Niagara Peninsula Conservation Authority

Stormwater Management Guidelines

Report

Approved by N.P.C.A. Board on March 17, 2010

Niagara Peninsula Conservation Authority

Stormwater Management Guidelines

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Executive Summary

Introduction

Water is essential for all life. Clean and abundant water is necessary to maintain the health of our natural environment, and ultimately the residents who live there. In partnership with the Niagara Peninsula Conservation Authority and the Ministry of Environment, the Niagara Region initiated the development of the Niagara Water Quality Protection Strategy. The goal of the Strategy is to protect and provide for the sustainable use of Niagara's water resources, and to ensure safe and abundant water for current and future generations.

Since the release of the Niagara Water Quality Protection Strategy, the watershed partners have been working diligently on implementing the recommendations and actions identified in the Strategy. This Stormwater Management Policies and Guidelines document was commissioned as a Direct Action arising out of the Niagara Water Quality Protection Strategy.

This document is intended to provide a long-term plan to guide the safe and effective management of runoff in urban and urbanizing areas, while sustaining the health of local rivers and streams. This report will provide detailed stormwater management (SWM), erosion and sediment control policies and criteria for existing and proposed development in the Niagara Region and the NPCA watershed.

The Stormwater Management Policies and Guidelines document is meant to be used as a companion to local municipal stormwater management policies and guidelines. It is not meant to supersede local municipal criteria. Rather, the intent of this document is to attempt to provide a consistent approach to stormwater management planning for all municipalities within the NPCA watershed.

This Executive Summary has been prepared to provide an overview of the work completed, as well as a background on SWM. The information has been organized and is presented under the following headings.

- Section 1: Introduction
- Section 2: Overview
- Section 3: Background
- Section 4: Stormwater 101

Overview

The Stormwater Management Policies and Guidelines report will have an effect on future land use, growth, environmental, and financial objectives. Typically, without SWM, erosion, and sediment controls, urban growth can contribute to a rise in runoff volumes and peak flows. In turn, this can lead to flooding, degraded water quality and the destruction of aquatic and terrestrial habitat.

A number of watershed and subwatershed studies have been developed for the Niagara Region and the NPCA which will provide guidance on setting SWM, erosion, and sediment control targets. The coverage however is not complete and an approach will be required to consolidate the existing information and fill the gaps on an interim basis as further subwatershed strategies are developed.

It is important to ensure that the Stormwater Management Policies and Guidelines report is developed in a manner that will provide input to all municipality initiatives. This could include cost implications to by-law updates, technical guidance for stormwater design criteria, linkages with the Official Plan Updates, and input to budgets.

This report will build on existing information and previous studies, outline the existing policies and criteria, and identify and evaluate alternative policies and criteria to address current needs and future growth.

What is the Goal?

To reduce, and eventually eliminate if possible, the undesirable impacts of stormwater, erosion and sediment on the built and natural environment, re-establish the benefits of precipitation, and protect and enhance water quality in the Niagara Region and the NPCA's water sources that emphasizes environmental, social, and economic considerations.

What are the Objectives?

Rationalize SWM, erosion and sediment policies and criteria within the municipalities and to develop a uniform strategy to guide staff and decision-makers in the planning, design, implementation, monitoring and maintenance of associated infrastructure and facilities. This will be carried out through the following:

- The development of the framework for integrated SWM, erosion, and sediment policies and criteria (principles, goals and objectives, priorities for action, and integration with other plans);
- The identification of a streamlined, co-ordinated institutional process for delivering SWM, erosion, and sediment control services (i.e., clarifying roles and mechanisms for external communications and co-operations); and
- The development of needed support tools (e.g., SWM erosion, and sediment policies, guidelines, by-laws and implementation with the Official Plans).

Where is the study area?

The study area encompasses the current boundary for the NPCA watersheds, and includes all municipalities lying within and on the NPCA jurisdictional boundary.

What factors are involved in the study?

The characterization is broad in scope, and it includes the consideration of all factors influencing SWM, erosion and sediment polices and criteria development. Areas of investigation include:

- The policy development process, including a review of current practices, Official Plan policies relating to SWM, and municipal design standards;
- A review of applicable SWM legislation on a federal, provincial, and municipal level;
- The framework for Master Drainage Planning including: legislative framework, watershed and subwatershed planning, the Environmental Management Plan, Master Drainage Plans and studies, Adaptive Environmental Management and monitoring plans, and SWM retrofit studies;
- SWM opportunities and constraints related to development types (e.g., greenfield, brownfield, and greyfield development, redevelopment and infilling, and existing development);
- SWM requirements including relevant existing watershed and subwatershed plans, water quality (surface and groundwater), and water quantity;
- Hydrologic and hydraulic analysis including model and parameter selection, storm event duration and climate and rainfall data;
- SWM BMPs for at source controls, conveyance controls, and end-of-pipe, as well as site analysis for BMP consideration, treatment train evaluation of performance, and typical performance standards for BMPs;
- SWM facility design guidelines;
- Construction and sediment control requirements;
- Report submission requirements;
- The approval process;
- Monitoring and maintenance before, during and post construction;

- SWM system funding; and
- Recommended policies and criteria, including by-laws.

Background

SWM implementation for an urban area is applied directly through the built infrastructure. The planning objectives for this study focus on a process that will allow the proponent to identify, protect and preserve natural features, and consider their functional role in SWM planning. It includes:

- At source controls at the lot level to reduce runoff and reduce pollutants entering into the drainage system;
- Conveyance controls, such as grassed swales, roadside ditches and pervious pipes to reduce flows and remove pollutants;
- End-of-pipe controls to control flows and remove pollutants prior to stormwater entering the receiving system such as streams on other water bodies;
- Best available practices while integrating or enhancing existing natural features into the system;
- Identification of a review process that ensures all agencies the opportunity to review and comment on SWM reports and planning; and
- Reflection and incorporation of the SWM objectives set out in current OPs, existing watershed and subwatershed planning, and Master Drainage Planning, especially regarding flood protection, erosion and protection of the receiving natural environment

The intent of SWM planning is to mitigate the impacts that urbanization has on ‘natural’ drainage systems such as changes to runoff, flow, water quality, erosion and sedimentation characteristics. Generally however, predevelopment conditions are not ‘natural’ and use is typically under ‘agricultural land use’. That is why the goals and objectives in a watershed or subwatershed strategy typically are based upon environmental goals that are judged to be acceptable to the community and society as a whole and are achievable given existing conditions. Regardless, the SWM planning is developed to provide a design on how the stormwater drainage and management structure is to be built to meet accepted goals.

Can the problem be completely solved?

The urban landform is a major stressor on infrastructure and environmental conditions. As well, where development occurs and how developments are planned and built have very significant effects on this issue. Imperviousness represents the imprint of land development on the landscape. Increased impervious area results in changes in baseflow, peak flow, and total runoff volume. Therefore, current and future conditions have to be acknowledged in every SWM Strategy.

Stormwater 101

Urban Runoff Pollution

What is the Problem?

Urban land uses generate residual and waste material from a myriad of individual and group activities. Each type of land use has unique characteristics that result in the generation of pollutants and runoff volume. Density or intensity of the land use and percent imperviousness also play a part. These factors also influence the pollution prevention and flow reduction opportunities.

Pollution Sources:

- Vehicular traffic accounts for much of the build up of contaminants on road surfaces. Wear from tires, brake and clutch linings, engine oil and lubricant drippings, combustion products and corrosion all account for build up of sediment particles, metals, and oils and grease. Wear on road surfaces also provides sediment and petroleum derivatives from asphalt;
- Lawn and garden maintenance in all types of land uses, including residential, industrial, institutional parks, and road and utility right-of-way, account for additions of organic material from grass clippings, garden litter, and fallen leaves. Fertilizers, herbicides, and pesticides can also contribute to pollutant loads in runoff;
- Air pollution fallout of suspended solids account for build up of sediments contaminated from traffic, industrial sources, and wind erosion of soils;
- Municipal maintenance activities including road repair and general maintenance (e.g., road surface treatment, salting, and dust control);
- Industrial and commercial activities can lead to contamination of runoff from loading and unloading areas, raw material and by-product storage, vehicle maintenance, and spills of petroleum products;
- Illegal connections of sanitary services to storm sewers can cause contamination with organic wastes, nutrients, and bacteria;
- Illegal disposal of household hazardous wastes can introduce waste oil and a multitude of toxic materials into storm sewers;
- Transportation spills from accidents can occur on heavily traveled arterial streets and highways;
- Construction activity can introduce heavy loads of sediment from direct runoff, construction vehicles, and wind-eroded sediment;
- Pet feces and wildlife litter introduce organic contamination, nutrients, and bacteria;
- Combined sewer overflows (CSOs) contain a mixture of sanitary, commercial and often industrial waste, along with surface drainage. CSOs can contain high levels of nutrients, suspended solids, metals, organic contaminants, oxygen demanding substances, and dangerous bacteria and viruses; and
- Runoff from residential driveways and parking areas can contain driveway sealants, oil, salt, and car care products.

Pollutant Impacts:

The receiving water quality impacts of municipal discharges vary depending upon the quality and quantity of the wastewater and the assimilative capacity of the receiving water body. Potential water quality concerns resulting from CSOs and stormwater include:

- Bacteria from fecal material in pet and wildlife litter, and sanitary wastes in CSOs could cause beach closures;
- Nutrient enrichment, from nitrogen and phosphorous compounds, may lead to nuisance growths of algae in the receiving water body;
- Deposits of contaminated sediments, could lead to degradation of benthic (bottom-dwelling) organisms and restrictions on dredging;
- Toxicity from ammonia, metals, and organic compounds present in the runoff and overflows, and potential human endocrine disruption from pesticides;
- Oxygen depletion potential (‘oxygen demand’ or BOD) of the wastewater from biodegradable organic material, which may lead to oxygen deprivation of the organisms in the receiving water body;
- Temperature changes due to an influx of water warmed by the ‘heat island’ effect of roads and buildings;
- Aesthetic impacts from floatable matter and sediments e.g., litter, grass clippings, sanitary items, and soil erosion); and
- Contamination of groundwater with soluble organic chemicals, metals, nitrates and salt.

Hydrologic Cycle

The concept of the hydrologic cycle is used as the basis for understanding watersheds and, in particular, response characteristics to precipitation and uses of water within the watershed. The hydrologic cycle concept describes the process of motion, loss and recharge of water within a watershed. A comprehensive illustration of the water cycle continuum is provided in **Figure 1**.

As shown, the major components are precipitation, evaporation, and runoff (surface and groundwater). Watershed management (including the pollution prevention measures in this document) is directly targeted at the runoff processes, either through managing runoff processes or controlling what contaminants enter runoff (e.g., pollutants). Some prevention measures also influence evaporation including those that relate to the types and amount of vegetation (e.g., grassed waterways and vegetative buffers).

The most important item to recognize from a management perspective is that the hydrologic cycle does not have a beginning or an end. As water evaporates from the land or water surfaces, it becomes part of the atmosphere. Water is stored until it precipitates to the earth where it is intercepted by plants and water surfaces. The precipitation that lands on the ground will either runoff or infiltrate. In Ontario, approximately one third of the intercepted water returns to the atmosphere by evaporation. Infiltrated water is stored in soil to be used or evapotranspired by plants, or travels deeper into the soil and eventually discharges to the receiving water body.

Impacts

Human activities affect or alter the water cycle in many ways. The major link in a watershed ecosystem is the flow of water. In a natural watershed, water flow is controlled by topography, geology, soil type, and vegetation. How and where the water flows determines the quantity and quality of the water, the shape and stability of streambanks, the state of the groundwater, the health and diversity of vegetation, and the availability of fish and wildlife habitat.

As human activities increase in a watershed, all these natural characteristics can change. Humans can change land drainage patterns, remove vegetation, pave previously porous areas, and allow contaminants such as road salt, oil residues and pesticides to enter local streams. The results are unstable and eroded streambanks, poor water quality and loss of fish and wildlife habitat. These changes eventually affect the quality and quantity of surface and groundwater and reduce the ability of humans to use and enjoy watershed resources.

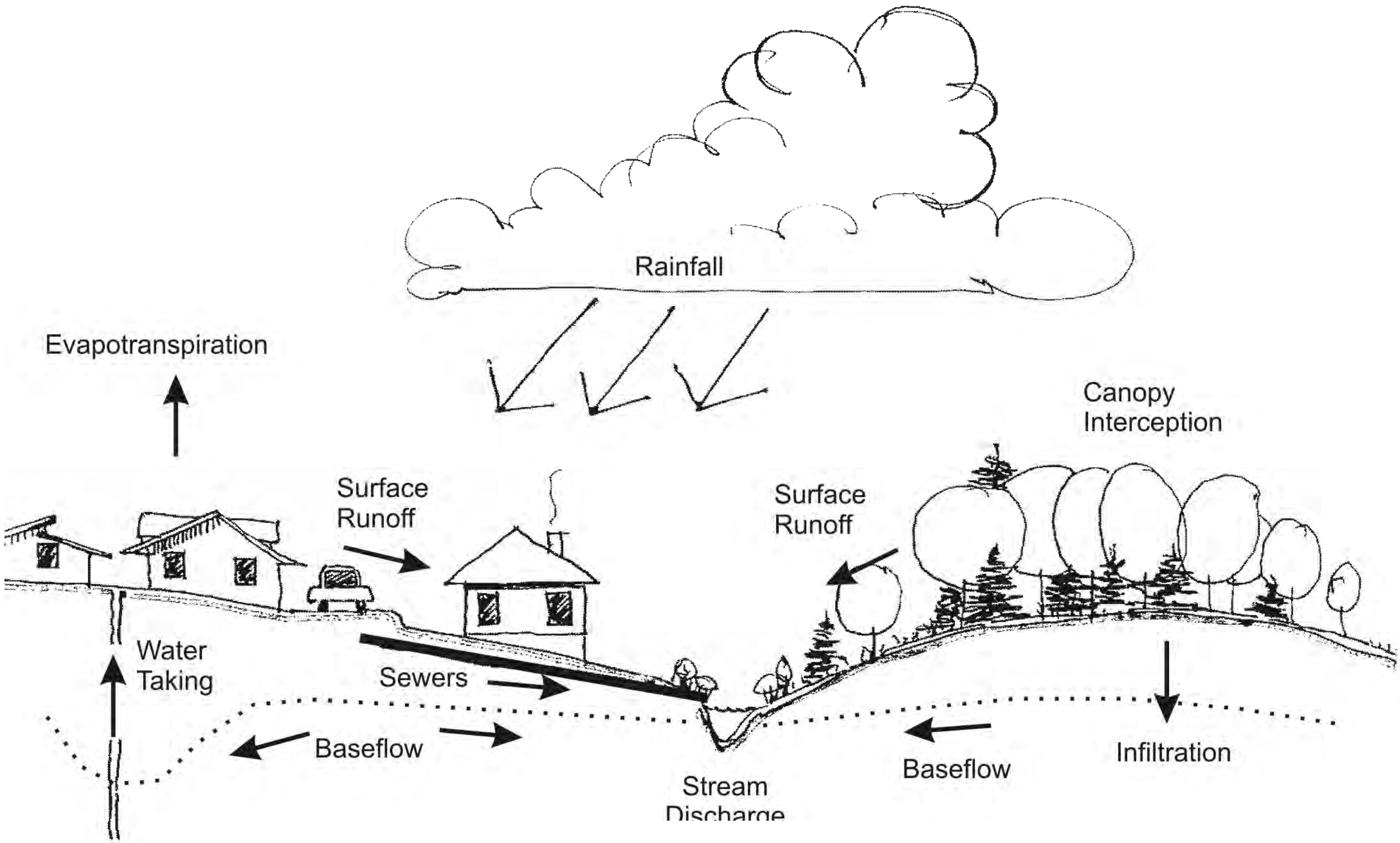

Figure 1
Hydrologic Cycle Components

Hydrologic Cycle and Pollution Prevention

Where water acts as the primary conveyer of pollution, pollution prevention measures generally provide an attractive means of reducing pollution impacts by preventing pollutants from entering the flow (hydrologic cycle), or by controlling the flow (i.e., flow reduction measures). In the development of an effective pollution prevention or management strategy, it is critical to understand the hydrologic cycle process to ensure that the measures are selected and implemented in an appropriate manner.

Management Implications

The impacts of land use practices and built form design, including the input of pollutants, results in negative impacts on water quality and ecosystem conditions. A watershed based management strategy provides an understanding of the ecosystem processes and what is needed in the way of management measures to mitigate or prevent land use impacts and provide overall enhancement. Common impacts considered in watershed plans and resulting management implications are outlined in **Table 1**.

Table 1 - Common Impacts Considered in Watershed Plans and Resulting Management Implications

Hydrologic Impacts	Water Strategies or Options
• Increased runoff (volume, frequency and duration) with impervious ground cover	• Runoff control for flood and erosion control • Measures to maintain existing recharge rates
• Reduced base flows in streams with land use changes	• Provide measures to maintain infiltration • Provide extended detention of runoff for low flows
• Increase pollutant loadings with runoff	• Provide measures to reduce pollutant sources, or remove pollutants, by settlement, absorption or filtering

Drainage systems have always served the basic function of containing and transporting water (and other materials) away from a source area to a selected discharge point. The basic concept has the same principle as a stream system in that it generally follows a tree pattern. The upper branches are smaller and distributed to pick up a number of source areas and all carry the water to downstream junction points where the branches become larger. The main collector or trunk is the largest and leads to one discharge point.

Conventional drainage systems follow the principals of a stream system with the main difference being that drainage is confined to a pipe or constructed channel that provides a specific capacity. If this capacity is exceeded the system may surcharge with resulting flooding of the source areas.

Evolution of Urban Drainage Systems

The design of urban drainage systems has followed an evolution to better serve the needs or objectives set.

Early Drainage Systems

When urban development first began, piped drainage systems did not exist. Drainage patterns followed the slope of the land and generally followed the roadways to any low point at streams or a body of water (see **Figure 2**). As hard materials began to be used for roadways, gutters were formed to convey flows along a channel to its outlet. The surface runoff carried all of the runoff and anything else that it could wash along. This included street debris, which often had waste materials from households and businesses and could even include privy waste.

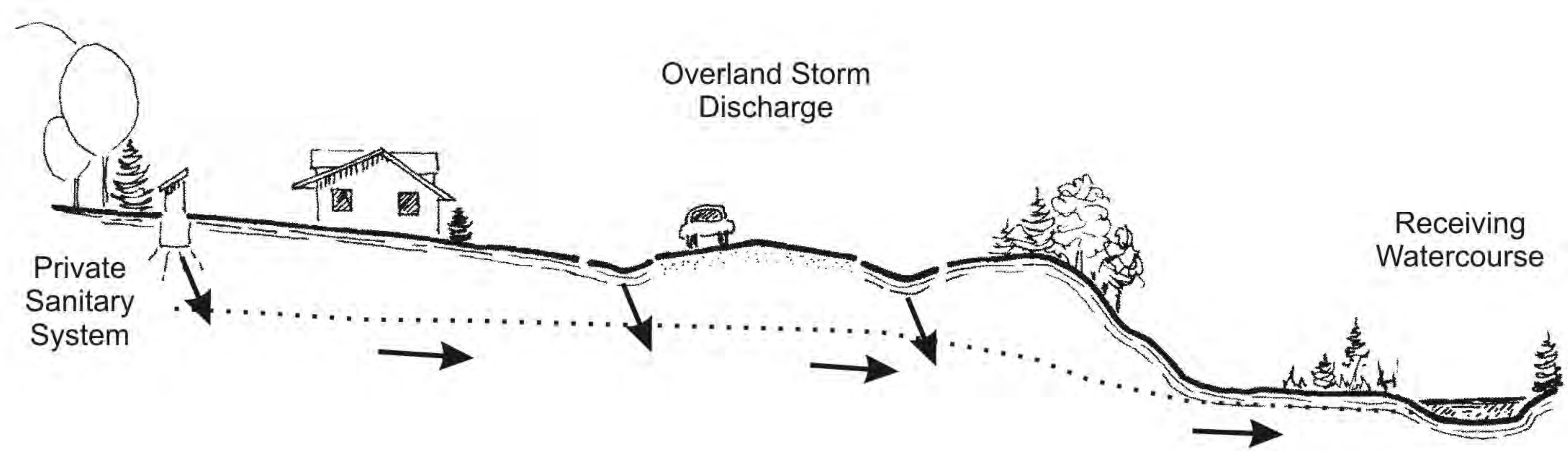

Figure 2
Drainage Patterns Following the Slope of the Land

Introduction of Piped Drainage

The unsanitary conditions of surface drainage led to the use of pipes to carry drainage underground. The early drainage systems carried all runoff and waste previously disposed of in the streets, and consisted of strapped together boards and brick.

As technology advanced and alternative materials became available (e.g., clay, lead, and iron) the piping was extended into homes and business to provide drainage from the inside of buildings to the streets. During this time drainage was combined (see **Figure 3**). All storm drainage and waste water was discharged to an outlet point which would have been a stream or lake. This approach reduced problems with waste discharge in surface runoff, but transferred the problem to the receiving waters. The impact was not immediately noticed, as the relatively small population contributing to the discharge was such that the receiving bodies could easily assimilate these loadings.

Introduction of Treatment Plants

As the population increased in urban areas, the problems with the discharge of waste to receiving waters became apparent and treatment plants were introduced (see **Figure 4**). These plants were developed to remove pollutants and dispose of them in a safe and controlled manner. Typically treatment plants were designed to control low flows that occurred during dry periods and some minor storm events. During larger runoff events, flows bypassed the treatment plant to the receiving water (see **Figure 5**).

Separation of Drainage Systems

Separate drainage systems have been largely constructed since 1956 in Ontario to provide storm sewers for runoff drainage and sanitary sewers for wastewater flow. This approach was introduced to avoid the problems of wastewater being flushed into receiving waters during significant runoff events (see **Figure 6**).

Although separate sewer systems are in use in newer areas, many municipalities still have combined sewers in the older, dense core areas of the municipalities. Significant pollutant loadings to receiving waters will continue to occur in older municipalities until measures are carried out to provide separated sewer systems or reduce the flows to the combined sewer or treatment plant. Increasing the plant capacity is another costly alternative, which may address the problem if sufficient pipe capacity is available to transport the sewage to the waste treatment facility.

Sanitary Sewer Systems

The municipal sewage carried by sanitary sewers consists of domestic, commercial and industrial wastewater, which is carried to a sewage treatment plant. These sources contribute so called conventional pollutants such as bacteria, organic matter, and suspended solids and nutrients, which are treated at sewage treatment plants.

In addition hazardous chemicals from industrial and commercial sites, as well as household sources, are present in sanitary sewage. Heavy rain running from roofs and excessive system use can cause combined sanitary sewers to overflow. When combined sewers overflow, this mixture is discharged to the nearest watercourse. Even with sewage treatment, persistent chemicals, such as chlorinated hydrocarbons and heavy metals, are not destroyed but pass through the treatment process into the water, are released into the air, or end up in the biosolids. An ideal use of biosolids is to spread them on agricultural land but this use is curtailed if metals or other contaminants are present in excessive amounts.

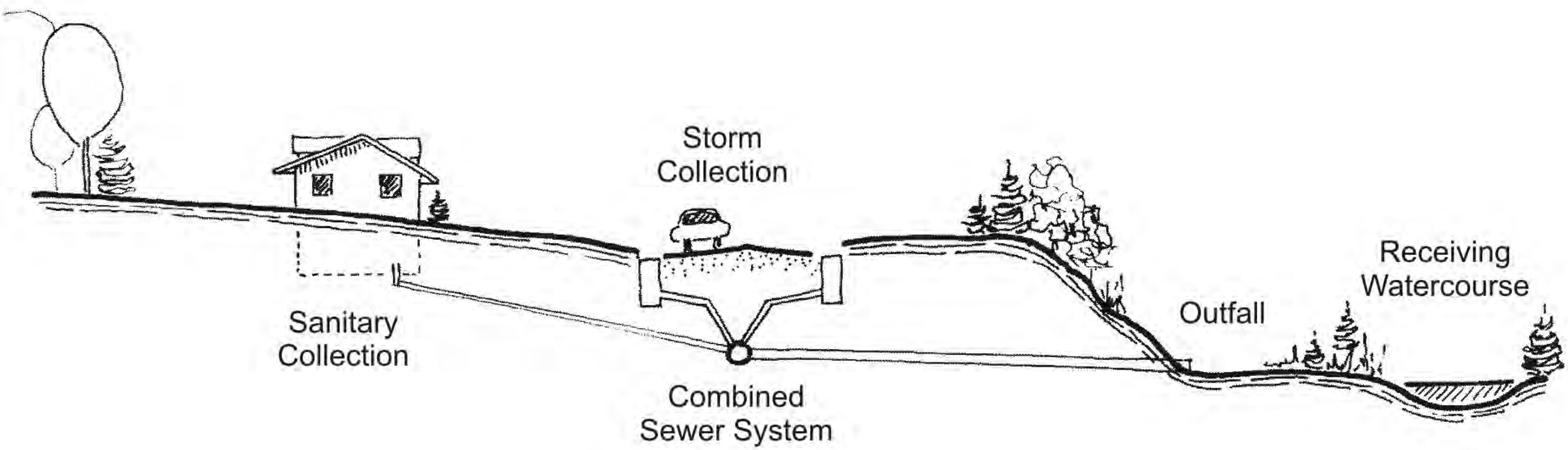

Figure 3
Combined Collection with No Treatment

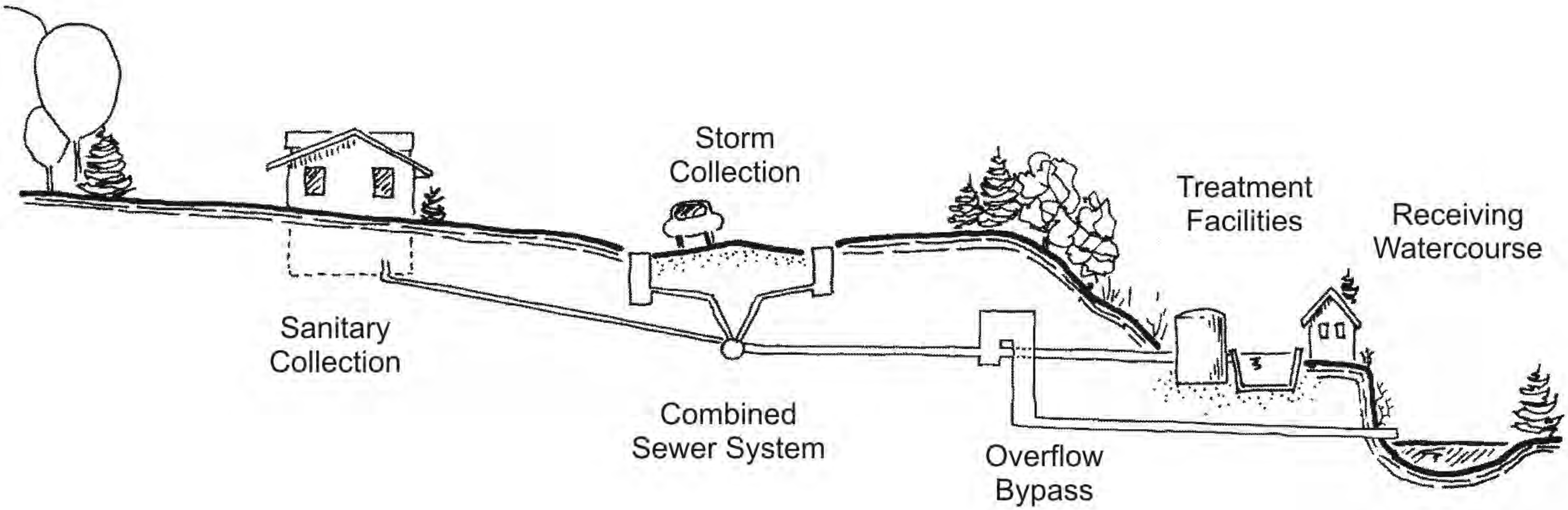

Figure 4
Combined Collection with Treatment

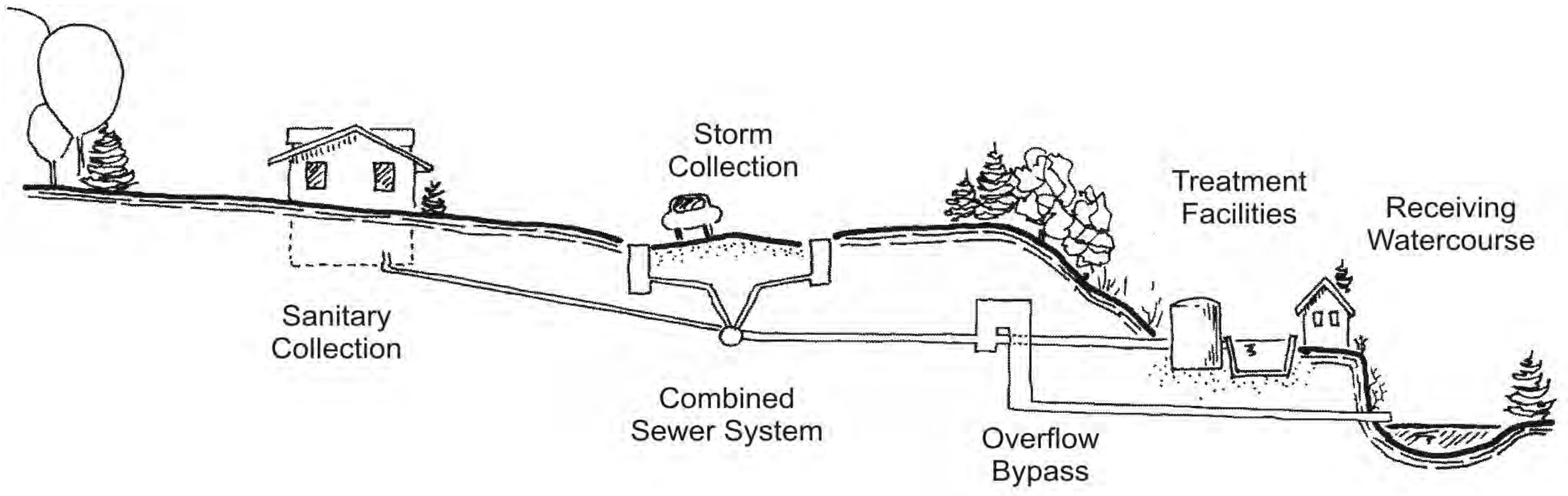

Figure 5
Flows Bypassing Treatment Plant to the Receiving Water

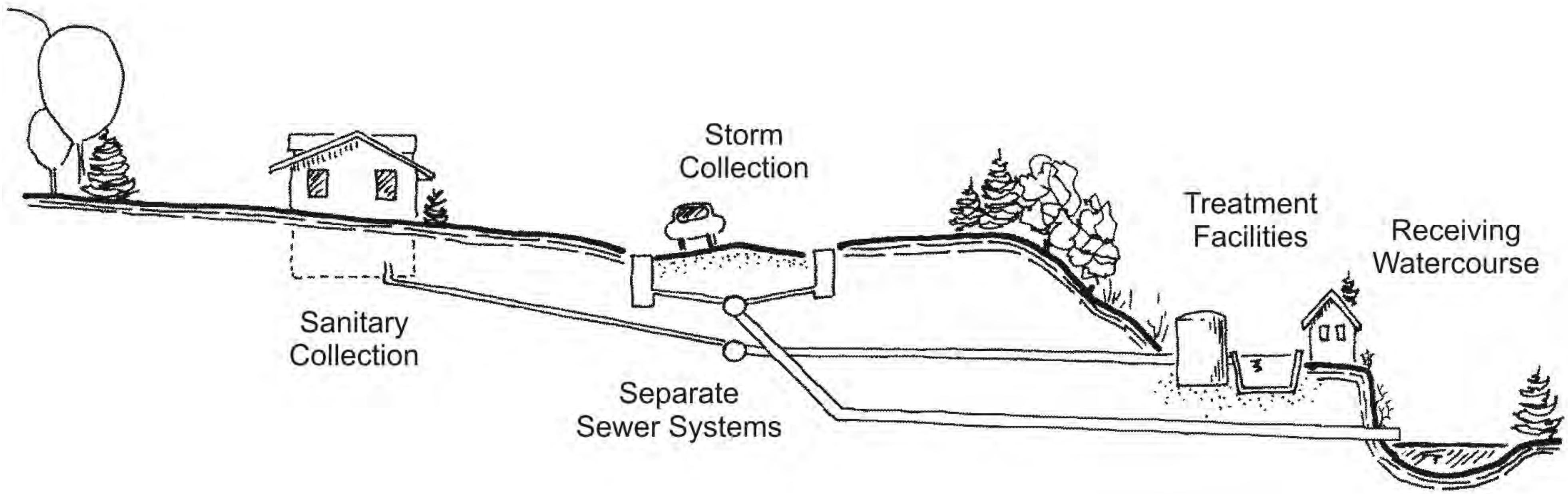

Figure 6
Separate Collection with Sanitary Treatment

Separate sewers are sized to handle the normal waste flows for different land uses plus some extraneous flows. The extraneous flows will consist of infiltration, which comes from normal leaks in sewage pipes (groundwater infiltration) and inflow that comes from sources such as foundation drains and downspouts. Some particular areas have been found to have abnormally high infiltration and/or inflow resulting in surcharged sanitary sewers during rainfall events. This often results in remedial works to reduce the amount of extraneous flows.

