STORM DRAINAGE POLICY

May 2004

Hamilton

PHILIPS ENGINEERING

CITY OF HAMILTON

STORM DRAINAGE POLICY

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Foreword to Users

This document is intended for a wide variety of users including:

- City of Hamilton staff
- Land Development industry
- Private Landowners
- Public Agencies
- General Public

This document is intended to:

- Outline storm drainage policy to be applied within the City of Hamilton.

- Specify storm drainage requirements to be applied to all new land development, re-development of existing lands, as well as the City of Hamilton Capital Works projects, where appropriate, for storm sewer system extensions and for reconstruction of existing infrastructure.

- Specify requirements for storm drainage design and reporting at various stages of the land development process.

- Provide reference and context to applicable federal, provincial, and Municipal policies and regulations which must be considered when planning or designing storm drainage systems.

There are several companion documents that support the Policy, including various Official Plans, Vision 2020, Hamilton Harbour Remedial Action Plan, as well as numerous federal and provincial publications.

The four most notable local (municipal) documents are:

- Development Engineering Guidelines - *draft
- Guidelines for Stormwater Infrastructure Design - *draft
- Existing Sewer Bylaws from each former Municipality
- Parkland Dedication Policy

The first document provides specific direction to new development that includes all services, process and criteria for same. There is some overlap with the Policy; however, in the overall context of stormwater and drainage management, the Policy provides upper level direction while the Development Engineering Guidelines outlines the specific application of the policies and criteria.

The Guidelines for Stormwater Infrastructure Design differs from the Policy as follows: the Policy explains "what" is required by the City for stormwater and drainage management; whereas, the Guidelines provide specific direction on "how" the City wants the stormwater drainage system designed. The Policy is intended for a broader audience including the public, Council, planners, developers and engineers, whereas the Guidelines are more specifically used by City staff and engineering consultants supporting development applications.

CITY OF HAMILTON

STORM DRAINAGE POLICY

1. INTRODUCTION

The City of Hamilton, (ref. Figure 1), has established the Storm Drainage Policy for use in the planning and design process for land development and redevelopment and storm drainage infrastructure within the municipality. Compliance will ensure that future urban growth and redevelopment will be provided with sustainable, safe, economical, and effective storm drainage systems.

1.1 Objectives and Goals

The primary goals and objectives for stormwater and drainage management within the City of Hamilton have been derived from four sources:

- Official Plans of former municipalities of Hamilton, Ancaster, Dundas, Flamborough, Glanbrook, Stoney Creek, as well as the Regional Municipality of Hamilton-Wentworth
- Federal and provincial policies, mandates, and regulations
- Riparian rights and obligations
- Local community design standards

The goals of the Storm Drainage Policy are to:

i) Provide present and future residents of the City of Hamilton with good engineering design that provides a high quality living environment that protects and enhances natural features and minimizes pollution of water, air, and land resources.

ii) Minimize risk to life and property from flooding and erosion.

iii) Encourage the use of stormwater as a resource such that it maintains and/or enhances:

- In-stream Water Quality
- Fisheries and Aquatic Habitat
- Hydrogeologic Function (i.e. baseflow, groundwater quality)
- Natural Channel Forming Processes (stream morphology)
- Terrestrial Linkages and Habitat

iv) Mitigate negative impacts to water resources, which would affect other riparian interests and users.

v) Provide direction for designs of stormwater infrastructure which are easily and effectively maintainable by the City's Public Works Department.

vi) Establish criteria for acceptable service levels for the hydraulic capacity of both the minor and major drainage systems to provide reasonable levels of service for the connected property owners.

Subsequent to the foregoing goals, the following Policy objectives have been derived:

(a) Commit to comprehensive water resource planning on a watershed and subwatershed basis.
(b) Minimize potential health hazards, as well as risks of loss of life and property damage from flooding, erosion and adverse environmental effects.
(c) Minimize changes to natural stream channel forming processes and erosion due to land use change.
(d) Minimize degradation of ground and surface water quality resulting from land use change.
(e) Minimize sediment loading to receiving waters from construction activities.
(f) Protect and enhance aquatic and terrestrial habitat.
(g) Encourage on-site infiltration of stormwater where conditions permit in order to maintain or enhance baseflow in receiving waters.
(h) Address existing and potential sources of pollution by implementing policies and standards as established by the Province or other organizations having jurisdiction.
(i) Encourage the reduction of combined sewer overflows where practical.
(j) Permit new development only on lands that can physically provide major and minor storm outlets and can safely convey major and minor storm flow within allowable conditions, as stated within the Criteria and Guidelines for Stormwater Infrastructure Design Manual. Ensure the safety of human life and property and the environment such that provincial environmental standards related to water quality are satisfied.
(k) Ensure that development of any nature in the City does not create the need to upgrade at the City's expense, drainage infrastructure currently considered adequate, based on future land use as per the City's Official Plan.
(l) Encourage the integration of passive recreation uses with stormwater management works, within the conditions of the current and governing Parkland Dedication Policy.
(m) Encourage retrofitting of existing infrastructure to provide stormwater management where no quantity or quality control is currently provided, where conditions permit, through a "cash-in-lieu" process or other relevant programs.

1.2 Historic Perspective

The current City of Hamilton constitutes an amalgamation of the historical communities of Hamilton, Ancaster, Dundas, Flamborough, Glanbrook, Stoney Creek and the Region of Hamilton-Wentworth (ref. Figure 1). These municipalities were amalgamated on January 1, 2001. Prior to amalgamation, each area municipality (except Hamilton) managed its own storm drainage system. The former Regional Municipality of Hamilton-Wentworth had jurisdiction for storm drainage on Regional roads and in the former City of Hamilton.

Historically, each of these municipalities, except the former City of Hamilton, managed their storm drainage system in generally the same way with differences related to physical setting or past development. The following table describes some of the key differences between the former municipalities, notwithstanding there are exceptions and the list is offered only for context and is not intended to be exhaustive:

TABLE 1 COMPARISON OF FORMER AREA MUNICIPALITIES STORM DRAINAGE SYSTEM CRITERIA AND POLICY					
Former Municipality	**Minor System Criteria**	**Foundation Drainage Requirements [2]**	**Combined Sewers**	**Roof Leader Policy**	**Major System Criteria**
Hamilton	18 – 50 yr [1]	Gravity	Yes	Direct to Sewer	100 yr
Ancaster	2 yr	Sump Pumps	No	Surface	100 yr
Dundas	2 – 5 yr	N/A	No [3]	N/A	100 yr
Flamborough	2 – 5 yr	Gravity/ Sump Pumps	No	Surface	100 yr/Regional [4]
Glanbrook	5 yr	Sump Pumps	No	Surface	100 yr
Stoney Creek	5 yr	Gravity	No	Surface	100 yr

[1] 1942 - 1992 (inclusive) used an 18 year storm event; post 1992 used 50 year. Both design storms uses in Modified Rational Area Method

[2] Foundation drainage requirement exceptions are currently permitted upon receipt of a SWM report.

