Terms of Reference for the Halton Hills Premier Gateway Phase 2B Scoped Subwatershed Study

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1.0 Introduction and Purpose

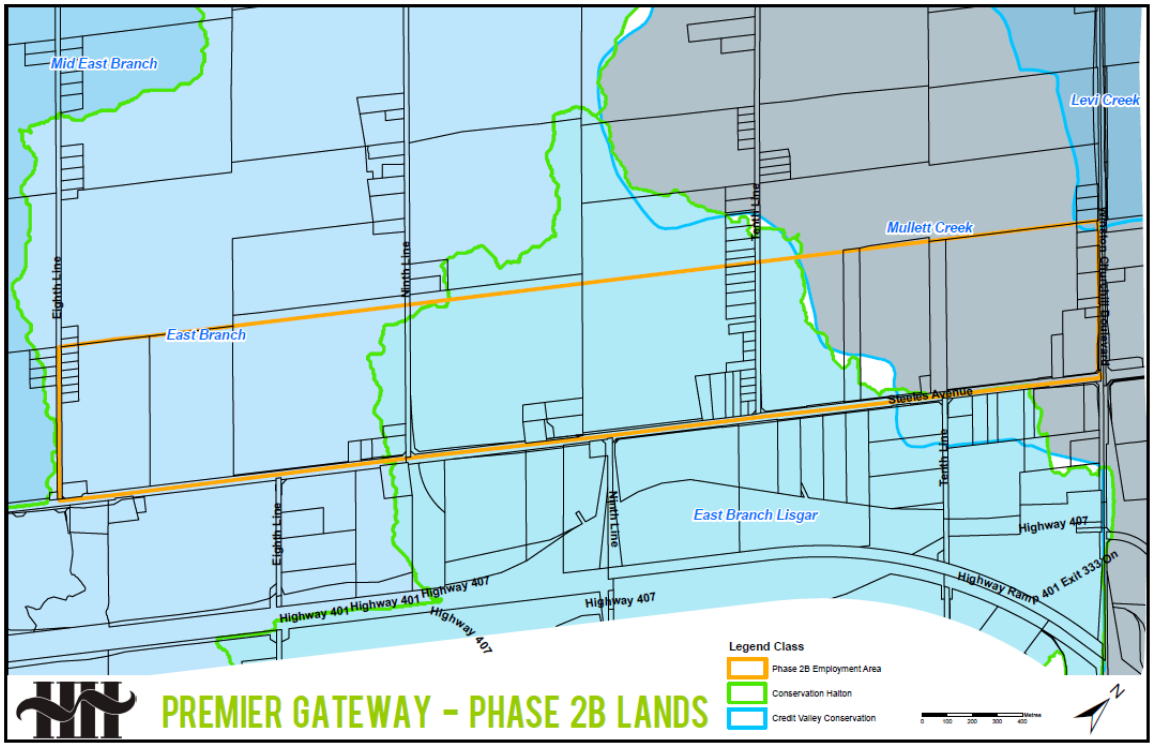
The following Terms of Reference have been prepared to direct the research and holistic evaluation of the subwatersheds located in the boundaries of the Premier Gateway Phase 2B Secondary Plan. The purpose of the Scoped Subwatershed Study is to evaluate specific portions of Subwatershed 6 (East Branch and East Branch Lisgar Subwatersheds) within the Sixteen Mile Creek Watershed and Subwatershed 4 (the Mullet Creek Subwatershed) within the Credit River Watershed to support the completion of the Secondary Plan and associated servicing studies. The Subwatershed Study will guide appropriate land use policies within the Secondary Plan. The Study will apply a systems-based approach to confirm the extent of the Regional Natural Heritage System (NHS) and measures to protect and enhance natural heritage features within the Regional NHS. The Primary goals of the Scoped Subwatershed Study (SWS) include:

- To inventory, characterize and assess natural hazard, natural heritage and water resource features and functions within the Study Area (i.e. constraints to development).
- To provide recommendations for the protection, conservation and management of natural hazard, natural heritage and water resource features within the Study Area.
- To provide sufficient detail to support the designation of NHS, through refinement of the Regional NHS, as well as identify areas for future development. To provide recommendations for a management strategy, implementation and monitoring plan to be implemented through the Secondary Plan(s) and future site/area specific studies.

1.1 Study Area

The Phase 2B Employment Area designation applies to an expansion to the Premier Gateway Employment Area north of Steeles Avenue, between Eighth Line and the City of Brampton boundary (marked in yellow on the map below). The focus of this Study will be the Primary Study Area, however scoped data collection, analysis and assessments will be conducted within Subwatershed 6, located in Halton Conservation Sixteen Mile Creek Watershed and Subwatershed 4 (the eastern section of Mullet Creek) within the Credit Valley Watershed.

Figure 1- Study Area



1.2 Background

The Halton Hills Premier Gateway Phase 2B Employment Lands were incorporated to the Urban Boundary through Official Plan Amendment No. 10 to accommodate the Town's employment needs to the year 2031. As part of the Premier Gateway Phase 2B Secondary Plan process, a scoped Subwatershed will need to be completed to define and establish the constraints and opportunities within the Study Area and provide recommendations for a framework for the protection, conservation and sustainable management of natural resources within and adjacent to the Primary Study Area.

There are a number of tributaries that drain through the lands, resulting in the need to consider upstream drainage areas and land use, the provision of protecting these tributaries through the Study Area, as well as mitigation of downstream impacts. There are also headwater tributaries within the Study Area that will need to be evaluated and classified with regard to the appropriate management approach, in accordance with current principles and guidelines. The background reports for the Premier Gateway Phase 1 Subwatershed Study provide watershed level guidance that is to be used in this Study.

1.2 Goals and Objectives

This Study will:

- Be conducted in accordance with Section C7 of the Halton Hills Official Plan, and all relevant policies, procedures and regulations of agencies with jurisdiction.

- Provide sufficient detail to support the completion of Secondary Plan servicing studies.
- Examine and refine the landscape scale analysis undertaken by Sustainable Halton to develop a Regional Natural Heritage System, in keeping with section 116 of ROPA 38 and guided by the implementation framework described in Sustainable Halton Report 3.02: Natural Heritage System Definition and implementation.
- Develop mapping for the protection, conservation and management of a Natural Heritage System, which is to include regulated natural hazards, wetlands and associated allowances.
- Recommend a management strategy, implementation and monitoring plan, including future studies, analysis and implementation requirements during development phases.

The Analysis and Management Strategy development is part of Phase 2 of the five phases identified for the Premier Gateway Secondary Plan project. The specific goals and objectives of the Study are identified in the subsections below.

1.2.1 Natural Hazards

Goal: To identify Natural Hazards and recommend a management strategy which prevents, eliminates or minimizes the risks to life and property caused by flooding and erosion hazards.

Objectives:

a) To ensure new development does not increase the frequency or intensity of flooding, the rate of natural stream erosion or slope instability.
b) To establish development standards and land use controls that ensure future development is located outside of and appropriately set back from flooding and erosion hazards.
c) To ensure new development, including infrastructure, incorporates appropriate mitigation measures in order to avoid adverse impacts to natural features and areas.
d) To consider climate change adaptation measures as part of the development of flooding and erosion management strategies.

1.2.2 Water Resources

Goal: To protect, improve or restore surface and groundwater resources within, adjacent to and downstream of the Primary Study Area, including the associated ecological and hydrologic functions.

Objectives:

a) To ensure fluvial processes and stream morphology are maintained or improved, recognizing important habitat attributes (pools, riffles, etc.), dynamic channel form and diversity contribute to maintaining a sustainable natural heritage system.

b) To prevent pollution and contamination of surface and groundwater resources due to development activities.
c) To encourage the maintenance or enhancement of aquatic habitat and terrestrial habitat, where feasible.
d) To ensure natural hydrogeologic functions are protected and that stream baseflow, groundwater discharge and recharge are maintained or enhanced, where appropriate;
e) To maintain linkages and related functions among groundwater features, surface water features, hydrologic and hydrogeologic functions, and natural heritage features and areas.
f) To consider climate change adaptation measures as part of the development of water management strategies.
g) To ensure that the riparian rights of downstream landowners is respected.

1.2.3 Natural Heritage

Goal: To protect, restore or enhance the biodiversity, connectivity, hydrologic functions and ecological functions of the natural heritage features and areas within, and where appropriate adjacent to, the Primary Study Area.

Objectives:

a) To ensure a systems-based approach is taken to Study and refine the Natural Heritage System.
b) To ensure that natural heritage features and areas, associated with a refined Natural Heritage System, including their ecological and hydrologic functions, are enhanced and protected from potential adverse impacts from development.
c) To ensure that corridors, linkages, enhancement areas and buffers are maintained, restored or, where possible, improved through the refinement of the Natural Heritage System.
d) To establish innovative development standards and land use controls that will ensure future development does not negatively impact the Natural Heritage System.
e) To consider climate change mitigation and adaptation measures as part of the development of natural heritage management strategies.
f) To consider opportunities for maintaining and enhancing the aesthetic and recreational value of the Natural Heritage System as part of the development of management strategies and where permitted through Provincial, Regional, Local and Conservation Authority policies.

1.2.4 Stormwater Management

Goal: To mitigate negative impacts related to the quality and quantity of stormwater within, adjacent to, and downstream of the Study Area.

Objectives:

a) To maintain/enhance baseflow to the receiving regulated watercourses.
b) To ensure that post to pre-development peak flow control (as a minimum) achieves flood control objectives for all events (2 year to 100 year) and including the Regional Storm event, where appropriate.
c) To ensure that stormwater runoff controls (i.e., storage) address the maintenance of existing flow-duration exceedance characteristics and other erosion indicators in the receiving regulated watercourses.
d) To ensure that the treatment of runoff mitigates surface water quality impacts in accordance with Ministry of the Environment, Conservation and Parks (MECP) guidelines, to an enhanced standard.
e) To mitigate thermal impacts from stormwater runoff to the extent possible.
f) To consider Low Impact Development (LID), and Best Management Practices (BMPs) to treat stormwater at its source.
g) To consider climate change adaptation measures as part of the development of stormwater management strategies.
h) To ensure that the overall sub-basin water balance meets the established targets.

