Workplan

Lower Spencer Creek

Integrated Subwatershed Study

March 2012

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STUDY PURPOSE

The purpose of the Lower Spencer Creek Integrated Subwatershed Study is to protect, maintain and enhance the ecological processes, functions and significant natural features of the area. This study will provide a framework through which a preferred plan to address existing flooding and erosion concerns is developed as well as improving aquatic health through the remediation of fish barriers along the length of Lower Spencer Creek and improvements to water quality and fish habitat. For the purposes of this study, Lower Spencer Creek is defined as the area from the base of the escarpment to the outlet to Cootes Paradise in the town of Dundas (Figure 1). Specific study components will require consideration of a larger area to fully incorporate the influence of areas outside of the immediate study area (Figure 2). The study will be undertaken in a manner which is environmentally sound and socially and economically sustainable.

The subwatershed plan will recommend how water resources and related subwatershed features and ecological functions should be protected and enhanced to coincide with existing and changing land uses. The following general goals will be refined through the subwatershed study:

- Control flooding within the subwatershed through remedial works and land use controls;
- Minimize soil loss through land management practices and remedial control measures.
- Protect, maintain and enhance aquatic communities, with special regard for fish and fish habitat;
- Maintain or restore water quality to a level which maintains ecological integrity and permits desired uses including recreational activities;
- Protect and maintain groundwater recharge/discharge areas and baseflow to a level which ensures adequate supply for desired uses;
- Protect and maintain self-sustaining natural ecosystems and significant natural features;
- Protect diverse recreational opportunities that are in harmony with the environment;
- Protect and enhance the environment in a manner which is in harmony with the natural features of the subwatershed;

Figure 1: Study Focus Area

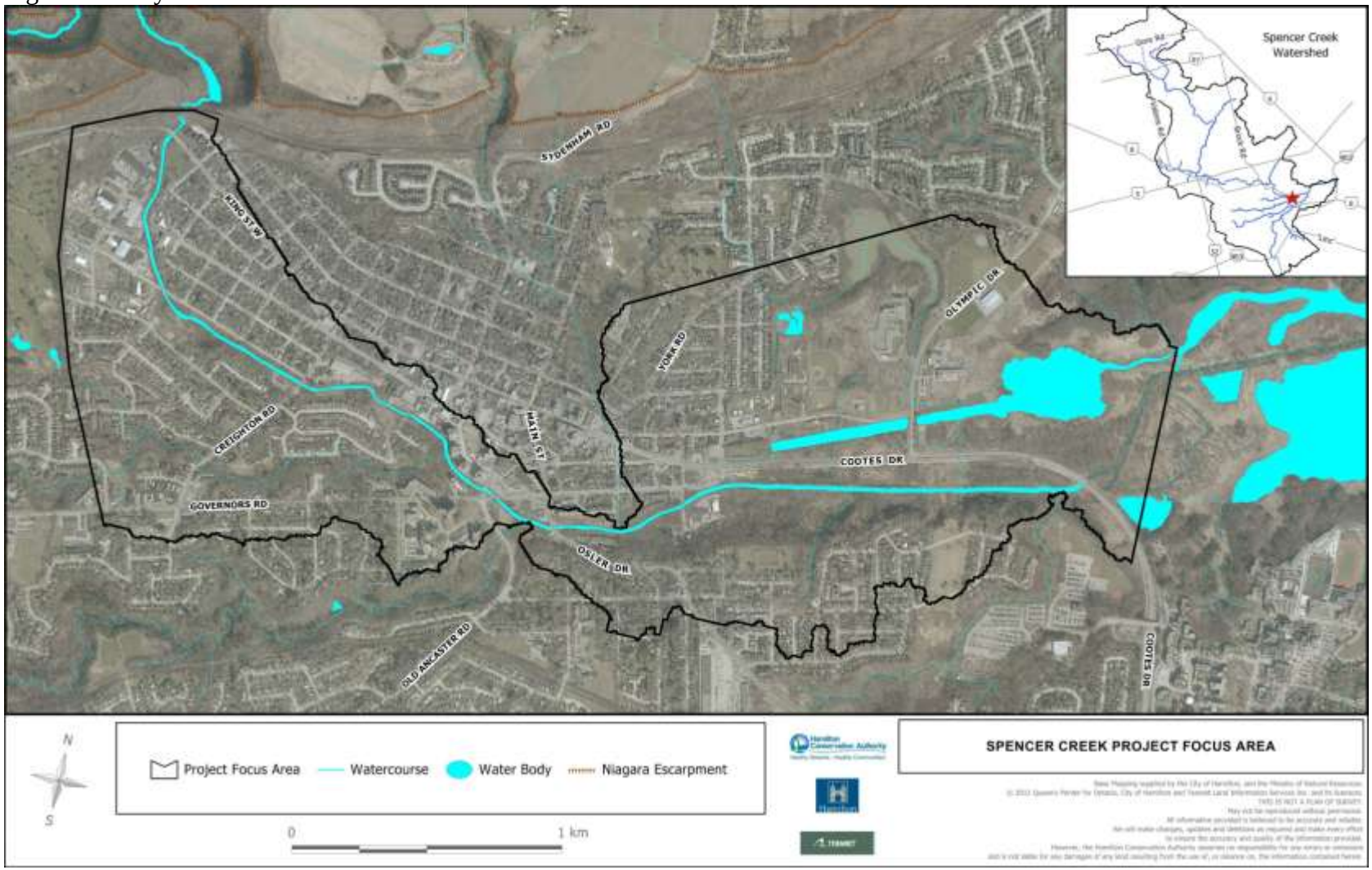
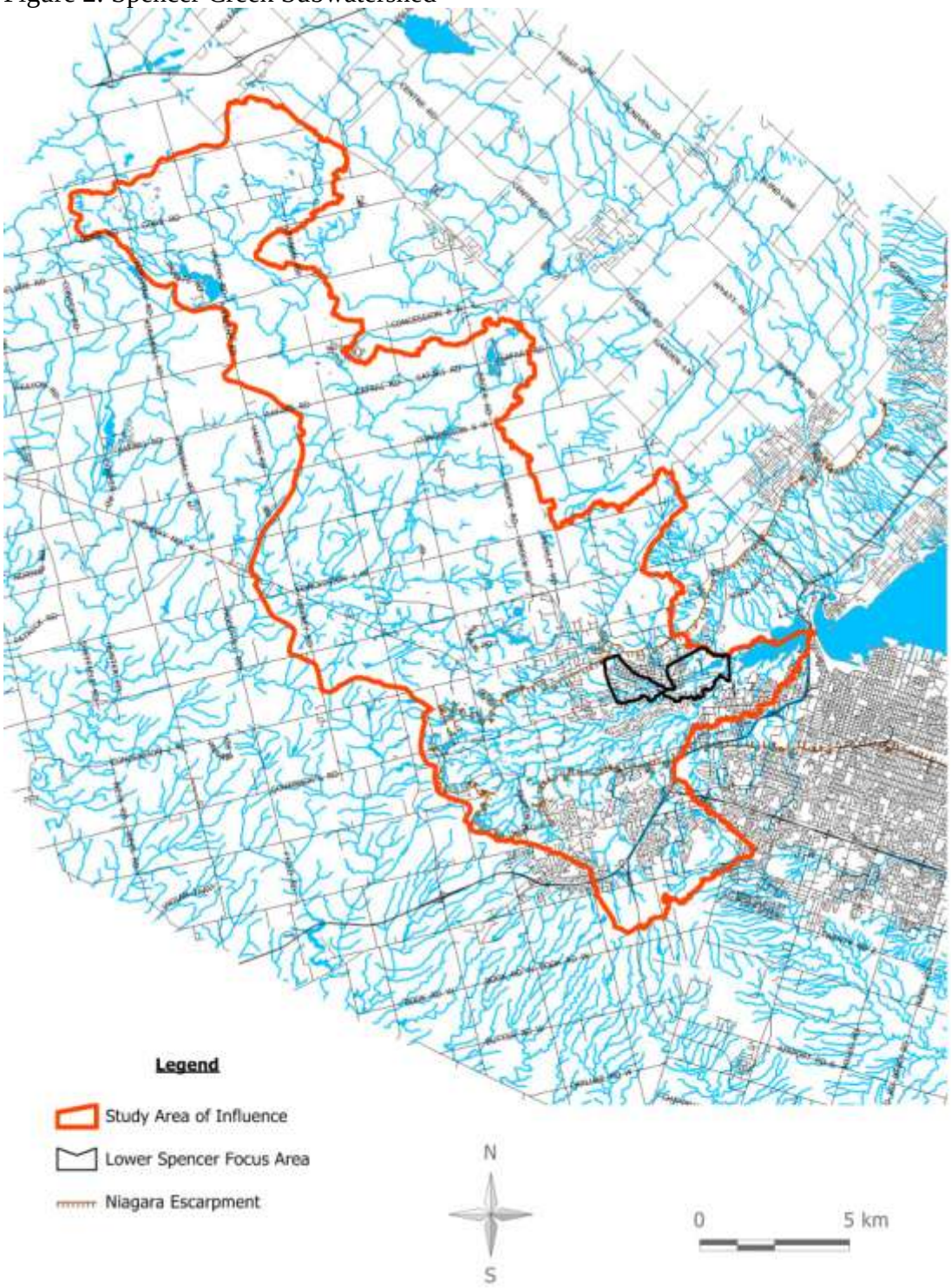