[3] The Pleasant Valley neighbourhood (Dundas) only has a combined sewer system permitted by By-Law.

[4] Regional event is Hurricane Hazel

1.3 Description of the City of Hamilton

Settlement in the current City of Hamilton dates back to the 1740's. Most of the early development occurred within Dundas and the northwest and north-central parts of Hamilton. Post Second World War saw rapid expansion of 'Hamilton Mountain' area. The 1970 – 1980 era saw significant residential development and growth in the Stoney Creek and Ancaster areas. From the 1990's to present, growth has continued in the Hamilton Mountain area, as well as the other communities, with particular emphasis on residential growth in Ancaster, Flamborough (Waterdown) and Glanbrook. As of 2001, the City of Hamilton's population was estimated to be approximately 503,000. In 2003, the City of Hamilton's population was the fourth largest city in Ontario and ninth largest in Canada.

The City is rich in natural resources including:

- Cootes Paradise
- Hamilton Harbour
- Niagara Escarpment
- Beverly Swamp
- Eramosa Karst
- Several waterfalls, including: Grindstone, Borer's, Tews, Websters, Shermon, Tiffany, Chedoke, Buttermilk, Albion, Felker's and Devil's Punch Bowl.
- Several Conservation Areas

The City is comprised of both an urban and a rural component with its land mass split between four Conservation Authorities: Hamilton Conservation Authority, Grand River Conservation Authority, Niagara Peninsula Conservation Authority and Conservation Halton (ref. Figure 2).
Some of the prominent watersheds which drain the City include:

Watershed	Conservation Authority
Bronte Creek	Conservation Halton
Grindstone Creek	Conservation Halton
Big Creek	Grand River Conservation Authority
Fairchild Creek	Grand River Conservation Authority
Ancaster Creek	Hamilton Conservation Authority
Battlefield Creek	Hamilton Conservation Authority
Borer's Creek	Hamilton Conservation Authority
Chedoke Creek	Hamilton Conservation Authority
Fifty Creek	Hamilton Conservation Authority
Red Hill Creek	Hamilton Conservation Authority
Spencer Creek	Hamilton Conservation Authority
Stoney Creek	Hamilton Conservation Authority
Sulphur Creek	Hamilton Conservation Authority
Tiffany Creek	Hamilton Conservation Authority
Forty Mile Creek	Niagara Peninsula Conservation Authority
Twenty Mile Creek	Niagara Peninsula Conservation Authority
Welland River	Niagara Peninsula Conservation Authority

2. LEGISLATIVE FRAMEWORK

The science of stormwater management has progressed rapidly in the past decade with an increasing emphasis on the linkages between the management of stormwater and the impacts on other resources such as: stream forming processes, groundwater, and aquatic and terrestrial resources. Accordingly, a growing number of these linkages have been identified through various federal, provincial and municipal policies and regulations.

Figure 3 illustrates primary legislation affecting stormwater management and stream valleys and watercourses.

Table 2.1 provides a summary of the current primary policy documents and guidelines with reference to the agencies responsible for administration of each policy.

Users of this document are encouraged to contact the responsible agencies to ensure that the most current legislation/policy and the most current versions of reference manuals, guidelines, and policies are referenced.

TABLE 2.1
SUMMARY OF PRIMARY POLICIES AND GUIDELINES AFFECTING STORMWATER MANAGEMENT IN THE CITY OF HAMILTON

Category	Objectives	Document Reference	Agency Responsible for Administration
Watershed Planning [1.]	Integrated ecosystem planning of water and water related features and functions	Towards an Ecosystem Approach to Land Use Planning: A Biophysical Environment Perspective, 1992 MOEE Water Management on a Watershed Basis: An Ecosystem Approach, 1993, MOEE Subwatershed Planning, 1993 (Interim Guidelines), MOEE Hamilton Harbour Remedial Action Plan Hamilton Harbour Watershed Urbanization and Land Management Program	Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton Ministry of Environment Environment Canada Bay Area Restoration Council
Environmental Assessment	Protection and conservation of the environment	Environmental Assessment Act, 1975, MOE Canadian Environmental Assessment Act, Canadian Environmental Assessment Agency, 1992 Municipal Class Environmental Assessment, MEA, 2000	Ministry of Environment Environment Canada Department of Fisheries and Oceans City of Hamilton
Water Quality	Protection of surface and groundwater quality	MOEE Water Management Policies; Guidelines, Provincial Water Quality Objectives July, 1994 ("The Blue Book") Planning Act 1996 Provincial Policy Statement "Water Quality and Quantity" Regional Municipality of Hamilton-Wentworth Pollution Control Plan	Ministry of Environment City of Hamilton Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton
Stormwater Management	Management of stormwater quantity and quality from new development. Protection of groundwater quality and quantity	Urban Drainage Design Guidelines, MOE, MMA, MTO, MEA, ACAO, UDI, 1987 Stormwater Best Management Practices MOE 1991 Stormwater Management Practices Planning and Design Manual, MOE, June 1994 Stormwater Management Planning and Design Manual, MOE, March 2003	City of Hamilton Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton Ministry of Environment Ministry of Natural Resources
Natural Hazards (Flooding and Erosion)	Protection of life and property from flood and erosion damage	The Planning Act, 1996 "Understanding Natural Hazards", MNR, 2001 Provincial Policy Statement "Natural Hazards" The Drainage Act (R.S.O. 1990) Conservation Authorities Act	Ministry of Natural Resources Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton
Stream Morphology	Design and management of stream channels/floodplain based on natural fluvial principles.	Natural Channel Systems, an Approach to Management and Design, MNR 1994	Department of Fisheries and Oceans Conservation Halton Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority
Fisheries	Protection of fish and fish habitat including water quality, hydrologic regime	Fish Habitat Protection Guidelines for Developing Areas, MNR, March 1994	Department of Fisheries and Oceans Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton
Sediment and Erosion Control	Prevention/control of erosion and sediment deposition damage	Erosion and Sediment Control Guidelines for Construction Sites, 1987, MOEE Sediment and Erosion Control Guideline, Grand River Conservation Authority Keeping Soil on Construction Sites, HRCA, 1994 Hamilton Harbour Remedial Action Plan	Hamilton Conservation Authority Niagara Peninsula Conservation Authority Grand River Conservation Authority Conservation Halton City of Hamilton
Storm Sewers		MOE Guidelines for Storm Sewers Interim, 1985 Ontario Water Resources Act, 1990	Ministry of Environment City of Hamilton