2.0 Detailed Work Plan and Deliverables

These Terms of Reference will serve as a framework to guide the preparation of a Detailed Work Plan by the chosen Project Consultant for the Study. This Detailed Work Plan will be reviewed and approved by the Town, in consultation with the Technical Advisory Committee, comprised of staff from the Town of Halton Hills, Region of Halton, Conservation Halton (CH) and Credit Valley Conservation (CVC).

2.1 Project Phases and Deliverables

The Scoped SWS will be completed in three phases. A description of each phase and specific deliverables are highlighted below:

<u>Phase 1 – Background Review and Characterization</u>

- Develop a characterization and assessment of the existing and potential subwatershed resources (physical, natural, social and economic) using standard methodologies and natural heritage components
- Determine existing land uses and subwatershed resources
- Identify existing and future constraints and opportunities including a refined natural heritage system as appropriate

Deliverables:

- Kick-off Meeting

- TAC meeting #1 to present the work plan
- Presentation of the background review, including a walking tour of the Primary Study Area, and proposed field investigation work plan
- Site inspection during the appropriate season(s) with Town of Halton Hills, Region of Halton, Conservation Halton, Credit Valley Conservation, Ministry of Natural Resources, and Fisheries and Oceans Canada to identify natural features (including habitat characterization) to be used in the development of the Natural Heritage System, and to gain a clearer understanding of local conditions incorporated into the hydrologic, hydrogeological, hydraulic and geomorphic analysis (a minimum of three site visits are anticipated)
- Phase 1 Subwatershed Characterization Report
    - This report will contain but not be limited to the following and will include all supporting data, and analysis (including discussion of methodology, detailed calculations, paper and digital copies of the modeling input and output files, discussion of assumptions made, and a sensitivity analysis related to the assumptions):
        - Hydrogeological assessment including water balance analysis for the present land use scenario
        - Identify the need to conduct any feature specific water balance. If such features are identified, deliverables in subsequent phases are to include respective actions such as “feature specific water balance analysis under proposed land use scenario” in Phase 2; and, “detailed pre- to post development feature specific water balance mitigation measures” in Phase 3
        - Watershed hydrology (existing)
        - Hydraulic assessment report and floodplain mapping (existing)
        - Existing land use and cultural heritage features
        - Erosion assessment (including fluvial geomorphology and geotechnical reports to identify erosion thresholds and watercourse meander belts, and slope stability analysis)
        - Natural heritage features and functions identification and evaluation within and adjacent to Primary Study Area (including internal and external linkages)
        - Classify regional natural heritage system components identified in the Study Area and potential refinements under consideration
        - stream classification, fish community inventory and fish habitat assessment
        - Water quality evaluation (including water chemistry and benthic)
        - Summary of applicable Federal, Provincial, Regional, Municipal and CA policies and legislation
        - Identification of hazard lands
        - Delineation of constraint lands
        - Identification of drainage density targets
- TAC Meeting #2 to present the Characterization Report
- Open House #1
- Open House #1 Summary Report
- Council Presentation of the Characterization Report
- Additional informal working meetings as required to resolve specific technical issues that may arise

<u>Phase 2 – Analysis and Management Strategy:</u>

- Set of preliminary targets to be met
- Prepare evaluations of the potential impacts of future land use scenarios
- Develop a recommended management strategy to mitigate impacts
- Identify a preferred subwatershed management Strategy

Deliverables:

- Phase 2 Interim Report- Watershed Targets and Opportunities Report detailing the following:
    - Anticipated location and forms of development and key transportation and servicing/utility corridors; maximum impervious coverage associated with each development form; and, any specific access/safety requirements associated with various transportation corridors (i.e. flood free access or safe access egress per MNR, minimum depth of cover at watercourse crossings for utilities, etc.)
    - Watershed hydrology (proposed)
    - Water balance analysis for the proposed land use scenario
    - Headwater drainage feature evaluation and classification
    - Hydraulic assessment report and floodplain mapping (proposed)
    - Potential impacts of future development (Water Quality and Quantity –flooding, erosion, and hydrogeology; Natural Heritage System- changes to extent and/or function of natural features and functions)
    - Preliminary recommendations for preferred management measures and future studies
    - Refinement of hazard and constraint lands
    - Digital copies of model input/output
- TAC Meeting #3 to present preferred subwatershed management Strategy
- Open House #2 to present preferred subwatershed management Strategy
- Open House #2 Summary Report
- Council Presentation of the preferred subwatershed management Strategy.
- Additional informal working meetings as required to resolve specific technical issues that may arise.

<u>Phase 3 – Implementation and Monitoring:</u>

- Develop Implementation Plans and detailed guidelines for development design and construction
- Prepare recommendations for establishing an appropriate monitoring and evaluation program to verify that predicted performance is achieved and to allow for adaptive management response
- Identify opportunities for enhancement
- Develop recommendations for future site specific subwatershed impact studies, including Stormwater Management Studies, which will describe in detail the specific measures which will be undertaken to implement the management objectives and meet the targets and further opportunities defined in this Study

Deliverables:

- Final Subwatershed Plan comprised of the following:
    - A General Report

    - A Technical Report which documents the Study findings and analysis in detail including pre- to post development water balance mitigation measures
    - Technical Appendix Reports
    - One digital copy of all GIS mapping collected or developed during the Study with either a master index or metadata
    - All documents and supporting data collection, analysis and models digital format
    - Two licensed copies of the Hydrologic and Hydraulic models including all input/output data
    - Digital species lists and ELC data sheets
    - Monitoring Program
- TAC Meeting #4 to present the Final Subwatershed Report
- Open House #3 to present the Final Subwatershed Report
- Open House Summary Report
- Council Presentation of the Final Subwatershed Report
- Additional informal working meetings as required to resolve specific technical issues that may arise.

2. 2 Report Distribution

One hard paper copy of each Characterization, Interim and Final report will be prepared for each member of the SWTAC. Digital copies will be distributed to all members as well. Copies of the Final Report will be distributed as follows:

- Fifteen copies each of the General Report and Technical Report and a digital copy.
- A copy of ESRI/GIS shape files must be provided with each Report.

2.3 Future Studies and Analysis

It shall be understood that the purpose of this scoped SWS is to identify constraints and preliminary design criteria that would be sufficient to develop a secondary plan and in no way replaces the need for further detailed Study as part of future Subwatershed Impact Studies/Functional Servicing Studies, or the need to obtain any other permits/and or approvals as may be necessary (e.g., Conservation authority permits, planning act approvals, building permits etc.). It is expected that the boundaries, Terms of References and other requirements for future studies will be established through the scoped SWS, and that those requirements and approval processes will be coordinated with and incorporated into the Secondary Plan Policies that will guide future Planning Act applications in this area. The Study Consultant shall therefore clearly identify what additional work may be required as part of a Subwatershed Impact Study/Functional Servicing Studies including, but not be limited to, the following:

- Detailed Design of Stormwater Management Facilities (Quality and Quantity)
- Detailed Water Quality Analysis and Implementation
- Additional Aquatic and Terrestrial Studies and Constraints not identified in this Study
- Additional Hydrogeology Studies
- Monitoring Requirements and Performance Measurements
- Detailed Implementation Plan and Phasing
- Traffic Impact Studies

- Area Servicing Plans

The scope of future Subwatershed Impact Studies/Functional Servicing Studies will be subject to consultation and approval by the SWTAC.

3.0 Study Organization

3.1 General

The Study will be consistent with the goals, objectives and targets of the Watershed Plans and Regional Official Plan Amendment No. 38 and the Halton Hills Official Plan as amended by Official Plan Amendment No. 10. Recognizing that previous watershed studies have been completed in the area, updated goals, objectives and targets should be established through this Study.

The Region, Town, Conservation Halton and Credit Valley Conservation have policies in place specifically related to watershed and subwatershed planning. The Study will conform to:

- Sections 116.1 and 145(9) and all other relevant sections of the Halton Region Official Plan 2009 (ROPA 38).
- Section C7 - Watershed Planning, and all other relevant sections, of the Halton Hills Official Plan.
- Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document, Conservation Halton, April 27, 2006, as amended August 11, 2011, November 26, 2015, February 25, 2016.
- CVC Watershed Regulations and Policies April 9, 2010, Resolution No. 48/10.

In addition, applicable Provincial and Federal legislation shall be integrated into the Study.

3.1.1 Environmental Assessment Act

The fundamental EA principles shall be incorporated into the subwatershed planning process. The information developed through this planning process should satisfy Phases 1 and 2 of the Municipal Engineers Association (MEA) Class EA requirements.

3.1.2 Canadian Environmental Assessment Act (CEAA)

Any future final design plans will require approval by the various regulating agencies and as such any design criteria recommended in this Study shall be consistent with the requirements of CEAA.

3.1.3 Other Legislation

Other legislation that may be relevant to this includes, but is not limited to, the Planning Act, Endangered Species Act, Species at Risk Act, Conservation Authorities Act, Fisheries Act, Migratory Birds Convention Act, Clean Water Act, Ontario Water Resources Act, Lakes and Rivers Improvement Act, Water Opportunities Act, the Greenbelt Act, Ontario Fish and Wildlife Conservation Act, and A Place to Grow Act.

3.5 Public Participation

Through the Secondary Plan Process, a Public Engagement and Consultation Strategy will be developed to ensure that the public is engaged through all stages of the process. The Public Engagement and Consultation Strategy will include newspaper advertisements, newsletters, a project website, email notification, and workshops if required.

In order to maintain transparency and obtain public input through the scoped SWS, the Project Consultant will hold a minimum of three Public Open Houses/Workshops during the course of the Study. The Project Consultant will also prepare a notice of commencement to inform the public of the Study and its objectives.

3.6 Subwatershed Technical Advisory Committee (SWTAC)

The SWTAC will be chaired by the Town and have the following representation:

- Town of Halton Hills– Four representatives including a Senior Policy Planner, the Manager of Planning Policy, the Manager of Transportation, and the Program Manager-Water Resources.
- Conservation Halton – Four representatives including a planner, an engineer, an ecologist and a hydrogeologist.
- Credit Valley Conservation – Three representatives including a planner, an engineer and an ecologist
- Region – Project Lead and Environmental Planner.
- Representatives from the Ministry of Natural Resources (MNR) and/or Ministry of Environment, Conservation and Parks (MECP) and Department of Fisheries and Oceans, as required.

