OAKVILLE

North Oakville Creeks Subwatershed Study

IMPLEMENTATION REPORT

August 2006

engineers architects planners

PARISH geomorphic

Natural Resource Solutions Inc.
Aquatic, Terrestrial and Wetland Biologists

Donald G. Weatherbe Associates

Morrison Environmental Limited
Groundwater Consultants

Environmental Water Resources Group Ltd.

North Oakville Creeks Subwatershed Study

IMPLEMENTATION REPORT

August 25, 2006

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

DD – Erosion Pin Analysis
EE – Summary of Rare Plant and Wildlife Species
FF – Aquatic Characterization
GG – Management Approach Criteria for Stream Systems
HH – Water Quality Loading Model Results
II – Sample Checklist for the Inspection and Monitoring Program
JJ – Sample of Contents for an EIR
KK – SWM Facility Monitoring Protocols
LL – Meeting Total Phosphorous and Total Suspended Solids Targets
MM – Core Area Comparison
    MM1 – Area #1
    MM2 – Area #2
    MM3 – Area #3
    MM4 – Area #4
    MM5 – Area #5
    MM6 – Area #6
    MM7 – Area #7
    MM8 – Area #8
    MM9 – Area #9
NN – Glossary
OO – References

7.0 IMPLEMENTATION OF SUBWATERSHED PLAN

7.1 General

The management strategy outlined in **Section 6.0** of the North Oakville Creeks Subwatershed Study (Subwatershed Study) provides a recommended approach for the management of the Natural Heritage System and guidance for future land use changes in accordance with the North East Oakville Secondary Plan (NOE-SP).

- **Natural Heritage System – Terrestrial** (**Section 6.3.3, 6.3.5**) – To meet the goals and objectives, a management approach was developed for the protection of the biodiversity of terrestrial and wetland features, (including the flora and fauna associated with terrestrial and wetland habitats), in an environmentally sustainable fashion. This includes provision for connections between habitats including linkages for species movements.

- **Natural Heritage System – Streams** (**Section 6.3.4, 6.3.5**) – For streams that have been identified as having environmental characteristics or watershed functions that require protection and/or enhancement to meet the subwatershed goals and objectives. A riparian corridor approach is to be applied which will consider all of the stream functions including:
  - Hydrologic;
  - Hydrogeologic;
  - Geomorphologic; and
  - Ecological (aquatic and terrestrial habitats).

- **Stormwater Management (SWM)** (**Section 6.3.5**) – The development of an approach that will protect and enhance environmental characteristics through managing stormwater response and conveyance processes.

This report outlines the implementation requirements for the recommended management strategy. The implementation requirements discuss the planning process, environmental reporting requirements, agency responsibilities, and the approval process with the Town of Oakville, Halton Region and Conservation Halton through the following sections:

- Implementation Process (**Section 7.2**);
- Land Use Planning Requirements (**Section 7.3**);
- Supporting Analyses Required (**Section 7.4);**
- Monitoring Strategy (**Section 7.5);**
- Long-Term Management of Natural Heritage System (**Section 7.6);**
- Agency Responsibilities (**Section 7.7**); and
- Administration Issues (**Section 7.8**).

This report should be considered a "living document". "Living document" refers to the ability of the document to be refined using the Adaptive Environmental Management (AEM) Approach. AEM means making decisions as part of an on-going process. Monitoring the results of actions provides a flow of information that may indicate the need to change a course of action or change the document. The management strategy also includes recommended policies that should be incorporated into Official Planning documents such as the NOE-SP. Over time, government

policies on relevant issues, such as terrestrial systems and SWM, will evolve. This strategy should always be applied with reference to the most recent applicable policies.

7.2 Implementation Process

The implementation plan should address the components outlined in the management strategy in **Section 6.0**. The implementation process that is included in these areas is illustrated in **Figure 7.2.1**.

The planning process for the North Oakville Creeks Subwatershed includes the major steps of:

- Official Plan (OP);
- Secondary Plan;
- Draft Plan (or site plan approval as necessary);
- Subdivision Design Plan; and
- Registered Plan;

The supporting studies that are necessary include:

- Subwatershed Study;
- Environmental Implementation Report (EIR) for the entire subcatchment area;
- Functional Servicing Study (FSS) for the proposed development;
  - Preferred Servicing Plan; and
  - Draft Plan of Subdivision (or site plan)

7.3 Land Use Planning Requirements

The North Oakville Creeks Subwatershed Study has been prepared in conjunction with the NOE-SP, as input into the planning process. The NOE-SP will provide a framework for future development in North Oakville, and set out the detailed studies required prior to any development approval. The following subsections summarize the directions in the management strategy, which have been considered in the finalization of the secondary plans.

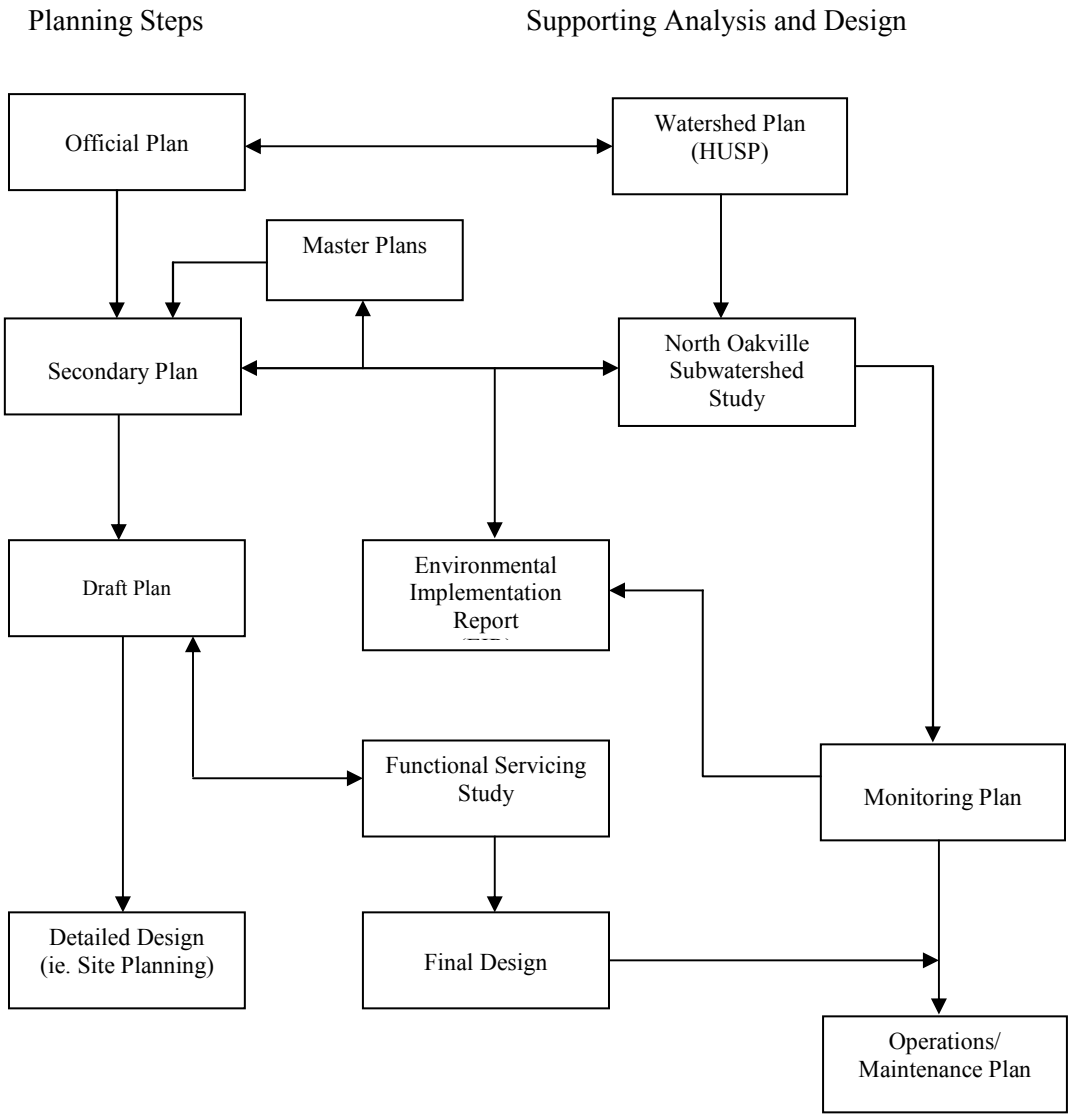
7.3.1 Natural Heritage System

The management strategy identified the potential to create a Natural Heritage System. It also specified the land use requirements (*i.e.,* constraint lands), together with associated management requirements, for the lands associated with the Natural Heritage System.

Specifically, the management strategy recommended that the Natural Heritage System be comprised of the following areas which are identified in **Figures 6.3.3** and **6.3.13**:

- Core Areas;
- Linkages; and
- High and Medium Constraint Stream Corridors.

Figure 7.2.1
Implementation Process



The NOE-SP has incorporated these areas and has labelled them as "Natural Heritage System Area" on the land use schedule to the Plan. The Plan identifies the components of the System on another schedule as "Core Preserve Area", "Linkage Preserve Area", "High Constraint Stream Corridor" and "Medium Constraint Stream Corridor". These terms are interchangeable with the terms used in the Subwatershed Study.

The Natural Heritage System, as reflected in the NOE-SP, would be established by policies and designations which differentiate between Core Preserve Area, Linkage Preserve Area, and High and Medium Constraint Stream Area.

In addition to the Natural Heritage System, it was recommended that the NOE-SP include policy direction related to other hydrological features as discussed below.

The following subsections summarize the key policy directions proposed for each component of the Natural Heritage System and other hydrological features, and the Implementation Plan.

Core Areas

The Core Areas, as shown on **Figure 6.3.3**, include key natural feature groupings together with their required buffers and related lands for the management of the area's ecological diversity and sustainability. The designation of these areas in the NOE-SP is intended to protect the function of these features and provide for the long-term sustainability of the Natural Heritage System, within the urban context.

Linkages

The linkages identified on **Figure 6.3.3** include areas that are designed to link the Core Areas together to maintain and enhance their environmental sustainability. Linkages follow natural features whenever possible and are intended to be of sufficient size and character to ensure the functionality and sustainability of the Natural Heritage System.

High Constraint Streams (red)

High Constraint Stream Areas (the red stream corridors shown on **Figure 6.3.13**) include certain watercourses with associated riparian lands, together with buffers measured from top-of-bank. High Constraint Stream Areas are located both inside and outside the Core Areas and Linkages. High Constraint Stream Corridors are to be protected in their current form and function.

Medium Constraint Streams (Blue)

Medium Constraint Stream Areas (the blue stream corridors shown on **Figure 6.3.13**) are to be maintained as open watercourses with a full "riparian corridor" (meander belt width plus erosion allowance and setback). The Medium Constraint Stream Corridors may be identified in the NOE-SP. However, since the final locations of the streams after development are not known, the policies should provide for the allowance of alteration of the Medium Constraint Streams. The requirements for any proposed alteration are to be identified at the EIR stage as outlined in the EIR discussion in **Section 7.4.1**.

Uses Permitted in Cores, Linkages and Medium and High Constraint Stream Corridors

The policies of the NOE-SP would, with a few limited exceptions, limit development to legally existing uses, buildings and structures as well as fish, wildlife and conservation management. These exceptions would be subject to detailed study, would likely have various conditions, and may include:

- Development or land disturbances for required flood and stream bank erosion control and protection of fish, wildlife, and conservation management;
- Infrastructure/utility access and crossings.
- Public pedestrian trails; and
- SWM facilities.

In particular, the required study would address the placement of such facilities in these areas to ensure that they are compatible with Core Area management, as discussed in **Section 6.3.5.** Note there is only one (1) area where a SWM facility may be compatible within a core and that is within core 11**.**

Other Hydrological Features

In addition to the components of the Natural Heritage System discussed above (*i.e.*, Core Areas, Linkages, and High and Medium Constraint Stream Areas), a number of other hydrological features located outside of the Natural Heritage System have been identified in the study area. These features include:

- Low Constraint Streams (*i.e.*, the green streams shown on **Figure 6.3.13**);
- Hydrological features associated with the Natural Heritage System, but located inside, the High and Medium Constraint Stream corridors (identified as Hydrologic Features "A" on **Figure 7.3.1)**;
- Hydrological features not associated with the Natural Heritage System. These features are identified as Hydrologic Features "B" on **Figure 7.3.1**); and
- Topographic Depressions not associated with the Natural Heritage System.

Low Constraint Streams

Low Constraint Streams (the green streams shown on **Figure 6.3.13**) will serve as conveyance streams only. There is no requirement to maintain a riparian corridor associated with these watercourses. The requirements for alteration or replacement of the Low Constraint Streams are to be identified at the EIR stage as outlined in the EIR discussion in **Section 7.4.1**. It is preferred but not necessary or required that the Low Constraint Streams be maintained as open systems. The function of all low constraint streams can be maintained through infrastructure and the proposed storm management approach.

Hydrologic Features "A" and Hydrologic Features "B"

Hydrologic Features "A" have hydrological functions, and consequently both their form and function shall be considered through a hydrological and hydrogeological assessment as part of an

EIR. This review will also consider the ecological benefits of these features. Further, any required buffers associated with these features will be determined through the preparation of the EIR, and will only be related to the hydrological function of the feature.

Hydrologic Features "B" may be relocated and consolidated with other wetlands, water features or SWM facilities, provided the hydrologic function of the feature is maintained. The hydrologic function of any Hydrologic Feature "B" will be appropriately maintained if the volume of water stored in the Hydrologic Feature "B" is added to, or it is otherwise demonstrated that it can be accommodated in, the extended storage component of a SWM pond. For such Hydrologic Features that have a permanent pool volume, the dead storage does not need to be incorporated into the storm water management facilities for the subcatchment area, just the active storage.

Topographic Depressions

Topographic depressions can be removed. However, the surface water storage volume associated with existing topographic depressions must be accounted for and included in any future SWM plans, as this is the primary function of these features.

7.3.2 NOE-SP Directions – Implementation

The NOE-SP will include policies with respect to the management of the Natural Heritage System and required environmental studies. The NOE-SP would include specific policies including the following directions:

- The description and process of the EIR to be prepared and submitted as a basis for the evaluation of development applications for new urban development. The requirements of an EIR are discussed in **Section 7.4.1.3**;
- The description and process of the FSS; and
- Recognition that the Subwatershed Study provides more detail on implementation and management.

7.4 Supporting Analysis Required

7.4.1 Introduction – Reporting Requirements

This section of the report outlines the items that are to be included in the EIR and FSS reports to demonstrate how any proposed land use meets the requirements of the management strategy.

7.4.1.1 Environmental Implementation Report (EIR)

The purpose of an EIR is to clearly demonstrate how the specific development application (such as a Draft Plan) will incorporate and follow the management strategy recommendations. **Appendix II** provides EIR study requirements.

The proponent will be required to demonstrate, through the preparation of an EIR, that the issues of SWM, infiltration, Natural Heritage System delineation and stream corridors have been addressed through the Draft Plan of Subdivision process, for the entire subcatchment area.

During the preparation of the EIR, consideration must be given to the Natural Heritage System as illustrated in **Figure 6.3.16**. The EIR reporting is to reflect the management requirements for the

Natural Heritage System and other hydrological features, as outlined in **Section 6.3**, and illustrated in **Figure 6.3.16** and summarized in **Tables 6.3.3** and **6.3.4**.

7.4.1.2 EIR – Study Boundaries

Figure 7.4.2 shows how the study area has been broken into separate subcatchment areas for the purposes of EIR preparation. The study area for an EIR will include not only the detailed assessment of the lands included within the land use application, but also an evaluation of how the lands within the application function within the subwatershed context and the impacts beyond the application boundaries. The EIR Study Nodes identified on **Figure 7.4.2** will aid proponents in determining EIR study boundaries for their development. The proponent should locate its application lands on **Figure 7.4.2**. An EIR will be required for the entire subcatchment draining to the EIR Study Node for the particular subcatchment area. It should be noted that there may be multiple drainage outlets at the downstream ends of the subcatchment areas. However for graphical purposes only one outlet per subcatchment area has been shown.

Where a portion of the Natural Heritage System is located within the subcatchment area, it will be important to demonstrate that the assessments required were completed with logical ecological boundaries or tributary areas. This may be accomplished with the co-operation of adjacent landowners to show consistency of treatment, or undertaken individually on a tributary area basis in the absence of other development plans.

7.4.1.3 EIR Requirements

The requirements for the EIRs are described specifically below and may be subject to refinement upon consultation with the approval agencies. The EIR will examine issues not detailed in the Subwatershed Study including:

- Watercourse relocations and modifications, as well as associated aquatic habitat assessment;
- Stormwater quantity and quality control requirements;
- Multi-landowner facility design and locations;
- Discrete monitoring requirements;
- Facility cost sharing; and,
- Conceptual fisheries compensation plans where necessary.