MOE Ministry of Environment
MOEE Ministry of Environment and Energy
MMAH Ministry of Municipal Affairs and Housing
MEA Municipal Engineers Association
ACAO Association of Conservation Authorities of Ontario
UDI Urban Development Institute
HRCA Hamilton Region Conservation Authority
MNR Ministry of Natural Resources

1. In the case of the Conservation Authority's, the proponent should reference the Watershed Plan (ref. Appendix "A")

The policies are intended to complement the foregoing. Hence, the key objective of the Policy is to guide the user to:

- Complementary federal and provincial policies and legislation
- City of Hamilton's policy, criteria, and role in implementation of the foregoing policies
- Application of stormwater management techniques or practices unique to the City of Hamilton.

Although stormwater management planning and design is influenced by mandates of various Ministries and public agencies, the City of Hamilton plays a central role in integrating the objectives of each policy into new development and redevelopment, and associated stormwater management works, as well as bearing ultimate responsibility for operation, ownership and maintenance of such works. Hence, the City's Planning and Development Department's primary objectives must include ensuring the economic sustainability and functional effectiveness of stormwater management works within the City.

2.1 Drainage Infrastructure Planning and Design

There are three main legislative vehicles for the planning and design of stormwater management and associated infrastructure:

- Environmental Assessment Act (Municipal Class Environmental Assessment Process)
- Planning Act
- Ontario Water Resources Act (Stormwater Management Planning and Design Manual, MOE, March 2003)

Protecting the function and quality of water resources, which form a basic element of natural ecosystems through proper stormwater management is essential to a successful, sustainable community. This concept has led to the acceptance of using the watershed boundary as an appropriate basis for land use planning.

Figure 4 provides an overview of the inter-relationship of watershed planning and land use planning.

2.1.1 Master Planning and the Class Environmental Assessment Process

The master planning concept represents the integration of long range planning and environmental assessment and has been recognized in the "Stormwater Management Planning and Design Manual", Ministry of Environment, March 2003 or latest edition.

This approach incorporates the following environmental planning principles:

i) Consultation with affected parties early and throughout the process
ii) Consideration of a reasonable range of alternatives
iii) Identification and consideration of the effects of each alternative on all aspects of the environment
iv) Systematic evaluation of alternatives in terms of their advantages and disadvantages to determine their net environmental effects
v) Provision of clear, complete documentation of the planning process to allow for traceability of the proponent's decision-making process

A Master Plan prepared according to the foregoing principles usually will have fulfilled Phases 1 and 2 of the Municipal Class Environmental Assessment (EA) Process (ref. Figure 5). There are four different approaches to master planning set out in Appendix 4 of the Municipal Class EA.

Class EA studies include documentation of the foregoing process, usually in the form of a Project File Report (Schedule B) or Environmental Study Report (Schedule C).

The following information is required to be included within the Project File or Environmental Study Report:

(a) Background to the project and earlier studies
(b) Nature and extent of the problem or deficiency, to explain the source of the concern and the need for a solution
(c) Description/inventory of the environment
(d) Alternative solutions considered and the evaluation process followed to select the preferred solution
(e) Final design selected and reasons for its selection
(f) Follow-up commitments, including any monitoring necessary
(g) Effects of the final design on the environment and a description of the mitigating measures to be employed to minimize adverse environmental effects
(h) Description of public consultation program employed and how concerns raised have been addressed

2.1.2 Planning Act

Stormwater management needs and opportunities must be identified at the earliest stage of the planning process. As a result, the City of Hamilton's Planning and Development and Public Works Department strongly encourages the preparation of master servicing plans with land use studies. This process is typically best addressed at the time of Secondary Plan preparation through the production of support subwatershed plans. All of the foregoing should follow guiding principles as set out in the Official Plan and senior governing documentation, such as Watershed Plans.

3. GENERAL STORM DRAINAGE POLICIES

Stormwater generated from development areas involves many varied and complex processes unique to each drainage system. Stormwater management methods identified in Watershed Plans should work towards satisfying basic principles that inherently incorporate the positive characteristics of natural drainage. These include reduced flow velocities, natural storage, and the provision of infiltration and recharge areas where appropriate. The inclusion of these natural attributes in urban drainage designs constitutes accepted stormwater management practice. Appropriate application of these techniques will afford an effective means of mitigating impacts on runoff quality and quantity in developing areas while maintaining aesthetics, and environmental function and form. The following section summarizes the primary stormwater management principles.

3.1 Management of Runoff Quantity

Urbanization causes increases in runoff volumes and rates due to an increase in impervious area and changes in conveyance systems. Without proper stormwater management, these increases may result in flooding and erosion.

3.1.1 Flooding Management

The specified level of control for subject lands in the City of Hamilton is designated by a Watershed/Subwatershed or Master Drainage Plan where they exist. Such plans account for additional constraints (i.e. economic and physical limitations) which may limit the capacity of proposed stormwater management systems. Such plans may also demonstrate that the existing downstream capacities are sufficient to accommodate local increases in post-development peak flows (i.e. oversized sewers or watercourse reaches with adequate capacity and resistance to flow increases).

Local Conservation Authorities through their mandate to control flooding and limit flood damage have developed criteria for runoff control. Hence, application of these criteria through a co-ordinated approach to drainage planning on a watershed and subwatershed basis is required to ensure effective runoff control and minimization of flood damages.

Several municipal jurisdictions have implemented a **"zero increase in peak runoff rate"** policy for controlling post-development runoff. While this type of policy provides simple and clear direction regarding stormwater management flood control, a uniform application of this type of policy does not consider the potentially negative effects on watercourses from extended periods of controlled peak discharge (i.e. increased erosion).