The purpose of the SWTAC will be to provide technical review and input into the Study. The SWTAC will consult directly with the Town, Region of Halton, Conservation Halton, Credit Valley Conservation, MNR and other appropriate agencies for their formal approval of all required components of the Study. The Committee will meet at the project initiation phase to discuss the project timeline and proposed work plan and after each phase /report is completed in order to address any question and concerns before proceeding to the next Phase. The role of the Technical Advisory Committee is as follows:

- Review technical document and provide comments during all phases of the Study
- Assist with issue identification and resolution
- Members to liaise with their respective organizations to ensure Study awareness and to provide one-window coordination on behalf of their organization
- Provide data input

- Meet on a regular basis to monitor the progress of the Study

3.7 Digital Information

- All digital information, data, sketches, drawings and reports generated by the Project Consultant for the purpose of this Study shall become the property of the Town of Halton Hills, Region of Halton, Conservation Halton and Credit Valley Conservation as applicable.
- For modeling related data products, digital copies of the model input and output, as well as licensed copies of any proprietary modeling software are to be provided to the Town, Region, Conservation Halton and Credit Valley Conservation.
- Digital copies of the written reports are to be provided in both MS Word 2010 and PDF format.
- All mapping products produced for the Study shall be geo-referenced to real world coordinates and have a standard UTM NAD 83, Zone 17 projection, with a Canadian Geodetic Vertical Datum of 2013 (CGVD2013). Consultation with CH staff is recommended regarding use of a consistent vertical datum for the purpose of floodplain mapping.
- All models and mapping will be generated from LiDAR data. The Successful Proponent will be provided raw LiDAR data associated with the first and last return, and associated contours.
- Map “layers” produced by the Project Consultant will be topologically correct (i.e. adjacent polygon features will be without gaps/overlaps and share vertices/nodes where appropriate). Additionally, the Project Consultant should ensure attribute names are not truncated when converting data between file formats.
- New features captured by the Project Consultant using GPS or heads-up digitizing from air photography will have a capture accuracy rating for the feature included as an attribute (e.g., +/- 30 cm accuracy).
- A mapping layer index will be provided listing the layer name and providing a description/abstract of the layer’s content. Alternatively, if a mapping layer index is not provided, FGDC compliant metadata shall be created for each layer produced by the Project Consultant.
- Digital data will be delivered in one of the following formats: a) ESRI geodatabasev9.3 feature classes or ESRI shape file format. If the Project Consultant utilizes ESRI ArcGIS to produce maps, the matching .mxd will be provided that corresponds to the map figure.
- If software limitations prevent the Project Consultant from meeting these requirements, alternate formats may be considered (e.g., DGN) with the written agreement of the Town. Town GIS staff should be consulted if additional technical details are required to these requirements.

- Species information is to be provided to Conservation Halton and Credit Valley Conservation in digital spreadsheet format and significant species must be geo-referenced. Ecological Land Classification data sheets are to be provided to Conservation Halton in PDF format.

4.0 Detailed Background Review and Analysis

4.1 Hydrology

A detailed hydrologic model shall be developed and calibrated for the sub-watershed for existing, and future development scenarios. The model should be a continuous, deterministic, hydrologic model, approved by the SWTAC, with strong physical representation of surface runoff, base flows, and surface groundwater interaction. The modeling should recognize the impacts of agricultural improvements such as tile drains, ditching, etc., as well as other changes to the landform which would impact infiltration, and evaporation (i.e., hummocky terrain).

Flows for the Sixteen Mile Creek and its tributaries were developed as part of a 1986 Flood Damage Reduction Study. Reports and HYMO modeling from this Study is available; however, the modeling platform must be updated to allow for continuous simulation, and the catchments reviewed and refined to reflect landscape level changes, updated detailed topographic information, and the scale of this Study. Physical feature mapping of the watersheds and subwatersheds, including subwatershed boundaries, upstream catchment areas, watercourses, drainage swales, wetland features, untrained depressions, and other drainage improvements(i.e., tile drains), shall be developed based on existing mapping and verified in the field. The review should include an analysis of other sources of hydrology data that are available at the time of Study. Sub basins should be determined to establish nodes at points of interest. The intent of the modeling is to provide the details required for subdivision planning. The model should be updated to reflect the new information obtained through the subwatershed Study, and be representative of the more detailed scope of the subwatershed Study. The model should then be calibrated to provide comparable flows at the sub basin outlet to those determined in the previous watershed studies for both specific design storms and low flows. The model input parameters should be compared to the previous watershed studies and modified to represent the more detailed subwatershed model. The model should then be validated based on local data collected (i.e. measured stream flow and precipitation data, as well as detailed geomorphologic information and local knowledge of past flooding frequencies).

Peak flows for Mullet Creek are available from the Peak Flow Study conducted in 2012 based on GAWSER model. In addition, Credit Valley Conservation staff has undertaken a hydrology update Study for the Mullet Creek using Visual Otthymo model. The discretization map based on LiDAR data will be available for this subwatershed Study. Moreover, a stream flow gauge is located at Century Avenue (i.e. d/s of Highway 401). The collected stream flow data will be available for the calibration and validation of the hydrology model.

A hydrologic analysis will be conducted for the existing and future development conditions to determine pre and post-development flows and investigate the impact of post development conditions on: flows, volumes, flood levels, stream erosion, and base flows. Consideration must be given to how modification of existing drainage systems (including drainage

improvements such as tile drains) will impact post development flows. This Study shall identify preliminary stormwater management requirements that ensure downstream peak flows are not increased, natural floodplain storage is not lost, downstream channel erosion is not increased and stormwater runoff is appropriately treated to meet water quantity and quality targets. Flood flows need to be maintained so that hydrological functions including the scouring of pools and the deposition of substrate as/on riffles are not lost. These functions need to be maintained so that the watercourses are able to maintain this function in perpetuity during the post development scenario. The recommendations will need to be defined in sufficient detail to support completion of the subsequent secondary planning level studies. Recommendations for future additional detailed analysis, which is to be carried out in the development application phase studies, shall also be included.

4.1.1 Background Review and Field Work

Background information on the Study Area will be collected from all available sources and by field inspection, including but not restricted to the following:

- Previous subwatershed studies and stormwater management studies
- Aerial photos
- Topographic and photo base maps, and refined mapping products
- Flow records, high water marks, precipitation
- Water use
- Stream flow monitoring
- Existing fish community data holdings with DFO, MNR, Conservation Halton and Credit Valley Conservation
- Existing aquatic invertebrate, water chemistry, channel morphology and water temperature holdings at Conservation Halton and Credit Valley Conservation
- Existing MECP permits to take water within and upstream of Study Area

4.1.2 Characterization Analysis

Tasks to be carried out by the Project Consultant are:

a) Based on background information and field investigation, provide recommendations for an appropriate number of stream flow and precipitation gauges needed for future analysis and performance review of water quality and quantity management strategies.
    - Identify costs for installing and monitoring one (1) strategically placed gauge as part of this project and as early as possible upon commencement of the project, to be used to validate the model. The location is to be reviewed and approved by the SWTAC. The recommended method of flow measurements will include: continuous flow gauging and recording, local rainfall recording, staff gauges with local high flow observers, collection of high water, and debris line data following high flow events.

b) Complete Seasonal in-stream measurement of spot base flow, particularly in conjunction with water quality sampling and fish and benthic sampling.

c) Undertake the hydrology Study with appropriate Engineering Standards. Hydrologic modeling on the Sixteen Mile Creek is to extend to the point where potential development lands constitute less than 10% of the drainage area of the system (i.e. to the 401 corridor) and on the Mullett Creek to minimum Winston Churchill Road, and if required, further extended to HWY 407.

d) Ensure the model accounts for the following processes: soil infiltration and moisture, channel storage and seasonal effects (snow accumulation and melt).
e) Analyze pre to post development water balance, identify, impacts and propose mitigation measures.
f) Document and justify hydrologic modelling parameters for each existing land use and each subcatchment. Determine return frequency flows based on the existing predevelopment conditions. Develop Return period flow estimates using continuous simulation and frequency analysis for a minimum of 30 years of data. Evaluate Municipal design storms along with several historical events including the Regional Event and any other design storms provided by the SWTAC (i.e. Regional IDF's if available, August 4, 2014 Burlington Storm, July 8, 2013 Mississauga Storm, etc.). Summarize output for both the continuous and event model runs.
g) Calibrate the existing condition watershed model relative to previously calibrated models (i.e. 1986 FDRP Study).
h) Validate the calibrated existing condition watershed model with available flow records and high water marks and stream flow/rainfall data collected during the Study. The refined existing conditions model will then form the basis of the post-development conditions model.
i) Use the results of the predevelopment modeling to set targets for outflow control rates -and return period flow rates at key locations as well as weighted flow rates for development areas.

4.1.3 Interim Analysis/Impact Assessment

Results of the hydrologic analysis for developed conditions will be used for the hazard land mapping and to determine a preliminary stormwater management strategy that will mitigate potential adverse development impacts. The fluvial geomorphologic and erosion assessments, in conjunction with the validated hydrologic analysis will ultimately be used to determine the precise amount of control required for all storm events.

The Project Consultant will establish a post development hydrologic model to assess the impact of development on stream peak flows and base flows and demonstrate that the proposed stormwater management strategy mitigates against both increases in the magnitude and duration of cumulative erosion threshold exceedance through evaluation, cumulative excess shear, cumulative effective stream power, and flow duration.