The EIR would be the recommended report to address drainage density requirements; however, since it has been determined that the drainage density targets have been met (**Section 6.3.4.1**), drainage density does not need to be addressed in the EIR or any other study.

EIRs may also require a number of technical studies, the need for which will have been identified in the Subwatershed Study. Although individual studies are listed below, it is possible that they will be combined given the interrelationship of these issues. Studies may include:

- Evaluation of Hydrologic Features “A” and “B” where relocations and modifications are proposed;
- Aquatic habitat where watercourse relocations and modifications are proposed;
- Full or scoped EIR for development within the Core Preserve Areas and Linkages;
- Studies to demonstrate that stream protection meets subwatershed objectives;

- Impacts associated with transportation, servicing and utility corridors;
- Functional SWM plan and outline approach and location of facilitates to meet management strategy requirements; and
- Natural Channel Design where watercourse relocations and modifications are proposed.

The requirements and expectations for these additional studies are discussed in detail in the following sections.

7.4.1.4 Functional Servicing Study

The FSS will relate to the lands proposed for development and must be supported by an EIR of the subcatchment area within which the lands are located. The FSS shall include the following, at a minimum:

- A preferred servicing plan based on an analysis of servicing requirements including:
  - Servicing design requirements;
  - Layout for roads and other transportation systems including transit and trails;
  - Preliminary sizing and location of SWM facilities and integration with environmental features and development areas;
  - Phasing and sharing of costs for other utilities and transportation systems; and
  - Preliminary locations for large above ground utility structures.
- Draft plans of subdivision or detailed land use concepts where applications have not yet been submitted, in accordance with the policies of the NOE-SP.

7.4.1.5 Test Catchment Design Case

In order to test the feasibility of the recommended measures for hydrologic, hydrogeological and water quality controls, a design example was set up for one of the catchments in the North Oakville Creeks Subwatershed area. The WM-1 subcatchment, a 38.2ha headwater area south of Burnhamthorpe Road in the West Morrison Creek subwatershed, was chosen. The existing land use includes a small proportion of residential/commercial land use, with the remainder being undeveloped woodlot and agriculture. A more detailed presentation is given in **Appendix JJ - Test Catchment Design Case**.

- **Hydrologic Criteria –** A SWM pond was sized to handle the Regional storm to the two-year storm with outflow rates equal to the predevelopment runoff for these storms. The active storage volume for the maximum event (Regional Storm) required is 3.5ha-m. Assuming an average depth of 1.5 to 1.0m, then the area needed for the pond is 2.3 to 3.5 ha or 6 to 9% of the land area. This amount of land is not excessive in comparison to other developing subwatersheds in southern Ontario. Pits or topographic depressions in the area account for 770m^3, or 0.077ha-m, and additional storage can easily be accommodated in the pond sized above without changing the area required.
- **Erosion Control Criteria –** Erosion threshold calculations were undertaken for the test catchment to determine permissible flows without causing excessive erosion. The method for the erosion threshold calculation was based in part on indicators of active processes (*e.g.,* widening or entrenchment) and channel substrate. The critical depth at this site was calculated to be 0.12m. Flow depth should not exceed this value post-development for more time than it does now so as not to increase or decrease current erosion rates. The

size of the stormwater ponds should be designed in consequence of this flow depth. The ponds should be of sufficient size so that the critical flow depth of 0.12m is not exceeded more frequently than it was pre-development. This requirement to control the rate of outflow from the pond would apply to the more frequent events (2 to 10-year return period) and may require that flows might be restricted further than shown in the flood control stage discharge assessment. This would not affect the overall storage sized for the more severe events (*e.g.,* 100-year return and Regional storm) and could easily be accommodated in the pond sized for these larger events.

- **Hydrogeological Criteria** – Due to the heavy soils (Halton/Wildfield Till) infiltration into deep soils is very slow. Infiltration targets are very difficult to achieve. As a result for this test catchment, additional infiltration to deep aquifers is assumed to not be practical. Note however that some additional water loss may be achieved by surface infiltration to top soils, although this would have limited to no effect on baseflow maintenance and deep aquifer recharging.
- **Water Quality Targets** – The steps described in **Appendix KK - SWM Facility Monitoring Protocols** were followed in this analysis. The target of achieving no increase in loading of total phosphorus (TP) was achieved by a combination of roof drainage to pervious areas and the provision of a SWM pond. It was assumed that 20 to 25% of roof areas could be drained to grassed areas which reduces water volume and phosphorus loadings to the SWM pond. The SWM pond is sized for an enhanced level of protection with an annual removal efficiency of 80% for Total Suspended Solids (TSS) and 65% for TP. The SWM wet pool pond volume required is to 6213 m^3, or 0.62ha-m. This volume is in addition to the active storage volume required for flood and erosion protection and would be provided inside the same land area (footprint). The SWM pond then would achieve several functions.

7.4.2 Natural Heritage System – Terrestrial

The following section presents a summary of the EIR and FSS requirements to ensure that the management strategy is correctly implemented in North Oakville with respect to the terrestrial and wetland components of the Natural Heritage System.

7.4.2.1 Core Area Boundary Verification

At the EIR stage, some refinement of the Core Area delineation will occur. However, it is anticipated that the refinement will be minimal and will focus on surveying the edges of features and locating buffers, as well as ensuring that overlapping factors/buffers are considered. It should be noted that any buffers have been included within the Core Preserve Areas and Linkage Preserve Areas in the NOE-SP. The following discussion provides guidance for these refinements.

Dripline of Woodland – A buffer of 10m from the dripline of areas of mature forest has been used as a factor for the delineation of Core Area boundaries in many locations. At the EIR stage the dripline of the woodland will be staked in the field, reviewed by staff of the Municipality in consultation with the Conservation Authority. The agreed line will be surveyed and the 10m buffer delineated based on this surveyed line.

Stream Corridor – The delineation of stream corridors is discussed in detail in **Section 7.4.3**. In some cases, the presence of a stream corridor near the edge of a Core is a factor in delineating the Core. In cases where the redside dace habitat applies (*i.e.*, sections of Fourteen Mile Creek and Morrison's Creek), additional setbacks from the stream corridor have been applied. See **Section 7.4.3** for additional information.

Floodplain – Delineation has been included in the identification of stream corridors (see **Section 6.3.4**). The accuracy of topographic mapping was not sufficient to finalize the floodlines for purposes of registration. Final floodline development will be required during the EIR stage. This will be required to conform to Conservation Halton requirements including setbacks to meet their requirements for fill line delineation for floodplain polices.

Width of Forest Interior Habitat – Minimum widths of Cores with forest interior habitat have been identified in some of the Core Areas. At the EIR stage, detailed delineation of vegetation communities within the Core will be used to verify the areas of habitat blocks within the Core. Minimum widths of forest interior blocks will be considered when confirming the Core Area boundaries, such that the delineation of the Core Area allows for the retention and in some cases ultimate restoration of woodlands of minimum width.

Width of Linkage within Core Areas – Section 7.4.2.4 includes a discussion of the analysis of linkages and widths at the EIR stage. Habitat connectivity within a Core Area differs from linkages between the Cores and focuses on cases where the Core consists of a number of distinct habitat patches that are recommended to be connected. One of the objectives of this type of habitat connectivity is to provide opportunities for forest interior species to reside within these connections, and to maximize the sustainability of the habitat cluster(s). In cases where there is more than one interior habitat node within a single Core Area, habitat connections between these units should be at least 200m wide. At the EIR stage, detailed delineation of vegetation communities within the Core will be used to verify the areas of habitat blocks within the Core Area.

Top of Bank – Section 7.4.3 includes a discussion of the analysis of top of bank considerations. In some locations where Core boundaries are described associated with woodlands (or other features), top of bank considerations may override these factors once detailed field investigations are completed at the EIR stage.

Exclusion of Residence or Other Buildings – As part of the review of the Core Area boundaries, existing residences, farm building complexes or other human-made structures in the vicinity of the Core Area were identified and not included in the Core. At the EIR stage, the presence of these types of features would be confirmed (note existing agricultural fields are not included as features for exclusion).

Edge of Wetland – A buffer of 30m from the edge of wetlands has been used as a factor for the delineation of Core Area boundaries in many locations. In some locations, larger buffers are recommended (*e.g.,* around the buttonbush swamp in Core #10). Where this is the case, the buffers are noted on **Figure 6.3.11**. At the EIR stage, the limit of the wetland will be staked in the field, reviewed by staff of the Municipality and in consultation with the Conservation Authority. The agreed line will be surveyed and the buffer delineated based on this surveyed line.

Edge of Thicket/Open Field Vegetation – Existing areas of thicket or open field have been used in some locations (along with other factors) to delineate Core Areas. At the EIR stage, detailed delineation of vegetation communities within the Core will be used to verify the areas of habitat blocks within the Core. Minimum areas of open field and thicket habitats will be considered when confirming boundaries. No buffers around thickets or field areas have been used for Core Area delineation.

As noted above, the delineation of the Cores considered a number of general habitat goals as well as site specific factors. At the EIR stage the multiple levels of factors and the overlap of factors must be considered.

7.4.2.2 Uses Within Core Areas

Table 6.3.2 of the management strategy provides an overview of the Core Areas and management. It provides a bullet summary of the types of management recommended for within the Core. This is further discussed in **Section 7.6** of this report.

Section 6.3.5 of the management strategy provides a discussion of the adjacent land uses to Cores, as well as possible uses within the Cores. As noted in **Section 6.3.5**, SWM facilities can only be included in Cores if compatible with the function (*i.e.,* if area under consideration was fully wooded this would not be compatible). There is one instance where open country habitats within Cores are found associated with a possible receiver of the facility discharge and that is Core 11. Site specific review of this site is required at the EIR stage to determine the feasibility of accommodating the goals of the Core with the proposed facility. This is discussed further in **Section 7.4.2.2.**

7.4.2.3 Core Crossings

Section 6.3.5. of the management strategy also provides a discussion of roadway crossings of Core Areas. At the EIR stage site, specific review of the characteristics of the Core would be required to evaluate the type and design of watercourse crossings. **Section 6.3.5** provides a number of recommendations for consideration at the EIR stage:

- Selecting roadway and linkage alignments to avoid unsafe intersections (*e.g.*, at curves);
- Use of plantings and wing-walls to direct wildlife using the linkage to culvert/bridge crossings;
- Design of culverts/bridges to accommodate wildlife movement;
- Consideration of alternative road designs to minimize the width of the gap created by the roadway (in either linkages or other natural areas);
- Locating services under the roadway is recommended to minimize roadway right-of-way; and
- Road alignments through Core Areas should be selected to avoid woodland and wetland features.

7.4.2.4 Verification of Locations and Width of Linkages

A detailed discussion of Linkages between Core Areas is included in **Section 6.3.3**.

From a location perspective the following factors were considered:

- Existing linkages (primarily associated with riparian habitats and hedgerows, but including some existing field linkages); and
- Potential linkages which take advantage of some pockets of vegetation, hedgerows or other natural features.

In many cases, the linkages have been identified to correspond to stream corridors. Therefore considerations presented in **Section 7.4.3** regarding stream corridor width and location would be key to the consideration of linkages at the EIR stage. In some cases, based on the character of the stream, reaches have been identified that may be relocated. In these cases, the linkage function of these streams would need to be assessed to ensure that the connectivity function is maintained or enhanced (especially with respect to connecting the desired end habitats).

In some cases, potential linkages were recommended where no existing natural feature currently exists. These locations were generally selected with the shortest distance between end habitats. At the EIR stage, the locations of these features would be detailed (taking into account the connections to suitable end habitats and a width of 100m).

7.4.2.5 Crossings of Linkages

Section 6.3.5 provides a discussion of the roadway crossings of Linkages. At the EIR stage, site specific review of the characteristics of the Linkage would be requried to evaluate, for example, the need for and design of culverts and bridges (see **Section 7.4.2.3**). Since many of the linkages are proposed to coincide with stream corridors, crossings of the streams would also need to consider aquatic habitat, fluvial, and hydraulic considerations (see **Section 7.4.3**).

7.4.2.6 Evaluation and Assessment of Hydrologic Features "A" and "B"

There are a number of wetland and pond features that are in the subwatershed, but not associated with a Core Area. In some cases these features are found within linkages, or associated with stream corridors. **Section 6.3.3** presents a summary of wetland locations relative to the Cores.

Many of the wetlands associated with the stream corridors, (especially high and medium constraint streams), provide a range of hydrologic, hydrogeologic, and nutrient inputs, as well as ecological functions. In addition to wetlands, numerous other hydrologic features (*e.g.,* ponds) are also found associated with these features and provide similar functions.

A review of the wetlands and ponds associated with the stream corridors was completed. An analysis of each of these wetlands (outside of Core Areas) as well as ponds concluded whether the wetland or pond was:

- Located online on a medium or high constraint stream;
- Located within the stream corridor of a medium or high constraint stream; and

Wetlands and ponds that satisfied one or more of these conditions were included as Hydrologic Features "A". All others were identified as Hydrologic Features "B".

The form and function of Hydrologic Features "A" located within medium and high constraint stream corridors must be carefully considered through a detailed hydrological, hydrogeological, and ecological assessment as part of the EIR. As part of the analysis of the stream corridors, the functions of the Hydrologic Features "A" must also be considered. This will require an analysis of the location of the feature relative to the stream (*e.g.*, headwaters or online). It is anticipated only minor changes in location will be permitted. If relocating these features, the form and function must be maintained. Hydrologic Features located outside medium and high constraint stream corridors may be treated as Hydrologic Features "B" which is described in further detail in the following paragraphs.

At the EIR stage, Hydrologic Features "B" must be identified. The hydrologic function of these features must also be detailed at the EIR stage. It is recommended that the hydrologic function of the Hydrologic Features "B" be maintained. These features may be relocated and consolidated with other features, provided the hydrologic function of the feature is maintained (generally will require that the feature be relocated within its existing subcatchment).

Preservation of Hydrologic Features "B" is encouraged, but not required. If a Hydrologic Features "B" is to be preserved, the EIR must characterize the hydrologic function of the feature and address mitigation impacts within the modified landscape (*i.e.,* maintain historic drainage area). If they are scheduled to be graded and filled for future development, the active storage volume of these features must be incorporated into the SWM facility for that subcatchment area.

Additional topographical depressions that provide a hydrologic function have been identified in the management strategy. These are discussed in **Section 7.4.4.**

7.4.2.7 Wildlife Crossings

This section provides recommendations for wildlife crossings in cases where roads cross the Cores or Linkages. The recommendations are based on the analysis of linkages included in

Section 5.9 in conjunction with the management recommendations for the Natural Heritage System in **Section 6.3.3.4.**

Based on the existing larger valleys in the area, the locations for bridge crossings would appear to be limited to Fourteen Mile Creek. Otherwise linkages are recommended to be a combination of at-grade and large culverts (associated with stream crossings and dry culverts).

The interrelationship between the Sixteen Mile Creek valley, associated contiguous woodlands and neighbouring Cores (Cores 3, 4, and 5) was recognized early in the Subwatershed Study (see **Section 6.3.2.4**). This network of interconnected Cores was also identified in subsequent discussions with staff from the Ministry of Natural Resources (MNR), Conservation Halton and the Region of Halton. For this portion of the study area, a range of crossing types are recommended. This will include:

- At-grade crossings to allow for movement of larger wildlife such as deer and coyote;
- Signage along roads identifying a wildlife crossing area;
- Management of the road verges to allow for sight-lines allowing wildlife and motorists reaction time to avoid collisions; and
- Culverts associated with road crossings of watercourses, as well as strategically located dry culverts, would be included in these areas.

Road networks being planned at the time of preparing this report included substantial roads in this area, namely Neyagawa Boulevard and Burnhamthorpe Road).

The culverts would be sized to accommodate predicted flows, as well as to allow dry "benches" and low flow channels within the culverts. The design of these crossings would be detailed at the EIR stage, and would include recommendations for focusing wildlife movements to appropriate crossing locations and/or structures. This could include landscaping, as well as the possibility of fencing. These measures would depend on site specific features and reported collision hazards. Culverts in the range of 1.8m in height with larger spans have been used successfully in other locations for wildlife crossings.

The linkages identified as part of the Natural Heritage System are primarily recommended to be wooded, since they have been located to connect wooded end habitats. **Section 6.3.5** discusses the recommendations pertaining to SWM ponds within linkages. The series of criteria identified included the allowance for SWM ponds within linkages adjacent to road crossings. Although it would seem that SWM ponds would not be compatible with the wooded character of the linkages, in these cases it was recognized that the positioning of the ponds, especially associated grading and landscaping, may have a multi-purpose use in directing wildlife towards the strategically located crossing structure (*i.e.,* culvert(s)).