One of the most effective programs is to disconnect downspouts, if they exist and if they are connected to the sanitary sewer, since this can be the largest inflow contribution to a sanitary system. Poor overland stormwater flow routes can also contribute to extraneous flows during large storms when rain water outlets to the sanitary sewer via the manhole frames and covers.

Storm Drainage System

Generally flows to a storm sewer system are more difficult to quantify than the flows in a sanitary system. A storm sewer is designed to provide conveyance for a minimum level event so that most of the storms in any given year can be accommodated. Typically the design event ranges from a 1:2 to 1:10 year event (i.e., 1:2 year is the largest event on average every 2-years). During more extreme events, the storm sewer system is surcharged and the higher flows are conveyed along the street.

Since storm sewers can only convey up to a specified event, a storm drainage system is designed to provide a minor and major system (see **Figure 7**). The minor system, (storm sewers) convey the more frequent design events (1:2 to 1:10 year). The major system is comprised of overland flow paths along roadways and open channels to provide safe conveyance of major storm events. The major event is generally set at a relatively high level to minimize risk to life and property (i.e., 1:100 year, or a recorded major event).

Watercourses within urban areas are often used as part of the conveyance system and suffer impacts due to changes in flows from urbanization. These include higher flood levels, increased erosion, and degraded water quality (from pollutant wash-off in urban areas). These impacts ultimately result in the collective degradation of the aquatic ecosystem.

SWM is practiced to protect natural waterways and receiving waters from urban impacts. Controls include peak flow control for flood control, peak flow, and volume control to mitigate erosion impacts and water quality controls for water quality impacts.

SWM was first introduced to provide for the control of stormwater to mitigate flood potential problems. SWM was first updated to provide for water quality protection to reduce the impact of urban development to the receiving watercourses. This lead to the first set of MOE SWM Guidelines. The most recent MOE guidelines now include reference to groundwater protection and erosion control. There has also been a trend away from the use of SWM ponds, placed at the discharge point where stormwater enters the watercourse, to a series of SWM measures that can be located within a development area. These are commonly put into one of three classifications" 'at source' control measures to control stormwater as close to the source as possible, 'conveyance' controls to treat stormwater as it is conveyed, and more conventional 'end-of-pipe' controls to treat stormwater prior to it entering the receiving system. This suite of controls are often referred to today as Low-impact-development (LID) or Best management practices (BMPs).

Low-impact Development

The *National Guide to Sustainable Municipal Infrastructure* (2003) describes LID as a site design strategy that aims to maintain or replicate the predevelopment hydrologic regime by creating a functionally equivalent hydrologic landscape.

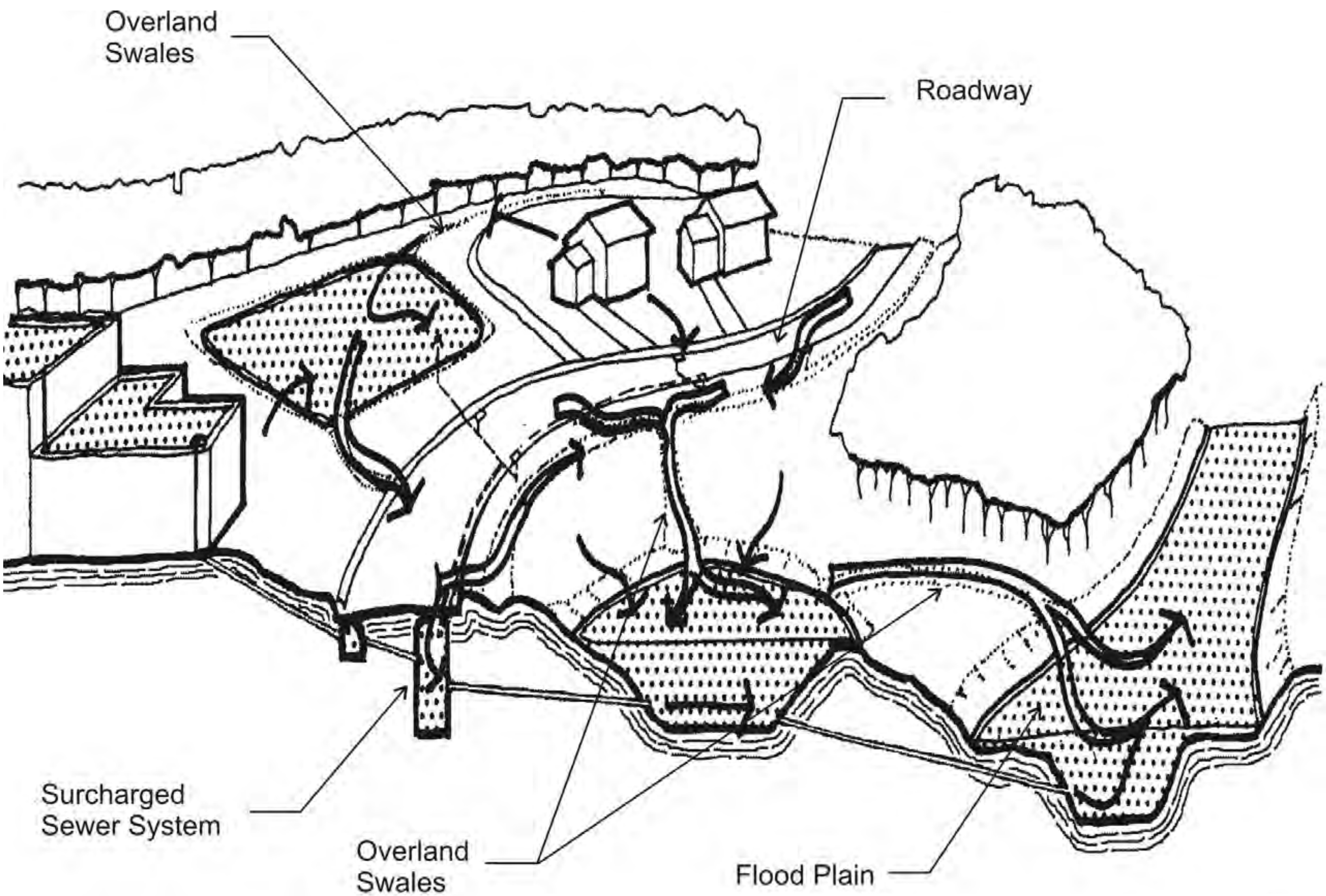

Figure 7
Major Storm Overland Path

Figure 1 illustrates the components of the hydrologic cycle of a watershed ecosystem, and the interrelationships between the various components. In a relatively natural watershed, the flow of water is controlled by topography, soil type, and vegetation. Urbanization typically involves the clearing of vegetation and large-scale earth grading that alters the topography and soil characteristics. The topography is often sculptured to create a smooth surface. For example, lawns that efficiently drain water to a drainage system and convey the runoff to a SWM facility where it is stored and treated before being released from the site. The LID approach looks at using a variety of micro-scale controls that help to restore or replicate some of the natural hydrologic pathways. Typical LID measures include:

- Conservation of natural features;
- Reducing impervious areas;
- Bioretention areas;
- Rain gardens;
- Green roofs;
- Rain barrels;
- Cisterns;
- Vegetated filter strips; and
- Porous pavements or permeable pavements.

LID attempts to replicate components of the hydrologic cycle to restore rainfall back to the hydrologic pathways. Retaining native vegetation or planting vegetation maintains interception and evapotranspiration. Rain gardens and bioretention areas may act as depression storage areas and can aid in promoting infiltration. Rain barrels, cisterns, and green roofs may act as the interception component. When applying these micro-scale controls across a drainage area, the cumulative impacts could potentially reduce the required SWM pond size.

Many of these practices are identified as stormwater BMPs in the *Stormwater Management Planning and Design Manual* (MOE, 2003). Micro-scale controls can be integrated into the infrastructure and located throughout a site making LID an effective means of reducing runoff volume and for treating stormwater runoff by filtering out the pollutants.

The main difference between the LID approach and past approaches is that the current approach focuses on conveying, storing and treating stormwater runoff at the base of the drainage area with emphasis on end of pipe facilities. LID practices on the other hand can be integrated into infrastructure throughout the site, and are more cost effective and aesthetically pleasing than traditional stormwater conveyance systems (EPA, 2000).

Accordingly, maximizing opportunities for SWM at the site level using the LID is a recommended approach for all future land uses within the NPCA watershed. Application of LID practices in cold climates does pose some challenges. The *Source and On-Site Controls for Municipal Drainage Systems* (National Guide to Sustainable Municipal Infrastructure, 2003) provides an overview of some of the source and on-site control practices available and the different elements to consider when choosing the right one. This document also highlights the unique challenges of implementing these practices in cold climates.

Table 2 on the following pages presents a summary of the stormwater management policies and technical guidelines presented in this report.

Table 2 – Summary of Stormwater Management Policies and Technical Guidelines

<table>
<tr><th>Topic</th><th>General Policy Statement</th><th colspan="3">Technical Guidelines</th></tr>
<tr><td rowspan="3">Stormwater Management Control</td><td rowspan="3">Sufficient SWM controls are required by the NPCA to ensure that flooding, pollution, surface erosion and conservation of land impacts due to development do not occur.</td><td colspan="2">Flooding/Quantity Control</td><td>Generally, the SWM controls required are to match or reduce post-development peak flows to pre-development peak flows for a range of design storm events (2, 5, 25 and 100-year storm events, unless directed otherwise).
Different design storm distributions and durations shall be assessed in order to determine the critical storm that yields the lowest pre-development peak flow and the highest post-development peak flow. At a minimum, the 3-hour Chicago, 12-hour AES and 24-hour SCS distributions should be considered.
All SWM plans are to assess the capacity of the receiving system in order to indentify hydraulic constraints or existing flooding hazards. These existing constraints/risks may require additional quantity controls over and above the typical post to pre peak flow controls.
Consideration may be given to not requiring peak flow controls if the assessment of receiving system capacity demonstrates little or no benefit to such controls. This would include scenarios such as discharge to major river systems or directly to a Lake. Pre-consultation with the NPCA and additional approval requirements are necessary for this to be considered.
Major overland flow routes are to be designed to have sufficient capacity for the Regulatory event (100-year or Regional storm event, as applicable).</td></tr>
<tr><td rowspan="2">Quality Control</td><td>TSS</td><td>A minimum of “Normal” level of water quality treatment, as defined in the MOE design guidelines (2003) is required for all SWM facilities. This is equivalent to a 70% TSS reduction.
“Enhanced” level of water quality treatment (80% TSS reduction) will be required on all watercourses containing Type 1 – critical fish habitat.
A detailed assessment of the receiving system will be mandatory for any proposed reduction in the level of water quality treatment required on a development site. The assessment contents must be appraised and approved by the NPCA prior to completion.</td></tr>
<tr><td>Temperature</td><td>The SWMP for a development site is required to include measures to eliminate or mitigate adverse temperature impacts due to the increase in impervious surfaces and the ponding of water in SWM facilities. Particular attention is to be given to those systems discharging to</td></tr>
</table>

Topic	General Policy Statement	Technical Guidelines		
				coolwater or coldwater receiving systems. • Post-development water temperature regime is to mimic or enhance the pre-development regime.
			Total Phosphorus	• Phosphorus removal targets will be typically provided for in the TSS removal targets, unless specific targets are developed through a management strategy.
			Spills	• SWM facility outlets are to be designed to allow the outlet to facilitate the containment of a spill. • Ensure sufficient access to SWM facility to allow spills to be cleaned.
		Water Balance		• As per the SWM Design Manual (MOE, 2003), water balance impacts should be evaluated during the design of a site stormwater management system. All efforts should be made to match pre- and post-development infiltration volumes in order to maintain groundwater recharge. • Hydrogeologically sensitive areas shall be identified as part of the SWM plan. • Untreated stormwater shall be prevented from being directly infiltrated.
		Erosion/Geomorphologic Considerations		• Quantity control to detain and release the 25mm, 4-hour Chicago design storm over a 24-hour period shall be provided for all receiving systems that are demonstrated to be stable watercourses or for proposed development that comprise less than 10% of the total area that drains to the receiving system. • The geomorphologic assessments and criteria contained in the SWM Design Manual (MOE, 2003) shall be used for all receiving systems that are unstable under existing conditions or for proposed developments that comprise a significant proportion of the total area draining to the receiving system. • Criteria identified in larger-scale studies that have directly evaluated the receiving systems, such as Subwatershed Studies or Master Drainage Plans, shall take precedence over the criteria presented herein.
		Construction Erosion and Sediment Control		• All applicants must include an Erosion and Sediment Control plan demonstrating that fish habitat and water quality are not affected by sediment from the property during or following site construction. • Guidelines and strategies to develop Erosion and Sediment Control plans can be found in the *Erosion and Sediment Control Guidelines for Urban Construction* manual (GGHA CA, 2006).

Topic	General Policy Statement	Technical Guidelines	
		Planting Considerations	• As part of SWM facility designs, planting strategies are required to address functional treatment aspects, including operations, public safety, and to help the facility blend in with the natural environment. • Native vegetation is to be used in the facility design (see **Appendix S** for the approved plant species list). • Consideration of nearby natural heritage features should be made in developing a planting strategy. • The different moisture zones within a SWM facility should be considered in choosing vegetation species: deep water, shallow water, shoreline/fringe zone (extended detention), flood fringe and upland areas.
		Oil/Grit Separators	• Oil/grit separators for stormwater treatment are discouraged for use in Greenfield residential development. • The use of oil/grit separators may be considered for commercial, industrial, or infill developments. • Consultation with the NPCA and the municipality is required in order to consider the use of oil/grit separators.
Location of Stormwater Management Facilities	The NPCA does not support the following SWM practices: 1. On-line SWM facilities for water quality; 2. Using natural wetlands as a SWM facility; 3. Locating SWM facilities in natural hazard areas, such as floodplains or erosion hazards, except outlets; and 4. Locating SWM facilities in Significant Natural Heritage Features.	• The discouragement of locating SWM facilities within natural hazard/regulated areas arises from the fact that SWM facilities are considered development, and as such are subject to the same development regulatory processes. Outlet works are the sole exception, since they must be located close to a receiving waterbody, most likely within its floodplain. • In certain circumstances, the NPCA is prepared to acknowledge that due to technical, economic and/or environmental considerations and constraints, SWM facilities may be required to be located within or close to natural hazard areas. Such an allowance would depend on the demonstration that the SWM facility would not impact the natural hazard area (i.e., no increase to flooding risks, etc.) and that the hazard area would not impact the function or lifespan of the SWM facility. Note that these facilities may be subject to additional detailed design requirements above and beyond those described in this manual or prescribed by the municipality. • SWM facilities are not permitted to be located within the 100-year floodplain or the hydraulic floodway, whichever is greater.	
Large-scale Stormwater Planning	The planning and implementation of SWM systems are encouraged by the NPCA to be performed on a catchment-scale basis, through the completion of Subwatershed Plans, Master Drainage Plans or other such strategies.	• Large-scale stormwater planning at the watershed, subwatershed or community plan level facilitate the most effective management strategies to reduce the impact of development on the natural environment. These studies can guide future development in ways that protect surface water features, groundwater features and natural areas. Refer to Section 2.3 and 2.4 of the SWM Design Manual (MOE, 2003) for an overview of the contents and benefits of large-scale SWM planning.	

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1. INTRODUCTION

1.1 Background

The Niagara Region and the Niagara Peninsula Conservation Authority (NPCA) has initiated the development of a report entitled Stormwater Management Policies and Guidelines. The need to develop a set of comprehensive Stormwater Management (SWM) policies (including erosion and sediment) that reflect a ‘state-of-the-art’ approach to water quantity and water quality management was identified in the Niagara Water Quality Protection Strategy (NWQPS). This was one of several action items that are required to provide an effective approach in the management of water resources within the Niagara Region for the protection and enhancement of water quality undertaken by the province.

1.2 Purpose

The purpose of the Stormwater Management, Erosion and Sediment Polices and Criteria report is to provide a detailed SWM framework for existing and proposed development in the Niagara Region and the NPCA watersheds. The policy will establish a consistent approach to SWM planning for all municipalities within the study area.

The SWM planning area includes the following municipalities:

- City of Hamilton;
- City of Niagara Falls;
- City of St. Catharines;
- City of Thorold;
- City of Welland;
- City of Port Colborne;
- Haldimand County;
- Town of Grimsby;
- Town of Lincoln;
- Town of Niagara-on-the-Lake;
- Town of Pelham;
- Town of Fort Erie;
- Township of Wainfleet; and
- Township of West Lincoln.

1.3 Policy Coverage

The policy will cover all municipalities entirely and partially located within the Niagara Region and the NPCA watersheds. **Figure 1.3.1** provides a map of the NPCA watersheds. The report is primarily focused on urban runoff and SWM for developed urban areas. As such it does not cover rural agricultural runoff explicitly, although many of the policies could be applied to drainage and watercourses in these areas.

The report does not cover source water protection, except as noted in Section 7.1.2.6.

Figure 1.3.1 NPCA Watersheds

2. OBJECTIVES

The following study objectives were derived from the Terms of Reference (TOR), the NWQPS, and input from the Steering Committee. The overall study objectives include the establishment of a set of SWM policies to be used consistently across the study area that consider flooding, erosion and sediment control, natural channel design, and Best Management Practices (BMPs). This study aims to reflect the objectives set out in existing Official Plans (OPs), other policies in existence, subwatershed studies, and improve the quality of water within the Niagara Region and the NPCA watersheds.

The planning objectives for this study focus on a process that will allow the proponent to identify, protect and preserve natural features, and consider their functional role in SWM planning. SWM planning will use the best available practices while integrating or enhancing existing natural features into the system (i.e., consider existing wetlands and woodlands for maintaining the hydrologic cycle). This study will identify a review process that ensures all agencies the opportunity to review and comment on SWM reports and planning. All SWM planning is to reflect and incorporate the SWM objectives set out in current OPs, existing watershed and subwatershed planning, and Master Drainage Planning, especially regarding flood protection, erosion and protection of the receiving natural environment. Municipalities will be encouraged to continuously update existing studies as new information and science becomes available. In addition, they will incorporate SWM measures in all future development (lot level to greenfield development) to achieve environmental protection and enhancement including flood storage, protection of local watercourses, erosion control, fishery and habitat protection, groundwater recharge and water supply protection, and recreational uses.

Technical objectives will include capturing rainfall at the source whenever possible and restore to natural hydrologic pathways (i.e., infiltration, evapotranspiration, or reuse). They will also ensure that the stormwater infrastructure can safely convey major storm events, provide SWM protection that at a minimum meets the MOE guidelines, and maximize the use of source control with pollution prevention.

The operational objectives will provide for efficient stormwater facility design that minimizes future maintenance requirements and can be easily monitored. Implementation objectives will promote SWM education (e.g., municipalities promoting BMPs on public lands, and existing developed area objectives to explore and consider all opportunities to retrofit existing developed areas either through updating existing facilities or the construction of new facilities, and plan for and promote SWM when redeveloping or infilling).

3. POLICY DEVELOPMENT PROCESS

This study is following a series of steps in the development of SWM policies and procedures:

1. Review of current practices.
2. Summarize existing policies and criteria.
3. Compare practices in other jurisdictions and SWM policy trends.
4. Identify SWM policy needs and opportunities for policy improvements.
5. Identify and compare alternatives for changes to SWM policies and procedures.
6. Develop recommended approach for SWM policies and procedures.

Figure 3.1.1 provides a flow diagram of the study steps.

3.1 Review of Current Practices

A questionnaire was circulated to all municipalities within the Niagara Region and the NPCA watersheds as part of the first step in identifying current SWM practices. A sample questionnaire and summary of results is provided in **Appendix A**.

The questionnaire results indicate that there is a wide variation within the municipalities as to whether current policies and formal guidelines are in place. They all follow current MOE Stormwater Management Guidelines (2003) for general direction, while some have developed guidelines more specific to their area. SWM targets have been developed in some areas, primarily based upon subwatershed strategies.

Technical design guidelines do not exist in all areas and some are being developed. The majority of the municipalities agree that there is a need for uniform SWM guidelines, but with allowance for specific site conditions. Not all municipalities have a formalized SWM maintenance program but see the need to have a consistent approach. Municipalities were also requested to forward copies of applicable and relevant guidelines for review in this study.

SWM design standards and/or policies were obtained for seven of the municipalities. Other drainage policies and by-laws relating to SWM were also downloaded from websites where available. **Appendix B** summarizes all SWM policies, standards, and by-laws that were used to compare SWM practices for locales within and outside the study area.

The literature review process undertaken is outlined below:

- Compare Practices in Other Jurisdictions and SWM Policy Trends – This review exercise helped to identify policy gaps and recommend policies that would benefit the municipalities within the Niagara Region and the NPCA watersheds. OPs, SWM policies and design standards were reviewed for other municipalities outside the study area to:
  - Observe current trends and advances; and
  - Identify policies and by-laws currently in use that would benefit municipalities within the study area;
- Identify SWM Policy Needs and Opportunities for Policy Improvements – Recommendations were made as to what policies would be appropriate for all municipalities region wide;

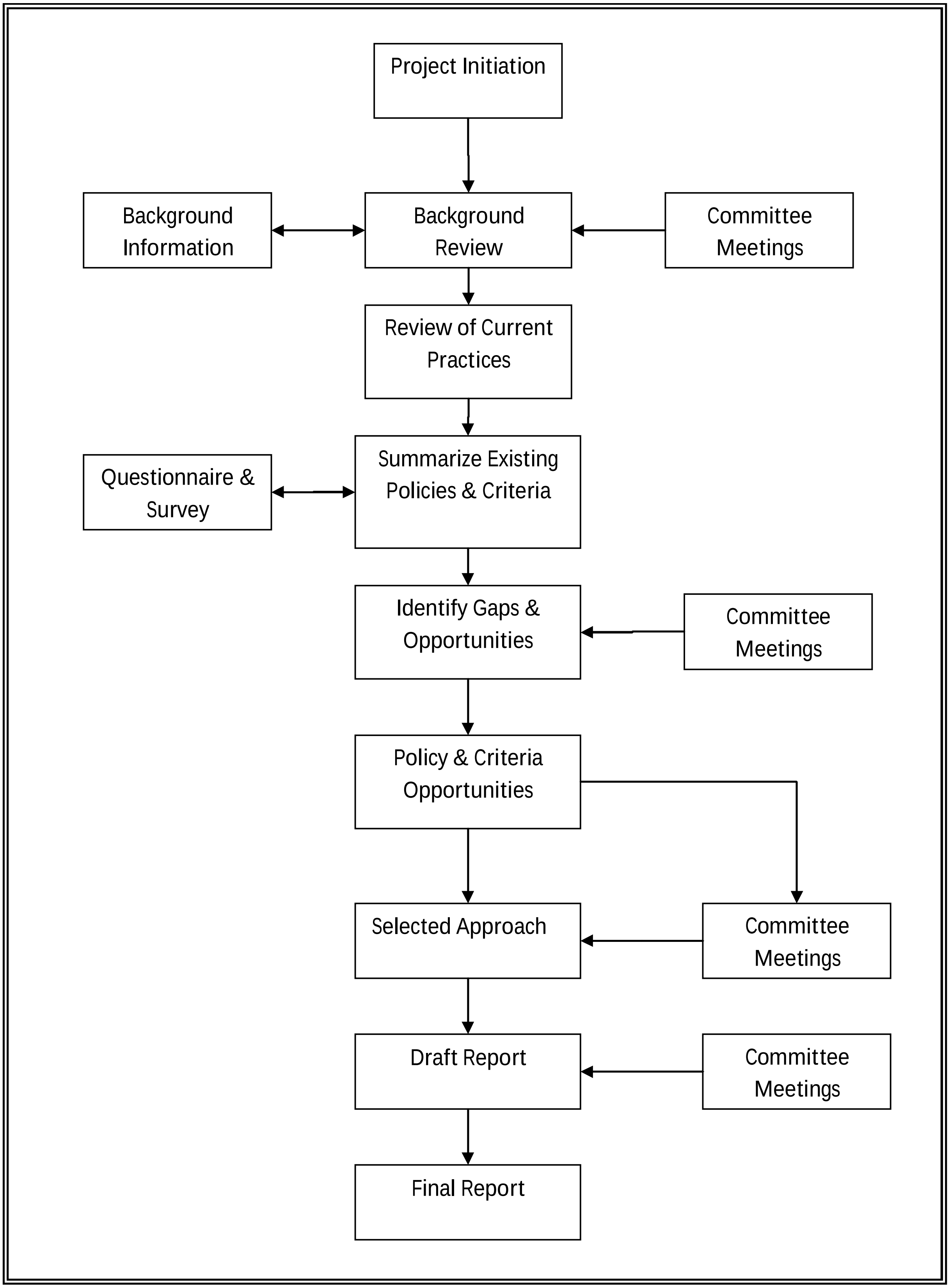


Figure 3.1.1 - Policies and Criteria Study Steps

- Identify and Compare Alternatives for Changes to SWM Policies and Procedures – Policy options were proposed that worked off the strength of policies and procedures within the study area and strengthening or enhancing with policies and procedures from outside municipalities; and
- Develop a recommended approach for SWM policies and procedures – The final step was to review with the committee policy and procedure options that would be implemented across the Niagara Region and the NPCA watersheds.

Appendix C provides the table that was used to compare SWM design standards and policies for municipalities within the study area.

The OPs available for each municipality were summarized in a table in order to make direct comparisons of policies relating both directly and indirectly to SWM. This table is located in **Appendix D**. Several municipalities within the study area have recently updated or are in the process of updating their OPs. Updated OPs, where available, were reviewed in preparation of this draft document.

As illustrated in **Figure 3.1.1**, committee meetings were required throughout the entire process to receive input and direction. **Appendix E** provides copies of the meeting minutes.

3.2 Review of Official Plans Policies Relating to Stormwater Management

OP policies for the municipalities within the Niagara Region and the NPCA watersheds were reviewed to get an understanding of the policies related directly or indirectly to SWM. Common themes were identified throughout the various OPs such as source water protection, watershed planning, and servicing requirements. **Appendix D** provides a summary of the different kinds of information found in the various OPs for the municipalities within the study area. OPs for municipalities outside of the Niagara Region and the NPCA watersheds were also reviewed to gain an understanding of the current trends and advances regarding SWM policies.

The OPs were reviewed to gather insight on how they are addressing SWM and whether they provide flexibility so that sustainable and innovative SWM techniques can be applied within the various municipalities. Each municipality has developed their own sets of policies specific to their area.

Based on the policies observed within the OPs, and current trends and advances found in other municipalities, draft recommendations were listed. These recommendations, if approved, would be adopted into the OPs through an amendment.

Table 12.2.1 highlights the recommended policies. Refer to **Appendix P** for a more detailed summary of the review of the OP policies.

3.3 Review of Municipal Design Standards and Policies

A summary of the design standards and policies relating to drainage and SWM design for the municipalities within the Niagara Region and the NPCA watersheds are provided in **Appendix C**. The municipal design standards provide the proponent with specific direction when designing and maintaining SWM infrastructure.

Through the initial questionnaire, municipalities were asked to forward their current design standards and SWM policies. Seven municipalities provided copies of policies relating to lot grading, drainage, and SWM. The following section provides an overview of the various policies relating to the design of SWM facilities, lot grading and drainage.

Several of the design standards and policies provided objectives and a drainage planning philosophy and corresponding design criteria to achieve the policies. **Table 12.2.2** highlights the recommended policies. More details can be found in **Appendix Q**.

4. APPLICABLE LEGISLATION

4.1 Background

In Canada, the Constitution Act allocates legislative powers to the federal and provincial levels of government. This Act gives each respective level of government exclusive authority to pass laws related to specific matters listed under the Act (Department of Justice Canada, 1867).

Section 91 of the Constitution Act gives the federal government jurisdiction over matters relating to water quality protection through their control over coastal and inland fisheries and navigation. Section 92 allows for the provinces to lead in regulating water management, though the federal government will play a role in certain matters. For example, the provincial government is responsible for water management, drinking water, natural resources, and property matters. However, the federal government has been the lead agency for management of waters that lie on or across international borders.

The Province of Ontario has enacted legislation that empowers municipalities in the areas of water management and public health. This means that, in Ontario, all three levels of government have roles and responsibilities for environmental protection in general, and water in particular. In practice, they have assumed separate and complementary roles with respect to water management.

The purpose of this section is to detail the roles of all levels of government and applicable legislation with respect to SWM.

4.1.1 Roles of Government in Municipal Stormwater Management

The province is the lead agency responsible for making sure environmental impact assessments are carried out and followed. They also monitor and manage the requirements for a permit, licence or Certificate of Approval (CofA) for the quality and quantity of the discharge and overall facility operation. The municipality builds, operates, and maintains the infrastructure. They are also responsible for meeting the requirements and the province is responsible for monitoring and ensuring they are met. The federal government is responsible for making sure the federal Fisheries Act is implemented with respect to fisheries habitat and non-deleterious discharges, and to enforce the Canadian Environmental Protection Act (CEPA). They are also responsible for ensuring there are no transboundary pollution problems (e.g., Great Lakes Water Quality Agreement). The federal government provides some funding for stormwater infrastructure through various programs, and provinces and municipalities typically cover the majority of costs.

The legislative roles of each level of government are described in more detail in the following sections.

4.2 Federal Level

The federal government exercises jurisdiction over fish and fish habitat, navigable waters, environmental impact assessments, toxic substance releases, and certain wildlife issues. The three main pieces of legislation that deal with stormwater include: the Fisheries Act; the Canada Water Act; and the CEPA. The Fisheries Act is the most significant piece of legislation to protect water from pollution. For example, Section 36(3) allows the government to impose imprisonment (up to three years) and/or a fine (up to $1,000,000) for those who fail to “[protect] fish-bearing waters from the deposit of any substance that is ‘deleterious’ or harmful to fish and aquatic life” (Department of Justice Canada. 1985a).

The Canada Water Act provides the federal government with the ability to designate any waters as a ‘water quality management area’, and maintain the water quality in that area (Department of Justice Canada, 1985b). The CEPA oversees the risks associated with toxic substances listed within its legislation (Department of Justice Canada, 1999).

There are other pieces of federal legislation that are relevant to SWM, and they are described below, along with the Acts mentioned above.

4.2.1 Fisheries Act

The Fisheries Act focuses on the protection of fish and aquatic habitat. It prohibits the deposit (direct discharging, spraying, releasing, spilling, leaking, seeping, pouring, emitting, emptying, throwing, dumping or placing) of harmful substances into waters frequented by fish, such as oceans, rivers, lakes, creeks, and streams, or into storm drains that lead to such waters. A harmful substance would alter or degrade water quality such that it would harm fish or fish habitat. A harmful substance can also be stormwater, wastewater, or other effluent that contains a substance in such quantity or concentration that it would, if deposited to waters frequented by fish, degrade or alter fish or fish habitat (DFO, 2006).

4.2.2 Canada Water Act

The Canada Water Act is divided into four parts. The first part, Comprehensive Water Resource Management, empowers the Minister of the Environment to establish consultative arrangements and to finalize agreements with the provinces respecting waters that are of significant national interest. The second part, Water Quality Management, allows the Minister to conclude agreements with provincial jurisdictions in designating certain areas as "water quality management areas" when the water quality has become a matter of urgent national concern. Section 9, covers the unlicensed dumping of wastes into the water of a water quality management area. It also forbids dumping wastes in any place, or under any conditions, such that the waste or the derivatives of that waste might flow into the waters of the protected area. The third part, nutrients, which contains provisions concerning allowable concentrations of nutrients in water treatment processes, was incorporated into Canadian Environmental Protection Act by proclamation in 1988. Guidelines originally issued under this part of the Act are now listed under Canadian Environmental Protection Act. These include the Canadian Drinking Water Quality Guidelines and the Guidelines for Effluent and Waste Water Treatment at Federal Establishments. The final part focuses on administration and enforcement of the Act.

4.2.3 Canadian Environmental Protection Act

The focus of the CEPA is pollution prevention and the protection of the environment, primarily through the control of toxic substances. The CEPA applies indirectly to SWM through Section 95 which outlines that there are duties to report and take remedial measures in the event of a spill of a listed toxic substance. If stormwater contains a listed toxic substance and is released, it could be considered a reportable offence (Department of Justice Canada, 1999).

4.2.4 Canadian Environmental Assessment Act

The Canadian Environmental Assessment Act (CEAA) is intended to make sure that projects carried out, funded, permitted or licensed by the federal government are properly scrutinized by authorities and demonstrate a solid commitment to sustainable development and the promotion of a healthy economy and environment. The CEAA is also intended to prevent any projects associated with the federal government from having any adverse environmental effects outside the jurisdictions in which they are undertaken. The Act is administered by the Canadian Environmental Assessment Agency, an independent agency that reports to the Minister directly.

4.2.5 Migratory Convention Birds Act

The Migratory Convention Birds Act deals with the protection of migratory game birds. The application to SWM focuses on the protection of water that may be used by migratory birds. Section 35 outlines that it is an offence to deposit or permit the deposit of oil, oil wastes or other substances harmful to migratory birds in water or any area frequented by migratory birds (Department of Justice Canada, 1994).