The Consultant's scope includes:

a) Update the validated existing conditions model in accordance with planned future land use (based on maximum imperviousness associated with the proposed development form). The selected hydrologic modelling parameters for each proposed land use and each sub-catchment should be documented and justified within the Interim Report.
b) Determine quantity control criteria based on event frequency for the 1:2 year through to Regional Storm distribution.
c) Utilize established erosion thresholds in conjunction with the continuous post development hydrologic model to determine a stormwater management strategy that will mitigate against both the duration and magnitude of cumulative exceedance relative to cumulative excess stream power and cumulative excess shear. Outflow control rates specific to erosion protection are to be set at key locations, and weighted

flow rates are to be provided for development areas. At this level of Study, a zero tolerance for erosion threshold exceedance is required, unless otherwise accepted by the SWTAC.

d) Develop a preliminary stormwater management strategy for the subwatershed, based on the erosion assessment (described in subsequent sections) and the hydrological assessment. The strategy should present unitary flow and storage rates per impervious hectare, and clearly identify the model sensitivity to changes in the ratio of impervious coverer identify the requirement to revisit unitary storage and discharge rates as part of subsequent studies should impervious coverage change.
e) Provide the conceptual design for the stormwater management pond blocks and include calculations and drawings showing SWM pond block location including sediment drying areas, maintenance access provisions and demonstrating consideration of grading limitations.
f) Determine return frequency flows based on future land use for both uncontrolled conditions and for controlled conditions with the anticipated stormwater management controls in-place. Return period flow estimates will be made using both event and continuous simulation analysis (with a minimum of 30 years of data applied for continuous simulation). The preliminary sizing of the stormwater management facilities may be completed using event based modeling, however output and results for both the continuous and event simulation must be presented to demonstrate that peak flow control and erosion mitigation has been achieved on both a continuous and event basis. Additionally, the SWTAC may provide other design storms to be evaluated (August 4, 2014 Burlington Storm, July 8 2013 Mississauga Storm) as part of the climate change sensitivity analysis.
g) Identify opportunities to utilize Low Impact Development methods (LIDs) and assess/quantify their feasibility based on site specific testing of soil conditions in accordance with Appendix C – Site Evaluation and Soil Testing Protocol for Stormwater Infiltration in Low Impact Development Stormwater Management Planning and Design Guide by CVC and TRCA, 2010. Stormwater runoff should be treated via a multi-barrier approach, incorporating onsite, conveyance, and end-of-pipe controls and LIDs to acceptable standards as determined in the MOECC's Stormwater Management Planning and Design Manual (2003) or more recent standard.
h) Undertake a low flow analysis for any watercourse diversions or drainage basin boundary modifications.
i) Determine whether post to pre-quantity control should be required for the Regional storm.
j) Propose a recommendation with respect to the incorporation of adaptation needs related to climate change within the stormwater management strategy.

4.1.4 Monitoring

The Final Report shall provide a recommendation for a future monitoring plan, including both during and post construction monitoring to demonstrate the functionality of the Stormwater Management system and sediment and erosion control system. The monitoring program is to specify quantifiable measurable targets for SWM and monitoring parameters that may be used as triggers for adaptive management.

4.2 Hazard Land Identification

The scoped SWS should identify the extent of the hazard lands within the Primary Study Area in accordance with MNR and Conservation Authority Guidelines. Hazard lands of key concern for this area include flood hazards, and areas subject to stream erosion and slope instability. Identification of natural hazards must be completed to the satisfaction of Conservation Halton, Credit Valley Conservation and SWTAC.

To determine the hazard limit associated with valleys (confined or unconfined), both the flooding and erosion hazards are to be considered. The hazard limit is set by the greater of the flood or erosion hazard, plus the applicable development setback based on the appropriate policy and regulatory requirements. It should be noted that additional buffers and/or corridor widths may be needed in consideration of other factors introduced by the Study assessment including, but not limited to, the protection of ecological and hydrologic functions such as critical function zones and impacts to adjacent lands. All hazard delineation and management recommendations of regulated features must be to the satisfaction of the Region of Halton and the Conservation Authorities. Note that the extent of the regulated area may change based on the headwater drainage feature assessment and feature characterization.

4.2.1 Background Review and Field Work

Background information on the Primary Study Area will be collected from all available sources and by field inspection, including but not restricted to the following:

- Review of the historical aerial photographs with attention being paid to land use changes, channel changes, and migration rates.
- Undertake research on what level of Low impact development treatment is feasible within the watershed.
- Reach delineation based on scientifically defensible methodology (see CVC's Fluvial Geomorphic Guideline -Fact Sheet IV).
- Preliminary determination of reach sensitivity and overall classification.
- Rapid assessment to evaluate stability of reaches based on acceptable protocols.
- Field survey of watercourse cross section and hydraulic structures.
- Geotechnical investigation to determine long term stable slope inclination may be required for confined valleys.

4.2.2 Flood Hazards

The Project Consultant will be required to review available hydraulic models and update modeling as required to reflect:

- The more detailed scale of this analysis
- Survey data
- Ensure the accuracy of the existing conditions floodplain

In addition, the Project consultant will develop flood lines for all watercourses not currently included in the existing flood plain mapping within the detailed Primary Study Area and a sufficient up and downstream distance to clearly characterize all hydraulic interactions. The floodplain calculations shall be based on the Technical Guide – River & Stream Systems: Flooding Hazard Limit, Ministry of Natural Resources & Watershed Science Centre, 2002.The U.S. Army Corps of Engineers HEC RAS model acceptable for the hydraulic analysis. Field survey of existing channel cross section and profile, floodplain characteristics, and crossing structures will be required. For floodplain areas, available topographic information (raw LiDAR

data)) may be utilized, provided a good correlation between the topographic mapping and detailed site survey is demonstrated.

For tributaries which have very small drainage areas, i.e., (<) 50 ha, it may be possible to scope the floodplain analysis. Consultation with the SWTAC to determine whether scoping is acceptable and whether alternate hydraulic capacity calculations may be applied.

The Characterization Report is to contain:

- References for all sources of topographic information (including a summary of any correlation analysis completed).
- References for all hydrologic information incorporated into the Study;
- A summary of the evaluation, justification for selected hydraulic parameters, and summary tables of the findings.
- A digital copy of all hydraulic modelling (including input and output files, as well as documentation on each of the model runs).
- Full size signed and sealed copies of floodplain mapping for the regulatory storm on topographic base mapping, overlain with the hydraulic cross section locations (labelled with cross section ID and the associated Regional and 1:100 year water levels).

4.2.3 Interim Analysis/Impact Assessment

Update floodplain modelling and mapping based on future hydrology and ultimate valley and channel conditions (i.e., consider future vegetation conditions in selected Manning roughness). The update is to be completed for the entire detailed Primary Study Area and a technically appropriate up and downstream distance, and will define the regulated floodplain hazard. This analysis should be completed in accordance with the standards set out in the MNR Technical Guidelines based on the flows resulting from the ultimate development scenario. The hydraulic model shall demonstrate water levels, storage, and velocities for all design storms including the regulatory storm. The U.S. Army Corps of Engineers HEC RAS model is acceptable for the hydraulic analysis.

The final model should be flexible enough to evaluate modifications to the existing floodplain including realignment or changes to the corridor width and profile.

The Interim and Final Reports are to contain:

- References for all sources of topographic information (including a summary of any correlation analysis completed).
- References for all hydrologic information incorporated into the Study.
- A summary of the evaluation justification for selected hydraulic parameters, and summary tables of the findings.
- A digital copy of all hydraulic modelling (including input and output files, as well as documentation on each of the model runs).
- Full size signed and sealed copies of floodplain mapping for the regulatory storm on topographic base mapping, overlain with the hydraulic cross section locations (labelled with cross section ID, and the associated Regional and 1:100 year water levels) and the proposed development plan.

4.2.4 Erosion Hazards

The erosion hazard limit associated with a watercourse is based on the valley characteristics – confined or unconfined. The stream characterization work (described below), in conjunction with a site walk with Conservation Halton and Credit Valley Conservation staff and other members of the SWTAC, will be used to determine the watercourse status. The Erosion Hazard Limit should be determined based on CVC's Geomorphic Guidelines for confined and unconfined watercourses. In the absence of site-specific Geotechnical Study, the recommended "Toe Erosion Component" should be based on CVC's Geotechnical Guidelines and the "Technical Guide – River & Stream Systems: Erosion Hazard Limit" (2002), which is 8m for cohesive soils (i.e., silty clays, clayey silts); and 15m for cohesionless soils (i.e., silt, sand).

During the site walk all confined systems will be identified, and the physical top of bank will be staked in the field by Conservation Authority staff. Geotechnical analysis is required to confirm the location of the long term stable top of slope, which forms the basis of the erosion hazard limit in a confined system. The intent of this Study is to establish a reasonably accurate identification of the erosion hazard limit, which may be further refined through future studies. Therefore, if geotechnical studies are undertaken at this time, conservative estimations of geotechnical parameters (i.e., a stable slope inclination of 3:1 and a toe erosion component of 8 m) must be used. The meander belt and long term stable slope limits are to be determined in accordance with the MNR's Technical Guidelines. Additional direction may be obtained through the CVC's Fluvial Geomorphic Guidelines (Fact Sheet I to V).

4.2.5 Analysis

a) Identify, by field inspection of all channels in the Study Area, sites where stream bank erosion and slope instability is present and/or should be considered as part of the erosion hazard.
b) Determine the historic toe erosion rates and anticipated future toe erosion rates (if localized increases to on-site erosion are deemed unavoidable and acceptable to the Town and Conservation Halton).
c) Meander belt and slope stability assessments shall be completed in accordance with MNR Technical Guidelines.
    - Where site-specific slope stability assessments cannot be completed, an appropriate preliminary hazard delineation should be agreed upon to the satisfaction of the Conservation Authorities.
d) Incorporate all water quality treatment requirements in the preliminary stormwater management plan.
e) Determine minimum stream corridor based on the erosion hazard using meander belt width and/or slope stability setback and other safety factors, as appropriate. The corridor sizing will build upon the procedures followed by CH in their generic regulation mapping. The intent is to provide a conservative representative corridor width, with the recognition that it would be refined at the subwatershed Impact Study (SIS) and Functional Servicing Study (FSS) stage.

The erosion hazard assessment must be completed by a qualified licensed professional engineer or professional geoscientist. Climate change should be taken into account when planning creek block widths.

At a minimum the corresponding report must include supporting field data, analysis, discussion on the methodology applied, and supporting calculations regarding determination of the erosion hazard, and a signed and sealed, full size, and scaled hard copy of a drawing showing:

- Detailed topographic information (0.5m contours preferred)
- The current watercourse centreline
- Reach break locations
- The Creek's central tendency (meander belt axis).
- Available historic watercourse centrelines
- The calculated meander belt (preliminary meander belt)
- The analyzed 1:100 year erosion setback (100 year migration rate)
- The regulated 15m allowance

A second copy of the above information overlain on the most current orthophoto should also be provided.