The recommended linkages will initially consist of open habitats and/or riparian habitats in cases where streams are found within the linkage. The narrower band of vegetation along the streams and small pockets of vegetation can provide good quality linkage habitats. This type of existing vegetation can focus wildlife movements, allow for patch to patch movements, and provide a source for the establishment of additional vegetation in the linkage.

7.4.3 Natural Heritage System – Streams

The following section presents a summary of the EIR and FSS requirements to ensure that the management strategy is correctly employed for the development of North Oakville with respect to the aquatic components of the Natural Heritage System.

7.4.3.1 Geomorphology

Low Constraint Riparian Corridors

It is preferred but not necessary or required that the Low Constraint Streams be maintained as open systems. The function of all low constraint streams can be maintained through infrastructure and the proposed SWM approach.

Drainage Density Targets

Based on the analyses completed within the management strategy, regional drainage targets are met within North Oakville through the red and blue streams and SWM facilities.

Riparian Corridor Widths

Meander belt/stream corridor widths were developed on a broad scale and, as such, should be subject to refinement during the EIR stage. This would also determine whether they are the constraining parameter for watercourse extent. For example, the stable slope and toe allowance setbacks will only be required for confined systems. Another critical point to consider is whether the reach is to be deepened during the development process to facilitate stormwater servicing requirements. In cases such as these, the meander belt width would not change, but the deepening may trigger the conversion of the reach status from an unconfined system to a confined system. Under these conditions, the riparian corridor width would then be subject to the additional safety factors.

Figure 6.3.15a provides a visual reference indicating all of the allowances contributing to the riparian corridor width, while **Figure 6.3.15b** provides a decision making flowchart that outlines the riparian corridor width determination protocol.

7.4.3.2 Aquatic Habitat - Fisheries

The management strategy for aquatic habitats within the study area is predicated on the fact that no stream currently functioning as fish habitat will be eliminated. The Subwatershed Study identified aquatic habitats based on background review and original field surveys. Reaches that were deemed by the study team to have in-situ fisheries habitats were identified as either high or medium constraint stream reaches. High constraint streams (red streams) will remain in place with potential enhancements, while medium constraint streams (blue streams) may be modified or relocated, but form and function (including habitat values) must be maintained. This approach ensures that fisheries habitats will not be eliminated within the subwatershed area.

The EIR assessment is to be conducted at a subcatchment level so that the extent and inter-relationship between reaches can be assessed. This approach to delineating the study area for an EIR forces the inclusion and consideration of entire branches despite the fact they may extend outside a specific landowners' property. The aquatic habitat characterization completed as part of the Subwatershed Study was a broad based characterization which grouped habitat into reaches based on homogeneity of habitat.

As part of this study, Department of Fisheries and Oceans (DFO) participated in a field reconnaissance of all streams within the study area. The purpose of this exercise was to confirm the classification of the aquatic habitat by the study team and to agree upon the upstream extent of aquatic habitat on each tributary. This provided the study team with a confirmation of their determinations as well as providing DFO with an opportunity to undertake a broad scale confirmation of habitat conditions such that this did not have to occur for each and every Fisheries Act approval. The classifications and the extent of habitat have been clearly defined and mapped for this study. Although it is envisioned that site specific EIR work might result in the proponent suggesting minor refinements to the extent of habitat, this is expected to be in the order of a few meters and substantive changes from the agreed upon limits (DFO and this study team) should not be considered. It is conceivable that the proponent may challenge the habitat classification for a particular reach, perhaps based on changes that may have occurred since this report. In these cases, the approving agency should review the information used to arrive at the classification to determine if habitat conditions have changed to the point that a change in classification is warranted. It is anticipated that such changes would only occur when development is delayed by several years from the timing of this report.

A more detailed assessment and documentation of habitat is required at the EIR stage. The discussion below provides guidance for the assessment of fish habitats at the EIR stage. There is considerable overlap in the various aspects of stream corridor management, and the recommendations/guidance provided in other portions of this report pertaining to hydrology/hydraulics, geomorphology, and SWM must be referred to.

Evaluation and Assessment of Habitat

The evaluation and assessment of aquatic habitats will be completed within the subcatchment study area. Within this area, the stream reaches assessed as part of the subcatchment study area are to be mapped and described. The study will include a review of the factors that lead to the identification of high, medium, and/or low constraint streams (from a habitat perspective).

Aquatic habitats must be mapped at a scale that fosters a clear understanding of the habitat that might be affected as a result of development. To this end, the watercourse edges from top-of-bank to top-of-bank should be confirmed by survey. The wetted perimeter of the stream should also be surveyed at that time. This will provide an appropriate basemap on which to map aquatic habitat.

The mapping of aquatic habitat should categorize homogenous lengths of stream habitats with respect to the habitat type. Examples include riffles, runs, and pools. The mapping should also identify important habitat features such as in-stream vegetation, boulders, undercut banks and woody debris, and the locations of such features clearly identified on the habitat map. If critical life stages of fish or other aquatic biota are being supported by a particular habitat area or feature, the extent of the features should appear on the map. For example, a spawning area or nursery habitat should be clearly identified on the aquatic habitat map.

The habitat map will serve as a basis for future review of individual permit applications for watercourse modification or relocation.

Aquatic Habitat Setbacks

The management strategy in the Subwatershed Study identified recommended setbacks for aquatic habitat protection. Some setbacks are required to conform to species specific requirements (*e.g.,* redside dace) while others are applied broadly to other watercourses as a minimum requirement for protection of aquatic habitat. The EIR should clearly demonstrate how these aquatic setbacks will be met. The setbacks for the purposes of protecting aquatic habitats was one factor considered in the identification of stream corridor widths. As such, the other factors must also be considered when arriving at a detailed review of setbacks from watercourses.

Riparian Corridor Management

The overall management approach for the three types of riparian (stream) corridors as illustrated on **Figure 6.3.13** are summarized in this section and in **Appendix GG – Management Approach Criteria for Stream Systems.**

High Constraint Streams (Red Streams) – The Subwatershed Study identified a number of stream reaches as high constraint streams. In these cases, the reach was deemed by the Study Team to provide current characteristics that suggested the reach could not be relocated. In addition, a number of specific reaches were identified that were recommended for enhancement. In many cases these enhancement areas were recognized based on fluvial needs. In all cases fisheries habitats will be maintained, and in the latter case, enhanced.

The EIR must identify the extent of these reaches. Any enhancement measures for these reaches must also be detailed as part of the EIR. The relationship of these reaches to any medium and/or low constraint reaches must be detailed.

Medium Constraint Streams (Blue Streams) – As noted above, the Subwatershed Study categorized stream reaches such that medium constraint streams could be relocated but the form and function of these reaches must be maintained. Many of these reaches were identified as medium constraint features based on a number of factors, including aquatic habitats.

Since the EIR will be done at a subcatchment level, the details of all channel modifications or relocations may not be detailed at this stage (*e.g.,* due to land ownership). However, at the EIR stage the relationship of proposed modifications/relocations throughout the subcatchment will be documented. The EIR must clearly demonstrate how ecological form and function will be maintained in modified or relocated channels. This analysis must first identify the types and extents of aquatic habitat in the existing channel and then demonstrate how that habitat type and extent will be replicated within the relocated or modified channel. This is anticipated to take the form of typical treatments for channel/habitat types within the area. These treatments are to be developed in consultation with pertinent agency and municipal staff. These plans will include conceptual location(s) for the channels, as well as typical sections of channel and typical cross-sections. At a minimum one typical section for each habitat type to be included in the new channel is required. This section should extend from top-of-bank to top-of-bank and should include details related to substrate type, intended slopes, location of features (*i.e.,* baseflow channel) and proposed vegetative treatment of the channel and banks. Generalized locations of specific habitat features will also be shown (*e.g.,* fish spawning and nursery habitats). These plans will ensure that an integrated approach to channel modifications is taken at the EIR stage. Again, other factors such as hydraulics, geomorphology, and servicing must also be taken into account. These plans will provide the basis for more detailed plans to be completed at the site plan/draft plan stage.

At the draft plan stage, details will be required to obtain permits (such as permits under the Fisheries Act). The details required must be determined in consultation with the pertinent agencies. The work completed at the EIR stage will provide a conceptual basis for the preparation of plans at the draft plan stage. This could include, but not be limited to, detailed plan views of the relocated channel demonstrating the extent and relative extent of each habitat type is required. This plan view should also show the location of specific habitat structure features to be included in the new channel. It must also show locations of any habitats to be created to provide for a specific life stage activity *(i.e.,* spawning or nursery habitat). A vertical profile of the new channel should also be included to demonstrate how the channel will be built to accommodate the inverts at the upstream and downstream end of the new channel. In addition to the plan views, cross-sections and other landscaping plans should be provided.

Hydrological Features "A" – As discussed previously in **Section 7.4.2**, a number of wetlands and ponds were determined to be associated with stream reaches. In the case of medium constraint streams, the form and function of these Hydrologic Features "A" must be detailed at the EIR stage. The plans prepared for the modification/relocation of the medium constraint streams must indicate the relationship of the Hydrologic Features "A" with aquatic habitats.

In many cases, Hydrologic Features "A" are actually online wetlands or ponds. It is foreseeable that some of these features have a negative impact on aquatic habitat, and as such the EIR must detail this relationship, as well as the treatment being proposed for the channel, and associated wetlands and ponds.

Redside Dace – There are two streams within the study area which must be managed for the protection of redside dace. All redside dace survival habitat falls within high constraint (red) stream corridors and therefore will not be modified or relocated. However, medium constraint (blue) streams feeding these red streams may undergo modification and/or relocation. The EIR should demonstrate how the stream treatments will consider the redside dace habitat downstream of the section to be modified. In most cases, opportunities exist for enhancing blue stream habitats such that they may become suitable for redside dace and this species may start to move into relocated and/or modified blue streams. In planning for the relocation and/or modification, important aspects include provision for riparian habitat dominated by grasses, shrubs and trees that provide shade and cover and produce insect forage. The redside dace habitat in the red stream areas will provide important site specific clues as to the type of habitat supporting this species. The subcatchment plans will ensure that an integrated approach to channel treatments is taken at the EIR stage. Again, other factors such as hydraulics, geomorphology, and servicing must also be taken into account.

Requirements

Conservation Halton interprets three distinct flow conditions/functions that must be mimicked or preserved. They are:

- Seasonal or ephemeral flow conditions that provide feeding and refuge migration from the main channel during flood events, refuge pools, and spawning;
- Semi-permanent (or intermittent) conditions that flow in response to most rain events and support some permanent refuge pools; and
- Permanent flow that supports multiple life stages of fisheries resources.

Technical studies will be required to support these conditions through SWM techniques as follows for each respective flow condition:

- **Seasonal Flow** – Through extended detention outlet connections;
- **Intermittent Flow** – Through extended detention outlet connection and baseflow protection techniques; and
- **Permanent Flow** – Through protection of all reaches downstream of two combined tributaries with flow conditions, or any reach with multiple extended detention outlets and baseflow protection techniques that result in permanent flow.

7.4.4 Stormwater Management

The following section presents a summary of the EIR and FSS requirements to ensure that the management strategy is correctly employed for the development of North Oakville with respect to the SWM component of the Natural Heritage/Open Space System.

Under existing conditions, the topography and soils in the subwatershed areas play a significant role in the hydrologic response of the catchments to precipitation. To prevent increases in flood and erosion potential in downstream receiving watercourses, SWM is to be provided to control volume and rates of runoff. The targets for peak flow control (flood protection) are discussed in this section of the report. The erosion protection targets are outlined in **Section 5.8.3.** In addition, the importance of volume control for water quality (particularly phosphorus) has been evaluated in this report and stormwater retention is discussed in **Section 7.4.4.3.**

The role of soil conditions and surface storage has been included in the hydrologic analysis and modelling in this study. This includes depression storage at the ground surface that is associated with topographic conditions. Under existing topographic conditions there are a number of identified small and localized topographic depressions that have the ability to store water during a rainfall event. Some of these areas have defined overflow points, whereas others have outlet areas that are not well defined and may exhibit sheet flow when overflowing. Following a precipitation event, the stored water will either infiltrate or evaporate. The depth of storage available varies from location to location.

The identified topographic depressions have been categorized as follows:

- Hydrologic Feature “A” – Depression features (vegetated or ponds) exhibiting signs of being wet most of the year and connected to a red or blue stream;
- Hydrologic Feature “B” – Depression features (vegetated or ponds) exhibiting signs of being wet most of the year but not connected to a red or blue stream;
- Wetland or water storage features in a Core;
- Topographic depressions large enough to be identified on the base map provided for this study; and
- Topographic depressions that are identifiable on aerial photography.

To ensure that the effect of surface storage on flow response conditions is accounted for in any future land use changes, two measurable targets are recommended as part of the SWM calculations:

1. The drainage and SWM approach and associated modelling must demonstrate that the flow targets in **Table 7.4.1** are met; and
2. The surface storage provided in existing identified topographic depressions is to be quantified. The SWM storage provided as part of any proposed works must not include the calculated surface storage on a drainage area basis for the full range of design storm events. This calculation should be carried out for the 2, 25 and 100-year, and Regional design storms.

The flow targets represent existing conditions peak flow levels for the full range of design events (2 year to Regional Storm). This is provided as a peak flow target to prevent the increase in flood potential to private property along receiving watercourses. In cases, such as Sixteen Mile Creek, where the floodplain is contained within a well defined, publicly owned valley system, consideration can be given to not controlling peak flows under Regional storm conditions, as long as flood potential is not increasing on private property. Control of lesser events is still required to protect local flow regime characteristics of the outlet. If considered, this will require evaluation at the EIR stage.

The SWM component identifies the hierarchy embedded in the SWM plans. It addresses specific quality, erosion, infiltration and quantity requirements for the various watercourses within the catchments. The Natural Heritage/Open Space System component clarifies the integration of the woodlots, wetlands, field swales, and stream corridors into the development plan depending on where they occur within the subwatershed.

SWM facilities and enhancement techniques will be required to ensure that hydrologic characteristics of the watersheds are maintained and ecological resources are protected. The approximate locations of SWM facilities are shown on **Figure 7.4.6**. A SWM plan must be prepared and included as part of the EIR. The SWM plan must demonstrate that the requirements of the subwatershed plan have been met.
The SWM approach should follow the intent of the revised *Stormwater Management Guidelines* (MOE, 2003) and the proposed Source Water Protection Act in developing an approach for erosion protection and maintaining the flow regime conditions in the catchments. This follows the same principle in the proposed protection of headwater streams. The distributed runoff control (DRC) outlined in the draft guidelines provide the principles for a SWM approach.

The following information will be provided:

- Identification of management objectives and sizing criteria from the Subwatershed Plan;
- Identification of management practices and design considerations necessary to ensure that the subdivision plan conforms to the Subwatershed Plan;
- Identification, screening and design of alternative management practices, based on guidelines provided in *Stormwater Management Planning and Design Manual* (MOE, 2003);
- Confirm floodplain limits based on detailed site topography and incorporate into survey base plan;
- Identify opportunities to maintain overland drainage to compliment woodlot protection or watercourse enhancement objectives;
- Define major/minor system drainage patterns and contributing areas. Address post development servicing area for the SWM facilities, as well as objectives for minimizing the number of ponds, while achieving practical development timing;

- Confirm sizing and release rates for ponds, including assessment of the release rate in terms of the site specific characteristics of the receiving watercourse for two meander lengths downstream of the pond;
- Confirm that online quantity controls are in place and functioning as required to ensure no downstream peak flow increases;
- Undertake site specific soil and groundwater investigations to assess the potential for infiltration/groundwater recharge and identify appropriate, feasible Best Management Practices. Identify and determine the relative benefits of other measures, such as lot level measures that could be implemented (i.e. LID practices). The investigation should determine the relative benefits and assess the impacts on the overall water budget and local groundwater conditions (*e.g.,* effects on water table position);
- Documentation in the EIR should address pre and post development conditions, proposed major and minor system patterns, selected SWM technique(s), locations of ponds, preliminary design including outlet characteristics and controls to reduce thermal impacts, outfall locations and relationship to the stream and riparian habitats, erosion, and channel stability with proposed release rates;
- Confirm volume of storage and tributary drainage area, conceptual design of ponds, and pond outlet locations;
- Watershed targets must be met using overall watershed wide criteria, but the local effect events must also be evaluated to ensure that the ponds are designed so that they will not be at risk due to locally intense events (*i.e.,* AES Chicago events);
- Demonstrate how storm sewers work in conjunction with pond operating characteristics;
- Demonstrate that development conforms to criteria established for quantity control;
- Identification of a monitoring program necessary to demonstrate that the SWM facilities are performing as designed and the water quality and quantity targets are being met;
- Provide for innovative SWM (including source control and protection of headwater swale systems, LID principles) to protect headwater stream functions and infiltration;
- Demonstrate infiltration management, particularly in areas that are highly pervious, for protection of flow regime conditions, and fisheries protection (*i.e.,* baseflow);
- Documentation on adherence to criteria related to fish habitat, extended detention, infiltration, erosion and sedimentation control, regional storm flood control and use of swales and artificial wetlands for water quality enhancement;
- Sediment and erosion control plans; and
- Operation and maintenance manual for proposed facility.