In cases where no Master Drainage Plan (MDP) or Watershed/Subwatershed Planning has been completed or development lands are considered as external drainage areas to a MDP, watershed/subwatershed planning areas, consultation with the City shall determine if runoff peak flows shall be controlled to pre-development levels or alternative stormwater management is required. Discussion with the City's Planning and Development Department shall be required to determine the scope of assessment based on the potential impact on the receiving storm system (ref. Conditions for Practice). Should the proponent establish to the satisfaction of the City's Planning and Development Department that the potential impact of the proposed development would be minimal, the City's Planning and Development Department could decide that detailed modelling and analysis may not be required, as per the Conditions of Practice within the Criteria and Guidelines for Stormwater Infrastructure Design Manual. Should the City's Planning and

Development Department deem a more detailed assessment appropriate, the proponent would need to demonstrate through appropriate modelling and analysis that uncontrolled flow will not cause detrimental impacts on downstream properties and watercourse systems as per the Criteria and Guidelines for Stormwater Infrastructure Design Manual. At the development application stage, before the City's Planning and Development Department will accept an increase in runoff rates, the proponent must also receive endorsement from the agencies having jurisdiction. Over-control of runoff (i.e. less than pre-development runoff) may also be required as it relates to downstream constraints. Flooding management policy with respect to the combined sewer system is described within Section 3.1.4.

3.1.2 Watercourse Erosion Control

Due to urbanization, the rate that uncontrolled runoff can accelerate the natural evolutionary processes of a watercourse depends upon topography and soil conditions. When erosion and/or bank instability is probable (e.g. from outlets from future development areas), the proponent shall either provide effective on-site or system controls (e.g. end-of-pipe controls), stabilize the receiving watercourse by appropriate remedial measures, or contribute to a fund designated towards future watercourse improvements, typically identified in Watershed and Subwatershed Plans. Should on-site or system controls not adequately control flows below the receiving system's erosion threshold, either off-site watercourse remedial measures or contribution to a fund shall be required.

Requirements for erosion control will generally be determined through upper level studies such as Watershed/Subwatershed/Master Drainage Plans. In these cases, the proponent(s) will be required to provide mitigation in accordance with the Watershed or Subwatershed Plans or with the Master Drainage Plans, as well as policies of the local Conservation Authority.

In areas where no Watershed, Subwatershed Plan or Master Drainage Plan exists, it shall be the responsibility of the development proponent to mitigate potential erosion impacts in accordance with Provincial Guidelines, unless it can be demonstrated through appropriate modelling and/or analysis that erosion processes will not be adversely affected by the proposed development.

In areas where the downstream receiving watercourse is determined to be unstable, or where control/over control of flow rates is either not possible or not feasible, design of watercourse alterations would be considered subject to design in accordance with Natural Channel Design principles.

The City of Hamilton supports Natural Channel Design Principles, as specified by the Province in Natural Channel Systems, "An Approach to Management and Design", MNR, 1994 (or most recent update) and "Adaptive Management of Stream Corridors in Ontario", MNR 2002 (or most recent update) Implementation of Natural Channel Design principles on area watercourses shall follow the guidance within the Criteria and Guidelines for Stormwater Infrastructure Design Manual. Any watercourse alteration shall be designed to the future flow regime with stormwater management controls in-place.

Storm sewer outfalls in natural channels should be provided with proper protection against erosion, which includes appropriate bank scouring protection on either side of the outfall and creek. When storm sewer outfalls outlet to steep and/or deep valleys, drop structures shall be designed in such a manner as to ensure bank stability. Such local erosion protection measures shall be designed so as not to interfere with the natural channel forming processes of the receiving watercourse system. Natural channels shall be designed to accommodate various flow regimes resulting from phased stormwater management measures.

Although both swales and ditches only provide a flow conveyance function and not the natural channel form, swales and ditches should be designed with appropriate erosion protection. Erosion protection measures shall be provided at storm outfalls and for the swale/ditch according to erosion thresholds.

3.1.3 Conveyance System

The **minor system** conveys urban drainage from relatively "minor" storms, typically having a frequency (return period) of between two and ten years in most southern Ontario municipalities. These works typically consist of storm sewers, inlet systems, catchbasins, roadway gutters and swales, foundation drains and roof leaders. Their purpose is to prevent frequent flooding which may inconvenience motorists, home and business owners, and pedestrians. The Criteria and Guidelines for Stormwater Infrastructure Design Manual provides specific criteria for design of the minor system.

Flows in excess of the minor system capacity (i.e. during periods of surcharging) are referred to as **major system** flow. The major system inherently comprises the minor system, as well as the overland route followed by runoff not captured by the minor system (i.e. either due to excessive flow or operational failures). Common elements of the major system include natural streams, valleys, swales, ponds, roadways, drainage channels, walkways and easements.

The design storm usually applied to major system components ranges from a return period of 25 to 100 years, up to the Hurricane Hazel Regional Storm event.

Minor System

The minor or convenience system, comprising street gutters, catchbasins and storm sewers, shall be designed to the appropriate frequency storm event, as specified within the Criteria and Guidelines for Stormwater Infrastructure Design Manual, without surcharging. Where new minor systems are designed for a higher return period event than the existing receiving infrastructure, appropriate stormwater management would be required to limit peak runoff to the receiving system.

The City's Planning and Development Department will not allow development to proceed until adequate storm drainage has been provided. Generally the City's Planning and Development Department requires the design and approval of storm sewers to serve urban road cross-sections. In some instances, the City's Planning and Development Department may approve the use of semi-urban standards for new development, which would be serviced by open roadside ditches.

The proposed minor system shall be designed to ensure that the interception capacity of inlets (including ditch inlets, manhole covers, catchbasins, etc.) is comparable to the design conveyance capacity of the system conduits. Where system surcharging is a perceived hazard by the City's Planning and Development Department (e.g. basement flooding for a 100 year event or more frequent), the proponent will be required to conduct a detailed hydraulic analysis of the storm sewer system under extreme flow conditions (i.e. 1 in 100 years) to ensure new development does not impact existing development. The Criteria and Guidelines for Stormwater Infrastructure Design Manual provides general guidelines for minor system hydraulic analysis.

For new development, basement floor elevations shall be constructed above the maximum 100 year hydraulic grade line; this may entail using inlet control devices in existing catchbasins. No surcharging should occur within either the existing or proposed storm sewer during the design storm event (ref. Criteria and Guidelines for Stormwater Infrastructure Design Manual) used in establishing the proposed storm sewer design. Should the existing sewer system be surcharged

under the design storm event, no increase in existing surcharge levels should result from the proposed development.