4.5 Geomorphologic Assessment

Based on the morphological attributes of each channel reach, determine the physical and biological health of the watercourses. The Geomorphic analysis will support the erosion assessment and determine threshold flows at appropriate sensitive erosion sites throughout the subwatershed Study Area.

4.5.1 Background Review and Field Work

Background information on the Primary Study Area will be collected from all available sources and by field inspection, including but not restricted to the following:

- Determination of drainage network areas divided into subcatchment areas, preliminary calculations of drainage densities and frequencies, stream orders, etc.
- Determination of the Erosion Threshold based on CVC's Geomorphic Guidelines.
- Update of the historical analysis of reaches with attention being paid to land use changes, channel changes and migration rates derived from aerial photographs.
- Reach delineation based on scientifically defensible methodology (see CVC's Fluvial Geomorphic Guideline -Fact Sheet IV).
- Preliminary determination of reach sensitivity and overall classification.
- Rapid geomorphic assessment to evaluate stability of reaches based on acceptable rapid assessment protocols.
- Define erosion thresholds based on scientifically defensible models.
- Detailed survey of watercourses to include channel profile and representative cross sections.

4.5.2 Analysis

A geomorphic analysis will be conducted to determine the character and behaviour of the subwatershed. A geomorphic assessment must be completed by a qualified fluvial geomorphologist. The steps involved in the analysis include:

a) Identify by field inspection, sites where stream bank erosion and slope instability is present and/or should be considered in the impact assessment report, as well as all locations where structures may be at risk.
b) Complete rapid field assessments while walking the entire subwatershed drainage network, and documenting areas sensitive to erosion, and any significant field conditions, i.e. bank erosion, slumping, woody debris jams, scour pools, depositional areas, age of point bar vegetation, etc. Photographs of significant features will be required.
c) Describe the form and stability of the system through analysis of historical aerial photographs and standard classification methods as directed by the SWTAC (e.g. Index of Stability (Downs 1995), Rapid Geomorphic Assessment (Ontario Ministry of Environment, Conservation and Parks (MECP), 2003) Rapid Stream Assessment Technique (Galli,1996), or other suitable methods in consultation with the SWTAC).
d) Analyze downstream trends in channel morphology and factors affecting stream stability, including any historic changes in flow regime.
e) Evaluate drainage network (density) on a sub-catchment basis, including an evaluation of channel functions, such as the supply, movement and storage of sediment.
f) Document the location and nature of sediment sources.
g) Ensure data is collected that enables proper determination of opportunities and constraints, including stream corridor delineation following protocols used in generic regulation mapping and Provincial Policy Statement protocols.
h) Complete a sensitivity analysis of the headwater channel systems.
i) Ensure linkages (e.g., relating channel form/stability measures to biological integrity measures) between fisheries, stream morphology and other disciplines are maintained.
j) Carry out measurements of channel and bank characteristics and bank full flow conditions using standard protocols and known field indicators of the bank full stage (include bank full channel widths and depths).
    - Analyze surficial channel bed materials using a modified pebble count method; where surficial materials are too fine for a pebble count, bulk samples should be collected and analyzed using standard sieve and hydrometer techniques.
    - Characterize Sub-pavement materials using bulk samples and standard sieve and hydrometer techniques.
    - Complete an evaluation of the bank vegetation, rooting depths, materials, percentage of cover and in situ shear stress for both banks at each detailed site.
    - Conduct a level survey encompassing the detailed site to provide an idea of the local energy gradient present in the reach.
    - Complete the installation of a monitoring site with permanent monument pins which can be revisited and re-measured for historical changes in the cross sectional area of the channel.
k) Utilize detailed cross-section surveys using level surveys and monumented pins for measurement of cross-section change. The detail of the survey should be fine enough to track changes (erosion, aggradation). This method is preferred over the erosion pin method due to the limitations of erosion pins and the potential disturbance caused by the installation of the pins.
l) Define erosion thresholds based on scientifically defensible models. A range of models should be applied to assess model sensitivity and gain a better understanding of the range of erosive conditions. Modeled results should be compared to actual field observations.

m) Identify flow constraints, which may avoid or reduce future bank and bed erosion problems.
n) Identify the sensitive reaches for detailed assessment. CVC will provide a spreadsheet tool to determine the reach sensitivity. CVC staff geomorphologist will provide recommendations on appropriate creek crossing location and sizes, and scour depths at the location of infrastructure crossings, where applied.
o) Complete hydraulic and geomorphic analyses and empirical relations from collected field data. This would include, but is not limited to bank full discharge, tractive force, permissible velocity, stream power, sediment transport, and hydraulic geometry relations.
p) Assess cumulative headwater functions by assessing sediment budgets, linkage with local hydrology and connection to larger scale, including input from supporting disciplines (e.g., TSS data from water quality; flows from hydrology; spot flow data from hydrogeology; habitat input from fisheries and terrestrial ecology).
q) Determine drainage density targets. Compare against regional values and provide targets on a sub-catchment basis.
r) Determine future watershed management strategies in a holistic way, including but not limited to consideration of aquatic and terrestrial linkages, hydrologic and hydrogeological inputs, sediment transport, and headwater function.
s) Estimate erosive velocities and identify, using the hydraulic Study results, sites that may be subject to erosion under existing and post-development conditions and undertake a flow duration or other threshold exceedance analysis based on existing and ultimate conditions.
t) Determine minimum stream corridor using meander belt width and other safety factors. The meander belt width delineation will build upon the procedures followed by CH and CVC in their generic regulation mapping. Meander belt widths should be determined at a landscape level. These widths are to be evaluated and refined as appropriate at the detailed design stage) Identify opportunities for enhancement.

It is recommended that consultation with CVC and CH staff occurs before initiating field work to scope work for eligible creeks. The report shall include recommendations relating to watercourse system attributes to provide guidance for open space blocks. Climate change should be taken into account when completing the erosion threshold analysis and planning creek block widths.

4.6 Hydrogeology

4.6.1 Background Review

Background information on the regional context and Primary Study Area will be collected from all available sources and through field investigation to establish a conceptual model of the subwatershed, including but not restricted to the following:

- Regional ground water studies (technical reports, pumping tests, geophysical surveys, etc.)
- Halton Region's Aquifer Management Plan
- Soils reports and geotechnical investigations.
- Surficial soils, overburden geology and bedrock geology of the area and their hydraulic properties, including infilled bedrock valleys

- Existing well records, groundwater level and quality datasets (e.g.: MECP Water Well Record Information Database and Provincial Groundwater Monitoring Network, geotechnical borehole data, etc.)
- Groundwater taking and use (e.g.: MECP Permit to Take Water Database, Water Taking Reporting System Database, etc.)
- Local climate data, Environment Canada climate data
- Hydrology reports and Water Survey of Canada data.
- Reports of studies completed as part of the source water protection program
- Aerial photographs, their use, and potential for inclusion in a monitoring program
- Identify data gaps and recommend future work for completion of subwatershed impact studies
- Reports of contamination and complaint files (MECP)

4.6.2 Characterization and Constraints

The Study characterization report with respect to hydrogeology shall be sufficient to help understand geological and hydrogeological conditions in the area, to determine the key characteristics of the bedrock and overburden systems and their functions in terms of controlling groundwater movement, availability, and quality in the area within the regional hydrogeological setting[1]. An integral component is to assess the interaction between the groundwater and surface water systems and to determine the overall role or function of this interaction in an ecosystem context. The scoped SWS will include an assessment of the site location in relation to the vulnerable areas delineated through Source Water Protection studies for the Halton Region Source Protection Area and Credit Valley Source Protection Area.

The characterization and constraints report should include, but not be limited to the following:

a) Maps of local physiography, topography and overburden and bedrock geology.
b) Maps of private water wells, monitoring wells, borehole locations, groundwater elevations and inferred direction of all local aquifers based on appropriate existing information and supplemented with recent data if necessary, levels, flows and quality in all aquifers within the area based on existing information.
c) Present construction details of available groundwater monitors
d) Estimate zone of influence of the proposed development on groundwater and identify all groundwater receptors within and adjacent to the zone.
e) Identification of existing recharge-discharge zones to help understand and maintain/enhance base flow and in stream water temperature.
f) Identification of groundwater recharge areas.
g) Identification of suitable sites for urban stormwater infiltration to avoid contamination of the water table and/or deeper aquifers.
h) An analysis of groundwater contribution to maintaining the existing natural areas (wetlands, environmentally sensitive areas, etc.).
i) A review of CVC source water protection Study documents and vulnerable areas assessment (a part of the SWS Study Area within Credit Valley Source Protection Area is designated as

[1] It is envisioned that sufficient information exits to complete the tasks associated with the Hydrogeology component of this scoped study. The study consultant shall therefore provide confirmation of this and if necessary, identify any additional specific field work or analysis required in their proposed work plan. Such additional work will be reviewed by the Subwatershed Technical Advisory Committee.

an High Vulnerable Area).Describe where groundwater discharge areas may be supporting specific life process of aquatic species (e.g., fish spawning).

4.6.3 Monitoring

The scoped SWS will include recommendation of a groundwater level and quality monitoring program for the pre, during and post construction phases to evaluate the effectiveness of measures implemented, and allow for adaptive management. It will also identify future monitoring requirements for completion of subwatershed impact studies. The consultant will propose the required water balance assessment/analysis to be completed for the existing (pre) and post-development conditions pertaining to development phases, and mitigation (low impact development - LID) measures, to ensure that hydrological condition in the existing condition be matched (as best as possible) in the post-development phase. The water balance reviews and LID proposals will follow methodology, guidelines and criteria approved by MECP and the relevant Conservation Authorities.

4.7 Water Quality

4.7.1 Background Review and Field Work

This component is intended to provide a characterization of the existing surface water quality, including temperature, within the Primary Study Area that would form the basis for identifying constraints and facilities requirements for the secondary planning area.