7.4.4.1 Hydrological

Runoff peak flow rate attenuation will be required on all new development. New development shall not increase the risk to public safety or increase the risk to property damages. Public safety refers to the risk to the loss of life and the loss of property from floodwaters and erosion.

New development (without SWM) increases the volume and peak flow rate of runoff while reducing the amount of infiltration and evapotranspiration. Increases in peak flow rates, if unattenuated, will increase the frequency of road/rail crossing overtopping, increase flood levels along the watercourses, and increase flood damages. Runoff increases resulting from new development must be attenuated to prevent increases to the risk of life and property damages.

Runoff attenuation will be required for all frequency events including the 2 through 100-year return periods and the Regional storm. Peak flow rates for each event will be calculated using a

unit area flow rate approach. The allowable release rate from a new development for a particular return period will be determined by multiplying the drainage area by a unit area flow rate. **Table 7.4.1** shows the unit flow rates for subcatchments upstream of the Dundas Street culverts. The location of the subcatchments and the culverts are shown on **Figure 7.4.7**. All new developments within the upstream watershed will use the same unit area flow regardless of the location within the watershed.

Allowable peak flow rates for each new development is based on maintaining downstream peak flow rates. Diversions from one watershed to another will not be allowed unless there are equal offsetting diversions.

The EIR will document existing conditions peak flow rates using the unit area flow rate approach, unattenuated peak flow rates based on new development, and peak flow rates from the proposed mitigation measures.

There are numerous depressions (pits, wetlands, and low lying areas) located within each subcatchment that retain or detain runoff as discussed at the beginning of **Section 7.4.4**. The depressions contribute to the hydrologic cycle within each subcatchment. They reduce downstream peak flow rates, increase infiltration, and increase evaporation. Hydrologically significant depressions are shown on **Figure 7.3.1**. The EIR should identify the depressions located within the development site and describe the depressions with respect to area, depth, length, width, and determine the amount of storage in each depression for the return period and Regional storms. The EIR will document the amount of storage that will be lost due to site re-grading. The amount of lost storage must be re-established in the SWM ponds.

7.4.4.2 Hydrogeological

As noted in the **Section 6.0 - Management Plan**, the clay rich soil common throughout North Oakville is poorly permeable, resulting in little infiltration. The estimated infiltration in North Oakville based on the stream flow estimates and hydrologic modeling averages about 40mm/yr.

One of the stated goals for the subwatershed study is to develop a plan that guides the planning of future land use planning, infrastructure, and resource development while protecting and enhancing the environment. From a hydrogeological perspective, the goal is to protect and enhance groundwater quantity and quality in North Oakville.

To do this, established targets must be achievable. Within each core area and within other areas where development will not occur, infiltration is expected to remain the same after development of the surrounding areas. It is also recognized that, because of the low hydraulic conductivity of the soils in the area, the infiltration target may not be met for each catchment area of each stream. However best efforts must be used to maintain infiltration at the same level as it is currently. Where opportunities may exist, such as toward the north end of the study area, enhancements to infiltration must be considered. Therefore, on a subwatershed level, the goal is to maintain or enhance the groundwater contribution to stream flow by sustaining infiltration at current levels.

To achieve these objectives, the following steps must be taken.

- Confirm existing hydrogeological conditions in each subwatershed/catchment area, including the estimated infiltration, the depth to water table, local groundwater flow direction, and areas of discharge and recharge.

- Refine the local water balance and determine acceptable and achievable local infiltration and recharge targets.
- Use these site specific details to determine the opportunities and measures within each catchment and/or subwatershed for maintaining and enhancing infiltration. These could include the use of various area wide measures such as infiltration along the alignment of storm sewers and enhanced infiltration techniques at SWM facilities or lot level measures such as the discharge of roof leaders to lawns and gardens.
- If infiltration within a specific catchment area cannot be maintained, identify other areas in the subwatershed where measures can be taken to augment or enhance infiltration to, at least in part, make up the infiltration deficit. Determine related changes in the groundwater flow regime and how the changes will affect stream flow, the local water table, and groundwater quality.

Should infiltration targets not be maintained, the impact on the base flows in local streams and the local water table must be predicted and mitigation measures suggested, if warranted.

7.4.4.3 Water Quality

Hierarchy of SWM Measures

The implementation of SWM measures should be done in a sequence that recognizes the hierarchy of preferred measures. The hierarchy is based on the following principles:

- Preference for measures located at the source on the lot level for quantity controls and that incorporate pollution prevention concepts for quality control;
- Preference for measures that satisfy more than one objective, such as infiltration and baseflow protection, as well as flow reduction and quality control;
- Preference for measures at source and in the conveyance system that take advantage of natural systems that reduce flow volume and filter out pollutants such as surface detention (i.e. bioretention, bioinfiltration, rain gardens); and
- Preference for measures that reduce the size of end-of-pipe structural measures.

Meeting Total Suspended Solids and Total Phosphorus Targets

The TSS and TP targets should be considered together, along with infiltration goals. The preferred approach is to consider source controls first, then conveyance, and finally end-of-pipe controls.

A step-by-step procedure for calculating targets for a developing area, and evaluating the degree to which control measures meet targets, is presented in **Appendix LL – Meeting Total Phosphorous and Total Suspended Solids Targets**.

Summary of Step-by-Step Procedure

1. Establish phosphorus target for the area beings developed:
    - Step 1 – Calculate runoff volume for the undeveloped area;
    - Step 2 – Calculate TP target based on the pre-development load;
    - Step 3 – Calculate post development runoff volume and TP load;
2. Account for infiltration measures at source and in conveyance system and the degree they meet infiltration targets (Step 4);
3. Account for surface retention measures that reduce overall flow and TP load reduction (Step 5);
4. Account for end-of-pipe stormwater ponds to meet TSS targets (sized for the reduced runoff) for the watershed, and account for the TP load reduced as well (Step 6);
5. If TP targets are not met with the combined measures, repeat the process with additional control (Step 6 plus):
    - Upgrade the end-of-pipe pond to remove more TSS and TP;
    - Add additional infiltration or surface retention measures; and
    - Add additional structural measures to remove TSS and TP, either in the conveyance system or end-of-pipe.

7.4.4.4 Erosion Control

In order to ensure that the receiving channels will not experienced higher than normal rates of erosion, a threshold flow needs to be incorporated into the design of the SWM facility. This is accomplished using traditional field protocols at the most sensitive reach downstream of the proposed facility. The sensitivity is defined based on Rapid Geomorphic Assessments. Once the field data is collected, the threshold is determined using empirical approaches. Typically, a shear stress value is appropriate, although depending on the nature of the channel (controlling factors such as vegetation), another approach such as permissible velocity or stream power may be more appropriate. The result should be compared against local values provided within this Subwatershed Study. Erosion threshold assessments were carried out as part of the Analysis report for seven reaches deemed sensitive by the RGA scores. The values calculated for these sites can be found in **Table 5.8.5**.

7.4.5 Servicing Studies

Overall master planning has been carried out as part of the NOE-SP to provide direction as to the overall servicing approach (Roads, Water, Sanitary, Stormwater Drainage, and Management) including layout of a master planning level. These studies are intended to provide overall direction in carrying out Draft Plan preparation and detailed servicing design.

During the preparation of an FSS and detailed design, consideration must be given to the objectives, targets and intent of the management strategy. The items to be included in servicing studies include:

- Any underground services must consider hydrogeologic functions/characteristics and must preserve and enhance these functions and characteristics as follows:
  - Protection of groundwater source to terrestrial features;
  - Protect and enhance wetland features (*i.e.,* maintain groundwater levels);
  - Protect and enhance baseflow to streams;
  - Protect groundwater quality;
  - Enhance groundwater recharge (*i.e.,* use of perforated storm sewers – Etobicoke Infiltration System);
- It is recognized that some stream systems (blue and green) will need to be lowered to provide for servicing. This should be designed to meet the aquatic/stream objectives for protection and enhancement;
- Road designs should be developed in a manner to meet any site specific wildlife linkage objectives. This should include consideration of road cross-sections that will provide for wildlife crossing objectives;
- Any SWM facility design should facilitate the proposed monitoring plan; and
- Designing servicing to result in a "no net change" to the hydrological and hydrogeological conditions within the Subcatchment Area.

7.5 Monitoring Strategy

7.5.1 Principles of Monitoring Program

Traditional master drainage planning has evolved since the 1970's into the comprehensive subwatershed planning now practiced. The concerns addressed have increased the complexity and scope of the studies from quantity control for flood and erosion protection, with the addition of many issues such as water quality, aquatic biota and habitat, and geomorphology. Monitoring has been included in the more recent studies as an integral part of implementation. The *Subwatershed Planning Report* (MOE and MNR, 1993) stated the following:

> "A subwatershed plan cannot be considered complete until its monitoring program is established. Monitoring programs should be designed to assess environmental changes in the subwatershed, to evaluate compliance with the plans, goals and objectives, and to provide information which will assist custodians of the plan to implement it and update it. The monitoring program should be presented as part of the subwatershed implementation plan."

Monitoring is now considered as a necessary continuation of the subwatershed plan, designed to evaluate the need to review or update subwatershed plans, or to trigger the implementation of contingency plans that may include remedial measures needed to achieve the subwatershed goals and objectives. The following principles are proposed as the basis of the monitoring framework.

1. Monitoring must be directed at fulfilling one or more objective sets, be subject to analysis and lead to potential actions.
2. Monitoring of receiving streams should be for identifying problems, establishing a background reference, and evaluating the effectiveness of controls.
3. Technology performance monitoring should be to confirm that SWM facilities operate as designed, and if not, determine if remedial design improvements or maintenance are needed. This will assist in improving future designs.
4. An ideal monitoring program should be directed at connecting receiving stream impact analysis with technology performance assessment in a watershed context.
5. The strategy should recognize and incorporate existing monitoring programs.
6. Reporting on results and taking appropriate follow up action is a key component that fulfils due diligence expectations.

7.5.2 Erosion and Sediment Control (ESC) Planning

Future construction activities taking place in North Oakville will require clearing of vegetation, topsoil stripping and earth grading that leaves exposed soils vulnerable to wind and water erosion. Stringent sediment and erosion control measures will need to be implemented to ensure that the adjacent natural heritage system is not negatively impacted by construction practices. Sediment release due to construction activities is not only detrimental to the health of the receiving NHS but will also result in costly future maintenance work of the existing downstream drainage infrastructure.

Prior to construction, comprehensive erosion and sediment control (ESC) plans must be submitted to the Town and Conservation Authority detailing the methods that will be used to prevent the release of sediment laden runoff from the construction site. There are extensive sediment and erosion control guidelines available that describe the design considerations,

application and function, implementation procedures, maintenance procedures and removal procedures for a wide variety of sediment and erosion control measures for construction sites. The following is a list of existing guidelines currently used in Ontario:

- *MNR Technical Guideline: Erosion and Sediment Control;*
- *MTO Drainage Management Manual (1995 – 1997); and*
- *Erosion and Sediment Control Guidelines for Urban Construction from Source to Solution.*

The *Erosion and Sediment Control Guidelines for Urban Construction from Source to Solution* has been written specifically for the GTA area. In order to develop the most effective ESC plans for North Oakville, these guidelines must be consulted before submission of an ESC plan. The comprehensive checklists provided in these guidelines are specifically designed to assist developers, contractors and inspectors with developing and implementing effective ESC plans.

Typical sediment and erosion control best management practices currently in use today include but are not limited to:

- Sediment traps, dewatering traps;
- Sediment control fencing;
- Check dams;
- Inceptor swales and ditches;
- Temporary stabilization measures of exposed soils (erosion control matting, seeding, hydro seeding, and mulches);
- Construction mud mats;
- Protecting surface inlets with filter cloth; and
- Applying water to control dust and wind erosion

In order for these measures to be truly effective, they will need to be monitored regularly by the contractor to ensure that these measures are maintained in proper working order throughout the construction phase and until the site has become fully stabilized.

7.5.2.1 ESC Inspection

Section 6.4.2.1 provides details of the inspection requirements for during construction monitoring. **Appendix II** provides sample checklist style report that the contractor can fill out and submit the Town of Oakville and Conservation Halton as part of the inspection and monitoring program.

7.5.2.2 ESC Monitoring

Section 6.4.2.2 provides details of the water quality monitoring and reporting required during construction. Monitoring data will be submitted to the Town as hard copy and digital format. The data will be inputted into a database that will provide details regarding construction start and end dates, construction site area, what watercourse(s) to which the site drains, date when the construction site has become 100% stabilized, number of rainfall events, types of BMP's used, frequency of maintenance.

The database will be used to monitor construction activities and to help set targets that will trigger inspections and when maintenance is required. The data collected will be used to measure the effectiveness of different BMP practices.

7.5.2.3 Construction Site Dewatering

Typically, after heavy rainfall events construction sites require dewatering in order to proceed with work. Dewatering may involve pumping water or constructing scratch ditches or channels to drain water away from construction areas. It will be very important to ensure that sediment laden water will not be released into the receiving NHS as a result of dewatering operations. Energy dissipation, large particle sedimentation and filtration of finer materials will be required through the use of effective measures. Water quality samples will be required during dewatering operations to measure the TSS concentrations of runoff leaving the site and evaluate the effectiveness of the dewatering measures.

7.5.3 Monitoring Parameters

A major component of a subwatershed plan is SWM. It usually results in the construction and operation of built works such as stormwater ponds, conveyance features, and infiltration facilities. These facilities are typically designed to meet some receiving water objectives such as flood control, channel erosion control, water quality protection/improvement, habitat protection, and protection of biota, including fish. Therefore, monitoring may involve biological, physical habitat, and water quality and quantity parameters that may be in-stream or at other locations.

In-stream monitoring parameters can be either specific constituents or surrogates. The specific parameters are typically related directly to the objective or use being protected, whereas, for SWM facilities, indirect parameters or surrogates are often used as indicators when monitoring system performance. In other words, different parameters will have to be identified and monitored to evaluate the system effectiveness in-stream and performance in the facility. The effectiveness is measured by comparing the monitoring results to the targets established for the parameters for each objective. **Table 7.5.1** illustrates this point. Monitoring in a watershed for the facility and watercourse elements will take advantage of the common elements for all objectives (*i.e.,* rain, flow, water quality, and toxicity data). Objective specific data will have to be collected for erosion control, and aquatic habitat and biota.

For the North Oakville Creeks Subwatershed, two types of monitoring programs are proposed:

1. Performance assessments of SWM facilities, and
2. Watershed effectiveness assessment.

7.5.4 Performance Assessment Monitoring for Stormwater Facilities

Objectives

- Determine whether performance of control facility meets design objective.
- Can facility be assumed from developer?
- What level of continued monitoring and maintenance are needed?

Following construction, each facility should be inspected and compared to the design by Municipal staff to ensure compliance and a monitoring policy should be implemented. The facility should be monitored for compliance for a minimum period of three-years under the ownership of the developer. A monitoring report should be provided to the Town, Region, and Conservation Halton per year for the three-year period. Responsibility for, and ownership of, facilities would be assumed by the Town of Oakville after a period of three consecutive years of monitoring that confirms the targets and objectives have been met.

Table 7.5.1
Monitoring Parameters for Stormwater Management Objectives

Objectives	Flood Control	Channel Erosion Control	Water Quality Improvement	Habitat/Biota Protection
SWM Facility	• Rainfall, peak flow rate, water level, flood flow routing, draw down time	• Rainfall, flow rate and duration, water level	• Pollutant removal efficiency, sediment accumulation	• Discharge water quality, toxicity
Watercourse	• Peak flow rate, water level, property damage	• Flow rate and duration, water level, bank erosion, channel modifications stable, velocity, bed substrate, bank recession, down cutting of channel, bank vegetation	• Water quality improved? Provincial Water Quality Objectives met? • Subwatershed targets met?	• Habitat parameters /indices (including physical parameters), toxicity, macro invertebrate indices/fish health indices, and biomonitoring.

Should the monitoring show non-compliance, the developer would be responsible for implementing the contingency plan/remedial measures and continued monitoring until the monitoring confirms compliance for three consecutive years.

A protocol for monitoring that could be followed by the developer is attached (**Appendix KK**). It is recommended that the Town of Oakville require the protocol be followed by developers prior to the Town assuming the ownership and operation of the end-of-pipe SWM facilities).

