Grove Road	**3.353**	**4.019**	1.47	2.35	5.42	8.10	14.3	20.6	21.7	27.4
2260 Middle Creek – Briardean Road	**3.937**	**4.602**	1.65	2.62	6.19	9.22	16.6	24.0	25.4	33.1
2285 Middle Creek – Speed River Outlet	**5.184**	**5.850**	1.83	2.70	6.75	9.39	18.5	23.8	31.2	38.7

*Note: all flows in m^3/s

As indicated in **Table C 3.2.6**, the inclusion of the additional 197 ha area from the historic West Creek subwatershed results in pre-existing peak flood flows in West Creek that are substantially greater than existing flows. Conversely, peak flows for Middle Creek are lower in the pre-existing scenario than for existing conditions. This is due to the selection of pre-development percent impervious values for the modified subcatchments, in addition to a decrease in the subwatershed area to account for pre-existing conditions.

The results of the modeling suggest that West Creek currently experiences flows in response to storm events that are significantly lower than those that occurred prior to the development of the Toyota site in 1986. However, although it is currently not exercising this option, Toyota is permitted to discharge a portion of runoff from the site to West Creek as part of its stormwater management strategy, providing that peak flows in the creek do not exceed pre-development peak flows. These flow targets were determined based on hydrological modeling of pre-development flows at the location of the diversion system outlet from the original stormwater management report for the Toyota site (Dillon, 1986). **Table C 3.2.7** compares the flood flows from that report with the results from the pre-existing conditions GAWSER model.

Table C 3.2.7 Comparison of Flows for Toyota Outlet to West Creek			
Event	Pre-Existing Flow - Diversion System Outlet		Existing Flow from Subcatchments 3101 & 3102
	Dillon (1986)	GAWSER	
2 year	0.8	1.41	0.47
15 year	2.3	2.83	1.32
10 year	3.5	4.48	2.51
25 year	5.4	6.26	3.71
50 year	6.9	7.35	4.43
100 year	8.8	10.6	6.41
REG	21.0	17.3	6.48

Table C 3.2.7 shows that the pre-existing flows calculated by the two models, at the location of what is now the outlet of the Toyota diversion system, are similar. Therefore, up-to-date peak flow targets for any future diversion of stormwater runoff from the Toyota Site to West Creek could be developed by subtracting the existing flow hydrograph for upstream subcatchments 3101 and 3102 from the pre-existing flow hydrograph using the GAWSER model. However, the fluvial component of this study has identified the entire length of West Creek in its current form as highly sensitive to disturbance (refer to Section B 4.0). Therefore, it is recommended that no flow diversion from the Toyota site to West Creek be permitted without a detailed assessment of potential effects on the downstream channel system.

C 3.2.4 In-Stream Erosion Potential

Flow exceedance results for Scenario 1 (existing conditions) and Scenario 3 (ultimate development with controls) are presented in **Table C 3.2.8**. A representative high value and low value for critical flow were selected for each of the fluvial geomorphology study reaches. Where no suitable low critical flow was available, the value was taken to be 75% of the high critical flow. A 39-year continuous simulation, as discussed in Appendix D, was performed using GAWSER to determine the mean annual number of hours that the critical discharge at each reach is exceeded. The resulting values are an index of the tendency of the channels to erode their beds.

The tables show that in-stream erosion potential tends to increase substantially for many of the study reaches. This result suggests that post-development stormwater management controls are not effective for controlling post-development erosion potential in East, Middle and West Creeks to pre-development levels. However, many of the critical flow values used in the analysis are very low because of the prevalence of fine bed sediment in most areas of all three watercourses. Typical stormwater detention ponds such as those modelled for Scenario 3 (with controls) tend to result in prolonged periods of relatively low flow following storm events as the extra volume that is collected from developed areas is slowly discharged. These low flows are exceeding the critical flow values associated with areas of fine sediment deposition in

East, Middle and West, which results in higher exceedence levels under post-development conditions. In areas of the watercourses where the bed material is coarser and critical flows values are higher, the increase in erosion potential from post-development conditions is significantly less.

The fine sediment that predominates the bed material of East, Middle and West Creeks is an indication of ongoing channel adjustment to upstream factors such as reduction in drainage area, agricultural practices, and lack of riparian buffers. Given the degree to which channel and basin alterations have occurred in each of East, Middle and West Creeks, it is not unusual to find that excess fines have not fed through the system. This settlement of fines over gravel substrate is reflected in the relatively low D_{50} characteristics of the bed material; this in turn is reflected in the exceedence values that cannot be controlled for by the stormwater management controls.

From a fluvial perspective, the original channel morphology of all sections of East, Middle and West Creeks was a result of the balance of forces which arrived from precipitation and time delivery of overland and shallow groundwater flow to the creeks, while they were under forested or open meadow conditions. As time progressed and land use changes occurred, changes to delivery of flow to the creeks resulted in channel readjustments. As land use changes continued, the creeks continued to adjust, and are still doing so. In the example of West Creek, the loss of drainage area by the creation of the Toyota Complex has thrust the channel into a channel evolution model, by which the cross-sectional area is decreasing through bank collapse. This excess sediment, which is finer than the original bed sediment, is harder to move through the system because of decreased flows resulting from decreased contributing area. Therefore it accumulates and spreads as a layer of fines.