4.2.6 Species at Risk Act

The Species at Risk Act was created to protect wildlife species from becoming extinct in two ways: by providing for the recovery of Species at Risk (SAR) due to human activity; and by ensuring through sound management that species of special concern don't become endangered or threatened. It includes prohibitions against killing, harming, harassing, capturing or taking SAR, and against destroying their critical habitats. Stormwater runoff from farm operations, lawns, golf courses, urbanization, and other pollution sources may carry contaminants, adversely affecting critical habitat and water quality for SAR (Department of Justice Canada, 2002).

4.3 Provincial Level

For the most part, waters that reside solely within the Province of Ontario's boundaries fall within their constitutional authority. Provincial legislative powers include, but are not restricted to, areas of:

- Flow regulation;
- Authorization of water use development;
- Water supply;
- Pollution control; and
- Thermal and hydroelectric power development.

Ontario uses legislative and non-legislative mechanisms (e.g., policies and guidelines) to regulate water quality and quantity. The statutes covering water are primarily administered by the MOE, which is responsible for overseeing environmental management of air, land, and water in the province, as well as drinking water safety. The MNR also has some responsibility for regulating water, primarily because it is the lead conservation and resource management agency. Their responsibilities include provincial parks, forests, fish, wildlife, and Crown lands and waters, as well as public safety and emergency response in the case of forest fires, floods, and drought.

Specific items are discussed in the following sections on various acts and policies and their scope and requirements.

4.3.1 Ontario Water Resources Act

The Ontario Water Resources Act (OWRA) is one of the most important pieces of legislation governing water quality and quantity in the province. It provides for the protection and conservation of water, and the control of the quality of drinking water supplied to the public. It has a prohibition against pollution activity:

"Every person that discharges or causes or permits the discharge of any material of any kind into or in any waters ... that may impair the quality of the water… is guilty of an offence" (Section 16.(1)).

This legislation is administered by the MOE, and the Director has the power to order the owner of a sewage works (i.e., a municipality owning a SWM pond or a storm sewer system) that could potentially discharge material into a watercourse to carry our works or activities to reduce or alleviate the water quality impairment.

How this Act applies directly to SWM is outlined below (Ontario, 1990a):

- Prohibits the discharge of polluting material in or near water (Section 30);
- Prohibits or regulates the discharge of sewage (Section 31);
- Enables the issuance of orders requiring measures to prevent, reduce or alleviate impairment of water quality (Section 32);
- Enables the designation and protection of sources of public water supply (section 33);
- Requires approvals for water works (Section 52);
- Requires approvals for sewage works (Section 53);
- Enables the Ontario Clean Water Agency to provide or operate water works or sewage works for municipalities (Sections 63 to 73);
- Designates and regulates areas of public water or sewage services (Section 74); and
- Imposes a duty on corporate officers and directors to take all reasonable care to prevent the corporation from discharging materials into or near water that may impair water quality (Section 116).

Under the Act, stormwater is included in the definition as sewage and, as such, requires to be managed properly. This is a result of the potential for contamination by urban land use. Stormwater works therefore require an MOE issued Certificate of Approval under OWRA Section 53.

4.3.2 Environmental Protection Act

The Environmental Protection Act is the main pollution control law in Ontario. It is used interchangeably with the OWRA to address sources of water pollution. Administered by the MOE, the Act contains a number of stipulations that can be used to protect surface water and groundwater against contamination.

How this Act applies directly to SWM is outlined below (Ontario, 1990b):

- Forbids the discharge of contaminants into the natural environment in an amount, concentration or level in excess of that prescribed by the regulations (Section 6);
- Allows for the issuance of binding administrative orders to prevent, control, minimize or remediate discharges of contaminants into the natural environment (Sections 7 to 12, Sections 17 to 18, Section 97, Part XI and Part XIV);
- Bans the discharge of contaminants into the natural environment that cause or are likely to cause an adverse effect (Section 14);
- Imposes duties to report and clean up pollutant spills and imposes civil liability for loss or damage arising from spills (Part X); and
- Imposes a duty on corporate officers and directors to take all reasonable care to prevent the corporation from causing or permitting unlawful discharges of contaminants into the natural environment (Section 194).

4.3.3 Planning Act

The Planning Act promotes sustainable economic development in a healthy natural environment. The Act enables municipalities to regulate land use and development at the local or regional level, subject to a provincial policy framework.

A number of provisions in the Planning Act can be used by municipalities in relation to SWM. They include (Ontario, 1990c):

- Declaring a provincial interest in protecting ecological systems and functions, conserving natural resources, ensuring the supply and efficient use of water, ensuring adequate provision of sewage and water services, ensuring the orderly development of safe and healthy communities, and protecting public health and safety (Section 2);
- Enabling the provincial government to issue policy statements on matters of provincial interest, and requiring municipalities to have regard for such policy statements (Section 3); and
- Empowering municipalities to prohibit or restrict the use of land, or the erection or use of buildings or structures, particularly in areas containing significant natural heritage or land that is “a sensitive groundwater recharge area, or headwater area, or land that contains a sensitive aquifer” (Section 34(1)).

4.3.4 Environmental Assessment Act

The Environmental Assessment Act (EAA) is Ontario's primary environmental planning statute, and is administered by the MOE (Ontario, 1990d). In general, public sector undertakings (e.g., provincial or municipal projects) are bound by the EAA unless exempted. However, for private sector undertakings (e.g., non-government organizations, private companies, and individuals) the EAA does not generally apply unless they are specifically designated by regulations as undertakings to which the Act applies (e.g., new or expanded large private sector landfills are routinely designated as being subject to the EAA, as well as electricity projects).

To fulfill the requirements of the EAA, proponents must identify and evaluate ecological, social, cultural, and economic impacts that may be caused by the undertaking and its alternatives. Such undertakings cannot proceed unless the proponent completes the required environmental assessment with agency and public input, and receives approval to proceed from the Minister of the Environment. The Minister also has the power to refer the matter, in whole or in part, to the Environmental Review Tribunal for public hearings.

The MOE has used the EAA to approve Class Environmental Assessments (Class EA), which impose structured planning procedures for certain defined classes of projects. Unlike the individual environmental assessment process, the proponent of a Class EA project follows the prescribed planning process without the need for project-specific approval from the Minister of the Environment or the Environmental Review Tribunal. Most Class EAs, however, include ‘bump up’ provisions which allow the Minister to order proponents to carry out an individual assessment of particularly significant or controversial projects. SWM projects fall under the Class EA process.

4.3.5 Sustainable Water and Sewage Systems Act

This Act provides the framework for implementing full cost accounting. It requires municipalities to assess the costs of water and to develop plans to charge appropriate rates and generate sufficient revenue to finance capital and operating costs of sewer and water systems. It is administered by the MOE (Ontario, 2002a).

4.3.6 Lakes and Rivers Improvement Act

The Lakes and Rivers Improvement Act regulates public and private use of lakes and rivers, regulates construction, repair and use of dams, and prohibits deposit of refuse, matter or substances into lakes and rivers contrary to the purposes of the Act. It is administered by the MNR (Ontario, 1990d).

4.3.7 Nutrient Management Act

The Nutrient Management Act controls nutrients on agricultural lands so that they do not enter surface water or groundwater. It is also meant to control pollution from biosolids (i.e., sludge from sewage treatment plants and manure) when they are spread on land. The Act is administered by the MOE and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (Ontario, 2002b).

4.3.8 Municipal Act

Municipal governments in Ontario are regulated by the Municipal Act administered by the Ministry of Municipal Affairs and Housing. The Municipal Act contains a comprehensive code for the creation, expansion, restructuring and dissolution of municipalities in Ontario. It also prescribes the composition, duties and meeting requirements of municipal councils, and establishes various officers of the municipal corporation).
The Act allows municipalities to construct and operate municipal sewer and water systems, and empowers municipalities to enact and enforce by-laws on a wide variety of water-related matters, such as industrial discharges into municipal sewers. Another important municipal power is the authority to set water rates. This is directly affected by the new provincial legislation, the Sustainable Water and Sewage Systems Act.

With respect to SWM, municipalities have the responsibility to (Ontario, 2001):

- Administer waste management, public utilities (i.e., sewage/water services), and drainage and flood control (Parts II and III);
- Manage and preserve the public's assets of the municipality;
- Provide services, and anything else, the municipality considers necessary or desirable for the effective management of stormwater;
- Promote current and future economic, social and environmental well-being of the municipality; and
- Participate and deliver in provincial programs and initiatives (e.g., Source Water Protection).

Under the Planning Act, the municipal land use planning process sets out a distinct framework for the development of environmental, social and economic goals and objectives for the municipality.

4.3.9 Conservation Authorities Act

The Conservation Authorities Act was established by the Province of Ontario in 1946, and gave CAs jurisdiction over natural areas based on delineation by watershed (MOE and MNR, 1993). Water and related land management are the responsibility of CAs working in conjunction with the municipalities. The CAs are to establish regulations dealing with environmental protection of their watershed's resources. Regulations made under the Conservation Authorities Act must be consistent across the province, and be compliant with the Planning Act.

With respect to SWM, the Conservation Authorities Act mandates the following:

- Enables the establishment of a CA at the request of municipalities within a watershed (Sections 2 and 3) or adjoining watersheds (Sections 8 to 9);
- Specifies procedural requirements respecting municipal representation on the CA (Section 14);
- Empowers CAs to undertake watershed management programs, acquire or expropriate lands, enter into landowner agreements, construct dams or reservoirs, and undertake flood control or watercourse diversion projects (Section 21);
- Authorizes CAs to make capital expenditures and apportion costs and expenses among participating municipalities (Sections 25 to 27);

- Empowers CAs to make regulations which restrict or regulate water use, prohibit or regulate watercourse diversion or channelization projects, and prohibit or regulate development which may affect flood control, erosion, pollution or land conservation (Section 28); and
- Empowers CAs to make regulations respecting the use of their lands or facilities (Section 29).

4.3.10 Places to Grow Act

This Act maintains that municipalities that share an inland water source and/or receiving water body should coordinate their planning for potable water, stormwater, and wastewater systems to ensure that water quality and quantity is maintained or improved. In conjunction with CAs, municipalities are encouraged to prepare watershed plans and use these plans to guide development decisions and water and wastewater servicing decisions. Finally, municipalities are encouraged to implement and support innovative SWM actions as part of redevelopment and intensification (Ministry of Public Infrastructure and Renewal, 2006).

4.3.11 Drainage Act

The Drainage Act provides a procedure for the construction, improvement and maintenance of drainage works. Not all ditches and buried pipes in a city are considered municipal drains. An engineer's report generally classifies a ditch or pipe as a municipal drain. Under Section 74 of the Drainage Act, municipalities are responsible to maintain municipal drainage systems within their jurisdiction (Ontario, 1990e).

4.3.12 Clean Water Act

The Clean Water Act and five associated regulations came into effect with the intent to ensure that communities are able to protect their drinking water supplies through developing collaborative, locally driven, science-based protection plans (referred to as Source Water Protection Plans). Communities are developing these plans to identify potential risks to local water sources and take action to reduce or eliminate the risks. Municipalities are working with Conservation Authorities and the local community in meeting these goals.

The main principles that are followed in developing a plan include:

- Require local communities to look at the existing and potential threats to their water and set out and implement the actions necessary to reduce or eliminate significant threats.
- Empower communities to take action to prevent threats from becoming significant.
- Require public participation on every local source protection plan. This means everyone in the community gets a chance to contribute to the planning process.
- Require that all plans and actions are based on sound science.

4.4 Municipal Level

The Province of Ontario passed legislation that delegates certain responsibilities to local institutions such as municipalities and CAs. This includes legislation allocating specific duties with respect to managing public utilities (Municipal Act), watershed management (Conservation Authorities Act), and planning (Planning Act).

4.4.1 City By-laws

City by-laws aid in promoting sustainable land use, while allowing for the implementation of an effective drainage system level of service for flood control. City Council has the authority to pass by-laws for municipal purposes respecting public utilities and the enforcement of by-laws made under this or any other enactment, and to regulate or prohibit and provide for a system of licenses, permits, or approvals. By-laws are not uniform from jurisdiction to jurisdiction, and can vary in their definition and application. However, there are generalizations that can be made according to the guidelines set out in the Watershed Plan and the resulting OP. For example, there are sewer and sewer use by-laws regulating connections to the storm sewer system, and what is acceptable or prohibited from being release into them.

4.4.2 Official Plans

The primary method of planning at the municipal level is the OP. This is a legal document that is used by council and landowners as a decision making guide. Under Section 16.1 of the Planning Act, municipalities in Ontario are required to prepare an OP.

The OP:

- Must contain goals, objectives and policies established primarily to manage and direct physical change and the effects on the social, economic and natural environment of the municipality or part of it, or an area that is without municipal organization; and
- May contain a description of the measures and procedures proposed to attain the objectives of the plan and a description of the measures and procedures for informing and obtaining the views of the public in respect of a proposed amendment to the OP or proposed revision of the plan or in respect of a proposed zoning by-law.

The OP sets out objectives and policies that establish the basis for land pattern change and for protecting and conserving natural resources. To implement the OP policies and objectives, municipalities pass zoning by-laws which establish certain land use rights on individual properties. Area municipalities approve the creation of new lots and their supporting services through plans of subdivision and consents to sever.

5. FRAMEWORK FOR MASTER DRAINAGE PLANNING

5.1 Legislative Framework

There is a broad framework of legislation that regulates land use and other activities within a watershed and along streams. **Table 5.1.1** provides the current legislation that applies to SWM strategy development and implementation.

Table 5.1.1 - Legislation that Applies to SWM Strategy Development and Implementation

Issue	Legislation/Policy Document	Administered By
Flood Protection stormwater conveyance design	• Municipal Act • Planning Act	MMAH MMAH
	• Building Code Act • Conservation Authorities Act	MMAH MNR
	• Ontario Reg. 150/90 • Lakes and Rivers Improvement Act • Environmental Assessment Act	CA MNR MOE
	• Navigable Waters Protection Act • Floodplain Criteria (1982)	TC MNR
	• Beds of Navigable Waters Act • Drainage Act	MNR OMAFRA
	• Public Lands Act • MTO Drainage Manual	MNR MTO
Sediment Control During Construction	• Municipal Act • Ontario Reg. 150/90 • Endangered Species Act • Environmental Protection Act	MMAH CA MNR MOE
	• Lakes and Rivers Improvement Act • Ontario Water Resources Act • Environmental Contaminants Act • Fisheries Act	MNR MOE EC DFO
Fisheries Protection	• Endangered Species Act • Fisheries Act	MNR DFO
Bacteria Control	• Environmental Protection Act • Ontario Water Resources Act • Environmental Protection Act • Nutrient Management Act	MOE MOE EC OMAFRA
Water Quality (Aesthetics)	• Pesticides Act • Environmental Protection Act • Ontario Water Resources Act • Environmental Contaminants Act • Nutrient Management Act	MOE MOE MOE EC OMAFRA
Watershed Planning	• Conservation Authorities Act • Ontario Reg. 150/90 • Crown Timber Act • Drainage Act	MNR CA MNR OMAFRA
	• Endangered Species Act • Environmental Assessment Act	MNR MNR

	• Environmental Protection Act • Forestry Act	MOE MNR
	• Game and Fish Act • Historical Parks Act • Lakes and Rivers Improvement Act • Municipal Act	MNR MTR MNR MMA
	• Ontario Planning and Development Act • Ontario Water Resources Act	MMA MOE
	• Aggregate Resources Act • Planning Act • Trees Act • Woodlands Improvement Act	MNR MMA MNR MNR
	• Canada Waters Act • Canada Wildlife Act • Navigable Waters Protection Act • Provincial Policy Statement [(1)]	EC DFO TC MMAH
Agencies: MMAH - Ministry of Municipal Affairs and Housing MTR - Ministry of Tourism and Recreation MNR - Ministry of Natural Resources CA - Conservation Authority TC - Transport Canada OMAFRA - Ontario Ministry of Agriculture and Food EC - Environment Canada DFO - Department of Fisheries and Oceans MOE - Ministry of Environment MTO - Ministry of Transportation of Ontario		

The Stormwater Planning and Design Manual (MOE, 2003) outlines the stages of involvement in the planning process which is summarized in the later sections. SWM planning requires starting at the watershed level down to the site planning level. The document increases in detail from the watershed plan down to individual site plan.

There are many interrelationships between SWM planning and municipal land use planning processes which are illustrated in **Figure 5.2.1**. Each stage of the SWM planning process is described in the following sections.

5.2 Watershed Planning

Watershed plans deal with the area drained by a major river and its tributaries, and are considered the highest level planning document (Infraguide, 2003). The study area is determined by the natural drainage boundaries of the watershed, and is usually a minimum of 100km2 in size. The NPCA has three major watersheds that drain to Lake Ontario, Lake Erie, and Niagara River.

The plan contends with addressing environmental issues associated with studies on scale with the OP. It is generally developed cooperatively by government agencies and stakeholders (e.g., landowners and watershed residents).

It is the overall plan that will be used as the guide for managing human activities that affect water, land/water interactions, aquatic life, and aquatic resources. The health of the ecosystem will be protected as land uses and management practices change. It outlines areas that should be preserved, enhanced or rehabilitated. It shows areas that are suitable for development and provides guidelines to be followed in development designs.

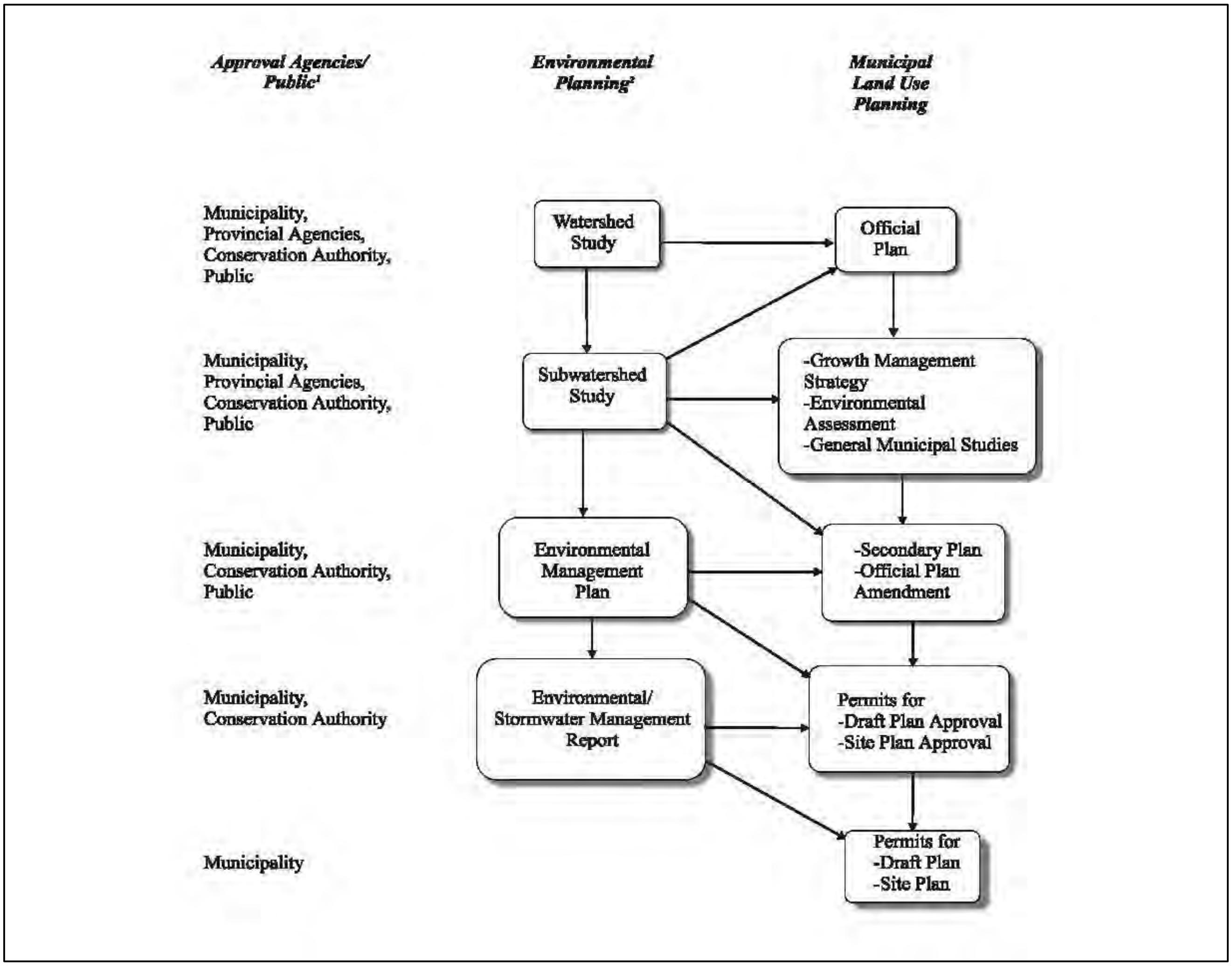


Figure 5.2.1 - General Relationship between the Environmental Planning and Municipal Land Use Planning Process (MOE, 2003)

[1] Approval agency/public involvement will vary from jurisdiction to jurisdiction
[2] For a given jurisdictional area one Environmental Planning component would generally be associated with on Municipal Land use component. Multiple arrows leading from the Environmental Planning component to the Municipal Land use component signify different approaches what are used in different jurisdiction.

The watershed plan is the umbrella document that will provide direction for ensuing subwatershed studies. For instance, information pertaining to key issues, constraints, resources, resource goals, sources of contamination and environmental targets could be provided. The watershed plan will contain goals and objectives together and the required actions to meet these goals.

Figure 5.2.1 identifies the typical agency based stakeholders and features of a watershed plan.

5.3 Subwatershed Planning

Subwatershed plans are an important mechanism for implementing watershed plans. They are intended to augment the land use planning process as well as provide for sound management of environmental conditions and natural resources. They are typically driven by development and led by a municipality.

A subwatershed plan will concentrate on resource features identified in watershed plans, undertake a more detailed study to identify the form and function of the natural systems and further identify areas for preservation, conservation, enhancement, rehabilitation, and development. Subwatershed plans can also provide more detailed goals, objectives, and recommendations for issues of concern identified in the watershed plan. They are typically 50 to 200 km^2 in size.

A subwatershed plan provides a management strategy (including land development) for the protection, enhancement and rehabilitation of natural features such as woodlots, wetlands, streams and wildlife. As outlined in **Figure 5.3.1**, there are four major phases in a subwatershed plan.

- **Phase I** - Typically involves establishing the form, function and linkages of the water and related environmental resources. This is done by examining environmental features and functions - soils, climate, groundwater, surface waters, river systems, habitats and wildlife - and how they interrelate.
- **Phase II** - Further characterization of subwatershed and data collection (based on focus provided by Phase I). Impact analysis of land use changes and analysis of effectiveness of management scenarios.
- **Phase III** - Development of a management strategy and implementation plan.
- **Phase IV** - Implementation and monitoring plan and evaluation/modification of management strategy.

The NPCA functions under the Conservation Authorities Act. One of the main purposes is to conserve and protect water-oriented natural resources throughout the Niagara Peninsula Watershed. Although the NPCA typically conducts subwatershed studies, their implementation as complete plans falls to area municipalities through their OP process and landowners. In addition, subwatershed plans should consider SWM retrofitting whenever possible.

Figure 5.2.1 identifies the typical stakeholders and features of a subwatershed plan.

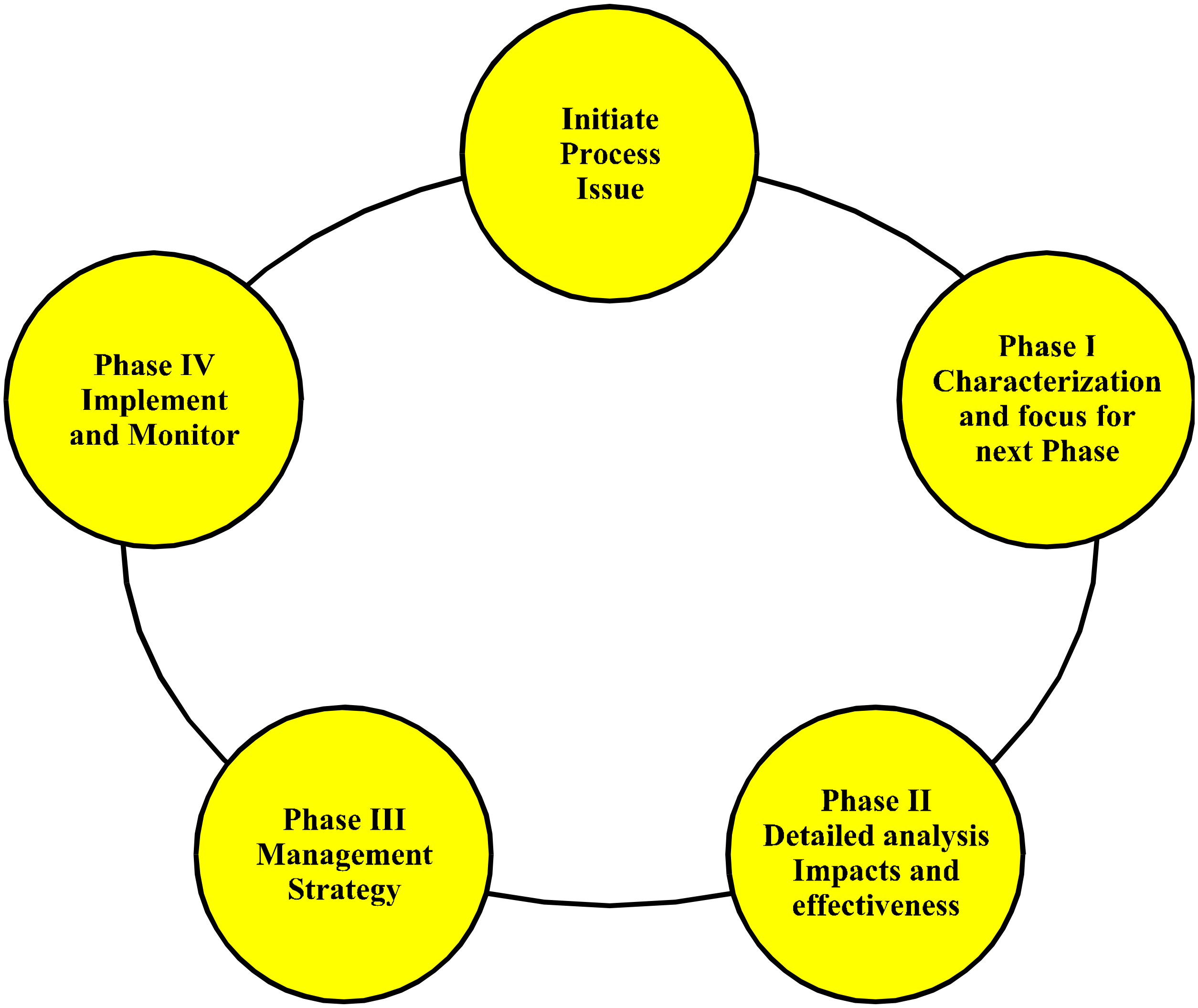


Figure 5.3.1 - Subwatershed Planning Process

5.4 Environmental Management Plan

An Environmental Management Plan (EMP) (also known as an Environmental Impact Report) is typically done before Draft Plan Approval. A typical study area is 2 to 10 km. The boundary may match the Secondary Plan boundary, tributary subcatchment boundary, or a portion of these areas. The level of detail should be such that individual subdivision plans may proceed pending its completion. The objectives of this should include:

- Identify the proposed/existing development in the context of the local and regional environment;
- Adequately illustrate all components of the proposed/existing development;
- Provide the basis of the advocate's EMP, which shows that the environmental impacts resulting from the proposed/existing development, including cumulative impact, can be acceptably managed; and
- Prepare a document that clearly sets out the reasons why the proposed/existing development should be judged by the approval agencies to be environmentally acceptable.

Figure 5.2.1 identifies the typical stake holders and features of an Environmental Management Plan.

5.5 Stormwater Management Report/Site Drainage Plans

This report is prepared to meet the requirements set at the Draft Plan or Site Plan stage. With a focus on SWM, it generally provides information regarding proposed measures and is submitted with grading and erosion plans, and site servicing plans.

The components of the report will vary according to whether a subwatershed study and/or an EMP has been completed. Deliverables of a SWM plan include:

- Detailed design of SWM plans, including connections and outfalls;
- Detailed design of environmental restoration works (e.g., stream protection works);
- Delineation/confirmation of constraint boundaries (e.g., significant woodland, top-of-bank, and geotechnical hazard area);
- Sediment/erosion control plans;
- Detailed reports relating to geotechnical and water resources;
- Major/minor systems;
- Delineation of grading limits and tree preservation planning;
- Re-vegetation/landscape plans;
- Access routes, disposal areas for operation/maintenance; and
- Landscape features including trails, benches and other recreational and interpretive amenities.

5.6 Master Drainage Plans/Master Drainage Studies

Master Drainage plans are sometimes completed for new development or existing development. Municipalities initiate drainage studies to obtain a comprehensive understanding of the performance of the existing urban drainage system. The anticipated impacts of future intensification on existing drainage infrastructure and the identification of future capital works are necessary to correct current deficiencies.

Reports can help the municipality identify existing drainage deficiencies and opportunities to incorporate water quality and quantity controls when performing upgrades.

The drainage study would identify which portions of the watershed are currently served by a water quality/quantity facility or future facility. Informed decisions could then be made for future development/intensification if the municipality has an understanding of where it will be occurring.

5.7 Adaptive Environmental Management and Monitoring Plans

Evolution of watershed management at all levels has recognized the importance of applying an Adaptive Management Approach. As resource management tools are enhanced and improved, and new approaches are developed, and societal characteristics and needs change, so do the subsequent management strategies. A management strategy must provide direction, as well as be flexible so modifications and fine-tuning can be carried out. Critical to the management strategy is a monitoring plan. These plans identify specific targets to be met and monitored. Performance of these targets can be used to evaluate the effectiveness of this management strategy in meeting the goals and targets set. If they are not being met, the strategy can be modified to make sure the goals can be acquired.

5.8 Stormwater Management Retrofit Study

This is an analysis of the developed urban area to determine the best means of retrofitting SWM measures. The study could be a Master Plan under the Municipal Engineers Association Class EA process. It is also referred to as a

SWM for existing development. This is a municipality based study, applied to the existing urbanized area. The project and timing is generally stand alone to address a known problem, such as bathing beach closures or excessive algae. It's often done to implement a subwatershed study or as a component of a Pollution Prevention and Control Plan or City-wide water quality strategy. The study components consist of the following five steps:

1. Set goals, objectives and targets. Which are based on health, safety, fishery protection, and water quality. Targets could be simple or complex, and examples include, in the order of complexity: percent area controlled by SWM measures; change in effective imperviousness; percent loading reduction of parameters (e.g., Total Suspended Solids (TSS) and Total Phosphorus (TP)); mass load reduction of pollutants; and change in watercourse concentrations of pollutants.
2. Inventory infrastructure including: Sewersheds and land uses; existing SWM measures; natural and modified stream systems; vacant public lands with potential for measures; road and underground infrastructure replacement and rehabilitation programs; and soil types.
3. Identify potential retrofit measures cost and locations:
   - Source control potential especially infiltration measures based on soil type and density/imperviousness of the developed areas;
   - Conveyance system potential based on upgrade of roadside ditches, and road and water/sewer rehabilitation program. Potential for oil-grit separators for use in site or conveyance system control;
   - Need and potential for spill control measures at industrial/commercial sites, in conveyance system for transportation related spills, and special measures built into end-of-pipe ponds;
   - Existing dry ponds that can be upgraded;
   - Vacant public land that a new SWM pond or other measure could fit; and
   - Other pollution prevention measures.
4. Evaluate performance in removing pollutants and achieving targets. The evaluation could consist of a loading model incorporating the parameters of interest (e.g., TSS, TP, bacteria, and percentage of area controlled) accounting for land-use type, control measures (source, conveyance, and end-of-pipe) and loads to the environment. A more complex study may account for watercourse effects as well such as the resulting concentration of bacteria at a bathing beach.
5. Formulate implementation plan with:
   - Specific measures location;
   - Timing of construction;
   - Cost – both capital and operation and maintenance;
   - Monitoring including reporting on progress; and
   - Need for specific class EA studies for measures.

Related Studies include:

- Pollution Prevention and Control Plan which primarily addresses combined sewer problems also often includes stormwater retrofit aspects; and
- Watershed/Subwatershed studies can be used to set receiving water based objectives and targets that form the driving force for a retrofit study.

6. SWM OPPORTUNITIES/CONSTRAINTS RELATED TO DEVELOPMENT TYPES

The following sections describe the various types of development and the different types of SWM opportunities.

6.1 Greenfield Development

Greenfield development provides the greatest opportunity for the protection and incorporation of features that play an important part in the hydrologic response function of a watershed role. It is a management tool that will assist in mitigating peak flow erosion increases related to land use changes (i.e., urbanization and agricultural uses). These features primarily include wetlands, woodlands, and the storage contained in riparian corridors along a stream system.

Most features are to be protected and remain in their natural state with vegetation preserved or enhanced. The features can contribute to water quality improvement in several ways:

- Maintain water balance, including maintaining infiltration to groundwater and natural runoff at low rates;
- Vegetation prevents erosion of soil; and
- Vegetation intercepts nutrients and pollutants in natural flow.