Analysis

- Operations Monitoring
  - Compare infiltration, flood control and quality control pond hydraulics to design specifications for flow splitting, volume controlled, drawdown time, and released flow rates. Compare total capture to expected volumetric control level. Compare quantity control hydrology to what was expected as the modelled performance. May

need to apply models for some analysis steps. Calculate removal rate efficiency of parameters and compare to established targets.

- Maintenance Monitoring
  - Observe or measure sedimentation in channels, sediment build-up in ponds, berm erosion, litter build-up, clogging of inlet and outlet structures, free operation of moveable control elements, health of wetland plants, pond security, and gratings.

Contingency Plan/Remedial Action (**Table 7.5.2**)

Table 7.5.2
Performance Assessment Monitoring for Stormwater Facilities Contingency Plan/Remedial Action

Result	Remedial Action
• Facility built and functioning as designed.	• Town assumes facility from developer.
• Facility outflows and drawdown rates not as specified.	• Modify pond hydraulics – continue monitoring until facility meets flow targets and can be assumed from developer.
• Litter build-up; shore erosion.	• Maintain pond.
• Sediment build-up greater than 5%.	• Remove sediment build-up.
Result	**Remedial Action**
• Performance less than specified.	• Retrofit additional controls in pond or upstream in drainage area – continue monitoring until facility meets targets and can be assumed from the developer; modify design and/or targets for future similar cases.

7.5.5 Effectiveness Assessment Monitoring

Proposed Program

Following stream modification and land development construction period, each stream course should be inspected by Municipal staff to determine whether targets are being met. The stream should be monitored for compliance for a minimum period of three-years by the developer. A monitoring report should be provided to the Town, Region, and Conservation Halton twice per year for the three-year period. Responsibility for future monitoring would be assumed by the agencies after three consecutive years of monitoring confirms the targets and objectives have been met. Should the monitoring show non-compliance, the developer would be responsible for implementing the contingency plan/remedial measures and continued monitoring until the monitoring confirms compliance for three consecutive years.

Objectives

- Determine effectiveness of measures (upstream control facilities) in-stream.
- Flow rates not increased over pre-development (flood and erosion objective).
- Flow velocities (impulse) not increased (erosion control objective).
- Maintenance of baseflows.
- Channel and bank erosion not increased.
- Water quality maintained or improved.
- Aquatic habitat conditions acceptable.

- Biota diverse and healthy.
- Lack of toxicity.

Analysis

- Compare observed conditions to Subwatershed Study results. Reference can be to upstream control, or pre-development conditions at the same site or to a parallel site. Also compare to published standards, (*i.e.,* PWQO), or chronic toxicity criteria. Finally, compare to Subwatershed targets.

Contingency Plan/Remedial Action (**Table 7.5.3)**

Table7.5.3 **Effectiveness Assessment Monitoring Contingency Plan/Remedial Action**	
Result	**Action**
• Flow targets not met.	• Apply remedial measures in stream to modify channel to handle higher flows; additional controls on flow for SWM ponds.
• Water quality targets not met; signs of toxicity in biota.	• Apply additional controls upstream by retrofitting measures at existing sites; add SWM measures to uncontrolled drainage; add pollution prevention measures to control specific parameter not meeting targets
Result	**Action**
• Habitat degraded.	• Improve stream habitat; consider if source of the problem is flow related and modify flows.

7.5.6 Monitoring Program

7.5.6.1 Hydrology

Performance targets from the monitoring should include minimal reduction in the entrenchment ratio to ensure the channel does not become incised and functionally removed from its floodplain. Bank erosion or migration should not exceed a rate of 10cm/yr and cross-sectional areas should experience no more than a 10% increase over the annual monitoring period. Additionally, substrate sizes should not vary more than half a standard deviation from the current D50.

Flood Protection

The monitoring strategy is to measure streamflow on a continuous basis at three locations within the study area. The streamflow measurements will be located along the main branch of Joshua's Creek at Dundas Street East, East Morrison Creek at Dundas Street East, and Fourteen Mile Creek at Dundas Street West.

Streamflow measurements will allow the calculation of annual peak flow rates as development progresses within the study area. Peak flow rates will determine if the *Implementation Strategy* has been successful. If peak flow rates increase, modifications may be required to the outlet works of the SWM facilities. In addition, continuous streamflow measurements will allow the determination of flow duration curves, baseflows, and annual runoff volumes.

Table 7.4.1 provides the target unit area peak flow rates for the existing land use.

7.5.6.2 Hydrogeology – Groundwater Monitoring

Changes to the groundwater regime are usually difficult to observe and quantify. Since the focus for managing changes to the groundwater system are founded in managing infiltration, the monitoring program should also have a similar focus. Future development will also result in changes to runoff and other components of the hydrologic cycle. Therefore, monitoring precipitation and streamflows will provide the data needed to determine the various components of the hydrologic cycle. The data can then be used to track the various components and compare the results to the original predictions. Although year-to-year variations are expected and may be relatively large, the tracking and comparison of long-term trends to both historical trends and predicted changes will enable a determination of the overall success of the management plan. Should significant variations in the long-term trend occur that affect the overall study area, opportunities for implementing alternative mitigation measures can then be explored.

To confirm that the management measures are working, changes in depth to the water table should also be monitored. To complete this monitoring, a series of permanent monitoring wells have to be established throughout the North Oakville area. One such monitoring nest has already been installed and is monitored by Conservation Halton (Moore Reservoir well).

The wells should be placed in each of the larger subwatershed areas (*e.g.,* Joshua's Creek, Morrison Creek, and Fourteen Mile Creek) in locations where their integrity can be protected. The well should be monitored at least semi-annually during periods of high and low water table (after spring melt and in late September). The monitoring should begin immediately to establish a track record for the wells and would continue into the future. It should be noted that, since there are relatively large seasonal and year-to-year fluctuations in the water table, many years of monitoring would be needed before conclusions could be made regarding long-term water level impacts.

7.5.6.3 Water Quality Monitoring

The water quality monitoring program is to be based upon the objectives and targets established, and management approach for water quality conditions as outlined in **Section 6.2** and **6.3.** The parameters to be included are:

- TP;
- TSS;
- Chloride; and
- Temperature.

The remaining water quality parameters are to be monitored in-stream and can be linked to streamflow monitoring to provide a representation of overall effectiveness of the management strategy. It is recommended that water quality be monitored at the proposed streamflow monitoring sites (*i.e.,* main branch of Joshua's Creek at Dundas Street, East Morrison Creek at Dundas Street, and Fourteen Mile Creek at Dundas Street). The monitoring program should include continuous monitoring for nine rainfall events for the first year (to collect additional base information), followed by three rainfall events per year for each consecutive year.

The recommended components of a monitoring plan are outlined in **Section 6.4** of the management strategy. The monitoring plan includes surface water, groundwater, and terrestrial

condition evaluations. Monitoring should be initiated at least one-year prior to land use changes to ensure that representative baseline information is obtained.

The recommended plan provides a framework for carrying out monitoring, however further details could be developed as implementation is carried out. The monitoring plan should be linked to the current monitoring program for the Town and Conservation Halton.

The agency monitoring responsibilities are outlined in **Section 7.7.**

7.5.6.4 Terrestrial

The terrestrial monitoring program discussed in **Section 6.4** of the management strategy is focused on detecting potential changes in habitats as well as plant and wildlife populations in the study area. Since natural systems are dynamic, the monitoring program will seek to identify a range of changes in the system. These will include:

- Maintenance of existing natural habitats, such as mature woodlands and swamp communities, and wildlife populations;
- Successional changes in habitats, especially early and mid-successional stages; and
- Success of restoration measures including natural vegetation on abandoned agricultural lands.

The natural systems in the North Oakville area are described in detail in the Subwatershed Study. From this characterization it is clear that there is a diversity of species and habitats that limit the ability to undertake monitoring of all components. Therefore the monitoring is focused on a number of factors/features that:

- Are readily measurable;
- Are sensitive to changes; and
- Have accepted, standardized monitoring methodologies.

This latter item allows the monitoring within the area to be integrated with other monitoring programs that are widespread throughout Ontario, and can therefore be used to compliment these growing provincial databases and can draw on the results of these widespread monitoring programs to assist with interpreting local changes.

Vegetation Communities

Vegetation monitoring can occur at two levels: (1) at the species composition level and (2) at the community level. Numerous vegetation monitoring programs are in place throughout Ontario which use species composition. In many cases these protocols rely on extensive species level assessments and repeated sampling of plots over time. The ultimate interpretation of the changes in species composition can be cumbersome and in some cases less sensitive to changes in the characteristics of the habitat in question. This can be due to a number of factors such as wide species tolerances, and variation in growing season characteristics. Typically this type of monitoring would be focused on restoration or sensitive systems as identified as part of detailed environmental analyses at the EIR or Draft Plan stages.

On the other hand, monitoring changes in general vegetation community composition and boundaries will assist in detecting changes as a result of natural succession, as well as potential impacts as a result of development. The use of the standardized Ecological Land Classification (ELC) system allows for the review and monitoring of vegetation community composition and boundaries over time. This approach has been used in a number of similar studies in which the extent of vegetation communities has been monitored using field surveys and/or aerial photography. This level of monitoring can be readily completed at a subwatershed level as part of an overall performance monitoring program or at the EIR or Draft Plan stage.

Wildlife

Wildlife monitoring is recommended to consist of breeding bird surveys as well as amphibian monitoring. These two groups of species are fairly readily monitored and are sensitive to changes in habitats and potential impacts of development. Standard monitoring protocols are in use throughout southern Ontario and can be used to track changes in species overtime.

- **Birds –** The Ontario Breeding Bird Atlas protocol should be used to monitor breeding birds at strategic locations in the study area.
- **Amphibians –** Early spring call surveys following the standard Marsh Monitoring protocol should be conducted at strategic wetland areas.

The need for monitoring terrestrial features could be triggered at a number of levels, as summarized in **Table 7.5.4.**

7.5.6.5 Fisheries

Riparian Vegetation

For a number of stream reaches, specific management recommendations exist regarding the planting of riparian areas, as outlined in the management strategy. Site specific vegetation monitoring of planting success is recommended. This program is considered adequate to

Table 7.5.4
Summary of Terrestrial Vegetation and Wildlife Monitoring

Level		Woodlands	Wetlands	Hydrologic Features "A"	Linkages	Riparian Habitats	Open Habitats	Trigger or Focus	Frequency
Subwatershed	Vegetation	• Use of air photos and ELC mapping to determine the extent of woodland cover and composition	• Use of air photos and ELC mapping to determine the extent of wetland cover and composition	• N/A (may be covered by wetlands monitoring)	• Use of air photos and ELC mapping to determine the extent of vegetation cover and composition within linkage area (see riparian habitats)	• Use of air photos and ELC mapping to determine the extent of vegetation cover and composition within linkage area (see linkages habitats)	• Use of air photos and ELC mapping to determine the extent of vegetation cover and composition	• This monitoring would be based on the generation of current air photos. Normally this monitoring would be completed at regular intervals for large portions of the subwatershed area. • Generally the focus of this level of monitoring would be to detect overall habitat at a coarse scale one-year (minimum, or see below).	
	Wildlife	• Use of standardized breeding bird and amphibian monitoring protocols	• Use of standardized breeding bird and amphibian monitoring protocols	• N/A (may be covered by wetlands monitoring)	• Use of standardized breeding bird and amphibian monitoring protocols	• Use of standardized breeding bird and amphibian monitoring protocols	• Use of standardized breeding bird and amphibian monitoring protocols	• A regular wildlife monitoring program at the subwatershed level is not anticipated. Use of volunteers or organizations to conduct periodic monitoring could occur or monitoring via province-wide breeding bird or marsh monitoring programs is encouraged.	
EIR	Vegetation	• Use of air photos, groundtruthing, staking of existing dripline, with ELC mapping to determine the extent of woodland cover and composition • Photographic inventory of edge conditions recommended.	• Use of air photos, groundtruthing, staking of existing edges, with ELC mapping to determine the extent of wetland cover and composition. • Photographic inventory of edge conditions recommended	• See wetlands	• Groundtruthing, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended.	• Groundtruthing, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended	• Groundtruthing, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended	• This monitoring should be based on subwatershed level monitoring results and integrated with above. • Monitoring would be triggered by land use changes, proposed modification/relocation of streams/linkages, as well as proposed restoration.	• Linked to the timing of the EIR, generally one year pre and two years post development

	Wildlife	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• See wetlands	• Use of standardized breeding bird and amphibian monitoring protocols	• Use of standardized breeding bird and amphibian monitoring protocols	• Use of standardized breeding bird and amphibian monitoring protocols	• Focused wildlife monitoring is recommended to occur at this stage, triggered by land use changes, proposed modification/relocation of streams/linkages, as well as proposed restoration.	• Will depend on the timing of the EIR, generally one year pre and two years post development • Predominantly in the spring
Draft Plan	Vegetation	• Staking of existing dripline, with ELC mapping to determine the extent of woodland cover and composition • Photographic inventory of edge conditions	• Staking of existing wetland edge, with ELC mapping to determine the extent of wetland cover and composition • Photographic inventory of wetland edge. • Monitoring of water regime to be integrated with monitoring of SWM, etc at this stage.	• See wetlands and/or restoration/riparian areas. • As these are likely to be predominantly restoration areas, establishment of monitoring plots or photographic inventory is recommended.	• Field surveys, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended.	• Field surveys, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended. • Monitoring to be integrated with monitoring of other stream corridor parameters.	• Field surveys, and ELC mapping to determine the extent of vegetative cover and composition. • As these are likely to be predominantly restoration or successional areas, establishment of monitoring plots or photographic inventory is recommended	• This monitoring should be based on EIR level and subwatershed level monitoring results. • Monitoring would be triggered by land use changes, proposed modification/relocation of streams/linkages, as well as proposed restoration.	• Linked to the timing of the EIR (may overlap with or replace EIR monitoring, generally one year pre and two years post development
	Wildlife	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• See wetlands and/or restoration/riparian areas. • As these are likely to be predominantly restoration areas, establishment of monitoring plots is recommended.	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• Use of standardized breeding bird and amphibian monitoring protocols. • Establishment of sample stations at strategic locations to be selected at the EIR	• Focused wildlife monitoring is recommended to continue at this stage based on the results of EIR and subwatershed level monitoring results. • Monitoring triggered by land use changes, proposed modification/relocation of streams/linkages, as well as proposed restoration.	• Linked to the timing of the EIR (may overlap with or replace EIR monitoring, generally one year pre and two years post development

determine if the specific habitat benefit envisioned for a particular reach is being achieved. This monitoring should be made a condition of any approvals to relocate or modify medium constraint (blue) streams. Similarly, where an EIR at the site plan level recommends vegetative enhancement in the riparian zone, monitoring of the riparian area should be made a condition of the site plan approval. Note that, monitoring can be made a condition of approvals.

Stream Temperature

Stream temperature monitoring should occur at a minimum for Fourteen Mile and East Morrison Creeks to determine success in moving towards the target water temperature of 18°C. The methodology used should be that described by Stoneman and Jones (1999). This methodology proposes periodic sampling on days when maximum air temperatures reach 24.5°C or higher. Our recommendation is that continuous data logging temperature monitors be installed on these systems. These units are now very affordable and easily installed. The monitors should be in place and recording data during the months of July and August each year. Continuous data allows trends to be detected which, in combination with multiple sampling locations, can help to pin down source problems in terms of stream warming. At a minimum, three stations should be established between the upstream on site limits of the stream and Dundas Street. A monitoring system as described above will allow measurement of the success of control measures (riparian vegetation and SWM) in moderating summer stream temperatures.

Suspended Sediment

A monitoring program is required to confirm the success of SWM initiatives to control suspended solids to the intended levels.

Biodiversity

Biodiversity monitoring is recommended for fish communities on Fourteen Mile, East Morrison and Joshua's Creeks and for invertebrate communities in the other watercourses. Both species richness (number of species) and evenness (distribution of individuals across species) must be incorporated in the measure of biodiversity. Simple, but well established biodiversity indices such as those developed by Shannon and Weaver, and Simpson are recommended or site specific indices can be developed provided that they are scientifically defendable. The number of sampling stations for the biodiversity program should be determined by some pre-sampling followed by statistical review (power analysis) of the pre-sampling data to determine the degree of sampling required to achieve statistical validity.

Linkages

As noted above, recommendations are provided for the establishment of native woody species along stream corridors. Much of this is anticipated to occur by natural regeneration. Monitoring the establishment of these plantings is recommended.

7.6 Long-Term Management of the Natural Heritage System

7.6.1 Core Areas

Based on these recommendations, **Table 7.6.1** and **Figure 7.6.1** were developed to indicate the generalized character of the management of the Core Areas.