Figure 2: Spencer Creek Subwatershed



The trigger for this study is the need for remediation measures to significantly reduce or eliminate flooding impacts to property and infrastructure resulting from storm events up to and including the Regional storm. In addition, an assessment and remediation strategy is required to address existing slope stability and slope erosion issues, while also developing a strategy to provide long-term stability to Lower Spencer Creek using a natural channel design approach. Sections of this creek have been heavily impacted by historic urbanization resulting in a straightened, concrete-lined channel in places. As such, recommendations are also required to identify opportunities for remediation of eight fish barriers and concrete lined channels to allow for enhanced fish passage and provide additional ecological improvements. Additional stresses on the subwatershed were identified in the Lower Spencer Creek Subwatershed Stewardship Action Plan (HCA, 2010). This plan highlights these stresses and provides recommendations for improving overall creek health. This integrated study will incorporate these recommendations.

The study will follow the Conservation Ontario Flood and Erosion Control EA process, the stated purpose of which is to remediate existing flooding and erosion concerns within a watershed. The focus of the EA is therefore on existing development and infrastructure and is not being commissioned to facilitate future development. However, the impact of increased urbanization on the existing infrastructure must also be considered to ensure that proposed solutions will be sustainable over the long term. As such, the general principles of an integrated subwatershed plan will be followed. This will provide guidelines to protect and enhance the needs of existing residents and the natural environment while at the same time providing useful information to local, regional and provincial governments in planning future developments and land use decisions. The study will also give direction to non-government organizations and private landowners for preparing development proposals. This approach will ensure the maximum benefit can be obtained from this work.

The subwatershed plan will establish constraints, opportunities and approaches for input into land use planning decisions (existing and proposed). The study will identify the locations of and provide information necessary to proceed to detailed design for remediation of flood and erosion hazards, fish barriers and engineered channels. The study will also provide information to landowners on private stewardship programs for the management of the natural resources for all stakeholders. Specific goals and objectives for the subwatershed plan will be developed through the study.

STUDY PRODUCTS

The product of this study is an integrated subwatershed plan that includes;

a) Specific subwatershed targets, goals and objectives to establish:
   - Natural systems linkages and functions
   - Surface and groundwater quantity and quality management
   - Considerations for open space areas and green space corridors.

b) Delineation, on a reconnaissance scale, of:
   - Recharge areas for regional groundwater systems
   - The groundwater resources potential for the area
   - Generalized groundwater flow patterns.
   - Groundwater recharge and discharge areas

c) Information and direction on:
   - Ecological integrity
   - The impacts of proposed remediation works on aquatic health, stream function and public safety.

d) Directives for future studies such as stormwater management plans and environmental implementation reports.

e) An implementation plan that includes specific implementation schemes and outlines roles and responsibilities to carry out all recommendations that result from this study.

f) A monitoring plan that includes:
   - A long term plan of action and a description of the information required for assessing whether the management plan objectives and targets are being achieved by all stakeholders.

g) Recommendations for improved agricultural practises that:
   - Minimize soil erosion from lands in the subwatershed
   - Minimize sediment transport to watercourses
   - Minimize nutrient, chemical, and bacterial loading to the watercourses and groundwater

h) Recommendations for stewardship of sensitive areas.

i) Recommended Plan that includes recommendations on:
   - Rehabilitation of flood and erosion sites
   - Remediation of infrastructure e.g. fish barriers, engineered channels
   - Planning and Policy

- Education and Stewardship – incorporating recommendations from the Lower Spencer Creek Stewardship Action Plan (HCA, 2010)
- Monitoring

STUDY APPROACH

The Subwatershed Planning process can be broken down into four separate but linked phases. Figure 3 describes the process and the key questions that will be answered at the end of each phase.

A Background Report will be prepared to present the results of the collection and review of background information. The Background Report is preliminary work to the integrated subwatershed study, with the background data and information supplemented by field work in Phase 1 to address information gaps.

Phase 1 assesses the resources associated with the subwatershed by study discipline i.e. hydrology/hydraulics, hydrogeology, water quality, stream morphology, aquatics and terrestrial. Background and supplemental field data is assessed within each discipline and then across disciplines to establish the form, function and linkages of the environmental resources. From this work, defined goals and objectives are developed relevant to the subwatershed.

Phase 2 starts out by identifying the threats (past, present and future), determining how impacts will be evaluated and assessing these impacts against the goals and objectives identified in Phase 1. A set of solutions is identified that offer different levels of mitigation to the identified impacts.

Phase 3 assesses the various solutions, establishes the preferred set of solutions and identifies a clear implementation plan that reinforces the identified goals and objectives. The Implementation Plan will be designed to ensure compliance by identifying specific actions in the following areas: Planning and Policy, Rehabilitation and Retrofit, Stewardship, Monitoring, and Research and Development.