This 'new' bed is finer than the original bed. Hydraulically, it is therefore easier to entrain than the original bed. Over time, as the channel adjusts to the new energy budget created from the decreased contributing area, this fine material will be flushed out of the system and the original bed characteristics will emerge. In other words, the hydraulic conditions arising from the model will be excessively competent for the sediment size in the channel in those areas where major channel adjustments are being made: in other areas the model and the sediment entrainment (excess shear) calculations are more compatible.

The post-development increase in erosion potential suggested by **Table C 3.2.8** may actually improve the capability for transport of the excess fine sediment that is being delivered to the watercourses. Conversely, the table suggests that the increase in erosion potential for coarser sediment, which often underlies the fine sediments and controls channel form in East, Middle and West Creeks, is low or even negligible. Therefore, the proposed stormwater management facilities provide an appropriate level of control to maintain in-stream erosion potential for channel-forming coarse sediments while potentially improving the ability of the channels to transport excess fine sediment.

Table C 3.2.8 Comparison of Mean Annual Flow Exceedences

Watercourse	Location	Node	Condition	Critical flow (m^3/s)	Existing Conditions		Ultimate Conditions with Controls	
					Hours	%	Hours	%
East Creek	Reach 1	1235	Low	0.02	1521	17.4%	2666	30.4%
			High	0.11	59	0.7%	274	3.1%
	Reach 2	1240	Low	0.03	585	6.7%	1854	21.2%
			High	0.08	141	1.6%	682	7.8%
Middle Creek	Reach 1	2262	Low	0.22*	254	2.9%	1273	14.5%
			High	0.29	198	2.3%	1099	12.5%
	Reach 2	2270	Low	0.18	348	4.0%	1402	16.0%
			High	0.99	35	0.4%	37	0.4%
	Reach 3	2285	Low	0.78*	191	2.2%	69	0.8%
			High	1.03	39	0.4%	39	0.4%
West Creek	Reach 1	3210	Low	0.10*	194	2.2%	193	2.2%
			High	0.14	80	0.9%	70	0.8%
	Reach 2	3235	Low	0.02	1068	12.2%	1533	17.5%
			High	0.09	380	4.3%	595	6.8%

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 subwatersheds. 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 subwatersheds 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 surfacewater, 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 subwatersheds), proximity to other biotic or abiotic features, and by c) the various effects of human presence in the subwatersheds. Existing land uses in the subwatersheds 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, drainage manipulation, or impacts from livestock.
- Existing residential and industrial 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 due to roads or other barriers.
  - favoring wildlife adapted to human settlements (Raccoons, Red Fox, Striped Skunk, 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).

Highway 401 traverses a corner the West Creek subwatershed, which:

- contributes to road kills of wildlife species, particularly terrestrial species.
- restricts wildlife movements due to habitats fragmented by road embankments.
- introduces road salt and other contaminants into the local 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).

Regional Road #24 traverses a small area of the East Creek subwatershed, in the vicinity of the confluence with the Speed River. Due to the raised character of the roadway in this area, and the presence of a substantial underpass in the area of the confluence, Regional Road #24 is not considered to represent a significant barrier to wildlife movement.

C 3.3.2 Management Alternatives

The management alternatives for the Natural Heritage and Greenspace System in the subwatersheds consist of increasingly stringent measures to maintain and enhance natural features and functions as areas within the subwatersheds 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 D includes guidelines for EIS in key areas of the subwatersheds 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 (1-10 metres) may be used to protect simple situations such as vegetated edges with no significant sensitivity issues (e.g., no wet soils, closed canopy, tall trees, or specialized habitats). Larger buffers (15 to 100+ metres) 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 adjacent to watercourses and wetlands are generally intended to be maintained in early successional cover (i.e., dominated by shrubs and herbaceous cover), to retain their water quality enhancement functions over time. However, buffers in conjunction with Enhancement Areas (see below) have a reduced need for intervention due to the overall width of protection from sensitive core features.

Buffers are an effective tool which will likely be utilized to a varying extent throughout the subwatersheds. 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 subwatersheds.

Field information from the present study indicates that most of the wetlands in the upper subwatershed areas are reliant on relatively flat topography and shallow water tables which are perched on finer textured soils, fed by seasonal flows originating from upstream, and occasionally by shallow groundwater flows (interflow) from the surrounding agricultural lands. South of Maple Grove Road, discharge situations were very common on all three creeks, representing substantial deposits of coarse textured soils over impermeable layers as well as bedrock.

Wetland conditions (i.e., hydric soils, seasonally high water table, and hydric vegetation) and associated upland forest are evident in irregular habitat mosaics associated with the East, Middle and West Creeks, ranging from minimal cover, to broad bands of natural cover up to 0.5 km in width. These gross corridor dimensions do not take into account the Regional Floodline, setbacks required to protect fish habitat, or requirements to achieve stable natural channel form.