Major System

The City of Hamilton supports the policies of the local Conservation Authorities (i.e. Hamilton Conservation Authority, Grand River Conservation Authority, Niagara Peninsula Conservation Authority and Conservation Halton) which generally require that no new building be subject to flood damages from the Regulatory flood as per the Technical Guidelines for Flood Plain Management in Ontario (MNR, 1986 or subsequent updates). The Regulatory flood is the greater of the Regional Storm [Hurricane Hazel flood (transposed)], modelled 100 year flood, observed flood, or frequency-based 100 year flood.

The Conservation Authorities Act (RSO 1980, Chapter C27, Section 28(1) or subsequent updates) allows Conservation Authorities to regulate the construction of any building or structure in any area susceptible to flooding as a result of a *"regional storm".* In addition, the Act gives the Authorities the right to regulate the placement of fill in any defined part of the area (where fill schedules are in place) over which it has jurisdiction, which in the opinion of the Authority will adversely affect the erosion, flooding, pollution, dynamic beaches or the conservation of land within a subject watershed.

The City of Hamilton defines Hazard Lands as having *"inherent environmental hazards"* such as flood susceptibility, erosion susceptibility, or any other physical conditions, which might be severe enough to pose a threat to the occupants. The Conservation Authorities also have regulations and definition of Hazard Lands. The Conservation Authority's Hazard Lands would be within City of Hamilton's Hazard Lands definition.

No development, other than necessary access or services, shall intrude upon Hazard Lands. In conjunction with this policy the City's Planning and Development Department shall require the developer at the Draft Plan stage to delineate floodplains in a proposed development resulting from the 100 year flood and Regional Storm for both the pre- and post-development conditions.

In addition to the formally regulated components of the major system, the balance of the roadway network in subdivisions, along with primary designated swales must be able to convey the 100 year flood without flooding private property and without exceeding flooding depths above the roadway crown, as per the Criteria and Guidelines for Stormwater Infrastructure Design Manual.

Where a new minor system designed using the design storm frequency as per the Criteria and Guidelines for Stormwater Infrastructure Design Manual, drains to existing infrastructure designed for a higher return period storm, provision shall be made at the interface, where practical, for capture of upstream major system flows up to the available downstream capacity using ditch inlets or catchbasins. Unless agreed by City's Planning and Development Department staff, due to special site circumstances, there should be no off-site increase in major system flows.

3.1.4 Combined Sewer System

The older parts of the City of Hamilton are served by combined sewers where a single sewer system conveys both sanitary sewage and stormwater runoff. During dry weather and light rainfall, the combined sewers convey all flows to the Woodward Avenue Wastewater Treatment Plant (WWTP). During heavy rainstorms, flows that exceed the capacity of the sewer system and/or the WWTP are diverted away from the WWTP. These combined sewer overflows (CSOs) are necessary in order to minimize basement flooding and overloading of the WWTP. In some areas,

the CSOs are captured by underground detention storage tanks that store the sewage during wet weather. The CSO tanks are filled by gravity, and when flows subside after a rainstorm, their liquid contents are drained and/or pumped back into the combined sewer system and conveyed to the WWTP where they receive treatment. The City of Hamilton's CSO Pollution Control and Prevention Plan establishes water quality objectives at CSOs and identifies solutions to reach these objectives. The installation of additional CSO tanks or treatment options at all remaining unregulated CSOs are examined within this document (ref. "Pollution Control Plan", Paul Theil Associates Ltd., Beak Consultants Ltd., 1991).

In accordance with MOE guidelines, it is the current practice of the City's Public Works Department to not construct any new combined sewer systems. Where an increase in hydraulic capacity is required, the City's Public Works Department will consider the installation of a storm relief sewer adjacent to the existing combined sewer. Local or temporary overflows between the two systems prevent the surcharging of the combined sewer system. In these cases, certain existing storm private drains, catchbasins and storm inlet chambers are disconnected from the combined sewer and connected to the new storm relief sewer. All future storm private drains, catchbasins and storm inlet chambers would be required to be connected to the storm relief sewer. All existing single private drains conveying combined sewage remain connected to the original combined sewer. At this time, private drains and yard sewers from the main sewer to the building are owned and maintained by the property owner.

The City has initiated discussions with the MOE and obtained approval in principle to replace the combined sewer with a single combined sewer with increased hydraulic capacity. Replacement of combined sewers are an option only if installation of a storm relief sewer is not possible due to physical constraints, or produces limited benefits to sewer separation.

3.2 Management of Runoff Quality

3.2.1 General

Urbanization typically increases the contaminant load (i.e. sediment, metals, nutrients, bacteria) to natural stream systems. To mitigate this effect, stormwater quality treatment is required for all new development and redevelopment (including reconstruction of roadways with additional lanes, widening and cross-section revisions as required by review on an individual case basis by the Ministry of Environment) within the City of Hamilton, except for areas draining directly to a combined sewer system.

Stormwater quality treatment should provide a comprehensive approach to both surface runoff and groundwater. Thus, as a general consideration, maintenance of the natural hydrologic cycle including infiltration is encouraged and the use of stormwater management practices (SWMP) which enhance or maintain infiltration should be considered for each development.

Generally, active infiltration measures, such as soakaway pits and rear yard ponding, will be most applicable in permeable soils areas and their use will require supporting soils property documentation. Passive measures such as disconnection of roof leaders have been historically applied in many areas and shall be implemented in all areas unless specific constraints (such as in the former City of Hamilton and Town of Dundas where zero lot line construction on narrow width lots is permitted, or in the older City of Hamilton downtown areas where there is insufficient pervious area) preclude these measures. In all cases, the potential for groundwater contamination shall be considered where infiltration of road runoff is contemplated. In areas where hydrogeologic concerns are identified, particularly in areas where groundwater is used for human consumption

and/or critical linkages to fisheries habitat are present, additional study and analysis may be required to determine the appropriate level of mitigation.

Stormwater quality treatment measures shall adhere to the specific guidelines for stormwater management practices that have been developed by the Province (ref. Stormwater Management Planning and Design Manual, Ministry of Environment, March 2003, or subsequent updates).

3.2.2 Existing Water Quality Policies

The design of stormwater quality facilities shall conform to existing Provincial requirements (ref. Stormwater Management Planning and Design Manual, MOE, March 2003, Water Management Policies, Guidelines Provincial Water Quality Objectives (Blue Book), MOEE, 1994), as well as current policies within the City of Hamilton (i.e. Hamilton Harbour Remedial Action Plan, Vision 2020), or subsequent updates of the foregoing. The main objectives of the above provincial requirements and municipal policies are:

The Stormwater Management Practices – Planning and Design Manual, MOE, March 2003 states that *'The manual was prepared to provide a holistic approach to stormwater management, beginning at the watershed and subwatershed level, and extending to the subdivision/site plan level.'* The manual outlines the requirements for stormwater quality measures.