Background information and reports will be utilized in the characterization of existing water quality conditions in the Primary Study Area. All relevant documents and data will be collected and reviewed to determine their applicability in undertaking a preliminary assessment of existing water quality conditions in the subwatershed.

Data sets to be reviewed include:

- Water chemistry and temperature data from CH's Long-term Environmental Monitoring Program, as available
- Water chemistry data from Provincial Water Quality Monitoring Network (PWQMN)
- Water chemistry and temperature data from CH's Long-term Environmental Monitoring Program, as available, and other available local studies

The sampling program will include three sample periods from spring through fall, and will focused on the following parameters of concern:

- Flow regime
- Water temperature
- E. Coli
- Nitrogen (nitrates, nitrites, TKN)
- Total phosphorus (Total phosphorus, soluble reactive phosphorus)
- Chlorides
- Metals (Copper, zinc, cadmium, lead)
- Suspended solids (TSS, turbidity)

- pH
- Dissolved Oxygen

The Project Consultant shall identify monitoring data gaps, which would help in recommending sampling locations and frequency of additional monitoring to establish pre-development conditions.

4.7.2 Characterization and Target Setting

The water quality analysis tasks associated with this Study include:

a) Identify pollution sources, loading and source control measures, both short term and long term from different land uses in the Primary Study Area; Review any thermal mitigation techniques that may be required to mitigate impacts from land use changes.
b) Review best practices to mitigate water quality impacts.
c) Prepare a summary of water quality statistics and identification of information or monitoring gaps to inform sampling locations and additional monitoring requirements.

4.7.3 Impact Analysis and Monitoring

The Project Consultant shall provide recommendations for a water quality monitoring program to monitor progress and adaptive management measures.

4.8 Fish and Aquatic Habitats

4.8.1 Characterization and Background

The Project Consultant will review available background information and determine the need for additional field studies. Initial assessment work could include existing habitat assessment, spawning survey, benthic inventory and fisheries inventory, identification of stream base flow sources and investigation of opportunities for base flow and habitat enhancement, and identification of current sources of degradation. The Project Consultant would work closely with Conservation Halton, Credit Valley conservation, Fisheries and Oceans Canada and the Ministry of Natural Resources when carrying out this assessment work.

The Project Consultant will set targets to ensure maintenance or enhancement, where possible, of quality and quantity of stream base flow and temperatures and recommend practices and techniques to achieve or exceed targets. In addition, the Consultant will apply recommended practices and techniques and investigate the impact of proposed urban development scenarios.

The composition of the benthic invertebrate community is an ecological reflection of the physical and chemical conditions of the watercourse. Various benthic taxa have well documented responses to water quality conditions; as such, they are commonly used as early warning indicators for environmental change and are an essential component of integrated watershed monitoring. The purpose of the sampling program is to characterize conditions under current land use, and thus establish base line data against which future land use scenarios can be assessed. This baseline data will also provide the foundation from which future monitoring programs can be developed.

A desktop review of all available current and historical fish community records is to be compiled for the area. Fish habitat conditions will be interpreted using biological (fish and benthic invertebrates), geomorphologic, hydrological, hydrogeological and water quality data from other components in this Study. An inventory of barriers to fish migration and existing on line ponds is to be completed. Reconnaissance of all watercourse stretches within the Primary Study Area should include visual surveys for the presence of spawning and refuge areas and important migratory routes.

Headwater drainage features should be classified with respect to their status as permanent, seasonal or ephemeral watercourses. Headwater streams are to be classified/characterized in accordance with the "Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines" (TRCA, 2014). All parameters related to aquatic habitat (e.g. stream morphology, riparian habitat, groundwater data, benthic invertebrates, fish community, water quality and quantity) should be collected at the same sampling locations. Once the data is complied, data can be compared with each other more easily due to the geographic scope of the sampling locations.

Streams should be characterized as green (low constraint streams), blue (medium constraint streams) and red streams (high constraint streams). These characterizations should be combined with other Study parameters (e.g. geomorphology, hydrology) to form an appropriate constraint ranking for each stream and/or stream reach

4.8.2 Background Review and Field Work

Background information on the Primary Study Area, and upstream and downstream of the Primary Study Area, will be collected from all available sources (which could include MNRF records as well as CVC Integrated Watershed Monitoring Program (IWMP) and CH Long-term Ecological Monitoring Program (LEMP) records, where available). Background information on the Primary Study Area will also be collected by field inspection. The same sampling locations are to be used in collecting the following data parameters:

- Revised Stream morphology
- Water quantity and quality (TSS, SRP, chlorides and water temperature etc.)
- Water temperature
- Benthic invertebrates
- Fish community

Sampling locations should be chosen where water flow is anticipated to occur in the months of April, May and June, provided that it is anticipated that the Ontario Ministry of Natural Resources will issue fish collection permits for sampling during these months. In addition to spring sampling (for migrant species), fish sampling should include summer sampling for resident species. In cases where April/May sampling for migrants is not possible, a fall sampling (during September/November) should be planned, as per the CH Guidelines for Ecological Studies. It is preferable that the locations be situated at sites that have healthy vegetated stream banks if possible, which are not located near existing road crossings. It is preferable that sites be chosen that exhibit both flat and steeper stream reach slopes.

4.8.3 Benthic Invertebrates Field Monitoring Methodology

Collection of aquatic invertebrate community samples at an appropriate number of locations using the Ontario Benthic Biomonitoring Network Protocol (MECP). Identification of the invertebrates in the sample should be undertaken to the species level and the data is to be analyzed using the following indices:

- % EPT
- Shannon Weaver Index
- Taxa Richness
- Hisenhoff Index
- % Oligochaeta
- % Chironomidae
- % Isopoda
- % Gastropoda
- % Dipteran
- % Insect

The following table is to be used to determine the relative health of the sites:

- Water Quality Index Unimpaired Possibly Impaired
- EPT >10 5-10 <5
- Taxa Richness >13 <13
- % Oligochaeta<10 10-30 >30
- % Chironomidae<10 10-40 >40
- % Isopoda <1 1-5 >5
- % Gastropoda 1-10 0 or >10
- % Diptera 20-45 15-20 or 45-50 <15 or >50
- % Insect 50-80 40-50 or 80-90 <40 or >90
- HFI <6 6-7 >7
- SDI >4 3-4 <3

Aquatic invertebrate samples should be collected for at least two years prior to development. Each sampling event should occur in the spring months, typically in April or May, when water flow is robust with cool or cold air and water temperatures.

4.8.4 Fish Community

- Fish community information should be collected in accordance with Sections 1 and 3 of the Ontario Stream Assessment Protocol Manual. Fish community samples should be collected in May or June when there is likely to be a greater abundance of flow, which will make fish sampling more feasible.
- Fish community abundance should be analyzed to provide a comprehensive explanation about the health of the fish community. Efforts should be made to analyze the fish community data with specific references and comparisons drawn to other data sets (e.g. benthic invertebrates, stream morphology, riparian vegetation, hydrogeological data and surface water quantity and quality) collected at the same locations.
- Sampling for fish species presence should be quantitative. It is expected that the Ontario Stream Assessment Protocols would be followed precisely rather than used as a general guideline.

4.8.5 Riparian Habitat

Riparian Habitat along watercourses should be assessed for a distance of 30 metres from each side of the bank full channel width of the creek. In addition, riparian habitat should be identified as vegetated or not vegetated. In areas where this riparian corridor is observed to be vegetated, the vegetation communities are to be assessed using the ELC protocol to the Vegetation Type level.

Upon consultation with Conservation Halton, Credit Valley Conservation, Fisheries and Oceans Canada and the Ministry of Natural Resources, the Project Consultant will appropriately characterize all watercourse and drainage features using integrated background data collected in the field from the following disciplines:

a) Water quantity and quality, stream morphology, benthic invertebrate communities, fish community and riparian vegetation assessment.
b) Identify existing habitat features which are critical for maintenance of the existing fishery.
c) Identify existing habitat features which may be presently limiting fish production (e.g. Elevated temperatures, sedimentation).
d) Using the information obtained, suggest opportunities to enhance fish production as development proceeds. (e.g. infiltration of stormwater, removal of on-stream ponds or structures, placement of spawning gravel over upwelling areas)
e) Examine fisheries problems and opportunities created under a variety of subwatershed development scenarios.
f) Through interaction with other disciplines, develop a preferred approach which documents habitat maintenance and enhancements.

4.9 Terrestrial Ecology- Natural Heritage System and Features

4.9.1. Characterization and Background

- Undertake a comprehensive, four season field investigation of the Primary Study Area and adjacent lands within 120 m to identify and evaluate all natural heritage features and areas, including but not limited to wetlands, forests, successional habitats, grasslands, wildlife travel corridors/ecological linkages, habitat of species at risk, woodlands, valleylands, wildlife habitat, as well as Environmentally Sensitive Areas (ESA's) or other features/areas that may be located within or adjacent to the Primary Study Area. The investigation component should identify both the form and functions (ecological and hydrologic) of the existing natural heritage features/areas as well as the ecological interactions between and among them.
- Provide sufficient detail to allow for local boundary adjustments through the assessment and implementation phases in keeping with the Regional Natural Heritage System framework established through ROPA 38. Reference should be made to Section 115.3 of the Regional Plan when reviewing, classifying and describing the components of the regional Natural heritage System.
- Review current evaluation methodologies and confirm approach with SWTAC for use in the Study as necessary. In particular, any unevaluated wetlands will need to be evaluated using the 3rd edition of OWES.

- Set detailed technical objectives and targets for appropriate preservation, protection and enhancement of natural features and their functions, which will need to be met by the proposed urban development, including any buffer/setback recommendations and associated restoration. Specify the best management practices that should be considered to meet these targets. The natural areas should be maintained, restored or, where possible, improved by the proposed management practices.

4.9.2 Background Review and Field Work

Background information on the Primary Study Area and adjacent lands will be collected from all available sources and by field surveys, including but not restricted to the following:

- Compilation of natural heritage information from existing sources (e.g. NHIC, Aurora District MNR, and CH and CVC species databases, provincial atlas projects, Halton Natural Areas Inventory) and master species lists to combine results from background reports with field assessments. Of particular note is the Region of Halton's *Natural Heritage System Definition and Implementation* Report.
    - Natural Heritage background sources should include Ontario Nature Reptile and Amphibian Atlas, Atlas of the Mammals of Ontario, Ontario Butterfly Atlas, eBird/Bird Studies Canada databases and any other relevant sources.