Wetland boundaries are generally indicative of historic limits beyond which active agricultural use of the land was impractical due to wet soils. Seasonally wet soils in agricultural fields beyond some wetland limits may warrant more protection around particularly sensitive features as shallow storage around the wetland usually helps to sustain moisture levels within the wetland through the year.

Based on preliminary site knowledge and averaged soil conditions, buffers of 30 metres around core wetland and upland features would accommodate the majority of shallow groundwater functions (i.e., storage, water quality buffering and shallow flows) that sustain key habitats. This dimension is based on the assumption that rural and industrial uses will predominate in the vicinity. Intensive residential development may require additional depth to maintain corridor functions in constrained areas.

Requirements for subsequent studies as part of scoped Environmental Impact Studies will be presented in Section D.

Assuming future industrial and residential uses, a 30 metre minimum buffer is considered generally adequate to protect treed areas and to provide filtration of sediments and nutrients, assuming that the buffer is maintained in meadow or early shrub succession.

Buffer protection is a key concern, as degradation of the buffer will eventually impact the actual feature that it is protecting. From an environmental perspective, physical delineation may or may not be preferred. Should the threat of encroachment be minimal or non-existent with a highly educated public, fencing would not be necessary. On the other hand, excessive encroachment and misuse of trails and open spaces would necessitate the requirement for fencing. Encroachment can take the form of dumping, informal trail development or extending the grass cutting area beyond the legal property limits. Regardless of the actual need, there is always a need to know where the limits of the buffer are, whether for park staff or for the adjacent landowner. In addition, boundary knowledge will result in trail systems that limit access to sensitive areas.

Options for the protection or delineation of buffer areas can include the following:

1. No active delineation. Adjacent landowners (homeowners or companies) may independently choose to delineate their properties.
2. Fencing of all buffer areas. This could occur with implementation by the City prior to development or by the developer at the time of development.
3. “Living fences" or areas of dense plantings will provide a natural definition and barrier to encroachment.
4. Concrete bollards located at key points (e.g., boundary direction changes or visible areas) can create the required level of property demarcation.
5. Public education about the sensitivity and benefits of the feature and the buffer will allow users to make informed decisions about their actions. While local citizens may choose to protect their environment, those from further away may not be aware of the feature or have a different environmental value set with respect to the local feature.

It is difficult to make a recommendation within the scope of this study and without the benefit of knowing what the future plans are. From an environmental perspective and from past experience in buffer management, we can state that some encroachment will occur. However, it may not be reasonable to expect the City to fence or bollard all environmental areas nor to implement the full fencing of the features by future development. Such actions, at least those that would be required by developers, would still not fully encircle the feature.

Therefore, as a minimum, an educational program should be implemented and bollards should be installed to delineate the open space areas. Selective fencing may be required at high traffic areas. Further recommendations on fencing requirements and standards should be prepared during the Community Plan or during development application when additional detail is available. In conjunction with the recommended trail strategy, this will allow for maximum flexibility at future stages.

A 30 metre buffer may be inadequate to sustain the movement of wildlife through narrower sections of the stream/wetland corridors, 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. Upland forest is relatively uncommon in the watershed due to past agricultural encroachments. Therefore the expansion of upland cover in buffers and enhancement areas, will benefit sensitive species which use habitats transitionally in the longer term.

A minimum 30 metre buffer around natural features in areas of the subwatersheds that will remain rural, is considered generally adequate. It is assumed that development in the rural areas will consist of isolated residences, septic systems, and occasional barns and outbuildings. Scoped EIS will be recommended when any development occurs within 30 metres 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 in proposed within 30 metres of any natural feature.

Core Natural Areas, Corridors and 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 re-colonized 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, two main types of corridors and linkages are identified as part of this study; those that that help connect existing natural heritage features contained *within* the subwatersheds, and linkages that connect broader natural heritage systems *outside but adjacent* to the Hespeler West subwatersheds.

While many 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 successional open spaces also either support adjoining linkages or serve as important terrestrial linkages in their own right. Since 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 (i.e., road kills), roads fragment and isolate populations because of their physical structure, noise, and high traffic volumes.

The other barriers to movement (for some species) are areas that simply lack natural cover. In the Hespeler West subwatersheds, these include existing built areas (primarily industrial, but also residential), and agricultural fields. While agricultural fields provide far greater opportunities for dispersal than do the 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 intend 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 exist 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 Hespeler West subwatersheds, wetland cover is strongly reliant on surface runoff and storage and, in the lower subwatersheds, groundwater conditions within individual subcatchments. The maintenance of these linkages between the physical and biological systems is critical to the protection of habitats reliant on groundwater recharge and discharge. 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 urbanizing 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 enhancement generally encompasses a wide range of activities including:

- ***Rehabilitation*** to address a broad range of physical and biological conditions such as soils disturbed by past activities, altered channel form, or removal of invasive species.
- ***Restoration*** of authentic native habitats through the reintroduction of forest, shrub and herbaceous

species, and/or the management of aggressive introduced species and monocultures.