The Water Management Policies, Guidelines Provincial Water Quality Objectives (Blue Book), MOEE, 1994, *"contains the Ministry of Environment and Energy policies and guidelines for the management of the province's water resources. It gives direction on how to manage the quality and quantity of both surface and ground waters'*.

The Hamilton Harbour Remedial Action Plan (1992) provides a plan of action designed to systematically address identified ecological restorative opportunities and identifies specific preventative measures. Its purpose is in part to bring about sustainable natural ecosystems in the Hamilton Harbour and throughout its watershed by improving conditions within the following pertinent project categories:

1. Water quality and bacterial contamination
2. Toxic substances and sediment remediation
3. Research and monitoring
4. Fish and wildlife
5. Watershed management (urbanization and land management)
6. Education and public information
7. Public access and aesthetics

The Vision 2020 Strategies for a Sustainable Community, 1998, provides for the following goals for improvement of the quality of surface and groundwater resources within the City of Hamilton:

- *'To ensure the water quality is not affected by run-off and sedimentation due to changes in the landscape.'*

- *'To ensure the quality of groundwater throughout the Region is suitable for drinking and is a source of pure recharge for surface waters.'*

In addition to the provincial and municipal water quality policies, adherence to Watershed and Subwatershed Plans is required in developing water quality management strategies for new

development and redevelopment. The development proponent shall consult with the City of Hamilton's Planning and Development Department to determine the existing watershed and subwatershed plans pertaining to the development study area.

3.2.3 Stormwater Management - New Development

All new development shall implement a stormwater quality management strategy, which considers surface runoff and groundwater in compliance with the existing provincial and municipal policies.

3.2.4 Stormwater Management - Existing Development

In areas of existing development where re-development is proposed, requirements for stormwater quality measures will be evaluated on a site-specific basis with regard to the feasibility of implementation. Where on-site measures are considered infeasible or in areas serviced by combined sewers, the City of Hamilton's Planning and Development Department may consider the potential for contributions to off-site improvements in the form of a cash-in-lieu policy, as in the current Provincial Stormwater Management Planning and Design Manual, March 2003, or subsequent updates. In order to appropriately direct these resources, a Master Storm Water Quality Plan (a regional assessment to identify retrofit locations and costs) is being contemplated by the City's Public Works Department. A 'pilot' study has been prepared for the former community of Stoney Creek.

3.2.5 Combined Sewer Overflow Policy

In situations where existing developments are to be redeveloped and there is a requirement for increased hydraulic capacity to meet the governing standard as set out in the "Criteria and Guidelines for Stormwater Infrastructure Design Manual", it is the current policy of the City's Public Works Department that the installation of a relief storm sewer be considered. In certain instances, as outlined in section 3.1.4, the City's Public Works Department may recommend the combined sewer to be reconstructed to improve local hydraulics.

3.2.6 Spill Management

In addition to providing a stormwater quality strategy, proponents of industrial and commercial developments which use, produce or refine liquid products which could impact water quality within the municipal storm system and/or receiving water body, shall, in addition to complying with the water quality protection provisions contained in the Sewer Use By-law and the Sewer and Drain By-law, provide an adequate spill control strategy to ensure that potential spills will not impact downstream water quality.

4. CASH-IN-LIEU POLICY

In areas of existing development where re-development is proposed, provisions for water quality measures will be evaluated on a site-specific basis, and shall consider the feasibility of implementation. Where on-site measures are considered infeasible, the City of Hamilton's Planning and Development Department may consider the potential for contributions to off-site improvements in the form of a cash-in-lieu policy. In addition, consultation with Conservation Authorities and the Ministry of Environment should evaluate potential impacts of re-development without stormwater quality measures on the receiving system to determine if a cash-in-lieu approach would be appropriate.

In order to appropriately direct these resources, a long-term regional assessment (i.e. Master Stormwater Quality Plan) that identifies retrofit locations and costs is being contemplated by the City's Public Works Department. The Master Stormwater Quality Plan would be based on the former City of Stoney Creek Stormwater Quality Management Strategy Master Plan, which may allow the City's Planning and Development Department to determine a stormwater quality rate for infill developments not providing on-site water quality control measures. The stormwater quality rate may be developed by considering the total required capital funding for the water quality retrofit sites and dividing the cost between the infill developments on a proportionate area basis. Stormwater quality development charges for infill developments will generally be less than the cost of equivalent on-site quality control measures.

In the interim period prior to the development of a City-wide Master Storm Water Quality Plan, for infill development and redevelopment sites outside of the Community of Stoney Creek, requirements for water quality measures shall be considered on a site-specific basis. Where on-site water quality controls are considered infeasible and a cash-in-lieu approach is considered appropriate by the Conservation Authorities and Ministry of Environment, the City's Planning and Development Department, in consultation with the proponent, shall determine a potential cash-in-lieu amount for an individual infill/redevelopment site. The cash-in-lieu amount will be used by the City's Planning and Development Department to fund retrofit projects to be identified in its Master Stormwater Quality Plan.

5. PLANNING AND DESIGN PROCESS

The amount and quality of information available at the Master Planning (Watershed and Subwatershed) and local Stormwater Management Plan stages are distinctly different. The information that should be presented with the respective submissions is correspondingly different.

Where a Functional Stormwater Management Plan is being produced for a site where no Master Planning has been undertaken, the requirements of the Master Planning methodology shall govern (as outlined below). If a Master Plan has been prepared, the Stormwater Management Plan requirements must be satisfied.

5.1 Stormwater Management Planning Process – An Overview

Typically, stormwater management planning and design occurs through a multi-phase process which is completed in concert with the land use planning process. The following preferred hierarchy of planning studies in the City of Hamilton has been identified (ref. Criteria and Guidelines for Stormwater Infrastructure Design Manual for reporting structure):

Watershed Plans ⇨ **Broad, Multi-objective Proponents**

Subwatershed Plans

Master Drainage Plans ⇨ **Multiple Development Proponents**

Tertiary Planning and Design Studies

Stormwater Management Plans ⇨ **Single Development Proponent**

- **Functional Design**
- **Detailed Design**

5.2 Watershed/Subwatershed Planning

5.2.1 Introduction

Changes in the manner in which society has considered the natural environment over the past decade have led to significant changes to the planning and design process of communities and their associated infrastructure. Formerly, land use and infrastructure planning was driven by narrowly defined "convenience and public safety" objectives. Currently the emphasis has shifted to an ecosystem-based approach which encompasses, in a more rigorous manner, sustainability of development in the context of the carrying capacity of key components of the natural systems.