The land development process changes the land use and the physical characteristics of the surface, most notably increasing the degree of imperviousness that increases runoff and decreases infiltration. The impervious surfaces collect pollutants from traffic, urban activities on the land and aerial fallout. The drainage system delivers these pollutants to the local watercourses. In developing the land, opportunities are available to meet water quality and other objectives at the source (the land use activity), the drainage conveyance system, and at the end-of-pipe prior to discharge. A treatment train approach, which utilizes more than one BMP in series to achieve objectives, is preferable to expecting the end-of-pipe facility to perform all functions to meet targets.

Master Drainage Plans and SWM Plans prepared as part of the development process will include consideration of management measures to meet different objectives. Many of the measures usually built for one purpose or objective can contribute to meeting more than one target related to other objectives. In choosing measures it is preferable to consider source control methods first and methods, such as infiltration or retention, which satisfy multiple objectives. In sizing end-of-pipe elements, consideration should be given to reductions in flow volume or pollutant loadings that occur upstream in the drainage system. This ‘treatment train’ approach will result in cost savings for the structural end-of-pipe measures such as SWM ponds.

6.2 Brownfield Development

A Brownfield is a site that is under utilized and where soil and/or groundwater contamination has occurred, or is perceived to have occurred, at one time or another. To encourage redevelopment, the provincial legislation provides general protection from environmental orders for historic contamination to municipalities, creditors, and others (MOE, 2006). Current Brownfield legislation provides property owners with general protection from environmental cleanup orders for historic contamination after they have appropriately remediated a site. The recently passed Record of Site Condition Regulation (O. Reg. 153/04) details requirements related to site assessment and clean up (replacing the Guideline for Use at Contaminated Sites in Ontario).

Many municipalities have a number of Brownfield locations. In many instances, these sites are vacant land and/or abandoned buildings that were located in a City's core area. There can be environmental and economic benefits for remediating Brownfield sites for SWM purposes. The development would be areas already serviced by roads, water, sewers and other hard service infrastructure. Once clean up of the site has occurred, Brownfields have the potential to be utilized as SWM facilities (MMAH, 2001).

There are examples of Brownfield cleanup sites becoming SWM facilities in the US. The Depot Park Project in Gainsville Florida involves the remediation of contaminants left by the former Gainesville Gas Company coal gas plant and turning the rehabilitated area into a stormwater park. Excavation and removal of coal tar will facilitate the creation of a stormwater basin that will capture and treat stormwater originating from downtown. Stormwater treatment will greatly reduce contaminants entering the Alachua Sink in Paynes Prairie that are harmful to wildlife and the Floridian Aquifer. The stormwater basin is also expected to reduce downtown redevelopment costs by preserving scarce land area for business creation, rather than stormwater detention (Gainsville, 2006).

Benefits to the community include: improvement of derelict sites; neighbourhood revitalization and linkages; increased assessment and property tax revenues; provision of affordable housing in tight housing markets; new residents for local business; economic spinoffs; and links to other property initiatives (CMHC, 2006).

6.3 Greyfield Development

Greyfields are older, economically obsolescent retail or commercial areas. They have outdated buildings, large parking lots, are in disrepair, and fail to generate the revenue that would justify their continued use. Many are well suited as the sites of new development that may include housing, retail, office, services, and public space. Redevelopment of these areas is beneficial since they are existing communities, near transit, with existing utilities and transportation systems, with potential for significant densification. Areas need require significant public and private sector intervention to stem decline (Sobel et al., 2002). They may allow for opportunities for revitalizing and intensifying urban centers (CHMC, 2006), as well as providing municipalities with SWM options to address water quantity and quality controls.

A section of Mississauga known as ‘Streetsville’ that was once residential has been converted to commercial uses. Over control is required for new commercial development since the drainage system was designed based on residential standards. In situations like this, future development may need to control the 10-year post development flows to the 2-year predevelopment.

6.4 Redevelopment and Infilling

Infill development may cause high peak stormwater flow, an increase in erosion, and greater contaminate loading (MOE, 2003). The Stormwater Management Planning and Design Manual (MOE, 2003) outlines guidelines focusing on this issue. A synopsis is presented in the following sections.

6.4.1 Lot level, Parcel or Street Level

6.4.1.1 Residential Infill

SWM plans for small scale residential infill are usually restricted to lot level controls because of the small area of land in individual ownership, and the presence of existing stormwater conveyance infrastructure. Also, having residential roof leaders discharge to ponding areas is an applicable practice (e.g., lawn). Certain types of soils could allow for soakaway pits or infiltration trenches to be used, however problems with long-term maintenance and longevity may occur because of private ownership and potential for lack of maintenance. A reduction in lot grading may be used where the soils permit, but the acceptability of this type of control should be confirmed by the local municipality (e.g., some municipal standards require a minimum 2% slope).

6.4.1.2 No Control

Some municipalities may not accept no control without an assessment of infiltration potential (carried out by the proponent for development), and it is constrained to small residential infill developments (only a single lot in some instances).

6.4.1.3 Minimum Runoff Capture

Requires the adherent to capture all runoff from a small design rainfall event (typically 5mm) and keep it on site until it infiltrates or evaporates. If possible, lot level/source controls should be used for all residential infill to mitigate collective erosion impacts. Where soils and municipal by-laws permit, roof drainage to soak away pits, infiltration trenches or cisterns, and flatter lot grading may be used. Roof leader discharge to pervious areas should be applied, even to single lots, unless it is physically not possible.

6.4.1.4 Conveyance/End-of-Pipe Controls

In addition to the lot level controls, some small residential infill projects may provide the option to apply conveyance controls. In situations where new stormwater infrastructure is necessary and soil conditions permit, swale drainage or pervious pipe systems may be used for clean stormwater. The decision to implement these types of controls should be validated by the municipality. Normally, end-of-pipe controls are not applicable to residential infill and are rarely used.

6.4.1.5 Off-Site System to Address Cumulative Stormwater Impacts

SWM that occurs on-site is usually ideal. However, in some situations it may be ineffective or impractical due to physical constraints. In these situations, off-site systems (OSS) may be considered for all residential infill beyond a single lot. Off-site treatment can help address erosion, flood control impacts, and water quality caused by development within a watershed. Proponents are still responsible to ensure that they meet all legislative requirements, including the Fisheries Act.

Off-site systems (OSSs) can be used in combination with minimum runoff capture and conveyance/end-of-pipe controls. A number of municipalities have used the approach of requesting a financial contribution toward the development of SWM at another location elsewhere in the watershed and have used various formulas to calculate required financial contribution. This is discussed further in Section 11.

6.4.1.6 Commercial/Industrial

The potential to apply SWM plans to small-scale commercial/industrial infill are usually greater than those found in residential infill. However land availability and costs as well as municipal zoning requirements (e.g., number of parking spaces) can be limiting factors. Surface SWM facilities, such as wet ponds, constructed wetlands and infiltration basins, often are not practical because of the relatively large amount of surface area required. Rooftop, parking lot, and superpipe storage may not be accepted by some approval agencies. Lot level controls should be used to the extent possible to supplement end-of-pipe controls. The majority of other SWM plans can be applied depending on stormwater quality, soil conditions, and the individual development's design. **Table 6.4.1** lists the types of SWM plans that can be used in infill situations, types of control they provide, and conditions which limit their use.

Table 6.4.1 - SWM Applications Applicable to Infill Development

Method	Type of Control	Comments
Rooftop Storage	Peak Flow	Application dependent upon building design.
Parking Lot Storage	Peak Flow	Application dependent upon grading.
Superpipe Storage	Peak Flow	Application dependent upon invert of street storm sewer.
Dry Pond (quantity control)	Peak Flow	Application dependent upon available surface area.
Pervious Pipe	Water Quality, Water Quantity	Application dependent upon soils. May be combined with superpipe to provide both peak flow and some water quality control.
Swales*	Water Quality, Water Quantity	Most useful where infiltration capacities are high.
Pocket Wetland*	Water Quality, Water Quantity	Requires high water table to sustain wetland.
Dry Pond (24 hr. retention)	Water Quantity, Erosion	Application dependent upon available surface area. Minimum orifice size may govern feasibility.
Dry Pond (48 hr. retention)	Water Quality, Water Quantity, and Erosion	Application dependent upon available surface area. Minimum orifice size may govern feasibility.
Infiltration Trench*	Water Quality, Water Quantity	Application dependent upon soil infiltration capacity and protection of groundwater.
Sand or Organic* Filters	Water Quality	Generally applicable.
Bioretention Filters*	Water Quality	Generally applicable.
Oil/Grit Separators*	Spills/Water Quality	Generally applicable.
***Should be used as part of a multi-component approach including more than one SWM plan when used as a water quality control unless it is demonstrated on a case-by-case basis that the water quality criteria can be met (MOE, 2003).**		

Each municipality should conduct a study looking at their individual infill and retrofit needs with respect to water quality. An example is the study conducted by the City of Kitchener.

6.4.1.7 No/Minimal Controls

This approach is normally only considered for small industrial/commercial infill comprising less than 0.3 ha (Note: this cut-off may be modified to reflect specific municipal conditions and policies), and may be coupled with off-site systems. See Off-site controls). Roof leader discharge to pervious areas should be applied if physically feasible and practical (unless there is potential for contamination from roof top). Oil/grit separators may be used for areas that have a higher potential for spills (such as gas stations).

6.4.1.8 Minimum Runoff Capture

This approach involves capturing all runoff (a small design rainfall event which is typically 5mm) and retain it on site (runoff volume is usually either infiltrated or evaporated). This method may be used for clean water where soils permit and infill that is greater than 0.3ha.

In highly impervious commercial and industrial infill developments, the prospective usefulness of this approach is dependent on the ability to infiltrate the runoff where there are no concerns about groundwater contamination (i.e., stormwater must be clean).

6.4.1.9 Conveyance/End-of-Pipe Controls

For conveyance and end-of-pipe controls in some areas, quantity controls (e.g., rooftop or parking lot storage) are required for commercial/industrial infill because of sewer system capacity and flooding concerns. The use of rooftop and parking lot storage may not be allowed by some approval agencies for overall flood storage requirements for a subwatershed. However, storage may be practical for municipalities due to limited sewer capacity.

End-of-pipe controls for peak flow control should be mandatory where there is concern for downstream storm sewer capacity or where there are flooding concerns and no opportunity for centralized flood control facilities. Facilities for erosion control should only be applied where there is a clear need or where there is a potential to combine the requirements for water quality/quantity and erosion control (e.g., a dry pond). Even where there is a planned off-site system within a subwatershed, additional water quality controls may be required where there is a high potential for wash-off of contaminants (e.g., oil and grease at gas stations).

6.4.1.10 Existing Development

Retrofitting is the process by which existing surface water runoff control structures or surface water runoff conveyance systems that were designed to control flooding are modified to that they also serve a water quality improvement function (NCDENR, 2005).

A study conducted by North Carolina Department of Environment and Natural Resources Division of Water Quality (NCDENR), and published in the Updated Draft Manual of Stormwater Best Management Practices (2005) identified that retrofitting should also be considered as an opportunity to improve existing water quality BMPs. Existing practices may be inadequate or performing poorly, or they may simply lack the pollutant removal capability of newer BMP designs. The least expensive and most practicable retrofit opportunities often involve the improvement of existing urban BMPs. Retrofitting affords the opportunity to improve existing urban BMPs at modest cost. An example of this is converting older, dry extended detention basins into more efficient wet detention basins. Factors such as the presence of existing development or a community’s financial constraints may limit runoff management options; targeting may be necessary to identify priority pollutants and select the most appropriate retrofit methods. This is particularly true in highly urbanized areas where land is limited and the use of conventional pond systems is restricted.

Retrofitting BMPs can:

- Improve the multi-use functions and appearance of existing facilities and reduce maintenance needs;
- Reduce the pollutant loadings to downstream waterbodies and wetlands;
- Reduce downstream storm peaks and flow velocities that may be causing stream bank erosion; and

- Provide stormwater treatment to the maximum extent practicable where no formal treatment exists for existing systems.

As urbanization occurs and areas of impervious surface increase, maintenance of water quality becomes increasingly difficult. Retrofit of structural controls is often the only feasible alternative for improving water quality in developed areas. Ideally, as land is developed, BMPs would be implemented to control present and future urban runoff problems.

However, controlling pollutants in runoff from new development alone does not solve water quality problems caused by previous development. Therefore, retrofitting is an important structural option for developed areas to improve urban runoff water quality.

Incorporating BMPs into existing developments can reduce the adverse hydrologic, hydraulic, and water quality effects that the developments generate. Without detention the older areas commonly have serious local drainage problems and contribute to downstream flooding and erosion problems. Retrofitting dry extended detention basins or other storage devices in vacant lots or park sites could effectively address both stormwater quality and drainage problems. Because of the expense of excavating, this type of retrofitting has occurred only to a limited degree.

BMP retrofitting could remedy local nuisance conditions, maintenance problems, and aesthetic concerns. Poorly designed or maintained facilities could be dramatically improved and protected through effective retrofitting. BMPs can be retrofitted into existing developments by using the same design concepts described for new developments. The major accommodation for existing developments is the need for greater ingenuity in identifying locations and opportunities for the individual BMPs.

6.4.2 Retrofitting Filter Strips or Buffers

Filter strips and buffers can be readily incorporated into some existing developments if relatively large vegetated surfaces can be used. On individual lots, the benefits of filter strips can be established by rerouting rooftop and sump-pump discharges across the lawns. Care must be taken to extend discharge points away from foundations. Discharge points can be extended by using a variety of commonly available devices, from elbows and downspout extensions to splash pads.

For large development sites, runoff from paved areas can receive the benefits of filter strips if the paved and grassed surfaces are graded to route drainage to, and across, vegetated areas. The rerouting sometimes requires only removing or slotting the curbs along the edge of roads or parking lots. The capacity of existing swales for conveying runoff also may have to be assessed and expanded where necessary. Parking lots with vegetated aisle dividers may be particularly amenable to this type of filter strip development.

6.4.3 Retrofitting Infiltration Devices

Infiltration measures, including infiltration trenches, permeable pavement, and bioretention, can be introduced at most sites where the soil permeability and depth to groundwater are sufficient. Prime areas for developing bioretention facilities include natural depressions, medians, parking lot aisle dividers, and roadside swales. Parking lots, fire lanes, and other paved surfaces with low traffic can become infiltration areas by milling and recycling the existing pavement and replacing with a permeable surface, such as paver blocks, plastic webbing, or gravel. Infiltration trenches can be used effectively along the down gradient edge of parking lots where they can also be interconnected to permeable pavement.

Alternatively, infiltration trenches can be developed along parts of an existing drainage system by reconstructing the drainage way with appropriate porous materials. For example, drain pipes can be replaced with infiltration trenches.

6.4.4 Retrofitting Detention Devices

Roofs are one of the largest sources of concentrated runoff from developed sites. If runoff can be retained at the source, pressure can be taken off of existing undersized detention basins that may be inadequate. Therefore, rooftop runoff management should be considered as part of any effort to retrofit runoff-peak detention in highly urbanized areas. In general, effective rooftop runoff management requires that buildings be flat-roofed.

Another approach for managing rooftop runoff is to direct water to a dry well with detention capacity, to a below grade detention basin (such as a tank or vault), or to an infiltration trench.

Detention basins themselves provide two potential approaches: to retrofit an existing basin or to build a new basin with water quality controls in an existing development. Basins designed primarily for preventing floods often can be retrofitted to provide greater hydrologic and water quality benefits. Recommended actions for significantly enhancing the achievement of BMP objectives include:

- Modifying the outfall to create a two-stage release to better control small storm events while not significantly compromising the structure for controlling larger storms;
- Modifying the outflow structure to create a permanent pool. For example, the invert elevation of the lowest opening could be raised either by creating a higher opening and plugging the existing one, or by attaching standpipe with invert at a higher elevation;
- Eliminating paved low-flow channels and replacing them with meandering vegetated swales;
- Eliminating low-flow bypasses;
- Incorporating low gravel berms as flow baffles to lengthen the flow path and eliminate short-circuiting;
- Incorporating forebays and/or micropools at the inlet and outlet, respectively, for enhanced settlement of suspended solids;
- Regrading the basin bottom to create a wetland area near the outlet or revegetating part of the basin bottom with wetland vegetation to enhance pollutant removal efficiency, reduce mowing, and improve aesthetics;
- Creating a wetland shelf along the periphery of a wet detention basin to improve shoreline stabilization, enhance pollutant filtering, and enhance aesthetic and habitat functions; and
- Creating a low maintenance and attractive “no-mow” wildflower ecosystem in the drier portions of the basin.

Although retrofitting can effectively reduce existing water quality problems and address certain maintenance or operation problems of dry extended and wet detention basins, additional measures sometimes are needed. In particular, retrofitting does not eliminate the need for effective maintenance of the dry extended and wet detention basins. Vegetation management (e.g., mowing, burning, replanting), occasional sediment removal, and inspection and cleaning of outlet structures should be part of a long-term maintenance plan for all dry extended and wet detention basins.

Non-structural BMPs also should be considered with retrofitting activities. In particular, source controls for household wastes, fertilizers, and pesticides can dramatically reduce contributions of problematic pollutants that adversely affect both multipurpose detention facilities and downstream water quality. For example, reducing fertilizer application in the watershed draining to a wet-detention facility reduces the potential for eutrophication of that facility. Similarly, effectively enforcing erosion and sediment control eliminates excessive sediment loadings to detention basins, which store runoff from developing lands.

7. SWM POLICIES AND TECHNICAL GUIDELINES

7.1 SWM Requirements

The policies and guidelines regarding water quantity and water quality outlined in this section will apply to all stormwater management measures in areas regulated by the NPCA, as per the *Development, Interference with Wetlands and Alteration to Shorelines and Waterways Regulation* (Ontario Regulation 155/06). The role of the NPCA will be two-fold in this regard: first, the NPCA will provide a Regulatory role as described in O.Reg 155/06 in SWM and erosion and sediment control approval; second, the NPCA will work with all municipalities in the watershed to provide commenting and technical review services as per applicable Provincial, Municipal and Conservation Authority policies, or as identified in a Memorandum of Understanding.

The following criteria need to be considered when determining the objectives for water quality (fisheries level of protection), water balance maintenance, flood control, and watercourse protection (erosion control).

7.1.1 Per Relevant Existing Subwatershed and Watershed Plans

If a watershed or subwatershed plan exists, then the objectives laid out in such plans should be incorporated into the SWM plan for a development.

In order to achieve the objectives of the watershed or subwatershed plans, the NPCA's review of proposed designs for regulatory purposes will focus on the function of the SWM controls. This focus is to ensure that the specific proposed controls will be effective in meeting the desired objectives. The *Stormwater Planning and Design Manual* (MOE, 2003) define many elements of SWM design that either directly or indirectly affect the function of SWM controls and will thus be of interest to the NPCA during regulatory approval processes.

In fulfilling the secondary role of the NPCA, namely in providing technical review and commenting services, technical advice will be provided to municipalities with regards to issues of function, as described above, as well as in other issues that may be of interest to the specific municipalities. Such issues may include pond side slopes and fencing, which involve issues of safety and municipal liability rather than function, and forebay sediment storage volume (and recommended clean out frequency), which are primarily involved with the life-cycle costs of SWM control ownership.

In the absence of a set of pre-set objectives from subwatershed plans, the *Stormwater Planning and Design Manual* (MOE, 2003) should be followed. This manual outlines three levels of protection for protection of fisheries, as described in the next section.

7.1.2 Water Quality – Surface

7.1.2.1 Total Phosphorous and Total Suspended Solids

Ideally development would have no impact on the receiving watercourse. In the context of water quality, this means that the loadings of significant pollutants after development are generally no greater than before development. Typically a SWM pond designed for and Enhanced level of protection would provide 80% of removal of TSS and 65% removal of TP (the phosphorus associated with suspended matter is removed along with the TSS, however very little of the dissolved phosphorus is removed). As such, the level of fishery sensitivity within the watercourse (refer to **Appendix F**) shall dictate the required stormwater quality control standard to be applied.

The NPCA will typically require that a Normal level of stormwater quality control be implemented as the minimum acceptable standard regardless of the condition of the receiving watercourse. This criteria

reflects the NPCA's efforts to recognize the potential of a watershed to be rehabilitated, as opposed to accepting and perpetuating a degraded condition.

The NPCA would note that in certain cases, additional measures to control TSS and TP would be required in order to achieve a more stringent standard than what is generally applied (i.e. Enhanced level of protection). The individual watershed plans would identify the rational and need to implement these additional measures (should they be required). For example, the target TP loadings recommended in the North Oakville Creeks Subwatershed Study (TSH, 2006) and for the Lake Simcoe Conservation Authority is zero increase after development. As such, it is strongly recommended that the NPCA be consulted early on in the design process in order to identify the level of stormwater quality control required.

7.1.2.2 Temperature

Typically, conventional stormwater management facilities serve to elevate the temperature of the water within the facility. As the majority of the watercourses within the NPCA's jurisdiction are warm-water systems, these elevated temperatures do not pose a problem. As such, no special measures are required to cool the water discharging out of the stormwater management facilities into these warm-water systems.

The NPCA would note however, that 12 Mile Creek is a cold-water system. Field work being undertaken to support other Watershed Plans within the NPCA's jurisdiction are revealing the potential for portions of other watercourses to be classified as a cold-water system. In these cases, the NPCA will require that measures be implemented to reduce the temperature of the water discharging from the stormwater management facilities in order to avoid negatively impacting the downstream aquatic ecosystem. It is strongly recommended that the NPCA be consulted early on in the design process in order to identify if stormwater temperature controls are required.

7.1.2.3 Road Salt

Road salt has chlorides which are soluble and not removed by SWM ponds. Environment Canada declared road salt toxic by adding road salt to the Priority Substances List of the Canadian Environmental Protection Act. Road salts are used in Canada as de-icing and anti-icing chemicals for winter road maintenance, with some use as summer dust suppressants. Environment Canada (Canada Gazette, April 3, 2004) issued a Code of Practice for the Environmental Management of Road Salts, under the Canadian Environmental Protection Act (1999). The Code of Practice was developed in consultation with a multi-stakeholder working group for road salts. It recommends that road authorities develop salt management plans to implement BMPs in the storage and application of road salts, and disposal of snow containing road salt. The notice states that "The environmental impact indicators listed in Annex A, the guidance for identifying vulnerable areas provided in Annex B and the data gathering and reporting provisions in Annex C of this Code should be considered during the development and implementation of the salt management plan". The Government of Canada is not banning the use of road salts or proposing any measures that would compromise or reduce road safety. The Niagara Region adopted a Road Salt Management Plan. They should update the Road Salt Management Plan to reflect the Code of Practice issued by Environment Canada, in particular to identify watercourses and groundwater locations vulnerable to salt damage. It is recommended that all municipalities develop and adopt a Road Salt Management Plan, and include consideration of areas vulnerable to salt damage.

7.1.2.4 Spill Potential

Concerns about potential spill effects on surface and groundwater depend on the type of land use and the sensitivity of the receiving water or aquifer. Possible control measures include: site spill control plans; spill control in the conveyance system (oil-grit separators), and SWM pond modifications such as an underflowing weir at the sediment forebay outlet and reverse pipe outlet from wet pond. It is recommended that the minimum target be that spill control provisions be added to all SWM facilities that receive drainage from industrial and commercial areas or roadways with a high volume of commercial/industrial traffic.

7.1.2.5 Oil/Grit Separators

The NPCA will entertain the use of oil/grit separators in certain applications. These include in-fill, commercial, and industrial developments. The NPCA typically discourages their use for green-field residential developments. It is strongly advised that the NPCA be consulted prior to consideration of these units as a SWM quality control device.

7.1.2.6 Source Protection

Our drinking water comes from surface water sources such as lakes, rivers, and streams, but it may also come from underground sources such as groundwater aquifers. Unfortunately, these sources of water are susceptible to contamination or overuse. Source Water Protection (SWP) is simply protecting these surface water and groundwater sources from such unwanted impacts.
SWP is the first barrier of a multi-barrier approach to ensuring safe drinking water that includes:

- Source water protection.
- Up-to-date water treatment systems.
- Reliable distribution systems (pipes & towers).
- Professional training for water managers.
- Careful and regular testing of our water supplies.

This multi-barrier approach was recommended in the O'Connor report, which followed from the Public Inquiry into the Walkerton tragedy. SWP is considered a key component of this approach, since the protection and enhancement of natural systems is considered one of the most effective ways of ensuring the safety of Ontario's drinking water. Also, conventional water treatment methods cannot cost effectively remove many hazardous chemicals if they are present in the source water.

The Clean Water Act (CWA) sets out a four stage process for Source Water Protection, including:

- Stage 1 – Establish Source Protection Areas, Source Protection Authorities and the Source Protection Committee to launch technical studies. As part of this phase, the Niagara Peninsula Source Protection Authority and Source Protection Committee was established (NPSPA and NPSPC).
- Stage 2 – Complete the Assessment Report (AR). The primary goal of the AR is to provide the necessary information to the establish source protection plan and make local policy decisions for the management and protection of our drinking water sources. Several technical studies are being prepared for the AR, including: Watershed Characterization Report, Water Budget and Water Quantity Threats Assessment, Groundwater Vulnerability, Surface Water Vulnerability and Threats Inventory and Issues Evaluation.
- Stage 3 – Prepare Source Protection Plans (SPP). The plan will build on information from the AR, setting out policies and risk management strategies to address any significant threats to the municipal drinking water supply.
- Stage 4 – Implementation. The municipalities will be substantially involved with the implementation of the SPP policies, as implementation may require amendments to Official Plans and revision to land-use zoning to abide by the goals expressed in the SPP.

7.1.3 Water Quality – Groundwater

7.1.3.1 Infiltration

The reader should refer to hydrogeological sensitivity maps in **Appendix G** to establish if infiltration should be accepted for the drainage area. In areas that are sensitive, it is recommended that a clay lining be incorporated in the SWM facility to prevent infiltration of untreated stormwater. For other areas where infiltration can be practiced, it is recommended that the stormwater receive pre-treatment with at least oil grit separator to prevent clogging of the infiltration media and protect groundwater. This issue takes precedence over water balance concerns.

7.1.4 Water Quantity

7.1.4.1 Water balance

Urbanization, usually with a change in land cover from the pervious soils of agriculture to impervious pavement and rooftops, results in increased runoff and peak flows, and reduced infiltration and evapotranspiration. To the extent possible, SWM measures should be used to retain the balance. Measures include lot level green roofs, roof downspouts discharging to rain barrels or grassed areas, and use of infiltration galleries. Conveyance systems can include enhanced roadside ditches and exfiltration systems. End-of-pipe measures can include infiltration systems. In the absence of a sub-watershed plan and where suitable soils exist, the NPCA will require that best efforts be made to maintain the pre-development water balance by including measures discussed above at the lot-level, in the conveyance system, and at the end-of-pipe.

7.1.4.2 Flood control

Within the Niagara Peninsula watershed, the NPCA is the primary agency responsible for the mitigation of flood risk due to proposed development. This responsibility requires that all proposed development does not increase flood risk to existing development, and is accomplished primarily by two methods. The first is the traditional practice of careful land use planning in areas of flood risk. The second is achieved through the development of drainage practices and SWM policies for proposed development, and is described in greater detail in this section.

The NPCA considers proper drainage practices to be one of the most critical factors in flood risk mitigation, wherein existing watershed boundaries and drainage patterns are maintained. These existing drainage characteristics should be maintained post-development, and a pre-consultation with the NPCA will be mandatory if modifications to these characteristics are proposed.

Typically, the NPCA will require that post-development runoff flows from a site are controlled to a level that matches or is below the pre-development flows for the 2, 5, 25, and 100-year design storm events. In assessing the pre- and post-development flows, the design storm which yields the lowest pre-development flows and the highest uncontrolled post-development flows should be used, considering multiple storm durations (i.e., 3-hour, 12-hour, 24-hour) and design storm types/distributions (i.e., Chicago, SCS Type II). End-of-pipe facilities should also consider a long-duration, high volume storm to assess safe facility operation. These design storm events should be based on the IDF curves for the specific municipality (see **Appendix H** for sample IDF parameters) as defined in their SWM standards. Alternatively, the IDF curve which is most geographically similar can be used if a municipal standard is not in place.

Note that there may be requirement for additional design criteria to be met above and beyond those described above if specified by the municipality, subwatershed study, or fluvial geomorphic analysis. In addition, the capacity of the receiving system should be completed during the development of proposed designs in order to determine if a pre-development flood risk. If such a risk exists, criteria can then be develop to maintain the risk at its pre-development levels or are reduced, potentially requiring over-control to flow rates below pre-development levels.

If the capacity assessment of the receiving system reveals that typical SWM controls managing flow levels to pre-development conditions either provide little benefit or have an adverse impact on flood risk (i.e., through delaying the runoff peak and adding them to upstream peaks), consideration may be given to not requiring peak flow controls. This will only be permitted following a detailed study of the receiving system. This study is to be completed by the proponent, and a detailed Terms of Reference for the study is to be submitted to the NPCA for review and approval prior to commencement. Note that some measure of SWM controls may still be required under these circumstances, such as measures to reduce runoff volumes to pre-development levels.

7.1.4.3 Erosion Control/Geomorphology

In the absence of a subwatershed study outlining specific requirements, the objective is to not increase the erosion forces in the receiving natural stream. The MOE outlined an interim approach in 1994 and updated it in the Stormwater Management Planning and Design Manual (MOE, 2003). This updated approach consists of either a detailed design approach or a simplified design approach that is currently being improved to address inadequacies. Accordingly, it is recommended that the general approach to be followed is as outlined in the Stormwater Management Planning and Design Manual (MOE, 2003). This consists of designing SWM ponds to include active storage for the runoff from a 25 mm storm, followed by a check on erosion velocities in the downstream receiver. The design of the outlet flow control structure should be adjusted so that the flow released during the drawdown period does not cause an increase in the erosion rate as measured by the Erosion Index (MOE, 1994). This approach can be updated when revisions to the MOE approach are available for consideration.

7.2 Hydrologic/Hydraulic Analysis

SWM facilities are designed to convey surface water from developed land to a water course, while in the process not increasing the amount of flow when compared to pre-development conditions. To ensure facilities meet these requirements, the amount and timing of runoff must be estimated. Individual municipal design standards should be the starting point for this design. In the absence of municipal design standards and in order to supplement them, the following guidelines and policies have been developed. The text is based on the *City of Hamilton: Criteria and Guidelines for Stormwater Infrastructure Design* (2007) with some input from the Ontario Ministry of Transportation *Drainage Management Manual* (1997).

7.2.1 Model Selection

When estimating flows for designing SWM structures, a model must be chosen that best provides the information needed. This modelling approach can be as simple as estimating peak flows with the Rational Method (See below) to sophisticated hydrologic and hydraulic computer models. The types of models along with some of their potential applications are outlined below. To aid in choosing a specific computer model, both the *Flood Plain Management in Ontario Technical Guidelines* (MNR, 2001) and the Ontario Ministry of Transportation *Drainage Management Manual* (MTO, 1997) provide guidelines. The MTO document lists the characteristics of each model, from which the proponent can evaluate the appropriateness of certain hydrologic models. Sound hydrologic modelling standards of practice should be followed in developing any hydrologic model and rationale for the model choice and assumptions made should be outlined in the SWM design document for review.

7.2.1.1 Rational Method

The Rational Method is one of the earlier developed methods of calculating peak flows. In spite of the availability of advanced computational techniques, it remains a valid approach to peak flow estimation for small drainage areas. The application of this method should be limited to watersheds less than 100 ha in size and should not be used for the design of SWM ponds.

Some applications of the Rational Method include:

- Determination of peak flows to size channels, sewers, ditches, and culverts;
- Preliminary design estimation for drainage systems; and
- Flow estimation to design erosion and sediment control devices.

The method is expressed as follows:

$Q = 0.0028 * C * i * A$

where:
Q = peak runoff rate, m3/s
C = weighted runoff coefficient for the catchment area
i = rainfall intensity, mm/h (see IDF Curves in **Appendix H**)
A = drainage area, ha

The peak rate of runoff, Q, is determined by using average rainfall intensity, i, over the entire watershed with a time duration equal to the area time of concentration, t_c. Suggested values of C for different land use categories are provided in **Table 7.2.1**.

Table 7.2.1 - Runoff Coefficients for Different Land Use Types

Land Use Category	Runoff Coefficient, C
Parks/Open Space	0.2
Low Density Residential	0.5
Medium Density Residential	0.65
High Density Residential	0.75
Institutional	0.75
Industrial	0.75
Commercial	0.9
Paved Areas	0.95

The rainfall intensity is generally taken from Intensity Duration Frequency (IDF) curves derived for the study area from historical rainfall data (see Section 7.2.3) at a nearby rain gauge. **Table 7.2.2** gives some sample standard IDF coefficients (a, b, c) for three locations in the Niagara Region where the intensity can be calculated using:

$$i = \frac{a}{(t_c + b)^c}$$

Table 7.2.2 - Sample IDF Coefficients in the Niagara Region

Location	Storm Frequency (years)	a	b	c
St. Catherines	2	567	5.2	0.746
	5	664	4.7	0.744
	10	724	4.3	0.739
	25	821	4.0	0.735
	50	900	3.8	0.734
	100	980	3.7	0.732
Welland	2	755	8	0.789
	5	830	7.3	0.777
	10	860	6.5	0.763
	25	900	5.2	0.745
	50	960	5.1	0.736
	100	1020	4.7	0.731
Niagara Falls	2	521.97	5.28	0.7588
	5	719.50	6.34	0.7687
	10	577.93	2.483	0.669
	25	1020.69	7.29	0.779
	100	1264.57	7.72	0.7814

7.2.1.2 Single Event Hydrologic Simulation

A single event model refers to a model that simulates the response of a watershed to a short duration (in general from 1 to 24-hours) design rainfall event. The design rainfall may be a physical event such as a historical storm or a synthetic storm based on a statistical analysis of recorded rainfall. Single event modelling is primarily used for estimating the peak flow rate and timing for sizing facilities (e.g., SWM ponds, channels, and sewers) with larger drainage areas.