- ***Naturalization*** of manicured areas, which is the reduction in maintenance levels, possibly in combination with plantings
- ***Reforestation***, which involves the planting of trees at sufficient densities to eventually yield a forest canopy.

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.

Enhancement Areas are identified in the lower subwatersheds in locations that would benefit most from enhancement activities. Longer-term enhancements in the upper subwatersheds could increase the size of core habitat areas, improve the range of available habitats, and improve linkages between habitats within and beyond the subwatershed boundaries. The area located along the northern boundary of the subwatersheds is considered a potentially important node that links the Speed River valley, Hespeler West subwatershed, Chilligo Creek (Ellis Creek) subwatershed and the Grand River valley corridor. Rehabilitation opportunities include the removal or reconfiguring of constructed ponds, restoration of channels to natural form and flood functions, improvement of riparian connections across local roads, and control of invasive plant species (e.g., purple loosestrife, European and Glossy 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 are already being developed to service new industrial lands, and 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 and Areas

Stewardship programs involve cooperative activities by residents, farmers and landowners to expand habitats in deficient areas, pick up garbage and debris, detect and control undesirable uses, and provide ongoing monitoring. The Hespeler West subwatersheds are suited in some respects to stewardship programs due to the presence of an existing agricultural community, and local residents. The involvement of industrial landowners in such programs will likely be a particular opportunity of the lands in the upper subwatersheds. The initiatives by a local industry on Royal Oak Drive to develop trails and integrate naturalized space around stormwater facilities is an excellent example of the opportunities that will exist as industrial uses are expanded. Areas of concentrated stewardship activity would be those where existing residential and industrial development are close to core features and watercourses.

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 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, industrial and rural landowners, 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/corporations.

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 –30 Metre Buffers

Based on averaged soil conditions, a 30 metre buffer "threshold" would accommodate the majority of shallow groundwater functions (i.e., storage, water quality buffering and shallow flows) that sustain key habitats in wetlands. The buffer could potentially be reduced (minimum of 15 metres recommended) adjacent to upland habitat with successional cover. However, where such reductions would constrain corridor functions in an urban context, they would not be permitted. Requirements for subsequent studies as part of scoped Environmental Impact Studies are presented in Section D.

The 30 metre minimum buffer is considered adequate to mitigate the protection of treed areas, 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, 30 metres is considered inadequate to sustain the movement of wildlife through narrower sections of the stream/wetland/upland corridors, 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 metre buffer also would be applied around wetland features in the rural areas of the subwatershed. In this case, a scoped EIS would be recommended when development is proposed within 30 metres of a wetland or upland forest 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 metres 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 in areas of the subwatersheds that will undergo intensive industrial or residential development.

Option 3 – 30 Metre Buffer and Enhanced Corridors

This Option would supplement the provisions of Option 2 (i.e., 30 metre buffers) with placement of enhancement areas and (where feasible) complementary land uses adjacent to corridors. The goal would be to create a consistent natural corridor through the urban portions, containing enhanced upland and successional cover as well as 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. Through enhancement, linkages would be added to ensure adequate connections to outlying rural lands in the upper subwatersheds, and to other habitats outside the subwatersheds.

On other grounds, it is considered that minimum buffers of 30 metres will not sustain current levels of landscape connectivity that exist in the rural portions of the subwatersheds, when they are converted to an urban context. Common wildlife species such as White-tailed Deer and Coyotes may create nuisance issues with residential or industrial uses unless a viable wildlife corridor is created. In this respect Option 2 (30 metre buffers) may be inadequate where corridor width is inadequate. Human proximity effects including noise, light, and pets typically reduce habitat usage by neotropical forest birds unless buffers of at least 100 metres are provided; buffers of up to 300 metres may be required to sustain nesting by species such as Mallards (Norman, 2000). Direct human encroachment into natural woodlands may exceed 60 metres (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 enhanced corridors (e.g., 100 to 300 metres in width) would help to offset these impacts, and sustain relatively unimpeded wildlife movements.

Different corridor enhancements are desirable according to intended functions and ecosystem trajectories, as follows:

- Primary Linkages of 100-300 metres (minimum) width that can sustain interior and interior edge species and significantly moderate future urban and human proximity effects.

- Local Linkages of 50 metres (minimum) that help maintain riparian functions along constrained corridors, and provide some connectivity to nearby core features.

The application of these standards is shown conceptually on Figure C 1.2.1 and its implementation is discussed in Section D 1.1 (Greenspace Management Strategy).

Although the impacts of landscape conversion from an agricultural to an urban matrix cannot be fully mitigated under Option 3, it would retrofit the existing corridors with substantial additional habitat and buffering to balance the conversion of the surrounding agricultural matrix. If upland habitats are established effectively within the enhancement and buffer areas, there will 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).