This fundamental change in the way current society plans and operates communities and related infrastructure has similarly led to significant changes in the management of stormwater.

Water resources are a key element in the function of natural ecosystems; hence, the protection of the functions of water and stormwater resources through proper stormwater management is paramount to a successful sustainable community. This concept has led to identification of the watershed boundary as an appropriate basis for land use planning and water resources management.

5.2.2 Objectives

Water resources management on a watershed basis has been advocated by the Province of Ontario as an ecosystem approach to land use planning. The objectives of the ecosystem (i.e. Watershed/Subwatershed) approach to land use planning include:

- Provision of watershed-wide policies and performance objectives
- Identification of opportunities to integrate stormwater management with passive recreational opportunities in accordance with the current Parkland Dedication Policy
- Understanding ecological form and function of the watershed unit
- Identification of ecosystem carrying capacity for sustainable development
- Protection/Enhancement of valley and green space linkages (internal and external)
- Management of water quality and quantity impacts in a co-ordinated fashion throughout the watershed
- Minimization of the cost and amount of stormwater management infrastructure through co-ordinated planning

5.2.3 Role in Land Use Planning

The City of Hamilton's Public Works and Planning and Development Departments support the implementation of Watershed/Subwatershed Planning Studies in concert with the land use planning process. Watershed/Subwatershed planning plays an important role in the development of Official Plan Land Use Designations and Secondary Planning. Existing Watershed/Subwatershed Planning Studies are listed in Appendix "A".

The necessity of a Watershed/Subwatershed Planning Study for Official Plan Amendments, Secondary Plans or individual developments will be determined by the City of Hamilton's Public Works and/or Planning and Development Department, the development proponent(s), the local Conservation Authority, Ministries or other public agencies having jurisdiction.

5.2.4 Decision-Making Process

The rationale and justification to undertake Watershed/Subwatershed Planning Studies must include consideration of:

- Type and extent of proposed land use changes
- Area of land use change with respect to the total watershed/subwatershed area
- Physical sensitivity/significance of the receiving watercourse
- Hamilton Harbour Remedial Action Plan objectives
- Existing downstream conditions and land use (i.e. flood and erosion hazards, water usage)
- Opportunities to improve stormwater quality both within and downstream of existing development
- Location and characteristics of the development area with respect to the potential to provide integrated servicing and stormwater management which would minimize the City's Public Works Department long term maintenance and operation cost.

5.2.5 Management and Funding

Generally, Watershed and Subwatershed initiatives are completed through a Study Team/Steering Committee, with appropriate Public consultation at various stages in the study in accordance with Municipal Class EA requirements. Generally the Steering Committee will consist of representatives

from the City's Planning and Development Department and Public Works Department, the local Conservation Authority, development proponent(s), Ministries or other public agencies and the Public. The cost of the study is normally funded by the development community with potential for Public funding dependent on the nature of the study and opportunity to address existing community problems (i.e. erosion, water quality retrofits) which would be determined by the City of Hamilton's Public Works Department at the time of commencement of the study design.

The final draft Watershed/Subwatershed Plan study must be circulated for comment to the Public and agencies prior to endorsement by the local Conservation Authority and City of Hamilton Council.

It is important to recognize that each Watershed/Subwatershed Plan will have widely varying goals and objectives specific to the issues within each area. For these reasons the study objectives, organization, and funding arrangements will necessarily differ for each study.

5.2.6 Development in the Absence of Watershed/Subwatershed Planning

Much of the development within the City of Hamilton has occurred prior to the widespread application of Watershed/Subwatershed planning, with numerous parcels of land currently in various stages of the planning process. Hence, much of the future development within the City of Hamilton will occur in the absence of specific direction from Watershed/Subwatershed Plans. In these situations stormwater management and drainage considerations have often been guided through narrower and more locally based Master Drainage Plans. The City of Hamilton recognizes that due to recent advances in stormwater management practices and associated policy changes, many Master Drainage Plans did not address current requirements with respect to water quality, fisheries habitat protection and stream morphology. Hence, these issues must be addressed through subsequent site specific stormwater management plans or through updates of the Master Drainage Plans.

5.3 Master Drainage Planning

Traditionally, Master Drainage Plans have been used by municipalities to evaluate and regulate proposed development in order to minimize runoff impacts. Through systematic analysis of post-urbanization conditions, various drainage constraints can be identified and alternative solutions subsequently recommended. A Master Drainage Plan identifies both the minor (convenience) and major systems, and provides information regarding design criteria of system elements. In summary, the principle objectives of a Master Drainage Plan are to:

- Establish basic watershed conditions (peak flows, runoff volumes, inventory of major hydrologic/hydraulic elements)
- Identify drainage constraints relating to existing and future flows as development comes on line
- Screen various stormwater management strategies and techniques and evaluate a reasonable range of alternatives
- Recommend stormwater management solutions based on sound economic evaluation of various feasible alternatives within the framework of this document
- Prepare general drainage plans, outlining both the major and minor systems along with detailed flow limits at critical points.

The current planning process, with its emphasis on an ecosystem approach, represents a natural progression to a more holistic approach to stormwater management. Notwithstanding this change in planning approach, much of the current and short-intermediate range development has been planned according to the Master Drainage Plan process and is legally bound to the recommendations of the current Master Drainage Plans.

Depending on the status of various development proposals, developments may also be required to meet current water quality and fisheries habitat protection requirements in addition to current Master Drainage Plan requirements. In such cases it may be advantageous to update the current Master Drainage Plan to ensure that the remaining development meets current legislative requirements and standards in an integrated manner. This would avoid a more costly, less effective site-by-site approach. There would still be a need for a stormwater management report detailing how the site will conform to the Master Drainage Plan.

Requirements or opportunities to update existing Master Drainage Plans to address current legislative requirements will be determined through consultation between the development proponent(s), City of Hamilton and public agencies with related mandates. The primary criteria used to evaluate requirements to update Master Drainage Plans include:

- Planning status of adjoining developments and neighbourhoods
- Size and relationship of development with respect to proposed stormwater management facilities
- Potential to minimize capital or long term operation and maintenance costs to the City's Planning and Development Department and Public Works Department respectively through consolidation of stormwater management facility locations
- Changes in land use designation

If through the foregoing consultation an update of the existing Master Drainage Plan is not warranted, the developer will be required to incorporate the necessary water quality and fisheries habitat protection measures into site specific stormwater management plans.