Sound hydrologic modelling standards of practice should be followed in developing an event based hydrologic model. The following standards of practice are intended to guide general model preparation for most hydrologic programs and techniques, however, this list should not be considered exhaustive.

1. The modeller should provide the purpose for developing the hydrologic model, such as determining flow rates, runoff volumes, flow routing effects for proposed development, and existing land use conditions.
2. The modeller should provide the study objectives and how they relate to the hydrologic modelling.
3. The modeller should provide the model selection criteria and how the model matches the criteria.
4. The modeller should provide the basis for the storm design information, outlining how the design storm has been selected.
5. The modeller should provide drainage area plans outlining both internal and external catchments, modelling schematics, and tables providing drainage area parameters.
6. Background information on the selection of the drainage area parameters should be provided to assist the reviewer in understanding on the assumptions leading to the drainage area parameters.
7. Background data on overland and minor storm systems should be provided with plans clearly presenting and labelling both systems.
8. Data should be provided on routing through natural and manmade storage systems, with detailed plans and calculations outlining how the stage/discharge relationship has been developed.
9. Sensitivity analysis should be conducted on a number of parameters which varies with model complexity.
10. Verification or validation of results should be provided through various methods such as calibration to recorded streamflow, unit flow rates and runoff volume comparisons using the techniques such as the MTO index method or equivalent. The application of the validation technique (number and type) will depend on the availability of data and the sensitivity of the analysis.
11. The modeller should provide all input and output details in a logical manner, with an explanation for potential errors.

For guidelines on choosing a specific event based hydrologic model see Section 7.2.1. For information on obtaining rainfall data, see Section 7.2.3. For information on setting model parameters, see Section 7.2.4.

7.2.1.3 Continuous Hydrologic Simulation

A continuous model refers to a model that simulates the response of a watershed to precipitation using actual continuous rainfall and snowfall data covering a long period of record. Typically, the minimum duration for meaningful continuous simulation is 20 to 25-years. With continuous simulation, antecedent moisture conditions are more representative of drainage conditions compared to parameters set in event based modelling, since they are not assumed but are a reflection of the sequence of wet and dry periods. When results of failure of a drainage system represent a significant risk to life or property damage, continuous analysis may be warranted. However, continuous simulation is expensive and requires significant computer time to calibrate the model. Such calibration also requires specialized hydrologic expertise.

Continuous models are typically used but are not limited to higher level studies such as watershed and subwatershed studies. Continuous modelling may also be used for studies with a scope requiring historical data inclusion. Continuous simulation is also preferred where low flow is of major interest (e.g., erosion and fisheries studies). In these cases, infiltration and evaporation losses are sensitive and continuous simulation is able to account for the losses more closely than single event simulation.

The proponent in selecting a continuous hydrologic model usually intends to develop frequency flows for the historical data period. The proponent should specify the assumptions and methodology for determining the frequency flows and typical year hydrographs. The proponent should provide validation of the selected probability distribution by using statistical tests. In addition, approval agencies (i.e., MNR, MTO, and others) other than the NPCA should be consulted to determine modelling requirements.

For guidelines on choosing a specific continuous hydrologic model see Section 7.2.1. For information on obtaining historical rainfall data, see Section 7.2.3. For information on setting model parameters, see Section 7.2.4.

7.2.1.4 Hydraulic Capacity

Drainage systems can be subdivided into both closed and open systems. The hydraulic capacity of the receiving minor and major storm system is to be determined to verify that drainage can be safely conveyed as proposed. The hydraulic capacity of a storm system can be determined through hydraulic modelling and for certain applications through the use of standard ‘hand calculations’. As for hydraulic modelling, standards of practice relate to the use of various techniques. The following standards of practice are intended to provide direction.

1. The proponent should clearly identify the study objectives and how they relate to the hydraulic modelling.
2. The proponent should provide the purpose for the hydraulic modelling.
3. The modeller should provide the model selection criteria and how the model matches the criteria.
4. The proponent should provide plans clearly presenting the closed and/or open hydraulic system.
5. For plans describing open systems, the proponent should note cross-sections, study limits, land use, crossing details, spill areas, ineffective flow areas, and flooding limits and elevations for the appropriate design event(s).
6. For plans describing closed systems such as storm sewers, the proponent should note the storm sewer network details including manhole numbers, storm sewer size, length, study limits, land use, slope, and sewer and ground elevations.
7. For combined hydrologic/hydraulic models such as the Storm Water Management Model (SWMM), the proponent should provide plans that not only describe the closed system but also the contributing drainage areas and overland flow system.
8. For all hydraulic models, the proponent should provide the downstream and, if applicable, the upstream boundary conditions for each storm modelled and the assumptions used to define the boundary conditions.
9. For all hydraulic models, the proponent should document the parameters established for hydraulic losses such as Manning’s ‘n’, inlet and outlet losses and other appropriate losses.
10. The proponent should summarize the selection of procedures for determining the computed energy grade line and water surface elevations.
11. The proponent should document the hydraulic results in summary form for the relevant storm events.
12. The proponent should prepare the model of an open system such that it fully contains the modelled flows without exceeding the hydraulic cross-section. Should it not be possible to contain the flows within the defined geometry of the open storm system, the proponent should provide details on the spill characteristics. In the event of a spill, rationale should be provided on whether or not to include a flow loss in the calculation.
13. The proponent should document potential impacts on existing infrastructure and possible mitigative measures.
14. Sensitivity analysis should be conducted on a limited number of parameters depending on the model type and complexity.
15. The proponent should, if possible, verify hydraulic results for an existing closed/open storm system by documenting historical flood elevations for specific storm events and comparing the hydraulic modelling results to the historical data; calibration of losses should be included, if sufficient data exists.

16. The proponent should provide the input and output data in a logical manner with an explanation of the potential error.

7.2.2 Storm Event Duration and Distribution

In general, there is not one distribution of rainfall that should be used exclusively within the Niagara Region. The Intensity Duration Frequency (IDF) curves have some variation across the municipalities (see **Appendix H**). Each distribution has unique characteristics that might be important depending on the location and type hydrological analysis. It is the responsibility of the proponent to determine which distribution would be best suited to establish the design events for a development or redevelopment to the satisfaction of the municipality. Consideration should be given to the drainage area(s), size, characteristics, and objective functions when establishing which temporal distribution is to be used. In the absence of specific municipality guidance on design storm choice, **Table 7.2.3** outlines the different distributions acceptable to the NPCA, their origins and characteristics.

Table 7.2.3 - Design Storm Distribution Types

Distribution	Origin	Characteristics
Chicago	Developed from an Intensity-Duration-Frequency (IDF) relationship.	Provides greater peak flows for urban areas than the Soil Conservation Services (SCS) Type II distribution.
SCS Type II	Utilizes mass rainfall curves to derive the design storm,	Provides the highest peak flow for rural catchments in comparison to the Chicago distribution.
AES	Used to develop hyetograph using information concerning total rainfall, time to peak and decay constant.	1-hour storm event should be considered in determining the controlling design storm in relation to the Chicago and SCS distributions,

The selection of the duration of the rainfall event should be based on the area characteristics and the SWM approach being considered.

The frequency of storm that needs to be used is dependant on the purpose of the study. When determining the frequency of storm required for sizing conveyance of the minor and major systems, refer to specific municipality and/or MTO guidelines (MTO, 1997). Other storm frequencies should be used to define the level of food risk to private property and roads.

It may be necessary to examine results based on more than one design storm distribution/duration and use the most conservative of the outcomes. In addition, other agencies involved in the project should be consulted when determining the design storm distribution and duration. Each municipality has the responsibility of approving the selected design storms.

7.2.3 Climate and Rainfall Data

The proponent should demonstrate that the historical meteorological time series selected for any SWM design has been obtained from the nearest rainfall gauge to the proponent's study area. This will often lead to a trade-off between duration of record and proximity. Typically, the minimum duration for meaningful design is 20 to 30-years. Historical rainfall data is available from the Niagara Region, the Niagara Agricultural Weather Network, and Meteorological Services of Canada. A description of the hydrometerological monitoring network for the NPCA (including snow course and river gauging stations) is given in the NWQPS (of note are Tables 3.1-3.3 and Figure 3.1).

7.2.4 Parameter Selection

As mentioned in the above sections, background information on the selection of the drainage area parameters should be provided to assist the reviewer in understanding the assumptions leading to the drainage area parameters. The proponent must establish appropriate parameters, showing calculations for:

- Land use (including imperviousness);
- Overland flow characteristics (length and slope);
- Soils parameters;
- Additional abstractions;
- Friction factor/roughness; and
- Any other parameters required by selected model(s).

Wherever possible, model parameters should be established based on field verified measurements and/or conditions. Where this is not possible, all assumptions used in defining parameters should be stated with relevant calculations outlined and information sources cited.

7.3 Stormwater Management Best Management Practices

7.3.1 Background

BMPs are tools used to manage stormwater drainage for adequate conveyance and flood control. Ideally, BMPs should retain as much of the 'natural' infiltration components and runoff characteristics of the undeveloped system as possible and reduce or prevent water quality degradation.

The following sections provide examples of BMPs that could be considered for stormwater quality and quantity control, details on choosing the appropriate BMP(s) for a site, treatment train performance evaluation, and a selection tool for choosing roadside drainage.

7.3.2 At Source and Lot-Level Quantity Controls

Source and lot-level quantity controls are generally the most effective means of providing water quality protection since they prevent pollutants from entering the drainage system and provide for flow retention at source. Most practices can assist in addressing the four criteria, quantity, quality, stream erosion, and hydrologic cycle, but they are more often associated with quality and quantity control (National Guide to Sustainable Municipal Infrastructure, 2003).

These controls can consist of the following:

- Non-Structural Source Controls;
- Housekeeping Practices;
- Control of Construction Activities; and
- Structural At Source Controls.

Each are described in further detail below (TSH et al., 2001; National Guide to Sustainable Municipal Infrastructure, 2003; Dillon, 2006).

7.3.2.1 Non-Structural At Source Controls

Public Education, Awareness and Participation

Success of SWM programs is extremely dependant on the mind-set of the public that these initiatives are affecting. Education, understanding, and awareness are key to achieving public support. If these variables are not attained, these programs could be viewed as pointless, restricting and an unnecessary financial expenditure.

Buy-in of the public is necessary throughout the SWM planning process. The public should be notified about issues, solutions, regulations, and financing. They should also be an active participant in remedial action, cost saving through volunteerism, and political support. Facets of communication can be conducted through schools, communities, and businesses to stress that non-point sources can contribute daily to significant water quality problems. Examples of key messages that should be put forth include:

- Stormwater and urban runoff are not normally treated. As these surface flows reach local bodies of water, they contain all of the pollutants that accumulate from everyday living, including residential, industrial, and recreational activities;
- Sources of stormwater pollution include automobile products, vehicle maintenance operations, litter, pet wastes, pesticides, fertilizer, erosion from construction sites and illegal sewer connections;

- Pollutants enter the storm drain as water from rainfall, overwatering or cleaning operations washes over outdoor surfaces;
- It is important to avoid pouring toxic chemicals down drains leading to the sanitary and storm sewer system;
- There are properly designed and controlled facilities to safely dispose of household hazardous waste in most areas of the country. The public is usually provided with telephone numbers and other information necessary to make arrangements to properly dispose of common toxic wastes;
- By making changes in daily habits, individuals can help to protect the health of local watercourses;
- Specific outreach messages to business and/or groups typically revolve around encouraging the business to implement BMPs for their particular activity.

Integrated Stormwater Management Planning

Integration of SWM with land use planning is practiced in a number of municipalities. An emerging practice in British Columbia is integrating watershed based planning processes such as watershed plans, catchment plans, master drainage plans, and stormwater plans. Integration into relevant municipal planning processes addresses the impacts of SWM on relevant community values. This approach treats stormwater as a resource that is to be protected and views the other values as complementary objectives.

Modified Use, Releases, and Disposal of Chemicals Entering Stormwater

These measures employ planning, and environmental and building by-laws and regulations to reduce releases of harmful chemicals into stormwater. This can generally be achieved by modifying some activities, the use of certain products, and their handling and disposal practices. Road salts, pesticides and household hazardous waste are examples of chemicals that can be controlled and managed through regulations and programs.

Development and Enforcement of Sewer By-laws

The types of activities addressed here include illegal dumping control, removal of contaminated sediment from sewers, prevention, detection, and removal of illicit connections and control of leaking sanitary sewers.

7.3.2.2 Housekeeping Practices

Toxicants entering stormwater can be reduced by good housekeeping practices employed by the general public, municipal employees, businesses, and others. These measures focus on introducing and following good procedures for storage, handling, and transporting materials which could end up in stormwater. Successful implementation requires education and training.

7.3.2.3 Control of Construction Activities

Many municipalities, provinces, and states have produced separate documents to describe specific planning and management activities to reduce the impact of construction on stormwater quality. These techniques usually have many similarities with other structural techniques, except they are essentially temporary. The steps included in such controls include erosion control, sediment collection, site water control, equipment storage and maintenance, materials storage, and litter control.

7.3.2.4 Maintenance Activities

Street cleaning, maintenance of parks, appropriate domestic waste collection, catch basin cleaning, and general road, storm channel, and creek maintenance are typically included in this type of source controls.

7.3.2.5 Structural At Source Controls

Structural at source controls are practices that reduce run-off volumes and improve stormwater quality before it reaches a conveyance system. These controls are applied at the individual lot level or on multiple lots that drain a small area. Overall, these measures involve ponding and/or infiltration on or into the developed area surfaces. In the following sections, descriptions of structural at source control measures are provided (MOE, 2003; National Guide to Sustainable Infrastructure, 2003; NCDENR, 2005; Dillon, 2006).

Catchbasin Restrictors

Catchbasin restrictors (or orifices) in urban storm sewer systems detain stormwater on parking lots or divert flows onto road surfaces, delaying the entry of stormwater into the conveyance system.

Foundation Drain Disconnection

Foundation drains discharge to the surface or soakaway pits, instead of into storm sewers. This can reduce the risk of basement flooding due to sewer backup and decrease downstream sewer discharge quantity and, at the same time, increase infiltration.

Lot Control

It is recommended that to ensure proper foundation drainage, typical lot grading standards within two to four metres of a building should still be maintained at two percent or higher. Outside this, the grading can be flattened to 0.5 percent to promote greater depression storage and natural infiltration. The type of soil and long-term behaviour as far as compaction is concerned also need special consideration as the overall grades may be substantially reduced over time through compaction. Reduced lot grading can be implemented for soil types with a minimum infiltration rate of 15 mm/hr or greater. Therefore soils should be coarser than loam; clay soils are generally not suitable. However, there are municipalities with heavier clay soils that are permitting soak away pits constructed with granular material that will capture and store some of the runoff.

Permeable Pavers

Infiltration through traditionally impermeable surfaces can be achieved through the use of specially configured interlocking concrete pavers that integrate gaps between paving blocks, allowing infiltration into the base material. The base material must be graded with coarse material to avoid the build-up of pore pressures that could negatively impact overall structural stability. Permeable pavers have been proposed for low traffic areas such as driveways, due to lower loads and the decrease in probability of infiltrating contaminants from the heavily travelled area.

Porous Paving

Infiltration through road or parking area surfaces may occur through the use of porous pavements (see Figure 7.3.1). It consists of a thin layer of open-graded asphalt over a crushed-stone base. Since a key major roadway design consideration is maintenance of a dry sub-base for structural stability, porous pavement is not suitable on heavily traversed roads. Climate plays a factor concerning suitability in certain areas, and should be investigated.

Figure 7.3.1 - Pervious Parking Area (http://www.invisiblestructures.com)

Rain Gardens

Rain gardens are an infiltration technique that consists of a planted depression designed to receive excess rainwater runoff from buildings and associated landscape. The rain garden fills with water after a storm and the water slowly filters into the ground rather than running off to a storm sewer. Compared to a conventional patch of lawn, a rain garden allows about 30% more water to soak into the ground (see **Figure 7.3.2**).

Figure 7.3.2 - Rain garden capturing roof runoff at downspout (CWP et al., 1997)

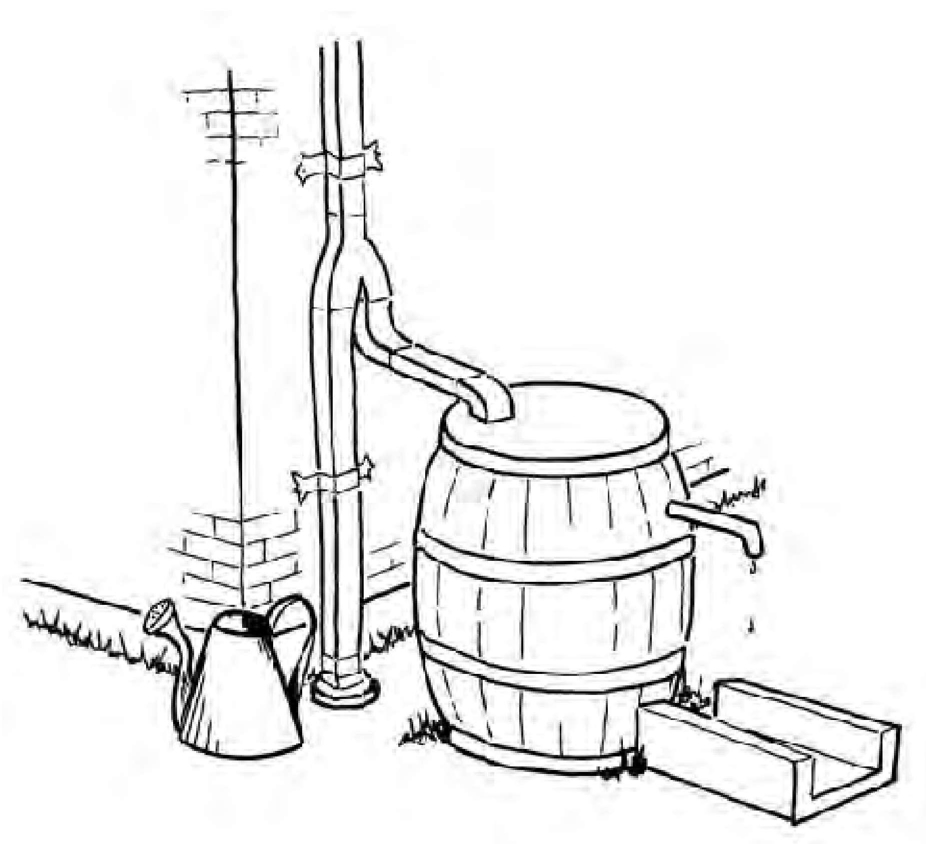
Rooftop Detention

Rooftop hoppers can be used to provide rooftop detention of stormwater on flat commercial or industrial roofs to reduce the peak flow in the storm sewers. This method is more appropriate to new developments rather than retrofits. The roof structure must be properly waterproofed and designed for the extra loading. A maximum ponding depth of 10mm is permitted before water can flow into roof hoppers.

Rooftop Runoff

Discharge of runoff from rooftops can be managed by applying the following methods:

- Discharge of roof leaders into underground infiltration trenches or soakaway pits to assist in the infiltration of rainwater into the groundwater system;
- Placing a splash pad at the outlet of the downspout to prevent erosion and to spread the runoff over the immediate area. This will then allow runoff to flow overland to the conveyance system;
- Utilizing shallow ponding areas (maximum depth 10cm) in rear yards or at the rear lot line, to detain water until it evaporates or infiltrates. The ponds should be located at least 4m from the building to prevent additional discharge into the foundation drainage. Ponding can be accomplished in depression areas and the use of raised rear yard catch basins; and
- Cisterns can be used to collect the discharge from roof leaders in an underground tank or rain barrels for later use (e.g., watering of lawns and gardens) (see **Figure 7.3.3**).



Slope Stabilization

Slope stabilization and erosion control measures, such as vegetating and benching, can reduce sediment loading to storm sewers, and downstream BMPs and receiving watercourses.

Bioretention

Bioretention facilities (also referred to as rain gardens) use plants and soils to remove pollutants from stormwater runoff through adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. In addition, bioretention provides landscaping and habitat enhancement benefits (see **Figure 7.3.4** and **Figure 7.3.5**).

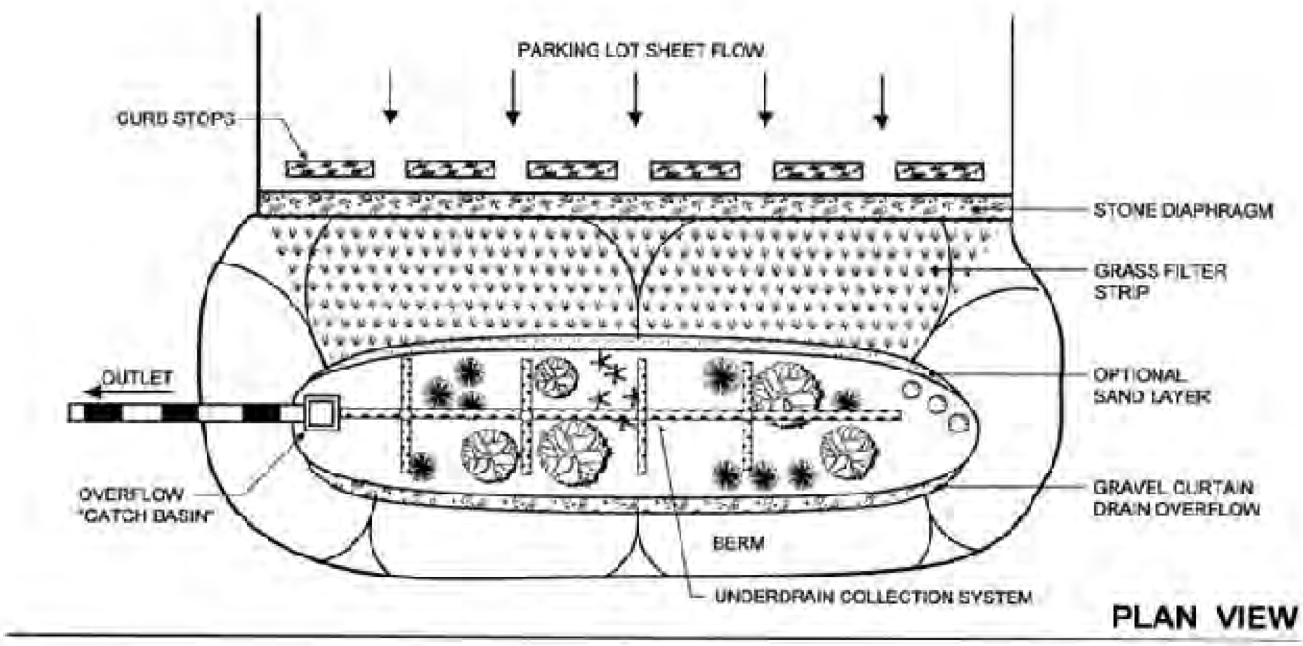


Figure 7.3.4 - Sample Bioretention plan (CWP et al., 1997)

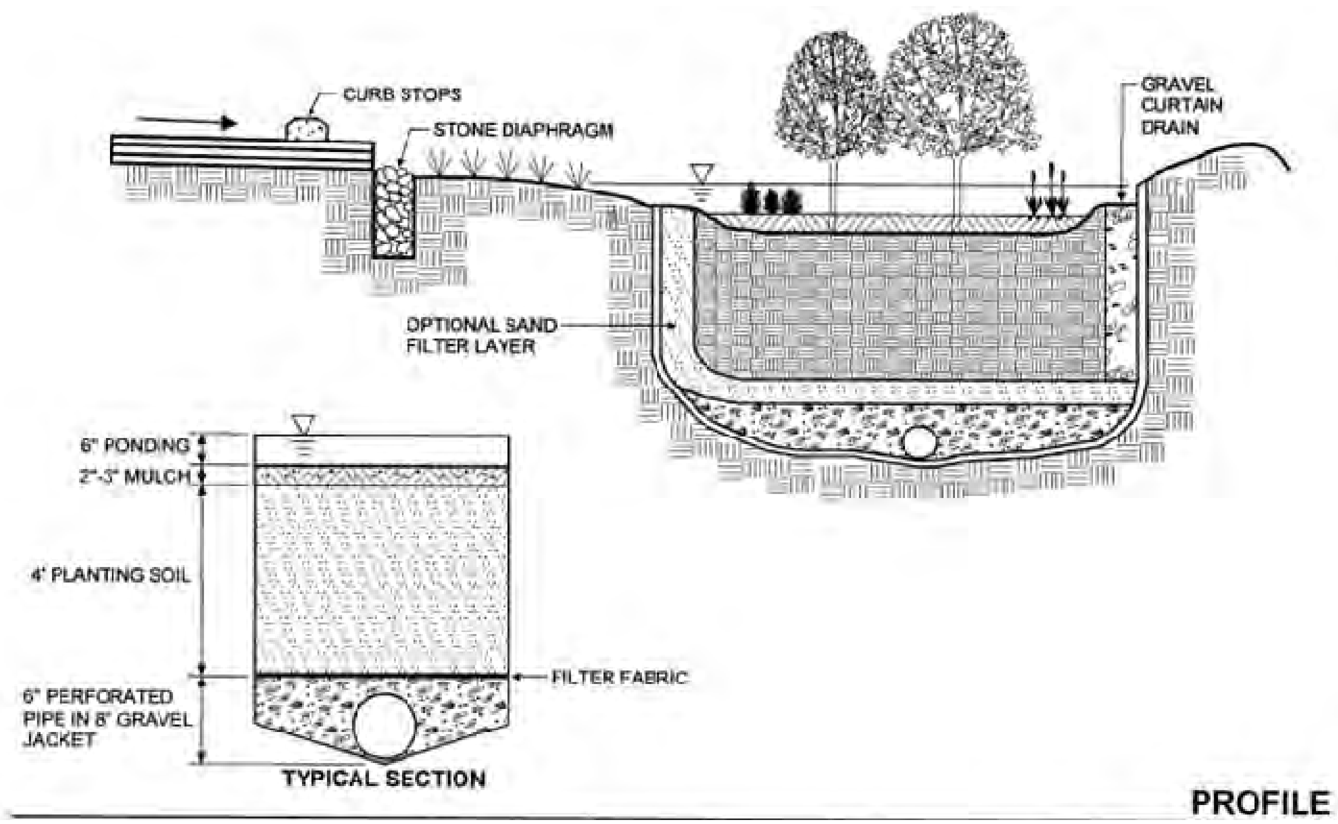


Figure 7.3.5 - Sample Bioretention profile (CWP et al., 1997)

Filter Strip

A filter strip is a linear section of land that can be forested or vegetated with turf grasses or other plants. It forms a boundary (with standardized mild slopes) along the perimeter of a waterbody, another BMP, or area that needs to be protected from upgradient development.

Buffer

Buffers can be natural or constructed low-maintenance ecosystems adjacent to surface water bodies. Trees, grasses, shrubs, and/or herbaceous plants act as a filter to remove pollutants from overland stormwater flow and shallow groundwater flow prior to discharge to receiving waters.

7.3.3 Conveyance Controls

Conveyance controls provide quality and/or quality control within the conveyance system between the source and outlet, to help mitigate the impacts of urbanization, (e.g., increased surface runoff, reduced soil moisture replenishment, and reduced groundwater recharge). They transport runoff from developed areas through storm sewers, roadside ditches, or vegetated swales.

The following examples outline various methods of conveyance controls (MOE, 2003; National Guide to Sustainable Infrastructure, 2003; Dillon, 2006).

7.3.3.1 Stream Corridor Protection and Enhancement

This involves limiting the supply of nutrients and sediment, stream shading, attenuate stream flow, and contributing to stream habitat diversity. Stream corridor measures are applied within the stream riparian zone, floodplain, valley slope or crest. They include native vegetation plantings, access controls, buffer treatments, and management practices. A healthy, naturally vegetated stream corridor provides stream shading; controls the overland movement of water and associated sediments, nutrients, and contaminants; adds nutrients (leaf litter) and woody debris to the stream providing food sources and habitat; and helps stabilize stream banks. In addition, stream corridors provide wildlife habitat and, depending on the width of the corridor, offer important linkages between other natural features that promote dispersion/migration of plant and animal communities.

7.3.3.2 Roadside Ditches

Roadside ditches convey and reduce peak flows; use infiltration in some cases. Roadside ditches are channels, usually along both sides of a roadway, designed to convey runoff from impervious surfaces and adjacent slopes, and dispose of it without damage from erosion, deposition, or flooding. Roadside ditches are also designed to prevent the lengthy accumulation of standing water. In some locations ditches may have ditch blocks or check dams to slow down the water, and promote sedimentation and infiltration before discharge into the receiving water course. Ditches are primarily used to convey stormwater but, depending on soil conditions, they could also be designed to promote infiltration. For this reason, ditches are applicable in many areas that swales are not, such as where soil conditions do not promote infiltration. Another difference between roadside ditches and grassed swales is that ditches are deeper to permit the drainage of the road sub-grade.

7.3.3.3 Vegetated Swales

Vegetated swales have replaced the curb and gutter in many places as a result of increased concerns about the quality of urban runoff (see **Figure 7.3.6**). Vegetated swales are broad, shallow channels with dense vegetation covering the side slopes and bottom. They are designed to trap particulate pollutants, promote infiltration, and decrease the velocity of stormwater runoff. Suspended solids can be removed by filtering through the vegetation and settling. Dissolved particulates may also be removed through chemical or biological mechanisms within the vegetation and soil. Swales may be inadequate to drain the road sub-grade if they are too shallow, and storm sewers may still be required in some applications for road sub-grade drainage. In areas where the soils do not support good infiltration, swales may act only as filters and, therefore do not contribute significantly to the hydrologic balance or erosion control unless properly designed.

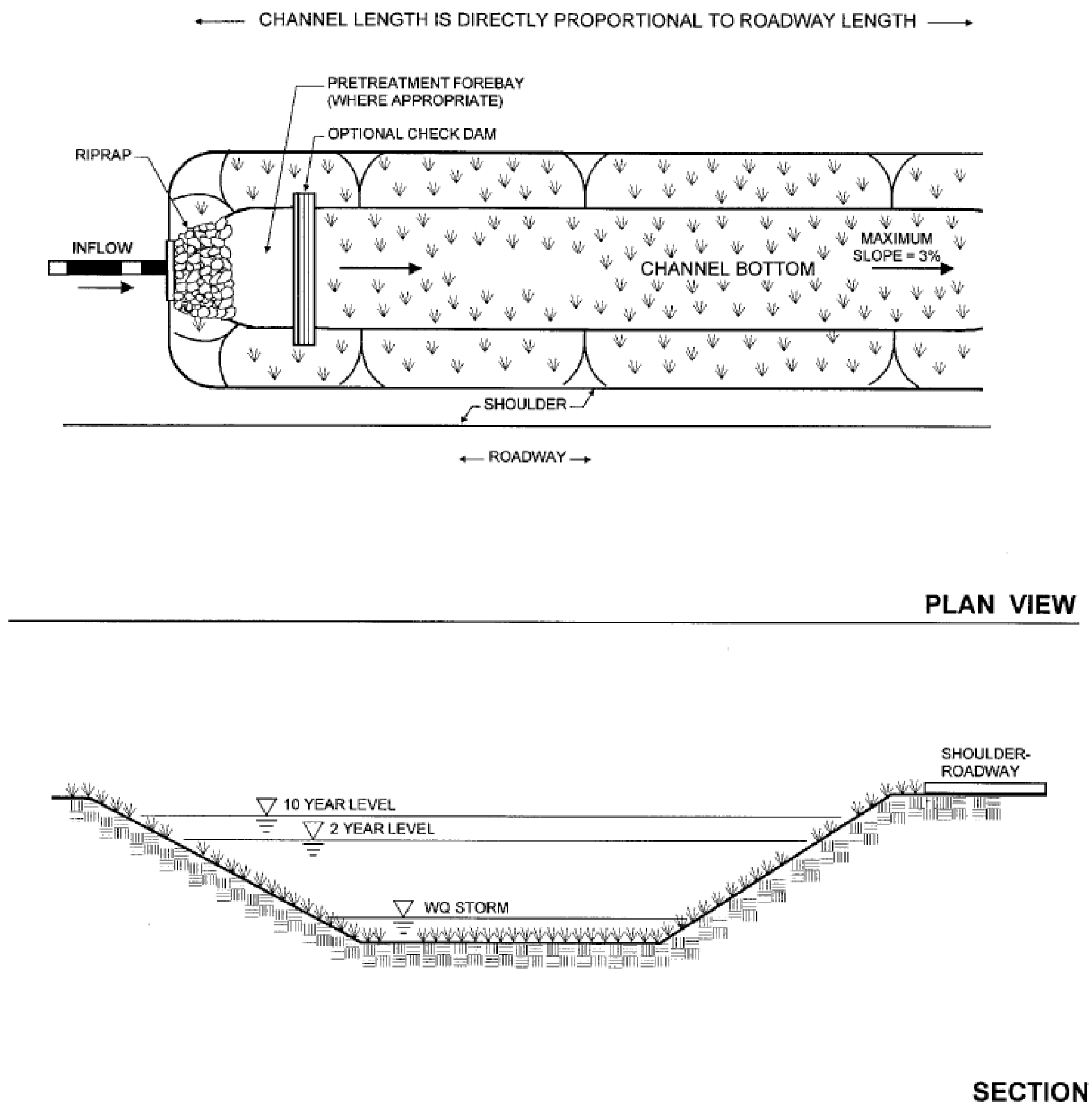


Figure 7.3.6- Sample Grass Channel plan and profile (CWP et al., 1997)

7.3.3.4 Pervious Pipe Systems

Pervious (or perforated) pipe systems convey runoff below ground level by allowing water to infiltrate through the pipe into adjacent soils (exfiltration), providing pollutant removal and reducing the amount of runoff in the storm sewer system (see **Figure 7.3.7**). This system is beneficial in areas with pervious soils and a low water table.