Phase 4 is a long-term initiative that checks on the implementation by assessing whether the assumptions made are appropriate and determines if parts of the plan should be modified.

Figure 4 shows the relationship between the land use planning process and environmental planning.

The following work plan conforms to this approach and provides an estimated cost breakdown with respect to the first three phases. Phase 4 will be further assessed at the conclusion of Phase 3. The timing of the overall study will be 18 to 24 months from the time of initiation.

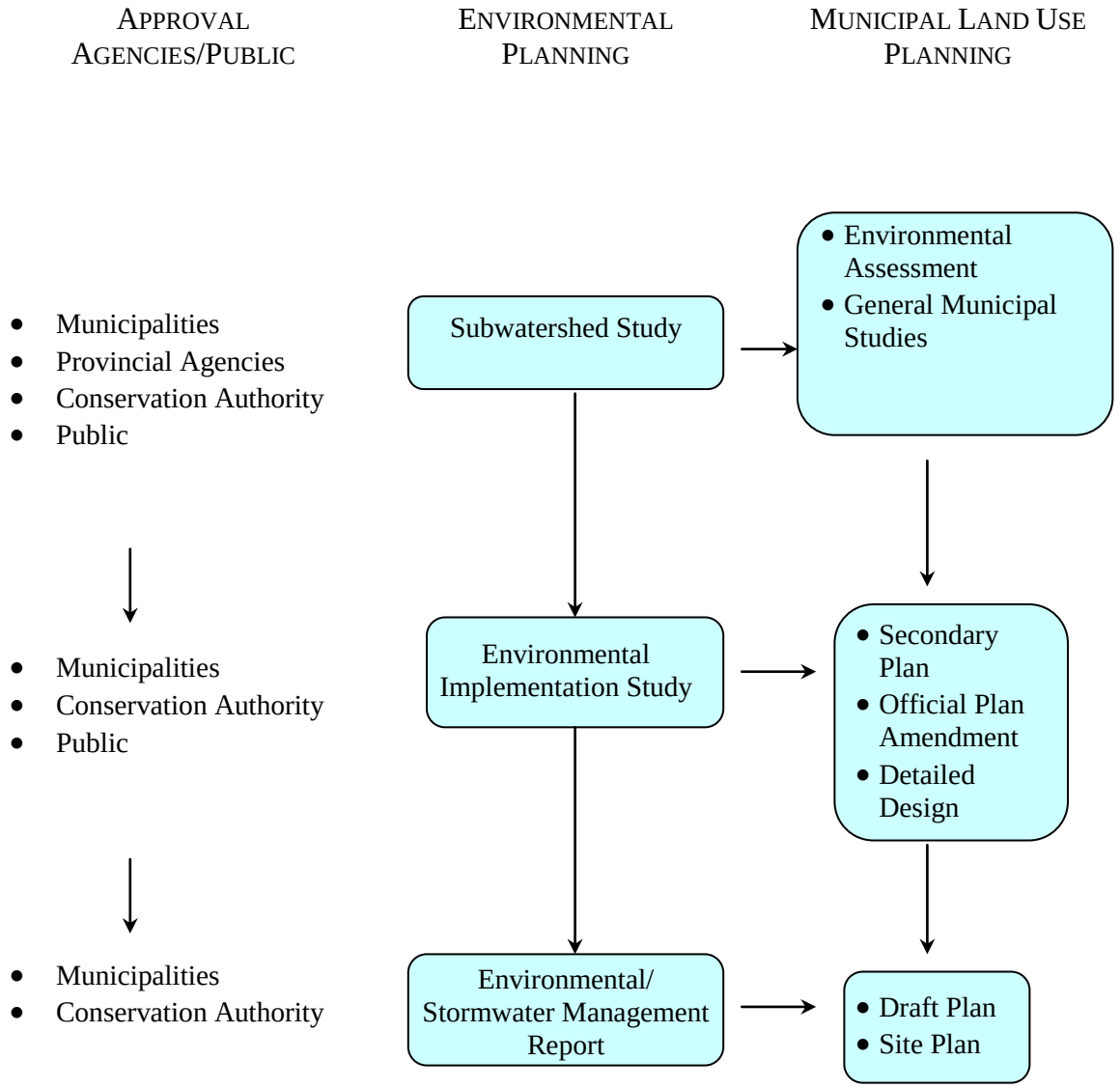
FIGURE 3: STUDY APPROACH FOR A SUBWATERSHED PLAN

Water Management Strategy (watershed plan) identifies:

- Sources of contamination
- Key issues
- Goals
- Preliminary mitigative measures
- Water resource targets
- Resource constraints

PHASE	QUESTIONS TO BE ANSWERED
Phase I Subwatershed Characterization	• What are the resources? • What are the functions and linkages between environmental resources? • What are the major gaps? • What are the goals for the subwatershed?
Phase II Prediction Impact analysis	• What are the stressors? • How will impacts be evaluated? • What are the impacts from the stressors?
Phase III Implementation Identify alternative solutions	• What are the pros and cons of all solutions (plan)? • What is the preferred plan, and what are the criteria for plan selection? • Who will be responsible for addressing the recommendations? • Have goals been met?
Phase IV Long term monitoring	• Are the original assumptions appropriate? • Should parts of the plan be modified when more information is available? • How do you integrate science, management and public needs?

FIGURE 4: ENVIRONMENTAL PLANNING AND APPROVAL PROCESS



STUDY ORGANIZATION

The Lower Spencer Creek integrated subwatershed study is being funded by the City of Hamilton as part of an on-going strategy to reduce flood and erosion hazards in area watercourses.

Hamilton Conservation Authority will complete the study as the lead agency. The Hamilton Conservation Authority Water Resources Engineer will manage the study on a day to day basis, overseeing all specifics of the study and ensuring its progress and successful completion.

The Lower Spencer Creek integrated subwatershed study organization also includes a Technical Committee and a Steering Committee. The Technical Committee is comprised of representatives from consultant firms, City of Hamilton, and HCA staff who have expertise in the components of the study which include hydrology, hydraulics, hydrogeology, water quality, fluvial geomorphology, terrestrial, aquatics and planning, as described in the following pages of this work plan.

The Steering Committee may include representatives from agencies which have an interest in the study such as the Ministry of Natural Resources, the Hamilton-Wentworth Stewardship Council, Trout Unlimited Canada, Ontario Streams, Royal Botanical Gardens, the Niagara Escarpment Commission, and the City of Hamilton.

STUDY COMPONENTS

HYDROLOGY

The objective of this study component is to characterize the hydrological aspects of the subwatershed, such as surface water flow paths and their interactions with the groundwater regime. This information in conjunction with a hydrologic computer model of the subwatershed will be used to help quantify changes in the hydrologic response of the subwatershed resulting from the proposed development scenarios or any stream rehabilitation/enhancement programs. Output from the hydrological model, in terms of peak and low flows, flow duration curves and water balance quantities, are used as input to the assessment procedures applied in the other study components.