5.4 Tertiary Planning and Design Studies

This intermediate level of study may be required in areas where multiple land ownership within the subwatershed occurs. This level of study focuses on integrating servicing and stormwater management of adjacent development to a greater level of detail than is normally achieved through the Subwatershed and Master Drainage Plan. Typically this study is required if the Subwatershed or Master Drainage Plans have been completed prior to the development of preferred land use and lot plans. The objectives of this level of study are to determine:

- Preferred servicing plan
- Road layout
- Integration of stormwater management facilities
- Opportunities to integrate passive recreation opportunities with stormwater management subject to the current Parkland Dedication Policy
- Phasing and cost sharing in areas of multiple ownership

The decision as to whether a Tertiary level design study is warranted will be determined through consultation between the various development proponents, the City of Hamilton's Planning and Development Department, and depends on:

- Level of planning information completed in the Secondary Plan process such as road layout, facility locations, and municipal servicing concept
- Number of development proposals/proponents involved in the study area and opportunity to integrate facilities and phase developments

5.5 Stormwater Management Plans

Stormwater Management Plans are prepared in support of individual development applications. The plans complement the planning process associated with Draft Plans of Subdivision or individual Site Plans. Stormwater management reporting associated with this planning stage would be in the form of a Functional Design Report. Subsequently, in support of final subdivision design, a Detailed Design Report is required.

5.5.1 Functional Design

This level of design typically involves demonstrating the feasibility of providing stormwater management for a particular development. In areas where no Master Drainage Plan or Subwatershed Plan has been completed, the Functional Design Report will be required to address additional issues such as environmental baseline conditions and screening of various stormwater management strategies and techniques as per the conditions of practice within the Criteria and Guidelines for Stormwater Infrastructure Design Manual. This may require a downstream impact assessment.

5.5.2 Detailed Design

The Detailed Design Report shall demonstrate how the required preliminary design, outlined in the Functional Design Report, has been integrated into the final design. As well, the Detailed Design Report will provide minor and major storm system design details, landscaping, safety and maintenance aspects of facility design, as well as outlining monitoring requirements. A summary of requirements is as follows:

- Minor drainage system including drawings illustrating all manholes, catchbasins, pipe sizes, slopes, and invert elevations at each manhole
- Major drainage system including drawings illustrating all roads, easements, pathways, ditches, swales, watercourses, with details including but not inclusive to typical sections, elevations and slopes
- Landscaping drawings for all stormwater management facilities
- Maintenance procedures, cost estimates and schedules for stormwater management facilities including schedule and specification of options for removal and disposal of accumulated sediments.

6. APPROVAL PROTOCOL

Pre-Consultation

Mandatory pre-consultation with the City's Planning and Development Department, Engineering Section is a condition of all development and redevelopment. The objective of pre-consultation is to exchange information between the City and the development proponent, including physical information such as legal plans, but also including proposed timelines and expectations. The goal of pre-consultation is to reduce the number of meetings and submissions later in the process.

Prior to the first meeting, the development proponent shall provide a general location map, a detailed location plan, development concept, and proposed timeline.

The development proponent shall undertake a similar pre-consultation meeting with the appropriate Conservation Authority (ref. Figure 2), to determine information regarding applicable standards and/or criteria and about environmental resources, including drainage outlet(s).

The City recommends that a concurrent pre-consultation meeting be scheduled with the local Conservation Authority and other agencies, such as MOE and MTO, as required.

APPENDIX ‘A’

LIST OF COMPLETED STUDIES

Appendix A : List of Completed Studies

1. Ancaster Master Drainage Plan, Philips Planning and Engineering Ltd., November 1987
2. Ancaster Industrial Park Drainage Areas No. 1 & 2 – (Older Reports)(Area 2 and Areas 1, 3, 4), A.J. Clarke and Associates, December 2002
3. Binbrook Urban Settlement Area and Southbrook on the Green – Stormwater Management Report, A.J. Clarke and Associates, November 2002
4. Borer's Creek Subwatershed Plan, Hamilton Region Conservation Authority, October 2000
5. Borer's Creek Floodline Mapping, M.M. Dillon Limited, November 1996
6. Borer's Creek Master Drainage Plan, Andrew Brodie Associates Inc, May 1983
7. Bronte Creek Watershed Study, Conservation Halton, December 2000
8. Clappison's Corner Industrial Business Park Master Drainage Plan, Totten Sims Hubicki Limited, January 1994
9. Grindstone Creek Watershed Study, Halton Region Conservation Authority, June 1998
10. The Grand Strategy (Grand River), Ministry of Environment, Grand River Conservation Authority, January 1994
11. Meadowlands Neighbourhoods 3, 4, 5, Planning and Engineering Initiative Ltd., A.J. Clarke and Associates Ltd., McKibbon Wakefield Inc., Lotowater Ltd., and Paradigm Transportation Solutions Limited, February 2000
12. Montgomery Creek Stormwater Study Management Class Environmental Assessment, Philips Engineering Limited, August 1997
13. Mount Hope Urban Settlement Area Master Stormwater Management Plan, Kenneth Youngs Engineering Incorporated, April 1995.
14. Mountain Brow Boulevard Crossing and Central Mountain Stormwater Management Environmental Assessment, Philips Engineering Ltd., September 2003
15. Niagara Water Quality Protection Strategy, Philips Planning and Engineering Ltd., CH2M, January 2003
16. Red Hill Creek Watershed Action Plan, Regional Municipality of Hamilton-Wentworth, October 1998
17. Spencer Creek Watershed Management Plan, Hamilton Region Conservation Authority, December 1997
18. Stoney Creek Flood Damage Reduction Study, Philips Planning and Engineering Ltd., June 1998
19. Stoney Creek Stormwater Quality Management Study, Philips Planning and Engineering Ltd., April 2004
20. Tiffany Creek Subwatershed Study, Hamilton Region Conservation Authority, July 2002
21. Watercourse No. 7 Creek System Improvement Class Environmental Assessment, Philips Planning and Engineering Ltd., September 2003.
22. Welland River – Flood Mapping Study, Philips Planning and Engineering Ltd., January 1999
23. Welland River Watershed Study, Niagara Peninsula Conservation Authority, November 1999