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

Figure C 3.3.1 and Map 3 present the Greenspace Management Strategy, including protected natural areas, buffers, and recommended enhancement and stewardship areas. The Middle Creek system is seen as the primary opportunity for a major connection between the Grand River/Chilligo Creek systems and the Speed River through the study area. The sections which follow discuss the recommended components (Environmental Constraint Areas, Existing Environmental Policy Areas, Enhancement Areas, Stewardship Area, and Buffers). Key components of the recommended Greenspace Management System, which are based on the issues, principles, concepts and management alternatives discussed in the preceding sections are as follows:

- **Middle Creek Corridor and Secondary Linkages north of Maple Grove Road**: The combination of core habitats, 30 m buffers, enhancement areas and stewardship areas are considered desirable to provide an overall future corridor (i.e., comprised of the five components) with a width in the range of 200 (minimum) to approximately 500 metres wide, and enhancement connections to major natural features on East Creek and beyond the subwatershed boundary. This would create an ecosystem within which urban and human proximity effects would approximate those present under existing rural conditions, and where interior species would be largely sustained.
- **Middle Creek Corridor and Secondary Linkages between Maple Grove Road and the Speed River**: Consolidation of habitats, buffers, enhancement areas, and stewardship areas to create a consistent 'corridor' (i.e., comprised of the four components) of approximately 100 metre width would moderate urban and human proximity effects, and sustain movements of interior-edge species. Other local connections of approximately 50 metre width would be desirable between core features that are not currently connected to the main channel.
- **East Creek Corridor and Secondary Linkages**: A minimum 'corridor' (i.e., comprised of buffers, enhancement areas, stewardship areas and core habitats) of approximately 50 metre width would be desirable to maintain riparian functions and/or provide local connectivity between isolated core features.
- **West Creek Corridor and Secondary Linkages**: This is a local feature currently of sufficient width (i.e., more than 50 metres wide) and of an incised nature such that its local linkage function can be maintained through the placement of the 30 metre buffer. Its connection to the Speed River system, currently impaired by Highway 401, can be improved by enhancement uses located east of Speedsville Road. Other local connections of approximately 50 metre width would be desirable between core features that are not currently connected to the main channel.

C 3.4 Hespeler West Trail Strategy

C 3.4.1 Introduction

The majority of the Hespeler West study area is comprised of (potential) industrial lands with a limited mixture of housing existing and open space/ greenway. Development in the Hespeler West area will be predominantly industrial/commercial such as the Loblaws Distribution centre on the corner of Fountain and Maple Grove Roads. Development such as this will be typical for the area and will create challenges and opportunities in providing a trail system. A trail system that takes advantage of buffers between large built lots in this developing area could satisfy a number of objectives in addition to environmental issues.

Informal trails and pathways occur within the study area, particularly 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 various opportunities within the study area to create trails and links to a wide assortment of destinations in the immediate area. Typical destinations are places of employment, schoolyards, parks and connections to larger trail systems. Future trails for this area would be multi-use (pedestrian and cycling) and to current City standards.

Figure C 3.4.1 shows existing park/trail facilities and a "Conceptual Trail Strategy" based on environmental findings of this 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 Hespeler West study area are made reference to in the *1996 Cambridge City-Wide Multi-Use Trail and Cycling Route Study,* as well as the *1993 Riverbank Long Range Concept Development Plans, Development Plans for the Preston and Hespeler Communities* and the *Cambridge Bikeway Network Study, June 1999.*

The *Multi-Use Trail Study* notes a potential trail route extending from the end of Hunt Club Road crossing Highway 401 and terminating at Riverside Park. A trail route is also noted running along Royal Oak Road and passing Park Lawn Cemetery on Fountain St (Map 3). The only existing municipal trail in this area is the Mill Run Trail which follows the Speed River from Clemens Ave. in Hespeler to Riverside Park in Preston.

Riverbank Long Range 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 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.

The *Cambridge Bikeway Network Study, June 1999,* makes reference to the Hespeler and Preston area in the following context.

A proposed on road paved shoulder bike lane is noted for Beaverdale Road, Maple Grove Road, Fountain Street, Speedsville Road, and Allendale Road (Map 4).

There are also proposed additions noted on Map 1 to the proposed Regional Cycling route already established along Allendale Road, Fountain Street and Mill Run Trail. The Regional routes are currently being finalized.

C 3.4.3 Existing Trail Systems

The Mill Run Trail is the only existing trail in the vicinity of the Hespeler West area. It runs along the north side of the Speed River from Beaverdale Road to a trailhead at the corner of Clemens Avenue and Sheffield Street. From there, trail users are directed along Sheffield Street to Guelph Avenue, which leads to downtown Hespeler. Currently, the trail surface is stone dust with small sections of boardwalk. The trail wanders through the trees with a width of approximately 2 to 3 metres.

The trail crosses from the north side of the Speed River to the south side using the Beaverdale Road vehicle bridge. West of Beaverdale Road, the trail runs along the south side of the Speed River, crossing Highway 401 under the Speed River bridge. This section of trail is surfaced with crushed limestone approximately 1.5 metres wide. The section immediately east of the highway crossing is narrower as it runs along the bank of the highway; however, the boardwalk under the bridge is wide and solid. West of Highway 401, the surface of the trail deteriorates somewhat until the Speedsville Road crossing. From Speedsville Road, the trail continues on a better surface, crossing a bridge over the Speed to reach Riverside Park. An interpretive trail in the park is accessed from the Mill

Run Trail just west of the bridge, and the Mill Run Trail eventually ends in another area of the park.