Phase 1 – Characterization

Purpose:
To collect and review all available background reports, field data, maps and other relevant information. This information will be used to provide the basis for subwatershed characterization and determine what additional field measurements may be necessary. The hydrologic characteristics of the subwatershed will be summarized by considering the various factors that influence the surface water flow in the basin, in terms of the climate setting, streamflow and surficial features (e.g. swamps, land use, land cover).

Approach:
- Background hydrology information including electronic modeling files can be found in the 1990 report titled "Spencer Creek Hydrology Study" by McLaren Plansearch. Other relevant reports and information will also be reviewed.
- For field monitoring, we can obtain recording raingauge information from the HCA real-time gauges at Market St. and Spencer Creek in Dundas and at Highway 5 and Spencer Creek in Flamborough. Precipitation is also available from the Royal Botanical Gardens (RBG) weather station located within Cootes Paradise. Note that precipitation data in the winter is not reliable due to unheated gauges.
- In addition to existing flow monitoring stations located at Market Street in Dundas, at Highway 5 and at Safari Road in Flamborough, and on Ancaster Creek in Ancaster, additional temporary flow monitoring stations may be established on other subwatershed tributaries. It is anticipated that two monitoring stations will be required.
- For daily climate data (max and min air temperature, daily rain and snowfall), information is available from the AES stations at the Royal Botanical Gardens and the Hamilton Airport. Daily information for these stations is available on-line at http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html for time periods of 1950 - present and 1970 – present respectively. Hourly data is also available.

- For hydrologic modelling purposes, some snow cover distribution surveys will be carried out in January or February 2012. These surveys will be used to confirm that the areal snow depth distribution patterns for different landscape units (e.g. forests, grasslands, agricultural crops) in Spencer Creek are similar to other parts of southern Ontario. This information will then be incorporated into the hydrologic modeling. Snow accumulation modelling is an essential component for accurate water balance assessments.
- Identify and quantify watershed processes and resources based on background information (e.g. regional climate information, soil types and existing land use), field data collected and knowledge gained in similar watersheds;
- Identify all major users or takers of water in the study area,
- Develop a conceptual understanding of the linkage between surface water and ground water flow systems

Deliverables:

- Mapping will be developed for all hydrologic resource features including streams, ponds, drainage areas, wetlands and drainage patterns;
- Streambed profile plots showing the surfical features as they intersect the streambed;
- Summary of streamflow and meteorological data.

Phase 2 – Impact Analysis

Purpose:

To quantify changes in the hydrologic response of the subwatershed resulting from future development or any stream rehabilitation/enhancement programs. For this purpose, we will develop a physically-based hydrologic model of the study watershed using the MIKE-SHE hydrologic model, for both existing and post-development conditions. This modeling incorporates both hydrologic and hydrogeolic components in an integrated model allowing for a more in depth analysis of the interactions between surface water and groundwater.

***Approach*:**

The following steps are required to set-up, calibrate/validate and apply the hydrologic model for a particular watershed:

- Delineate subwatershed/subcatchment boundaries. These will be chosen in consultation with the study team, but will include all required flow points of interest (including monitoring stations, erosion sites, hydraulic features such as wetlands, on-line detention ponds and hummocky detention areas) and will be based upon major characteristics of the subwatershed as determined in Phase I. Urban (and potential urban), rural and wetland areas will be treated as separate elements. Because Upper and Mid-Spencer, as well as other subwatersheds within Spencer Creek supply input to Lower Spencer Creek, these subwatersheds will be modelled as well. It is anticipated that guidance from previous modeling work will be used as a starting point for catchment delineation, particularly the work initiated by Paulin Colibaly of McMaster University. This project developed a preliminary MIKE-SHE model for the Spencer Creek watershed on behalf of HCA.
- Soil type and land use area estimates. Quaternary Geology maps will be used to ascertain soil type groupings. This enhances integration between the hydrology and groundwater

components of the study, as both parts are using the same reference database. For each hydrologic source area, the representative drainage characteristics are well defined and summarized in the book, *"Hydrology of Floods in Canada"*.

- Guidance on parameter selection and model approach will also be taken from the report "Hamilton Conservation Authority Flood Plain Mapping Review" (Environmental Water Resource Group Ltd. 2010).
- Subcatchment characteristics include representative main and off-channel cross-sections to define the overland routing parameters. This allows the different responses between urban and rural areas to be modelled.
- Stream channel cross-section information is utilized for the channel routing procedures. Some new information will be collected in this study.
- Hydraulic control structures (e.g. wetlands, on-line ponds, or diversions) will be treated as separate elements with their own storage-outflow tables.
- For Historical modelling, hourly discharge measurements are available from Water Survey Canada for the gauge on Spencer Creek at Market Street (40 years), Spencer Creek at Highway 5 (24 years) and Spencer Creek at Westover (40 years).
- Daily climate information (maximum and minimum air temperature, daily rainfall and snowfall) is available from AES stations at RBG and Hamilton Airport.
- Peak flows, runoff and recharge volumes (water balance quantities) will be computed using the calibrated hydrologic model for various scenarios, including:
  - existing land use conditions;
  - future development scenario;
- Flood flow estimates will be made using the applicable Municipal design storms for return period events (2, 5, 10, 25, 50 and 100 year) and the Regional Storm pattern. The subsequent flows will be calibrated against those developed with the continuous model to ensure a representative floodline estimation. Recharge and runoff volumes (Water Balance) will be assessed using the continuous modeling approach.
- Low flow frequency estimates (2, 5, 10, 25, 50 and 100 year) will be made based on output from the hydrology model for a 30 plus year simulation.
- Information regarding future development will be established by the Project team from discussions with the Steering Committee.
- Climate change impacts will be assessed using a risk management framework e.g. by assessing risk associated with a shift in the frequency response curve.

Deliverables:

- A hydrologic model of the study watershed, setup for existing and post-development scenarios (with and without controls).
- Computer files for the hydrologic model, both event related and continuous simulation and watershed data files supplied in electronic format.
- Hydrology Report summarizing model setup, calibration/verification, application of design storms, flood and low flow analyses, water balance calculations, flow duration curves and impact evaluations.
- In conjunction with the groundwater and water quality studies, the hydrologic model can be used to estimate the distribution of the water resources across the watershed, flow duration and critical flow exceedance information, recharge and discharge areas, existing recharge

rates, potential recharge rates, and recharge rates which might be associated with future development or management scenarios (with and without recharge enhancement facilities);

Phase 3 – Implementation

Purpose:
In this study component, the flood and erosion hazard and fish passage enhancement scenarios that were anticipated in Phase II will begin to occur, and the recommended strategies from Phase II need to be monitored.

HYDRAULICS

The hydraulics component will develop a strategy to reduce or eliminate the risk of flooding on public safety, public health, and property damage.