- Acquire any necessary permits for sampling (e.g. ESA permit, Wildlife Scientific Collector's Permit) well in advance of planned field season.
- Conduct wetland evaluation and assessments according to the OWES and review/utilization of any available evaluations completed by the Ministry of Natural Resources and Conservation Halton. Mapping of wetland features will require delineation/staking of wetland boundary, to be conducted with Conservation Halton and/or CVC.
- Assess significant wildlife habitat (See Methodology – Appendix B).
- Assess significant woodlands (See Methodology – Appendix B).
- Assess species at risk (See Methodology – Appendix B).
- Conduct fish and fish habitat inventories assessment (see above section).
- Identify potential pollution point sources to the stream, i.e. storm outfalls, old dump sites.
- Identify enhancement opportunities for all environmental components.
- Carry out multi-season inventory of flora and fauna to address any information gaps noted during the background review of previous studies and inventories and update background information as necessary. Undertake targeted surveys for birds, amphibians, reptiles, plants, odonates, butterflies, bats and mammals.
- Conduct ELC of all natural features and semi-natural features to Vegetation Type.
- Identify existing ANSI's and ESA's.
- Review of current Study evaluation methodologies and based on consultation with stakeholders, provide recommendations for any necessary revisions to the previous evaluation methodology for use in the Study and additional information needs.
- Include a table with the date, stop and start time, weather conditions, personnel and purpose of all fieldwork conducted. Background information from the broader Study Area should also be consulted to provide an appropriate landscape context.

4.9.3 Analysis

The Project Consultant will:

a) Review previous studies on the natural heritage systems and areas. The Halton Natural Areas Inventory (2006) and information from CH and CVC should be used to determine species' local status within respective watersheds.
b) Identify and map all natural and semi-natural vegetation communities, wildlife corridors, wildlife habitat areas, significant wildlife habitat, significant woodlands, significant valleylands, provincially and regionally/locally significant wetlands and Areas of Natural and Scientific Interest (ANSI's) and Environmentally Sensitive Areas (ESA's) that may be located within, or adjacent to the Primary Study Area.
c) Define functional relationships between wildlife and natural areas, with particular attention to movement and seasonal habitat requirements. Identify Critical Function Zones around wetlands, from which appropriate setback distances/buffer treatments would be established.
d) Where necessary to ensure appropriate level of knowledge/documentation complete inventory of the vegetative and wildlife resources of each area, confirm previous findings.
e) In conjunction with the Hydrology and Hydrogeology section, determine the water needs of these natural systems and appropriate buffers.
f) Identify the circumstances, which promote the observed resources and their associated functions. Set targets and recommend practices to ensure their maintenance or enhancement, where possible.
g) Identify potential refinements to the regional Natural Heritage System boundary including additions, deletions and/or boundary adjustments in accordance Section 116.1 of the Regional Official Plan.The identified modifications to the regional Natural heritage System should consider Sustainable Halton Report 3.02, Natural Heritage System Definition and Implementation.
h) Develop a natural heritage system constraints map that incorporates the natural heritage features and areas identified through the Study process, including restoration and enhancement areas, required to protect or improve the ecological and hydrologic functions of the system for the long term.
i) Identify opportunities to link isolated natural areas to the Regional Natural Heritage System, where appropriate.
j) Identify future monitoring requirements to be conducted as part of and following the completion of the Subwatershed Impact Studies.
k) If for any reason Ontario Wetland Evaluation System (OWES) assessments is not completed as part of the SWS, a process to confirm status of wetlands in later stages should be established. All wetlands should be treated as Provincially Significant until OWES assessments are complete.

5.0 Additional Background Review

5.1 Municipal and Land Use Planning

The following municipal and land use planning background material should be included as part of the review:

- Existing and future land use
- Official Plans and Zoning By-laws
- Population projections, population densities
- Planning and development studies
- Existing and future transportation corridors
- A Growth Plan: Growth Plan for the Greater Golden Horseshoe (2019)
- Provincial Policy Statement (in effect)
- Greenbelt Plan
- The Region of Halton Buffer Refinement Framework
- Conservation Halton *Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document, Conservation Halton, April 27, 2006, as amended August 11, 2011, November 26, 2015, February 25, 2016.*
- CVC Watershed Regulations and Policies April 9, 2010, Resolution No. 48/10

The background review will include all relative reports and information sources. The Project Consultant will:

a) Lay out a frame work for the organization, management and presentation of resource data
b) Identify all wetlands, ponds, drainage paths, and defined watercourses using aerial photos and field inspections
c) During the field inspections, observe and comment on existing land uses, vegetative cover, quantity of flow, wildlife and fish habitat and pollution sources
d) Identify data deficiencies and requirements for field monitoring of specific parameters or characteristics to augment the data base
e) Specify standards for collection of additional data. Additional field data shall be collected where necessary and added to the existing databases such that the level of detail will support the decision making process of the subwatershed Study
f) Consider post development monitoring requirements when sighting locations of additional stations. Additional data requirements identified by field survey
g) Prepare a base map of the Primary Study Area which can be used throughout the Study to overlay subwatershed attributes and plan components
h) After carrying out the review, prepare a background report which will:
    - Summarize the findings of the review
    - Formulate an issue and problem statement
    - Prepare a detailed work plan for the Study. The background report should be prepared in such a way that it can be used as introductory chapters in the final Study report (see Schedule A).
i) Work closely with the SWTAC chairman and members of other on-going studies

5.2 Subwatershed Synopsis

- The Project Consultant will summarize the targets, constraints and opportunities identified in Study including:
    - Natural/semi-natural cover targets and constraints
    - Stormwater flow and volume constraints for flood and erosion control
    - Constraints on urban development to meet flows and volume targets.
    - Susceptibility of groundwater to contamination from urban stormwater infiltration
    - Potential recharge and discharge zones to maintain/enhance base flow and water temperature in the stream
    - Existing sources of pollution and corresponding remedial action- water quality targets based on desired fish community objectives and feasible methods for managing water quality
    - Constraints on urban development to maintain/enhance water quality
    - Circumstances which promote or affect the feasibility of target fish species
    - Constraints on urban development to enhance fish habitat
    - Natural heritage system and associated restoration opportunities(including, but not limited to, wetlands, environmentally sensitive areas (ESA's), stream corridors, Conservation Authority regulated areas, ANSIs)
    - Natural heritage system and stream corridor management boundary for the streams and other natural heritage features within the subwatersheds, with consideration for adjacent features. The stream corridor should be determined so as to include natural, cultural and historic features where protection and preservation is important to meet the goals and objectives of the Study. Features to be included are floodplains, wetlands, woodlands, erosion prone areas, significant wildlife areas, ecologically important areas and any recommended buffers

Appendix A – Studies and References

- SIS, SWS and EA studies completed in the area.
- A Guide to Road Ecology in Ontario. 2010. Prepared by the Ontario Road Ecology Group, Toronto Zoo.
- Assessing the Degradation Effects of Local Residents on Urban Forests in Ontario, Canada. 2010. McWilliams, W., P. Eagles, M. Seasons and R. Brown.
- Arboriculture & Urban Forestry 2010. 36(6): 253-260.
- Birds of Hamilton and surrounding areas: including all or parts of Brant, Halton,
- Haldimand, Niagara, Norfolk, Peel, Waterloo and Wellington. 2006. Prepared by Robert Curry and the Hamilton Naturalists' Club.
- Effectiveness of Boundary Structures in Limiting Residential Encroachment into Urban Forests, McWilliam et al., 2011.
- Halton Natural Areas Inventory. 2006. Prepared by Halton/North Peel Naturalists 'Club, Conservation Halton, South Peel Naturalists' Club, Halton Region and Hamilton Naturalists' Club.
- Study Report: thermal impacts of urbanization including preventative and mitigation techniques, CVC, 2011.
- The Herpetofaunal Atlas for the Halton Region. 1999. Prepared by Lori Macadamand published by The Halton/North Peel Naturalist Club.
- The Impacts of Urbanization on the Hydrology of Wetlands: a literature review,TRCA, 2011.
- The Reptiles and Amphibians of the Hamilton Area: An Historical Summary and the Results of the Hamilton Herpetofaunal Atlas. 1994. Prepared by William G.Lamond and published by the Hamilton Naturalists' Club.
- Assessment Report for the Halton Region Source Protection Area, Version 2.1, dated January 26, 2012. Prepared by Halton-Hamilton Source Protection staff.
- Sixteen Mile Creek Watershed Plan, prepared in support of the Halton Urban Structure Plan, February 1996.
- Sixteen Mile Creek Watershed Plan, Technical Report # 2, Evaluation of Potential Development Impacts, prepared in support of the Sixteen Mile Creek Watershed Plan and the Halton Urban Structure Plan, February 1995.
- Sixteen Mile Creek Watershed Plan, Technical Report # 3, Regional Hydrogeology, prepared in support of the Sixteen Mile Creek Watershed Plan and the Halton Urban Structure Plan, February 1995.
- Sixteen Mile Creek Watershed Plan, Technical Report # 4, Natural Environment, prepared in support of the Sixteen Mile Creek Watershed Plan and the Halton Urban Structure Plan, February 1995.
- Gateway West Subwatershed Study Update (Update in Progress), Kidd Consulting
- Study Report: Thermal Impacts of Urbanization including Preventative and Mitigation Techniques, January 2011, Credit Valley Conservation.
- Fluvial Geomorphic Guidelines fact Sheet I to V, Credit Valley Conservation Stability, Erosion, and Development Setback Components Definition &Determination, July 2011, Credit Valley Conservation.
- Stormwater Management Criteria-Draft April 2012, Credit Valley Conservation Halton Region's Aquifer Management Plan.
- Low Impact Development Stormwater Management Planning and Design Guide by CVC and TRCA, 2010.