Informal trails lead away from the Mill Run Trail at various points, particularly east of Beaverdale Road. These trails are generally used to access the banks of the Speed River. It is also noteworthy that the sight lines at the Beaverdale Road crossing are poor as the rise of the road over the bridge obstructs the view of oncoming traffic. Upgrading of this trail may be considered, such as pavement, safety measures at road crossings and linkage to future trails. The Mill Run Trail is found on Figure C 3.4.1 as "Existing Trail."

C 3.4.4 General Opportunities and Constraints

C 3.4.4.1 Trail Planning Principles

The following general design principles have been prepared in discussions with Steering Committee members, city staff and the Study 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, i.e., keep trails out of Provincially Significant wetlands.
- 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 trail building and maintenance.
- To identify interpretation and education opportunities.

C 3.4.4.2 Environmental Considerations

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

- Trail routes should avoid or minimize impact on the creeks 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. This may also assist in

ensuring a wide base trail for safety reasons/perception of safety.

- Minimize the disturbed area of trail routes recognizing the development and maintenance requirements of current City standards for trails.
- Minimize mowed edges of trails where possible and the proximity to the sensitive environmental feature warrants this approach. This will need to be accomplished while balancing the need for 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 may 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 Interpretive Opportunities

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

- Any trail development adjacent to Middle, East or West Creek could present opportunities to educate trail users about the interactions between the hydrogeology of the creeks and their corridors,
- Through the identification of unique habitats along the proposed trail routes interpretive locations could be identified and developed,
- Trail routing would take advantage of Historical areas such as Idylwild Park as a potential interpretive historical location.
- Close proximity to the Chilligo Creek Conservation Area and future trail development proposed within the Hespeler West area would provide interpretive opportunities as well as providing a destination for trail users within the Greater Hespeler and Preston area.
- The proposed Country Side Line could provide a significant opportunity for interpretive areas as well as a major East-West trail corridor linkage.

C 3.4.5 Trail Routing Opportunities

During our on site investigation we observed numerous locations that offered interesting views and experiences in natural and rural 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 in natural areas 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.

A significant amount of on road bike lanes and sidewalks have been identified in the Hespeler West area. Although a significant portion of the area is currently or will be developed as industrial land there still exists opportunities for on road trail users to take in views and vistas along the proposed on street routes.

Interesting views have been documented as opportunities for trail routes as well as potential trail routing options. 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 3.4.1.

Trail Opportunity Location 1 (see **Photograph C1 and C2**)

The following picture was taken looking East down Ratcliffe Road which currently terminates in a cul de sac. As noted in the middle right of the photograph the road way has significant width to accommodate trail users along its shoulder. The picture below shows the existing informal trail developed at the end of Ratcliffe Road towards the East. This condition was also noted at the end of Starr Crescent and Burnham Crescent and indicates the necessity for trail links in these locations.

Trail Opportunity Location 2 (see **Photograph C3**)

The following picture was taken looking West down the access road to the Arriscraft property. Although the entry and roadway was noted as private property there could be an opportunity to provide a trail alignment along the shoulder of the access road. This entry road and its usage as a publicly accessible trail should be explored in partnership with Arriscraft. This access road also provides a direct link the open space area along the Speed River adjacent to the Arriscraft property.

Trail Opportunity Location 3 (see **Photograph C4**)

The following picture was taken at location number 3 noted on Figure C 3.4.1 looking southeast at the corner of Briardean Road. This access road links to the Arriscraft property and skirts a wetland area to the north-west. This location provides a unique vista of the surrounding area and also could be a potential interpretive area due to its close proximity to the existing wetland area to the north-west. Using the access road as a potential trail route should be explored with the property owner, and the potential of an on-street route along Briardean Road should be explored here as well.

Trail Opportunity Location 4 (see **Photograph C5**)

The Mill Run Trail along the south side of the Speed River is a major trail linkage to Riverside Park as well as Cambridge and the surrounding communities. Beaverdale Road is the ideal on-street route to link the Hespeler area to the surrounding communities through the existing Mill Run Trail.

Trail Opportunity Location 5 (see **Photograph C6**)

Boxwood Drive adjacent to the Toyota plant is a potential on-street trail linkage with opportunity for a off route link to the West Creek area. The vista to West Creek here is exceptional and the creek's current geomorphology lends to potential trail development. Buffer areas proposed surrounding this portion of the creek should facilitate trail development and exploit potential interpretive areas along the trail route while still providing protection for the creek.

Destination Opportunity Location 6 (see **Photograph C7**)

Park Lawn Cemetery location along Fountain Street should be incorporated into the trail routing for this area as a potential destination point. The lush, landscaped grounds of the cemetery would provide an inviting and relaxing respite for the weary biker. This destination point would have to be linked via an on-street route. This could be problematic due to the speed of motorists along Fountain Street which would merit a dedicated bike lane or paved shoulder to facilitate increase bike usage.