A variation on the system uses filtration rather than exfiltration and is applicable to areas with tighter soils. The flow from the catch basin is discharged to a length of perforated pipe within a gravel-filled trench (where the storm sewer is also bedded). The runoff filters down through the trench and is collected by a second perforated pipe at the bottom of the trench. The second pipe conveys flow to the next downstream manhole and into the conventional sewer system. If the trench volume or catch basin capacity is exceeded, a second, higher level outlet in the catch basin allows flow to be conveyed to the conventional storm sewer. Long-term clogging as a result of a lack of pre-treatment and catch basin maintenance is the main drawback.

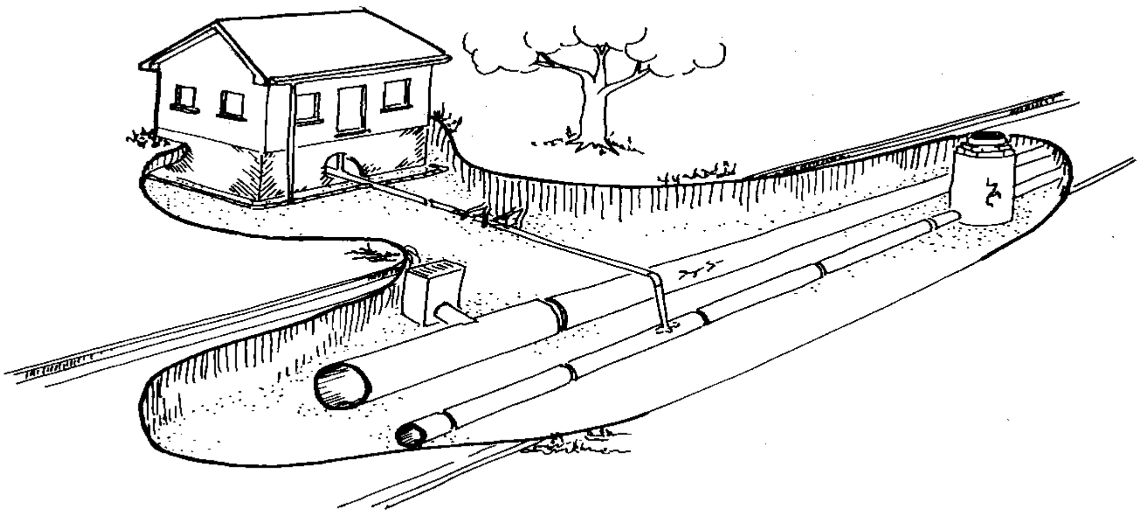


Figure 7.3.7 - Pervious pipe system (TSH, 2001)

7.3.3.5 Pervious Catch Basins

A pervious catch basin is a normal catch basin with a large sump, which is connected to exfiltration storage media. Some designs have the storage is located directly beneath the catch basin through a series of holes in the catch basin floor. Other designs use the catch basin sump for pre-treatment of runoff, and discharges low flows through the wall of the catch basin to the exfiltration storage media located beside the catch basin.

The exfiltration of road runoff is often not desirable due to the elevated levels of pollutants. Long-term clogging as a result of a lack of pre-treatment and catch basin maintenance is the major drawback. Frequent catch basin cleaning is required to ensure longevity and ultimately, the exfiltration storage media will become clogged and need to be replaced.

7.3.3.6 On-Line/Off-Line Storage

This technique provides storage to take stress off the downstream system. On-line and off-line storage facilities are implemented to regulate and moderate peak flows in locations where the capacity of the storm sewer is insufficient during high-flow events. They are normally installed as an alternative to upgrading an entire sewer system. Both the on-line and off-line systems incorporate a flow regulator and a large storage capacity, which makes optimal use of the downstream sewers. The on-line storage unit is generally a large-diameter pipe installed into an existing sewer system. All flow through the system enters the superpipe at its upstream end, and flows toward the regulator at the downstream end. Excessive flows are retained in the superpipe until the peak has passed, at which point the superpipe begins to drain the flow and the sewer system returns to normal. The off-line storage system uses a regulator to divert excessive flow out of the sewer system and into an off-line tank. The tank provides storage until the flow rates in the sewer are below the downstream capacity, at which point the stored volume is slowly released back into the sewer.

7.3.3.7 Real Time Control

This method has a better use of existing collection system facilities, to minimize flooding and maximize capture. Real time control optimizes the use of in-system storage. Under this scenario, control structures are put in place, and flows are stored in, or diverted to, parts of the sewer system where capacity is available during a rainfall event. Two modes of control can be considered: reactive, in which the system is operated in response to its state as the storm progresses over the catchment and predictive (or anticipatory), in which the system is operated in response to the anticipated state of the system before the occurrence of a rainfall event. In addition, two types of control can be distinguished: local, which relates to a single control point, and global, which relates to the total sewer system or the integrated system. Modelling of the sewer system is required regardless of which type or mode of control is used.

7.3.3.8 Selection tool for Roadside Drainage

The current approach to mitigate the impacts of urban stormwater runoff involves the use of a combination of SWM practices at the lot level, along the conveyance system, and at the end-of-pipe. Together these practices help maintain or restore a more natural cycling of water by encouraging infiltration, reducing runoff volumes and velocities, and filtering pollutants carried by the stormwater. In order to retain these functions and re-establish beneficial uses of receiving watercourses and water bodies, municipalities are seeking more effective SWM practices for use in new developments and retrofit situations (Tufgar et al., 1998).

In a study conducted by Tufgar et al. (1998) they outline a selection tool for roadside drainage. The selection tool starts with a long list of alternate drainage system features (conveyance and control elements). Drainage elements include twenty-two choices such as curb and gutter; conventional storm sewers; roadside ditches with culverts; shallow ditches with swales; several variations of perforated pipe systems that provide for infiltration of stormwater into the groundwater; stormwater ponds; and oil/grit separators.

The tool then screens the site and development characteristics with specific numerical criteria with a view to excluding unsuitable measures. Many of the screening criteria given are conditional with additional information given to the user for consideration with the option of overriding the condition, allowing the feature to stay in contention.

Site characteristics include soil type, groundwater and bedrock levels, and slope. Infiltration measures, for example, are not considered suitable in areas of high water table, shallow depth to bedrock, impervious soils, or where there are expectations of high pollution loads. Oil-grit separators have almost no conditions, except that the drainage outlet must be below 2m.

Development characteristics such as type of land use, density, right-of-way size, and lot features are considered next. For example, ditches with culverts are considered unsuitable on streets with narrow right-of-way, or high density residential areas with narrow lot frontages.

Following the screening steps, the remaining measures are considered to be compatible drainage features suitable for the site and development being considered. It is noted that the only measure that has no screening criteria that would exclude it is the curb-and-gutter system. However, it should be noted, this measure meets fewer environmental objectives and is costly.

7.3.4 End-of-Pipe

End-of-pipe controls allow for flow attenuation, major flow conveyance, and water quality enhancement of stormwater before outletting into a receiving water body. A number of end-of-pipe alternatives are available for applications that are dependent on the characteristics of the upstream catchment, and the regulations and requirements for water quality in the receiving waters (Alberta, 2006). They allow for quality and quantity mitigation at or near the downstream end of the conveyance controls.

The following examples outline various methods of conveyance controls (MOE, 2003; National Guide to Sustainable Infrastructure, 2003; Alberta, 2006; Dillon, 2006).

7.3.4.1 Wet Ponds

Wet ponds provide storage, peak flow reduction, and sedimentation control and pollutant removal (**Figure 7.3.8**). They are less land intensive than wetland systems and are normally reliable in operation, especially during intense conditions (e.g., spring freshet). Wet ponds can be designed with extensive landscaping and associated recreational amenities, to become the centrepiece of a development. They are less suitable for retrofit situations and are typically unsuitable for infill situations, because of their relatively large land area and drainage area requirements (typically greater than 5ha to allow for sufficient turnover and sustainability). Wet ponds can have negative impacts on stream temperatures, and the use of wet ponds on coldwater tributaries is normally discouraged. They encourage mosquito breeding, and do not typically provide infiltration and so they provide minimal benefit from a water balance perspective. Other concerns include safety issues, particularly during winter, and proper operation to maximize water quality benefits.

7.3.4.2 Dry Ponds

Dry ponds offer peak flow reduction, storage, and sedimentation. They contain water during runoff events and for a short time after. As dry ponds have no permanent pool of water, they can be effectively used for erosion control and quantity control; however, the removal of stormwater contaminants in these facilities is purely a function of the drawdown time in the pond. They mainly consist of large grassed areas, (e.g., football fields and ball diamonds) that can provide the needed storage capacities at relatively shallow depths, and maximize land use through dual usage of land dedicated for recreational uses. However, the cost of silt and debris removal and restoration to landscaping following may be quite high.

7.3.4.3 Wetlands

Wetlands can offer peak flow reduction, storage, filtration, sedimentation, biological uptake, and adsorption. They are beneficial from a water quality perspective as they have the ability to trap and hold contaminants and pollutants. Wetlands are suitable for providing the storage needed for downstream erosion control purposes. However, they will usually be limited in their quantity control role, because of the restrictions on active storage depth to ensure the viability of vegetation. Therefore wetlands require more land to accommodate active storage volumes at lower depths.

Wetlands can be designed with extensive landscaping and associated recreational amenities, to become the centrepiece of a development. They are usually less suitable for retrofit situations and are typically unsuitable for infill, because of their comparatively large land area and drainage area requirements to allow adequate turnover and sustainability.

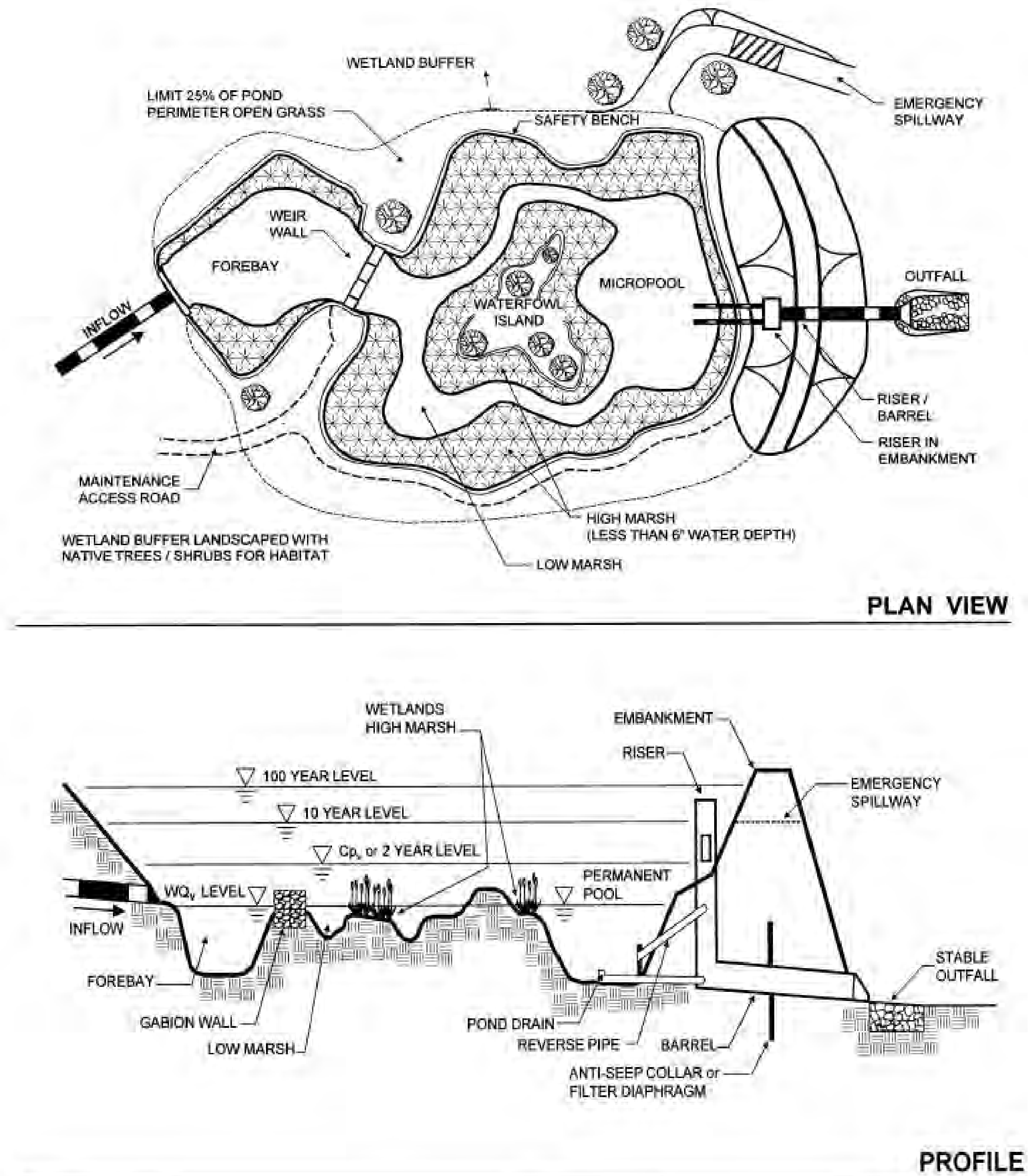


Figure 7.3.8 - Shallow wetland SWM facility (CWP et al., 1997)

7.3.4.4 Underground Tanks/Tunnels

Underground tanks and tunnels (also referred to as 'superpipes') can be used for the temporary storage of stormwater. These structures store runoff and release it gradually after the peak flow has passed. This helps to prevent the excess flows from causing combined sewer overflows to receiving waters. Tanks and tunnels can act as retention treatment basins by allowing the suspended solids in the stored flow to settle out over a period of time. Since they are built underground, these facilities provide minimal social/environmental impacts, except for short-term disturbances during construction. They are beneficial in areas that require remedial works, and where there is insufficient space available to control runoff above ground.

7.3.4.5 Infiltration Basins

Infiltration basins are above-ground pond impoundment systems that promote recharge. Water percolating through an infiltration basin either recharges to the groundwater system or is collected by an underground perforated pipe system and discharged at a receiving system or aquifer. Infiltration basins provide water quality benefits, but are ineffective for water quantity control, as is recommended as a secondary facility. They should not be located near septic fields or where infiltrated water could interfere with groundwater uses (e.g., drinking water sources). Their appearance is similar to that of a wet or dry pond.

7.3.4.6 Sand Filters

Sand filters are above or below ground treatment devices that encourage pollutant removal from overland runoff or storm sewer systems. Sand filters do not provide a recharge benefit as filtered stormwater is discharged to the storm sewer or receiving water. They can be constructed above or below ground, and are appropriate for drainage areas less than five hectares. They are usually used in a treatment train and constructed with liners to prevent filtered water from entering the groundwater system.

7.3.4.7 Screening

Screening devices are generally installed upstream of storage/treatment facilities or overflow structures. They are used for aesthetic reasons to remove floatable material before the water discharges into the receiving waters. Some screens have fish handling devices that minimize the adverse environmental impact on aquatic life that comes in contact with the screens. Screening requires relatively high-cost maintenance and can be prone to clogging.

7.3.4.8 Oil/Grit Separators

Oil/grit separators are a below ground structure that takes the place of a conventional manhole in a storm drain system. Grit and sediment in the runoff entering the separator are settled out, and oil is removed through skimming and trapping. The separator implements the use of permanent pool storage in the removal of hydrocarbons and sediment from stormwater runoff before discharging into receiving waters or storm sewers. They have a small footprint which makes them suitable for retrofit and highly urbanized areas. They must be regularly maintained otherwise re-suspension of pollutants may occur.

7.3.5 Site Analysis for Best Management Practices Consideration

SWM plans can vary with location and time as a result of changes to land use occurring through development or redevelopment. A single BMP cannot satisfy all stormwater control objectives, and therefore cost-effective combinations are required to achieve all objectives. This section provides a synopsis of guidelines for choosing BMPs.

BMPs should discourage site design that would create large uninterrupted impervious surfaces that concentrate stormwater (Dillon, 2006; NCDENR, 2006). Preferably, impervious surfaces would be hydrologically divided so that runoff could be delivered in smaller volumes that can be accommodated by smaller, less expensive and less obtrusive BMPs. The recommended approach is based on using a combination of stormwater control measures that are selected for (NCDENR, 2006):

- Achieving water quality, peak-runoff, and groundwater recharge goals;

- Replicating the natural processes of depression storage, vegetative filtering, and infiltration that occur in the water cycle; and
- Fitting naturally into the landscape design of the site.

Table 7.3.1 provides a guide for selecting BMPs according to the size of the upgradient drainage area. The table illustrates how the options for selecting BMPs decrease as the size of the tributary drainage increases. In most cases, a larger drainage also means higher capital costs and higher maintenance requirements, which are illustrated in **Table 7.3.2**.

Table 7.3.1 - Guide for Selecting Structural BMPs According to the Size of the Up-gradient Drainage Area

Applicable BMPs	Up-gradient Drainage Area			
	0 to 1 acre	**1 to 5 acres**	**5 to 25 acres**	**Greater than 25 acres**
Sediment Control				
Manufactured BMP Systems	X			
Peak Attenuation				
Wet Detention Basin			X	X
Dry Extended Detention Basin		X	X	X
Infiltration Device – dry well[1]	X			
Rooftop Runoff Management	X			
Water Quality				
Stormwater Wetlands			X	X
Bioretention	X	X		
Grassed Swale	X	X	X	
Filter Strip[2]	X	X		
Buffer[2]	X	X		
Sand Filter	X	X	X	
Oil/Grit Separators	X	X		
Groundwater Recharge				
Infiltration Devices (trench, basin)	X			
Permeable Pavement	X	X		
[1] **Dry well with detention storage,** [2]**Area interpreted as acres per 200 feet of BMP or stream frontage**				
Source – NCDENR, 2005; Alberta, 2006				

Table 7.3.2 - Maintenance Requirements and BMP Efficiency

BMP	BMP Type	Maintenance Level	BMP Efficiency
Stormwater wetland	Structural	High	High
Bioretention	Structural /Vegetative	Medium	Medium
Wet detention basin	Structural	High	High
Dry Extended Detention basin	Structural	Medium	Low
Grassed swale	Structural /Vegetative	Low	Low
Filter strip	Structural /Vegetative	Low	Low to Medium
Oil/Grit Separators	Structural	Medium	High
Infiltration devices	Structural	Medium	Medium

BMP	BMP Type	Maintenance Level	BMP Efficiency
Manufactured BMP systems	Structural	High	Medium to High
Buffer	Structural /Vegetative	Low	Medium
Permeable pavement	Structural	Low	Medium
Rooftop runoff management	Structural	Medium	Medium
Sand filter	Structural	High	Medium to High
Maintenance Descriptions • High = Weekly inspections, frequent repairs, maintenance to remove accumulated sediment and debris. Periodic adjustments to outlets and drains. Periodic monitoring of discharged water. Inspections after runoff events. • Medium = Monthly inspections. Occasional repairs. • Low = Quarterly inspections. Routine cleaning and housekeeping. Infrequent repairs.			
BMP Efficiency Descriptions (for TSS Removal) • High = Can generally be designed to achieve 85% TSS removal • Medium = Typical TSS removals in the range of 50 to 85% • Low = TSS removals generally less than 50%			
[1] Infiltration device - trench longevity dependent on site conditions and maintenance effectiveness.			
Source – NCDENR, 2005; Alberta			

Vegetative BMPs generally require less maintenance. BMPs that require large impoundments, such as dry extended detention (ED) basins, wet detention basins, and stormwater wetlands, require active programs for operation, maintenance, and periodic repair.

However, many site-specific conditions may impose restrictions on the use of some BMPs. **Table 7.3.3** can be used as a guide to some of the limitations. In some cases, adverse site conditions can be overcome through careful design. Combinations of BMPs can sometimes alleviate difficulties. For instance, high sediment loads that might adversely affect bioretention facilities can be overcome by providing filter strips in upgradient areas. However, improperly located BMPs can lead to poor performance or excessive maintenance requirements.

Table 7.3.3 - Potential Site Restrictions for BMPs

BMP	High Water Table	Shallow Depth to Bedrock	High Sediment Input	Poorly Drained Soils	Steep Slope	Space Limitations
Stormwater wetland		X	X		X	X
Bioretention	X	X	X	X		
Wet detention basin		X			X	X
Dry Extended Detention basin	X	X	X		X	X
Grassed swale		X	X		X	
Filter strip			X		X	X
Infiltration devices	X	X	X	X	X	
Manufactured BMP systems						
Oil/Grit Separators		X			X	

BMP	High Water Table	Shallow Depth to Bedrock	High Sediment Input	Poorly Drained Soils	Steep Slope	Space Limitations
Buffer					X	X
Permeable pavement	X	X	X	X		
Rooftop runoff management						
Sand filter			X			
X – Potential Restriction						

7.3.6 Treatment Train Evaluation of Performance

In many cases, a single BMP cannot provide the required control capability. Therefore, to meet the required control and provide enhanced treatment of pollution, two or more BMPs can be applied in a series known as a treatment train formation.

The most common approach in selecting components for a treatment train is to start at the source where runoff volumes can most readily be controlled, followed by the conveyance system and then, if needed, at the end-of–pipe or outlet to receiving waters. End-of-pipe controls are typically required where 1) recharge requirements cannot be met with at-source BMPs due to soil conditions, or limited land availability; 2) where extended detention of increased runoff rates is required to meet erosion control requirements; or 3) where peak flow attenuation is required for flood control (Dillon, 2006).

A procedure for calculating the efficiency of several measures applied in series or treatment train is provided by Li et al. (1998).

"A multi-efficiency model is used to estimate the cumulative volume (Nv) and solids loading (Ns) reduction efficiencies of a series of RSWMPs"

$$N_v = \left| 1 - \prod_{i}^{n} (1 - \eta_v) \right| * 100\%$$

$$N_s = \left[1 - \prod_{i}^{n} (1 - \eta_v)(1 - \eta_s) \right] * 100\%$$

where i is the ith RSWMP, n is the total number of RSWMPs, ηv is the runoff volume reduction efficiency of a RSWMP, and ηs is the solids concentration reduction efficiency of a RSWMP. For a RSWMP which reduces solids concentration only (e.g., oil/grit separators, ponds), ηv is zero (the large pi is the symbol for product summation). For a RSWMP which reduces runoff volume only (e.g., downspout disconnection and stormwater exfiltration systems), ηs is zero. When calculating performance of multiple methods in meeting targets for TSS removal or TP control in new developments the following assumptions are made:

- Source control measures are implemented first;
- Infiltration measures are implemented secondly, with a reduced load of TP and/or TSS. Loadings of TP and TSS are reduced in proportion to the amount of water infiltrated. The amount of infiltrated water is compared to infiltration targets. Since infiltration maybe limited by site/soil characteristics, retention could be considered as a similar means of TP and TSS removal; and
- End-of-pipe measures are implemented last in the treatment train, and remove a portion of the remaining pollutants after source control and/or infiltration measures are applied.

7.3.7 Typical Performance Standards for Best Management Practices

BMP performance can vary considerably based on differences in the design criteria and performance standards the BMP must meet. In Canada, the effectiveness of different BMPs, specifically source and on-site controls, are being assessed (National Guide to Sustainable Municipal Infrastructure, 2003).

The effectiveness of BMPs at controlling stormwater flows depends on:

- Reductions in the peak flow rate across the BMP;
- Total storage volume provided in the BMP;
- Infiltrative capacity of the BMP;
- Retention time in the BMP;
- Relationship of post-development hydrologic conditions to predevelopment hydrology; and
- Retention volume necessary for receiving stream channel protection.

Additional information can be found in the City of Toronto's Wet Weather Flow Management Master Plan (2003).

7.4 Stormwater Management Facility Design Guidelines

7.4.1 Design Guidelines

The MOE (2003) provides standard design guidelines for SWM facilities, on physical sizing of facilities for use in design. Municipalities are encouraged to develop their own SWM guidelines.

7.4.1.1 Location of SWM Facilities

Generally, the NPCA does not support the following SWM practices:

1. On-line SWM facilities for water quality;
2. Using natural wetlands as a SWM facility;
3. Locating SWM facilities in natural hazard areas, such as floodplains or erosion hazards, except outlets; and
4. Locating SWM facilities in Significant Natural Heritage Features.

The discouragement of locating SWM facilities within natural hazard/regulated areas arises from the fact that SWM facilities are considered development, and as such are subject to the same development regulatory processes. Outlet works are the sole exception, since they must be located close to a receiving waterbody, most likely within its floodplain.

In certain circumstances, the NPCA is prepared to acknowledge that due to technical, economic and/or environmental considerations and constraints, SWM facilities may be required to be located within or close to natural hazard areas. Such an allowance would depend on the demonstration that the SWM facility would not impact the natural hazard area (i.e., no increase to flooding risks, etc.) and that the hazard area would not impact the function or lifespan of the SWM facility. Note that these facilities may be subject to additional detailed design requirements above and beyond those described in this manual or prescribed by the municipality.

The MOE (2003) recommends that end-of-pipe SWM plans should be, as a rule, located outside the floodplain (above the 100-year elevation). If the facility is multi-purpose in design (e.g., providing quantity control in addition to quality and erosion control) it should be located above the highest design flood level. In some cases, SWM plans may be allowed in the floodplain if there is adequate economic or technical justification, and if they meet certain requirements, which are outlined below:

- The collective effects resulting from changes in floodplain storage and balancing cut and fill do not negatively impact existing or future development;
- Effects on corridor requirements and functional valleyland values must be assessed. SWM plans would not be allowed in the floodplain if damaging impacts could occur to the valleyland values or corridor processes;
- The SWM plans should not affect the fluvial processes in the floodplain; and
- The outlet invert elevation of the SWM plan should be higher than the 5-year floodline and the overflow elevation must be above the 25-year floodline.

7.4.1.2 Aesthetic Guidelines

Developing aesthetic design guidelines is a useful way to ensure consistency when designing SWM facilities across a particular municipality. Aesthetic guidelines can address public safety, reduce maintenance requirements, and help blend the facility with the natural environment.

SWM facilities may be integrated with local natural features if they are designed in such a way as to allow for frequent monitoring and maintenance. The MOE, 2003 states that the main purpose of SWM facilities is for managing stormwater and they must be maintained. Accordingly, SWM facilities should not be considered as significant natural areas or fish habitat that require environmental protection.

Refer to **Appendix I** for sample aesthetic guidelines.

7.4.1.3 Mosquito Control

West Nile Virus monitoring programs are wide spread across Ontario and are usually administered through the Region or County. Programs are in place across the province that monitor and if necessary larvicides roadside catch basins. Modern SWM ponds have design features, such as the inclusion of wetlands and vegetated edges that encourage natural mosquito larvae predators (Downey, 2003).

City of Edmonton and the City of Calgary provide management options such as increasing circulation, water level controls and designing the facility to attract natural predators such as dragonflies and minnows.

7.5 Construction Sediment and Erosion Control Requirements

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

Prior to construction, comprehensive erosion and sediment control (ESC) plans must be submitted to the municipality and NPCA detailing the methods that will be used to prevent the release of sediment laden runoff from the construction site. There are extensive sediment and erosion control guidelines available that describe the design considerations, application and function, implementation procedures, maintenance procedures and removal procedures for a wide variety of sediment and erosion control measures for construction sites. The following is a list of existing guidelines currently used in Ontario:

- MNR Technical Guideline: Erosion and Sediment Control;
- MTO Drainage Management Manual (1995 – 1997); and
- Erosion and Sediment Control Guidelines for Urban Construction from Source to Solution (GGHA CA, 2006).

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

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

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

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

Refer to **Appendix J** for a sample ESC inspection form.

7.6 Summary

Table 7.6.1 below contains a summary of the stormwater management policies and technical guidelines presented throughout this section.

Table 7.6.1 - Summary of SWM Policies and Technical Guidelines

<table>
<tr><th>Topic</th><th>General Policy Statement</th><th colspan="3">Technical Guidelines</th></tr>
<tr><td rowspan="3">Stormwater Management Control</td><td rowspan="3">Sufficient SWM controls are required by the NPCA to ensure that flooding, pollution, surface erosion and conservation of land impacts due to development do not occur.</td><td colspan="2">Flooding/Quantity Control</td><td>Generally, the SWM controls required are to match or reduce post-development peak flows to pre-development peak flows for a range of design storm events (2, 5, 25 and 100-year storm events, unless directed otherwise).
Different design storm distributions and durations shall be assessed in order to determine the critical storm that yields the lowest pre-development peak flow and the highest post-development peak flow. At a minimum, the 3-hour Chicago, 12-hour AES and 24-hour SCS distributions should be considered.
All SWM plans are to assess the capacity of the receiving system in order to indentify hydraulic constraints or existing flooding hazards. These existing constraints/risks may require additional quantity controls over and above the typical post to pre peak flow controls.
Consideration may be given to not requiring peak flow controls if the assessment of receiving system capacity demonstrates little or no benefit to such controls. This would include situations such as discharge to major river systems or directly to a Lake. Pre-consultation with the NPCA and additional approval requirements are necessary for this to be considered.
Major overland flow routes are to be designed to have sufficient capacity for the Regulatory event (100-year or Regional storm event, as applicable).</td></tr>
<tr><td rowspan="2">Quality Control</td><td>TSS</td><td>A minimum of “Normal” level of water quality treatment, as defined in the MOE design guidelines (2003) is required for all SWM facilities. This is equivalent to a 70% TSS reduction.
“Enhanced” level of water quality treatment (80% TSS reduction) will be required on all watercourses containing Type 1 – critical fish habitat.
A detailed assessment of the receiving system will be mandatory for any proposed reduction in the level of water quality treatment required on a development site. The assessment contents must be appraised and approved by the NPCA prior to completion.</td></tr>
<tr><td>Temperature</td><td>The SWMP for a development site is required to include measures to eliminate or mitigate adverse temperature impacts due to the increase in impervious surfaces and the ponding of water in SWM facilities. Particular attention is to be given to those systems discharging to coolwater or coldwater receiving systems.
Post-development water temperature regime is to mimic or enhance the pre-development regime.</td></tr>
</table>

Topic	General Policy Statement	Technical Guidelines		
			Total Phosphorus	• Phosphorus removal targets will be typically provided for in the TSS removal targets, unless specific targets are developed through a management strategy.
			Spills	• SWM facility outlets are to be designed to allow the outlet to facilitate the containment of a spill. • Ensure sufficient access to SWM facility in order to allow spills to be cleaned.
		Water Balance		• As per the SWM Design Manual (MOE, 2003), water balance impacts should be evaluated during the design of a site stormwater management system. All efforts should be made to match pre- and post-development infiltration volumes in order to maintain groundwater recharge. • Hydrogeologically sensitive areas shall be identified as part of the SWM plan. • Untreated stormwater shall be prevented from being directly infiltrated.
		Erosion/Geomorphologic Considerations		• Quantity control to detain and release the 25mm, 4-hour Chicago design storm over a 24-hour period shall be provided for all receiving systems that are demonstrated to be stable watercourses or for proposed development that comprise less than 10% of the total area that drains to the receiving system. • The geomorphologic assessments and criteria contained in the SWM Design Manual (MOE, 2003) shall be used for all receiving systems that are unstable under existing conditions or for proposed developments that comprise a significant proportion of the total area draining to the receiving system. • Criteria identified in larger-scale studies that have directly evaluated the receiving systems, such as Subwatershed Studies or Master Drainage Plans, shall take precedence over the criteria presented herein.
		Construction Erosion and Sediment Control		• All applicants must include an Erosion and Sediment Control plan demonstrating that fish habitat and water quality are not affected by sediment from the property during or following site construction. • Guidelines and strategies to develop Erosion and Sediment Control plans can be found in the *Erosion and Sediment Control Guidelines for Urban Construction* manual (GGHA CA, 2006).
		Planting Considerations		• As part of SWM facility designs, planting strategies are required to address functional treatment aspects, including operations, public safety, and to help the facility blend in with the natural environment. • Native vegetation is to be used in the facility design (see **Appendix S** for the approved plant species list). • Consideration of nearby natural heritage features should be made in developing a planting strategy. • The different moisture zones within a SWM facility should be considered in choosing vegetation species: deep water, shallow water, shoreline/fringe zone (extended detention), flood fringe and upland areas.