Table 7.6.1
Summary of Core Area Themes and Management (see Figure 7.6.1)

Name:	Themes	Management
Core #1: 14 Mile Creek (Main)	**Forest Interior**: associated with woodland in northern portion of core **Linkage**: habitats provide a potential linkage to lands north of Highway 407 and south of Dundas St **Open Country**: open country habitats are found along the northern and eastern edges of this area **Redside Dace**: population of known redside dace in lower portions of creek in this area	• The existing woodlands and wetlands are recommended for retention. • Linkages between the forested component of the Core and lands to the south, east and north should be connected. Significant gaps in these connections will be created by major roadways and highways in the area. • The connections should be wooded. • Balance is required between management of the open and wooded habitats. The configuration of the Core would allow for a block of open country habitat in the north of approximately 5.2 ha and a block approximately 8.8 ha in area in the southeastern portion of the Core. The rest of the Core should be wooded.
Core #2: ORC (14 Mile Creek East)	**Forest Interior**: associated with wooded portion of the area	• The existing woodlands and wetlands are recommended for retention. • Focus of long term management of this Core is to allow the majority of it to reforest to maximize the extent of forest habitat.
Core #3: 16 Mile Creek	**Forest Interior**: associated with woodlands throughout the valley **Linkage**: valleylands provide a linkage to lands north of Highway 407 and south of Dundas St.	• The existing woodlands and wetlands are recommended for retention. • Forested linkages to Core #4 and #5 are recommended.
Core #4: Hwy 407 East of 16 Mile Creek	**Forest Interior**: associated with wooded portion of the area **Linkage**: the western end of this core provides a potential link to the 16 Mile Creek valley	• The existing woodlands and wetlands are recommended for retention. • Forested linkages to Core #3 and #5 are recommended.
Core #5: Neyagawa	**Forest Interior**: associated with wooded portion of the area **Linkage**: the western end of this core provides a potential link to the Sixteen Mile Creek valley **Open Country**: inclusion of the landfill area within the core	• The existing woodlands and wetlands are recommended for retention. • The north and south linkages associated with West Morrison Creek are 100m wide. • Management of the landfill portion of the Core is recommended to be a balance of created forested connection in the south margin and continued open country habitat.
Core #6: Woodlot NW of Burnhamthorpe/6th Line	**Forest Interior**: core is entirely wooded **Linkage**: woodlot provides part of potential linkage between other	• The existing woodlands and wetlands are recommended for retention. • These two Cores are proposed to be linked to each other over a fairly short span (approx.

Table 7.6.1 Summary of Core Area Themes and Management (see Figure 7.6.1)		
Name:	**Themes**	**Management**
Core #7: Woodlot SW of Burnhamthorpe/6th Line	woodlands in this area (due to proximity and through direct connections)	100m), although this includes residences and a major roadway. • Connection of the southern Core to West Morrison Creek and to Core #5. • The northern Core is proposed to be linked to Core #8 to the north, again across a major roadway. • The connectivity of these two Cores is likely more a function of proximity. This may help to explain the presence of some forest interior bird species in the smaller northern Core, despite it being only 200 x 200m large.
		•
Core #8: Earth Science Woodlots	**Forest Interior**: associated with wooded portion of the area Pits and hummocks have created small seasonal and event level water pondings, some of which are significant vegetation communities **Linkage**: woodlot provides part of potential linkage between other woodlands in this area (due to proximity and through direct connections)	• The existing woodlands and wetlands are recommended for retention. • Although potential linkages are shown to the north across Highway 407, this highway will create a substantial barrier to many species. • As noted under Core #6, the linkage from this Core to the south will also be affected by major roads and considerable distances. The proximity of the Cores #6 and 7 is seen as a potential connectivity opportunity for some species in these Cores. Direct forested linkages beyond the Core itself are fairly limited.
Core #9: Trafalgar Woodlot	**Forest Interior**: associated with wooded portion of the area **Buttonbush Swamp**: associated with the small pockets of swamp within the Core	• The existing woodland and wetlands are recommended for retention. • Linkage to the south associated with the creek provides possible connectivity to habitats south of Dundas Street. Linkage is to remain open country habitat based on redside dace.
Core #10: Buttonbush	**Forest Interior**: associated with wooded portions of the area **Open Country**: open country habitats are found associated with the southern portion of this Core **Linkage**: associated with connections between the three wooded 'nodes' within the Core, as well as a linkage to Core #11 to the east **Buttonbush Swamp**: associated with large swamp within the Core	• The existing woodlands and wetlands are recommended for retention. • Within the Core, connectivity between the forested blocks of a minimum 200m width.
Core #11: Joshua Creek	**Forest Interior**: associated with wooded portions of the area **Linkage**: associated with linkage to lands south of Dundas St	• The existing woodlands and wetlands are recommended for retention. • A key linkage for this Core is a potential forested connection west to Core #10. The proposed location follows a tributary and incorporates a portion of the large floodplain west of the Core.

Table 7.6.1 Summary of Core Area Themes and Management (see Figure 7.6.1)		
Name:	**Themes**	**Management**
		• A second linkage along the main creek to the south of Dundas Street is also proposed. The natural habitats to the south of Dundas are quite wide (approx. 150m), but the 30 to 40m gap created by Dundas Street is noted. • Reforestation of open portions of this Core is recommended and will substantially increase the amount of forest interior.

7.6.2 Linkages

Many of the aspects of the management of linkages are discussed in the Subwatershed Study (**Section 6.3.3** of the management strategy).

Any pockets of woodland and wetland should be incorporated into the linkage where possible. In many cases the proposed linkages cross lands where existing vegetation is limited or not existent. Therefore the issue of protecting the vegetation is not as important as encouraging the establishment of vegetation in these areas.

7.6.3 Riparian Corridors

The management of the corridor will be closely related to the management of the stream corridors and the many other factors that must be considered (*i.e.,* aquatic habitats, hydrology, and geomorphology).

The preferred management of the corridors from a linkage perspective would be to retain existing woody and wetland vegetation associated with the corridors, and allow for the establishment of woody vegetation within the stream corridors. This is consistent with the management recommendations from an aquatic perspective (see below). In some cases, pockets of woodland and wetland are found associated with these stream corridors and these existing vegetation features should be incorporated into the corridor where possible.

It may occur that the existing riparian vegetation found within stream corridors is limited or not existent. Therefore the issue of protecting the riparian vegetation is not as important as encouraging the establishment of vegetation in these areas.

Broad level management recommendations have been discussed to achieve certain targets on a system wide basis. Recommendations fall into the following broad categories:

- Plant woody vegetation to supplement existing herbaceous vegetation where an herbaceous cover is well established;
- Allow vegetative succession of woody vegetation to continue undisturbed. In these cases woody vegetation is far enough advanced that natural succession should be left alone;
- Remove online ponds because they are considered detrimental from a temperature moderation perspective;

- Bank revetment required to repair bank erosion problems. Very site specific areas where advanced erosion is evident;
- Movement of channel recommended to remove it from negative land use practices (*e.g.*, moving a channel out of a road ditch);
- Leave undisturbed, existing vegetation community is doing well and should not be disturbed. This applies mainly to heavily wooded reaches, or reaches where shrubs and herbaceous vegetation are very well established;
- Do not modify channel form as redside dace are supported in reach. Riparian plantings and vegetation enhancement can occur but the channel is stable and should not be modified in any way; and
- No management required applies mainly to reaches which have been designated as supporting no in-situ aquatic habitat.

7.6.4 Stormwater Management Facilities

The permitting of SWM facilities within the NHS has been described in the management report. Maintenance of these facilities must take into account the management recommendations of the NHS. When providing for future maintenance work access to the facility must be via a public ROW. For example, SWM facilities located within linkages must be maintained from the road or through public lands and not directly through the NHS.

7.6.5 Rehabilitation Measures

Streams requiring rehabilitation have been identified in the management strategy and are illustrated in **Figure 6.3.13.**

It is recommended that the stream and riparian corridor enhancement works be carried out as development proceeds since it provides increased resiliency in the stream system, particularly headwater streams. Since some headwater streams are not identified for protection, enhancement of the balance of the streams will serve to protect the overall watershed functions. It is further recommended that these works be completed as a requirement of land development. Additional site level enhancements, such as fish barrier removal, would be carried out by public agencies.

7.7 Agency Responsibilities

The implementation of the subwatershed plan leads to responsibilities for the various agencies involved. The components of the plan have been identified and summarized in **Table 7.7.1** along with the responsibilities of the various agencies.

Table 7.7.1
Responsibilities for Implementation of Management Strategy

Management Recommendation	Purpose (Why)	Responsibilities (Who)	Timing (When)	Other Considerations (How)
Stormwater Management				
Quantity Control - Infiltration - Peak Flow - Extended Detention	• Duplicate runoff conditions to protect creek. • Protect supply to groundwater.	• Incorporate in Municipal and Conservation Authority policies.	• Immediately.	• Change municipal policies as necessary.
Infiltration - Provide infiltration. - Provide as close to at-source as possible where possible.	• Maintain baseflow • Potential to enhance baseflow during low periods.	• Municipality and Conservation Authority.	• Immediately. • Policy in Official Plan.	• Implement policies.
SWM plans to be established for proposed developments.	• Identify details of SWM plans and encourage at-source controls (i.e. rain gardens, bioretention, etc.).	• Incorporate in Municipal and Conservation Authority policies.	• Draft Plan Stage • Official Plan	• SWM Plans to be submitted to demonstrate compliance. • Policies for development in Local Recharge Area
Quality Control - Provide Level 1 Control. - Phosphorus to existing levels.	• Protect water quality and fish habitat.	• Municipality and Conservation Authority.	• Draft Plan Stage.	• Change policies as necessary.
Non-point source controls - Property owners should conduct an environmental practice assessment.	• Minimize excess chemical loadings to the groundwater system.	• Municipality and individual owners.	• Immediately.	• Work co-operatively to develop an environmental assessment for individual property owners if no property assessment has been done.
Encourage pollution prevention Measures.	• Protect water quality.	• Municipality, Subwatershed Implementation Committee.	• Immediately.	• Initiate programs to encourage pollution prevention (i.e. social marketing). • To be incorporated in SWM plans by developers.
Natural Heritage System				

Table 7.7.1
Responsibilities for Implementation of Management Strategy

Management Recommendation	Purpose (Why)	Responsibilities (Who)	Timing (When)	Other Considerations (How)
Protect significant stream corridors – main branch and tributaries. Protect floodplain, fill line.	• Protect life and property • Water quality buffer • Preserve hydrologic functions • Habitat protection • Provide wetland and stream protection and facilitate engagement.	• Municipality, Conservation Authority, Landowners and Community.	• Develop and adopt policies immediately • Implement at draft plan stage.	• Designate greenspace • Implement flood and fill line regulations • SWM design • EIR for adjacent developments • SWM, trail and greenspace to be interface between wetland and development.
Protect woodlots with significant wildlife habitat Protect and enhance supporting areas.	• Wildlife habitat. • Landscape ecology and aesthetics.	• Landowners, Municipality, MNR. • Municipality, landowners, community groups.	• Change Official Plan as necessary. • EIR at draft plan stage • Ongoing Management.	• Designate greenspace • EIR for adjacent developments. • SWM, trail and interface between greenspace and development.
Require EIR for development in adjacent lands and/or category two areas	• Protect and enhance function of Natural Heritage System, develop amenity benefit for human residents	• Conservation Authority, Region, Municipality to review Developer EIR.	• Draft plan stage. • Policy in Official Plan.	• Refer to specific features and function laid out.
Aquatic Management and Restoration				
Carry out riparian enhancement and stream rehabilitation.	• To improve aquatic habitat and increase resiliency of stream system to permit future urban development.	• Municipality, conservation authority and developers.	• Prior to development.	• Include as a condition for development.
Monitor riparian habitat in areas designated as redside dace "survival habitat"	• To ensure maintenance of herbaceous riparian cover	• MNR in cooperation with Redside Dace Recovery Team	• Yearly beginning prior to development	
Monitoring				
Inspect SWM facilities following construction.	• Ensure compliance	• Developer (prior to assumption) • Municipality (after assumption).	• Following construction and after assumption.	• Include in subdivision agreements.
Monitor SWM facilities.	• Ensure long-term function.	• Developer, Municipality	• Every year for first two-years from when the subdivision has been assumed.	• Developer responsible for first three-years, City thereafter.

Table 7.7.1
Responsibilities for Implementation of Management Strategy

Management Recommendation	Purpose (Why)	Responsibilities (Who)	Timing (When)	Other Considerations (How)
Aquatic species monitoring and stream water quality	• Monitor stream health.	• Municipality, Conservation Authority.	• Every five-years.	• Town responsibility with costs passed on to developers?
• Require compliance and performance monitoring as part of the development review process.	• To ensure that mitigation measures are properly built and maintained and that they perform as intended.	• Development proponents under the direction of Municipalities, eventually transfer responsibility for long term inspection to Implementation Committee.	• As part of the draft plan process to continue on a volunteer basis after completion of the development.	• Build on existing site inspection and monitoring requirements • Regular inspection and repair if needed of fences buffers trails.
• Effectiveness Monitoring	• Ensure targets are met.	• Municipality, Conservation Authority.	• Immediately, annually.	• At specified.
Implementation				
Assign a staff member to coordinate implementation - Environmental Coordinator.	• Consistent implementation • Efficient use of money, staff resources, and community volunteers.	• City and/or Conservation Authority.	• Immediately and ongoing.	• Permanent half time staff commitment. • Create a new position or reorganize staff priorities and work load.
Use Implementation committee for special projects, fund raising, volunteer coordination etc.	• Cost savings • Civic pride • Peer enforcement of protection measures.	• Municipality.	• As needed.	• Environmental Coordinator to coordinate and support community committees.
Require EIR for new development proposals and subject them to normal review process involving the public and committees as appropriate.	• Site specific implementation of policies.	• Municipality, Conservation Authority.	• Part of Draft plan process.	• Use EIR guidelines to scope studies
Develop a Terrestrial Monitoring Strategy.	• Identify and respond to negative changes.	• Municipality. • Community volunteers. • Implementation committee.	• Immediately.	• Regular inspection of buffers, fences, trails, state of the watershed reporting, on a periodic basis.
Treat the strategy as a "living document" implement it on an interim basis in advance of land use policy changes and apply all relevant federal, provincial and municipal policies as they are amended.	• To keep up with changing science and social priorities.	• Approval Authorities.	• Immediately.	• Regular review and approval process.

Table 7.7.1
Responsibilities for Implementation of Management Strategy

Management Recommendation	Purpose (Why)	Responsibilities (Who)	Timing (When)	Other Considerations (How)
Use interpretive signage at SWM facilities, trails and other mitigation measures.	• Public education and expanded Stewardship.	• Municipality Development Proponents.	• As they are built.	• Conditions of Draft Plan Approval or Site Plans. • Municipal projects funded by implementation budget.