Phase 1 – Characterization

The Phase 1 Characterization will identify the flood plain along Lower Spencer Creek from Greensville to the outlet into Cootes Paradise and the location and number of buildings within the flood plain. Included will be a field survey to update culvert and bridge crossings and to field verify building locations. Representative cross-sections throughout Lower Spencer Creek will also be required to incorporate low flow information. The number of buildings within the flood plain will be determined for the Regional, 100, 50, 25, 10, 5 and 2 year return period storms. A climate change scenario will also be considered.

Existing HEC modeling will be reviewed and updated. Previous modeling includes:

- "Fill Regulation Mapping Spencer Creek" by C.C. Parker and Associates, 1976
- "Lower Spencer Creek Urban Design Study" Paragon Engineering Limited, 1992
- Crooks' Hollow Dam Removal Floodplain Mapping Update, Environmental Water Resources Group, 2011
- Other models as applicable associated with development in the watershed

Due to the age of some of the existing modeling it is anticipated that substantial effort will be required to update current information.

Floodplain mapping will follow the protocol established in the "HCA Flood Plain Mapping Review" Environmental Water Resources Group Ltd., 2010. This protocol is similar to that established in the 1989 Flood Damage Reduction Protocol program.

Comprehensive floodplain maps will be generated as part of Phase 1 based on the existing conditions scenario flows generated in the MIKE-SHE modeling. As Dundas is a two-zone special policy area, 100-year and Regional flow flood extents will be shown on final maps.

Phase 1 Characterization will also determine flood plain hydraulics and the impact of the flood plain on the watershed hydrology. Phase 1 will include coordinated efforts with the hydrologic analysis and the fluvial geomorphologic analysis.

Deliverables:

- Electronic copy of all hydraulic modeling files used to generate the model
- Tables indicating flooded properties under the 2, 5, 10, 25, 50, 100 and Regional storm events.

- A report containing relevant supporting documentation used to develop floodplain as outlined in the HCA Floodplain Mapping Review Document
- 1:2000 Floodplain maps for the 100-year and Regional Storms from the downstream side of Crooks' Hollow Dam to the outlet at Cootes' Paradise.

Phase 2 – Impact Analysis

Phase 2 Impact Analysis will determine the impact of future development and creek improvements on the flood plain characteristics for the Regional storm and 100 year through 2 year storm events. Future development will include land use scenarios for ultimate watershed development. The location and number of buildings will be identified. The impact of future development is the difference in the flood plain characteristics between existing and future conditions.

Modeling of flood, erosion, and fish barrier improvement scenarios will be completed to determine impacts on the floodplain of these remediation efforts.

Comprehensive floodplain maps will be generated as part of Phase 2 based on the future development scenario. 100-year and Regional flow flood extents will be shown on final maps.

Floodplain mapping will follow the protocol established in the "Flood Plain Mapping Review" Environmental Water Resources Group Ltd., 2010.

Phase 2 will include coordinated efforts with the hydrologic analysis, fluvial geomorphologic analysis and Aquatics analysis.

Deliverables:

- Electronic copy of all hydraulic modeling files for all scenarios investigated
- 1:2000 Floodplain maps for the 100-year and Regional Storms from the downstream side of Crooks' Hollow Dam to the outlet at Cootes' Paradise under future conditions incorporating the proposed improvement works.

Phase 3 – Implementation

Activities in the Phase 3 implementation will ensure that future creek improvements will not increase the risk to public safety, the risk to public health, and the risk of increased property damage.

Deliverables:

- A prioritization scheme will be developed for proposed works to establish an appropriate phasing of projects to maximize benefit and address hazards.

HYDROGEOLOGY

The objective of this study component is to characterize the geologic and hydrogeologic conditions for the Lower Spencer Creek subwatershed. Through this characterization, hydrogeologically sensitive areas, such as areas of significant recharge supplying significant aquifers, or areas of significant baseflow or upwellings that support fish habitat and the linkages between the hydrogeology and the other study components will be identified. Finally, the study will allow for the development of various guidelines, policies and recommendations intended to protect the groundwater resource and the development of a monitoring program to assess changes in groundwater quantity and quality with time.

Phase 1 – Characterization

In the Phase I component of the study, the major goal of the hydrogeology component will be the development of a hydrostratigraphic model of the subwatershed that can be used to define and understand the system, and also to model temporal changes to the system as a result of, for example, land use changes or climatic changes. In order to do this, the first task will be a synthesis and review of all existing data. Existing data that may be useful includes, but is not limited to: the MOE water well record database, the MOE records of Permits to Take Water, City of Hamilton hydrogeological research / reports of the region, Hamilton-Halton Source Water Protection reports, Ontario Base Maps, Ontario Geological Survey (GSC) maps, existing water supply sources, mapping and database generated by HCA in a 2005 project in association with OGS and consultants' reports. Once this information is reviewed and summarized, a database will be created for the subwatershed that will include the pertinent data that will enable future changes in any of the significant parameters, such as water taking or land use, to be included in the model. When possible, the data will be geo-referenced for use with GIS.

After reviewing existing data, data gaps will be identified with a field component developed to address these gaps as required.

Following the review and synthesis of all of the pertinent data in the database, the information will be incorporated within the integrated MIKE-SHE model. This will allow for straight-forward analysis of surface and groundwater interactions. Once streambed profiles and boundary conditions are incorporated into the model, it can be used for simulation and analysis of groundwater flow and transport. The model will be used as a tool to identify data gaps in hydrogeologically sensitive areas, delineate areas of significant groundwater recharge and discharge, and complete a preliminary water budget.

Once created, the model will be calibrated with existing stream flow data, as well as gauge data and water level data, where available. Stream flow data collected as part of HCA's monitoring program will be supplemented with additional stream flow data at a number of sub-catchments within the subwatershed. This information will also be used for the hydrology component of the study.

Deliverables:

- A database containing all existing hydrogeologic data for the watershed.
- A field program to fill in any data gaps.
- An integrated MIKE-SHE model capable of delineating areas of significant groundwater recharge and discharge, producing a preliminary water budget, and quantifying surface and groundwater interactions.
- Maps illustrating the data.

Phase 2 – Impact Analysis

Following the completion and calibration of the MIKE-SHE model of the subwatershed, an impact analysis will be completed. In this phase, following an accepted model for impact prediction, the groundwater and surface water resources will be assessed based on their sensitivity. The first component of the impact analysis will be the evaluation of the potential sources of impact from a proposed land use. Such sources include significant water takings (e.g. irrigation), reduction of recharge due to development, contaminant inputs, climate change etc. Reference to the Spencer Creek Stewardship Plans can assist with identifying possible hydrogeologic stresses in the watershed. The second component of the impact analysis is the identification of the impacts that can result from sources of impact. Such impacts include lowering of water level in aquifers, reduced baseflow to streams, reduced wetlands and the degradation of groundwater and surface water quality. With this information, a sensitivity analysis can be completed with the computer model to predict the magnitudes of the impacts resulting from the various sources in different areas of the subwatershed. For example, the potential effect that development in an important recharge area will have on groundwater supply or baseflow downgradient can be simulated in the model. Impacts of proposed creek restoration and flood and erosion reduction strategies will also be assessed.

Deliverables:

- Impact analysis of various watershed stresses on the groundwater regime.
- Assessment of proposed erosion and flood reduction strategies on groundwater regime.

Phase 3 – Implementation

Deliverables:

Areas determined to be hydrogeologically sensitive and/or requiring rehabilitation that will require some degree of protection will be presented. Recommended actions and associated time frames will be presented under the heading of Planning and Policy, Rehabilitation and Retrofit, Stewardship and Education, Research, Development and Monitoring.

WATER QUALITY

The objective of this study component is to characterize the existing and estimate the potential water quality conditions of Lower Spencer Creek and to use these results to provide input to the recommended subwatershed plan. Interpretation of the water quality results, gained through the integration of both chemical and macroinvertebrate (biological) data, will primarily focus on the impact to the health of the fish communities of Lower Spencer Creek.

Phase 1 – Characterization

All relevant documents and data will be collected and reviewed to determine their applicability in assessing the existing water quality conditions in the subwatershed. Documents to be reviewed include relevant planning and servicing reports for the City of Hamilton, assimilative capacity and other studies for the Dundas Sewage Treatment Plants (STPs), and the Certificate of Approval for the Dundas STP. Data sets to be reviewed include:

- water chemistry data from the three Provincial Water Quality Monitoring Network (PWQMN) stations on Spencer Creek as well as historical PWQMN information,
- water chemistry data from Ancaster Creek analyzed by the City of Hamilton
- benthic information from Ontario Benthic Biomonitoring Network (OBBN) Stations,
- HCA fish monitoring records and historic fisheries information,
- flow data from Water Survey of Canada's gauge stations on Spencer and Ancaster Creek,
- annual reports from the Dundas STP.
- Water Quality Monitoring Review for Hamilton Conservation Authority by Donald G. Weatherbe Associates Inc. 2011
- Any available stormsewer discharge data for outlets to the creek

Results of statistical summaries and trend analysis of the PWQMN data will be integrated with the benthic and fisheries results. The Weatherbe Associates Inc. report provides analysis of existing water quality sampling data. Information gaps will be identified and the need for fieldwork will be assessed to fill in these gaps. In addition, flows from the Market Street gauge station will be analysed for low flow conditions and extrapolated to the STP discharge point for the purposes of assimilative capacity analysis.

The baseline health of the macroinvertebrate community in Lower Spencer Creek will be based on three existing stations (one annual station and two Year 2 stations) in the Lower Spencer Creek subwatershed and at least five other stations sampled specifically for the subwatershed study. At the least, diversity (Shannon-Weiner), % EPT, Hilsonhoff Biotic Index, Taxa Richness, and % Dominance will be used to assess the health of the benthic community at each site. In addition, any studies from the City of Hamilton will also be considered as part of assessing water quality conditions with respect to the fisheries.

The results from the water quality assessments will be integrated with fisheries, hydrogeology and fluvial geomorphologic assessments and summarised in the Phase I Characterization Report.

Deliverables:

- A summary of the water quality assessment and classification of water quality based on reach.
- Maps illustrating the status of the water quality throughout the study area.

Phase 2 – Impact Analysis

Alternative scenarios will be reviewed to assess potential impacts (positive or negative) to watershed health, including water chemistry and benthic communities, as they relate to fisheries health. Impacts based on changes in land use and population will be used to estimate potential changes to water chemistry and benthic communities. Results will be compared to Provincial Water Quality Objectives and other relevant standards. Depending on the extent of changes in the alternative land use scenarios, impacts to water quality from land use changes will also be considered using a simple loadings model.

For each sub-catchment in Lower Spencer Creek, changes in the condition of benthic macroinvertebrates will be estimated based on:

- current conditions
- predicted changes in substrate
- predicted changes in groundwater flows
- predicted changes in riparian canopy
- predicted changes in nutrient and dissolved oxygen levels
- predicted changes in percent impervious area.
- predicted changes resulting from climate change

Deliverables:

The results from the testing alternatives will be integrated with results from other disciplines. Documentation of the testing methods and interpretation of results will be provided in the Phase II Impact Analysis Report.

Phase 3 – Implementation

Deliverables:

Recommendations to achieve optimal water quality will be provided under the following subject headings:

- Planning and Policy (i.e. recommendations to protect aquatic and riparian habit in areas with sensitive communities)
- Rehabilitation and Retrofit (i.e. impacts of fish barrier remediation)

- Stewardship and Education (i.e. recommendations for preventing pollution at source)
- Research and Development (i.e. recommendations for future studies)
- Monitoring (i.e. monitoring for expected changes)

FLUVIAL GEOMORPHOLOGY

The objective of this study component is to develop, assess and select a preferred Stream Corridor Restoration Plan based on geomorphic considerations with due regard for the integration of other sciences, and project goals. The approach involves characterization of the behaviour of Lower Spencer Creek and estimation of the potential impacts that can result from changes in land use, flow and sediment regimes. This is done through a combination of geomorphic analysis of field data and hydrology based modeling. This component of the study will also provide:

- Methodologies to develop constraint delineation associated with channel thresholds and stream corridor extent;
- Recommendations for a monitoring program which will provide data for constraint delineation, and monitor the status of the sensitive reaches and threshold indicators; and,
- Recommendations for an implementation strategy, which will consider goals for rehabilitation and retrofit while being mindful of fish passage enhancement targets.

Phase 1 – Characterization

An extensive background review will be undertaken to ensure the use of existing information, to identify data gaps and to identify subsequent short term and long term monitoring needs. Review shall include the City of Hamilton Watercourse Erosion Restoration Implementation Plan completed by Aquafor Beech in 2011 as well as other relevant studies. Lower Spencer Creek will be characterized through a hierarchical approach, starting at the basin scale and working down to the reach and site level. A data summary and analysis of the relationships between land/water processes and linkages will also be undertaken to determine channel sensitivities and thresholds.

Approach:
Establish goals and objectives with the study team.

Review all relevant documents and mapping to identify data gaps and to develop a preliminary list of processes and limiting factors that are operating within Lower Spencer Creek. Since there is relatively little data on Lower Spencer Creek a considerable field program is warranted.

A geomorphic analysis will be conducted to determine the character and behaviour of Lower Spencer Creek. The steps involved in the analysis include:

- Description of the form and stability of the system. Stability will be characterized using RGA and RSAT techniques.
- Delineation of Management/Response Reaches
- Analysis of downstream trends in channel morphology and factors affecting stream stability
- Analysis of temporal trends in the discharge record (e.g. cumulative departure curves)

- Document the location and nature of sediment sources
- Determination of rates of change (e.g. dendrochronology on point bars, aerial photo analysis, resurveying historical cross sections)
- Determination of geomorphic thresholds of stability for use in impact analysis (e.g. Phase II)
- Determine fisheries and geomorphic linkages (e.g. relating channel form/stability measures to biological integrity measures)
- Determination of risks to existing infrastructure resulting from creek processes
- Assessment of impacts resulting from historical channelization and hardening treatments

A modeling analysis will be conducted to develop indices of change. These indices will be correlated with observed changes noted in the geomorphic analysis for the historical period examined. These relations form the basis for prediction of future impacts and the assessment of management prescriptions (Phase II). The steps involved in this analysis include:

- Flood frequency analysis for normal periods using partial duration series for formative discharges.
- Comparison of erosion thresholds to percent exceedance
- Prediction of channel enlargement from percent impervious and comparison with measured data (if available)
- Development of regime equation for the prediction of channel width (e.g. w = f[Q, s, d50]).
- Analysis of stream power conditions (e.g. generation of stream power index from HEC RAS modeling).
- Develop relations between above variables and measured indices of channel stability and aquatic community health

Deliverables:

- A delineation of the study area into reaches including classification of each reach
- Establishment of a long-term monitoring program

<u>Phase 2 – Impact Analysis</u>

This phase will focus primarily on assessing the impacts of possible future land use changes on the geomorphic processes in the Lower Spencer Creek Watershed. Liaison with the other component leaders is essential to assess the implications of land use change on flow and sediment regimes, and its relationship to fish habitat and channel stability. This phase will also identify opportunities for protection, enhancement, rehabilitation and development.