Topic	General Policy Statement	Technical Guidelines	
		Oil/Grit Separators	• Oil/grit separators for stormwater treatment are discouraged for use in Greenfield residential development. • The use of oil/grit separators may be considered for commercial, industrial, or infill developments. • Consultation with the NPCA and the municipality is required in order to consider the use of oil/grit separators.
Location of Stormwater Management Facilities	The NPCA does not support the following SWM practices: 1. On-line SWM facilities for water quality; 2. Using natural wetlands as a SWM facility; 3. Locating SWM facilities in natural hazard areas, such as floodplains or erosion hazards, except outlets; and 4. Locating SWM facilities in Significant Natural Heritage Features.	• The discouragement of locating SWM facilities within natural hazard/regulated areas arises from the fact that SWM facilities are considered development, and as such are subject to the same development regulatory processes. Outlet works are the sole exception, since they must be located close to a receiving waterbody, most likely within its floodplain. • In certain circumstances, the NPCA is prepared to acknowledge that due to technical, economic and/or environmental considerations and constraints, SWM facilities may be required to be located within or close to natural hazard areas. Such an allowance would depend on the demonstration that the SWM facility would not impact the natural hazard area (i.e., no increase to flooding risks, etc.) and that the hazard area would not impact the function or lifespan of the SWM facility. Note that these facilities may be subject to additional detailed design requirements above and beyond those described in this manual or prescribed by the municipality. • SWM facilities are not permitted to be located within the 100-year floodplain or the hydraulic floodway, whichever is greater.	
Large-scale Stormwater Planning	The planning and implementation of SWM systems are encouraged by the NPCA to be performed on a catchment-scale basis, through the completion of Subwatershed Plans, Master Drainage Plans or other such strategies.	• Large-scale stormwater planning at the watershed, subwatershed or community plan level facilitate the most effective management strategies to reduce the impact of development on the natural environment. These studies can guide future development in ways that protect surface water features, groundwater features and natural areas. Refer to Section 2.3 and 2.4 of the SWM Design Manual (MOE, 2003) for an overview of the contents and benefits of large-scale SWM planning.	

8. REPORT SUBMISSIONS

The SWM Report should describe the effect of the planned development on the existing drainage area and environment, and include proposed mitigation measures. If a watershed/subwatershed plan is available for the proposed area of development, then the SWM Report should refer to those conclusions and recommendations.

It is necessary to have substantial SWM information for rezoning, special exception, special permit applications, Plans of Subdivision, and Site Plan Control applications. This information must be substantial regarding existing drainage conditions and proposed SWM and adequate outfall measures. This allows for a more thorough review of SWM and BMPs. The objective of a SWM Report is to identify the quality and quantity impacts of the change in stormwater runoff on existing infrastructure and watercourses due to a proposed development, and to recommend how to manage rainwater/snowmelt for the proposed development which is consistent with NPCA, provincial and federal regulations

The SWM Report should be submitted in conjunction with the development application. The applicant is encouraged to discuss the need, scope and the proposed SWM concepts and design assumptions with municipal staff prior to preparing the report. For Plans of Subdivision, the report is to be submitted in two stages. The Preliminary Report outlines the design assumptions and conceptual engineering schemes to manage both quantity and quality of runoff. The Preliminary Report is to be submitted when the application is initiated and must be accepted prior to draft plan approval of a Plan of Subdivision. The Final Report provides the detailed calculations and the design of the SWM facilities and drainage systems based on the accepted principles in the Preliminary Report, and must be accepted prior to the final approval of the Plan of Subdivision. For Site Plan Control applications the Final Report are to be submitted in conjunction with the development application must be accepted prior to site plan approval. An Environmental Impact Study may be required to address the impact of development on water resources features or functions on and off site.

8.1 Principles

A SWM Report must be based on established SWM principles, BMPs, and the interim guidelines used in each service district and the MOE Policies. The authority to request this work is provided by the Planning Act, the Provincial Policy Statement, and the OP.

A SWM Report carried out by a Registered Professional Engineer qualified in municipal engineering/SWM, and must follow the interim guidelines on preparation of SWM Reports that are currently used in each service district. The submission must include reports, plans, computer modelling results and design calculations relating to how stormwater runoff is to be managed.

8.2 Required Contents

A SWM Report should include the basic quantity and quality assumptions upon which the report is based, and all appropriate functional plans of infrastructure elements for major and minor flow, which could have an impact on the layout of the Plan of Subdivision. These infrastructure elements could include SWM facilities, all water resources features and functions (i.e., watercourses, riparian areas, and recharge/discharge areas), existing overland flow routes, surface features (i.e., top of bank of valleys), and existing infrastructure (i.e., water and wastewater infrastructure, and underground utilities). Where a development proposal may impact a water resources features or function, the SWM Report must incorporate into the design the recommendations from the separate Environmental Impact Study referenced above. The Preliminary Report must provide sufficient engineering information to allow for the necessary review and acceptance of the proposed SWM schemes in principle. This report should address the following:

- Identify constraints and potential opportunities - quantitative, qualitative, erosion sensitivity and environmental concerns related to water resources for both interim and ultimate development conditions, both on and off site;
- Identify the inlets (from upstream) and outlet (to downstream) for the minor and major systems, including overland flow routes;
- Identify all external drainage areas under existing and future development conditions for minor and major flows;
- Demonstrate that the proposal has maximized source control measures to reduce runoff from the site and maximized conveyance control measures to infiltrate and/or treat runoff as appropriate consistent with water quantity and quality objectives;
- Indicate if offsite land or works are required to implement the SWM proposals and comment to what extent (e.g., easements, dedication, and land acquisition);
- Indicate the interim measures required for erosion, pond siltation and sedimentation, downstream works, and riparian flow considerations during the construction phase;
- Indicate if other agencies are required to grant approvals or issue permits; and
- Submit plans and calculations to support the proposals.

The report should include the following information:

- Location map of the subject property;
- Property description;
- Present owner contact;
- An external drainage plan including all upstream lands and any diversion of drainage routes;
- An internal drainage plan including flood and fill lines and overland flow routes;
- Schematic layout of existing and proposed sanitary and storm sewer networks;
- Schematic layout of the subwatershed showing the main watercourse, tributaries, and trunk sewers;
- Any supporting calculations and drawings, such as:
    - Calculation of surface run-off;
    - Calculation of permissible release rate and required on site storage;
    - Methods of run-off attenuation and on site storage;
    - Measures to maintain or improve water quality; and
    - Measures to minimize impact of run-off downstream including erosion and flooding.

The Final Report should include a detailed analyses (computer modelling results and calculations) and design of the major and minor systems and proposed SWM facilities based on the proposed design concepts and parameters accepted in the Preliminary Report. A sample TOR and submission checklist can be found in **Appendix K**.

8.3 Table of Contents

The table of contents should include:

1.0 Background – Reference supporting documents that set the goals and objectives

2.0 Introduction – Discussion of area to be covered by proposed SWM plan, type of development, outlet location and conditions

3.0 Goals, Objectives, Targets to be Met – Summary of goals, objectives, and targets to be met by the SWM plan (from the subwatershed study). If no subwatershed study is available, then the design criteria should be provided by local agencies (municipality, NPCA, MNR, DFO and MOE).

4.0 SWM Opportunities and Constraints – Identify and outline opportunities and constraints to SWM, develop options, cover source conveyance and end-of-pipe, and considerations for BMP, LID.

5.0 Proposed SWM Plan – Include detailed description of analysis/modeling, details of proposed plans, and monitoring plan.

8.4 Summary

The level of detail for a SWM Report depends on the type of application, the size of the development and the types of SWM schemes proposed. For example, a report for a Plan of Subdivision will typically be more complex than a report in support of a Site Plan Control application.

9. APPROVALS

9.1 Review and Approval Processes

The engineering review process for the various municipalities within the Niagara Region and the NPCA watersheds was reviewed in order to understand the different approval approaches for Plans of Subdivision, creation of new lots and development/redevelopment/infilling of existing lots. A review of available site plan and subdivision control manuals was also reviewed across the study area.

Each municipality has their own internal approval process for receiving and processing subdivision and site plan applications. For example, some municipalities require that the development application be submitted directly to the municipality and then they distribute to the agencies. Other municipalities require that the consultant representing the applicant submit the development application to the municipality and obtain approvals from all other agencies that may be affected.

With an engineering review, it is important that SWM is considered to ensure that every attempt is being made to protect and enhance water quality and quantity. The proposed development's impact on water resources, particularly from polluted stormwater runoff, should be a major consideration of engineering reviews. To ensure that these impacts are addressed, it is critical that the appropriate agencies are given the opportunity to comment on proposed development as part of the approval process.

Municipalities should incorporate the NPCA pre-screening checklist into subdivision control and site plan control applications to help ensure that the NPCA is provided with the opportunity to comment. Developments that are exempt from the site plan control process should still be assessed as to whether there is potential to implement stormwater quality and quantity controls. In addition, municipalities should pre-consult with the NPCA prior to approvals.

To ensure that a consistent approach is followed when reviewing development submission applications municipalities should refer to **Table 9.1.1** (Halton Region, 2006) for an overview of the various organizations' responsibilities for SWM review and **Appendix L** which contains a flow chart outlining the typical approval process for SWM design.

Table 9.1.1 – Guidelines for Detailed Engineering Reviews and the Responsibilities of Each Organization

Issue/Concern		NPCA	Local Municipality	Region of Niagara	MOE
Watercourses & Valleys	Floodline Delineation	X (Lead) (1)	X		
	Low Flow Channel Design & Fluvial Geomorphological Considerations	X (Lead)	X		
	Trail Design	X (depending on project)	X (Lead)		
	Geotechnical Considerations (Slope Stability, Natural Hazards)	X (Lead)	X		
Road and Utility Crossing	Geometric Design		X	X Reg. Roads	
	Hydraulics (Riparian Issues and Channel Design)	X (Lead)	X		
	Hydraulics (Minor systems)		X	X Reg. Roads	
Shoreline Design		X (Lead)	X		
Stormwater Management	Type of facility (of facilities), if not determined within approved SWS	X	X (Lead)		
	Location of facility with respect to vision of area		X (Lead)		
	Location of facility with respect to watercourse, flood plain, valleys, woodlots etc.	X (Lead)	X		
	Location of facility with respect to structural setbacks	X	X (Lead)		
	Location of facility with respect to functionality	X	X (Lead)		
	Confirmation of drainage areas	X	X (Lead)	X Reg. Roads	X
	Sizing of facility with respect to quality, erosion and quantity controls, including release rates and settling calculations	X	X (Lead)		X (3)
	Other potential impacts on receiving watercourse e.g.	X (Lead)	X		
	Outlet structure and spillway design	X	X (Lead)		
	Outfall to watercourse	X (Lead)	X		
	Safety – Side Slopes, grating, grading, emergency access		X		
	Landscaping/Revegetation	X	X (Lead)		
	Long term maintenance		X		
	Major and minor flow conveyance (internal to subdivision)	X	X (Lead)	X Reg. Roads	
	Hydraulic grade line analysis of storm sewer system and outlet		X		
Erosion and Sediment Control Plans		X	X (Lead)	X. Reg. Roads	
Other	Grading of Lots Adjacent to Regulated Areas	X	X (Lead)		
Source -					

Note: 1
Lead= Decision Maker X- Commenting Role

Note: 2
Individual Situations may require further discussion

Note: 3
Environmental and Approvals Branch of the MOE reviews all systems that fall under s53 of the OWRA including residential systems.

10. MONITORING AND MAINTENANCE

10.1 Principles of Monitoring Programs

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

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

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

The following principles are proposed as the basis of the monitoring framework.

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

10.2 Construction Monitoring

The following section outlines monitoring during and post construction. **Appendix M** contains a detailed report outlining the steps that a municipality should undertake to develop an ESC plan for land development.

10.2.1 During Construction Sediment and Erosion Control Inspection

Approved sediment and erosion control plans are to be monitored at the start of construction and throughout the construction phase until the site has become fully stabilized. The contractor will be required to perform routine (minimum once a week) sediment and erosion control inspections to ensure that the sediment and erosion control measures are maintained and functioning as intended. Sediment and erosion control measures shall be inspected:

- Prior to forecasted rainfall events to ensure that the measures are in proper working condition;
- During rainfall events to observe in-situ performance; and
- After rainfall events to identify measures that may require immediate repair or maintenance.

The following provides examples of thresholds for when maintenance work should be performed:

- Once sediment accumulation in sediment traps, sedimentation basins, dewatering traps, catchbasins among others occupies 60% of the available volume a cleanout will be required;
- If sediment accumulation depths behind silt control fencing, granular berms, for example, exceeds 300 mm the sediment must be removed; and
- Filter fabric protection of surface inlets and discharge points to be checked and replaced regularly (i.e., after heavy rainfall events).

The inspection reports will verify that the sediment and erosion control measures are in place and properly maintained. In the event that the proposed ESC plans are not operating as intended corrective measures shall be taken immediately.

Appendix J contains sample checklists that the contractor can fill out and submit to the municipality and NPCA as part of the inspection program. All checklists should be developed based on templates provided in the Erosion and Sediment Control Guidelines for Urban Construction Guidelines (GGHA CA, 2006) and modified accordingly for the construction scenario.

10.2.2 During Construction Sediment and Erosion Control Monitoring

In addition to weekly inspections the contractor would also be responsible for carrying out water quality monitoring. As explained above, the inspections will verify and ensure that sediment and erosion control measures are in place and maintained. The water quality testing will ensure that the sediment and erosion control measures are performing and preventing the release of sediment laden water into the receiving watercourses during the construction phase.

Water quality testing for TSS would provide the municipality with an indication of how the concentrations compare to typical TSS concentrations for construction sites with similar soil types. Threshold concentrations will be established to trigger when municipal staff need to perform independent inspections. Through site inspections it can be determined whether the sediment and erosion control measures are in need of maintenance, are improperly installed or whether additional measures need to be added to the existing treatment train to lower TSS concentrations to acceptable levels.

10.3 Performance Assessment Monitoring for Stormwater Facilities

In order to ensure that SWM facilities are in compliance with respect to water quantity and quality, municipalities are strongly encouraged to establish a monitoring protocol that can be followed by developers during construction and by the municipality during the post-construction phase. In general, it has been found that there are two main types of protocols that exist: a stand-alone (site-specific) protocol that is developed for a single development and associated infrastructure, and a broad-level protocol that is part of a Master Planning document such as a watershed plan, subswatershed plan, or Class EA (City of Hamilton, 2004). While the former may be the initial cost-friendly option, the latter is the preferred choice. This is because a Master Planning document for the watershed should have provisions for water quality and quantity monitoring established, and therefore will already have baseline (pre-development) data to compare construction and post-construction monitoring data with. Conversely, if a Master Planning document for the watershed is not in place, then it is unlikely that any baseline data exists and therefore no basis for comparison with development and post-development conditions exist. Therefore it is recommended that:

- Municipalities develop and implement watershed monitoring programs (system-wide monitoring) to develop baseline conditions for their watershed/subwatershed. Baseline data will provide a frame of reference to compare development and post-development monitoring data; and
- Based on the watershed monitoring program, municipalities develop a protocol for monitoring SWM facilities (during and post-construction) that the developer must follow.

10.3.1 Case Studies

The following section outlines two case studies of how SWM facility development monitoring has been handled in two different southern Ontario Municipalities.

The first example is from the City of Hamilton's Criteria and Guidelines for Stormwater Infrastructure Design (2007). This is an example of a simplified plan that does not appear to be part of a Master Planning Document. The document states that proponents are responsible to submit a Development Impact Monitoring Plan to the City for approval by the City's Planning and Development Department. If however there is a Master Planning Document in place, the proponent must demonstrate how the development and its infrastructure comply with the plan. The plan includes a general list of suggestions for types of data that should be monitored, including:

- Hydrometeorologic (rainfall, streamflow, groundwater levels, and baseflow);
- Water Quality (benthic invertebrates, water temperature, water chemistry, TSS, and fisheries);
- Water Quantity (inflow/outflow at SWM facilities);
- Fluvial Geomorphology (stream cross-sections, sediment transport, erosion pins, bank properties, and long profile survey); and
- Natural Heritage System (Community structure/health, and local hydrology).

While specifics as to the length and frequency of the monitoring program is not covered, the document does assert that this relates largely to the characteristics of the development and in-situ conditions, including sensitivity of the local receiving stream and the availability of existing information.

The City of Hamilton protocol requires that a monitoring program must be in place for development to proceed, it is clear that not all development is monitored under the umbrella of a Master Planning document.

The second example is the City of Waterloo Laurel Creek Watershed Monitoring Program (1999). This is a SWM development monitoring policy that is part of a well established watershed management plan. This framework emphasizes the importance of continuous watershed level monitoring to act as a basis for comparison when performing site-specific SWM development monitoring. Therefore, it recognizes the necessity to view the watershed as a dynamic, interrelated system of components. As such, when site-specific SWM construction is proposed, monitoring results can be compared to an already established (watershed-wide) base of data.

In general, the City of Waterloo Program identifies three main stages in SWM development monitoring: Pre-Construction, During-Construction, and Post-Construction. In addition, there are eight targets that should be monitored, which include:

- Flow discharge;
- Baseflow;
- Air temperature/precipitation;
- Phosphorous;
- TSS;
- Dissolved oxygen (warmwater and coldwater fisheries);

- Temperature (warmwater and coldwater fisheries); and
- Bacteria.

10.3.2 Suggested Monitoring Protocol

The following outlines components of a SWM Development Monitoring Program. The first component is 'System' or 'Watershed Monitoring', which aims to compile baseline environmental data concerning the watershed. The second component is 'Post-Construction Performance Assessment Monitoring', which deals primarily with ensuring that the SWM facility operates according to design specification. The last component is 'Effectiveness Monitoring'. It aims to determine the environmental affect that the SWM facility has had on the watershed ecosystem. For reference, a sample SWM Pond Inspection Checklist can be found at **Appendix N**.

10.3.2.1 System Monitoring (Watershed-Wide)

The purpose is to establish a long-term environmental baseline for the watershed. These baseline levels are compared with levels measured during development and post-development to determine if adverse impacts resulted and if mitigation is required (City of Waterloo, 1999).

10.3.2.2 Post-Construction Performance Assessment Monitoring

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

In stream monitoring parameters can be both specific constituents or surrogates. The specific parameters are typically related directly to the objective or use being protected, whereas, for stormwater facilities, indirect parameters or surrogates are often used as indicators when monitoring system performance. In other words, different parameters will have to be identified and monitored to evaluate the system effectiveness in-stream and performance in the facility. The effectiveness is measured by comparing the monitoring results to the targets established for the parameters for each objective. **Table 10.3.1** illustrates this point. Monitoring in a watershed for the facility and watercourse elements will take advantage of the common elements for all objectives (i.e., rain, flow, water quality, and toxicity data). Objective specific data will have to be collected for erosion control, and aquatic habitat and biota.

Table 10.3.1 - Monitoring Parameters for SWM Objectives

System Element	Flood Control	Channel Erosion Control	Water Quality Improvement	Habitat/Biota Protection
SWM Facility	Rainfall, peak flow rate, water level, flood flow routing, draw down time	Rainfall, flow rate and duration, water level	Pollutant removal efficiency, sediment accumulation	Discharge water quality, toxicity
Watercourse	Peak flow rate, water level, property	Flow rate and duration, water level, bank erosion,	Water quality improved? Provincial	Habitat parameters /indices (including

	damage	channel modifications stable, velocity, bed substrate, bank recession, down cutting of channel, bank vegetation	Water Quality Objective (PWQO) met? Subwatershed targets met?	physical parameters), toxicity, macro invertebrate indices/fish health indices, biomonitoring.

For the Niagara Region and the NPCA watersheds, two types of monitoring programs are proposed:

- Performance assessments of stormwater facilities, and
- Watershed effectiveness assessment to ensure targets are met.

14.3.2.3 Effectiveness Monitoring

Following construction, each stream course should be inspected by municipal staff to determine whether targets are being met. The stream should be monitored by the developer for compliance for a minimum period as specified by the municipality. A monitoring report should be provided to the municipality and NPCA twice per year for maintenance period specified by the municipality. Responsibility for future monitoring will be discussed with the agencies after the monitoring confirms the targets and objectives have been met. Should the monitoring show non-compliance, the developer would be responsible for implementing the contingency plan/remedial measures and continued monitoring until the monitoring confirms compliance.

Objectives include:

- Determine effectiveness of measures (upstream control facilities) in-stream;
- Flow rates not increased over pre-development (flood and erosion objective);
- Flow velocities (impulse) not increased (erosion control objective);
- Maintenance of base flows;
- Channel and bank erosion not increased;
- Water quality improved;
- Aquatic habitat conditions acceptable;
- Biota diverse and healthy; and
- Lack of toxicity.

The proponent needs to compare observed conditions to Subwatershed Study results. Reference can be to upstream control, pre-development conditions at the same site or to a parallel site. Also compare to published standards, (i.e., PWQO), or acute lethality criteria and compare to subwatershed targets.

The Contingency Plan/Remedial Action involves:

- Remedial measures in stream;
- Additional controls upstream;
- Retrofit control within existing facilities; and
- Modify control requirements for future sites.

10.4 Maintenance Monitoring

Upon assumption of the stormwater facility, the owner is advised to produce a set of standard operating procedures (SOPs) that can be used to guide monitoring and maintenance of their newly acquired facility. Typically, procedures are set out for:

- Sediment monitoring of SWM facility;
- Inspection procedure for SWM Facility; and
- Water [Quality] sampling of SWM Facilities and streams.

Table 10.4.1 provides specific headings that should be included in a typical standard operating procedure are provided below, as well as an example of a completed standard operation procedure.

Typical Structure of a Standard Operating Procedure (adapted from Town of Richmond Hill, 2006)

Table 10.4.1 - Typical Structure of a Standard Operating Procedure

Heading	Description
Procedure Title:	Title of procedure
Procedure Number:	Identification number for tracking purposes
Procedure Type:	Type of Procedure to be performed i.e. monitoring
Description:	Purpose and description of the procedure
Staffing and Resources:	Supervisory authority, staff needed, equipment needed
Method:	Setup of procedure, how and when it will be conducted and by whom
Required Records:	Detail of what forms will be filled out and filed/saved to disc.
Environmental Implications:	Detail regarding significant or potential impacts that the procedure could have on the environment. Also includes mitigative solutions and consequences of not following the procedure.
References:	References used to write the standard operation procedure.
Changes/Revisions to Procedure	Record any changes to procedure from previous version.
*** Adapted from Town of Richmond Hill, 2006**	

10.5 Developing an Operation and Maintenance Manual for Stormwater Management Facilities

Regular inspection and maintenance of SWM facilities is of critical importance to ensure that they perform consistently to water quality and quantity design standards. Failure to maintain these systems can have adverse impacts on the watershed and community at large, including (Clar et al., 2004):

- Increased discharge of pollutants downstream;
- Increased risk of flooding downstream;
- Increased downstream channel instability, which increases sediment loadings and reduces aquatic habitat;
- Potential loss of life and property, resulting from catastrophic failure of the facility; and
- Aesthetic, nuisance, or health problems, such as mosquitoes or reduced property value, due to degraded facility appearance.

Each SWM facility is tailor-designed to the site and community of which it is a part. It therefore follows that each stormwater facility will require different maintenance needs, largely depending upon size, type, and condition of the watershed that contributes runoff to the pond. In addition, the location of the pond within a community also influences the maintenance program. For example, people have more favourable impressions of wet ponds, and are less likely to throw urban debris in them and are more likely to clean and maintain them when they are provided a prominent position in the development (LOSRC, 2006).

In general, an effective operation and maintenance (O&M) program:

- Specifies what O&M actions are needed and corresponding timeline;
- Identifies responsible parties; and
- Requires adequate funding for maintenance activities.

An example of Standard Operating Procedures from the Town of Richmond can be found in **Appendix O**.

When developing a maintenance program, one must be aware that there are generally two types of actions to be performed during the lifetime of a SWM facility, specifically, those that are ‘routine’, and those that are ‘non-routine’. Routine actions are those that are performed regularly (i.e., monthly, semi-annually, and annually). **Table 10.5.1** illustrates the frequency of maintenance actions.

Table 10.5.1 - Components of a Maintenance Program

Routine Maintenance Actions	Non-Routine Maintenance Actions
• **Inspection** • **Vegetation Management (i.e. grass trimming, weed control, plantings)** • **Urban debris/litter control (removal)** • **Graffiti removal** • **Mechanical components maintenance**	• Bank stabilization • Sediment testing, removal, and disposal • Outlet structure maintenance/replacement
***modified from LOSRC (2006), Town of Bradford (2006), and Clar *et al.* (2004).**	

In addition to actions differing in timing (i.e., routine or non-routine), actions can also differ according to the type of work being done. The first kind, termed ‘aesthetic maintenance’, relates to actions that help maintain and improve the visual appearance of the facility such as vegetation management, urban debris removal, and graffiti removal. It is important to ensure that stormwater facilities be kept in good condition so that they can easily integrate into and be accepted by mainstream society. The second type is ‘functional maintenance’, which is important for performance and safety reasons. Functional maintenance can be further subdivided into either preventative or corrective maintenance. Preventative maintenance would be procedures performed routinely to keep the SWM pond in proper working order such as grass trimming, removal of trash or debris, maintenance of mechanical components, and elimination of Mosquito Breeding habitats (Clar et al., 2004). Secondly, corrective maintenance is required on an emergency or non-routine basis to correct problems and to restore safe operation and function of SWM facility.

Table 10.5.2 outlines a list of typical inspection and maintenance activities found in an O&M manual. **Appendix O** has an example of O&M checklists that can be used as a template for creating a SWM O&M manual.

Table 10.5.2 - Inspection and Maintenance Activities

Inspection Activities	Suggested Timeline/Schedule
• **After several storm events or an extreme event, inspect for: bank stability, signs of erosion, and damage to, or clogging of, the inlet/outlet structures**	Non-routine – As Needed
• **Inspect for: trash and debris; clogging of inlet/outlet structures; excessive erosion; sediment accumulation in basin, forebay and inlet/outlet structures; tree growth on dam or embankment; presence of burrowing animals; standing water where there should be none; vigour and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability**	Routine – Semi-annually
• **Inspect that the inlet/outlet structures, pipes, sediment forebays, and upstream, downstream, and pilot channels are free of debris and are operational**	Routine - Annually

Inspection Activities	Suggested Timeline/Schedule
• **Check for signs of unhealthy or overpopulation of plants and/or fish (if used)** • **Note signs of algal growth or pollution, such as oil sheens, discoloured water, or unpleasant odours.** • **Check sediment marker(s) for sediment accumulation in the facility and forebay.** • **Check for proper operation of control gates, valves or other mechanical devices** • **Note changes in wet pond or contributing drainage area as such changes may affect pond performance**	
Maintenance Activities	**Suggested Timeline/Schedule**
• **Clean and remove debris from inlet and outlet structures** • **Mow side slopes (embankment) and maintenance access. Periodic mowing is only required along maintenance rights-of-way and the embankment. The remaining pond buffer can be managed as a meadow (mowing every other year) or forest**	Routine - Monthly
• **If wetland vegetation is included, remove invasive vegetation**	Routine - Semi-annually
• **Repair damage to pond, outlet structures, embankments, control gates, valves, or other mechanical devices; repair undercut or eroded areas** • **Remove pollutants or algal overgrowth as appropriate**	Non-routine - As Needed
• **Perform wetland plan management and harvesting**	Annually (if needed)
• **Remove sediment from the forebay. Chemical testing is required to determine the toxicity of the sediments which dictates how sediments will be disposed.**	Non-routine - 5 to 7 years or after 50% of the total forebay capacity has been lost
• **Monitor sediment accumulations, and remove sediment when the pond volume has become reduced significantly or the pond is not providing a healthy habitat for vegetation and fish (if used).**	Non-routine - 10 to 20 years or after 25% of the permanent pool volume has been lost
Knox County, 2006	

11. STORMWATER MANAGEMENT SYSTEM FUNDING

It is necessary to do long term funding projections to plan for SWM. This includes estimating the cost of capital projects, operations and maintenance as well as special projects such as watershed studies, environmental assessments and public education programs. Below is a list of potential funding sources and alternatives for SWM.

11.1 Tax levy and general budget

The tax levy and general budget most often provide the largest portion of the SWM budget in most municipalities within Canada. Setting the tax rate to ensure SWM in the form of watershed studies, operation and maintenance of existing infrastructure and capital projects can be funded adequately is essential. However, increasing tax rates can be politically difficult and selling SWM to the public is time consuming and difficult compared to more tangible, immediate needs.

11.2 Development Charges

The Development Charges Act, 1997 (DCA) of Ontario allows municipalities to charge those developing new parcels of land or increasing development on already developed parcels of land in order to compensate for the increased levels of services required. These charges are limited to covering 'net growth related capital costs'. To ensure SWM is adequately covered, these development charges must be set appropriately and follow the rules and requirements set out in the DCA. All provisions for development charges for stormwater facilities must be contained in a DCA by-law in each municipality and justified with supporting background study before individual charges can be imposed.

Table 11.2.1 describes examples of Development Charges in other municipalities in Ontario.

Table 11.2.1 - Municipalities with Development Charges Programs

Municipality	Charge Description
Halton Hills	• Present value of maintenance cost associated with developed land stormwater facilities.
Waterloo	• \$321-\$1037/dwelling unit for residential. • \$2.33/m^2 total floor area for non-residential.
Hamilton	• \$1008-\$2589/dwelling unit for residential. • \$0.2591/ft^2 (\$2.79/m^2, discounted rate) for non-residential. • A 67% discount is given to subdivisions with a centralized SWM plan provided at the cost of the developer.

11.3 Cash-in-Lieu

Many by-laws require developers to manage stormwater on site for both quantity and quality before it is released to the municipality's stormwater system. In some development areas within the municipality, this is either not practical or not possible due to site configuration or size. This is especially common in infill situations where (re)development occurs on land surrounded by developed land or in areas where servicing already exists. In these instances municipalities may decide to charge a fee in lieu of SWM so that they might build a central facility to manage stormwater for several properties being developed in another location or increase stormwater capabilities of high priority to improve the entire system. In the latter case, projects undertaken must follow priorities set out in local subwatershed plans and stormwater master plans. In all cases, charges must follow requirements under the DCA and the Planning Act and must be written in to the DCA by-law.

In general, there are two ways of determining cash-in-lieu charges – the facility cost method and the Area/Impervious Method (MOE, 2003). The facility cost method involves determining the cost of a facility that would be required to treat the water on the site. In the area/impervious method, an average cost associated with increased stormwater costs due to impervious areas is generated and charged to all developing parcels that qualify.

Table 11.3.1 gives examples of municipalities that have cash in lieu programs and outlines their criteria for development joining the program.

Table 11.3.1 - Municipalities with Cash-in-Lieu Programs

Municipality	Type of Program	Charge (2003)	Criteria
Kitchener	Facility cost	$15,000/ha	Within redevelopment/infill boundaries and unable to redirect stormwater to existing water quality pond.
Mississauga	Facility cost	$35 100/ha ($21700/gross ha.)	All developing properties with discounts to those providing some SWM.
Markham	Area/ Impervious	$21,855.77/imp. ha (quality) $29,056.24/imp. ha (quantity and quality)	From MOE, 2003
Belleville	Area/ Impervious	$10,000+$10,000/imp. ha	From MOE, 2003

11.4 Long-Term Financing

For large capital projects, it might be impractical and even impossible to fund the entire project within the fiscal year of construction. For instance, a municipality may not be able to raise taxes in a single year by the amount necessary to fund a large. In these cases, a municipality may decide to borrow money to complete the project and repay the loan over a longer term. Although delaying payment and incurring debt increases the overall cost of a project, it spreads the financial burden to future users who benefit from the services provided.

The long term financing approaches to consider for capital and O&M works include would include DCA charges, taxes, cash-in-lieu policies, water rates (monitoring), and stormwater rates.

11.5 Outside Partnerships

At some times, the CA, Provincial Government and Federal Government have initiatives to improve infrastructure, including stormwater infrastructure, and/or improve water quality. Municipalities must be constantly aware of these initiatives and apply for funding through these sources whenever possible. These programs are often targeted towards specific goals and are short term or one time payments. They must be exploited when available but can not be used in long term planning and projections.

11.6 Stormwater Rates

Many municipalities in Canada and throughout North America are heading towards funding stormwater through a dedicated rate similar to a water or sewage rate. These rates can be based on property assessed values, a flat fee, the total parcel area or the impervious area on a given parcel of land. **Table 11.3.1** outlines municipalities within Canada that have water rates and their basis. In the United States, rates based on impervious area of properties have been developed and legally defended.