- Proposed Source Protection Plan for the Halton Region and the Hamilton Region Source Protection Areas, Halton-Hamilton Source Protection Committee, March 2014.
- Proposed Source Protection Plan for the Credit Valley, Toronto and Region, and Central Lake Ontario (CTC) Source Protection Areas.
- Requirements for completion of hydrogeological studies to facilitate Conservation Halton's reviews, November 2014 available at: *https://www.conservationhalton.ca/policies-and-guidelines.*
- Landscape Design Guide for Low Impact Development, CVC, Version 1.0 June 2010.
- Evaluation, Classification and Management of Headwater Drainage Features Guideline. Toronto and Region Conservation Authority and Credit Valley Conservation, TRCA Approval July 2013 (Finalized January 2014).
- Best Practices Guide to Natural Heritage System Planning, Ontario Nature, 2014.
- Phase 3, Sustainable Halton Report 3.02: natural Heritage Definition and Implementation, North-South Environmental, April 2009.
- Relevant CVC Source Water Protection Document.
- Information collected for Halton Region for Halton Zone 4 Feedermain Project along Trafalgar Road (re: Hornby bedrock valley aquifer).
- Study for Halton Region: *Construction of a Proposed Watermain and Sanitary Sewer – Steeles Avenue from Trafalgar Road to Winston Churchill Boulevard*, prepared by AMEC, dated October 2011.
- CH's Road Ecology Best Management Practices – Quick Reference Guide (Sept. 2018).
- Ontario Nature – Reptile and Amphibian Atlas.
- Credit River Fisheries Management Plan, A Cooperative Management Planning Initiative for the Credit River Fishery Ministry of Natural Resources and Credit Valley Conservation, 2002.
- Information collected for Halton Region for Halton Zone 4 Feedermain Project along Trafalgar Road (re: Hornby bedrock valley aquifer).
- Study for Halton Region: Construction of a Proposed Watermain and Sanitary Sewer – Steeles Avenue from Trafalgar Road to Winston Churchill Boulevard, prepared by AMEC, dated October 2011.
- Conservation Halton Road Ecology Best Management Practices – Quick Reference Guide (Sept. 2018) and Ontario Nature – Reptile and Amphibian Atlas.

Appendix B – Terrestrial Field Methodologies

ELC fieldwork will include three season botanical surveys and will result in the identification of vegetation community types, faunal and floral species, as well as existing levels of disturbance. ELC data cards will be required, which encompass vegetation, wildlife, soils, and human disturbance information. In Summary, the ELC and botanical work will collect/document the following:

- Thorough inventory of flora species composition and abundance within vegetation community.
- Vegetation community structure, densities, and age.
- Assessment and evidence of natural and cultural disturbance, and document cultural features (i.e. trails or structures).
- Identification and relative abundance (abundant, occasional, rare – see ELC manual) of disease and invasive species.
- Note any other natural features. May include but not limited to vegetation community inclusions, old growth, watercourses, swales, seeps, specialized wildlife habitat, Rare Vegetation Communities, including the provincial S-rank of the community, where applicable, and kettle wetlands.
- Identify, map the location, and describe the abundance of locally rare or uncommon species, their location and distribution based upon the *Halton Natural Areas Inventory (2006)*;
- Provide an assessment of the current health of the vegetation considering factors using the Floristic Quality Assessment System (Oldham, Bakowsky and Sutherland, 1995).
- Calculate Floristic Quality Assessment, Coefficient of Conservatism, and Wetness.
- Index for vegetation communities.
- Confirm lands with potential old growth or trees (≈100 years or greater).
- Identify the representativeness and rarity of the natural features and functions, by ELC vegetation type, within the context of the Primary Study Area, Municipality, Conservation Halton and Credit River Watersheds, and the Province of Ontario. *Note: Ranking by Rarity in the Province of Ontario as prepared by W. Bakowsky of the Ontario Natural Heritage Information Centre (NHIC)* Wildlife surveys will utilize the following standard protocols. Where survey methodologies for certain taxa are lacking, consultation and approval by the TAC will be required.
    - Winter Wildlife Surveys following the Significant Wildlife Habitat Technical Guide(OMNR 2000) as well as the RISC (Resources Inventory Standards Committee)species inventory methods manual.
    - Owl and Raptor Surveys during migration and nesting season (Winter 2013).
    - Breeding bird surveys in accordance with the Ontario Breeding Bird Atlas protocol(OBBA, 2001), Forest Bird Monitoring Program, (CWS, 2002) or the Marsh Monitoring Program (BSC, 2003).
    - Breeding Amphibian Surveys (April, May, June) in accordance with Bird Studies
    - Canada Marsh Monitoring Program.
    - Targeted wildlife surveys for reptiles (snakes and turtles), odonates (damsel flies and dragonflies), butterflies, mammals and salamanders; incidental

observations of moths and other insects. Survey protocols for these taxa are to be approved by the SWTAC.

- Specialized, migration, seasonal concentration areas or other SWH habitat types, as appropriate for ELC communities, and other habitat features (e.g. Waterfowl Staging Areas).
- Through the wildlife surveys, the following data will be assembled:
    - Identification of any rare or uncommon species, their location and distribution based on the *Halton Natural Areas Inventory* as well as Priority Land bird Species as identified by Ontario Land bird Conservation Plan: Lower Great Lakes/St. Lawrence Plain (North American Bird Conservation Region 13), Priorities, Objectives and Recommended Actions (OPIF, 2005).
    - Review data against the Significant Wildlife Habitat Technical Guide and associated supporting documents to determine which vegetation communities meet designation criteria for significant wildlife habitat.

Appendix C – Technical Engineering Recommendations

- When modeling the Regional Event, should a theoretical rainfall distribution for the initial 73 mm of rainfall over the initial 36 hours be modelled, it must be demonstrated that the selected theoretical rainfall distribution generates peak flows and volumes consistent with the peak flows and volumes modeled on the basis of running only the final 12 hours of the Hurricane Hazel Rainfall Distribution with saturated/nearly saturated ground conditions (and IA set to 0) at the start of the final 12 hours.

- The Regulatory Storm is defined as the greater of the 1:100 year or Regional (Hurricane Hazel) storm.

- Post to pre quantity control may also be required for the Regional storm. If regional controls are not incorporated into the SWM design, the Subwatershed Study must carry out an investigation of the potential increase to flood risk to determine what level of control will be required. Such an analysis is to include the increase in risk to life as well as the potential for flood risk to private, Municipal, Regional, Provincial and Federal property under Regional Storm conditions. If the Study finds that no increase in risk occurs to downstream landowners or public uses, and the Town, Conservation Halton and Credit Valley Conservation accept that finding, the Town in conjunction with Conservation Halton and Credit Valley Conservation will conclude, subject to consideration of any other relevant factor within their respective mandates that control at the Regional Storm level is not required.

- Evaluation of risk associated with not establishing Regional storm control may include, but is not limited to:
    - All existing development within the Primary Study Area for the watershed under consideration.
    - The potential increase in flood risk associated with flood elevations or velocities that may adversely affect all landowners (including individuals, municipal agencies, provincial agencies (MTO, MECP, etc.) and federal agencies), all land uses including road crossings, private access roads, parks, storm sewer outlets, etc., for the watercourse to the 401. The evaluation may also consider potential for the implementation of mitigation measures to address any increase in risk as an alternative to the requirements to control Regional Storm flows. It is understood that not all increases in flood velocity or flood elevation will necessarily lead to an increase in risk.

In addition to these initial scenarios, the Project Consultant must be prepared as part of the testing of alternative plans, to test the sensitivity of flows and volumes to variations in land use density and best management practices, and document how the design has given consideration to future functionality in the face of climactic change.

- Diversions should be minimized; however, should the proponent propose a watercourse diversion or modification of drainage basin boundaries, a low flow analysis and geomorphic assessment must be completed, in addition to the analysis outlined in other sections of this document. The purpose of the low flow analysis and geomorphic

assessment is to determine the impacts of water takings and land use changes on base flows and stream functions, and recommend strategies to avoid or mitigate these impacts. The hydrologic model will be used to model low flow conditions. A low flow frequency analysis for key nodes in the subwatershed will be completed for the existing and future development scenarios. An impact assessment of existing water taking permits, unlicensed or potential water takings based on land uses, and the potential for future water taking permits and land use changes will be included in this analysis. The impacts on ecologic flow needs to support aquatic health must also be considered, with specific reference to the MECP's March 2000 "Water Allocation and Water Taking Management Strategy for Sixteen Mile Creek (reference P. 43 for recommendations associated with Subwatersheds 4, 5, and 6). The analysis will also consider how the modified flow regimes in the receiving and losing systems will impact fluvial geomorphic processes.

- <u>Recommendations for future monitoring work are to consider:</u>
    - monitoring specifics related to construction as per the approved plans, the stability of the stormwater management system as installed, and the functionality of the system relative to the design targets associated with water quality, peak flow control and protection against unnatural rates of downstream erosion
    - timeframe and duration of monitoring
    - qualifications required to complete monitoring works
    - appropriate adaptive management requirements should a trigger be reached
    - on-going validation and re-calibration if required of the refined watershed hydrologic model

- Conservation Halton and Credit Valley Conservation may support floodplain modifications based on the outcome of this Study, recognizing it should result in an ecological gain to the natural heritage system and not impact with the functions of the watercourse. The Subwatershed Study will need to provide conceptual level details for any re-alignment to ensure proposed conditions floodplain mapping will be based on a constructible corridor width and profile.
- Where modifications to natural features are recommended, the Study will incorporate sufficient analysis to ensure that any loss of riparian flood storage or changes which result in potential negative impacts (i.e. increased flooding depth, frequency, duration, velocity or erosion) are avoided/fully mitigated over the full range of anticipated flow conditions. Preservation of riverine floodplain stage-storage-discharge must be demonstrated over a full range of return period flood levels and on an appropriate incremental basis in accordance with the directions of Conservation Halton. Note: Artificially restricting the channel corridor to throttle flows and elevate water levels to balance flood storage will not be permitted where restrictions are required within the meander belt.
- CH staff will need to bring forward a report to CH's Board of Directors regarding the Final SWS to recommend that the proposed management strategies and NHS refinements for features regulated under Ontario Regulation 162/06 (e.g., wetlands, watercourses) be endorsed. Without this endorsement, CH staff will not be able to issue permits for works in regulated areas that do not conform to CH's Board endorsed policies.