Trail Opportunity Location 7 (see **Photograph C8 and C9**)

The vistas along Middle Block Road to Middle Creek are exceptional. The flat topography allows for long vistas to Middle Creek and provide a distinct contrast to its heavily vegetated edges. The provision of a dedicated bike lane as well as rest area(s) would allow trail users to fully appreciate the natural beauty along this potential trail route.

Destination Point Trail Opportunity

Although located outside of the study boundary the winding road alignment of Speedsville Road gives varied views and vistas as one travels along it. Certain portions of the road provide restricted vistas which open onto exceptional sweeping views as noted in the picture above. With numerous views such as the one noted above this portion of Speedsville Road could be considered as destination point and merits an on road dedicated bike lane to allow bicyclists opportunity to appreciate the natural beauty of this area. Unfortunately, the highway bridge is a constraint to bike and pedestrian movement from Riverside Park/Mill Run Trail. This bridge would have to be upgraded or an alternative pedestrian bridge provide to allow for proper movement.

C 3.4.6 Trail Options

Internal Trail System

There are several opportunities to provide a looped trail in the area of Ratcliffe Drive, Burnham Crescent, Hunt Club Drive and Starr Crescent serving these neighbourhoods and the adjacent Hespeler and Preston areas. Trail routes in these areas could link with trail routes provided along buffer areas adjacent to Middle, West and East Creeks creating a north-south axis that could link to the future proposed "Country Side Line" or the Speed River. The surrounding on-road cycling routes would augment the off-road loop system. The provision of trails within the buffer areas of the creeks would be determined at after further examination of ecological and geomorphological constraints at the Community Plan stage or with a scoped EIS.

Gaining access to the open space adjacent to the Arriscraft property is key in establishing a trail spine along the Speed River. The Mill Run Trail is well established on the south side of the Speed River, however the north side of the Speed River is lacking a formal trail route. The provision of a trail along this side of the Speed would create East-West spine that could connect the Hespeler West area to the Speed. Linking this trail to the Mill Run Trail could also create a looped trail system encircling the Speed from Speedsville Road to Beaverdale Road as well as linking the Hespeler area to the Cambridge core. Partnerships with property owners should be explored that facilitate trail development in these areas.

In discussions with the City of Cambridge there was a good possibility the "Country Side Line" could become a reality. The provision of this feature would create a significant East-West spine that the Hespeler West area could link into. The provision of such a feature should be fully explored and if realized would highly benefit trail development in the Hespeler as well as the surrounding areas. How trail development would work in this area should also be determined after further review of the ecology and geomorphology of the area.

In discussions with City of Cambridge staff it was noted that a large community park sport facility may be considered for the Hespeler West area. Upon determining the location of such a facility trail development should be designed to allow a direct linkage to the facility and the looped trail network proposed within the Hespeler West area. Also, a dedicated bike route lane along the on-street route of the facility would promote access to the site via bicycle.

A component of a Trail Strategy could be the development of smaller loops which can function as "Lunch Hour" destinations for local employees.

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 employment areas, schools, parks, the Hespeler Town Centre, Preston urban fabric 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 access was gained to the Arriscraft lands adjacent to the Speed River.

Linkages to the Chilligo Conservation Area and Riverside Park should be explored as these areas could become key destination point for trail users in the Hespeler West area.

Improvements to the Speedsville Road bridge or a pedestrian bridge across the Speed River linking this area to the Mill Run Trail would assist in proper pedestrian/bike movement.

Ecological Characteristics Influencing Trail Route Options

Any proposed trail routing will take into account the location of significant ecological features and functions. Trail routing will avoid conflicts with existing features or functions deemed significant.

Natural Corridor Access and Connections

To integrate future residential and industrial development with the major open space associated with East, Middle and West Creeks, trails should connect to natural corridors at connection points along its perimeter. This could include the use of existing roads (such as Ratcliffe Drive, Starr Crescent and Burnham Crescent and Hunt Club Road). The provision of the trail along the Speed River should also be explored however access points to the river should be minimized in order to avoid potential disturbances of flora and fauna.

On-street routes should provide safe entry into natural corridors. The provision of signage and markings at potential natural corridor access points should be provided where necessary as well as facilities for trail users (i.e., garbage receptacle, bench etc.).

Access to trails within the natural corridors along East, Middle and West Creeks 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.

C 3.4.7 Conceptual Trail Framework

Based on 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 3.4.1.

North-South Axis: The north-south axis of the Hespeler West trail system will primarily follow on street routes. Secondary off-road trails will be provided within buffer areas along East, Middle and West Creeks. Access points to these trails will be provided at numerous locations to facilitate trail user entry. The off-road trail linkages will link to the proposed Country Side Line to the north and the Speed River to the south. Adjacent communities would be accessed through on street routes to the east and west of the site.