Solutions to address existing creek erosion / instability issues and improve fish passage will be presented.

Approach:

Provide recommendation on required corrections to stream morphology to address flooding and erosion concerns under a future flow scenario. Assess aquatic resources and identify recommendations for improvement of aquatic habitat, including in stream, stream bank and flood plain habitat enhancement, removal of barriers, and retrofitting existing altered habitats. The assessment will relate physical characteristics/processes of the aquatic environment to biological communities.

Prepare a conceptual design of any recommended changes to stream morphology.

Detailed analysis of both bank erosion and stability will be provided for future flow conditions. Recommendations will be provided on how to address erosion and instability issues in relation to current stream layout and geometry, and under any proposed changes to stream location, form, and geometry.

Deliverables:

- Recommended approaches for reducing flood and erosion risk and improving fish passage
- Conceptual designs to support recommendations

Phase 3 – Implementation

This phase involves the development of a prioritization plan for the proposed works developed in Phase 2.

Approach:

The works proposed in Phase 2 will be assessed based on degree of urgency, cost, aquatic impact, and access constraints.

Deliverables:

- A table ranking the proposed works in order of priority will be established.

TERRESTRIAL

The objective of this study component is to characterize the terrestrial systems within the Lower Spencer Creek Subwatershed (which includes both upland, wetland and riparian areas, as well as other related features); assess their roles and significance within the system; analyze potential impacts from future land use changes; and, finally to prepare a set of management recommendations to further their long term protection, enhancement and to facilitate the establishment of a monitoring program. This approach will rely on the *Ecological Land Classification for southern Ontario* (Lee et.al., 1998) and the principles of landscape ecology.

Phase 1 – Characterization

The Ecological Land Classification System provides a consistent means of identifying, classifying and mapping natural communities (e.g. old fields, woodlands and wetlands) that are 0.5 hectare or larger. These methods will form the basis from which the landscape in the subwatershed will be analyzed.

HCA has recently completed community series mapping for the Lower Spencer Creek Subwatershed based on 2009 aerial photography. The community series identifies the habitat classification (ex. Forest habitat – deciduous)

Other features to mapped and/or documented include evaluated and unevaluated wetlands, significant wildlife habitat, species at risk (SAR) element occurrences, SAR regulated habitats, Environmentally Significant Areas, significant woodlands, significant valleylands, other corridors, Areas of Natural and Scientific Interest and Niagara Escarpment Protected Area. In addition, existing reports and mapping will be reviewed and integrated into the analysis as appropriate.

Detailed fieldwork will be carried out during the spring and summer and fall to provide detailed information on priority areas. Fieldwork will result in a refinement to information on classification of vegetation communities, breeding bird surveys (following the *Ontario Breeding Birds Atlas* protocol), waterbodies, incidental wildlife surveys, breeding amphibian surveys (following the *Marsh Monitoring Protocol*) species at risk, and the identification of significant wildlife habitat as well as existing levels of disturbance. Reconnaissance level fieldwork will also be carried out in other areas to verify the mapping and classification of terrestrial features. The terrestrial system within the Subwatershed will then be analyzed and a determination of the significance of individual areas or patches will be made.

Deliverables:

- Mapping delineating the Land Classifications and significant habitat features within the watershed.
- A summary report outlining the results of all field work completed.

Phase 2 – Impact Analysis

Following the characterization, an assessment of potential impacts from land use changes can be initiated. The sensitivity to change will be determined for each area identified in Phase 1. Impacts from land use change scenarios will then be assessed based on the individual and cumulative interactions of other study components (hydrology, hydrogeology, fluvial geomorphology) on the terrestrial system as well as direct impacts resulting from physical changes to the landscape.

Phase 3 – Implementation

Upon completion of the impact assessment, a series of management recommendations will be prepared dealing with "Planning and Policy", "Rehabilitation and Retrofit", "Stewardship and Education", "Monitoring" and "Research and Development". Specific areas will be identified for protection and/or restoration as will time lines and cost estimates.

AQUATICS

The objective of this study component is to characterize the fish communities that provide an integrative environmental indicator of the health of their respective subwatershed. The sensitivity of the fishery, including the physical and chemical habitat requirements, needs to be understood in order to prevent, mitigate or correct any degradation. The impact of fish barriers, engineered channels and water quality within Lower Spencer Creek will be determined. This information will provide baseline monitoring data and the ability to model impact predictions. This approach is supportive of the Federal Fisheries Act and the Hamilton Harbour and Watershed Fisheries Management Plan (HHWFMP).

Phase 1 – Characterization

All fish collection records available for the study area will be summarized with emphasis on the presence of indicator species. Additional fish collections will be made if gaps or particular areas of concern are identified. Stream classification consistent with the HHWFMP will be assigned. Lower Spencer Creek does support a coolwater fishery. It is recommended that 2 new fish collection sites be considered further upstream in a protected Escarpment area and another where a headwater area may be developed.

Spawning surveys of Rainbow trout (*Oncorhynchus mykiss*) and Chinook salmon *(Oncorhynchus tshawytscha)* will be completed to identify critical habitats for protection and as a fisheries monitoring tool. This information is also valuable when correlated with important discharge areas identified in the hydrogeology component. Some trout (brook and to a lesser extent brown) rely on groundwater discharge areas to incubate their eggs over the winter.

Fish habitat conditions will be interpreted using biological (fish and macroinvertebrates), geomorphological, hydrological, hydrogeological and water quality data. Observations from experience in the subwatershed(s) will also be integrated.

Existing recreational uses of the creek in terms of fishing opportunities and the passive observation of fish spawning will be presented. The need for a fish food contaminant analysis will be assessed and recommendations forwarded to the Ministry of Environment.

Phase 2 – Impact Analysis

Following an accepted model of impact prediction based on proposed changes, fish communities will be assessed based on their sensitivity and stream classification. Impacts usually relate to key parameter changes identified from hydrology, hydrogeology, geomorphology, terrestrial or riparian ecology, and water quality components. It is assumed that indicators such as changes in groundwater recharge and peak flows related to urbanization will be considered. Thermal

impacts from stormwater management is also a concern requiring analysis. Sewage treatment and water taking may also be considered for assessment.