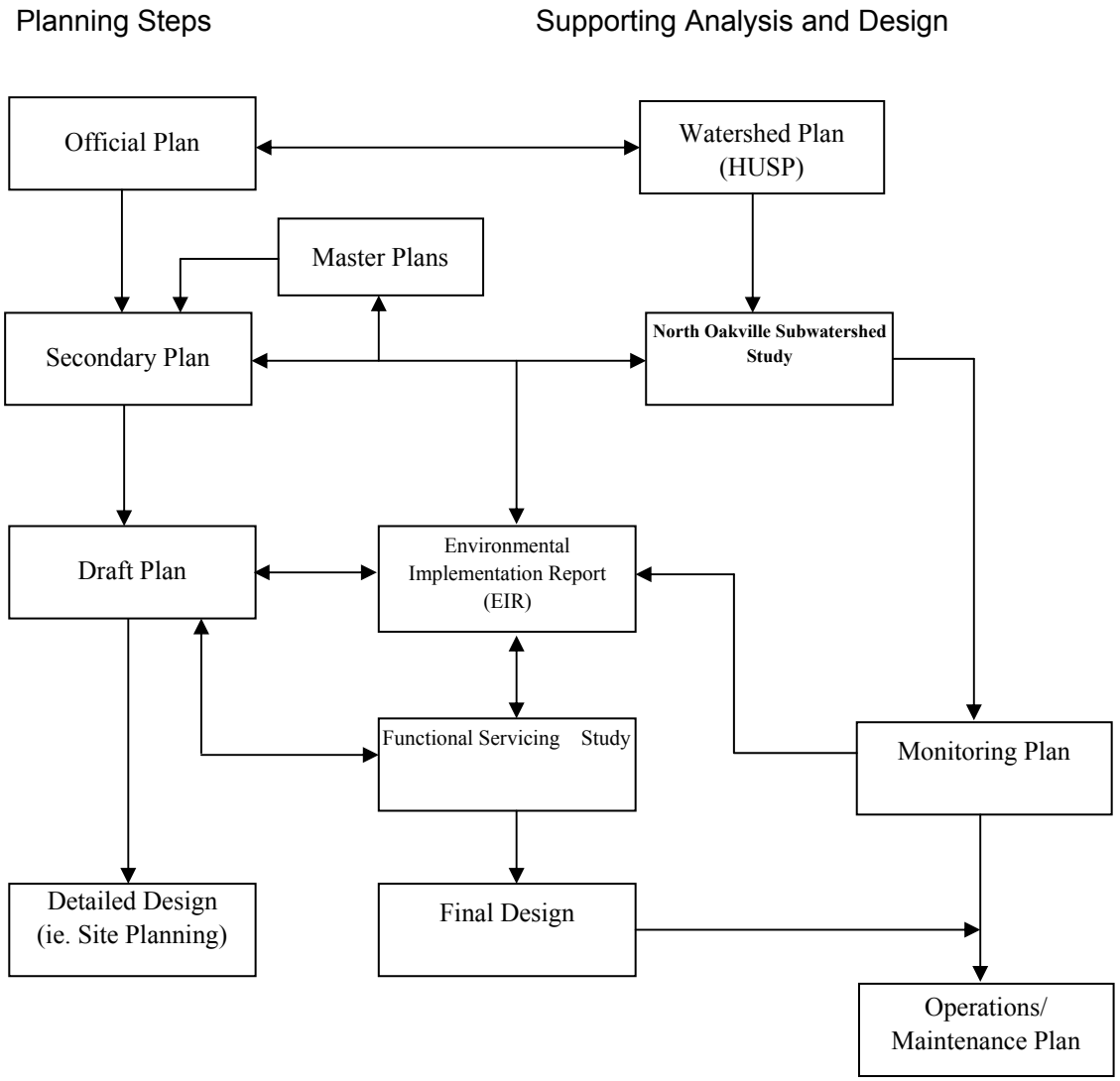
Approvals of stream works are also the responsibility of DFO in conjunction with Conservation Halton. Any watercourse work (including Medium Constraint – Blue streams) will require approval of DFO, Conservation Halton, and MNR.

7.8 Administration Issues

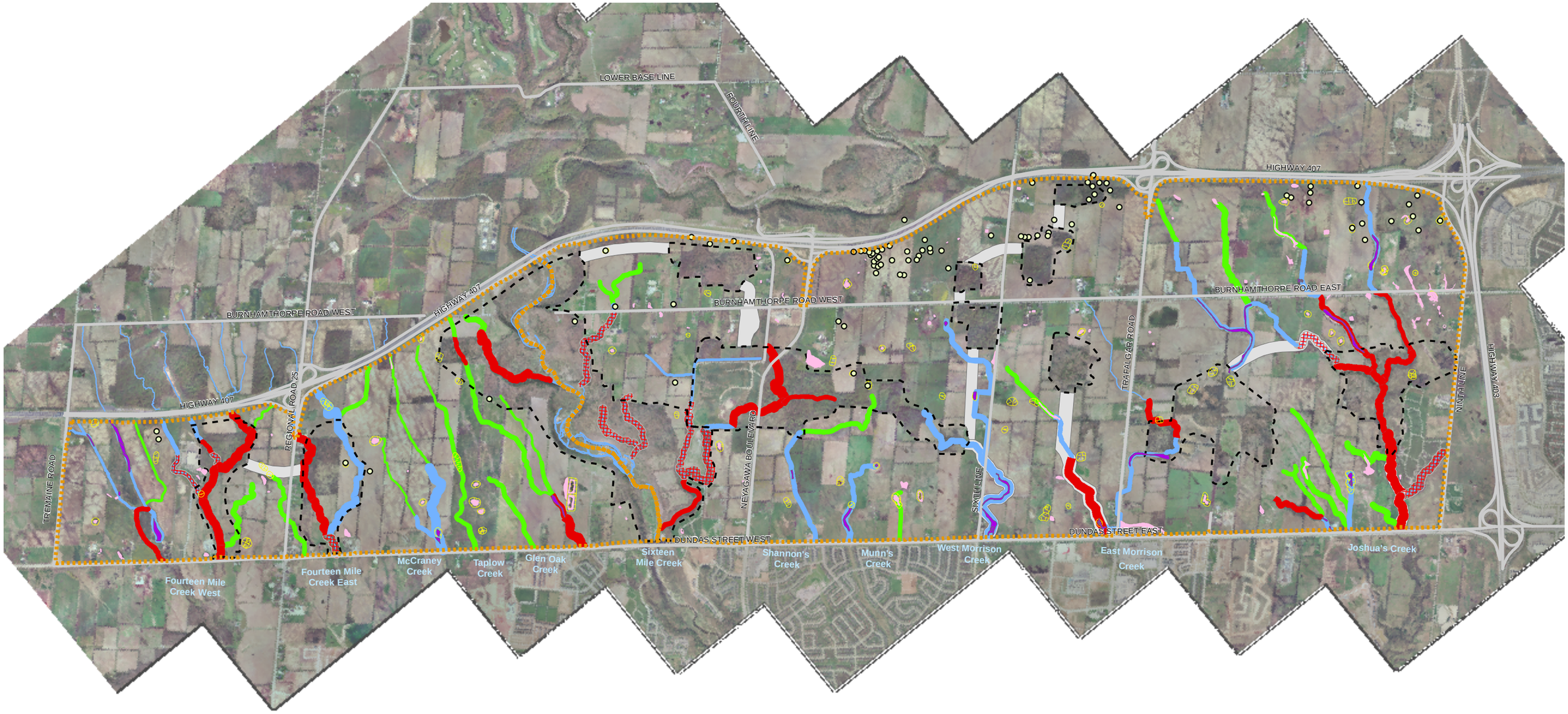
7.8.1 Subwatershed (Environmental) Engineering Co-ordinator

The subwatershed plan will be implemented by the Town of Oakville in co-ordination with the governing agencies. It is recommended that a staff position as an Environmental Co-ordinator be provided at the Municipality and/or Conservation Authority. This will likely require the commitment for a half-time position. Previous experience with watershed studies across the province has shown that dedicated staff time is absolutely necessary to ensure that the report recommendations and monitoring tasks are implemented. Experience has also shown that a great deal of valuable implementation work can be accomplished by volunteers, if there is a person to co-ordinate and support the work. In order to ensure consistency and efficient progress towards subwatershed goals, this responsibility should be assigned to one person. The person in this position should be responsible for ensuring the implementation of this management strategy, including input to the budget setting process. The position should be co-ordinated with Conservation Halton and the MNR stewardship program, as well as volunteer efforts from local interest groups.

Figure 7.2.1
Implementation Process



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY



TSH engineers architects planners
PARISH geomorphic
Natural Resource Solutions Inc. Aquatic, Terrestrial and Wetland Biologists
Donald G. Weatherbe Associates
Morrison Environmental Limited Groundwater Consultants
EWRG Environmental Water Resources Group Ltd.
OAKVILLE

August 2006

N

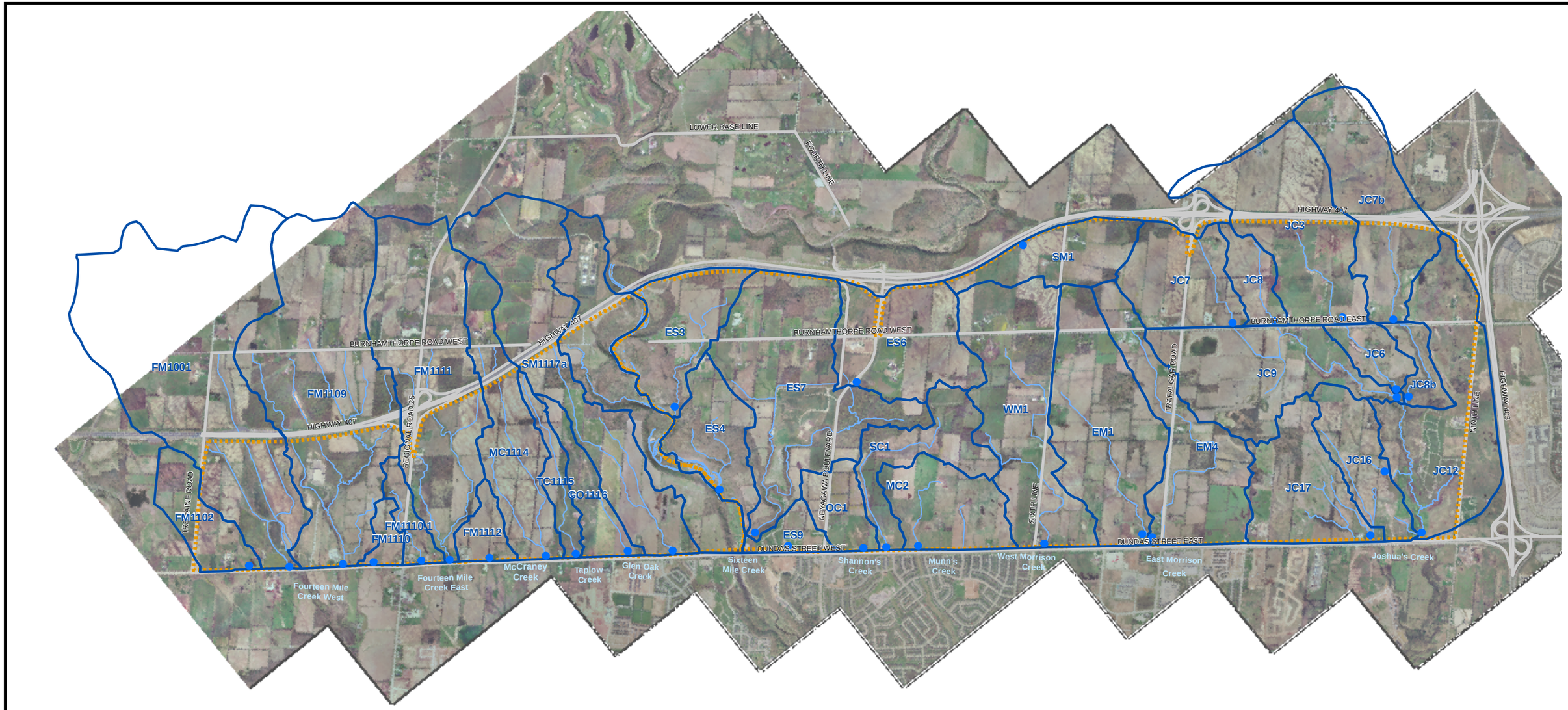
0 500 1,000
Meters

- Secondary Plan Boundary
- Core
- Linkage
- Hydrologic Feature 'A'
- Hydrologic Feature 'B'
- Topographic Depressions (with Hydrologic Component)
- Topographic Depressions
- Watercourse

Stream Corridor
- High Constraint
- High Constraint - Requiring Rehabilitation
- Medium Constraint
- Low Constraint

Topographic Depressions with Hydrologic Components

Figure 7.3.1



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

August 2006

0 500 1,000
Meters

Legend

- Road
- Watercourse
- Secondary Plan Boundary
- EIR Nodes
- EIR Subcatchments

EIR Subcatchment Plan

Figure 7.4.2

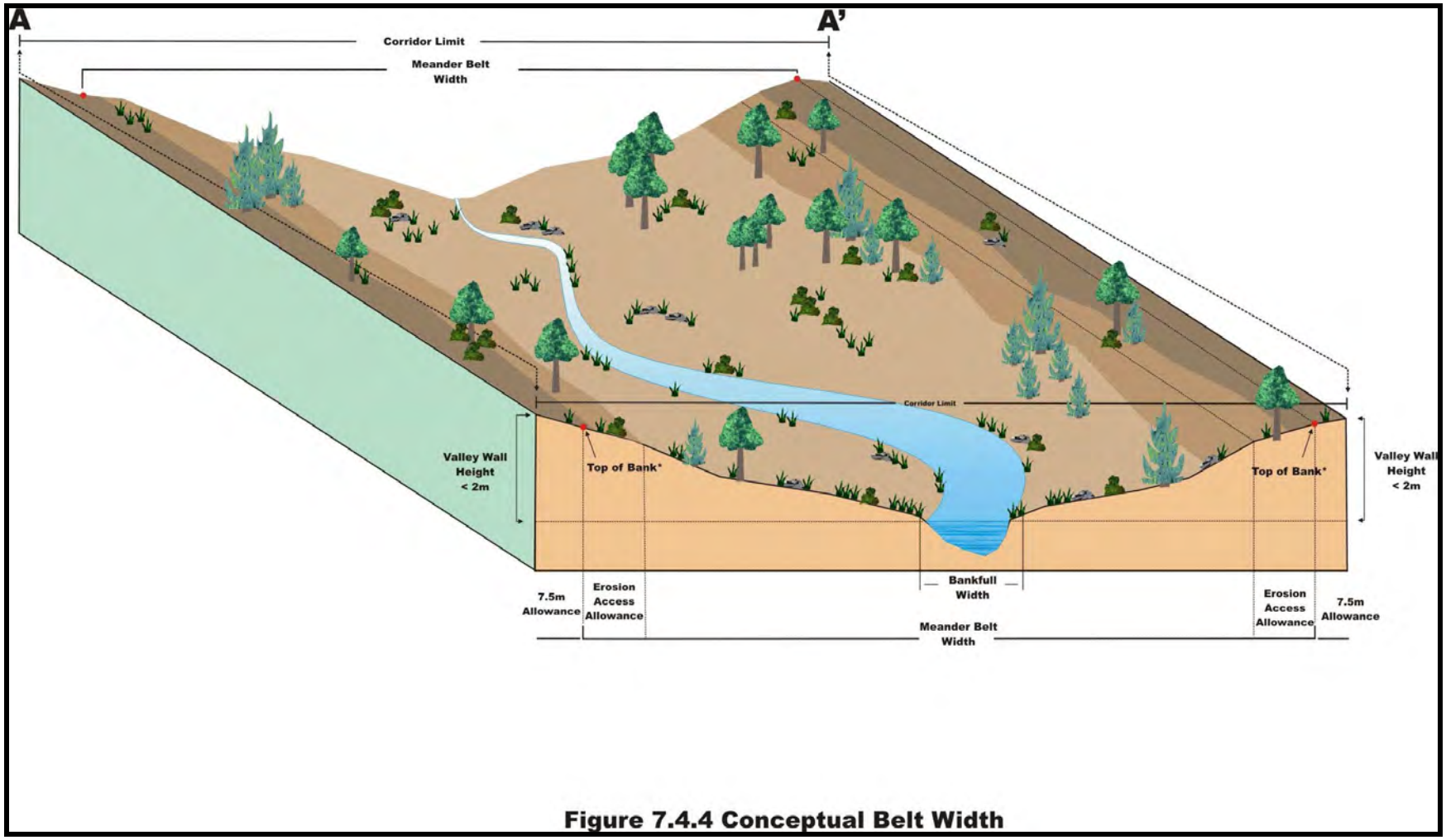
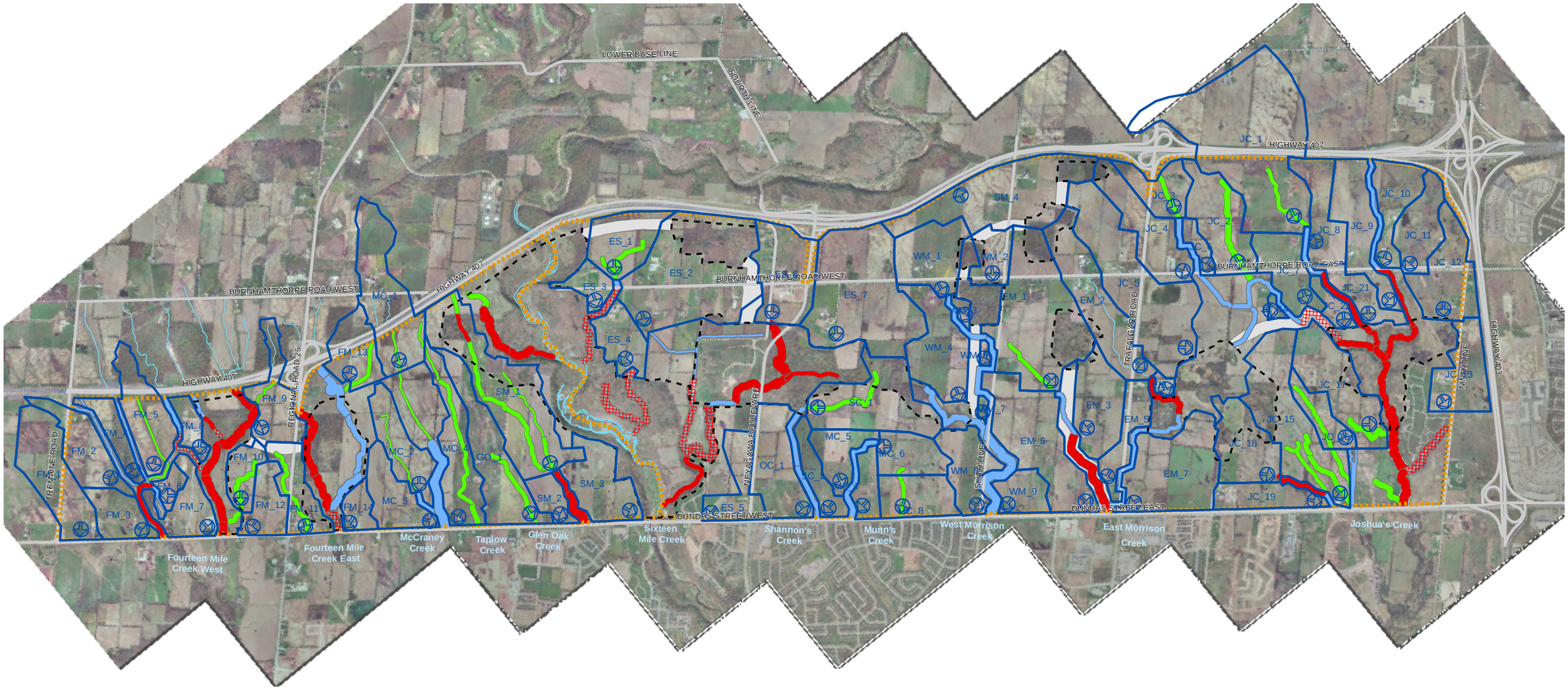