A long-range future potential node is noted adjacent to the Grand River at the extreme north of the plan. This node is contingent on a bridge crossing the Grand River in the area.

East-West Axis: The east-west trail axis for this area would again follow primarily on-street routes. Off-road trails would be provided along the Speed River (providing property owner cooperation) and within the proposed "Country Side Line". Trail development in these areas would have to be coordinated with additional studies to avoid potential conflict with existing significant natural features.

Trail Access Points: Trail access points have been noted at the Hunt Club Drive, Ratcliffe Drive, Starr Crescent and Burnham Crescent as there is already informal trail development noted in these locations.

On-road trail access points have been noted where potential exists for linking to proposed off road trail within buffer areas adjacent to East, Middle and West Creeks. These access points coincide with areas of visual interest or potential interpretive locations.

Trail Construction: Within the PSWs buffer 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 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 3.4.1 will ensure that there will be no adverse ecological impacts. Asphalted trails are not recommended within creek/wetland setback but may be allowed within the 30 metre buffer but outside the 15 metre buffer subject to a scoped EIS. A natural (limestone screening or woodchip surface) trail should also remain outside of the minimum 15 metre setback from any wetland boundary or creek system.

Trail routing, as identified on Figure C 3.4.1 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.);
- 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 3.4.8 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 framework illustrates “opportunities” and there is no expectation that all trails described would be developed. This trail framework would have minimal impact on the character of the Hespeler West natural areas.

Figure C 3.4.1 “Conceptual Trail Framework”, graphically portrays the following conclusions:

1. Further information from the Community Planning process will influence the final trail network.
2. Placing trails outside of the 15 metre wetland or 15 metre stream setback has placed a strong emphasis on environmental protection.
3. Providing a variable loop trail system option adjacent to residential and industrial development will allow users access to trails within their general area, providing them with linkages to adjacent trails and points of interest (i.e., Speed River, Chilligo Conservation Area).
4. Development of any trails on private property would be subject to the consent and approval of the private property owner.
5. A significant portion of the trails within the Hespeler West area will be multi purpose on-road routes. Roads being reconstructed should be retrofitted with bike lanes or paved shoulders. Future roads should also be developed with bike lanes in the right-of-way to accommodate bicycle traffic.
6. Access points and connections to roads and institutional/residential areas should be finalized at the Community Plan stage.
7. A potential pedestrian bridge over the Speed River could provide a linkage to surrounding communities as well as marking the Hespeler West area a destination point for other trail users.
8. The provision of the “Country Side Line” would create a long-term trail axis from the Hespeler West area to the surrounding adjacent communities. How this feature would be designed and how trail routes would be incorporated within its boundary will be determined at the Community Plan level and will also merit a scoped EIS of the proposed “Country Side Line” lands.
9. 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.
10. Trails are to be designed, constructed and maintained to current City of Cambridge trail standards.
11. Development of the final trail plans at the Community Plan Stage is to be reviewed by the Cambridge Trails Advisory Committee prior to adoption.

A Community Trail system will be considered through a comprehensive trail analysis at the Community Plan stage. The general goals of the trail system are:

- to encourage passive recreational use of least environmentally sensitive or most resilient natural areas;
- to provide non-motorized options for people in a way that is efficient, convenient, enjoyable, and reasonably safe;
- to channel pedestrian traffic away from areas of special ecological sensitivity, steep slopes, areas of erosion, and to discourage the creation of new unauthorized trails;
- strive to achieve pedestrian and wildlife safety in a natural setting;
- to provide opportunities for the appreciation of nature;
- to provide interpretive opportunities that educate the public as to the environment that surrounds them;
- to design trail treads with pervious material;
- to provide a healthier, better informed, appreciated, human/environment relationship;
- to facilitate efficient maintenance by parks staff; and
- to provide connection to existing and future communities and to serve as links in the trail network spanning Cambridge.

Public participation through the Community Plan process will assist in the trail system planning.

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 and/or are not stabilized by vegetative cover, are prone to erosion by wind and water. In addition, the number of different soils found in combination with different slope and drainage 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 potentially 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 row crops.

C 3.5.2 Social Economic Component

Approximately one-third of the subwatersheds are in agricultural production. In the agricultural area, the land 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 subwatersheds contain sod operations that have direct public sales.

The subwatersheds do not contain high value infrastructure such as greenhouse operations but has the infrastructure associated with a research station.

C 3.5.3 Recommendations

Given the information summarized in the previous sections, recommendations for programs in the subwatershed can be grouped into five general categories as follows:

- Do nothing.
- Initiate a general rural public education program.
- Link programs to the GRCA Rural Water Quality Program and/or to work programs completed or in

process at the University of Guelph/OMAF research station.
- Optimize results and dollars spent through site specific rehabilitation efforts.
- Design a subwatershed specific program with the assistance of the University of Guelph/OMAF research station (part of the station is located within the subwatershed).

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 of all aspects of the PPS. However, if provincial policy is 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. This policy-related sequence or hierarchical classification of agricultural land would suggest that the better agricultural lands 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; and
- 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 moralsuastion 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 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. However, 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.

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.