Targets for fish passage will be established for the various fish species in Lower Spencer Creek and integrated with stream morphology component to establish barrier remediation objectives. An analysis of the proposed creek improvements will be completed and benefits to fish habitat quantified.

Phase 3 – Implementation

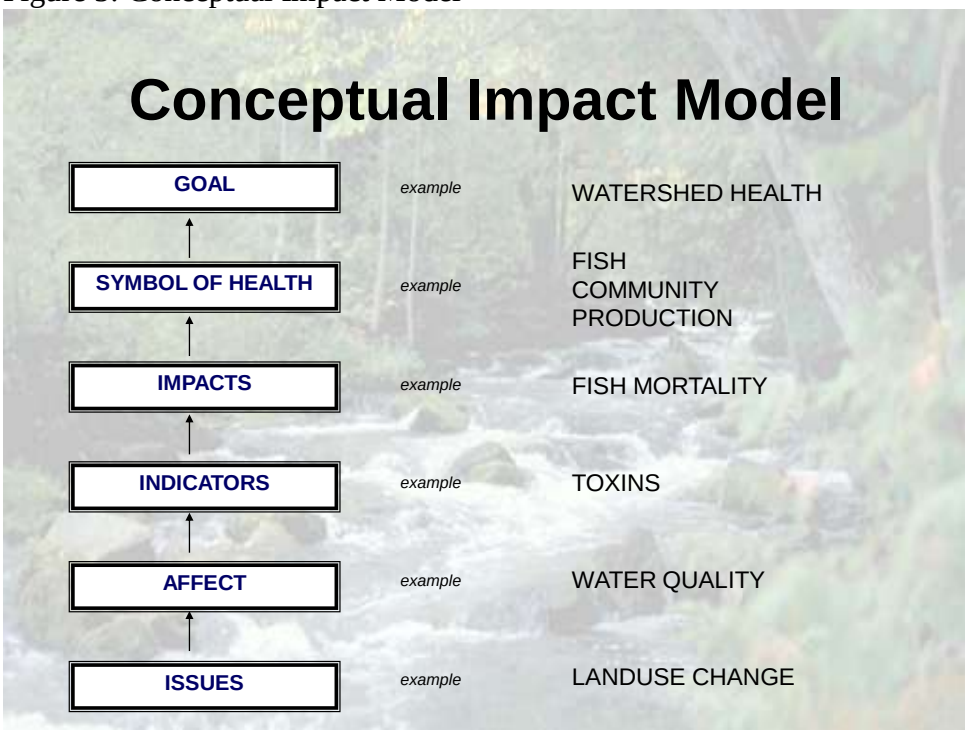
Areas and targets for protection and rehabilitation will be presented in relation to the most limiting factors to fish productivity. Recommended actions and associated time frames and costs will be presented under the headings of Planning and Policy, Rehabilitation and Retrofit, Stewardship and Education, and Research and Development.

INTEGRATION

In the context of watershed and subwatershed planning the science of integration is employed to connect scientific disciplines (e.g. hydrology, fluvial processes, aquatic habitat etc.) to establish linkages between environmental features and their functions both spatially and temporally (Figure 5). In other words, determining how the natural system works in generating the ecosystem we see.

In this manner integration is used as a tool to establish critical indicators in the ecosystem that are sensitive to change. An impact analysis can then be carried out to assess the resilience of key linkages to the change by employing the use of an impact model. In this manner the proposed change can be assessed to see if desired goals are met.

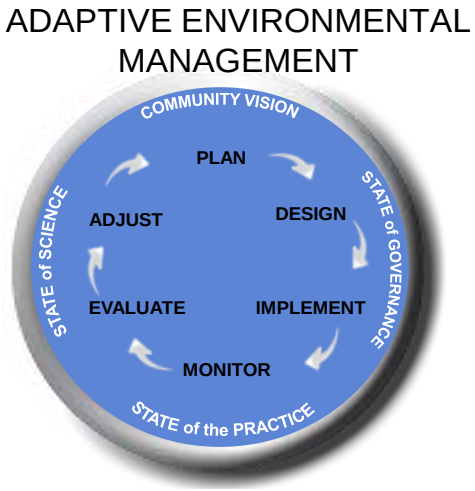
Figure 5: Conceptual Impact Model



Integration as a concept can also be used to manage vital resources on a watershed basis in order to achieve good water quality, healthy fish populations i.e. maintaining resilient healthy watersheds. For example, water is managed by many agencies in Ontario with overlapping and duplicating mandates. Integration of the various mandates can be achieved by Agreements to achieve a "co-management" approach to managing vital resources if strong science-based watershed and subwatershed plans are in place with which to manage.

The principle of adaptive management is fully embraced in watershed and subwatershed plans. The 4 phases when complete results in a watershed/subwatershed plan which puts forward a management approach to be implemented. Follow-up monitoring would allow for evaluation and identify the need for adjustment when next the plan is updated. The concept of integration is imbedded in all 4 phases of an adaptive management approach (Figure 6).

Figure 6: Adaptive Environmental Management



SUPPORTING FUNCTIONS

The objective is to provide the necessary support to all study components and the overall study. These components include Project Management, Mapping (GIS support) and Communications.

Project Management

This function will provide direct project coordination of the subwatershed study components and will include monitoring expenses, schedules, chairing meetings and public information centres, report writing and printing and responding to questions. The study project manager will liaise with City staff for overall coordination.

Mapping

This function will provide and create all mapping requests for all study components as well as creating displays for the communications function. All GIS generated mapping will be delivered to the City of Hamilton upon completion of the study.

Communications

Communications activities will act as a catalyst to help the community to have meaningful opportunities for participation and better understand the subwatershed study findings and to implement the study's recommendations. This plan will follow the Conservation Ontario Class EA process including three Public Information Centres.

A Stakeholder Advisory Committee may also be established to act as community liaisons. This group would be comprised of individuals and local NGO's such as Royal Botanical Gardens, Trout Unlimited, Dundas Resident's Association, etc.

The communication activities for the study will respond to community needs as determined by the Stakeholder Advisory Committee. They will also be designed based on the type of information to generated as the research progresses. Examples of some of the type of activities that could take place in response to community and study needs include:

- presentations by HCA staff and/or project team members to special interest groups
- public open houses including displays
- guided bus tour of areas of special interest or concern
- four page, colour insert into local newspapers
- partnership with local educators to have students conduct parts of the field work as a learning experience

HCA will be establishing a website which will highlight the progress and findings of this project. In addition, the site will include reciprocal links between it and the sites of other interested community partners.

REPORTING

Meetings

See schedule in Appendix 1. Attendance at additional meetings may be requested by the City or HCA.

Reports

Ten draft and ten final hard copies of reports have been budgeted. Electronic copies of all reports and modeling input and output will be produced at the conclusion of the study.

Communication

All materials needed for focus group and Steering Committee meetings will be produced by HCA. Any mailouts will be the responsibility of the City of Hamilton.