Figure 7.4.4 Conceptual Belt Width



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

engineers architects planners
PARISH geomorphic
Natural Resource Solutions Inc. Aquatic, Terrestrial and Wetland Biologists
Donald G. Weatherbe Associates
Morrison Environmental Limited Groundwater Consultants
Environmental Water Resources Group Ltd.
OAKVILLE

August 2006

0 500 1,000
Meters

Legend

- Secondary Plan Boundary
- Road
- Watercourse
- SWM Pond (Approximate Location)
- SWM Pond Drainage Area

- Core
- Linkage

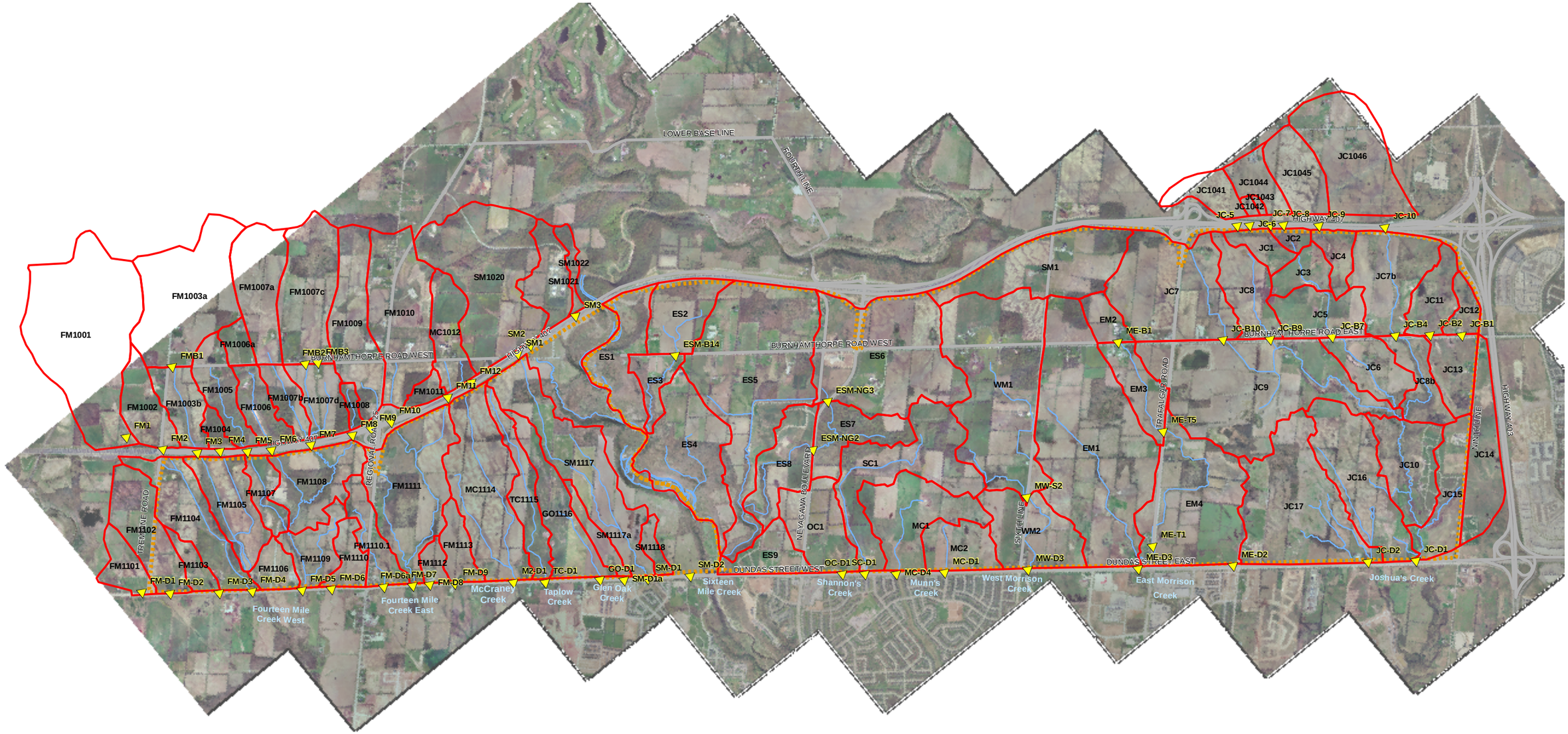
Stream Corridor

- High Constraint
- High Constraint - Requiring Rehabilitation
- Medium Constraint
- Low Constraint
- SWM Pond Drainage Area
- Approximate SWM Pond Locations

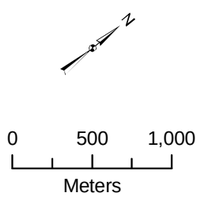
Approximate Stormwater Facility Locations

Figure 7.4.6

NORTH OAKVILLE CREEKS SUBWATERSHED STUDY



August 2006

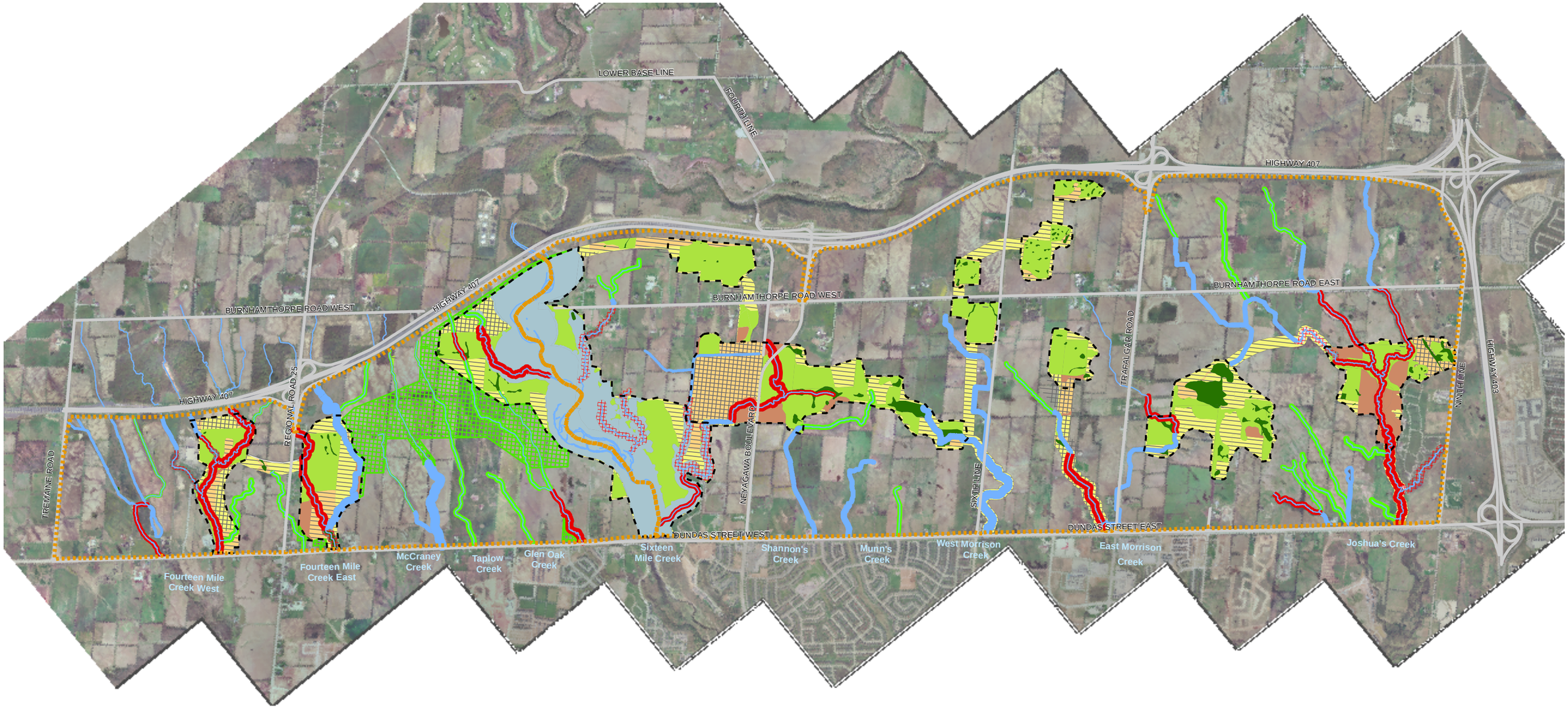


Legend

- Study Area
- Road
- Watercourse
- Subcatchments
- Culvert

Unit Flow Rate Target Locations

Figure 7.4.7



NORTH OAKVILLE CREEKS SUBWATERSHED STUDY

TSH engineers architects planners
PARISH geomorphic
Natural Resource Solutions Inc. Aquatic, Terrestrial and Wetland Biologists
Donald G. Weatherbe Associates
Morrison Environmental Limited Groundwater Consultants
EWRG Environmental Water Resources Group Ltd.
OAKVILLE

August 2006

N

0 500
Meters

- Secondary Plan Boundary
- Watercourse
- Core
- Linkage
- Wetland
- Major Valley
- Red Riparian Corridor
- Red Riparian Corridor - Rehab
- Blue Riparian Corridor
- Woodlot
- Thicket/Savannah
- Cultural Meadow - Restore/Naturalize to Woods
- Cultural Meadow - Open Habitat
- Agricultural - Restore/Naturalize to Woods
- Agricultural - Open Habitat
- ORC Lands

Proposed Management of Natural Heritage System

Figure 7.6.1

TABLE 7.4.1 TARGET UNIT AREA PEAK FLOW RATES
EXISTING LAND USE

Location	Culvert No.	Drainage Area (ha.)	Regional Storm	100 year storm	50 year storm	25 year storm	10 year storm	5 year storm	2 year storm
				m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
14 Mile Creek									
Dundas St. W.	FM-D2	47.2	2.1	0.74	0.64	0.55	0.42	0.33	0.18
	Flow rate / Area ($m^3/s/ha$)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D3	11.8	0.54	0.19	0.17	0.15	0.11	0.09	0.05
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.014	0.013	0.009	0.008	0.005
	FM-D4	427.5	19.2	6.8	6	5.2	3.9	3.1	1.8
	Flow rate / Area ($m^3/s/ha$)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D5	340.8	14.7	5.2	4.5	3.9	2.9	2.3	1.2
	Flow rate / Area ($m^3/s/ha$)		0.043	0.015	0.013	0.011	0.009	0.007	0.004
	FM-D6	17.2	0.78	0.28	0.25	0.22	0.17	0.14	0.08
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.015	0.013	0.01	0.008	0.005
	FM-D6a	26.9	1.2	0.42	0.37	0.32	0.24	0.19	0.11
	Flow rate / Area ($m^3/s/ha$)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
	FM-D7	248.4	10.9	3.8	3.4	2.9	2.2	1.7	0.95
	Flow rate / Area ($m^3/s/ha$)		0.044	0.015	0.014	0.012	0.009	0.007	0.004
	FM-D8	8.6	0.38	0.14	0.12	0.11	0.08	0.07	0.04
	Flow rate / Area ($m^3/s/ha$)		0.044	0.016	0.014	0.013	0.009	0.008	0.004
	FM-D9	18.9	0.86	0.31	0.27	0.24	0.19	0.15	0.09
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.014	0.013	0.01	0.008	0.005
McCraney Creek									
Dundas St. W.	MC-D1	127.2	5.7	2	1.8	1.5	1.2	0.95	0.55
	Flow rate / Area ($m^3/s/ha$)		0.045	0.016	0.014	0.012	0.009	0.007	0.004
Taplow Creek									
Dundas St. W.	TC-D1	33.8	1.5	0.54	0.47	0.41	0.31	0.25	0.14
	Flow rate / Area ($m^3/s/ha$)		0.044	0.016	0.014	0.012	0.009	0.007	0.004
Glen Oak Creek									
Dundas St. W.	GO-D1	47.5	2.2	0.77	0.68	0.59	0.45	0.37	0.21
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.014	0.012	0.009	0.008	0.004
West 16 Mile Creek Tribs.									
Dundas St. W.	SM-D1	84	3.6	1.3	1.1	0.94	0.71	0.56	0.3
	Flow rate / Area ($m^3/s/ha$)		0.043	0.015	0.013	0.011	0.008	0.007	0.004
	SM-D1a	12.7	0.58	0.21	0.18	0.16	0.12	0.1	0.06
	Flow rate / Area ($m^3/s/ha$)		0.046	0.017	0.014	0.013	0.009	0.008	0.004
	SM-D2	8	0.37	0.13	0.12	0.1	0.08	0.06	0.04
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.015	0.013	0.009	0.007	0.004
East 16 Mile Creek Tribs.									
Sixteen Mile Creek	----	387.3	16.4	5.6	4.9	4.1	3.1	2.3	1.1
	Flow rate / Area ($m^3/s/ha$)		0.042	0.014	0.013	0.011	0.008	0.006	0.003
Osenego Creek									
Dundas St. W.	OC-D1	44.7	2.1	0.74	0.65	0.57	0.44	0.35	0.21
	Flow rate / Area ($m^3/s/ha$)		0.047	0.017	0.015	0.013	0.01	0.008	0.005
Shannon's Creek									
Dundas St. W.	SC-D1	84.6	3.6	1.3	1.1	0.94	0.71	0.56	0.29
	Flow rate / Area ($m^3/s/ha$)		0.043	0.015	0.013	0.011	0.008	0.007	0.003

TABLE 7.4.1 TARGET UNIT AREA PEAK FLOW RATES
EXISTING LAND USE

Location	Culvert No.	Drainage Area (ha.)	Regional Storm	100 year storm	50 year storm	25 year storm	10 year storm	5 year storm	2 year storm
				m^3/s	m^3/s	m^3/s	m^3/s	m^3/s	m^3/s
Munn's Creek									
Dundas St. W.	MC-D1	30.6	1.4	0.5	0.44	0.38	0.29	0.24	0.14
	Flow rate / Area ($m^3/s/ha$)		0.046	0.016	0.014	0.012	0.009	0.008	0.004
	MC-D4	59.9	2.7	0.96	0.84	0.73	0.56	0.45	0.26
	Flow rate / Area ($m^3/s/ha$)		0.045	0.016	0.014	0.012	0.009	0.008	0.004
West Morrison Creek									
Dundas St. E.	MW-D3	202.4	8.8	3.1	2.8	2.4	1.8	1.4	0.81
	Flow rate / Area ($m^3/s/ha$)		0.044	0.015	0.014	0.012	0.009	0.007	0.004
East Morrison Creek									
Dundas St. E.	ME-D2	359.9	15.6	5.4	4.7	4.1	3.1	2.4	1.4
	Flow rate / Area ($m^3/s/ha$)		0.043	0.015	0.013	0.011	0.009	0.007	0.004
Joshua's Creek									
Dundas St. E.	JC-D1	985.5	42.9	15	13.1	11.3	8.7	6.9	3.8
	Flow rate / Area ($m^3/s/ha$)		0.044	0.015	0.013	0.011	0.009	0.007	0.004
	JC-D2	135.6	5.9	2.1	1.8	1.6	1.2	0.93	0.51
	Flow rate / Area ($m^3/s/ha$)		0.044	0.015	0.013	0.012	0.009	0.007	0.004