Table 11.6.1 - Municipalities with Stormwater Rates (2005-2006)

Municipality	Description	Rate
Edmonton, AB	• All property owners are charged based on their property area (A, m^2), a development intensity factor (I) and a runoff coefficient based on land zoning (R). I is 1.0 by default unless property owners can show they contribute significantly less stormwater runoff than other similarly zoned properties.	Charge/month=AxIxRxRate Rate(December 2005) = \$0.013270/m^2
Richmond, BC	• A tax rate based on assessed property values is levied for Storm Drainage for all properties. In addition, a yearly flat rate fee for dyke improvements is collected for every property in the City.	C_R =0.06597%/year C_c=0.24460%/year C_{Ind} =0.24832- 0.31614%/year C_{dyke}=\$11.11/year
Aurora, ON	• A flat rate for all residential and commercial properties.	C_R =\$55.40/year C_c=\$673.80/year
London, ON	• A flat rate for residential (C_R), commercial (C_c) and institutional (C_{Ins}) property owners is collected monthly and an area (A) based charge is levied to industrial property owners (C_{Ind}).	C_R =\$7.95/month C_c=\$9.59/month C_{Ins} =\$7.67/month C_{Ind} =\$678.74- 798.37/ha/month
St Thomas, ON	• A charge (C) is levied based on property land area (A). Commercial properties over 1800m^2 are a separate case (C_c).	C=Ax\$0.013/m^2/month C_c=Ax\$76.43/ha/month

In conjunction with long-term watershed and SWM planning, municipalities should plan long- term for funding any studies, operations and maintenance and capital projects.

12. RECOMMENDED POLICIES

12.1 Official Plans Policies Relating to Stormwater Management

OP policies for the municipalities within the Niagara Region and the NPCA watersheds were reviewed to get an understanding of the policies related directly or indirectly to SWM. **Appendix D** provides a summary of the different kinds of information found in the various OPs for the municipalities within the study area. OPs for municipalities outside of the Niagara Region and the NPCA watersheds were also reviewed to gain an understanding of the current trends and advances regarding SWM policies.

Based on the policies observed within the OPs, and current trends and advances found in other municipalities, draft recommended policies have been provided. **Appendix P** provides a more detailed summary of the OP review. **Table 12.2.1** provides a summary of recommended draft OP policies relating to SWM.

12.2 Municipal Design Standards and Policies Relating to Stormwater Management

A review of all available municipal design standards and policies relating to drainage and SWM design for the municipalities within the Niagara Region and the NPCA watersheds was conducted and is summarized in **Appendix C**. **Appendix Q** summarizes the municipal design standards and policy review for municipalities within the study area and the current trends and advances. **Table 12.2.2** summarizes recommended SWM policies pertaining to municipal design standards.

Table 12.2.1 - Summary of Recommended Official Plan Policies

Documents Reviewed	Summary of Findings
Watershed and Subwatershed Planning	• OPs should be updated to include watershed and subwatershed planning in cooperation with NPCA policies, other agencies, and neighbouring communities. • Municipalities should include the importance and need for subwatershed planning, and the need to keep plans current as science evolves. • Update OPs to include formal recognition of watershed and subwatershed planning through existing and future plans. • Development should not take place until a subwatershed study has been completed that include SWM planning, and quality and quantity targets. • A sample TOR of a Subwatershed Study can be found in **Appendix R**.
Secondary Plans/Neighbourhood Plans/Urban Renewal Plans	• OPs require that the development of neighbourhoods should be planned through preparation of Secondary or Neighbourhood Plans in cooperation with the NPCA and neighbouring municipalities. • OP provides list of what the Secondary Plans should include and that it should be planned in conjunction with a subwatershed study. • OP should provide goals of the secondary plan such as 'flexibility to adapt to new development trends'. • Secondary Plans should include policies for compact urban form, redevelopment, promoting sustainable development, and green technologies. • Prior to the approval of any new or expanding urban area, comprehensive Secondary Plans would be required with the exception of individual site specific development proposals. • Secondary Plans should indicate how the goals and policies of the OP, specifically relating to SWM are to be implemented prior to development. • A sample TOR of a Master Drainage Plan can be found in **Appendix R**.

Documents Reviewed	Summary of Findings
Servicing, SWM Requirements and Sediment and Erosion Control	• OPs require that all new development and redevelopment be served by a storm drainage system that is satisfactory to the municipality, NPCA, and MOE. • Require that all new development and redevelopment include the design of a major and minor drainage system. • Storm drainage to be constructed completely separate of sanitary sewers. • Develop comprehensive SWM plans for development taking place in both urban and rural areas. • New development and lands undergoing redevelopment will need to consider SWM for both water quality and quantity before discharging into the receiving watercourse or drainage system. • Implement a hierarchy of SWM measures to manage stormwater at the source and supplement with conveyance and end-of-pipe controls. • Encourage the public to minimize the contamination of stormwater through pollution prevention and effective use of BMPs. • Require that all development and redevelopment, regardless of size, implement sediment and erosion control practices in accordance with current BMPs. • Include policies in the OP that require the proponents to design and undertake a monitoring program for construction sites to ensure that sediment controls are effective during construction and after landscaping.
Municipal Drains	• OPs should include policies to ensure that Municipal Drains authorized under the *Drainage Act* are designed, constructed and maintained in accordance with BMPs to avoid significant detrimental effects on farmland, water resources, natural areas and wildlife habitat. • Include policies in the OP that encourage the use of programs such as the Wetland Drain Restoration Project, which restores wetlands and their flow moderation roles of runoff.
Design Principles and Urban Design Guidelines	• Promote the use of innovative methods for reducing the impacts of stormwater runoff and maximize SWM at the source where feasible. • Update urban design guidelines.
Parking Standards	• OPs should support shared parking, loading, and storage areas. • Encourage innovative parking lot design that includes landscape features such as peripheral plantings and landscaped islands in both private and municipal parking lots.
Road Standards	• Encourage alternative road standards that would for example reduce the width of the right of way and decrease impervious cover. • Encourage the integration of SWM measures within the road right of way.
Innovative SWM Design Standards	• Consider naturalized methods for SWM and make them integral features of the landscape. • Design guidelines for tree planting planted to form canopy over roads when mature which would improve interception, but still must accommodate street lights and roadway illumination; • Encourage infiltration to maintain base flow through grading • Through the OP municipalities should make a commitment towards implementing innovative SWM design on public lands as pilot projects.
Urban Form Standards	• Encourage alternative development patterns such as clustering of residential units to preserve natural features found on site. • Encourage development to incorporate environmentally sustainable building design and construction practices that reduce stormwater flows and create innovative green spaces.
Plans of Subdivision, Site Plan Control and Approvals	• Consider including a policy in the OP that notes that even though some developments are exempt from the site plan control process, SWM measures will need to be considered as a condition of obtaining a building permit. • OPs should state that grading, drainage, and SWM to be addressed through site plan control process. • Master Lot grading plans (*e.g.*, part lot control and short form development).
Greening and Ecological Policies	• Encourage environmental education, environmental compliance, and incentives. • Protect, restore, and enhance existing green spaces. • Support agencies, community organizations, and private landowners in their efforts to protect and enhance through private habitat restoration, stewardship, land trusts, public acquisition, conservation easements, and property tax mechanisms. • Integrate existing natural wetlands in urban areas wherever feasible with the drainage system to provide stormwater runoff treatment.
Monitoring	• Recognize the need to include in OP policies the importance of partnerships and watershed monitoring in order to make informed management decisions with respect to land use and development. • OP policies should require that SWM infrastructure will be monitored and maintained to ensure that it is in a good state of repair and in compliance with the CofA.
Source Water Protection	• To ensure consistency across the study area, municipalities should update their OP policies to ensure compliance with the *Clean Water Act* source water protection legislation, such as identification of significant recharge areas, highly vulnerable aquifers, and intake protection zones.

Table 12.2.2 - Summary of Recommended Municipal Design Standards and SWM Policies

Documents Reviewed	Summary of Findings
Water Quantity & Quality Control Targets	• In all cases, the fishery sensitivity of the receiving system should be established through reference to the fishery sensitivity maps.
Watercourse Erosion	• Refer to **Section 7.5Error! Reference source not found.** for recommended policies
Hydrogeological Sensitive Areas	• Municipalities should reference the hydrogeologic sensitivity maps referred to in **Section 7.1.3** when selecting appropriate SWM BMPs for their area. • Municipalities should look to reduce the use of salt on roads and in parking areas to reduce the impacts to stormwater quality and risk to groundwater contamination. • Develop education programs that result in pollution prevention through increasing public awareness and behavioural changes.
Hydrologic and Hydraulic Analysis	• The City of Hamilton's SWM modelling guidelines provide a detailed approach to SWM design and recommend municipalities to follow this policy in the absence of their own standards and guidelines. • Flood control policies are administered by the NPCA. • Refer to **Appendix H** for available IDF curves within the study area. • Hydrologic and hydraulic applications are to be standardized and administered by the NPCA.
Minor and Major System	• All developments shall provide a minor and major flow system.
Spill Management	• Require Spill Management Plans for industrial and commercial lands that process, store or refine liquids. • Consider installing oil and grit separators in storm sewers that drain roads identified as potential spill routes (*e.g.*, truck routes). • Areas that are subject to the collection of contaminants or spills shall be fitted with adequately sized oil and grit separators. • Source protection – spill management plans need to be in place in hydrogeologically sensitive areas. • Sewer use by-law for spill management. • Site plan control includes new development for spill containment.
Foundation Drains	• Use of a foundation drain collector (FDC) is an acceptable approach to foundation drains where appropriate. • If an FDC is not used then it is preferred that no gravity connection can be made to the storm sewer and that sump pumps be used to pump water and discharge at grade, if feasible.
Roof Leaders	• Roof leader connections to storm sewers or impervious surfaces is discouraged. • Direct roof leaders to pervious area and provide splash pad to prevent erosion, where feasible. • If soils are conducive and space is available roof leaders should be directed to landscaped features that would store and infiltrate rainwater.
Combined Sewers	• It is a concern that combined sewer separation might lead to untreated storm sewer discharges to waterways. It is recommended that measures that control the total discharge be favoured, or that stormwater be controlled separately to a minimum level of treatment to provide a normal level of protection for fisheries (70% TSS removal). • Recommend that steps be taken to reduce/eliminate untreated discharges. • Existing development take existing urban areas and retrofit.
Natural Watercourses	• Municipalities should implement erosion studies to inventory and prioritize erosion sites (in some cases there are no online quality and/or quality facilities. • Municipalities should consider opportunities to daylight watercourses or utilize open channels instead of closed pipe systems, where feasible. • Opportunities for the daylighting of watercourses are to be identified on a watershed basis for environmental and water quality enhancement. • Where a watercourse requires reconstruction it is to be completed in a way that utilizes soil bioengineering principles and practices. The reconstruction shall maintain and wherever possible improve the form and functions of the watercourse. • Consideration is to be given to the development and adoption of drainage density targets by watershed to facilitate the decision making process on which watercourses to leave open.
Storm Outfalls	• Discourage outletting pipe drains directly into creeks where possible. • If outletting a storm sewer to a watercourse must design in accordance with the policies listed above. • Municipalities should inventory existing outlets and develop monitoring programs for identifying suspect outfalls.
Lot grading criteria	• Include in lot grading standards and policies opportunities for implementing alternative engineering standards that facilitate at source controls and innovative SWM practices. • Encourage lot grading criteria that help to detain and treat stormwater as part of the overall stormwater treatment train process at the lot level. • Encourage alternative lot grading criteria that will make implementing innovative SWM techniques easier and meet the Ontario Building Code. • Restrict heavy equipment access to certain area of the construction site and out of areas with high infiltration potential to maintain the infiltration capacity of the soil.

Documents Reviewed	Summary of Findings
	• Roof water should be controlled on site through practices such as rain barrels, rain gardens, soak away pits, and infiltration trenches. • Where appropriate, municipalities should encourage the use of alternative landscaping techniques over turf, such as naturescaping, that incorporates a diversity of native vegetation. Landscaping using native drought resistant species helps to reduce water consumption by reducing the need to irrigate. Landscaping with trees and shrubs rather than grass, and creating subtle depressional areas, will help to detain and treat stormwater at the site level. • The use of enhanced swales or bio-swales when designing backyard swales to convey stormwater runoff as an alternative to the conventional grass swale should be promoted (e.g., features such as wetland pockets could be incorporated into the swale design to detain and enhance treatment performance). • Consider specifying a minimum 300 mm depth of topsoil to line drainage swales to act as an absorbent layer. • Compact soils that are not amended with a soil conditioner can be similar in nature to impervious areas. Recommend that lot grading consider soil amendments to ensure infiltration of stormwater. Conditioning soils with compost will increase the organic matter content of the soil. The organic matter acts a sponge and absorbs rainfall that helps to trap and store water which means less stormwater is running off the site. The organic matter also helps treat the stormwater and remove pollutants and enhance water quality. • Educate the public about the importance of source and conveyance controls to understand their role in SWM and protecting water quality and quantity. Since these types of SWM measures are more difficult to maintain, it will be important the landowners are aware of their significance.
Reverse Driveways	• Reverse slope driveways and other features that would be likely to capture runoff or fail to drain during major rainfall events should be discouraged.
Cash-in-Lieu Policies	• Cash-in-lieu is to be used off site where it would be more effective, if the receiver is a low sensitivity, limited rehabilitation opportunity, small or infill development. • Refer to **Section 11.3** for more information.
Centralized Systems	• More economical, allows for greater control, requires fewer people, and produces only one discharge to monitor instead of several. • However, municipalities should be flexible in which options they choose (source controls, centralized and de-centralized systems), based on potential opportunities, aesthetics and financial abilities. Source controls and de-centralized systems are optimal for applying Low Impact Design concepts.
SWM and Passive Recreational Opportunities	• SWM ponds are often incorporated into parks and green spaces for passive recreational uses and planning and design must consider public safety
SWM Facility Design and Landscaping Guidelines	• In the absence of formal SWM facility design and aesthetic guidelines follow guidelines from the MOE and MTO manual. • Municipalities should develop their own SWM facility design and aesthetic guidelines. • When selecting vegetation for landscaping use plant species approved by the NPCA. • **Appendix S** provides sample aesthetic guidelines and a plant list approved by the NPCA
SWM BMPs	• Encourage using the treatment train approach to SWM which, in some cases, can lead to smaller pond facilities and obtain higher performance. Source/conveyance/control • As discussed earlier, LID is a site design strategy that aims to maintain or replicate the predevelopment hydrologic conditions. BMPs such as rain gardens, bioinfiltration, bioretention, and green roofs help to capture, store and treat rainfall to simulate a predevelopment hydrologic conditions. Municipalities, such as the City of Waterloo, have implemented stormwater BMP pilot projects such as retrofitting the City Hall with a green roof. The City has also implemented a monitoring program in cooperation with community partners to measure the SWM benefits these technologies provide. • Municipalities should implement SWM BMPs on public lands to demonstrate their commitment towards innovative and sustainable development. • Municipalities should provide flexibility in their design standards to promote innovative SWM design. • Municipalities are encouraged to refer to **Section 7.3** for the different types of SWM BMPs available and are encouraged to implement them when opportunities arise.
Site Plan Control	• Municipalities should designate site plan control areas to ensure that the goals and objectives of the OP are reflected in development and redevelopment. Site plan control provides the opportunity to ensure that OP policies such as ‘opportunities for innovative SWM design’ are being considered as part of the site design. • Municipalities should develop site plan control manuals that outline development expectations with respect to SWM and to maximize water quality and quantity controls. • Encourage new development and redevelopment applications to consider and implement innovative SWM design. • New developments and redevelopments should integrate SWM into the landscape and incorporate drought resistant plant material in order to reduce long term maintenance and conserve water. Landscape plans should utilize a diversity of native plant species from a pre-selected list (see **Appendix S**). Utilize species that are drought tolerant to reduce watering and future maintenance requirements. Tree survey plans be submitted to identify existing vegetation on site and determine what vegetation can be preserved. • Site plans should be prepared by a qualified planner, Professional Engineer, or landscape architect.

Documents Reviewed	Summary of Findings
	• For preliminary site reviews that include watercourses and other natural features, it may be beneficial to include staff from the NPCA at preliminary development meetings. • Consider the requirement that development applications create and submit a map of the proposed site plan that specifically identifies the features of the site that facilitate the natural processing of stormwater. Features such as watercourses, wetlands, existing vegetation, infiltration areas, slopes, swales, and natural depressional areas should be identified. The map would help the engineer, architect or planner to justify site configuration and demonstrate how the natural stormwater processing features have been maintained or enhanced. • Encourage innovative landscape design by considering the natural features of the landscape and ensuring the integration of SWM features, site plan submissions to integrate SWM in parking areas through landscape features, and site plans to demonstrate how the site was configured to isolate impervious areas and infiltrate stormwater where appropriate (See site plan control section in **Appendix Q**). • Municipalities should consider SWM for parking lot expansions or redevelopment to incorporate SWM quality and quantity controls when no controls currently exist. Consider amending site plan agreements to include provisions for stormwater quality and quantity controls.
SWM Report Submission Requirements	• Refer to **Section 8** for recommended policies.
Approvals	• Refer to **Section 9** for recommended policies. • To ensure that a consistent approach is followed when reviewing development submission applications municipalities should refer to **Table 13.1.1** for an overview of the various organizations' responsibilities for SWM review and **Appendix L** which contains a flow chart outlining the typical approval process for SWM design. • To ensure that the NPCA is given the opportunity to provide comments on development submission, the NPCA pre-screening checklist should be built into the development applications.
Erosion and Sediment Control Monitoring	• Refer to **Section 7.5Error! Reference source not found.** and **Section 10** for recommended policies. • Expose the smallest practical area of land for the shortest possible time. • Apply soil erosion control practices as a first line of defence against on-site damage. • Apply sediment control practices as a perimeter protection to prevent off-site damage. • Implement a thorough maintenance and follow-up operation.
Development Monitoring of SWM Facilities	• Refer to **Section 10** for recommended policies.
Assumed SWM Facility Monitoring and Maintenance Programs	• Refer to **Section 10** for recommended policies. • Recommend that all Municipalities develop maintenance and monitoring program for all existing and future SWM facilities including a list of criteria for prioritizing maintenance. • All SWM Facilities should be monitored after assumption to ensure continued hydrologic and hydraulic performance and meeting the conditions of the approval to operate. • Municipalities should require the submission of an operation and maintenance manual prior to assumption of the SWM facility.
Maintenance and Monitoring of Private SWM Facilities	• Refer to **Section 10** for recommended policies. • Easements on new development and redevelopment sites should be established to access SWM facilities to deal with reported problems if the landowner is not taking the appropriate actions.
Redevelopment and Infilling	• Municipalities are encouraged to developed separate SWM policies to deal with redevelopment and infilling for areas not subject to a subdivision agreement or site plan control. The policies would require consideration of water quality and quantity controls on a site specific basis. If SWM controls are not feasible, then the municipality may consider contributions in the form of a cash-in-lieu policy. • In accordance with the *Places to Grow Act* "municipalities are encouraged to implement and support innovative SWM actions as part of redevelopment and intensification". • The ultimate outlet for the drainage system should be the deciding factor as to what level of treatment is required. **Section 6.4** provides further direction on how to determine the appropriate level of treatment based on the sensitivity of the receiving system. If the sensitivity of the receiving system is unknown, the level of treatment should meet levels set in the Sewer Use By-law or to the satisfaction of the municipality and NPCA.
Alternative Design Standards	• The solution must be better than the standard solution, or else equitable trade-offs may be considered. • Must meet the basic safety, durability, longevity, and functionality criteria. • All initial costs to provide enhanced infrastructure should be considered at the expense of the development, as a share in the risk of the project.

12.3 City By-laws

12.3.1 Background Review

A review of the existing available by-laws was conducted to determine what policies existed relating directly and indirectly to SWM. By-laws outside the Niagara Region and the NPCA watersheds were also reviewed for comparison purposes and identifying opportunities. **Table 12.3.1** presents a summary of the applicable by-laws relating to SWM for all the municipalities across the Niagara Region and the NPCA watersheds. Refer to **Appendix T** for an overview of the various municipal by-laws and how they relate directly or indirectly to SWM.

Table 12.3.1 - Municipal By-Law Summary

Municipality	Fill and Site Alteration, Topsoil Preservation By-Law	Maintenance and Occupancy of Property By-Law	Sewer Use By-Law/ Management of a System of Sewer Works and Drainage Works	Downspout Disconnection By-Law	Tree Harvesting, Destruction, Injury By-Law	Site Plan Control By-Law and/or Policy
City of Hamilton	X					
City of Niagara Falls	X	X			X	
City of St. Catharines			X	X		
City of Thorold		X	X			
City of Welland						X
Haldimand County		X				
Town of Fort Erie	X		X		X	X
Town of Grimsby						
Town of Lincoln	X					
Town of Niagara-on-the Lake	X	X				
Town of Pelham	X					
Town of Port Colbourne			X			
Town of Wainfleet		X				X
Town of West Lincoln						
Region of Niagara	X		X		X	

12.3.2 Recommendations

It is important that municipalities adopt by-laws such as the ones described in **Appendix T** that support SWM objectives and the protection of water quality and quantity. Accordingly, municipalities are encouraged to adopt and update by-laws.

Municipalities are strongly encouraged to adopt site alteration by-laws that will protect lands before a development application is submitted. This by-law will help to ensure that site alteration on private lands is being carried out in an environmentally responsible manner that will, among other things, not impact water quality and quantity.

Municipalities are strongly encouraged to adopt sewer use by-laws that will control discharges to storm sewers, sanitary sewers and Combined Sewer Overflows (CSOs). The sewer use by-law should include policies that provide direction regarding storm drainage requirements such as the adoption and implementation of pollution prevention techniques and measures. The by-law should accent the consequences of impairment to water quality as a result of discharging poor water quality into the drainage works. To ensure continued efficient operation of privately owned SWM facilities municipalities should create, adopt or update their sewer use by-laws to include policies for maintenance of privately owned SWM facilities.

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14. ACRONYMS

BMPs	Best Management Practices
CA	Conservation Authority
CEAA	Canadian Environmental Assessment Act
CEPA	Canadian Environmental Protection Act
Class EA	Class Environmental Assessment
CofA	Certificate of Approval
CMHC	Canadian Mortgage and Housing Corporation
CSO	Combined Sewer Overflow
DCA	Development Charges Act
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
EAA	Environmental Assessment Act
EC	Environment Canada
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
ESC	Erosion and Sediment Control
FDC	Foundation Drain Collector
IDF	Intensity Duration Frequency
km	kilometre
mm	millimetre
MMAH	Ministry of Municipal Affairs and Housing
MNR	Ministry of Natural Resources
MOE	Ministry of Environment
MTO	Ministry of Transportation
MTR	Tourism and Recreation
NCDENR	North Carolina Department of Environment and Natural Resources
NPCA	Niagara Peninsula Conservation Authority
NWQPS	Niagara Water Quality Protection Strategy
O&M	Operation and Maintenance
OMAFRA	Ontario Ministry of Agriculture and Food
OP	Official Plan
OSS	Off-Site systems
OWRA	Ontario Water Resources Act
PWQO	Provincial Water Quality Objective
SAR	Species at Risk
SCS	Soil Conservation Services
SWM	Stormwater Management
SWMM	Storm Water Management Model
TC	Transport Canada
TOR	Terms of Reference
TP	Total Phosphorus
TSH	Totten Sims Hubicki Associates
TSS	Total Suspended Solids

15. Glossary

Adaptive Management - A type of natural resource management that implies making decisions as part of an on-going process. Monitoring the results of actions will provide a flow of information that may indicate the need to change a course of action. Scientific findings and the needs of society may also indicate the need to adapt resource management to new information.

Aquatic Habitat - Habitat that occurs in free water.

Aquifer - A porous water bearing geologic formation generally restricted to materials capable of yielding an appreciable supply of water

Base flow - The portion of streamflow that is not due to storm runoff, and is supported by groundwater seepage into a channel.

Basin - A hollow or depression within which water can be contained.

Best Management Practice (BMP) - 1. Conservation measures intended to minimize or mitigate impacts from a variety of land use activities. 2. A structural or non-structural device designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities.

Bioretention - A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff by collecting it in shallow depressions before filtering through a fabricated planting soil media.

Biota - All living organisms of a region, as in a stream or other body of water.

Buffer - A land area that is designated to block or absorb unwanted impacts to the area beyond the buffer. Buffer strips along a trail could block views that may be undesirable. Buffers may be set aside next to wildlife habitat to reduce abrupt change to the habitat.

Calibration - A check of the precision and accuracy of measuring equipment.

Catchbasin - A box-like underground concrete structure with openings in curbs and gutters designed to collect runoff from streets and pavement.

Catchment Area - Also referred to as drainage basin, a catchment area is an area drained by a stream or other body of water. The limits of a given catchment area are the heights of land-often called drainage divides, or watersheds-separating it from neighbouring drainage systems. The amount of water reaching the river, reservoir, or lake from its catchment area depends on the size of the area, the amount of precipitation, and the loss through evaporation (determined by temperature, winds, and other factors and varying with the season) and through absorption by the earth or by vegetation; absorption is greater when the soil or rock is permeable than when it is impermeable. A permeable layer over an impermeable layer may act as a natural reservoir, supplying the river or lake in very dry seasons. The catchment area is one of the primary considerations in the planning of a reservoir for water supply purposes.

Channel - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

Channel erosion - The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to large floods.

Clay - A natural earthy material, smaller than silt, possessing plastic properties and consisting of fine particles of complex hydrous silicates smaller than 0.002mm.

Corridor - Elements of the landscape that connect similar areas. Streamside vegetation may create a corridor of willows and hardwoods between meadows where wildlife feed.

Conveyance - Any natural or manmade channel or pipe in which concentrated water flows.

Culvert - A covered channel or a large-diameter pipe that directs water flow below the ground level.

Detention - The temporary storage of stormwater to control discharge rates, allow for infiltration, and improve water quality.

Discharge - A release or flow of stormwater or other substance from a conveyance or storage container.

Drainage - 1. The removal of excess surface water or ground water from land by means of surface or subsurface drains. 2. Soil characteristics that affect natural drainage.

Drainage Area - The area contributing runoff to a single point measured in a horizontal plane, which is enclosed by a ridge line.

Ecosystem - An arrangement of living and non-living things and the forces that move among them. Living things include plants and animals. Non-living parts of ecosystems may be rocks and minerals. Weather and wildfire are two of the forces that act within ecosystems.

Environment - Environment means: (i) air, land or water; (ii) plant and animal life, including man; (iii) the social, economic and cultural conditions that influence the life of man or a community; (iv) any building, structure, machine or other device or thing made by man; (v) any solid, liquid, gas odour, heat, sound, vibration or radiation resulting directly or indirectly from the activities of man, or; (vi) any part or combination of the foregoing and the interrelationships between any two or more of them.

Environmental Assessment (EA) - A systematic analysis of site-specific activities used to determine whether such activities have a significant effect on the quality of the human environment and whether a formal environmental impact statement is required.

Erosion - 1. The process by which the land surface is worn away by the action of water, wind, ice, or gravity. 2. Detachment and movement of soil or rock fragments by water, wind, ice or gravity. The following terms are used to describe different types of water erosion.

Evapotranspiration - The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

Exfiltration - The downward movement of water through the soil; the downward flow of runoff from the bottom of an infiltration BMP into the soil.

Facility - Is a collection of industrial process discharging stormwater associated with industrial activity within the property boundary or operational unit.

Fertilizer - Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Floodplain - Areas adjacent to a stream or river that are subject to flooding or inundation during a storm event that occurs, on average, once every 100-years (or has a likelihood of occurrence of 1/100 in any given year).

Grading - The cutting and/or filling of the land surface to a desired slope or elevation.

Gravel – An unconsolidated natural accumulation of rounded rock fragments, mostly of particles larger than sand (diameter greater than 2 mm), such as boulders, cobbles, pebbles, granules, or any combination of these.

Groundwater - Water stored underground in the pore spaces between soil particles or rock fractures.

Habitat - An area or type of area that supports plant or animal life.

Hydrologic cycle - Also called the water cycle, this is the process of water evaporating, condensing, falling to the ground as precipitation, and returning to the ocean as run-off.

Hydrology - The science dealing with the study of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Impermeable – Cannot be penetrated by a fluid, such as water, or air.

Impervious Area - A hard surface area (*e.g.*, parking lot or rooftop) that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Infiltration - 1. The penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. 2. A land application technique where large volumes of wastewater are applied to land, and allowed to penetrate the surface and percolate through the underlying soil.

Infiltration Rate - The rate at which stormwater percolates into the subsoil measured in inches per hour.

Landfill - An area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

Major Drainage System - The major drainage system is that part of the overall drainage system which is designed to convey a specified rare flood event. This system may comprise:

- Open space floodway channels, road reserves, pavement expanses and other flow paths that can act as overland flow paths for flows in excess of the capacity of the Minor Drainage System;
- Detention basins and lagoons; and
- Major underground piped systems installed where overland flow is either impractical or unacceptable.

Master Plan - A Master Plan is a long range plan, integrating infrastructure requirements for present and future land use with environmental planning principles. The plan examines the whole infrastructure system in order to outline a framework for planning for subsequent projects and/or developments.

Minor Drainage System - The minor drainage system includes curbs and channels, roadside channels, inlets, underground drainage, junction pits or access chambers and outlets designed to fully contain and convey a design minor stormwater flow of specified Average Recurrence Interval. This arrangement may also include:

- Field gully inlet pits, installed to collect surface runoff from within allotments, as well as the roof water drainage provisions for buildings;
- Cross drainage under minor roads where delay or inconvenience during major flows is acceptable. This also includes low flow pipes or box culverts installed under floodways; and
- Low flow pipes installed under drainage reserves or park areas.

Mitigation - The activities carried out, or proposed, by a proponent of an undertaking to minimize or ameliorate the environmental effects of the undertaking.

Monitoring - The activities carried out by the proponent after approval of an undertaking to determine the environmental effects of the undertaking ("effects monitoring"). Monitoring can also refer to those activities carried out by the MOE in ensuring that a proponent complies with the EA as accepted and the terms and conditions of the approval of the undertaking ("compliance monitoring"). "Effectiveness monitoring" is a third type of monitoring in which a proponent evaluates how effectively its class EA parent document or proposal, plan or program EA is working in the planning and implementation of its class EA projects or constituent undertaking, respectively.

Non-point Source Pollution - Pollution whose source is not specific in location. The sources of the discharge are dispersed, not well defined, or constant. Rain storms and snowmelt often make this type of pollution worse. Examples include sediments from logging activities and runoff from agricultural chemicals.

Off-Line - A management system designed to control a storm event by diverting a percentage of stormwater events from a stream or storm drainage system.

On-Line - A management system designed to control stormwater in its original stream or drainage channel.

Outfall - The point, location, or structure where wastewater or drainage discharges from a sewer pipe, ditch, or other conveyance to a receiving body of water.

Outlet - The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

Permeability - The quality of a soil that enables water or air to move through it. Usually expressed in inches/hour or inches/day.

Permeable - Soil or other material that allows the infiltration or passage of water or other liquids.

Point Source - Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

Pollutant - Any dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discharged equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Pond - Still deep water area in a natural or constructed depression with little vegetation throughout.

Precipitation - Any form of rain or snow.

Redevelopment - Any construction, alteration, or improvement exceeding five thousand square feet of land disturbance performed on sites where existing land use is commercial, industrial, institutional, or multifamily residential.

Rehabilitation - To restore to good or normal condition

Remedial - Fix a problem (*i.e.*, remedial action on a stream to improve erosion conditions).

Retention - The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

Retrofit - The modification of SWM systems in developed areas through the construction of wet ponds, infiltration systems, wetland plantings, stream bank stabilization, and other BMP techniques for improving water quality. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older SWM structure, or a combination of improvement and new construction.

Riparian - A relatively narrow strip of land that borders a stream or river often coincides with the maximum water surface elevation of the 100-year storm.

Runoff - That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters.

Sand - Small substrate particles, generally from 0.06 to 2 mm in diameter. Sand is larger than silt and smaller than gravel.

Sanitary Sewer - A system of underground pipes that carries sanitary waste or process wastewater to a treatment plant.

Sedimentation - The process of depositing soil particles, clays, sands, or other sediments that were picked up by flowing water.

Sewage – The liquid waste from domestic, commercial, and industrial establishments.

Silt – An alluvial material intermediate in particle size between sand and clay (0.002 – 0.02mm). It is usually non-plastic.

Stormwater - Includes stormwater runoff, snow melt runoff, surface runoff and drainage. It excludes infiltration.

Stormwater Management (SWM) - Practices implemented to protect natural waterways and receiving waters from urban impacts. Controls used include peak flow control for flood control, peak flow and volume control to mitigate erosion impacts and water quality controls for water quality impacts.

Stormwater Pond - A land depression or impoundment created for the detention or retention of stormwater runoff.

Stormwater Wetland - Shallow, constructed pools that capture stormwater and allow for the growth of characteristic wetland vegetation.

Subwatershed - A watershed is an area of land defined by the characteristic that all runoff drains to a common main river (or lake, or chain of lakes) via a series of tributaries. Each of the tributaries of the main river or lake system has its own drainage area, known as a subwatershed.

Total Phosphorus (TP) - The total amount of phosphorus that is contained within the water column.

Total Suspended Solids (TSS) - The total amount of particulate matter that is suspended in the water column.

Tributary - A river or stream that flows into a larger river or stream.

Watercourse - A river, creek, or stream in which water flows permanently or intermittently in a natural or artificial channel.

Watershed - The entire region drained by a waterway (or into a lake or reservoir). More specifically, a watershed is an area of land above a given point on a stream that contributes water to the streamflow at that point.

Watershed Management - The analysis, protection, development, operation, or maintenance of the land, vegetation, and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents.