AUSABLE BAYFIELD CONSERVATION AUTHORITY

Stormwater Management Policies and Technical Guidelines

Draft Appendices

February 2009

Stantec

Table of Contents

APPENDIX A

Study Terms of Reference

Ausable Bayfield Conservation Authority
Stormwater Management Policy Review

Terms of Reference
&
Request for Proposals

August 16, 2007

BUILDING BETTER ENVIRONMENTAL CONSCIENCE
A Ausable
Bayfield B
Conservation C

Table of Contents:

Table of Figures:

1.0 Introduction

This document provides the Terms of Reference (TOR) and Request for Proposals (RFP) for the review and updating of the Ausable Bayfield Conservation Authority (ABCA) Stormwater Management (SWM) Policy. The following section provides some background on the ABCA SWM Policies and introduces the project.

1.1 Project Background

In 1994, the ABCA created a set of documents entitled Stormwater Management Policies and Technical Guidelines for use by ABCA staff in reviewing SWM plans and also to provide direction to engineering consultants who would be completing SWM Plans for development within the ABCA Watershed area.

While this document set has served well since their creation, there are now new SWM guidelines produced by MOE, and the consulting and development industries have developed new best management practices which can be utilized to achieve the goals of today's SWM policies.

In addition, municipalities have had a number of years experience in relation to maintenance of SWM facilities.

2.0 Project Overview

The ABCA is requesting proposals from consultants to complete the specific study tasks as identified in Section 4 – Project Scope.

The consultant shall complete the work using sound engineering practice and any required technical guidelines during the course of the study.

The project has been divided into two parts based on budget limitations. The first part of the project has been approved for funding of $11,250 for the 2007 budget year. Funding for Phase 2 to complete the project will be included in the proposed 2008 budget which is anticipated to be finalized by January 2008.

The consultant will identify an appropriate point in the study tasks as the dividing point between Phase 1 and Phase 2. Identified budget for Phase 2 of the successful consultant will be used in the budget preparation for 2008.

3.0 Project Management and Consultant Responsibilities

The ABCA will:

- serve as the primary contact
- provide any of the available background information

The consultant will:

- be responsible for preparation of all meeting agendas and minutes
- provide the technical expertise in fulfilling the Terms of Reference for this project or additional services identified by the project team
- be required to enter into an engineering agreement for the work required to complete the study

- keep the ABCA informed of all proposed schedule/ study task changes and difficulties that may arise throughout the project
- keep project costs to a minimum

4.0 Project Scope

The major components of the project are as follows.

1) The consultant will conduct a thorough review of the existing ABCA documentation relating to SWM Policies and review.

2) The consultant will allow for a meeting with ABCA staff and other interested parties to review the study tasks and make recommendations for changes where appropriate.

3) The consultant will conduct a review of existing guidelines or those in draft form which relate to SWM in Ontario from both a quality and quantity perspective. A written summary of this review will be provided to the ABCA as well as form part of the final report.

4) The consultant will arrange for a meeting with appropriate municipal staff (9 municipalities within the ABCA watersheds) with the purpose of discussing the following:

a) review the development guidelines and policies of the municipalities to assist with determining if policies developed by ABCA will be compatible with municipal polices. Any policies which may be in conflict should be identified and a possible solution proposed.

b) review the concerns or needs of the municipality in relation to the municipal assumption and maintenance of SWM facilities.

c) review planning documents to identify areas designated for future development. These areas will be assessed based on the potential impact of SWM and the SWM Policies which are needed to address future concerns. Areas which may require a master drainage plan approach should be identified.

5) The consultant will prepare a report which reviews the existing SWM Policies and reference material as well as information collected from watershed municipalities and clearly indicates changes which are required to update existing ABCA SWM Policies documentation. 3 copies of this report will be provided to the ABCA for review.

6) The consultant will meet with ABCA staff and other interested parties to discuss the report noted in Task 5 and confirm the method of revising the existing documentation. It is anticipated that a new document set (Policies and Appendix) will need to be produced. Relevant sections of existing documentation may be included in the new set.

7) Three draft copies (paper format) of all final documentation will be provided for ABCA review. The documentation should include a stand alone executive summary (in paper and digital format) which would be suitable to provide to municipalities for their comments.

8) Once comments on the draft information have been provided, the consultant will meet with the ABCA to discuss the comments and determine how the report will be finalized.

9) Once all documentation has been approved by the ABCA, 25 hard copies of all documentation will be provided to the ABCA. In addition 50 copies of all documentation in pdf format which would be suitable for distribution to municipalities, developers and engineering consultants will be provided. One master copy of all documentation in both pdf and where appropriate MS Word format will be provided to the ABCA.

10) As part of the new documentation, a review template will be prepared to assist ABCA staff in the review of new SWM plans being submitted. Two days of training will be provided for training ABCA staff in the effective use of the review template. Training may take the form of walking through a current review and providing staff with appropriate instruction and assistance.

11) If required, the consultant will recommend an appropriate SWM software package for use by ABCA staff in SWM review. If this purchase takes place, there will be one day of training provided for the software.

12) As part of this project, the consultant will be required to present the results of the project at a meeting for municipal staff, developers and consulting engineers. The meeting time and location will be decided in conjunction with ABCA staff. The ABCA will look after booking the facility for the meeting and advertisement of the meeting.

Should proposed costs exceed the project's total budget, the ABCA reserves the right to adjust the scope of work.

5.0 Project Timing and Milestones

As mentioned in Section 2, due to 2007 budget constraints, the project will be divided into 2 phases with Phase 1 being completed by December 14, 2007. The consultant will determine an appropriate point in the study tasks which will mark the completion of Phase 1 based on staffing resources and available funding.

The intermediate milestones for this project are to be recommended by the consultant; however, the required milestones are as follows:

Milestone 1: Proposals Received by the ABCA (September 6th, 2007)
Milestone 2: Selection of Consultant (by September 21st, 2007)
Milestone 3: Project Initiation (by October 12th, 2007)

- Consultation information and background
- Meeting with ABCA staff
- Critical dates established
- Review contract/insurance
- Review of existing documentation

Milestone 4: Phase 1 Summary Report Submitted to the ABCA (December 14th 2007) Details of summary report to be confirmed after consultant selection.

Milestone 5: Final Report Submitted to the ABCA (September 19th 2007)

Milestone dates 4 and 5 are proposed to be used in the final engineering agreement.

6.0 Project Budget

The total project budget estimate is $11,050 for the portion of the work to be completed in 2007 (Phase 1). A budget figure for 2008 (Phase 2) will be determined from the proposal of the successful consultant and will be included in the draft ABCA 2008 budget submission.
Should the full 2008 budget amount not be approved, the ABCA will reserve the right to adjust the scope of work. Cost estimates for the work will be a consideration in the selection of the successful consultant; however, the contract will not necessarily be awarded to the proposal with the lowest cost estimate.

As part of their proposal, interested parties shall provide a detailed schedule and budget estimate which shall include the staff time and expenses required to perform the work as outlined in their proposal. The detailed cost estimate shall also include (but not be limited to):

- equipment rental
- office and field expenses

Per Diem staff rates to be charged to the project shall be included as well as estimated time spent on each project component.

6.1 Budget Estimates in Proposal

Budget estimates in the proposal should be provided as a minimum for each Activity as grouped in the example in Section 6.2.

It is acceptable to show budget estimates by each of the 12 tasks identified in the scope of the project.

6.2 Invoicing the ABCA

Invoices for completed work and activities shall be issued to the ABCA monthly. The invoices shall include, but not be limited to the information contained in the example table below:

Activities	Budget	Previously Billed	Current Invoice	Total to Date	Balance Remaining	% of Activity to Complete
Background Review (Tasks 1 and 3)	$	$	$	$	$	%
Meetings (tasks 2, 6, 8, 12)	$	$	$	$	$	%
Tasks 4, 5	$	$	$	$	$	%
Tasks 7, 9	$	$	$	$	$	%
Task 10	$	$	$	$	$	%
Task 11	$	$	$	$	$	%
Totals	$	$	$	$	$	%
GST	$	$	$	$	$	N/A
Billing Totals	$	$	$	$	$	%

All costs shall include PST where applicable; GST to be shown separate.

7.0 Proposal Requirements

Two hard copies of proposals are to be submitted to,

Ausable Bayfield Conservation Authority
C/o Alec M. Scott
RR #3, 71108 Morrison Line
Exeter, ON N0M 1S5

by no later than noon (12 pm), local time on September 6th, 2007. PDF copies by email (ascott@abca.on.ca) will be accepted, providing that 2 hard copies are received at the address above no later than 4:30 pm September 7th 2007.

Part A shall include, but not be limited to:

- the scope of work
- proposed methodologies
- identification of the Project Manager and key project staff
- a brief statement of the related experience of the Project Manager and key staff
- identification of current projects the Project Manager and key staff will be involved with during the same time frame as this project
- the anticipated amount of background review
- anticipated reliance on ABCA resources (ie. mapping, reports, staffing)
- the proposed schedule of work
- proposed meeting allowances
- a statement of insurability
- a brief statement of the relevant corporate experience
- references for similar completed projects (contact name, number)
- a brief description on what will be included in the deliverables for this project

Part B of the proposal shall contain cost information including, but not limited to:

- Per Diem rates for the staff involved in the work
- disbursement, expenses and sub-consultants/contractors
- an itemized cost assessment for undertaking the work broken down but not limited to:

  Budget estimates in the proposal should be provided as a minimum for each Activity as grouped in the example in Section 6.2.

  It is acceptable to show budget estimates by each of the 12 tasks identified in the scope of the project.

7.1 Consultant Selection

The successful consultant will be selected based on a combination of the following factors:

- relevant experience
- proposed methodologies
- schedule
- cost

Upon review of the proposals the ABCA will score and rank Part A of the proposals. Part B of the proposals will then be scored and ranked independently of Part A Selection of the consultant will be based on the consideration of both Part A and Part B. The lowest cost will therefore not necessarily be selected. As always, cost effective quality engineering is desired, allowing for the timely completion of the project.

7.2 Agreement

The successful consultant will be expected to enter into an agreement with the ABCA for the provision of services as outlined in this Terms of Reference and the consultant's proposal. The ABCA uses an agreement based largely on the CEO, MEA agreement for professional services. The agreement will utilize the consultant's estimate as the upset limit for this project.

7.3 Insurance

The successful consultant will be required to provide the ABCA with proof of comprehensive general liability insurance to the amount of $2,000,000. The consultant will also be required to carry personal liability insurance in the amount not less than $1,000, 000. The insurance companies involved must be licensed to operate and do business within the Province of Ontario. Any concerns with the insurance requirements for this project may be addressed to the ABCA.

8.0 Background Information

The following list sources the available documentation pertinent to the current project:

- **ABCA Stormwater Management Policies and Technical Guidelines Final Report December 1994**
- **ABCA Stormwater Management Policies and Technical Guidelines Technical Guidelines**

Hardcopies of these documents are available for review at the ABCA offices. Please make arrangements for meeting to review these documents if required.

ABCA WATERSHED AREA

APPENDIX B

Phase 1 Summary Report Conclusions and Recommendations

Table of Contents – Appendix B

B.1 PHASE 1 SUMMARY REPORT - GENERAL

The completion of Task 5 of the Policies and Technical Guidelines update work included the creation of a “Phase 1” Summary Report documenting the results of the team’s review of the existing SWM Policies and reference material, information collected from watershed municipalities, and outlining the anticipated changes required to update the existing Policies documentation.

Forming the basis for the completion of the Policy and Technical Guidelines update, the conclusions and recommendations of the report have been reproduced within Appendix B to outline the approach followed in completing the overall update. The contents of the Phase 1 report are largely reproduced within various sections of this Appendices document, most notably Appendix C and E.

B.2 PHASE 1 SUMMARY REPORT CONCLUSIONS

The review of the current state of the practice of SWM in Ontario and, more specifically, the identification of numerous specific SWM issues and concerns of importance pertinent to watershed stakeholders has confirmed the need to review and update the *ABCA Stormwater Management Policies and Technical Guidelines, Final Report* (Triton Engineering Services Limited, 1994) is justified at this time. Our review of the 1994 document confirms that it was quite comprehensive and remains relatively current, as many of the watershed issues identified at the time remain today. Indeed, it is expected that the much of the material presented within the 1994 policy will be included within the new document with only minor revisions.

Notwithstanding the above, however, a not insignificant evolution in SWM philosophies, approaches, and technological innovations has occurred since the time of the 1994 document. It is noteworthy that the MOE saw fit to update the 1994 version of the industry standard *Stormwater Management Practices – Planning and Design Manual* in 2003 for many of the same reasons.

From a watershed perspective, the interconnection between the ecological functions and hydrologic conditions within a watercourse and the need / benefits of managing stormwater on a watershed basis have become recognized and incorporated into the environmental protection policies in Ontario. Aspects such as climate change and the potential for impacts on a watershed basis suggest substantial benefits could be realized through consideration of revised water and stormwater management controls. The idea of developing polices aimed at improving the resiliency of a watershed to ensure flexibility to uncertain changes of this magnitude is beginning to take root in the province and abroad.

On a smaller-scale, both geographically and in terms of day-to-day implementation, a recurring theme expressed by watershed stakeholders was the desire for improved direction from the Conservation Authority Policy, and the provision of guidance and consistency in terms of establishing criteria and design standards for SWM, as well as clarification on the roles and responsibilities of the various stakeholders. Key watershed management issues of concern directly tied to stormwater include such areas as the increasing extent of gully erosion and water quality along the Lake Huron shoreline.

The items touched on above and others are discussed in more detail in the following section outlining the initial recommendations for inclusion in an update watershed SWM policy document.

B.3 PHASE 1 REPORT RECOMMENDATIONS FOR POLICY UPDATE

It is suggested that the update to ABCA's SWM policies, design criteria, and implementation requirements should consider and attempt to address the following recommendations:

- Recognizing the primary users of the document are public and private stakeholders pursuing clear direction as to technical expectations of designs, it is recommended that the main body of the Policy document be streamlined as possible to provide easy and clear access to the required materials. In this regard, it is suggested that as much of the supporting material, while technically valuable and important to those looking to drill deeper, should be compiled as appendix material to the main policy document.
- The SWM policy document should clearly and concisely identify the preferred approach, goals, and objectives of SWM in recognition of the evolution of SWM and environmental protection policies in Ontario to be implemented consistently across the watershed.
- Based on the information summarized herein, and through the establishment of memorandums of understanding, the roles and responsibilities of each review and approval agencies should be clearly identified and summarized so as to help the development industry plan and manage expectations. In particular, the roles, responsibilities, and process of the Conservation Authority should be clarified.
- Stormwater management criteria should reflect the sensitivity of the aquatic habitat and stability of the receivers, as well as the interdependencies of adjacent natural features on the surface and groundwater regime in the area. Criteria should be established to ensure that the quality and quantity of stormwater runoff is controlled to prevent flooding, water quality degradation and downstream erosion, in recognition of site and subwatershed conditions, and that the overall water balance across the development is maintained to ensure the water regime for which adjacent natural features may rely is not negatively impacted.

- Specific policies should be included to recognize the high erosion potential within the local drainage features that occur along the Lake Huron shoreline and reduce potential for impacts, particularly those associated with any proposed land use change.

- The implementation of Low Impact Development approach to planning and associated SWM designs should be encouraged.

- Clear direction should be provided regarding the identification of acceptable locations for the construction of SWM facilities, such as confirming whether such measures may be permitted within floodplain areas or adjacent to natural features and what conditions (i.e. buffers, setbacks, restoration, design) must be satisfied in order to permit such structures.

- It is recommended that there is limited benefit to the ABCA policy documents incorporating detailed design guidance of specific SWM measures as there are numerous similar such reference documents readily available to the design practitioner. Simply referring the policy document users towards appropriate reference material should suffice and relieve the requirement for this document to "stay current".

- The process for the preparation, review, and approval of SWM plans and reports should be identified. In this regard, the need for and benefits associated with a comprehensive pre-consultation program, undertaken prior to design and submission activities, should be emphasized. Format of review comments should be tailored to illustrate where comments originating from either a regulatory or advisory perspective.

- SWM design submission standards should be established to ensure consistency across the watershed. The creation of a SWM submission checklist identifying the information requirements, submission standards, deliverables and supporting documents should be established to required to outline agency expectations, improve the overall quality of submissions, and to maximize the potential for complete submissions to the betterment of alls stakeholders.

- The potential impacts on SWM associated with climate change prediction, such as prolonged droughts and/or increased intensity and frequency of rainfall and flood events, should be considered in establishing SWM criteria for water quantity control and as further justification for maintaining a hydrologic water balance across the watershed;

- Specific requirements for the implementation of monitoring programs prior to, during and following construction is encouraged to ensure the proper functioning and maintenance of erosion and sediment controls and to ensure that the SWM facilities, which will ultimately be owned and maintained by the municipality, are functioning as designed prior to assumption;

- The document should be made available through the ABCA website to maximize access and availability to the public

At the time of creation of the current *Phase 1 Summary Report*, these recommendations were considered as preliminary and intended to serve primarily as the basis for upcoming stakeholder presentations and discussions.

APPENDIX C

Stormwater Management - General

Evolution of Stormwater Management - Ontario

Evolution of Stormwater Management - Ontario

Implementation of SWM in Ontario

Selection of Available On-Line SWM Resources

Table of Contents – Appendix C

List of Tables

C.1 STORMWATER MANAGEMENT – GENERAL

C.1.1 SWM Goals and Objectives

The basic goals and objectives of SWM are described in any number of different ways throughout the available literature, a sampling of which is contained below as a starting point for this section:

> The ultimate goal of stormwater management is to maintain the health of streams, lakes and aquatic life as well as provide opportunities for human uses of water by mitigating the effects of urban development. To achieve this goal stormwater management strives to maintain the natural hydrologic cycle, prevent an increased risk of flooding, prevent undesirable stream erosion, and protect water quality. (MOE, 2003a)

> SWM involves "the planning, analysis, collection, storage and controlled discharge of stormwater that is based on the philosophy of minimising the environmental impacts of urbanization while providing for safety and convenience in land development, while emphasising the need to identify existing environmental limitations, to define the predicted effects and to establish the means to mitigate against potentially adverse impacts" (Perks and Wisner, 1978 in Smith *et al*., 1993).

> "Stormwater management is the process of controlling and processing run-off so it does not harm the environment or human health" (Roesner, 1999).

> [SWM] is a way to "achieve the goal of minimising the adverse environmental impacts of urbanization when providing for safety and convenience in land development…by making developers accountable for increased run-off and possibly deteriorated water quality resulting from the developments" (Korsiak and Mulamootil, 1986).

> "SWM involves the control of storm water run-off by means of programs that include land use control, run-off detention / retention, erosion control and drainage" (Yeager, 1988).

> As of the late 1970's, SWM represented a "change in attitude which accepts the complexity of urban water problems and uses a range of water resource approaches available for their resolution" (Perks and Wisner, 1978).

Goals are defined as the long-term ends towards which prolonged efforts are directed. The three basic goals of SWM include the:

- Protection of public health and safety
- Protection of public and private property
- Protection of the natural environment from the potentially adverse impacts of development.

More specifically, the MOE suggests that the ultimate goal of SWM is to maintain the health of streams, lakes, and aquatic life, as well as provide opportunities for human uses of water by mitigating the effects of urban development. To achieve these goals, SWM objectives strive to:

- Maintain the natural hydrologic cycle
- Prevent an increase in the risk of flooding
- Prevent undesirable stream erosion
- Protect water quality (including erosion and sediment control) (MOE, 2003a).

The long-term SWM goals can be realized by consistently implementing practices and technologies that achieve the objectives on a site-specific, sub-watershed, or watershed basis. The following sections provide further detail on how these objectives are achieved.

C.1.1.1 Maintaining the Natural Hydrologic Cycle (Water Balance)

As a result of the creation of roadways, sidewalks, parking areas and various structures associated with urban development, the impervious cover of an area is increased following development. By increasing the impervious cover and removing the soil and natural vegetation from an area, groundwater recharge within these areas is reduced, which may lower the groundwater table and consequently reduce baseflows to wetlands and watercourses (USEPA, 1993, p.17). Increased impervious cover also increases the volume of post-development stormwater to be managed, due to reduced infiltration, reduced evapotranspiration, and increased run-off, which would increase downstream flooding and erosion potential if not mitigated.

Through the maintenance of the natural water balance on a site, post-development recharge and run-off volumes are controlled to pre-development levels, thereby maintaining the natural supply of water to the environment. Natural groundwater recharge results from infiltration of relatively uncontaminated precipitation through pervious surfaces, such as wetlands, grasslands and woodlands (Pitt et al., 1999).

Following the development of an area, the water that is available for recharge generally carries increased quantities of pollutants, including nutrients, pesticides, organic compounds, pathogens, metals and dissolved minerals (Pitt et al., 1999). This poses a possible danger to groundwater and drinking water resources (Sieker and Klein, 1998). Maintaining infiltration of relatively clean stormwater following development as near to the source as possible is required to protect the receiving groundwater resources (i.e. maintain baseflow and drinking water) and to protect public health and safety.

C.1.1.2 Preventing an Increase in Flood Risk (Water Quantity Control)

Urban areas generate more run-off than natural or rural areas as a result improved conveyance systems and increased impervious cover. Therefore, the control of water quantity is required to ensure post-development stormwater flows are not increased to downstream areas, which typically implies that control of the volume, peak flow rates, hydrograph shape, and most likely a combination of the three should be provided to pre-development levels (MOE, 1994). By controlling the rate of water flowing from a development, SWM systems are designed to detain and control the release of stormwater to minimize downstream flooding, thereby preventing property damage and protecting public safety. Ideally, flood control requirements should be determined on a watershed or subwatershed basis through an assessment of potential flood hazards (i.e. bridge crossings, floodplain land uses) (MOE, 1994).

Traditionally, the Rational Method was used to calculate run-off from a developed area, and considered an imperviousness co-efficient, the intensity of a design storm event, (i.e. 1, 2, or 5-year storm) and the drainage area (Warwick, 1978; Chocat et al., 2001). More recently, any number of computer simulation models ranging from simplistic to very complex, have been developed to more easily and, when applied correctly, more accurately determine or predict the hydrograph characteristics from a specific area based on a soil type, topography, vegetation cover, and proposed development parameters. As software model complexity increases the complexity of input parameter set follows.

C.1.1.3 Prevent Undesirable Stream Erosion (Maintaining Stream Morphology)

Natural channels within urban areas that receive uncontrolled stormwater adjust to the new hydrological conditions (i.e. increase in peak discharge, volume and velocity of run-off; increased frequency and severity of flooding) (Schueler, 1987), often in ways that result in negative impacts on downstream properties and the environment. These adjustments often include widening of the channel to accommodate increased storm flows, increasing the elevation of the floodplain to accommodate the higher post-development peak discharges, undercutting and slumping of the streambanks, and temporary storage of eroded sediment within the channel substrate (Schueler, 1987). Through the control of the quantity and distribution of stormwater discharging to downstream watercourses, these impacts can be avoided in order to protect private property, public safety, and maintain the natural environment.

C.1.1.4 Protecting Water Quality (Water Quality Control)

Urban areas generate large quantities of pollutants, which are consequently released to downstream areas during a storm event (USEPA, 1999). Pollution sources associated with urban areas include vehicular traffic, lawn maintenance, air pollution, construction materials and manufacturing. The pollutants accumulate on streets, rooftops, lawns and other surfaces, to be washed off during storm events or snowmelts, often becoming suspended in stormwater and transported to downstream areas or infiltrated to the groundwater system, posing a potential risk of contamination (MOE et al., 2001).

While pollution prevention measures are encouraged to reduce or eliminate pollutants at the source (MOE et al., 2001), the introduction of contaminants into stormwater is inevitable in urban areas. Therefore, water quality control measures are required to remove these pollutants from the stormwater before they are released to the downstream environment. The recommended level of water quality control is based on the sensitivity of the receiving waters to potential introduction of contaminants (MOE, 1994).

C.1.1.5 Erosion and Sediment (E & S) Control

During the construction of subdivisions, grading, fill placement and other construction activities disturb the natural vegetation cover of an area and makes the soil unstable and susceptible to erosion. During a storm event, soils particles become suspended in stormwater and are transported and deposited downstream, which can result in the sedimentation of lakes, rivers and wetlands thereby affecting flood control and conveyance, fish habitat, navigation, water supplies, and recreational activities (MNR, 1987a). Therefore, the implementation of erosion and sediment controls during all phases of construction helps to control erosion and protect downstream areas

While erosion and sediment control is often viewed in isolation from the other aspects of SWM, E&S controls are a temporary form of stormwater quality control intended to prevent or minimize the impacts of construction on water quality and the natural environment.

C.1.2 Stormwater Management Controls

The options available to the SWM practitioner as a means of addressing the SWM control objectives described in the previous sections are numerous and ever-expanding. While the options are many, they all rely on one or more of three primary mechanisms to treat stormwater, namely physical, chemical, and biological approaches. Table B1 provides a summary of the various functions performed by SWM practices to achieve the various objectives of SWM. As shown on the Table, those SWM approaches that rely on physical control are the most effective at achieving the range of SWM objectives as described in the previous sections, while biological and chemical functions primarily address water quality concerns.

C.1.2.1 Functions

The physical functions identified on Table B1 are the most effective means to achieving the range of SWM objectives outlined in Section B.1.2, while the biological and chemical functions primarily address water quality concerns. The physical functions control the movement, location, and contaminants of stormwater. Detention, retention, and sedimentation require the storage of stormwater to control the rate of stormwater discharge allowing suspended sediments to settle out of suspension. Retention also allows for the dilution of the “first flush” of stormwater, which is typically considered the most contaminated portion of run-off from urban areas (Yeager, 1988; Smith et al., 1993; Faulkner, 1999; Niemczynowicz, 1999). As well, pollutants can be physically removed from stormwater through filtration and flotation.

The chemical functions that improve water quality occur through the alteration or removal of pollutants by chemical processes. Adsorption of metals to clay particulates during infiltration removes these contaminants from infiltrating stormwater and prevents these metals from impacting groundwater resources. Open pools of water provide the necessary conditions for the removal of organic compounds, including pesticides and herbicides, through volatilization, hydrolysis, and photolysis (USEPA, 1999). Ultra-violet disinfection involves the use of high intensity ultraviolet light to kill bacteria found within stormwater.

Finally, biological functions that are naturally performed by vegetation and bacteria can be used to improve stormwater quality. The use of constructed wetlands or grassed swales provides an opportunity to remove nutrients (i.e. nitrogen, phosphorous) from stormwater as aquatic vegetation use these nutrients for growth. As well, similar to the use of bacteria in septic systems, bacteria can breakdown or degrade complex and toxic organic compounds into less harmful compounds, reducing the toxicity of runoff to aquatic biota in receiving watercourses (USEPA, 1999).

C.1.2.2 Technology

A SWM practice is a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater run-off (USEPA, 1999). There are essentially two types of SWM practices: (1) structural controls and (2) non-structural controls. Structural controls are engineered and constructed systems that improve water quality or control the quantity of run-off (USEPA, 1999). Non-structural controls include institutional, education, or pollution prevention practices designed to limit the generation of stormwater run-off or reduce the amount of pollutants contained in the run-off (USEPA, 1999).

SWM practices can also be divided by the relative location where the various functions occur. These locations include: (1) lot level / on-site controls; (2) conveyance controls; and (3) end-of-pipe controls. Lot level controls involve measures to treat stormwater before it reaches the conveyance system. Conveyance controls are implemented as part of the system that transports stormwater from source to discharge location. End-of-pipe controls are typically the last chance for stormwater treatment prior to discharge to the receiving waters (MOE, 2003b). Various combinations of these SWM practices should be incorporated into the design of storm systems for all new developments to ensure the effective control of stormwater run-off.

Over the years, a number of SWM practices have been designed to perform the necessary functions required to achieve the various SWM objectives. Some SWM practices focus primarily on one objective, while others perform a variety of functions that achieve a variety of objectives. However, no single SWM practice can address all stormwater problems (Perks and Wisner, 1978; MOE and MNR, 1991a; USEPA, 1999; MOE, 2003). A number of considerations are required to determine the suitability of individual SWM practices for a specific site, including drainage area, land use, soil type, slopes, topography, and climate.

End-of-pipe constructed wetlands represent perhaps the most complete single treatment measure, but even they have limitations in that they are not suitable to treat stormwater for drainage areas less than 5 hectares in size because they require sufficient drainage area to maintain the necessary water regime to support wetland vegetation (MOE, 2003b).

The selection of appropriate SWM practices for an individual site should be left to experienced stormwater practitioners (engineers), with input from ecologists, biologists, planners, and agency staff, to ensure the necessary functions are provided to achieve the site specific SWM objectives as part of an overall plan to achieve watershed goals.

Table C1 Functions of SWM Practices that Achieve Various SWM Objectives

Functions Provided by Various SWM Practices	Description	SWM Objectives				
		Quantity Control	Quality Control	E&S Control	Groundwater Recharge	Stream Morphology
Physical						
Detention	Temporary storage and passive release of stormwater	x		x		x
Retention	Permanent storage of stormwater	x	x	x		x
Sedimentation	Removal of suspended particulates through gravitational settling		x	x		
Infiltration	Recharge of surface stormwater to the groundwater system	x	x		x	
Filtration	Removal of contaminants by passing water through a porous media		x	x		
Flotation	Separation of contaminants with a specific gravity less than that of the stormwater (e.g. oil)		x			
Conveyance	Transport of stormwater between locations	x				
Chemical						
Adsorption	Binding of dissolved metals to particulates		x			
Degradation	Volatilization, hydrolysis and photolysis of organic compounds		x			
UV Disinfection	Removal of bacteria using ultraviolet light irradiation		x			
Biological						
Uptake	Removal of nutrients by aquatic plants, algae and microorganisms		x			
Conversion	Degradation of contaminants by bacteria into less harmful materials		x			

C.2 EVOLUTION OF STORMWATER MANAGEMENT - GENERAL

The provision of safe drinking water, flood protection, drainage, and sanitation has been addressed since the times of early civilization. Some of the earliest urban drainage structures were constructed 5000 years ago in the Mesopotamian Empire, while the storage and filtration of stormwater is known to have occurred in Venetian city squares until the 17th century (Chocat et al., 2001). Following the decline of the Roman Empire, however, sanitation practices typically deteriorated with surface streets and open drains used as the only means of conveyance and disposal of wastewater (Chocat et al., 2001). Such practices lead to numerous epidemics of disease in urban areas, prompting governments to find a solution for the control and treatment of stormwater and other wastewater.

Uncontrolled stormwater run-off results in increased peak discharges, volumes and velocities and decreased infiltration, baseflows, and recharge capacity. These various changes to the drainage system caused by urbanization lead to greater risks associated with flooding, deteriorated water quality, erosion and decreased groundwater levels (Schueler, 1987). While these main issues form the basis of contemporary SWM, the relative attention given to these issues in the past has varied. Based on a review of available literature, the approach to the control and treatment of stormwater has evolved through the following five distinct eras as summarized within this section.

C.2.1 Traditional Conveyance Approach (1850s to 1970s)

The need to prevent flooding in urban areas and to protect the public from pests and disease associated with standing water prompted governments to determine methods to remove stormwater from urban areas. As a result, stormwater and other "wastewater" were directed to a common collection and distribution network of sewers beginning around the late 1870s (Chocat et al., 2001). The continuous motion of water in all parts of the city was necessary to prevent disease and sickness (Chocat et al., 2001). Following the French Revolution, political pressure to treat all citizens equally lead to a decision to provide stormwater and wastewater control for all people (Chocat et al., 2001). As a result, all wastewater was directed to a communal sewer system, which consisted of curbs and gutters (eliminating ditches), paved sidewalks, catchbasins and storm sewers.

The development of the rational method by Mulvany in the 1850s (Ireland, 1851 in Chocat et al., 2001) allowed for the proper sizing of drainage pipes based on empirical design methods for the conversion of rainfall into run-off. This allowed for the design of drainage pipes to convey stormwater and other wastewater to areas outside of the urban environment as quickly as possible (Ristenpart, 1999). The Rational method dominated engineering drainage practice until the late 1960s, which saw the development of hydrographs, stormwater models and the use of computers to predict run-off and design sewer networks.

This approach was very efficient at collecting and transporting run-off during smaller storms. When the public complained about localized flooding, usually during snowmelts or large storms, the solution was to install another catchbasin (MNR et al., 1987b). As a result, too much stormwater entered the storm sewers causing them to surcharge, which often resulted in basement flooding where foundation drains were connected to the storm sewers (MNR et al., 1987b). In addition, these "efficient" storm sewer systems combined with urban development lead to severe downstream problems (i.e. flooding, erosion, pollution) associated with increased run-off and peak discharges of stormwater.

C.2.2 Stormwater Detention Approach (1970s to early 1980s)

In the early 1970s, the realization that upstream development had downstream impacts led to a shift in the approach to managing urban stormwater (Stephens, 1999). Due to the construction of large impervious surfaces within urban areas, which decreased infiltration and groundwater recharge and increased the volume and peak discharges of stormwater to receiving watercourses, severe flooding and transport of pollutants to downstream areas lead to increased flood damage and degradation of receiving watercourses (Niemczynowicz, 1999). According to Delleur (1982), peak surface run-off rates from an area with a population density of 13,000 people per mile2 is 10 times greater than that in an area with only 100 people per mile2. The realization that urban development, in particular the traditional approach of stormwater conveyance, was causing these problems lead to a philosophical change from the removal of urban stormwater to the control and management of stormwater run-off.

In order to control this increased run-off, engineers designed detention ponds, underground storage tanks and settling ponds to control the amount and rate of run-off discharging from new subdivisions to receiving watercourses. Therefore, rather than removing stormwater as quickly as possible, controlling post-development run-off to pre-development levels minimizes downstream flooding and other negative impacts on receiving watercourses. The principal of a zero increase in run-off following development still remains a key SWM objective today.

This responsibility falls on the developers who are accountable for the increased run-off and potential deterioration of water quality resulting from development (Korsiak and Mulamootil, 1986). In doing so causes the "internalization of externalities", whereby those who alter the natural water cycle are forced to account for the consequences of their actions and prevent negative impacts (McBean et al., 1985 in Korsiak and Mulamootil, 1986).

However, in the mid 1960s and early 1970s, there was a mounting concern over the quality of the stormwater entering receiving watercourses (Smith et al., 1993). Consequently, the US Environmental Protection Agency (USEPA), under Section 208 of the Clean Water Act, required major municipalities to develop non-point source pollution control plans for run-off from their urban areas. While these plans were never established, the National Urban Run-off Program (NURP) that was created by USEPA to support these studies resulted in the collection of a large body of data on the quality of urban run-off (Roesner, 1997). This signified the beginning of another change in the philosophical approach to SWM.

C.2.3 Stormwater Retention Approach (early 1980s to mid 1980s)

During the early 1980s, Florida, Maryland, and Delaware implemented regulatory requirements for the treatment of stormwater run-off (Roesner, 1999). The Denver Urban Drainage and Flood Control District and the City of Seattle also undertook the development of rules and regulations for the control of urban run-off quality.

The new approach to SWM established during this period was to protect the integrity of receiving waters from the impacts of the increased concentration of pollutants found in urban stormwater. The principal types of pollutants found in stormwater include suspended sediments, organic matter, nutrients, metals, pesticides, hydrocarbons, temperature and debris (USEPA, 1993). The removal of these pollutants from stormwater protects the water quality and aquatic ecosystems of receiving watercourses.

The degradation of aquatic ecosystems in urban streams, through declining species diversity and communities composed of more tolerant species, is evidence of the negative impacts of urban development on the natural environment (Schueler, 1987). Therefore, in an attempt to prevent further degradation of these environments, water quality, erosion and sedimentation controls were designed and constructed to remove these contaminants from stormwater. This approach reflects a more holistic view of the potential impacts of stormwater.

The objectives of this new approach were: (1) to minimize and control erosion during construction; (2) to control smaller, more frequent storm events and (3) to use the "treatment train" approach to control urban run-off quality. Erosion rates for construction sites with no erosion control measures are 200 to 400 times higher than the natural erosion rate for rural land use (MNR et al., 1987a). Therefore, erosion is minimized through the use of silt fences and straw bales to filter stormwater, rock check dams to slow the conveyance of run-off, and sediment forebays and detention ponds to allow for sedimentation to occur.

The smaller storm events account for 70 to 85 percent of the precipitation that falls on urban catchments (Roesner, 1997) and constitute the contaminated "first flush" portion of stormwater run-off from urban areas. Therefore, improving the quality of the run-off from the smaller storm events, through the use of wet retention ponds and constructed wetlands, provides a substantial improvement to the overall control of stormwater quality.

Finally, the basis of the treatment train philosophy is that urban run-off water quality is best controlled at or near its source through a series of measures (Roesner, 1997; Niemczynowicz, 1999). The combination of source, lot level, conveyance and end-of-pipe controls is a reliable and cost-effective way to prevent the contamination of stormwater, reduce the amount of stormwater run-off and improve the overall quality of stormwater discharging to receiving waters (Roesner, 1997).

Together, erosion control, "first flush" treatment and the use of the "treatment train" approach prevents the contamination of downstream watercourses as a result of polluted urban run-off. In order to ensure that this water quality control was being implemented, the United States Congress added Section 402(p) to the Clean Water Act in 1987, which required the USEPA to establish regulations to regulate stormwater discharges. Beginning in 1990, Phase 1 of the National Pollutant Discharge Elimination System (NPDES) established regulations that prohibit non-stormwater discharges into the storm sewers (USEPA, 1999). Phase 2 of the NPDES regulations regulates the control of stormwater discharge (USEPA, 1999). However, while these regulations ensure the protection of water quality in downstream watercourses, the cumulative impacts of urban development on the whole ecosystem are not addressed.

C.2.4 Ecosystem Approach (late 1980s to mid 1990s)

Originally coined by A.G. Tansley in 1935, an "ecosystem" is defined as a system whereby all of the organisms in a given area interact with the physical environment so that a flow of energy leads to an exchange of materials between its living and non-living parts (Johnston et al., 1994). The organisms within an ecosystem (plants, animals, and humans) interact with each other and the environment (land, water, and air) in which they exist, creating a system of complex interconnections that are essential to maintain ecosystem integrity. Therefore, these interconnections must be protected in order to maintain the integrity of the ecosystem (Kay and Schneider, 1994). If an ecosystem has integrity, it has the ability to maintain normal operations under normal environmental conditions and to recover from anthropogenic stresses (i.e. urbanization) placed on its components (Bocking, 1994). In this case, the boundaries of a subwatershed are used to define the limits of the ecosystem.

The adoption of the ecosystem approach to SWM signifies the fourth major philosophical change in the approach to SWM, which provides an opportunity to implement sustainable resource development (Smith et al., 1993). In addition to water quantity and quality control, additional issues relating to groundwater recharge, terrestrial and aquatic habitat, maintaining baseflow, maintaining natural stream morphology, monitoring and wetlands are addressed (Mather, 1991; MOE, 1993b). These multiple objectives represent a more complex and interrelated approach to the control of stormwater.

While increased impervious area in the watershed, removal of trees and vegetation and soil compaction increases the quantity and velocity of urban stormwater, it also decreases infiltration of stormwater to groundwater (USEPA, 1993). In turn, this lowers the groundwater table and decreases the groundwater portion of the baseflow to wetlands and watercourses, especially during the summer months. Therefore, the use of infiltration trenches, constructed wetlands, grassed swales, porous pavement, and the discharge of roof drainage to rear yards promotes infiltration in an attempt to maintain baseflows (Pitt et al., 1999).

However, infiltration of contaminated stormwater can negatively impact on the quality of groundwater, which is of concern to public safety if groundwater is the source of municipal drinking water. Therefore, infiltration practices must be carefully designed using sufficient site specific information (soil characteristics) to protect groundwater resources and to achieve the desired water quality improvements objectives (Pitt et al., 1999). Infiltration of stormwater with potentially high concentrations of pollutants requires either adequate pre-treatment (sedimentation) to remove some of the pollutants, or the diversion of this stormwater away from infiltrative SWM practices.

Another example of the complexity of SWM deals with the basic objective of controlling stormwater quantity to prevent flooding. By detaining and prolonging the release of stormwater discharge, which increases the frequency and duration of bankfull flows, downstream erosion problems were created (USEPA, 1999). Therefore, to protect the natural stream morphology of the receiving watercourses, the discharge of stormwater must be designed and managed such that these problems are not aggravated.

In addition, requiring water quantity control to pre-development levels in all situations was found to be effective locally but not effective on a watershed basis (TRCA, 1989 in P’ng, 1992,). Controlling the discharge of stormwater through detention measures, which delays and prolongs peak discharges, may result in these peak discharges coinciding with the peak flows in receiving watercourses, thereby increasing potential flood elevations (Faulkner, 1999). Therefore, water quantity, as well as all other objectives, should be set on a subwatershed basis to avoid such problems and the use of blanket policy statements that apply to all situations should be avoided.

An action or change in one location within a subwatershed has potential implications to many other natural features and processes that are linked by the movement of surface and ground water (MOE and MNR, 1993b). Therefore, implementing the ecosystem approach to SWM involves determining how these components are linked and how they are impacted by human influences in order to determine methods of ensuring that all components and interconnections within the ecosystem (subwatershed) are protected.

With the increased complexity and requirements for the control of multiple objectives, the costs associated with designing, constructing and maintaining these SWM practices in perpetuity have also increased. These increasing costs pose one of the major impediments to the effective implementation of SWM (Finnemore, 1982; Yeager, 1988; Andoh and Declerck, 1997,; Scheckenberger and Guther, 1998; USEPA, 1999; Kok et al., 2000). According to Niemczynowicz (1999), technical problems can be overcome, but in most cases the financial and social constraints will influence the selection of SWM practices. While not a new concept, the increasing costs associated with SWM have lead to the most recent philosophical change in the approach to SWM.

C.2.5 Integrated Approach (mid 1990s to present)

The concept of sustainability has become the main driving force for protecting or improving the natural environment. The need to address the sustainability of SWM has lead to the establishment of an integrated approach, whereby stormwater is treated as part of a larger interrelated system of water management. Treating stormwater as part of the total urban water cycle requires the integration of numerous concerns and disciplines, co-ordination among participants, public support and a shift in the perception of stormwater. This is similar to the reduce-reuse-recycle concept implemented in waste management streams, where the focus is not solely on the treatment of stormwater but rather in reducing the quantity and contaminant loads in run-off and reusing stormwater as a resource, thereby minimizing the amount of stormwater requiring quantity and quality controls.

This concept is best illustrated through the Low Impact Development (LID) approach to SWM, which attempts to mimic the predevelopment site hydrology by using site design techniques that store, infiltrate, evaporate, and detain runoff (Prince George's County, 1999). Use of these techniques helps to reduce off-site runoff and ensure that adequate groundwater recharge occurs to minimize post-development drainage, thereby reducing the quantity of required treatment. LID is seen as an advancement in the implementation of SWM that enhances the ability to protect surface and ground water quality, maintain the integrity of aquatic living resources and ecosystems, and preserve the physical integrity of receiving streams (Prince George's County, 1999).

The main goals and principles of LID include:

- improved technology for environmental protection of receiving waters;
- economic incentives that encourage environmentally sensitive development
- develop the full potential of environmentally sensitive site planning and design;
- encourage public education and participation in environmental protection;
- build communities based on environmental stewardship;
- reduce construction and maintenance costs of the stormwater infrastructure;
- introduce new concepts, technologies, and objectives for SWM (i.e. multifunctional landscape features (bioretention areas, swales);
- mimic or replicate hydrologic functions and maintain the ecological/biological integrity of receiving streams;
- encourage flexibility in regulations that allows innovative engineering and site planning to promote smart growth principles; and
- encourage debate on the economic, environmental, and technical viability and applicability of current stormwater practices and alternative approaches (Prince George's County, 1999).

LID is a comprehensive technology-based approach to managing urban stormwater. Stormwater is managed in small, cost-effective landscape features located on each lot rather than being conveyed and managed in large, costly pond facilities located at the bottom of drainage areas. This focus on source controls over end of pipe solutions is quite different from earlier approaches to SWM. Hydrologic functions, such as infiltration, frequency and volume of discharges, and groundwater recharge can be maintained with the use of reduced impervious surfaces, functional grading, open channel sections, disconnection of hydrologic flowpaths, and the use of bioretention/filtration landscape areas.

The integrated approach to SWM requires a paradigm shift in the perception of stormwater as a resource that functions and is utilized as part of the total water cycle, rather than as a nuisance (Roesner, 1999). While this perception has not yet become commonplace among all practitioners of SWM, treating stormwater as a resource to enhance the quality of life of a community will improve the integration of SWM into other aspects of the total urban water cycle. Examples include harvesting nutrients from stormwater as a resource for agriculture (Chocat et al., 1999; Niemczynowicz, 1999) or utilizing run-off from rooftops and other relatively clean surfaces for non-drinking water uses or to replenish depleted aquifers (Niemczynowicz, 1999).

Integrating SWM facilities into green spaces, or designing them with recreational and aesthetic values in mind, provides a means to treat stormwater while improving the quality of life for the people using these facilities (Roesner, 1999). Aesthetic value can also be added to highly developed areas by incorporating a water features that use and treat stormwater run-off from surrounding buildings and streets (Roesner, 1999).

C.3 EVOLUTION OF STORMWATER MANAGEMENT - ONTARIO

Mirroring the broader-scale evolution in SWM philosophy and implementation over the past few decades, the practice of SWM in the Province of Ontario responded to the realization that without effective intervention, the environment would continue to be unduly degraded in part as a result of urbanization. **Table C2** provides a timeline that outlines the key components of the evolution of SWM in Ontario with additional discussion on the chronology contained in following sections.

Table C2 Evolution of Stormwater Management in Ontario

Year	Policy, Program and Guidelines
1970	
	Canada Ontario Agreement on Great Lakes Water Quality (Canada & Ontario, 1971)*
	Canada - United States Agreement on Water Quality (Canada & USA, 1972)
	International Joint Commission Urban Drainage Subcommittee (IJC, 1972)
1975	
	Urban Drainage Policy Committee (COA, 1977)
1980	Urban Drainage Policy Implementation Committee (MOE, MNR, Conservation Ontario, etc., 1980)
1985	Urban Drainage Management Program (UDPIC, 1985)
	Guidelines on Erosion and Sediment Control for Urban Construction Sites (MNR *et al.*, 1987)
	Urban Drainage Design Guidelines (MNR *et al.*, 1987)
1990	
	Stormwater Quality Best Management Practices Manual (MOE, 1991)
	Interim Stormwater Quality Control Guidelines for New Development (MOE & MNR, 1991)
	Urban Drainage Program (Environment Canada, 1991)
	Stormwater Management Practices Planning and Design Manual (MOE, 1994)
1995	SWAMP Program (MOE, TRCA, etc., 1995 to 2003)
	Provincial Policy Statement (MMAH, 1997)
2000	
	Stormwater Pollution Prevention Handbook (MOE & TRCA, 2001)
	Stormwater Management Practices Planning and Design Manual (MOE, 2003b)
2005	Provincial Policy Statement (MMAH, 2005)
	Guidelines on Erosion and Sediment Control for Urban Construction Sites (GTA CAs, 2006)

* Revised in 1976, 1982, 1986, 1991, 1994, 2002

C.3.1 Early Provincial, Federal and International Commitments

During the mid 1970s, research on pollution from urban drainage sources was conducted through the Canada-Ontario Agreement on Great Lakes Water Quality (COA) (1971) and the Canada-United Stated Agreement on Water Quality (1972) (P'ng, 1992). In 1972, the International Joint Commission (IJC) established the Urban Drainage Subcommittee under the COA to address downstream pollution and erosion problems stemming from combined sewer overflows (CSOs) and urban run-off (Mills, 1978). This agreement has continued to date through subsequent signings of the COA in 1976, 1982, and 1986, 1991, 1994, 2002, and 2007.

By the late 1970s, practitioners began to realize the need for a change in attitude and the creation of SWM guidelines and criteria to guide this new approach to urban drainage (Perks and Wisner, 1978). In 1977, the Urban Drainage Policy Committee was formed through the COA to consolidate current research and development findings to establish comprehensive "model" SWM policies for pollution abatement and relief from flooding in urban areas (P'ng, 1992). Their recommended approach was described and outlined in five recommendations, all of which remain applicable today, as follows:

1. Municipalities and Conservation Authorities should develop Master Drainage Plans for all watersheds within their boundaries;
2. Municipalities should formulate and implement a comprehensive pollution control strategy that addresses both wet and dry weather pollution sources;
3. Drainage systems in all new developments should be designed using the major-minor concept, which recognizes the need to minimize property damage and loss of life during major storm events and to provide conveyance during minor storm events;
4. Proponents of new urban development should indicate the effects of the development on the watershed and carry out mitigative measures as required (i.e. control post-development flows to pre-development levels); and
5. Proponents of new urban development should plan for and carry out an erosion and sediment control program during all phases of development. (P'ng, 1992; Weatherbe, 1997).

In 1980, the MOE, MNR, MMA, Municipal Engineers Association and Conservation Ontario established the Urban Drainage Policy Implementation Committee to provide recommendations on the use of the COA model SWM policies (P'ng, 1992). They concluded that the "model" policies noted above were appropriate for Ontario, that adequate legislation existed to support these policies and that administrative procedures were available to implement them (P'ng, 1992).

C.3.2 Urban Drainage Management Program (1985)

In 1985, the Urban Drainage Policy Implementation Committee established a more pro-active planning approach to SWM entitled the Urban Drainage Management Program (UDMP). This program was meant to guide the implementation of a more preventative and less expensive SWM program through consideration of various control options, municipal budget constraints, time frames and pollution reduction targets (Kok et al., 2000).

The eight objectives of this program were to:

1. prevent loss of life and minimize property damage and health hazards;
2. minimize inconvenience from surface ponding and flooding;
3. minimize adverse impact on the local groundwater systems and baseflows in receiving watercourses;
4. minimize downstream flooding and erosion;
5. minimize pollution discharges to watercourses;
6. minimize soil losses and sediments to sewer systems and water bodies from construction activity;
7. minimize impairment of aquatic life and habitat; and
8. promote orderly development in a cost-effective manner (MNR et *al*., 1987b).

While municipalities had expressed a very strong desire to implement SWM (Korsiak and Mulamootil, 1986), they also expressed a very strong demand for SWM guidelines (Perks and Wisner, 1978; Korsiak and Mulamootil, 1986; Mulamootil et al., 1995). Following from the Urban Drainage Management Program, the participants combined their efforts to produce the *Guidelines on Erosion and Sediment Control for Urban Construction Sites* (MNR et al., 1987a) and the *Urban Drainage Design Guidelines* (MNR et al., 1987b), which outlined the specific measures by which the new method of SWM should be implemented.

The UDMP signified a shift towards incorporating planning as an integral part of SWM, whereby it proposed the use of the following three different levels of planning: (1) watershed level; (2) subwatershed level and (3) draft plan of subdivision level (MNR et al., 1987b; P'ng, 1992).

Watershed level planning, generally undertaken by Conservation Authorities, involves identifying floodplain areas, areas susceptible to erosion or bank instability, and the effects of urbanization and SWM measures on water quantity and quality across the watershed (MNR et al., 1987b).

Representing a more detailed assessment of the local ecosystem, subwatershed plans recommend how water resources and related resource features are protected and enhanced to coincide with existing and changing land uses. As well, other major uses of water, outside the municipal planning process, need to be factored into land use decisions. These uses include withdrawals, channel alterations, diversions, etc., that are carried out under various pieces of legislation and the federal Fisheries Act. Briefly, subwatershed plans allow water-related environmental objectives and targets to be set at a time when they can be effectively incorporated into land use planning documents.

Master Drainage Plans (MDPs) identify the drainage requirements and stormwater measures needed to develop a specific area and to indicate the approximate sizes and locations of SWM ponds, channels and other SWM measures (MNR et al., 1987b). In that they are developed largely in support of large-scale development strategies, MDPs are not necessarily constrained to the boundaries of a drainage shed, but tend to reflect jurisdictional or development proposal limits.

Finally, the subdivision level of planning involves designing the major and minor conveyance systems and SWM facilities to satisfy the constraints and requirements of the Master Drainage Plan (MNR et al., 1987b). Together, the goal of this multi-level process was to avoid costly on-site detention facilities within each new development and to implement SWM controls to address specific downstream constraints.

The primary focus of the UDMP remained on stormwater quantity control to prevent flooding, although some emphasis was added on the control of erosion and sediment during construction (Kok et al., 2000). It also recognized that some emphasis should be placed on improving the quality of stormwater run-off, although there was little experience with the planning, selection, design and monitoring of stormwater quality controls. While the *Urban Drainage Design Guidelines (1987)* identified the need to protect downstream water uses, including recreation, water consumption, flood storage and fish habitat through SWM, the primary focus was on addressing quantity concerns (P’ng, 1992; Kok et al., 1999).

Therefore, in order to address concerns regarding the quality of stormwater run-off and its impacts on downstream watercourses, the MOE prepared the *Stormwater Quality Best Management Practices Manual* (MOE and MNR, 1991a). This document follows from the UDMP with respect to the various levels of planning required to implement SWM and provides a process and context for the selection, design, costs and maintenance of various stormwater quality measures. As well, the MOE and MNR prepared the *Interim Stormwater Quality Control Guidelines for New Development* (MOE and MNR, 1991b) to provide guidance for the planning of stormwater quality control, which became a requirement for incorporation into all new urban developments.

C.3.3 Urban Drainage Program (1991)

In order to identify, research, develop and improve these best management practices for quantity and quality control, Environment Canada, in partnership with various provincial ministries and other agencies, established the Urban Drainage Program in 1991. This program was created as part of the Municipal Wastewater Program of the Great Lakes 2000 Cleanup Fund to help Great Lake communities achieve their pollution reduction goals at a reasonable cost. Its aim was to promote the development of new technologies, planning strategies and management tools to ensure effective and efficient use and adoption of SWM by municipalities (Kok et al., 2000). This program was instrumental in advancing the state of the art of SWM in Ontario (Kok et al., 2000).

Through funding partially provided by the Great Lakes 2002 Cleanup Fund, research into the development and monitoring of new technologies and case studies on the effectiveness of individual SWMPs has continued. For example, the Stormwater Assessment, Monitoring and Performance (SWAMP) Program was established in 1995 to evaluate SWM technology performance according to design and compliance parameters and to disseminate study results and recommendations within the stormwater management industry (SWAMP, 1999). This program is a co-operative initiative of agencies interested in monitoring and evaluating the performance of various SWM technologies. The SWAMP Program allowed federal, provincial, municipal and other agencies or groups to pool their resources (i.e. finances, expertise) in support of shared research interests in SWM planning and long-term monitoring of stormwater quality practices (Kok et al., 2000).

C.3.4 SWM Practices Planning and Design Manual (1994)

In the meantime, the MOE, in consultation with various other ministries and agencies, produced the *Stormwater Management Practices Planning and Design Manual* (MOE, 1994). Originally conceived as a technical manual to provide guidance and criteria for the design of structural and vegetative SWM practices, the scope of this manual was expanded in recognition of the importance of watershed and subwatershed planning and the use of an integrated and ecosystem approach to SWM (P'ng, 1992; MOE, 1994). As a result, this manual not only provides detailed design calculations, maintenance specifications, operation and maintenance costs and review checklists for various lot level, conveyance and end-of-pipe controls, it also incorporates the selection of these practices into a more holistic strategy for the planning and design of the new subdivisions. It became the industry standard for the design, review and approval of stormwater quality and quantity control in Ontario.

The most progressive aspect of this manual was not that it recommended the implementation of specific practices but that it recognized and assisted in the continued evolution of SWM. It recognized the need to adapt the selection and design of SWM controls to site-specific conditions within each individual development as the conditions or characteristics of a site should govern over the guidance provided in the manual (MOE, 1994). It also recognized that innovation and research into developing new technologies should not be stifled by a strict adherence to the guidelines provided in the manual (MOE, 1994). The manual was not intended as a rulebook that states how SWM should be practiced, but rather it provided recommendations for the selection of control measures that past experience has proven effective in certain situations.

C.3.5 Provincial Policy Statement (1997)

In 1997, the Province of Ontario created the *Provincial Policy Statement* (PPS), which required new developments to protect and enhance the quality and quantity of surface water will be. The quality and quantity of water is measured by indicators such as minimum baseflow, oxygen levels, suspended solids, temperature, bacteria, nutrients, hazardous contaminants and hydrologic regime (MMAH, 1997). This policy entrenched the requirement for SWM into the planning process, whereby all decisions regarding the approval of new developments was required to have regard to the PPS.

C.3.6 New Environmental Technology Evaluation (2000)

With the evolution of SWM, the MOE recognized that new technologies not discussed in the existing manuals would be developed. As such, the MOE initiated a program called the New Environmental Technology Evaluation (NETE) program to evaluate and assess new environmental technologies by reviewing the information and data submitted by applicants, conducting relevant literature searches on similar technologies and utilizing relevant engineering and technical knowledge/expertise of reviewing engineers and/or scientists.

Following the assessment, a NETE “Opinion Letter of Technology Assessment” or a “Certificate of Technology Assessment” is issued to the applicant commenting on the technical merits of the technology, its potential to meet jurisdictional environmental standards and potential areas of application.

C.3.7 Stormwater Pollution Prevention Handbook (2001)

While the requirement to control and management stormwater remains a priority, the recognition that efficiencies could be achieved and retrofit opportunities enhanced through a preventative approach to SWM was reflected in the *Stormwater Pollution Prevention Handbook* (MOE and TRCA, 2001). This guideline document identifies recommendations, tools and resources for the establishment of pollution prevention plans through the use of watershed planning, sewer use by-laws, and education to minimize potential sources of contamination, as well as successful examples of where such programs have been implemented.

C.3.8 SWM Practices Planning and Design Manual (2003)

Many SWM advancements, policy amendments and regulatory changes occurred during the late 1990's and early 2000's. In order to incorporate such advancements, the MOE revised the *Stormwater Management Practices Planning and Design Manual* in 2003. While the intent and guidance provided by this document remained relatively consistent, with the promotion of an integrated, treatment train approach to SWM, the most significant changes to this document included the following:

1. recognition of in-stream erosion control and water balance objectives;
2. inclusion of approaches to designing end-of-pipe facilities that prevent undesirable geomorphic changes;
3. inclusion of measures to protect groundwater and baseflow characteristics; and
4. incorporation of better site design techniques, with some emphasis placed on low-impact development strategies.

This document remains the current standard for the design, review and approval of SWM plans and practices in the Province of Ontario, which provides a more integrated approach to SWM. In recognition of comments received regarding the original 1994 SWM Manual, design examples to show the level of detail required in stormwater design submissions and supporting documents for applications to approval agencies have been provided as an Appendix to the 2003 report.

C.3.9 Provincial Policy Statement (2005)

A five year review of the PPS was undertaken by the MMAH to determine whether changes to the PPS were warranted. Stakeholders indicated that the section pertaining to the protection of water did not provide sufficient detail, direction, or the priority it deserved (MMAH, 2002). As a result, the water section of the PPS was expanded to incorporate concerns for the protection of surface water quality, wellhead protection areas, permeability and surface run-off resulting from development, watershed planning, cumulative impacts and to recognize that water is a key linkage for the protection of wetlands and other natural features (MMAH, 2002).

Section 2.2 of the PPS now includes requirements for planning authorities to protect, improve and restore the quality and quantity of water through the use of the watershed approach, identifying and protecting surface water features and hydrologic functions, and ensuring SWM practices minimize stormwater volumes and contaminant loads and maintain or increase the extent of vegetative and pervious surfaces (MMAH, 2005). This policy entrenches the need to consider quantity and quality control, maintaining a water balance, and protecting downstream areas through the use of SWM practices as part of the planning process.

C.3.10 Sustainable Technologies Evaluation Program (STEP)

The Sustainable Technologies Evaluation Program (STEP) is a multi-agency program, led by the Toronto and Region Conservation Authority (TRCA), which was developed to provide the data and analytical tools necessary to support broader implementation of sustainable technologies and practices within a Canadian context.

Its main objectives are to:

- monitor and evaluate clean water and clean air technologies;
- develop strategies to overcome implementation barriers;
- develop tools, guidelines and policies; and
- promote broader use of effective technologies through research, education and advocacy

Technologies evaluated under STEP are not limited to physical structures, but rather include preventative measures, implementation protocols, alternative urban site designs, and other innovative practices that help create more sustainable and liveable communities. The mandate and organizational structure for the water component builds upon experiences from the SWAMP program and feedback from various agency and industry representatives.

A number of projects for which research is currently being conducted, or for which guidelines and examples have been provided, include green roofs, permeable pavement, rainwater harvesting, erosion and sediment control ponds, bioretention systems, roof runoff infiltration and exfiltration systems.

The STEP program website (www.sustainabletechnologies.ca) contains a variety of downloadable resources pertaining to research, conceptual technologies and example policies and guidelines. A list of additional policies and guidelines not included in this report, as available through the Step Program website, is provided in **Appendix A**.

C.3.11 MTO Policy Directive B-014 (2007)

This document, dealing with the MTO's drainage management policy and practice, became effective on August 23, 2007 (replacing Directive B-237) in order:

1. To state Ministry policy on drainage management practice in planning and design for provincial highways.
2. To state Ministry policy concerning drainage management for development areas that may have drainage impacts on provincial highways.
3. To provide direction to consultants undertaking planning and design of drainage management for Ministry projects, and projects requiring approval or endorsement by the Ministry.

To achieve the purpose(s) of this directive, the directive is divided into five Policy Areas that outline Ministry policies in five areas of Ministry interest. The Policy Areas are:

1. Drainage of Ministry Owned Lands;
2. Drainage of Lands Owned by Others;
3. Planned Shared Use of a Drainage System;
4. Ministry Involvement in Watershed Planning; and
5. Ministry Involvement in Municipal Planning.

The directive presents a number of principles respecting the fundamental purposes of highway right-of-way and the Ministry's approach for drainage systems be they owned by the Ministry or by others. Key aspects of the Directive as they pertain to the ABCA's Policies include:

- The Ministry endorses the use of the watershed planning process to achieve coordinated and comprehensive planning for good drainage management.
- The Ministry involvement in developing Watershed Planning Documents includes the participation, possible financial contribution and endorsement.
- The Ministry involvement with existing Watershed Planning Documents consists of the review and endorsement of these documents.
- Official plans and secondary plans are reviewed to ensure the Ministry's interests are protected.
- Plans of subdivision and site plans should be circulated to the Ministry if within the area of control of a provincial highway before the issuance of permits under the Public Transportation and Highway Improvement Act can take place.

Involvement in Plans of Subdivision and Site Plans

1. For land development within the Ministry Permit Control Areas, any Ministry concern regarding drainage should be identified at the Plan of Subdivision or Site Plan review stage and a request should be made to the plan approval agency that a satisfactory stormwater management plan be required as a condition of approval.
2. For land development outside of the Ministry Permit Control Areas, the Ministry expects the municipality to ensure that any and all drainage plans it approves do not adversely impact highway drainage systems in accordance with drainage common law. Should the municipality chose to circulate stormwater management plans to the Ministry, the Ministry will review and comment on these plans.

C.4 IMPLEMENTATION OF SWM IN ONTARIO

The process by which SWM criteria and controls are identified, selected, constructed and maintained, and the extent to which various stakeholders are involved, has a direct impact on the effectiveness and efficiency of SWM implementation. This objective of this section is to provide some clear and consistent understanding of the implementation process within the Province and the ABCA watershed, and the various roles and responsibilities of each stakeholder.

C.4.1 SWM Planning Process

Subdivision planning should not be undertaken independently of SWM, nor should each subdivision necessarily have its own SWM facility. While the planning process provides the vehicle by which site specific SWM control measures are implemented, the selection of these controls should be guided by and integrated into a larger scale plan.

Therefore, in Ontario, the planning and implementation of SWM occurs at three different spatial scales:

a. subwatershed;
b. subdivision / site plan; and
c. SWM plan.

C.4.1.1 Subwatershed Planning and Master Drainage Plans

In the early 1980s, Master Drainage Plans (MDPs) were promoted and recognized as the preferred mechanism for the planning and design of urban drainage systems. As a result of increased environmental awareness and pressure from the public, objectives of these plans shifted from addressing water quantity concerns (flooding, conveyance) to maintaining and enhancing the natural systems within developing watersheds (Mather, 1991). From the mid- to late 1980s, this shift in objectives resulted in an increase in the number of issues addressed in MDPs, including erosion and sediment control, water quality, habitat, baseflow, monitoring, wetlands and groundwater (Mather, 1991), reflecting the change in the approach to SWM to the more ecosystem-based approach.

By the early 1990s, a subwatershed approach to planning was being promoted through the preparation of Subwatershed Studies (SWSs) (MOE and MNR, 1993b). Similar to MDPs, these plans provide a mechanism to address and minimize the cumulative impacts of new development on a watershed scale, thereby implementing an ecosystem approach to environmental management.

Subwatershed Plans set water-related environmental objectives and targets to be incorporated into land use planning documents such as Official Plan, SWM Plans and Environmental Impact Studies (MOE and MNR, 1993b). With this information, Subwatershed Plans can provide information and practical recommendations on boundaries, links to other planning tools, management objectives and methods for implementation, which in turn should expedite the subdivision approval process by identifying the specific design criteria.

C.4.1.2 Subdivision / Site Plan Approval Process

The process of subdividing land into separate lots or blocks is governed by Section 51 of the *Planning Act*. In order to obtain approval from the approval authority, the design and layout of a new subdivision must comply with existing legislation, policies and municipal by-laws and must avoid or minimize the potential negative impacts of development on the existing economic, social and natural environments.

In support of a proposed development, the applicant is required to submit sufficient information to demonstrate that the proposed development will not negatively impact the downstream environment, such as SWM reports and Environmental Impact Studies. This information is reviewed by the approval authority and various agencies to ensure the science is sound, the plans are complete and the proposal complies with applicable policies and guidelines.

In regards to the subdivision approval process, draft plan approval is often granted where the information demonstrates that the conceptual design and potential impacts of the development can be addressed, with final details, such as plans for erosion control, site restoration and buffer enhancement, to be designed and submitted as conditions of approval.

In the case of stormwater run-off, the quantity and quality of post-development run-off should be controlled to pre-development levels, or better, in order to minimise negative impacts on receiving waters (i.e. watercourses, wetlands). This process establishes the criteria, polices and guidelines to be used to select and design the appropriate controls through the preparation of a SWM Report and associated plan.

C.4.1.3 Stormwater Management Plans and Reports

The final level used to plan and implement SWM is at the site specific or local scale, whereby SWM Plans and Reports are prepared for individual subdivisions. These plans and reports identify and describe the specific SWM practices within a subdivision that will be used to control stormwater run-off and protect downstream watercourses.

Stormwater management reports and plans outline the process, alternatives and rationale for selecting specific SWM controls for a site, which should comply with the corresponding requirements and guidelines for the planning area. These reports are intended to:

- describe how the pre-development discharge of water during flood conditions will be maintained;
- assess potential impacts on the receiving water due to erosion, groundwater infiltration and water levels;
- provide the design scheme for the SWM system for the proposed development; and
- describe how the mitigation measures will prevent any water pollution likely to result from development.

Addressing stormwater concerns through MDPs and SWSs allows for the implementation of a large-scale, watershed or ecosystem-based approach to SWM. Within the subdivision approval process, SWM plans and reports allow for the mitigation of specific stormwater impacts on a local scale and minimise potential impacts on downstream areas. Together, these different planning levels provide the necessary tools to mitigate local-scale impacts and achieve watershed-scale goals and objectives.

C.4.2 Recommended SWM Practices in Ontario

A wide range of SWM practices is available to control stormwater run-off from urban areas, as outlined in the various guideline documents described in Section 3. **Table C2** provides a summary of the recommended SWM control measures from the various provincial and municipal guideline documents.

As the goals and objectives of the approval authorities change over time, so to do the recommended practices. Over time, new technologies emerge as a result of research initiatives, experiments and pilot projects. The need for innovative designers to develop better designs must be recognized and reviewing agencies should encourage innovation by showing flexibility in applying agency criteria (MOE, 2003b).

Table C3 Recommended Stormwater Management Practices in Ontario

SWM Control Measures / Practices	*Guidelines on Erosion and Sediment Control* MNR et al. (1987a)	*Urban Drainage Design Guidelines* MNR et al. (1987b)	*Stormwater Quality Best Management Practices* MOE, MNR (1991a)	*Interim Stormwater Quality Guidelines* MOE, MNR (1991b)	*SWM Practices Planning and Design Manual* MOE (1994)	*SWM Practices Planning and Design Manual* MOE (2003)
Water Quantity Controls						
rooftop storage		x		x	x	x
parking lot storage		x		x		x
park storage		x		x		
sump pump to storm sewers					x	x
reduced lot grading						x
pipe storage		x		x	x	x
tile drains		x			x	x
underground storage tanks			x			
orifices			x		x	x
flow deflector / splitter					x	x
baffles					x	x
dry ponds		x	x	x	x	x
outlet channel	x				x	x
rooftop gardens						x
Water Quality Controls						
oil/grit separators			x		x	x
UV disinfection			x			
Erosion & Sediment Control						
strawbale filters	x			x		
silt fences	x					
sod filter				x		
brush barriers	x			x		
seeding topsoil stockpiles	x			x		
filter cloths	x	x			x	x
mulching or sodding	x			x		
aggregate cover	x			x		
chemical stabilisation	x					
catchbasins		x	x	x		x
sediment traps	x	x		x		
rip-rap	x	x	x	x	x	x
gabian baskets		x		x		
wetponds		x	x	x	x	x
sediment forebays		x			x	x
Groundwater Recharge						
seepage trenches		x	x	x		x
soak away pits		x		x	x	x
rear yard ponding					x	x
porous pavement		x	x	x	x	x
pervious pipes		x			x	x
pervious catchbasins					x	x
infiltration trench			x	x	x	x
infiltration basin		x	x	x	x	x
Multiple Functions						
vegetation planting	x	x			x	x
grassed waterways	x					
natural channels		x		x		x
grassed swales		x	x	x	x	x
rock check dams	x			x		x
constructed wetlands			x		x	x
hybrid wet pond / wetland						x
buffer strips	x		x	x	x	x
vegetated filter strips			x	x	x	x
sand filters					x	x

C.4.3 Legislation, Policies, and Guidelines - Roles and Responsibilities

The implementation of SWM involves the participation and coordination of numerous different municipal, provincial and federal agencies with diverse mandates and regulatory roles. These participants in SWM have specific, and occasionally overlapping, mandates towards which their regulatory authorities and, therefore, their comments, concerns and recommendations are aimed. The process of reviewing and approving individual subdivisions and SWM systems by the various participants provides a comprehensive perspective on the control of stormwater run-off.

Various statutes exist providing the legal basis to protect against off-site impacts through the control of stormwater run-off. A summary of the SWM-related aspects of the various statutes, as well as other policy and guideline documents, is included on **Table C4**, with additional agency-specific discussion in the following sections.

A list of available resources, guidelines and other materials to aide in the implementation of SWM is provided at the end of this section. While not exhaustive, this list includes the key relevant documents and websites where information can be disseminated regarding the current state of the practice of SWM.

C.4.3.1 Ministry of the Environment

The Ministry of the Environment (MOE) is responsible for the protection and conservation of Ontario’s air, water and land environments, whereby human health, ecosystems, recreation, commerce and industry are sustained by clean air, water and land. The MOE is actively involved at all stages of SWM implementation, including the preparation of provincial guidelines, the review of SWM Plans and the issuance of Certificates of Approval (C of A) for the construction of storm sewers and SWM facilities.

Section 53 of the Ontario Water Resources Act requires approval through the issuance of a C of A prior to establishing, altering or replacing new or existing sewage works, which included storm sewers and SWM facilities. The purpose of this process is to maximize the resource value and minimize the waste component of stormwater run-off (Thornley, 1999) in order to minimize the impact of discharge on the impairment of water quality in receiving streams. Of note, the Ontario Water Resources Act and the Municipal Act are the only pieces of legislation that recognize stormwater as a type of “sewage”.

Stormwater is not considered “sewage” under the Environmental Protection Act (EPA). However, the MOE may take an enforcement role under Section 6(1) of the EPA, which controls the discharge of contaminants that may impair the natural environment. Section 6(1) of the EPA states that no person shall discharge or permit the discharge into the natural environment of any contaminant in an amount, concentration or level in excess of that prescribed by the regulations.

Table C4 SWM Aspects of Various Legislation and Policies[1]

Lead Agency	Act / Policy	Stormwater Management Issue[2]								
		Flooding	Conveyance	Water Quality[3]	Water Balance	Erosion (Stream and Gully)	Erosion and Sediment Control	Location of SWM within Hazard Lands	Large-Scale Stormwater Planning	Sufficient (Legal) Outlet
DFO	Federal Fisheries Act			x		x	x			
MOE	Ontario Water Resources Act	x	x	x	x					x
	Environmental Protection Act			x						
	Environmental Assessment Act								x	
MNR	Lakes and Rivers Improvement Act		x							
MTO[4]	Policy Directive B-014, Drainage Management Manual		x			x	x		x	x
ABCA	Conservation Authorities Act / Ontario Regulation 147/06[5]	x	x	x	x	x	x	x		
	Shoreline Management Plan					x				
OMAFRA	Drainage Act	x	x							x
MMAH	Municipal Act (creation of by-laws)		x							
	Planning Act / Provincial Policy Statement	x		x	x	x			x	

Acronyms:

DFO – Department of Fisheries and Oceans
MNR – Ontario Ministry of Natural Resources
OMAFRA – Ontario Ministry of Agriculture and Rural Affairs
EC – Environment Canada
MTO - Ontario Ministry of Transportation
MMAH – Ministry of Municipal Affairs and Housing
MOE – Ontario Ministry of the Environment
ABCA – Ausable Bayfield Conservation Authority

Notes:

1. Many Acts exist relating to the management of surface and groundwater resources. This Table focuses on those that may reasonably expect to be relied upon or considered through agency review of land development applications and the associated stormwater management designs within the watershed. The intent is to illustrate the number of agencies and legislation that guide such applications.
2. Stormwater prevention, SWM consultation, and climate change, as a consideration in the implementation of SWM, are not included in any relevant legislation or policies and, as such, are not identified herein.
3. Water quality includes protection against pollutants, contaminants, and deleterious substances, such as sediments, heavy metals, organic pollutants, and temperature impacts
4. MTO is typically only interested in matters pertaining to SWM and drainage applications when their infrastructure has the potential to be impacted by the proposed land use change.
5. Ontario Regulation 147/06 is also known as the *ABCA Development, Interference with Wetlands and Alteration to Shorelines and Waterways Regulation*

C.4.3.2 Conservation Authorities

The mandate for Conservation Authorities involves working with local communities to ensure the conservation, restoration and responsible management of water, land and natural habitats through programs that balance human, environmental and economic needs. They are typically actively involved in SWM in both an advisory and regulatory capacity, with interests in the overall impacts on the watershed and local conditions.

Considered one of the lead SWM implementation agencies in Ontario, Conservation Authorities develop SWM strategies, design and implement retrofit projects, research and monitor SWM Facilities and promote the use of SWM control measures (Walters et al., 1999). They are also involved in the preparation of SWSs and the review of subdivision plans, SWM Plans, Environmental Impact Studies and current provincial policies. Based on this review, comments are provided to municipalities in an advisory capacity with respect to the potential impacts of development on natural heritage features (i.e. wetlands), natural hazards (i.e. flooding, erosion) and surface water quality and quantity.

While the services provided by individual Conservation Authorities vary according to their resources and municipal agreements, all Authorities are actively involved in the review and approval of SWM and erosion and sediment control plans for new developments, in one form or another (Walters et al., 1999).

Pursuant to the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation, which in the case of ABCA is Regulation 147/06, any development within a regulated area or interference with a wetland or watercourse requires the prior issuance of a Permit from the conservation authority. This applies where a SWM facility is proposed within or adjacent to a regulated area (floodplain, wetland, steep slope, watercourse or shoreline. The issuance of a Permit will only be granted where the proposal complies with the conservation authorities policies, examples of which are provided in Section 5.2, and where the proposal will not affect the control of flooding, pollution, dynamic beaches, erosion or conservation of land.

C.4.3.3 Municipalities

In Ontario, municipalities have the main responsibility for the management of urban drainage (Korsiak and Mulamootil, 1986; Price and Tran, 1992). This responsibility stems from their responsibility to ensure the health, safety and welfare of its inhabitants while having regard for relevant social, economic and environmental matters, which is conferred on them by the Planning Act and Municipal Act.

Section 2 of the Planning Act requires that municipalities have regard to matters of provincial interest when making land use planning matters decisions. Guidance in this matter is provided through the identification of their goals, objectives and policies within an Official Plan, in compliance with Section 16 of the Planning Act. Prior to making a decision regarding the appropriateness of a new development, municipalities circulate, review and approve subdivision plans, SWM Plans through the subdivision approval process (as discussed earlier). As a result, the municipal planning and engineering staff are involved in day-to-day SWM implementation.

Section 102 of the Municipal Act provides the ability to pass by-laws or make regulations for the health, safety and welfare of the inhabitants of a municipality. According the Municipal Act, municipalities may pass by-laws prohibiting or regulating discharges into sewers (Section 210(150)) and the establishment of works for the interception and purification of sewage (Section 207(13)), which includes stormwater. As of 2001, over 250 municipalities in Ontario have adopted such by-laws (MOE et al., 2001).

C.4.3.4 Ministry of Municipal Affairs and Housing

The goal of the Ministry of Municipal Affairs and Housing (MMAH) is to achieve strong communities, with dynamic local economies and an attractive quality of life, featuring efficient local governments and a housing market that serves the full range of housing needs of the public and encourages private sector building. In some cases, the MMAH retains the approval authority role over Planning Act decisions and is involved in the circulation of applications and reports for review and comment by the other Provincial Ministries (MOE, MNR) through the One Window approach. In other cases, this responsibility has been delegated to the upper-tier municipality.

C.4.3.5 Department of Fisheries and Oceans

Under Section 35(2) of the Federal Fisheries Act, approval is required from the Department of Fisheries and Oceans (DFO) for the harmful alteration, disruption or destruction (HADD) of fish habitat. Therefore, although DFO is not involved in the day-to-day review and approval of SWM, they can become involved if the proposed SWM facility may impact on fish habitat. They will also become involved if there is a contravention of Section 36(3) and there is a release of a deleterious substance (i.e. sediment) into a watercourse or wetland.

C.4.3.6 Partnerships

Often, these agencies combine their efforts to share their diverse knowledge and ideas. This allows for the establishment of various partnerships and programs aimed at improving the practice of SWM. Such participation and co-ordination occurs through agency involvement in preparing guideline documents, providing technical expertise, hosting conferences, sitting on committees and through the delegation of responsibilities.

While the municipalities are the most well-placed agencies to implement SWM, they are often limited by a lack of funding, resources and technical expertise (Korsiak and Mulamootil, 1985; P’ng, 1992; Mulamootil et al., 1995). Therefore, provincial agencies and conservation authorities provide technical advice pertaining to wetland impacts and a review of SWM Plans for individual subdivisions. Many of these provincial agencies also relieve this impediment by sponsoring training and education programs involving workshops or conferences (P’ng, 1992) or by providing their expertise through their involvement in multi-agency technical and planning committees.

These efforts illustrate the partnerships that exist among the various participants, which are meant to increase awareness, share responsibilities and ensure adequate and equitable implementation of SWM.

The ability of these agencies to participate SWM is directly related to the support provided by the Provincial Government. They provide financial support and legislative controls that allow these agencies to develop and participate in programs, to provide technical expertise and to enforce the protection, conservation and management of the natural environment.

However, providing an adequate and consistent level of support to these agencies has been a problem in recent years. In 1995, the Provincial Government's Common Sense Revolution decreased funding to the MOE, MNR, Conservation Authorities and municipalities, limited the scope and impact of environmental regulations and handed down environmental protection responsibilities to the municipalities and private industries (Clark and Yacoumidis, 2000).

Since 1995, the MOE and MNR budgets have been cut by 60% and 21% respectively (Clark and Yacoumidis, 2000). By 1999, funding for Conservation Authorities was reduced by 70% over the 1995 funding (Clark and Yacoumidis, 2000). This drastic decline in funding has resulted in a loss of staff and a decline in technical support. Conservation Authorities have lost 25 to 50% of their staff over this time (Clark and Yacoumidis, 2000). Combined with this cut in funding, amendments were made to almost every law protecting water resources from pollution and harmful alteration between 1995 and 1997, which allegedly reduced regulatory oversight, permitted more pollution and increased opportunities to alter aquatic habitat (Clark and Yacoumidis, 2000). As a result, the decreased budgets and enforcement tools, combined with the downloading of provincial responsibilities, meant that the various provincial agencies began to withdraw from their day-to-day involvement in SWM review.

While the budget cuts and amendments to the enforcement tools limited the ability of the provincial agencies to add value to the process, the downloading of responsibilities to the municipality has been portrayed as an attempt to streamline the SWM review and approval process. Conflicting requirements or practices from different agencies have been cited as hindrances to the efficiency of the subdivision approval process (Korsiak and Mulamootil, 1985; Mulamootil et al., 1995). Therefore, minimising the number of agencies involved in the approval process and the delays, duplication and conflicting requirements associated with their involvement streamlines the review and approval process (P'ng, 1992).

This streamlining is provided through the delegation of responsibilities to the municipalities or conservation authorities or through deferring review of certain components of SWM to other agencies. For example, the MNR has delegated their review responsibilities to the various conservation authorities, while the MOE has delegated their responsibility for the review of quantity control to various municipalities (i.e. City of London). As a result of these delegations, the level of direct Provincial involvement in the subdivision approval process has declined over the past decade, resulting in the municipalities relying on their own resources, peer review services (i.e. consultants) or input from conservation authorities.

C.5 Selection of Available On-Line SWM Resources

1. Stormwater Management Policies and Guidelines

a) Ontario

City of Hamilton Stormwater Management Master Plan (http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/CapitalPlanning/StrategicPlanning/StrategicEnvironmentalPlanningProjects/GRIDS/Stormwater+Management+Master+Plan.htm)

City of Kitchener Stormwater Management Program (http://www.kitchener.ca/storm_water_mgt.html)

City of Ottawa Stormwater Management Strategy Study Commencement (http://www.ottawa.ca/public_consult/stormwater/index_en.html)

City of Toronto List of CSO/Stormwater Control Alternatives (http://www.toronto.ca/involved/projects/archived/wwfmmp_archive/cso.htm)

Ontario Ministry of Environment Stormwater Pollution Prevention Handbook (http://www.ene.gov.on.ca/envision/water/stormwaterpph.htm)

Ontario Ministry of the Environment Stormwater Management Planning and Design Manual (http://www.ene.gov.on.ca/envision/gp/4329eindex.htm)

Stormwater Management Requirements for Land Development Proposals, Ontario Ministry of Transportation (http://www.mto.gov.on.ca/english/engineering/drainage/stormwater/)

b) Canada

British Columbia Ministry of Environment's Stormwater Management Guide (http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html)

Canada Introductory Manual For Greening Roofs (ftp://ftp.pwgsc.gc.ca/rpstech/Service_Life_Asset_Management/PWGSC_GreeningRoofs_wLinks.pdf)

Canada Mortgage and Housing (Homeowner's Guides): Alternative Stormwater Management Practices for Residential Projects (http://www.cmhc-schl.gc.ca/en/inpr/su/waco/alstmaprrepr/index.cfm)

City of Coquitlam Stormwater Management Policy and Design Manual (http://www.coquitlam.ca/NR/rdonlyres/2D5BEB15-F830-49A0-BC6E-C09F03374665/33844/StormwaterManagementPolicyandDesignManual.pdf)

Halifax Stormwater Management Guidelines (http://www.halifax.ca/environment/documents/HRMStormwaterManagementGuidelines2006.pdf)

c) International

Auckland Regional Council - Stormwater Management Devices: Design Guidelines Manual (http://www.arc.govt.nz/arc/library/y56507_2.pdf)

California - Statewide Stormwater Quality Practice Guidelines, May 2003 ((http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/management_ar_rwp/CTSW-RT-02-009.pdf)

California Stormwater Quality Association (www.cabmphandbooks.com)

CalTrans BMP Retrofit Pilot Program Final Report, January 2004 (http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050.pdf)

CalTrans Comprehensive Monitoring Protocols Guidance Manual, November 2003 (http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/monitoring/CTSW-RT-03-105/CTSW-RT-03-105.pdf)

Canterbury Stormwater Management Manual (http://www.canterbury.nsw.gov.au/resources/documents/stormwaterman1.pdf)

Center for Watershed Protection Stormwater Management (http://www.cwp.org/stormwater_mgt.htm)

Centre for Watershed Protection Stormwater BMP Design for Cold Climates (http://www.cwp.org/cold-climates.htm)

Centre for Watershed Protection: Site Planning for Urban Stream Protection (http://www.cwp.org/SPSP/TOC.htm)

International Stormwater BMP Database (http://www.bmpdatabase.org/)

Iowa Stormwater Management Manual (http://www.ctre.iastate.edu/PUBS/stormwater/index.cfm)

Local Goverment Commission's First Stop Shop for Water Resources: Stormwater Management (http://water.lgc.org/urban-stormwater-management)

Massachusetts Stormwater Technical Handbook (http://www.mass.gov/dep/water/laws/swmpolv2.pdf)

Metropolitan Council Urban Small Sites BMP Manual (http://www.metrocouncil.org/environment/Watershed/BMP/manual.htm)

National Association of Home Builders (www.toolbase.org/index-toolbase.asp)

National NEMO Network (www.nemonet.uconn.edu)

New York State Stormwater Management Design Manual (http://www.dec.ny.gov/chemical/29072.html)

Portland’s Stormwater Management Manual (http://www.portlandonline.com/bes/index.cfm?c=35117)

Stormwater Authority (http://www.stormwaterauthority.org/)

Stormwater Manager’s Resource Center (www.stormwatercenter.net)

Swedish Environmental Technology Network (http://www.swedentech.com/)'

U.S. Environmental Protection Agency (www.epa.gov/owow/nps/urban.html)

U.S. Environmental Protection Agency Urban Stormwater BMP Performance Monitoring (http://www.epa.gov/waterscience/stormwater/monitor.htm)

U.S. Environmental Protection Agency Urban Watershed Management Research (http://www.epa.gov/ednnrmrl/index.htm)

U.S. EPA Sustainable Technologies Division (http://www.epa.gov/nrmrl/std/)

University of New Hampshire Stormwater Centre 2005 Data Report (http://ciceet.unh.edu/news/releases/stormwater_report_05/)

Vermont Stormwater Program (http://www.anr.state.vt.us/dec/waterq/stormwater.htm)

Waterbucket: Rainwater Management (http://www.waterbucket.ca/rm/)

Western Australia, Department of Water, Stormwater Management Manual (http://portal.water.wa.gov.au/portal/page/portal/WaterManagement/Stormwater/StormwaterMgtManual)

Western Washington Stormwater Management Manual (http://www.ecy.wa.gov/programs/wq/stormwater/manual.html)

2. Low Impact Development Resources

Low Impact Development Centre (http://lowimpactdevelopment.org/)

Low-Impact Development Design Strategies: An Integrated Design Approach (Prince George's County, Maryland) ((http://www.epa.gov/nps/lidnatl.pdf)

Low-Impact Development Technical Guidance Manual for Puget Sound (http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf)

Natural Approaches to Stormwater Management, Low Impact Development in Puget Sound (http://www.epa.gov/watertrain/smartgrowth/resources/pdf/lid_natural_approaches.pdf)

Office of Policy Development and Research (http://www.huduser.org/Publications/PDF/practLowImpctDevel.pdf)

Practice of Low Impact Development, U.S. Department of Housing and Urban Development (http://www.huduser.org/Publications/PDF/practLowImpctDevel.pdf)

LID Urban Design Tools (www.lid-stormwater.net)

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APPENDIX D

Conservation Authority and Municipality Questionnaires

Table of Contents – Appendix D

D.1 Conservation Authority and Municipality Questionnaires

A determination of the current status of SWM policy and implementation across the Province and within the watershed was undertaken through the use of questionnaires distributed to various Conservation Authorities (CAs) and all watershed municipalities. The cross-section of Conservation Authorities selected were based on the criteria of proximity to the ABCA watershed and/or those containing areas of substantial urban development.

Copies of the questionnaires sent to the various CAs and municipalities are contained on the following pages, with the results summarized in Appendix D.

AUSABLE BAYFIELD CONSERVATION AUTHORITY
STORMWATER MANAGEMENT POLICIES UPDATE (2007)

CONSERVATION AUTHORITIES QUESTIONNAIRE

The Ausable Bayfield Conservation Authority (ABCA) has retained Stantec Consulting Ltd. to update their Stormwater Management (SWM) Policies document for application across the watershed. The previous version of the Policies was developed by Triton Engineering Services Ltd. in 1994. The current update is being undertaken in recognition of the various evolutions in the SWM field in the intervening period, and the desire of the Authority to stay current. The policy document is intended for use by ABCA staff in reviewing SWM Plans and to provide direction to engineering consultants or other agencies completing and/or reviewing the SWM Plans on behalf of development applications.

This questionnaire is intended to collect information on policies and procedures that exist within other Conservation Authorities. It is generally similar to the 1994 version completed by your Authority in conjunction with the original Policy document, with minor revisions / updates included as applicable. A compilation of policy information from across a range of CAs will aid in the development of policies consistent with other agencies.

You are asked to please fill out the following questionnaire and return it to the address identified on page 4. Please feel free to attach additional comments if insufficient space has been allotted herein. A summary of all CA responses will be created and circulated to those respondents that indicate a desire for such information. Thank you in advance for your time and efforts.

Please check off and provide comments as appropriate.

1. Conservation Authority____

2. Person completing this questionnaire ________________________________

3. Position ____

4. Does your Authority currently review stormwater drainage/management plans and reports?

   ____________ yes   ____________ no

   Is this consistent across your watershed, or variable based on Municipality?

   ____

5. Does your Authority currently have formal stormwater drainage / management policies in place for use in the review of development applications?

   ____________ yes   ____________ no

   If so, when were they created / last updated? ________________________________

   If so, could you please attach a copy with this questionnaire. If the answer is no, skip to question 9.

6. Have you developed these policies jointly with member municipalities?

____________ yes ____________ no

Have you included input from Provincial Ministries?

____________ yes ____________ no

If so, which Ministries? ____

7. Are these policies uniform across the watershed under the jurisdiction of the Authority?

____________ yes ____________ no

If not, do they vary by:

Watershed	____________ yes	____________ no
Municipality	____________ yes	____________ no
Flood center or other physical feature	____________ yes	____________ no

8. Do your policies specify the control of development impacts on stormwater runoff for aspects such as:

Water quantity control	____________ yes	____________ no
Water quality control (TSS based)	____________ yes	____________ no
Water quality control (non-TSS based)	____________ yes	____________ no
Water balance (groundwater)	____________ yes	____________ no
Fluvial geomorphologic considerations	____________ yes	____________ no
Natural areas (wetlands, woodlands)	____________ yes	____________ no

9. If your Authority does not currently have policies in place, do you rely on current Ministry Guidelines for stormwater drainage/managements?

____________ yes ____________ no

If yes, what guidelines? ____

____

10. Has your Authority or member municipalities developed watershed studies, sub-watershed studies or master drainage plans for use in developing stormwater drainage/management policies specific to an area?

____________ yes ____________ no

If so, what studies? ____

11. How are stormwater management targets defined for development applications in areas where sub-watershed studies or master drainage plans have not been completed? Are blanket assumptions applied in areas where data gaps exist (e.g. assumption of Enhanced quality control unless determined otherwise)?

____

____

____

Is pre-consultation required?____________________ yes ___________ no

12. Does your Authority review applications for the existence of a legal drainage outlet?

___________ yes ___________ no

If no, are you aware of how this is considered? _________________________________

____

13. For what types of development applications does your Authority provide SWM review?

Permits	___________ yes	___________ no	___________ varies
Subdivisions	___________ yes	___________ no	___________ varies
Site Plans	___________ yes	___________ no	___________ varies
Severances	___________ yes	___________ no	___________ varies
OP Review	___________ yes	___________ no	___________ varies

Other (please specify) ____

Does this vary across the watershed? ___________ yes ___________ no

14. Do you have development review procedures developed (i.e., a checklist to follow in the review of design submissions)

___________ yes ___________ no

If so, please provide a copy with this questionnaire.

15. Do you utilize a fee-for-review service?

___________ yes ___________ no

If so, please provide any relevant documentation with this questionnaire.

16. Can you provide an estimate of typical turn-around time for review of SWM submissions?

____

17. Can you generally characterize your Authority's relationship with its member municipalities as it pertains to SWM review? In your opinion, are your municipalities satisfied with the current state of practice in this regard within your watershed? What, if anything, would you change?

____

____

____

____

____

18. If you do not currently have policy or procedure documents, do you plan to prepare some in the future?

Stormwater Drainage Management Policies ____________ yes ____________ no

Review Procedures ____________ yes ____________ no

19. Do you wish to receive a copy of the summarized questionnaire results?

__________________ yes ____________ no

Thank you for the time and effort taken to complete this questionnaire. Your input to this project is sincerely appreciated and we hope to improve the implementation of SWM as a result of your experience, comments and suggestions.

Please return to: Mr. Alec Scott, P. Eng.
Ausable Bayfield Conservation Authority
RR # 3, 71108 Morrison Line
Exeter ON
N0M 1S5

Ph: (519) 235-2610
Fax: (519) 235-1963
e-mail: ascott@abca.on.ca

Please return by: December 14, 2007

AUSABLE BAYFIELD CONSERVATION AUTHORITY
STORMWATER MANAGEMENT POLICIES UPDATE (2007)

MUNICIPALITIES QUESTIONNAIRE

The Ausable Bayfield Conservation Authority (ABCA) has retained Stantec Consulting Ltd. to update their Stormwater Management (SWM) Policies document for application across the watershed. The previous version of the Policies was developed by Triton Engineering Services Ltd. in 1994. The current update is being undertaken in recognition of the various evolutions in the SWM field in the intervening period, and the desire of the Authority to stay up-to-date.

The policy document is intended for use by ABCA staff in reviewing SWM Plans and to provide direction to agencies, developers, engineering consultants, member municipalities, and any other parties involved in completing and/or reviewing SWM Plans. The development of these policies will ensure a consistent approach across the watershed and facilitate the review of development applications.

Key to the successful completion and implementation of the updated policy document is the participation of the member municipalities in the process. Municipal input from across the watershed, reflecting the similarities and differences in approaches and concerns, is essential to the creation of a usable policy document. The intent of this questionnaire is to collect information on policies, procedures, existing or anticipated development pressures, and other concerns that may exist within the member municipalities, in order to help the Authority focus on areas of highest priority. It is generally similar to the 1994 version completed in conjunction with the original Policy document, with minor revisions / updates included as applicable.

You are asked to please fill out the following questionnaire and return it to the address identified on page 5. Please feel free to attach additional comments if insufficient space has been allotted herein. If the completion of specific answers (#'s 4, 5, and 6, for example) requires a staff time expenditure that is not readily available, please feel free to provide an estimated response. If your municipality happens to straddle the watershed boundary, please only concern yourself with that portion which lies within the Ausable Bayfield watershed. Lastly, feel free to utilize a "not applicable" response if such is the case – for example, if no portion of your municipality is urban or urbanizing, a number of questions included herein will be irrelevant, e.g. 4 - 8, etc., and can be noted as such.

A summary of all municipality responses will be created and circulated to those respondents that indicate a desire for such information. Thank you in advance for your time and efforts.

Please check off appropriate areas and provide comments as appropriate.

1. Municipality ______________________________

2. Person completing this questionnaire ______________________________

3. Position ______________________________

4. What is the approximate land area in your municipality currently zoned for urban development?

   ______sq. km.

5. How much of the land zoned for urban land use is currently developed (approx.)?

____________ sq. km.

6. What percentage of the land with urban development is currently serviced?

Municipal water	____________%
Storm sewers	____________%
Sanitary sewers	____________%

7. If you have any maps illustrating the lands zoned for urban land use and currently developed areas, please return a copy with this questionnaire.

8. To your knowledge, do you have areas within your municipality where existing or proposed urban development is or could be impacted by any of the following:

Flooding	____________yes	____________no
Erosion	____________yes	____________no
Water quality	____________yes	____________no

If yes to any of the above, can you provide specifics?

____

____

____

9. a. Has your municipality had to undertake any remedial measures to solve erosion and/or flooding problems (outside any carried out with the Authority)? If so, what measures have been undertaken and where?

____

____

____

b. Are you aware of any areas where flooding or erosion is a concern that will require remedial work in the future? If so, what measures will be required and where?

____

____

____

10. Does your municipality have policies or standards in place that are used for drainage design or lot grading for new development? (i.e. sewer size, swale capacity, etc)?

_______________ yes   ____________ no

If yes, could you please forward a copy with this questionnaire.

11. Do you have a copy of the "Stormwater Management Planning and Design Manual" issued by the Ministry of the Environment, March 2003?

_______________ yes   ____________ no

If yes, do you apply these guidelines?

_______________ yes   ____________ no

12. Are you aware / do you apply those components of the most recent Provincial Policy Statement that pertain to stormwater management?

_______________ yes   ____________ no

13. Does your municipality have any policies in place for the control of development impacts on stormwater runoff for aspects such as:

Water quantity (flooding)	____________ yes	____________ no
Water quality (sediment control)	____________ yes	____________ no
Water quality (other)	____________ yes	____________ no
Water balance (groundwater recharge)	____________ yes	____________ no
Erosion and sediment control during construction	__________ yes	____________ no
Erosion within receiving watercourses	____________ yes	____________ no
Natural areas (wetlands, woodlands)	____________ yes	____________ no

14. If you do not have policies currently in place, do you plan to develop policies in the future?

Drainage policies/standards	____________ yes	____________ no
Stormwater management policies	____________ yes	____________ no

15. If you do have policies in place, please provide specifics. Any documentation in this regard that could be attached to your response would also be appreciated.

Water quantity (flooding) ____

Water quality (sediment control) ________________________________

Water quality (other) ____

Water balance (groundwater recharge) ______________________

Erosion and sediment control during construction ______________________

Erosion within receiving watercourses ______________________

Natural areas (wetlands, woodlands) ______________________

Design event for storm sewers ______________________
(e.g., sewer sized to convey 5-yr. event)

Design event for road crossings ______________________
(e.g., road crossing to pass 25-yr. event)

Design event for roadside ditches ______________________
(e.g., ditch to carry 5-yr. event)

Design event for major storm ______________________
(e.g., largest event for flood prevention)

Design storm based on what rainfall gauge______________________
(e.g., location of data, have specific IDF parameters been developed)

Methodology used to calculate design flows (e.g., Rational method, modeling)

____

16. For what types of development applications does your municipality require SWM review?

Subdivisions	________ yes	________ no	________ varies
Site Plans	________ yes	________ no	________ varies
Severances	________ yes	________ no	________ varies

Other (please specify) ______________________

17. Does your municipality regularly obtain the services of a private engineering consultant to complete peer review of stormwater management design applications?

________ yes ________ no

If yes, which firm? ______________________

18. Do your land use policies currently provide for the protection of identified natural resource features which contribute to the management of stormwater (i.e. wetlands, woodlands, streams, buffers, etc)?

________ yes ________ no

19. Our study is addressing stormwater management requirements for lands draining to gullies along the Lake Huron shoreline due to identified concerns regarding erosion of the gullies and bacteria levels along the shoreline. If applicable to your Municipality, what kinds of standards do you feel are appropriate for these lands?

____

____

____

20. Do you have any other concerns or requirements which you would like to see addressed regarding stormwater within the updated Policy document?

____

____

____

____

____

____

21. Do you wish to receive a copy of the summarized questionnaire results?

__________________ yes ____________ no

Thank you for the time and effort taken to complete this questionnaire. Your input to this project is sincerely appreciated and we hope to improve the implementation of SWM as a result of your experience, comments and suggestions.

Please return to: Mr. Alec Scott, P. Eng.
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Please return by: December 14, 2007

APPENDIX E

Summary of Various Conservation Authority SWM Policies

Table of Contents – Appendix E

E.1 SUMMARY OF VARIOUS CONSERVATION AUTHORITY SWM POLICIES

This section summarizes those policies and/or approaches implemented by various Conservation Authorities with regards to SWM, and reflects questionnaire responses where received, as well as a review of published documentation in this regard.

E.1.1 Credit Valley Conservation Authority (CVC)

A response to the circulated questionnaire was not received from the CVC.

The *CVC Stormwater Management Guidelines* (CVC, 1996) were prepared to assist developers, consultants, municipalities and others dealing with stormwater in the Credit River watershed and are aimed at helping people understand the existing approvals process for SWM plan submissions. The intent of the CVC was to create a document that increased the understanding of the environmental impacts of stormwater and the regulatory requirements for SWM. The *Guidelines* contain a recommended approach to developing a SWM plan as a means of improving the practice of SWM and creating a standardized and streamlined approach to addressing stormwater throughout the watershed. These guidelines were intended to be advisory, not prescriptive.

The report identifies the potential effects from the discharge of uncontrolled stormwater resulting from altered channel, flow and groundwater characteristics, the loss of wetland and wetland habitat, erosion and pollutants. The environmental impacts to water quality, water quantity, stream morphology and aquatic habitat / communities caused by uncontrolled stormwater run-off from urban areas are identified. Of note, while these impacts of stormwater are identified, guidance for the preparation of SWM plans included in this report focuses solely on the control of water quality, in accordance with the MOE SWM Manual (MOE, 1994), and water quantity, including flood and erosion controls. Finally, this document outlines the deliverables required in support of preparing, designing and reviewing SWM plans at various stages of the development process. A copy of Table 5.2 from the document is provided on the following pages.

Specific SWM policies are not included in the *CVC Watercourse & Valleyland Protection Policies* (1996). While the document recognizes the need to protect watercourses and water quality from the impacts of development, it recommends that such objectives be achieved through the promotion of watershed and water management planning during the land use planning process, and through the establishment of appropriate buffers and setbacks from watercourses to address water quality and erosion control. The document refers to the *Interim Stormwater Quality Control Guidelines for New Development* (MNR and MOE, 1991b) for guidance on specific buffer requirements from fish habitat, but does not suggest the use of this document for the design or implementation of SWM in the watershed. Similarly, the *CVC Authority Policies on Floodplain Management* (1994) does not include specific SWM policies.

TABLE 5.2 Deliverables Required for Stormwater Management Planning

Deliverables Required for Background Study Report

1.1 Hydrologic modeling (pre-development flows based on external and internal drainage patterns)
1.2 Hydraulic modeling
1.3 Water quality monitoring
1.4 Hydrogeology assessment
1.5 Geotechnical assessment
1.6 Fluvial Geomorphology/erosion potential assessment
1.7 Environmental Impact Assessment
1.8 Constraint and Opportunity Mapping

- Base Topographical Map (at appropriate scale)
- Location of watercourses and drainage features with appropriate fisheries classification setbacks
- Location of significant recharge or discharge areas
- Limit of geotechnical hazard area (erosion and stability components)
- Staked Top of Bank
- Staked ESA Boundary
- Staked Wetland Boundary and Identification of buffer area of interest
- Significant Woodlands
- Regional Floodline Mapping
- Development Setback from greatest limit of technical/environmental constraints
- Area requiring special land use grading and SWM Practices Considerations

Deliverables Required for Stormwater Management Plan Prior to the Issuance of Conditions for Draft Approval

2.1 Post-development flows
2.2 SWMP analysis - short list of integrated preferred options
2.3 Proposed development concept/layout
2.4 Location of stormwater management facilities
2.5 Preliminary design and sizing of SWM facilities
2.6 Preliminary design of control/diversion manholes and/or pond bypass or flow splitter structures
2.7 Confirmation of safe conveyance of Regional overland flows through the proposed development
2.8 Outfall locations
2.9 Proposed instream works
2.10 Revegetation/Landscape Plans to be noted as a requirement of Detailed Engineering Submission
2.11 Proposed zoning of SWM facilities
2.12 Preliminary Sediment Control discussion
2.13 Preliminary Grading and Drainage Plans (to be circulated with the Draft Plan)

DRAFT

TABLE 5.2 cont...

Deliverables Required for Stormwater Management Implementation Report Prior to Site Registration & Pre-servicing

3.1 Detailed design of SWM Facilities, connection and outfalls
3.2 Detailed Lot Grading Design
3.3 Detailed Drainage Design (minor/major system)
3.4 Detailed Sediment Control
3.5 Detailed Revegetation/Landscape Design
3.6 Implementation Strategy of Approved Preliminary SWM Plan
3.7 Appropriate Zoning
3.8 Detailed Fluvial Geomorphological Design of Instream Works
3.9 List of Drawings

- Site Location Plan
- Grading Plan showing limits of development (lot lines) and proposed geodetic elevations
- Storm Drainage Plans showing lot drainage and major overland flow routes, ponding areas and associated zoning i.e. easements
- Servicing Plans showing minor system, stormwater facilities, connections and outfalls
- SWMP Detail Designs
- Natural Channel Design Plans
- Revegetation/Landscaping Plans
- Sediment Controls Plans
- Road Crossing Details

FOR COMMENT

E.1.2 Grand River Conservation Authority (GRCA)

The GRCA recognizes that SWM facilities are regulated through the Ministry of the Environment (Certificate of Approval) in accordance with the most recent version of the *SWM Planning and Design Manual* (MOE, 2003b). Largely through agreements with their member municipalities, the GRCA reviews SWM plans and reports to provide comments in an advisory capacity at the plan review and/or subwatershed planning stage.

Where SWM facilities are proposed within a Regulated Area, Permits are required from the GRCA and must comply with the *GRCA Policies for the Administration of Ontario Regulation 150/06* (2007). According to these policies, SWM facilities may be permitted within the floodplain but outside of the riparian zone or effective flow area, whichever is greater, provided that there is no feasible alternative site outside the floodplain and it can be demonstrated that:

i) there is no loss of flood storage,

ii) natural erosion and sedimentation processes within the receiving watercourse are not impacted,

iii) where unavoidable, intrusions on significant natural features or hydrologic or ecological functions are minimized and it can be demonstrated that best management practices and appropriate remedial measures will adequately restore and enhance features and functions,

iv) facilities are excavated with minimal berming, stage-storage discharge relationships and floodplain flow regimes for a range of rainfall events including the Regional Storm are maintained, and all excavated material is removed from the floodplain; and

v) design and maintenance performance requirements as determined by the GRCA for the receiving watercourse are met and the effect of the floodplain flow regime on the intended function of the facility is incorporated into the siting and design (Policy 8.1.14)

Stormwater management facilities are generally not permitted within a wetland. However, in some cases, SWM facilities may be permitted within a wetland for flood control purposes provided that a comprehensive plan (i.e. EA, subwatershed study) supported by the GRCA demonstrates that all alternatives to avoid wetland loss have been considered, that a flood control structure is required to alleviate an existing flood or erosion problem of a regional scope, and where it can be demonstrated that:

a) all structural components and actively managed components of the stormwater management facility are located outside of the wetland;

b) a detailed study (i.e. scoped EIS) consistent with the comprehensive plan demonstrates how the hydrologic and ecological functions of the wetland will be protected, restored and/or enhanced;

c) pollution and sedimentation during construction and post construction are minimized using best management practices including site and facility design, construction controls, and appropriate remedial measures;

d) design and maintenance requirements as determined by the GRCA are met; and

e) works are constructed, repaired or maintained according to accepted engineering principles and approved engineering standards or to the satisfaction of the GRCA, whichever is applicable based on the scale and scope of the project. (Policy 8.4.11)

SWM facilities for water quality control are not permitted within a wetland, but may be permitted within the area of interference around a wetland if these above listed conditions can be satisfied (Policy 8.4.12).

Further guidelines regarding the design and implementation of SWM and erosion and sediment control are provided in the *GRCA Stormwater Management Guidelines* (GRCA, 1982), which are similar to the *Urban Drainage Design Guidelines* (MNR et al., 1987b).

In an attempt to improve the quality of submissions and reduce the time and effort spent reviewing SWM submissions, a series of checklists were developed by the GRCA in 2005 through consultation with the Waterloo Region Homebuilders' Association / GRCA liaison committee. The pre-consultation, preliminary SWM, and final SWM checklists are intended to be completed through consultation with GRCA staff and should accompany the appropriate submission as a means to ensure that all necessary components of a SWM submission are included (i.e. complete submission) and as a quick reference to GRCA staff that all supporting information has been provided, prior to proceeding with a circulation and/or review.

E.1.3 Maitland Valley Conservation Authority (MVCA)

The *MVCA Draft Shoreline Policies For Existing Plans of Subdivisions and Town of Goderich along the Lake Huron Shoreline within the MVCA Area of Jurisdiction* (2007) outlines the Authority's aims of maintaining the ecological integrity of terrestrial and aquatic ecosystems, including the maintenance of essential coastal and physical processes, genetic diversity and sustainable utilization of species and ecosystems. Notwithstanding the above, the document does not contain specific policies relating to SWM by which the goals are to be achieved.

E.1.4 Nottawasaga Valley Conservation Authority (NVCA)

The *Nottawasaga Valley Conservation Authority Development Review Guidelines* (2006) provides SWM and SWM Planting Guidelines in order to provide a fair, reasonable and uniform basis for development approval decisions within the Nottawasaga Valley Watershed. Future plans include the expansion of the content of these guidelines to include sediment and erosion control, floodplain management, flood proofing, landscaping and environmental impact assessment guidance.

At present, specific policies are provided for quantity control, quality control, hydraulic impacts, riparian rights and water balance, as follows:

- Quantity Control - every effort should be made to maintain existing watershed boundaries and drainage patterns, with pre-consultation considered mandatory for any proposed shift in drainage boundaries. Unless specified otherwise by the municipality, subwatershed study, or fluvial geomorphic analysis, post development peak flow rates must not exceed corresponding pre-development rates for the 1:2 year through 1:100 year design storm events.
- Quality Control - Best Management Practices must be applied to all development in order to provide Enhanced water quality treatment. Oil and grit separators may be used as part of a multi-component approach (treatment train) to achieve enhanced quality control and are not to be used independently.
- Hydraulic / Flood Plain Issues - all major overland flow routes must be sized for the Regulatory storm event, and must be transferred to the governing municipality. SWM facilities must be located outside of the 1:100 year flood plain and if the facility is proposed within the Regional Storm Floodplain, the proponent should pre-consult with NVCA staff to determine the acceptability of the location, and any other required design constraints.
- Riparian Rights – it is the developer’s responsibility to demonstrate safe conveyance of the Regulatory Storm through the development site to a sufficient outlet, such that no adverse impacts will be incurred on upstream or downstream landowners, whereby a sufficient outlet typically constitutes a permanently flowing watercourse or lake
- Water Balance - every attempt should be made to match post development infiltration volumes to pre-development levels on an annual basis. Infiltration targets may be achieved through the incorporation of a variety of best management practices (Policy 2.1.5)

Additional guidance and direction is provided for model approaches, precipitation events, hydrograph computation, and other technical methods and approaches required to design a SWM system. As well, submission standards and a submission requirements list are provided in the document, copies of which are included on the following pages.

Nottawasaga Valley Conservation Authority – Submission Requirements

April 2006

2.4 Submission Requirements List

In order to provide more efficient service, the NVCA will only perform a detailed engineering review upon receipt of a complete submission. The following list details items typically required as part of a complete submission, however as the list is intended to cover a broad range of development proposals, portions of the submission list may not be applicable. Exemptions will be made on a site by site basis, through pre-consultation with the NVCA.

Stormwater Management Report

1. Printed and digital copies of the Stormwater Management Report must be submitted with each development proposal. Digital copies are to be submitted in .pdf format, and include report text, drawings and appendices, as well as the full set of engineering drawings. The report must be signed and sealed by a Professional Engineer of Ontario and meet, as a minimum, the submission requirements outlined below.

Background

2. Introductory material describing the property location, including both municipal and legal descriptions, planning status, proposed development scheme, construction phasing plan, intent of the report, and existing / historic land use.
3. Reference for the topographic information used to determine internal and external catchment areas under existing and proposed conditions

Criteria

4. Outline the SWM criteria being applied in the report

Water Balance

5. Outline water balance methodology and input parameters, and summarize results, placement detail, and functioning of any proposed infiltration measures

Hydrology and Water Quality

6. Outline pre-development conditions including: internal and external catchment areas and catchment I.D.s, flow routes across the site and applicable external lands, hydrologic parameters used for modeling, and pre-development peak flow rates for the 1:2 through 1:100 year design storms (both 4 hour Chicago and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.
7. Outline of post development conditions including: internal and external catchment areas and catchment I.D.s, major and minor flow routes, hydrologic parameters used for modeling, and post development peak flow rates for the 1:2 through 1:100 year design storms (both 4 hour Chicago and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.

Nottawasaga Valley Conservation Authority – Submission Requirements

Stormwater Management Guidelines

April 2006

8. Certification of safe conveyance of regulatory flows from both the subject site and any external lands, through the development to a sufficient outlet, with no adverse impact to either the upstream or downstream landowners. A sufficient outlet constitutes: a permanently flowing watercourse or lake; a public right of way (provided the proponent has obtained written permission to discharge stormflows from the land owner); or in the case of privately owned lands, a legal right of discharge registered on title.
9. Description of how enhanced level quality control has been achieved across the site
10. Description of proposed erosion and sediment control measures to be in place during the construction period
11. Appended documentation demonstrating all stormflow outlets are sufficient outlets, as described above)
12. Appended printed copies of the hydrologic modeling, including input and detailed output files for the 1:2 through 1:100 year return period events, 25 mm 4 hour Chicago quality storm, and Timmins storm for existing and future landuses
13. Appended digital copies of all modeling. Digital files must include all files necessary to run the model, (i.e., both input and storm files) as well as the detailed output files generated for the regional and 1: 2 through 1:100 year design storm events. Digital files are to include both pre and post development scenarios.
14. Appended paper and digital copies of the NVCA SWM Facility Submission Tool (if required)
15. Appended paper and digital copies of the NVCA Erosion and Sediment Control Submission Tool

Tables

16. Relevant Storm Design Parameters Table - Identifying the design storm duration and distribution; referencing the source of the rainfall intensity duration and frequency values; and listing the intensity-duration-frequency values for the 1:2 through 1:100 year return periods. Any other relevant design storm values not specified above should also be included.
17. Underlying Soil Characteristics of Individual Subcatchments Table – Listing the areal distribution of each soil type (expressed as a %) within every subcatchment
18. Model Input Parameters Table - Summarizing key input parameters for existing and future land use for each catchment including subcatchment I.D., drainage area, CN, IA, Tp, Slope, % impervious, modeling time step, pervious and impervious Manning's roughness, etc.
19. Flow Validation Table - comparing calculated pre-development flows with validation flows obtained using the Headwater Drainage Area Equations given in Section 2.2.7.
20. Summary of Diversions Table (if required) – Listing discharge storage values for each diversion structure, i.e., list is to include total discharge to the structure, total maximum

Nottawasaga Valley Conservation Authority – Submission Requirements

Stormwater Management Guidelines

April 2006

inlet capture flow rate, number of inlets and inlet capacities of each diversion structure, and the hydrograph ID for major and minor flow systems

21. Stage vs. Discharge and Storage Table (if required) – Note: As a minimum, the table is to include every point used in the reservoir routing command
22. Summary of Significant SWMF Features Table - including:
    - type of facility;
    - contributing drainage area;
    - lumped catchment imperviousness ratio;
    - permanent pool, extended detention and quantity control volumes;
    - elevations for: base of pond, base of forebay, normal water level, active storage and quantity control design high water level, regional and 1:100 year design storm high water levels, and top of berm;
    - inlet and outlet structure design details such as: pipe size, orifice size, weir length, and invert elevation;
    - total draw down time required for the extended detention volume.
16. Comparison of Predevelopment, Uncontrolled Post Development and Controlled Post Development Flows Table – showing peak flows for the Regional and 1:2 through 1:100 year design storm events at significant points of interest throughout the catchment area.

Figures (reference all map sources)

17. Watershed Location Plan
18. Pre-development internal and external catchment areas and catchment I.D.s on a topographic base showing existing land use
19. Post development internal and external catchment areas and catchment I.D.s on a topographic base showing future land use, and major and minor flow routes
20. Pre and post development watershed modeling schematics reflecting the model subcatchment I.D.'s and catchment areas.
21. For routing analysis: watercourse plan and profile plots, labeled with the location of the routing cross sections, and watershed subcatchments; and cross section plots of each routing cross section, labeled with Manning's roughness coefficient values, and downstream channel slope.
22. Pre and post development hydrograph plots for all significant points of interest.
23. Placement and detail of any required infiltration measures
24. Full set of **folded** Engineering Design Drawings, signed and sealed by a licensed Professional Engineer of Ontario

Nottawasaga Valley Conservation Authority – Submission Requirements

Stormwater Management Guidelines

April 2006

Calculations

25. Model input parameters, i.e., CN, IA, Tc, % imperviousness, etc.
26. Conveyance capacity of the major system flow path
27. Stage vs. discharge spreadsheet. Note: Calculation equations, coefficients, and design parameters for all hydraulic structures should be clearly identified.
28. Incremental volume calculations for the stormwater management facility
29. Sizing of reservoir emergency outlet for Regulatory flows
30. Sizing of erosion control structures
31. Water balance calculations showing post to pre infiltration volume analysis

Stand Alone Reports

32. Operation and Maintenance Manual
33. Geotechnical Engineering Report, signed and sealed by a Professional Engineer of Ontario, confirming geotechnical feasibility of all stormwater management facilities prior to issuing draft plan conditions, and certifying that all aspects of the proposed stormwater management facilities will function as intended from a geotechnical perspective, that the design meets all current geotechnical standards, and that the proposed operation and maintenance procedures outlined in the manual are suitable from a geotechnical perspective.

E.1.5 St. Clair Conservation Authority (SCCA)

The SCCA does not have specific SWM policies or guidelines, but utilizes the most recent version of the MOE SWM Manual (MOE, 2003b) and any specific subwatershed recommendations.

E.1.6 Toronto and Region Conservation Authority (TRCA)

Where SWM facilities are proposed within a valley or stream corridor regulated by the TRCA, a Permit is required and must comply with the *TRCA Valley and Stream Corridor Management Program* (TRCA, 1994), which provides the policies for protecting and rehabilitating the valley and stream corridors within their jurisdiction. SWM facilities and storm sewer outfalls may be permitted within the valley and stream corridor (Policy 4.3(a)(3) and 4.3(a)(4). In order to obtain such permission, these facilities shall be sited and designed to prevent the risk of flooding, erosion and slope instability, protect and rehabilitate existing landforms, features and functions, and provide for aquatic, terrestrial and human access (Policy 4.3(b)), with the following restrictions:

- storm sewer headwalls shall not be located within the meander belt or 100 year erosion rate of a watercourse (Policy 4.3(b)(10)); and
- SWM facilities shall not be located within significant areas (Policy 4.3(b)(13)).

Pursuant to Policy 4.3(b)(15), SWM facilities (or other infrastructure) should not:

i) restrict fish movement or migration for spawning, nursery or feeding (i.e. no on-line ponds

ii) increase water temperatures by reducing shade, reducing groundwater flows, or permitting inputs from top draw structures;

iii) decrease baseflow characteristics;

iv) reduce food sources through the reduction of in-stream or terrestrial (riparian) vegetation;

v) impair substrate characteristics; and/or

vi) impair surface water and/or groundwater quality such as through the introduction of sediment or other contaminants or pollutants.

Stormwater management facilities implemented for the purposes of reducing or eliminating groundwater or surface water impairment and/or risks associated with flood and erosion may be permitted where:

1. a comprehensive analysis demonstrating that alternative servicing design techniques have been incorporated to the extent possible (Provincial guidelines for siting, selection and design of SWM practices are available);
2. water quality improvement will offset negative impacts related to public safety and other ecological and environmental quality concerns within the corridor;

3. the SWM facility location results in the greatest net public benefit, an evaluation which must consider public safety, social, economic and recreational and other ecological and environmental quality concerns; and
4. wherever feasible, SWM facilities shall not be located within the meander belt (as calculated from the existing meander amplitude) or within the 100 year erosion limit of a watercourse, or within the 100 year floodplain, whichever is greater. (Policy 4.3(c))

In addition, Policy 4.1.1(g) states that surface drainage from any building, structure or paved surface adjacent to valley corridors is not be permitted to discharge directly onto the valley wall, which is an attempt to minimize erosion potential.

In addition to the policies noted above, the *TRCA's Terrestrial Natural Heritage Program Environmental Impact Statement Guidelines* (2006) recognize and suggest that the impact of SWM facilities on the linkage functions along a river corridor should be considered during the assessment of the ecological functions and potential impacts of development on the natural heritage system. Further guidance is provided as an appendix to this guideline document in the form of planting guidelines for SWM facilities. The general suggestion is to utilize a variety of small, early successional native species of trees, shrubs and herbaceous vegetation that are compatible and complementary to the adjacent natural areas. This vegetation should also be suited to the water regime present within each of 5 moisture zones typically found within a wet quality pond, including the deep water, shallow water, shoreline fringe/extended detention, flood fringe and upland areas. Consideration for planting of various SWM facility outfall types, including spreader swales, infiltration trenches and outfall channels is also recommended.

In order to protect downstream cool to coldwater fisheries, these guidelines suggest that bottom-draw outlet structures should be employed and complemented by high densities of shading trees and shrubs. It is recognized that increased solar heating of standing pond water may have thermal impacts on downstream aquatic resources, which will require mitigation through the design of the outlet structure (i.e. use of infiltration techniques or other devices) to further mitigate thermal impacts to the receiving watercourse.

Finally, additional guidance is provided for the calculation of terrestrial and aquatic plant materials required to stabilize the SWM facility and initiate the establishment of sufficient vegetation cover to achieve the additional water quality benefits associated with wet pond designs. In all cases, monitoring is recommended to ensure that water elevations in the pond are functioning properly for a minimum of 2 years prior to planting the aquatic vegetation, in order for conditions within the SWM facility to stabilize.

The TRCA is involved in the STEP program, as discussed above, and is an active participant in the research and design of new SWM approaches and technologies. One such endeavour is summarized in the *Stormwater Management and Watercourse Impacts: The Need for a Water Balance Approach* (Aquafor Beech, 2006), which critiques the current design practice of maintaining flow rates but ignoring the impacts associated with prolonged discharge of larger volumes of water on the receiving watercourses. Instead, they promote maintaining a natural water balance that minimizes changes to runoff volume and discharge rates in order to protect the aquatic ecosystem in downstream watercourses. This also avoids the debate about what an acceptable hydrologic impact and any uncertainties associated with ensuring the post-development flow regimes will not impact downstream habitat.

E.1.7 Upper Thames River Conservation Authority (UTRCA)

The UTRCA provides technical review and commenting services to all municipalities in the watershed in regards to SWM and E&S control. Where municipalities have the required expertise to undertake detailed reviews, the UTRCA may limit its review to catchment level plan preparation and defer the review of detailed projects to the municipality. In all cases, the *UTRCA Environmental Planning Policy Manual* (2006), which was approved by the UTRCA Board of Directors on June 28, 2006, outlines the SWM policies to be followed.

Policy 3.5.2.1 suggests that the UTRCA will advocate for the planning and implementation of SWM facilities on a catchment area basis through the completion of Subwatershed Plans or other watershed based studies, which is a requirement where development potential extends beyond the limits of the subject property. Exceptions to this policy are limited to minor infill developments or cases where the coordination of SWM for the catchment cannot be practically achieved.

While the one of the guiding principles is the support of the use of natural designs for SWM facilities (Policy 2.5.3), the UTRCA generally does not support the following SWM facilities:

a) on-line SWM ponds designed to enhance water quality;

b) the use of natural wetlands for SWM;

c) SWM facilities within natural hazards, such as floodplains or erosion hazards, except outlets; and

d) SWM facilities within significant natural heritage features (Policy 3.5.2.2).

Stormwater management facilities and associated measures may only be permitted in the flood plain if it can be demonstrated that there is a ‘net public benefit’ in selecting the floodplain location and that all other potentially viable locations have been dismissed (Policy 3.5.2.3). Any encroachment of SWM facilities into the floodplain must be justified with a catchment scale assessment (i.e. Subwatershed Plan, Master Drainage Plan, Environmental Assessment), which provides the opportunity to evaluate the location and function of SWM facilities based on technical, environmental, economic, and social factors.

The following principles are considered when assessing proposals to locate SWM facilities in the floodplain:

a) Impact of the SWM facility on floodplain function (i.e. conveyance, flood storage) and implications for other natural hazards;

b) Net ecological benefit of locating the SWM facility in the floodplain; and

c) Cultural benefits of locating the SWM facility in the flood plain (although the natural hazard and natural heritage implications are paramount) (Policy 3.5.2.3).

Similar to the GRCA checklists, the UTRCA has incorporated an outline or description of the information requirements necessary to constitute a complete submission, as follows:

a) The characteristics of the catchment area, including physical characteristics, existing or approved development and the opportunities or constraints for SWM at the specific property within the context of the catchment;

b) Identify and integrate the findings of any previous reports for the site or the catchment;

c) Water balance must be addressed, with requirements based on maintaining the existing hydrologic cycle in and surrounding a development area to the extent technically, physically and economically practicable, as follows:

   i) Water quality requirements are to be established based on characteristics of the receiving water body and/or natural heritage feature, including but not limited to aquatic habitat, local and/or regional significance, human and wildlife water use.

   ii) Water quantity control requirements are to be based on both flooding and downstream erosion considerations. Quantity control typically ensures that post-development flow rates approximate pre-development rates for all return period increments from the 2 year to the 250 year. Any modifications to pre-development hydrology must be justified on the basis that they enhance the pre-development condition and must consider factors such as flood severity, flood timing and in-stream erosion potential of the receiving watercourse.

   iii) Monitoring and maintenance plans are required.

d) A conceptual SWM report is required for review and approval prior to supporting development proposals that create multiple lots (i.e. in support of draft plan conditions), which must be prepared by a qualified professional to establish the type, size and location of stormwater facilities and must address the areas of concern previously outlined

e) The UTRCA requires that erosion control at the source be implemented along with supplementary treatment between the source and receiving watercourse.

f) Sediment and erosion control measures are to be used on all construction sites to limit the effects of the proposed development on the surrounding natural environment and receiving drainage network. (Policy 3.5.2.4)

APPENDIX F

SWM Policies and Standards of Watershed Municipalities

Table of Contents – Appendix F

F.1 SWM POLICIES AND STANDARDS OF WATERSHED MUNCIPALITIES

This section provides a summary of various local policies, guidelines, and standards obtained from upper and lower-tier municipalities within the ABCA watershed. These examples were compiled based on the information readily available or where provided by the various municipalities in response to the circulated questionnaire (see Appendix C).

Planning authorities are presently required to protect, improve, or restore the quality and quantity of surface and groundwater through the implementation of restrictions on development and site alteration and/or by ensuring SWM practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

The following is a summary of the SWM policies implemented in various municipalities within the watershed.

F.1.1 Upper-Tier Municipalities

F.1.1.1 County of Middlesex

According to the County of Middlesex Official Plan (2006), the County encourages "local municipalities to implement suitable and economically viable methods of reducing urban stormwater runoff and to improve stormwater quality in the furtherance of the Resource Management policies of this Plan" (Section 2.4.5.1(j)). Therefore, SWM is seen as a component of an integrated approach to land use planning intended to protect the quality of the natural environmental and to conserve those natural resources necessary for future economic growth, on a sustainable basis.

The County also encourages SWM practices that minimize stormwater volumes and contaminant loads, as a means to implement the Elgin-Middlesex Groundwater Study (2004) (Section 2.4.7(b)).

F.1.1.2 Lambton County

Lambton County views SWM as an integral part of the piped services in Urban Centres and most Urban Settlements, where both quantity and quality of stormwater discharges from new development areas must be managed in accordance with best management practices and Provincial Regulations, as outlined in the Lambton County Official Plan (Lambton County, 2006).

SWM facilities are viewed as a significant opportunity for linking various parts of individual municipalities and the County as a whole, and therefore should be addressed in local official plans and identified on secondary plans for the development of urban centres (Section 3.3.2(c)).

To achieve the goal of developing urban centres in a manner that alleviates environmental concerns, the County requires that all development proposals are required to have regard for stormwater drainage and surface water infiltration on-site in direct relation to the scale of the development (Section 7.8.5). They also encourage the following:

- local SWM policies that include the use of infiltration as a means to replenish groundwater supplies and minimize offsite flooding and erosion, where feasible (Section 7.8.6);
- the establishment of municipally owned and operated stormwater quality treatment facilities, where feasible and practical, based on the findings of watershed and subwatershed studies (Section 7.8.9);
- the incorporation of stormwater quality best management practices into the design and long term maintenance of development proposals (Section 7.8.10); and
- Development projects and associated stormwater outfalls adjacent to watercourses should incorporate naturalization techniques where appropriate to enhance and maintain vegetation and habitat (Section 7.8.11).

In order to protect and enhance the natural attributes and functions of watercourses in the County in order to maintain and improve wildlife habitat and water quality, as well as to protect headwater areas and groundwater resources from land uses that have the potential to degrade downstream watercourses and groundwater aquifers, the County directs local municipalities to address SWM through appropriate local official plan policies that are consistent with the County's Infrastructure policies (Section 8.1.5.13).

F.1.1.3 Huron County

While the *Huron County Official Plan* (1998) recognizes that the community values a healthy environment, including the quality of the water, and recognizes water as an integral component of a healthy ecosystem (Section 6.1), it does not include specific provisions or policies for the implementation of SWM. Instead, the County promotes the incorporation of relevant policies for the protection of water quality and quantity through watershed management at the local level (Section 6.3(i)).

The *County of Huron Subdivision and Condominium Approval Procedures - An Applicant's Guide* does identify the requirement to determine the way surface water is to be directed, collected and managed on-site in order to obtain draft plan approval.

A *Water Protection Steering Committee* was established in 2004 to protect the quality of groundwater and surface water in the County by undertaking and supporting research studies, planning initiatives, monitoring, outreach and education projects. SWM has not been a priority, although the Committee has expressed an interest in the update to the ABCA SWM policy through the County planner. This committee consists of representatives from the Provincial, County and Municipal government, Conservation Authorities, agriculture, manufacturing and tourism associations, and citizen groups.

F.1.2 Lower-Tier Municipalities

Sections E.1.2.1 – E.1.2.5 reflect information received via the circulated questionnaires and/or research conducted as part of the current study. Sections 1.2.6 – E.1.2.8 are taken verbatim from the 1994 Policy document Appendices and have not been verified within the current study.

F.1.2.1 Municipality of Central Huron

The Central Huron Official Plan (2006) includes the long-term servicing goal of providing affordable, effective and safe SWM services in the Municipality (Policy 2.4). The implementation of SWM is identified as a means to protect significant natural environment areas in the Municipality, whereby proposed SWM activities shall be evaluated to minimize impacts on watercourses, fish habitat and water quality (Policy 3.2.3.4.3). Specifically, water quantity and quality issues may be considered within SWM reports as a condition of development and may include recommendations for reducing storm-run off and implementing conservation efforts (Policy 6.1.11). SWM plans are a requirement for submission of a development application for new and infill developments, campgrounds and RV parks (Policy 3.4.3.3 and 3.4.3.4) and will form part of any development agreement (Policy 4.3.3.1).

F.1.2.2 Township of Middlesex Centre

The Municipality of Middlesex Centre does not currently have approved policies for the implementation of SWM identified within their Official Plan, though it does use design standards that are typical for a number of smaller municipalities throughout the County of Middlesex and Elgin County, as prepared by Spriet Associates.

F.1.2.3 Municipality of Perth South

The Municipality of Perth South applies the guidelines contained within the MOE SWM Manual (MOE, 2003b).

F.1.2.4 Township of Adelaide Metcalfe

There are no policies or guideline documents currently in place for the Township of Adelaide Metcalfe dealing with the implementation of SWM.

F.1.2.5 Municipality of North Middlesex

The Municipality has design guidelines and construction standards that deal with aspects of SWM and specify the use of 3-5 year storm event for design of storm sewer, roadside ditch, and road crossings.

F.1.2.6 Village of Grand Bend

- Storm Sewer Sizing – use Rational Method with C+.35, rainfall of 2.5 in./hr. for 20 minutes and a duration of 10 to 20 minutes.
- SWM – Control to pre-development level for 1:2 to 1:100 year storms unless it can be demonstrated that controls are not needed.
- Sediment control is to be provided.
- Have lot grading standards in place.

F.1.2.7 Town of Exeter

- Storm Sewer Sizing – use 1:5 year design for sewers and ABCA requirements for major system design – a variety of models are acceptable for use.
- SWM – minor storm control is required, but no level is specified
- Lot grading standards are in place.

F.1.2.8 Town of Parkhill

- Storm Sewer Sizing – use 1:5 year design storm using London, Sarnia, or Goderich gauges and Rational Method.
- No SWM is required.
- Have lot grading standards.

APPENDIX G

Outline of Typical SWM / Servicing Report Contents

Pre-Consultation and SWM Submission Checklists

Technical Reviewers Checklist

Table of Contents – Appendix G

G.1 TYPICAL PRELIMINARY SWM / SERVICING REPORT CONTENTS

While the summary lists provided herein do not deal solely with SWM items, they are not intended as "catch-all" lists for information that the ABCA may require. It is strongly recommended that the ABCA be consulted prior to or as part of the design process for any application requiring their approval. The intent of this document is to provide guidance for the overall submission and review process.

1.0 **Introduction** – introduces the proponent, the site location (high level), the type of application being proposed, and other general information that may be pertinent to the reviewer. A large-scale location plan sufficient to orient the reader in the subject municipality should be provided.

1.1 **Study Approach** – outlines the step-by-step process followed in the development of the SWM design and the breakdown of the report.

1.2 **Background** – typically comprised of a listing of historic reports or correspondence that served as guidance or support to the current document. Such background documentation could range in scale from studies completed specifically for the subject lands to subwatershed / watershed-scale policy and guidance documents, or even provincial / federal design guidance.

2.0 **Existing Conditions**

2.1 **Existing Land Use** – describes the current land use conditions both on-site and on adjacent lands that may be impacted by the proposed land use change.

2.2 **Soils** – generally summarizes the results of the detailed soils investigation, to be completed by a qualified soils consultant, listing such elements as soil types, grain sizes and distributions, stratigraphy and depths, penetration results (blow counts), permeability, and groundwater characteristics (elevations, perched or otherwise, etc.). An assessment of the suitability of the native soils for the implementation of engineered infiltration systems, private sewage systems, or water supply, if applicable, should be included.

Figures identifying locations of field sampling (boreholes, hand holes, mini-piezometers, etc.), the soil logs, groundwater flow directions, and depth-to groundwater characteristics (in areas where shallow groundwater may impact on development potential) are required. Submission of a geotechnical investigation report containing these figures is sufficient, i.e. there is no requirement to duplicate within SWM documentation.

2.3 **Topography** – summarizes general description of on-site and surrounding topography, with an emphasis on stormwater drainage. A figure (or Plan, as necessary) at 1:1000 scale or finer, including contour information at 0.5 m intervals should be provided. Average slope values as well as catchment delineation (used in existing conditions hydrology) should be indicated.

2.4 **Receiving System Characterization** –identification and characterization of the receiving system through use of historic records or field assessments / analysis completed as part of the proposed project. Information should be conveyed through discussion and graphically, where appropriate.

Background documentation could include, but not necessarily be limited to, such sources as:

- Subwatershed studies / master drainage plans
- Resource mapping identifying sensitive or significant areas
- Water Survey of Canada streamflow gauge data
- Municipal Drain classifications
- MOE water well records and existing users of both groundwater and surface water resources (Permits-to-Take-Water), etc.

The characterization should including elements such as:

- Overview of watercourse system, total watershed area to flow point of concern, existing Regulatory floodlines or limits of other hazard lands, geomorphologic characteristics (stability assessments), stream order, other local tributaries and Municipal drains, etc.
- Flow regime including any available gauge data with an emphasis on seasonal fluctuations and critical periods such as summer baseflows
- Water quality characterization including typical sediment loads and concentrations of various contaminants that may be impacted by development (phosphorous, bacteria, thermal regime, etc.)
- Habitat classification including identification of any existing constraints such as dams, culverts, channelization works, and other storm outlets
- Other site constraints that may impact on development and SWM servicing strategies such as existing sewer systems, existing or proposed septic systems, roads, utilities, historic soil compaction / contamination, fill areas, and structures

Where existing information is non-existent or insufficient to characterize the receiving system adequately to establish design criteria and/or evaluate potential post-development impacts, field assessments and/or analysis must be completed to eliminate the data gaps.

2.5 **Existing Conditions Hydrology** – includes discussion and summary of key model input parameters / assumptions and results. While details and derivations of input parameters / assumptions are best included as appendix material, summary tables within the report should identify aspects such as:

- subcatchment areas,
- pervious / impervious coverage estimates,
- length, width, and slope parameters used in estimating Time of Concentration / Time to Peak for each subcatchment
- parameters associated with the selected rainfall abstraction approach (i.e. SCS, Horton, Green-Ampt, Proportional Loss, etc.) and any depression storage assumptions, and
- rainfall data, including the station, IDF parameters, event durations, etc.

A model schematic outlining catchment connectivity should be included with the appended modeling files. The results of any model sensitivity assessments on elements such as rainfall event duration / distribution or calculation time step should be summarized.

A summary table of key results (peak flows, volumes, duration of critical erosive flow exceedance) should be provided.

3.0 **Stormwater Management Criteria** – summarizes the range of SWM objectives and/or criteria established as part of the pre-consultation program, review of existing guidance studies, ecologic assessment of receiving systems, or other means.

Discussions and summary analysis are required to address the various stormwater impacts as outlined in the main Policy document. Aspects typically include:

- Water quantity controls (flooding)
- Instream erosion (critical flow regimes, flow-duration analysis)
- Water quality (TSS, temperature, bacteria, phosphorous, oils/greases, etc.)
- Water balance (groundwater recharge)
- Baseflow maintenance

4.0 **Proposed Conditions**

4.1 **Development Layout and Form** – summary of proposed development concept with definition of all resource areas and limits of development

4.2 **Water Supply** – summary of proposed water supply. If communal or private servicing is proposed, hydrogeologic study on suitability of source and possible impact on base flow in adjacent watercourses or hydrologic impact on other natural features such as wetlands is required

4.3 **Sanitary Servicing** – summary of proposed sanitary servicing strategy. If private servicing is proposed, soil assessment on suitability to be included. Clearance distances to watercourses or other natural water features need to be outlined. Any constraints and/or requirements for raised tile beds need to be outlined.

4.4 **Stormwater Servicing** – summary of the proposed stormwater conveyance approach, use of rural or urban cross-section or, in the case of the latter, the minor / major drainage concept proposed

4.5 **Proposed Conditions Hydrology** - includes discussion and summary of key model input parameters / assumptions and results. While details and derivations of input parameters / assumptions are best included as appendix material, summary tables within the report should identify aspects such as:

- subcatchment areas,
- pervious / impervious coverage estimates,
- length, width, and slope parameters used in estimating Time of Concentration / Time to Peak for each subcatchment, and
- parameters associated with the selected rainfall abstraction approach (i.e. SCS, Horton, Green-Ampt, Proportional Loss, etc.) and any depression storage assumptions.

A model schematic outlining catchment connectivity should be included with the appended modeling files.

A summary table of key results (peak flows, volumes, duration of critical erosive flow exceedance) should be provided.

4.6 **Stormwater Management** – summary of the proposed stormwater management approach including an outline of the various lot level, conveyance, and end-of-pipe treatments to be implemented. In accordance with the guidance of the *Stormwater Management Planning and Design Manual* (MOE, 2003), preference should be given to measures that serve to minimize stormwater runoff and/or treat it closer to the source (i.e. the lot-level measures), followed by conveyance level controls, and finally to the end-of-pipe treatment systems. Rationale for selection and/or omission of the various SWM measures available to the practitioner should be provided.

Discussion and summary tables outlining how the proposed SWM design addresses each of the criteria developed in Section 3.0 should be clearly presented. A table outlining key SWM facility design and operating characteristics is often the most efficient means of summarizing the target and achieved design information.

Typical design aspects of primary importance include:

- Contributing drainage area and impervious coverage
- Required / provided permanent, active, and total pond storage volumes and depths
- Required / provided control targets
- Operating characteristics for design events (ponding levels)
- Key configuration aspects such as length:width ratios, forebay characteristics (including % of permanent pool), slopes, planting strategy, inlet configuration / flow splitters, outlet configuration, maintenance access locations / routes

Scalable report figures and/or engineering drawings should clearly identify the proposed lot level, conveyance, and end-of-pipe SWM system components, minor and major flow routes.

5.0 Erosion and Sediment Control (E&SC) During Construction

5.1 **Evaluation of Erosion Potential** – includes an assessment of the soil erodibility, surface slope gradients, length of slopes, rainfall intensities, and runoff potential.

5.2 **Construction Approach** – Aspects of construction timing and/or phasing of operations should be discussed, with a mind to limiting erosion potential. Other aspects such as anticipated locations of topsoil stockpiles and/or the existence of sensitive receivers should also be considered in the preliminary E&SC strategy.

5.3 **E & S Control Techniques** – Based on the erosion potential and proposed construction approach strategies described in the two previous sections, a suite of E & S control measures should be defined.

5.4 **Inspection and Maintenance Requirements** – E & S control measures require frequent inspection and maintenance activities to ensure proper construction and operation.

6.0 Floodline Analysis

6.1 **Policy Areas** – The type of policy area should be identified (i.e. One-Zone, Two-Zone, or Special Policy Area).

6.2 **Existing Floodlines** – Regulatory floodplain mapping, if developed, can be obtained from the ABCA.

6.3 **Existing Conditions Model** – The ABCA should be contacted to obtain an up-to-date HEC model defining the floodlines in the area of the proposed development, if available. If an existing model is not available, the proponent may be required to undertake the appropriate analysis, which could include hydrologic and hydraulic models.

6.4 **Proposed Floodplain Alterations**

a) Hydrologic Model Update – In areas where the development has not been considered within the hydrologic modeling of the regulatory flows, or where such represents a significant revision from existing models, there may be a need to update the hydrologic model.
b) Cross-section Alterations / Additions / Deletions – Any alterations to the floodplain (fill, cut, crossings, etc.) should be incorporated within the hydraulic model.
c) Any parameter revisions (e.g. Manning's 'n' coefficients, bridge modeling approaches, expansion / contraction coefficients, encroachments, etc.) should be indicated and justified.

6.5 **Model Results** – Any floodline alterations should be illustrated on the development plan. It should be clearly indicated that upstream / downstream flood elevations are not negatively impacted by the proposed revisions. If the development occurs in a Two-Zone or Special Policy Area, any floodproofing requirements should be clearly identified.

7.0 **Instream Requirements**

7.1 **Canopy Cover Restoration** – The assessment of canopy cover restoration should be based on a creek walk of the receiving systems. Canopy cover restoration should be promoted where the receiving waters are sensitive to temperature and the development / stormwater plan has the potential to negatively impact watercourse temperatures.

7.2 **Streambank Protection / Restoration** – Streambank protection / restoration should be based on a creek walk of the receiving systems. In situations where the development will have a negative impact on streambank erosion and/or stability, protection / restoration works may be required. Channel alterations may also be proposed based on required watercourse crossings. Any channel alterations should incorporate natural channel design techniques.

8.0 **Required Blocks / Easements** – The locations of any blocks or easements required to convey and/or treat stormwater should be identified on the legal and engineering plans.

9.0 **Conclusions and Recommendations** – A summary of key findings and proposed designs.

Appendices

Typical Appendix material includes:

- Existing and Proposed Conditions Hydrologic Modeling (soft copy) complete with derivation (sample calculations) and/or reference materials in support of model parameters. Existing and proposed conditions hydrograph plots at all significant points of interest should be provided.
- Existing and Proposed Conditions Hydraulic Modeling (soft copy) complete with derivation and/or reference materials in support of model parameters.
- Any SWM specific agency correspondence, pre-consultation and preliminary SWM report submission checklists

Figures

Location Plan / Key Plan	Site location and surrounding land uses
Soil Map	Major soil types and borehole locations
Resource Map	Natural resource areas (recharge, wetlands, stream and valley corridors, high and/or steep slopes, floodlines, Regulation Limits)
Development Plan	Topographical map showing proposed development areas (should be combined with resource map, if possible), including lot layout servicing and private sewage system locations
Drainage Plans	Drainage areas, including external drainage for existing and proposed development conditions (separate figures) showing catchment IDs.
Modeling Schematics	Schematics of the existing and proposed conditions modeling should be prepared illustrating the subcatchment IDs, their connectivity, and any routing / storage elements.
Stormwater Controls	a) Locations for lot level controls, conveyance controls, and end-of-pipe controls b) Minor and major system flow paths c) Easement locations A preliminary layout / configuration of any proposed stormwater controls should be shown. The layout should show the proposed locations for inlets / outlets, direction of flow, approximate flow path length, width, depth, typical proposed grades (actual grading will not be possible), and property ownership (if relevant).
Instream Works	Canopy restoration, streambank protection / restoration.

Tables

Receiving Water Characteristics	Characteristics such as habitat classification, Rosgen stream type (if applicable), temperature regime, baseflow regime, erosion potential, flooding potential, water quality data, uses,
Soil Types	Area of each dominant soil type, associated rainfall abstraction parameters (CN values, Horton infiltration parameters, Green-Ampt coefficients, etc.)
SWM Criteria	Criteria to be used for SWM deign (quantity, quality, streambank / gully erosion, groundwater recharge, spills control, etc.)
Design Rainfall Events	The characteristics of the storms utilized in the design including station location / ID, storm distribution, storm duration, and time step.
Modeling Modification	Hydrologic modeling parameters for each subcatchment including elements such as: subcatchment nomenclature, area, % impervious / runoff coefficients, directly connected vs. indirectly connected impervious, depression storage, infiltration parameters, unit hydrograph constants, slope, length, width, and times of concentration / time to peaks.
Stage-Storage-Discharge Curves	The stage-storage-discharge relationships for any storage-type BMP should be included in the report and modeling. Incremental volume calculations for the SWM facility should be provided.
Modeling Results	A table should be produced, reflecting existing and proposed development conditions, and outlining peak flows, duration of critical erosive flow exceedances, or any other parameter of concern. The table should the control volumes (or the like) required for water quality treatment, erosion control, and flood control (for the range of design events).
Hydraulic Results	If a floodline analysis is undertaken, a table should be produced indicating the parameters used in the hydraulic analysis (i.e. Manning's 'n' values for channel and overbank areas, encroachments) and the results of the existing and proposed conditions floodline assessments for representative cross-sections across and adjacent to the study area. The comparison of computed water surface and energy grade line elevations should be presented for the range of design events to illustrate the lack of impact at variable recurrence intervals.

G.2 TYPICAL FINAL SWM REPORT CONTENTS

The reporting, analysis, and drawing requirements for final design closely parallel those identified in the previous section for preliminary design submissions reflecting the desire of the various agencies, the ABCA in particular, to resolve issues as early in the process as possible, rather than attempting to substantially revise designs having granted approval of preliminary materials. The variation between preliminary and final designs will ideally be limited to minor revisions required to address details unforeseen earlier in the process.

1.0 **Introduction** – introduces the proponent, the site location (high level), the type of application being proposed, and other general information that may be pertinent to the reviewer. A large-scale location plan sufficient to orient the reader in the subject municipality should be provided.

1.1 **Study Approach** – outlines the step-by-step process followed in the development of the SWM design and the breakdown of the report.

1.2 **Background** – typically comprised of a listing of historic reports or correspondence that served as guidance or support to the current document. Such background documentation could range in scale from studies completed specifically for the subject lands to subwatershed / watershed-scale policy and guidance documents, or even provincial / federal design guidance. The titles and dates of preliminary submission and approval documentation should be referenced.

2.0 **Existing Conditions**

2.1 **Existing Land Use** – describes the current land use conditions both on-site and on adjacent lands that may be impacted by the proposed land use change.

2.2 **Soils** – generally summarizes the results of the detailed soils investigation, to be completed by a qualified soils consultant, listing such elements as soil types, grain sizes and distributions, stratigraphy and depths, penetration results (blow counts), permeability, and groundwater characteristics (elevations, perched or otherwise, etc.). An assessment of the suitability of the native soils for the implementation of engineered infiltration systems, private sewage systems, or water supply, if applicable, should be included.

Figures identifying locations of field sampling (boreholes, hand holes, mini-piezometers, etc.), the soil logs, groundwater flow directions, and depth-to groundwater characteristics (in areas where shallow groundwater may impact on development potential) are required. Submission of a geotechnical investigation report containing these figures is sufficient, i.e. there is no requirement to duplicate within SWM documentation.

2.3 **Topography** – summarizes general description of on-site and surrounding topography, with an emphasis on stormwater drainage. A figure (or Plan, as necessary) at 1:1000 scale or finer, including contour information at 0.5 m intervals should be provided. Average slope values as well as catchment delineation (used in existing conditions hydrology) should be indicated.

2.4 **Receiving System Characterization** –identification and characterization of the receiving system through use of historic records or field assessments / analysis completed as part of the proposed project. Information should be conveyed through discussion and graphically, where appropriate.

Background documentation could include, but not necessarily be limited to, such sources as:

- Subwatershed studies / master drainage plans
- Resource mapping identifying sensitive or significant areas
- Water Survey of Canada streamflow gauge data
- Municipal Drain classifications
- MOE water well records and existing users of both groundwater and surface water resources (Permits-to-Take-Water), etc.

The characterization should including elements such as:

- Overview of watercourse system, total watershed area to flow point of concern, existing Regulatory floodlines or limits of other hazard lands, geomorphologic characteristics (stability assessments), stream order, other local tributaries and Municipal drains, etc.
- Flow regime including any available gauge data with an emphasis on seasonal fluctuations and critical periods such as summer baseflows
- Water quality characterization including typical sediment loads and concentrations of various contaminants that may be impacted by development (phosphorous, bacteria, thermal regime, etc.)
- Habitat classification including identification of any existing constraints such as dams, culverts, channelization works, and other storm outlets
- Other site constraints that may impact on development and SWM servicing strategies such as existing sewer systems, existing or proposed septic systems, roads, utilities, historic soil compaction / contamination, fill areas, and structures.

Where existing information is non-existent or insufficient to characterize the receiving system adequately to establish design criteria and/or evaluate potential post-development impacts, field assessments and/or analysis must be completed to eliminate the data gaps.

2.5 **Existing Conditions Hydrology** – includes discussion and summary of key model input parameters / assumptions and results. While details and derivations of input parameters / assumptions are best included as appendix material, summary tables within the report should identify aspects such as:

- subcatchment areas,
- pervious / impervious coverage estimates,
- length, width, and slope parameters used in estimating Time of Concentration / Time to Peak for each subcatchment
- parameters associated with the selected rainfall abstraction approach (i.e. SCS, Horton, Green-Ampt, Proportional Loss, etc.) and any depression storage assumptions, and
- rainfall data, including the station, IDF parameters, event durations, etc.

A model schematic outlining catchment connectivity should be included with the appended modeling files. The results of any model sensitivity assessments on elements such as rainfall event duration / distribution or calculation time step should be summarized.

A summary table of key results (peak flows, volumes, duration of critical erosive flow exceedance) should be provided.

3.0 **Stormwater Management Criteria** – summarizes the range of SWM objectives and/or criteria established as part of the pre-consultation program, review of existing guidance studies, ecologic assessment of receiving systems, or other means.

Discussions and summary analysis are required to address the various stormwater impacts as outlined in the main Policy document. Aspects typically include:

- Water quantity controls (flooding)
- Instream erosion (critical flow regimes, flow-duration analysis)
- Water quality (TSS, temperature, bacteria, phosphorous, oils/greases, etc.)
- Water balance (groundwater recharge)
- Baseflow maintenance

4.0 **Proposed Conditions**

4.1 **Development Layout and Form** – summary of proposed development concept with definition of all resource areas and limits of development

4.2 **Stormwater Servicing** – summary of the proposed stormwater conveyance approach, use of rural or urban cross-section or, in the case of the latter, the minor / major drainage concept proposed

4.3 **Proposed Conditions Hydrology** - includes discussion and summary of key model input parameters / assumptions and results. While details and derivations of input parameters / assumptions are best included as appendix material, summary tables within the report should identify aspects such as:

- subcatchment areas, pervious / impervious coverage estimates,
- length, width, and slope parameters used in estimating Time of Concentration / Time to Peak for each subcatchment, and
- parameters associated with the selected rainfall abstraction approach (i.e. SCS, Horton, Green-Ampt, Proportional Loss, etc.) and any depression storage assumptions.

A model schematic outlining catchment connectivity should be included with the appended modeling files.

A summary table of key results (peak flows, volumes, duration of critical erosive flow exceedance) should be provided.

4.4 **Stormwater Management** – summary of the proposed stormwater management approach including an outline of the various lot level, conveyance, and end-of-pipe treatments to be implemented. In accordance with the guidance of the *Stormwater Management Planning and Design Manual* (MOE, 2003), preference should be given to measures that serve to minimize stormwater runoff and/or treat it closer to the source (i.e. the lot-level measures), followed by conveyance level controls, and finally to the end-of-pipe treatment systems. Rationale for selection and/or omission of the various SWM measures available to the practitioner should be provided.

Discussion and summary tables outlining how the proposed SWM design addresses each of the criteria developed in Section 3.0 and how the measures adhere to or diverge from common design guidance literature should be clearly presented.

A table outlining key SWM facility design and operating characteristics is often the most efficient means of summarizing the target and achieved design information. Typical design aspects of primary importance include:

- Contributing drainage area and impervious coverage
- Required / provided permanent, active, and total pond storage volumes and depths
- Required / provided control targets
- Operating characteristics for design events (ponding levels)
- Key configuration aspects such as length:width ratios, forebay characteristics (including % of permanent pool), slopes, planting strategy, inlet configuration / flow splitters, outlet configuration, maintenance access locations / routes

Scalable report figures and/or engineering drawings should clearly identify the proposed lot level, conveyance, and end-of-pipe SWM system components, minor and major flow routes.

4.5 **Maintenance Requirements / Responsibilities** – section should outline anticipated maintenance requirements and frequencies

5.0 **Erosion and Sediment Control (E&SC) During Construction**

5.1 **Evaluation of Erosion Potential** – includes an assessment of the soil erodibility, surface slope gradients, length of slopes, rainfall intensities, and runoff potential.

5.2 **Construction Approach** – Aspects of construction timing and/or phasing of operations should be discussed, with a mind to limiting erosion potential. Other aspects such as anticipated locations of topsoil stockpiles and/or the existence of sensitive receivers should also be considered in the preliminary E&SC strategy.

5.3 **E & S Control Techniques** – Based on the erosion potential and proposed construction approach strategies described in the two previous sections, a suite of E & S control measures should be defined.

5.4 **Inspection and Maintenance Requirements** – E & S control measures require frequent inspection and maintenance activities to ensure proper construction and operation.

6.0 **Floodline Analysis**

6.1 **Policy Areas** – The type of policy area should be identified (i.e. One-Zone, Two-Zone, or Special Policy Area).

6.2 **Existing Floodlines** – Regulatory floodplain mapping, if developed, can be obtained from the ABCA.

6.3 **Existing Conditions Model** – The ABCA should be contacted to obtain an up-to-date HEC model defining the floodlines in the area of the proposed development, if available. If an existing model is not available, the proponent may be required to undertake the appropriate analysis, which could include hydrologic and hydraulic models.

6.4 **Proposed Floodplain Alterations**

d) Hydrologic Model Update – In areas where the development has not been considered within the hydrologic modeling of the regulatory flows, or where such represents a significant revision from existing models, there may be a need to update the hydrologic model.
e) Cross-section Alterations / Additions / Deletions – Any alterations to the floodplain (fill, cut, crossings, etc.) should be incorporated within the hydraulic model.
f) Any parameter revisions (e.g. Manning's 'n' coefficients, bridge modeling approaches, expansion / contraction coefficients, encroachments, etc.) should be indicated and justified.

6.5 **Model Results** – Any floodline alterations should be illustrated on the development plan. It should be clearly indicated that upstream / downstream flood elevations are not negatively impacted by the proposed revisions. If the development occurs in a Two-Zone or Special Policy Area, any floodproofing requirements should be clearly identified.

7.0 **Instream Requirements**

7.1 **Canopy Cover Restoration** – The assessment of canopy cover restoration should be based on a creek walk of the receiving systems. Canopy cover restoration should be promoted where the receiving waters are sensitive to temperature and the development / stormwater plan has the potential to negatively impact watercourse temperatures.

7.2 **Streambank Protection / Restoration** – Streambank protection / restoration should be based on a creek walk of the receiving systems. In situations where the development will have a negative impact on streambank erosion and/or stability, protection / restoration works may be required. Channel alterations may also be proposed based on required watercourse crossings. Any channel alterations should incorporate natural channel design techniques.

8.0 **Required Blocks / Easements** – The locations of any blocks or easements required to convey and/or treat stormwater should be identified on the legal and engineering plans.

9.0 **Conclusions and Recommendations** – A summary of key findings and proposed designs.

<u>Appendices</u>

Typical Appendix material includes:

- Existing and Proposed Conditions Hydrologic Modeling (soft copy) complete with derivation (sample calculations) and/or reference materials in support of model parameters. Existing and proposed conditions hydrograph plots at all significant points of interest should be provided.
- Existing and Proposed Conditions Hydraulic Modeling (soft copy) complete with derivation and/or reference materials in support of model parameters. This applies to all proposed conveyance systems as well as the receiving waterbody.
- Any SWM specific agency correspondence, pre-consultation and preliminary SWM report submission checklists

Figures

Location Plan / Key Plan	Site location and surrounding land uses
Soil Map	Major soil types and borehole locations
Resource Map	Natural resource areas (recharge, wetlands, stream and valley corridors, high and/or steep slopes, floodlines, Regulation Limits)
Development Plan	Topographical map showing proposed development areas (should be combined with resource map, if possible), including lot layout servicing and private sewage system locations
Drainage Plans	Drainage areas, including external drainage for existing and proposed development conditions (separate figures) showing catchment IDs.
Modeling Schematics	Schematics of the existing and proposed conditions modeling should be prepared illustrating the subcatchment IDs, their connectivity, and any routing / storage elements.
Stormwater Controls	a) Locations for lot level controls, conveyance controls, and end-of-pipe controls b) Minor and major system flow paths c) Easement locations Final configuration and details of all proposed stormwater controls should be shown. The layout should show the proposed locations for inlets / outlets, direction of flow, approximate flow path length, width, depth, typical proposed grades (actual grading will not be possible), and property ownership (if relevant). Placement and details of any required infiltration measures are also required.
Instream Works	Canopy restoration, streambank protection / restoration.

Tables

Receiving Water Characteristics	Characteristics such as habitat classification, Rosgen stream type (if applicable), temperature regime, baseflow regime, erosion potential, flooding potential, water quality data, uses,
Soil Types	Area of each dominant soil type, associated rainfall abstraction parameters (CN values, Horton infiltration parameters, Green-Ampt coefficients, etc.)
SWM Criteria	Criteria to be used for SWM deign (quantity, quality, streambank / gully erosion, groundwater recharge, spills control, etc.)
Design Rainfall Events	The characteristics of the storms utilized in the design including station location / ID, storm distribution, storm duration, and time step.
Modeling Modification	Hydrologic modeling parameters for each subcatchment including elements such as: subcatchment nomenclature, area, % impervious / runoff coefficients, directly connected vs. indirectly connected impervious, depression storage, infiltration parameters, unit hydrograph constants, slope, length, width, and times of concentration / time to peaks.
Stage-Storage-Discharge Curves	The stage-storage-discharge relationships for any storage-type BMP should be included in the report and modeling. Incremental volume calculations for the SWM facility should be provided.
Modeling Results	A table should be produced, reflecting existing and proposed development conditions, and outlining peak flows, duration of critical erosive flow exceedances, or any other parameter of concern. The table should the control volumes (or the like) required for water quality treatment, erosion control, and flood control (for the range of design events).
Hydraulic Results	If a floodline analysis is undertaken, a table should be produced indicating the parameters used in the hydraulic analysis (i.e. Manning's 'n' values for channel and overbank areas, encroachments) and the results of the existing and proposed conditions floodline assessments for representative cross-sections across and adjacent to the study area. The comparison of computed water surface and energy grade line elevations should be presented for the range of design events to illustrate the lack of impact at variable recurrence intervals.

G.3 PRECONSULTATION AND SWM SUBMISSION CHECKLISTS

As described within Section 4 of the main Policy document, the ABCA is modifying the SWM review and approvals process to introduce and formalize a pre-consultative component into the process, and to more clearly identify those technical items that should be included in any complete SWM design package submission. In improving the clarity of what is expected of design submissions, the ABCA hopes to improve typical submission quality leading to a simpler, faster review and approval process.

The checklists contained on the following pages are considered 'working documents' and will be revised periodically as necessary to improve clarity, account for new elements, or eliminate elements that are rarely or never encountered. Electronic versions of the most up-to-date checklists will be available from the ABCA's website for download and it is recommended that practitioners utilize that resource so as to ensure that current versions are utilized.

ABCA SWM PRECONSULTATION CHECKLIST

The objective of the Preconsultation process is the definition of a terms of reference for the reporting and analysis required to support a proposed development application. This checklist is intended to provide a brief synopsis of the expectations of both the ABCA and the Consultant team, and should be completed jointly, prior to the initiation of studies and/or detailed design work. It is anticipated that the preparation of this checklist will help ensure complete submissions thereby minimizing the time and effort spent in the review / approval process. This checklist should be included with all submissions. The checklist was created in conjunction with the *SWM Policies and Technical Guidelines* document update (2008) and will be updated periodically as needed, with the current version available for download from the ABCA website (www.abca.on.ca).

Project Name / Type of Application (sub'n, sev, condo,…)				**ID #**			**General Location (attach Plan)**	
Watershed Study or Master Drainage Plan / Watercourse Name				**Development Area** ha			**Legal Outlet Available?** Yes No	
Surface Runoff Receiver	Major River	Creek	Municipal Drain	Unnamed Trib.	Existing Storm Sewer	Wetland	Internally Drained	Other :
Watercourse Receiver Classification	Cold Water	Warm Water	Water Supply	N/A	Other :			
Groundwater Receiver	Wellhead	Wetland	Local Stream	Regional Groundwater	N/A	Other :		
Development Concept	Single Residential	Multi-residential	Mixed	Rural Estate Residential	Commercial	Industrial	Other:	
Monitoring Requirements								
Permit Requirements								
Timelines / Expectations								

SWM Criteria

Water Quantity	Match Pre-devel Flows for : 2 5 25 100		Regional Flows	Unit Flows	Downstream Constraints	Other :			
Hydrologic Approach (Exis.Model?, Software, Discrete vs. Continuous)			**Hydraulic Approach (Existing Model?, Software)**				**Rainfall Data (Location, Duration)**		
Water Quality	Level 1 (Enhanced)	Downstream Constraints	PWQO	Bacteria	Temperature	None	Other :		
Stream Erosion	13 mm 25 mm	2 yr Vol 5 yr Vol	Existing Water Balance	Shear Stress	Critical Velocity	Impulse	Distributed Runoff Control	N/A	Other :
Recharge Quantity	None	25 mm Rooftop	Match Pre-development Infiltration	Match Pre-development Runoff	Match Baseflow	Other :			
Recharge Quality	None	Resid. Rooftops Only	All Rooftops	Some Roads	All Roads	Other :			

Other Criteria & Additional Notes (attach additional information as required)

Consultant Team Contact Information:	Landowner Contact Information:	Checklist Prepared by::
	ABCA Contact Information:	Date:

ABCA PRELIMINARY SWM SUBMISSION CHECKLIST

This checklist is intended for use by the Consultant to ensure that all components of a Preliminary SWM submission are included in an effort towards minimizing the time requirements of the review and approval process. Along with the Preconsultation Checklist, this checklist will also serve as a reference to ABCA staff that all supporting infomation has been provided, prior to proceeding with a circulation and/or review. It is recognized that the PSWM submission is typically submitted as a component in the Draft Plan Approval process. The user should note that this checklist covers only the SWM aspects of an overall submission and that items such as the Draft Plan itself and any other supporting environmental documentation may also be required. This checklist should be included with the Preliminary SWM submission. The checklist was created in conjunction with the *SWM Policies and Technical Guidelines* document update (2008) and will be updated periodically as necessary, with the current version available for download from the ABCA website (www.abca.on.ca).

Project Name	ID #

Main Report

Summary Listing of Background Report(s)	Yes	No	N/A
SWM Objectives / Criteria Summary	Yes	No	N/A
Description of Existing Conditions including Topography, Surface Drainage (with Externals), Soils, Groundwater Characteristics	Yes	No	N/A
Infiltration - Requirements, Proposed Strategy, Preliminary Results	Yes	No	N/A
Water Quality - Requirements, Proposed Strategy, Preliminary Results	Yes	No	N/A
Erosion Protection for Receivers - Requirements, Proposed Strategy, Preliminary Results	Yes	No	N/A
Water Quantity - Requirements, Proposed Strategy, Preliminary Results	Yes	No	N/A
Summary of Monitoring Programs completed, on-going, or anticipated	Yes	No	N/A
Erosion Potential Evaluation and Preliminary Control Strategy	Yes	No	N/A
SWM Infrastructure Ownership and Maintenance Strategies	Yes	No	N/A
Reports / Plans signed and sealed	Yes	No	N/A

Figures / Plans

Location Plan	Yes	No	N/A
Pre-Development Storm Drainage Boundaries - include internal and external contributing areas and existing topographic information	Yes	No	N/A
Post-Development Storm Drainage Boundaries - include preliminary drainage / grading information	Yes	No	N/A
Schematic Representations of Pre- and Post-Development Hydrologic Models	Yes	No	N/A
Preliminary Plans of SWMF's and Outlet Configurations (Plan and Profile)	Yes	No	N/A
Preliminary Grading and Servicing Plan(s) - include delineation of natural hazards (floodplains, wetlands, steep slopes, etc.), associated buffers, ABCA Regulated Limits and maximum flooding limits associated with proposed overland flow routes	Yes	No	N/A
Groundwater Elevations Plan - relative to preliminary grades (required primarily in areas where groundwater table may be an issue)	Yes	No	N/A

Appendices

Pre-Consultation Checklist	Yes	No	N/A
Hydrologic Modeling Input Parameters with Supporting Justification (calcs and/or references)	Yes	No	N/A
Stage-Storage-Discharge Table for SWMF (include sample equations and outlet characteristics)	Yes	No	N/A
Sediment Forebay Sizing Calculations (incl. % of perm. pool area, settling/dispersion lengths, velocity, cleanout frequency requirements)	Yes	No	N/A
Pre-Development Hydrologic Analysis	Yes	No	N/A
Post-Development Hydrologic Analysis	Yes	No	N/A
Pre-Development Hydraulic Analysis	Yes	No	N/A
Post-Development Hydraulic Analysis	Yes	No	N/A
Water Balance Analysis (Sizing of Infiltration Trenches / Galleries)	Yes	No	N/A
Geotechnical / Hydrogeological Report & Plan(s) - include groundwater contour mapping where high grwoundwater table may be an issue	Yes	No	N/A

Additional Items and/or Clarification Notes (attach additional information as required)

Consultant Team Contact Information:	Landowner Contact Information:	Checklist Prepared by::
	ABCA Contact Information:	Date:

ABCA FINAL SWM SUBMISSION CHECKLIST

This checklist is intended for use by the Consultant to ensure that all components of a Final SWM submission are included in an effort towards minimizing the time requirements of the review and approval process. Along with the Preconsultation Checklist and Preliminary SWM Checklist, it will serve as a reference to ABCA review staff that all required supporting infomation has been provided. This checklist should be included with the Final SWM submission. The checklist was created in conjunction with the *SWM Policies and Technical Guidelines* document update (2008) and will be updated periodically as necessary, with the current version available for download from the ABCA website (www.abca.on.ca).

Project Name	**ID #**		
Main Report			
Background Report(s) Summary	Yes	No	N/A
SWM Objectives / Criteria Summary	Yes	No	N/A
Description of Existing Conditions including Topography, Surface Drainage (with Externals), Soils, Groundwater Characteristics	Yes	No	N/A
Infiltration - Requirements, Proposed Strategy, Results	Yes	No	N/A
Water Quality - Requirements, Proposed Strategy, Results	Yes	No	N/A
Erosion Protection for Receivers - Requirements, Proposed Strategy, Results	Yes	No	N/A
Water Quantity - Requirements, Proposed Strategy, Results	Yes	No	N/A
Summary of Monitoring Programs completed, on-going, or anticipated	Yes	No	N/A
Erosion Potential Evaluation and Anticipated Control Strategy	Yes	No	N/A
SWM Infrastructure Ownership and Maintenance Strategies	Yes	No	N/A
Reports / Plans signed and sealed	Yes	No	N/A
Figures / Plans			
Location Plan	Yes	No	N/A
Pre-Development Storm Drainage Boundaries - include internal and external contributing areas and existing topographic information	Yes	No	N/A
Post-Development Storm Drainage Boundaries - include proposed grading information	Yes	No	N/A
Schematic Representations of Pre- and Post-Development Hydrologic Models	Yes	No	N/A
Plans and Profiles for SWM Facilities and Outlet Configurations - include summary of operational levels for design storm events	Yes	No	N/A
Preliminary Grading and Servicing Plan(s) - include delineation of natural hazards (floodplains, wetlands, steep slopes, etc.), associated buffers, ABCA Regulated Limits and maximum flooding limits associated with proposed overland flow routes	Yes	No	N/A
Cut/Fill Plan(s) - required primarily in floodplain areas or where high groundwater table may be an issue	Yes	No	N/A
Groundwater Elevations Plan - relative to proposed grades (required primarily in areas where high groundwater table may be an issue)	Yes	No	N/A
SWM Facility Landscape Plan(s)	Yes	No	N/A
Erosion and Sediment Control Plan(s)	Yes	No	N/A
Appendices			
Pre-Consultation Checklist	Yes	No	N/A
Hydrologic Modeling Input Parameters with Supporting Justification (calculations and/or references)	Yes	No	N/A
Stage-Storage-Discharge Table for SWMF (include sample equations and outlet characteristics)	Yes	No	N/A
Sediment Forebay Sizing Calculations (including Settling / Dispersion Lengths and Cleanout Frequency requirements)	Yes	No	N/A
Sizing analysis for all other components of the SWM system - conveyance, stability, etc.	Yes	No	N/A
Pre-Development Hydrologic Analysis	Yes	No	N/A
Post-Development Hydrologic Analysis	Yes	No	N/A
Pre-Development Hydraulic Analysis	Yes	No	N/A
Post-Development Hydraulic Analysis	Yes	No	N/A
Water Balance Analysis	Yes	No	N/A
Geotech./Hydrogeo. Report & Plan(s) - including groundwater contour mapping where high groundwater table may be an issue	Yes	No	N/A

Additional Items and/or Clarification Notes (attach additional information as required)

Consultant Team Contact Information:	Landowner Contact Information:	Checklist Prepared by::
	ABCA Contact Information:	Date:

G.4 TECHNICAL REVIEWERS CHECKLIST

This appendix provides a systematic checklist aimed at facilitating the review of SWM plans associated with development submissions by ABCA staff. The intent of this checklist is to promote a consistent approach to reviewing applications and to help staff ensure that all required information is provided. The checklist contains a comprehensive summary of the SWM aspects that *could* be of importance to a given application and will, therefore, contain a number of elements that may not be applicable to all development proposals.

Completion of the checklist should include sufficient detail to quickly summarize the information reviewed and the reviewer's conclusions of same. In some areas, simple checks will suffice to indicate the presence of the required information, while in others (e.g. background documentation) some point form notes will be more appropriate.

TECHNICAL REVIEWERS CHECKLIST

PROJECT NAME ____________________

REVIEW DATE ____________________

REVIEWED BY ____________________

MUNICIPALITY ____________________

PROJECT DESCRIPTION ____________________

____

SUBMISSION CONTENTS

BACKGROUND

- **RECEIVING WATER BODY (WATERCOURSE, WETLAND, ESA, LAKE, ETC.)** ____________________
- **EXISTING LAND USE** ____________________
- **WATERSHED AREA** ____________________
- **SOILS AND TOPOGRAPHY** ____________________
- **HYDROGEOLOGIC CONDITIONS** ____________________
- **FLUVIAL GEOMORPHOLOGIC CONDITIONS** ____________________

SWM CONSTRAINTS AND CONTROL CRITERIA	CRITERIA MET?		
WATER QUANTITY CONTROL - FLOODING	Y	N	N/A
WATER QUALITY CONTROL			
TSS REDUCTION	Y	N	N/A
TEMPERATURE	Y	N	N/A
BACTERIA	Y	N	N/A
EROSION (INSTREAM)	Y	N	N/A
EROSION (GULLY)	Y	N	N/A
WATER BALANCE (GROUNDWATER RECHARGE)	Y	N	N/A

SUITABLE OUTLET EXISTS FOR PROPOSED DISCHARGE? ____________________

LAND USE PLANNING FOR OTHER AREAS WITHIN WATERSHED (i.e. ADJACENT, UPSTREAM, OR DOWNSTREAM LANDS DEVELOPED OR ANTICIPATED TO BE DEVELOPED?) ANY EFFECT ON SWM OR DRAINAGE REQUIREMENTS?

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TECHNICAL REVIEWERS CHECKLIST

DRAINAGE

MAJOR FLOW ROUTES

- DESCRIPTION ____________________
- CAPACITY ____________________
- LAYOUT ____________________
- OUTLET ____________________
- EXTERNAL AREAS CONSIDERED? ____________________
- CONTAINMENT ____________________

MINOR CONVEYANCE SYSTEM

- DESCRIPTION ____________________
- CAPACITY ____________________
- LAYOUT ____________________
- OUTLET ____________________

EROSION AND SEDIMENT CONTROL

EROSION ASSESSMENT COMPLETED? ____________________

EROSION CONTROL STRATEGY

- GRADING TO BE PHASED? ____________________
- EXTENT OF EXPOSED AREA FOR A GIVEN PHASE ____________________
- REVEGETATION / STABILIZATION STRATEGY ____________________
- DITCH INVERTS ____________________
- CULVERT ENDS ____________________
- STORM OUTLETS ____________________
- SLOPE STABILITY ____________________
- MISCELLANEOUS ____________________

SEDIMENT CONTROL STRATEGY

- SILT FENCES ____________________
- STRAW BALES ____________________
- TEMPORARY SEDIMENTATION BASINS ____________________
- SWALES / DIVERSION BERMS ____________________
- CATCHBASIN PROTECTION ____________________
- TOPSOIL STOCKPILE PROTECTION ____________________
- OTHER ____________________

____

MONITORING / REPORTING REQUIREMENTS ____________________

____

TECHNICAL REVIEWERS CHECKLIST

FLOODLINES

- EXISTING FLOODPLAIN ON OR ADJACENT TO PROPOSED DEVELOPMENT ______
- PROPOSED ENCROACHMENT INTO FLOODPLAIN ______
- POTENTIAL FOR IMPACT ON FLOOD ELEVATIONS OR VELOCITIES ______
- IMPACT MITIGATION STRATEGY ______
- PROPOSED FLOODOPLAIN DELINEATION ______
- MISCELLANEOUS ______

HYDRAULIC MODELING

- APPROACH OR SOFTWARE UTILIZED ______
- MODELING INCLUDED ______
- FLOWS ANALYZED ______
- SECTION SPACING ______
- SECTION LOCATION ______
- LOSS COEFFICIENTS ______
- 'n' VALUES ______
- MISCELLANEOUS ______

HYDROLOGIC MODELING

- APPROACH OR SOFTWARE UTILIZED ______
- IDF DATA (STATION / DATE OF DATA USED) ______
- STORM DISTRIBUTION ______
- STORM DURATION ______
- RETURN-PERIOD EVENTS ASSESSED ______
- SENSITIVITY ANALYSIS COMPLETED ON DISTRIBUTION / DURATION ______

EXISTING DEVELOPMENT CONDITIONS

- DRAINAGE PLAN ______
- MODEL SCHEMATIC ______
- INPUT PARAMETERS AND JUSTIFICATION ______
- MISCELLANEOUS ______

PROPOSED DEVELOPMENT CONDITIONS

- DRAINAGE PLAN ______
- MODEL SCHEMATIC ______
- INPUT PARAMETERS AND JUSTIFICATION ______
- MISCELLANEOUS ______

TECHNICAL REVIEWERS CHECKLIST

STORMWATER MANAGEMENT STRATEGY

LOT LEVEL CONTROLS ______________________

CONVEYANCE LEVEL CONTROLS ______________________

END-OF-PIPE CONTROLS

FACILITY TYPE
- **WET POND** ______________________
- **CONSTRUCTED WETLAND** ______________________
- **HYBRID WET POND / CONSTRUCTED WETLAND** ______________________
- **DRY POND** ______________________
- **OTHER** ______________________

INLET ELEVATION ______________________

OUTLET ELEVATION ______________________

OUTLET CHARACTERISTICS ______________________

PERMANENT POOL DEPTH
- **FOREBAY** ______________________
- **MAIN CELL** ______________________

EXTENDED DETENTION EVENT (40m^3/ha, 25mm, other?) ______________________

EXTENDED DETENTION DEPTH ______________________

MAXIMUM OPERATING DEPTH / EVENT ______________________

FREEBOARD ABOVE MAXIMUM OPERATING DEPTH ______________________

% PERMANENT POOL AREA OCCUPIED BY FOREBAY ______________________

PLANTING STRATEGY INCLUDED AND APPROPRIATE ______________________

MAINTENANCE REQUIREMENTS / FREQUENCY ______________________

MAINTENANCE ACCESS PROVIDED ______________________

MISCELLANEOUS ______________________

OTHER SWM COMMENTS ______________________

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APPENDIX H

IDF Data for Watershed Stations

The IDF data presented herein cover the four AES gauge stations effectively bounding the watershed and reflect the most current information available for download from Environment Canada as of the printing of this document. Some key parameters about the data provided are summarized as follows:

Station Name	Station ID	Latitude	Longitude	Period of Record	
				Interval	Duration (yrs)
Goderich	6122847	43°46'	81°43'	1970-2003	18
London CS	6144475	43°02'	81°09'	1943-2003	55
Sarnia A	6127514	43°00'	82°19'	1962-2002	38
Stratford MOE	6148105	43°22'	81°00'	1966-2003	36

A fifth station, historically located just east of the watershed at Prospect Hill, has some IDF data available but the period of record is somewhat limited at 10 years and dated (last year of record was 1970) and, as such, this data was not included herein.

SWM practitioners within the watershed may wish to periodically review the available on-line data, as Environment Canada does complete periodic updates.

The data can be found at: http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

DATA INTEGRATION DIVISION
LA DIVISION DU TRAITEMENT DES DONNEES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 1 GODERICH ONT (COMPOSITE) 6122847

LATITUDE 4346 LONGITUDE 8143 ELEVATION/ALTITUDE 214 M

****

YEAR ANNEE	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
1970	6.6	8.6	12.4	16.0	16.0	16.5	23.1	25.7	36.8
1971	6.6	12.7	14.7	27.4	38.1	42.2	47.2	47.2	47.2
1972	7.4	11.9	15.2	23.9	35.1	63.0	77.5	77.5	77.5
1973	8.4	16.0	20.6	33.8	38.9	44.7	58.4	62.0	62.0
1974	8.9	17.3	18.0	19.0	20.6	22.6	33.5	45.0	47.5
1975	8.1	11.2	16.0	24.1	33.0	36.8	36.8	40.6	41.7
1976	10.7	14.5	20.8	34.8	41.7	41.7	41.7	44.2	57.4
1977	13.2	18.5	22.6	35.1	47.2	71.9	89.9	92.2	93.0
1978	7.0	11.8	14.8	17.1	19.8	23.2	28.8	32.6	45.6
1979	9.5	11.8	11.8	11.8	16.4	20.0	23.4	32.9	33.8
1980	7.0	13.0	15.8	17.1	17.8	18.0	26.2	30.7	32.0
1997	12.6	15.6	18.0	19.8	23.0	26.6	27.0	27.0	33.0
1998	15.0	23.0	30.8	39.2	39.4	39.4	39.4	39.6	39.6
1999	11.2	12.8	13.4	15.4	16.8	18.8	26.6	27.2	33.0
2000	19.8	36.8	44.2	56.0	75.2	79.8	80.2	80.4	80.8
2001	8.6	15.2	17.0	23.0	33.4	40.6	56.2	69.8	71.0
2002	11.8	15.4	21.4	26.2	28.4	28.6	29.6	30.0	35.8
2003	12.8	21.0	28.6	41.0	42.4	42.4	42.4	44.0	44.0

NOTE:-99.9 INDICATES MSG DATA
DONNEES MANQUANTES

	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
# YRS. ANNEES	18	18	18	18	18	18	18	18	18
MEAN MOYENNE	10.3	16.0	19.8	26.7	32.4	37.6	43.8	47.1	50.6
STD. DEV. ECART-TYPE	3.5	6.3	8.0	11.4	14.9	18.6	20.7	20.5	18.7
SKEW DISSYMETRIE	1.25	2.30	1.95	1.03	1.30	.99	1.11	.99	1.03
KURTOSIS KURTOSIS	5.11	9.82	7.58	4.38	6.06	3.79	3.60	3.27	3.38

WARNING / AVERTISSEMENT
YEAR 2000 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 2000 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 36.8 100 YEAR/ANNEE = 35.8

NOTE: -99.9 INDICATES LESS THAN 10 YEARS OF DATA AVAILABLE
INDIQUE MOINS DE 10 ANNEES DE DONNEES DISPONIBLES

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES
GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

****

TABLE 2 GODERICH ONT (COMPOSITE) 6122847

LATITUDE 4346 LONGITUDE 8143 ELEVATION/ALTITUDE 214 M

****

RETURN PERIOD RAINFALL AMOUNTS (MM)
PERIODE DE RETOUR QUANTITIES DE PLUIE (MM)

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS	# YEARS ANNEES
5 MIN	9.7	12.8	14.8	17.4	19.3	21.2	18
10 MIN	14.9	20.5	24.2	28.9	32.3	35.8	18
15 MIN	18.5	25.5	30.2	36.1	40.5	44.8	18
30 MIN	24.8	34.9	41.5	49.9	56.1	62.3	18
1 H	30.0	43.1	51.8	62.8	70.9	79.0	18
2 H	34.6	50.9	61.8	75.5	85.7	95.8	18
6 H	40.4	58.7	70.8	86.1	97.5	108.8	18
12 H	43.8	61.9	73.9	89.1	100.3	111.5	18
24 H	47.6	64.1	75.1	89.0	99.2	109.5	18

WARNING- VALUE IN DURATION 12 H IS GREATER THAN VALUE IN DURATION 24 H
(PROBABLE SAMPLING PROBLEM)
AVERTISSEMENT - LA VALEUR DE DUREE DE 12 H EST PLUS GRANDEQUE LA
VALEURE DUREE DE 24 H
WARNING- VALUE IN DURATION 12 H IS GREATER THAN VALUE IN DURATION 24 H
(PROBABLE SAMPLING PROBLEM)
AVERTISSEMENT - LA VALEUR DE DUREE DE 12 H EST PLUS GRANDEQUE LA
VALEURE DUREE DE 24 H
WARNING- VALUE IN DURATION 12 H IS GREATER THAN VALUE IN DURATION 24 H
(PROBABLE SAMPLING PROBLEM)
AVERTISSEMENT - LA VALEUR DE DUREE DE 12 H EST PLUS GRANDEQUE LA
VALEURE DUREE DE 24 H

RETURN PERIOD RAINFALL RATES (MM/HR)-95% CONFIDENCE' LIMITS
INTENSITE DE LA PLUIE PAR PERIODE DE RETOUR (MM/H)-LIMITES DE CONFIANCE DE 95%

DURATION/DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS
5 MIN	116.6	153.6	178.1	209.1	232.0	254.8
	+/- 17.8	+/- 29.9	+/- 40.4	+/- 54.5	+/- 65.2	+/- 75.9
10 MIN	89.5	122.9	145.1	173.1	193.9	214.6
	+/- 16.1	+/- 27.1	+/- 36.6	+/- 49.3	+/- 59.0	+/- 68.7
15 MIN	73.9	102.1	120.8	144.4	161.9	179.3
	+/- 13.5	+/- 22.8	+/- 30.8	+/- 41.5	+/- 49.7	+/- 57.9
30 MIN	49.7	69.7	83.0	99.8	112.3	124.6
	+/- 9.6	+/- 16.2	+/- 21.9	+/- 29.5	+/- 35.3	+/- 41.2
1 H	30.0	43.1	51.8	62.8	70.9	79.0
	+/- 6.3	+/- 10.6	+/- 14.3	+/- 19.3	+/- 23.1	+/- 26.9
2 H	17.3	25.5	30.9	37.8	42.8	47.9
	+/- 3.9	+/- 6.6	+/- 9.0	+/- 12.1	+/- 14.4	+/- 16.8
6 H	6.7	9.8	11.8	14.4	16.3	18.1
	+/- 1.5	+/- 2.5	+/- 3.3	+/- 4.5	+/- 5.4	+/- 6.3
12 H	3.6	5.2	6.2	7.4	8.4	9.3
	+/- .7	+/- 1.2	+/- 1.6	+/- 2.2	+/- 2.7	+/- 3.1
24 H	2.0	2.7	3.1	3.7	4.1	4.6
	+/- .3	+/- .6	+/- .8	+/- 1.0	+/- 1.2	+/- 1.4

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 3 GODERICH ONT (COMPOSITE) 6122847

LATITUDE 4346 LONGITUDE 8143 ELEVATION/ALTITUDE 214 M

****

INTERPOLATION EQUATION / EQUATION D"INTERPOLATION: R = A * T ** B
R = RAINFALL RATE / INTENSITE DE LA PLUIE (MM /HR)
T = TIME IN HOURS / TEMPS EN HEURES

STATISTICS STATISTIQUES	2 YR ANS	5 YR ANS	10 YR ANS	25 YR ANS	50 YR ANS	100 YR ANS
MEAN OF R MOYENNE DE R	43.2	59.3	70.0	83.6	93.6	03.5
STD. DEV. R ECART-TYPE	41.7	55.7	65.0	76.8	85.5	94.2
STD. ERROR ERREUR STANDARD	15.8	24.3	29.9	37.0	42.3	47.5
COEFF. (A) COEFFICIENT (A)	24.8	34.7	41.3	49.5	55.6	61.7
EXPONENT (B) EXPOSANT (B)	-.741	-.734	-.732	-.729	-.728	-.727
MEAN % ERROR % D'ERREUR	13.5	16.1	17.2	18.1	18.6	19.1

SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR-
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A

GODERICH (Composite) ONT

GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD

1970 - 2003 18 YEARS/AN

PREPARED BY - PREPARE PAR LE
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

DATA INTEGRATION DIVISION
LA DIVISION DU TRAITEMENT DES DONNEES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

****

TABLE 1 LONDON CS ONT (COMPOSITE) 6144475

LATITUDE 4302 LONGITUDE 8109 ELEVATION/ALTITUDE 278 M
****

YEAR ANNEE	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
1943	18.3	24.1	26.2	36.3	51.1	53.8	53.8	56.1	78.7
1944	7.6	8.1	11.2	15.2	21.1	34.3	47.0	51.8	56.1
1945	6.6	9.7	12.7	17.3	19.3	25.4	34.3	39.4	47.8
1946	13.2	14.5	15.5	29.7	48.3	60.5	61.5	61.5	83.3
1947	10.9	19.3	23.9	29.2	29.2	29.2	40.9	43.2	46.7
1952	7.9	12.7	15.2	28.7	30.5	30.5	38.4	39.9	74.2
1953	15.7	24.6	36.8	56.9	83.3	83.3	83.3	83.3	83.3
1954	10.9	12.7	17.0	21.6	29.2	32.8	39.1	52.6	78.0
1955	6.6	9.1	11.2	14.2	14.7	17.3	32.5	44.2	51.1
1956	9.1	10.7	11.7	16.8	20.1	35.3	40.4	42.7	53.8
1957	6.3	9.4	12.4	16.5	26.2	28.2	35.6	47.5	55.6
1958	7.6	9.7	11.2	15.7	16.5	18.5	29.2	39.1	39.9
1959	8.6	10.9	13.0	15.5	23.4	39.6	50.3	50.5	50.5
1960	9.1	12.7	16.8	27.7	28.2	38.9	39.9	42.4	46.7
1961	11.4	20.1	23.9	29.0	39.9	43.2	43.4	43.4	43.4
1962	8.6	16.5	17.0	17.0	18.8	26.7	29.0	34.8	35.1
1963	5.6	7.9	9.1	10.4	10.4	11.4	21.3	21.3	23.9
1964	7.9	10.9	14.2	19.0	23.9	32.3	38.1	59.2	67.3
1965	5.6	10.4	11.7	14.2	18.3	21.1	29.0	38.4	43.7
1966	8.4	8.4	8.9	14.2	19.3	27.4	43.9	52.6	52.6
1967	7.9	11.9	12.2	19.3	20.6	22.4	33.5	37.3	41.4
1968	10.4	13.2	16.0	24.6	28.7	32.3	53.1	67.6	84.6
1969	6.9	10.2	13.5	15.7	15.7	18.5	27.4	39.9	47.5
1970	10.9	13.0	16.5	17.0	21.1	22.1	23.9	33.3	36.8
1971	8.9	15.0	22.4	32.5	39.1	42.7	42.7	42.7	42.7
1972	14.5	20.1	22.9	22.9	34.3	40.6	58.4	59.7	62.5
1973	7.4	9.4	13.5	17.0	17.8	19.6	31.5	40.4	52.1
1974	4.8	7.9	9.1	10.9	13.2	22.4	29.2	30.2	35.3
1975	9.1	12.4	15.2	18.5	21.1	21.1	27.9	30.5	30.5
1976	18.5	26.9	27.7	29.2	30.5	30.7	37.8	40.9	50.0
1978	6.6	10.9	14.2	14.4	14.4	14.4	23.5	27.3	29.6
1979	19.2	33.5	37.6	45.9	46.0	46.0	46.6	65.4	68.2
1980	11.5	20.6	27.8	30.6	32.5	32.6	37.7	47.1	61.7
1981	10.1	12.5	13.2	13.2	16.2	26.7	35.0	37.5	43.5
1982	6.8	10.8	15.1	22.2	24.6	28.6	35.4	36.8	37.6
1983	13.5	23.4	29.5	37.6	41.1	41.1	47.0	55.8	64.4
1984	9.8	10.6	14.5	27.4	27.8	43.5	50.8	56.0	69.7
1985	8.3	10.9	13.7	22.8	29.0	35.1	43.2	56.8	65.0
1986	12.4	22.7	24.2	24.5	30.6	42.2	43.8	49.7	89.1
1987	6.7	9.4	11.0	13.2	14.3	17.7	27.2	44.5	56.5
1988	7.9	11.2	15.5	18.2	18.3	26.9	33.0	41.9	61.6

1989	8.7	10.9	13.5	23.3	25.7	25.8	25.8	34.0	34.8
1990	11.9	16.7	18.7	30.4	35.1	37.9	41.6	54.1	75.5
1991	9.7	11.6	13.9	17.5	20.6	22.0	28.1	32.2	32.2
1992	6.5	11.5	15.9	20.9	35.0	45.2	51.8	58.6	76.3
1993	9.4	14.3	15.1	19.1	21.9	25.0	28.5	30.7	49.2
1994	7.5	11.3	12.1	16.8	20.6	33.2	38.9	40.3	46.5
1995	8.2	11.3	12.6	15.8	21.8	28.0	37.8	45.0	56.1
1996	9.4	15.8	17.9	26.1	39.2	68.1	82.7	83.5	89.0
1997	10.6	17.0	19.6	21.8	21.8	24.8	31.1	33.9	33.9
1998	12.6	14.7	15.8	17.6	20.4	20.4	20.4	20.4	33.0
1999	7.3	11.2	11.8	12.7	13.3	19.0	25.9	26.1	32.9
2000	11.5	15.3	17.6	23.0	30.6	40.6	42.7	59.2	82.8
2001	6.3	7.9	10.6	13.2	13.4	14.0	24.0	35.0	41.2
2003	10.0	18.4	23.2	26.2	26.2	27.8	31.2	40.8	40.8

NOTE:-99.9 INDICATES MSG DATA
DONNEES MANQUANTES

# YRS. ANNEES	55	55	55	55	55	55	55	55	55
MEAN MOYENNE	9.6	13.9	16.8	21.9	26.4	31.8	38.7	45.1	53.9
STD. DEV. ECART-TYPE	3.2	5.4	6.4	8.8	12.2	13.4	12.9	13.2	17.5
SKEW DISSYMETRIE	1.30	1.50	1.51	1.65	2.18	1.51	1.52	.78	.45
KURTOSIS KURTOSIS	4.80	5.36	5.27	7.02	10.75	6.55	6.47	4.15	2.31

WARNING / AVERTISSEMENT
YEAR 1953 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1953 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 56.9 100 YEAR/ANNEE = 49.5

WARNING / AVERTISSEMENT
YEAR 1953 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1953 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 83.3 100 YEAR/ANNEE = 64.6

WARNING / AVERTISSEMENT
YEAR 1953 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1953 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 83.3 100 YEAR/ANNEE = 73.9

WARNING / AVERTISSEMENT
YEAR 1953 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1953 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 83.3 100 YEAR/ANNEE = 79.2

WARNING / AVERTISSEMENT
YEAR 1979 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1979 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 33.5 100 YEAR/ANNEE = 31.0

WARNING / AVERTISSEMENT
YEAR 1979 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1979 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 37.6   100 YEAR/ANNEE = 37.0

WARNING / AVERTISSEMENT
YEAR 1996 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1996 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 82.7   100 YEAR/ANNEE = 79.2

NOTE: -99.9 INDICATES LESS THAN 10 YEARS OF DATA AVAILABLE
INDIQUE MOINS DE 10 ANNEES DE DONNEES DISPONIBLES

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 2 LONDON CS ONT (COMPOSITE) 6144475

LATITUDE 4302 LONGITUDE 8109 ELEVATION/ALTITUDE 278 M

****

RETURN PERIOD RAINFALL AMOUNTS (MM)
PERIODE DE RETOUR QUANTITIES DE PLUIE (MM)

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS	# YEARS ANNEES
5 MIN	9.1	11.9	13.8	16.2	17.9	19.7	55
10 MIN	13.1	17.8	21.0	25.0	28.0	31.0	55
15 MIN	15.7	21.4	25.2	29.9	33.5	37.0	55
30 MIN	20.5	28.3	33.4	39.9	44.7	49.5	55
1 H	24.4	35.2	42.3	51.3	58.0	64.6	55
2 H	29.6	41.5	49.3	59.3	66.6	73.9	55
6 H	36.6	48.0	55.6	65.1	72.2	79.2	55
12 H	42.9	54.6	62.3	72.1	79.3	86.5	55
24 H	51.1	66.5	76.7	89.6	99.2	108.7	55

RETURN PERIOD RAINFALL RATES (MM/HR)-95% CONFIDENCE' LIMITS
INTENSITE DE LA PLUIE PAR PERIODE DE RETOUR (MM/H)-LIMITES DE CONFIANCE DE 95%

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS
5 MIN	108.8	142.8	165.4	193.9	215.0	236.0
	+/- 9.3	+/- 15.7	+/- 21.3	+/- 28.7	+/- 34.3	+/- 40.0
10 MIN	78.3	107.0	126.1	150.2	168.0	185.7
	+/- 7.9	+/- 13.3	+/- 18.0	+/- 24.2	+/- 29.0	+/- 33.7
15 MIN	62.9	85.6	100.7	119.7	133.9	147.9
	+/- 6.2	+/- 10.5	+/- 14.2	+/- 19.1	+/- 22.9	+/- 26.7
30 MIN	41.0	56.5	66.8	79.8	89.4	99.0
	+/- 4.3	+/- 7.2	+/- 9.7	+/- 13.1	+/- 15.6	+/- 18.2
1 H	24.4	35.2	42.3	51.3	58.0	64.6
	+/- 3.0	+/- 5.0	+/- 6.7	+/- 9.1	+/- 10.8	+/- 12.6
2 H	14.8	20.7	24.7	29.6	33.3	37.0
	+/- 1.6	+/- 2.7	+/- 3.7	+/- 5.0	+/- 6.0	+/- 7.0
6 H	6.1	8.0	9.3	10.9	12.0	13.2
	+/- .5	+/- .9	+/- 1.2	+/- 1.6	+/- 1.9	+/- 2.2
12 H	3.6	4.5	5.2	6.0	6.6	7.2
	+/- .3	+/- .4	+/- .6	+/- .8	+/- 1.0	+/- 1.1
24 H	2.1	2.8	3.2	3.7	4.1	4.5
	+/- .2	+/- .3	+/- .4	+/- .5	+/- .6	+/- .8

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 3 LONDON CS ONT (COMPOSITE) 6144475

LATITUDE 4302 LONGITUDE 8109 ELEVATION/ALTITUDE 278 M

****

INTERPOLATION EQUATION / EQUATION D"INTERPOLATION: R = A * T ** B
R = RAINFALL RATE / INTENSITE DE LA PLUIE (MM /HR)
T = TIME IN HOURS / TEMPS EN HEURES

STATISTICS STATISTIQUES	2 YR ANS	5 YR ANS	10 YR ANS	25 YR ANS	50 YR ANS	100 YR ANS
MEAN OF R MOYENNE DE R	38.0	51.4	60.4	71.6	80.0	88.3
STD. DEV. R ECART-TYPE	37.8	50.3	58.6	69.1	76.9	84.6
STD. ERROR ERREUR STANDARD	8.7	14.8	18.9	24.0	27.8	31.6
COEFF. (A) COEFFICIENT (A)	22.2	30.0	35.1	41.6	46.5	51.2
EXPONENT (B) EXPOSANT (B)	-.714	-.722	-.726	-.729	-.731	-.733
MEAN % ERROR % D'ERREUR	7.8	10.4	11.5	12.5	13.1	13.5

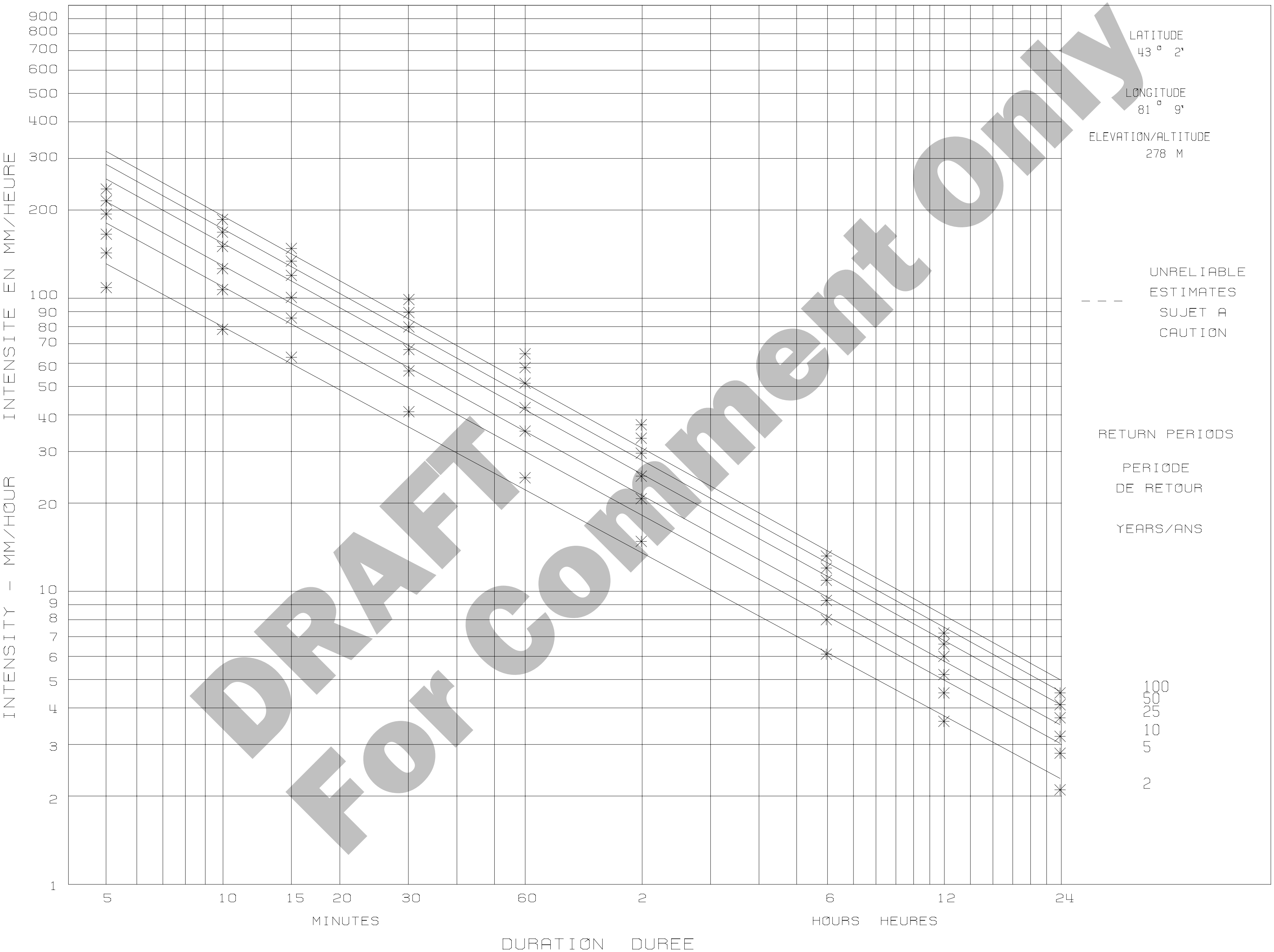
SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR-
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A

LONDON CS (Composite) ONT

GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD

1943 - 2003 55 YEARS/AN



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SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

DATA INTEGRATION DIVISION
LA DIVISION DU TRAITEMENT DES DONNEES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

****

TABLE 1 SARNIA A ONT (COMPOSITE) 6127514

LATITUDE 4300 LONGITUDE 8219 ELEVATION/ALTITUDE 181 M

****

YEAR ANNEE	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
1962	8.4	14.0	17.3	30.5	48.3	57.2	66.1	69.6	86.5
1963	7.4	10.2	12.4	18.0	21.6	27.7	39.9	42.2	48.6
1964	10.7	18.0	18.8	20.8	21.6	22.9	43.4	47.2	48.5
1965	4.6	7.6	8.4	9.1	10.4	11.2	23.1	34.3	45.7
1966	11.2	12.2	12.7	14.5	20.6	25.4	50.5	53.3	57.9
1967	11.4	15.5	17.3	18.0	20.6	22.4	32.1	40.5	47.9
1968	20.6	31.0	35.3	40.9	41.4	41.4	48.5	58.9	66.2
1969	6.6	10.7	14.5	15.5	21.6	25.9	30.2	39.6	44.1
1970	6.6	11.2	15.2	22.6	31.5	38.6	64.8	64.8	64.8
1971	23.9	28.4	32.3	33.8	33.8	34.5	34.5	43.7	43.7
1972	3.6	5.8	6.3	8.1	11.4	17.3	26.7	38.6	62.5
1973	10.9	20.3	24.4	29.0	29.0	29.0	29.0	29.0	30.7
1974	7.6	9.7	13.2	22.1	24.9	28.4	30.0	30.0	37.1
1975	11.2	15.5	18.3	19.8	22.1	22.4	41.9	49.3	49.5
1976	10.2	15.2	20.8	22.1	23.4	23.4	33.8	39.4	56.9
1977	10.9	12.4	16.0	19.0	21.1	21.6	21.8	36.1	40.9
1978	11.7	11.7	11.7	12.7	12.7	14.5	23.8	27.4	27.4
1979	14.6	25.0	29.1	39.5	44.6	56.1	63.8	63.9	63.9
1980	13.1	17.6	18.3	20.8	23.1	28.4	30.9	30.9	35.2
1981	7.0	11.2	13.0	17.6	23.0	29.8	39.2	54.7	57.4
1982	2.3	4.5	6.5	12.7	25.2	29.7	49.6	52.6	52.6
1983	9.8	12.5	13.7	17.1	20.4	25.4	35.8	40.8	40.9
1984	12.1	22.7	29.0	32.9	38.7	46.0	64.9	68.4	88.6
1985	12.9	18.7	22.0	28.6	31.0	31.6	32.0	39.8	63.2
1986	11.0	16.3	20.4	26.4	26.4	35.8	41.4	58.0	59.6
1987	10.6	13.4	16.5	21.0	24.3	25.7	37.7	56.7	56.9
1988	10.2	12.2	15.3	30.6	36.8	37.0	51.7	80.3	85.6
1989	14.0	16.8	22.0	24.8	27.2	28.8	31.8	31.8	45.4
1990	6.8	10.2	12.9	14.9	17.2	20.5	25.0	27.0	36.7
1992	10.6	17.6	26.4	35.2	36.6	38.9	46.9	51.6	51.6
1993	10.3	11.8	16.4	23.7	25.7	36.2	41.6	44.4	72.6
1994	17.4	19.9	24.6	31.7	34.3	36.8	47.2	47.2	53.4
1995	10.2	16.9	21.8	27.4	33.6	55.6	78.8	79.0	79.0
1996	10.6	13.7	18.4	35.7	45.8	47.4	49.2	85.4	98.5
1998	5.7	9.0	11.2	12.3	16.1	20.0	41.0	42.2	52.3
2000	10.0	15.6	17.1	23.1	31.5	31.7	43.1	70.0	70.0
2001	5.6	7.6	8.1	12.6	17.2	22.7	29.8	41.5	52.8
2002	7.0	7.5	8.2	13.3	17.4	19.1	19.1	25.6	25.8

NOTE:-99.9 INDICATES MSG DATA
DONNEES MANQUANTES

# YRS. ANNEES	38	38	38	38	38	38	38	38	38
MEAN MOYENNE	10.2	14.5	17.5	22.6	26.6	30.7	40.5	48.3	55.3
STD. DEV. ECART-TYPE	4.2	5.8	6.9	8.5	9.5	11.1	13.9	15.8	17.1
SKEW DISSYMETRIE	1.05	.90	.63	.36	.54	.83	.83	.65	.61
KURTOSIS KURTOSIS	5.61	4.22	3.37	2.52	2.96	3.58	3.60	2.89	3.37

WARNING / AVERTISSEMENT
YEAR 1971 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1971 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 23.9 100 YEAR/ANNEE = 23.5

NOTE: -99.9 INDICATES LESS THAN 10 YEARS OF DATA AVAILABLE
INDIQUE MOINS DE 10 ANNEES DE DONNEES DISPONIBLES

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 2 SARNIA A ONT (COMPOSITE) 6127514

LATITUDE 4300 LONGITUDE 8219 ELEVATION/ALTITUDE 181 M

****

RETURN PERIOD RAINFALL AMOUNTS (MM)
PERIODE DE RETOUR QUANTITIES DE PLUIE (MM)

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS	# YEARS ANNEES
5 MIN	9.6	13.3	15.8	18.9	21.2	23.5	38
10 MIN	13.5	18.7	22.1	26.4	29.6	32.7	38
15 MIN	16.4	22.5	26.6	31.7	35.5	39.3	38
30 MIN	21.2	28.7	33.7	40.0	44.7	49.4	38
1 H	25.1	33.4	39.0	46.0	51.1	56.3	38
2 H	28.9	38.7	45.2	53.5	59.5	65.6	38
6 H	38.3	50.5	58.6	68.9	76.5	84.0	38
12 H	45.7	59.6	68.9	80.5	89.2	97.8	38
24 H	52.5	67.6	77.6	90.2	99.6	108.9	38

RETURN PERIOD RAINFALL RATES (MM/HR)-95% CONFIDENCE' LIMITS
INTENSITE DE LA PLUIE PAR PERIODE DE RETOUR (MM/H)-LIMITES DE CONFIANCE DE 95%

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS
5 MIN	114.6	159.5	189.3	226.8	254.7	282.3
	+/- 14.8	+/- 25.0	+/- 33.7	+/- 45.5	+/- 54.4	+/- 63.4
10 MIN	81.1	112.0	132.5	158.3	177.4	196.5
	+/- 10.2	+/- 17.2	+/- 23.2	+/- 31.3	+/- 37.4	+/- 43.6
15 MIN	65.5	90.1	106.4	126.9	142.1	157.3
	+/- 8.1	+/- 13.7	+/- 18.5	+/- 24.9	+/- 29.8	+/- 34.7
30 MIN	42.4	57.5	67.5	80.1	89.4	98.7
	+/- 5.0	+/- 8.4	+/- 11.3	+/- 15.3	+/- 18.3	+/- 21.3
1 H	25.1	33.4	39.0	46.0	51.1	56.3
	+/- 2.8	+/- 4.6	+/- 6.3	+/- 8.5	+/- 10.1	+/- 11.8
2 H	14.4	19.4	22.6	26.7	29.8	32.8
	+/- 1.6	+/- 2.7	+/- 3.7	+/- 5.0	+/- 6.0	+/- 6.9
6 H	6.4	8.4	9.8	11.5	12.7	14.0
	+/- .7	+/- 1.1	+/- 1.5	+/- 2.1	+/- 2.5	+/- 2.9
12 H	3.8	5.0	5.7	6.7	7.4	8.1
	+/- .4	+/- .6	+/- .9	+/- 1.2	+/- 1.4	+/- 1.6
24 H	2.2	2.8	3.2	3.8	4.1	4.5
	+/- .2	+/- .3	+/- .5	+/- .6	+/- .8	+/- .9

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 3 SARNIA A ONT (COMPOSITE) 6127514

LATITUDE 4300 LONGITUDE 8219 ELEVATION/ALTITUDE 181 M

****

INTERPOLATION EQUATION / EQUATION D"INTERPOLATION: R = A * T ** B
R = RAINFALL RATE / INTENSITE DE LA PLUIE (MM /HR)
T = TIME IN HOURS / TEMPS EN HEURES

STATISTICS STATISTIQUES	2 YR ANS	5 YR ANS	10 YR ANS	25 YR ANS	50 YR ANS	100 YR ANS
MEAN OF R MOYENNE DE R	39.5	54.2	63.9	76.3	85.4	94.5
STD. DEV. R ECART-TYPE	39.7	55.3	65.7	78.7	88.4	98.0
STD. ERROR ERREUR STANDARD	8.3	11.5	13.6	16.4	18.4	20.4
COEFF. (A) COEFFICIENT (A)	22.9	30.9	36.2	42.8	47.7	52.6
EXPONENT (B) EXPOSANT (B)	-.715	-.728	-.733	-.738	-.741	-.744
MEAN % ERROR % D'ERREUR	6.5	6.5	6.5	6.5	6.5	6.5


SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR-
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A
SARNIA A
(Composite)
ONT
GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD
1962 - 2002
38 YEARS/AN
LATITUDE
43 ° 0'
LONGITUDE
82 ° 19'
ELEVATION/ALTITUDE
181 M
UNRELIABLE
ESTIMATES
SUJET A
CAUTION
RETURN PERIODS
PERIODE
DE RETOUR
YEARS/ANS
100
50
25
10
5
2
INTENSITY - MM/HOUR
INTENSITE EN MM/HEURE
MINUTES
HOURS HEURES
DURATION DUREE
PREPARED BY - PREPARE PAR LE
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA
DRAFT
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RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

DATA INTEGRATION DIVISION
LA DIVISION DU TRAITEMENT DES DONNEES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 1 STRATFORD MOE ONT 6148105

LATITUDE 4322 LONGITUDE 8100 ELEVATION/ALTITUDE 354 M

****

YEAR ANNEE	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
1966	11.7	14.0	15.0	17.0	17.8	28.2	39.9	40.1	43.4
1967	11.9	15.2	20.8	24.9	25.4	34.3	39.6	39.6	40.1
1968	10.4	17.5	18.5	22.9	33.0	54.9	70.1	73.2	83.1
1969	8.6	14.2	16.8	19.8	19.8	35.3	55.9	56.4	56.4
1970	7.1	11.9	14.7	19.6	27.9	39.9	62.0	64.3	67.8
1971	5.8	10.2	15.2	17.0	17.0	22.4	27.9	31.7	31.7
1972	7.9	9.9	11.2	14.7	14.7	15.5	26.2	40.1	56.6
1974	6.1	7.9	10.4	10.4	10.9	14.0	24.9	35.1	46.5
1975	9.1	14.0	18.3	22.6	29.5	34.3	40.4	51.3	55.1
1976	15.2	16.0	17.3	17.3	17.3	18.0	38.1	56.4	61.0
1977	10.9	18.5	21.6	24.9	27.7	30.0	41.9	43.7	43.7
1978	5.2	7.2	9.4	15.9	20.2	37.2	43.0	43.0	48.1
1979	6.0	10.1	14.1	14.1	15.7	15.8	30.3	44.0	46.4
1980	9.7	13.1	17.4	21.3	27.3	33.9	38.0	38.0	38.0
1981	-99.9	-99.9	-99.9	41.4	41.6	44.5	56.9	59.8	88.2
1982	8.0	11.3	13.8	17.2	20.6	22.4	46.7	48.0	48.0
1983	12.2	20.4	26.1	40.2	43.2	79.2	135.2	141.1	142.8
1984	9.3	10.5	10.9	14.9	17.7	18.7	36.0	40.6	44.8
1985	6.0	12.0	17.3	23.5	31.4	35.8	37.4	38.2	40.9
1986	8.9	13.9	19.0	27.7	37.6	44.6	51.8	68.9	106.6
1987	6.7	11.4	12.6	20.2	30.4	33.3	38.2	38.2	38.2
1988	7.6	11.3	14.5	20.2	22.3	28.2	34.2	41.2	47.4
1989	8.8	9.6	11.8	13.2	13.4	16.9	21.7	39.4	41.6
1990	8.5	13.7	17.2	27.3	34.7	53.9	72.6	72.6	72.6
1991	7.2	10.9	15.7	19.4	19.4	19.7	26.0	26.4	26.7
1992	10.8	16.6	18.4	24.1	27.1	35.4	40.4	42.0	61.0
1993	7.0	9.9	10.6	12.1	17.6	18.5	23.2	23.6	43.7
1994	13.4	16.3	16.9	17.3	17.5	19.4	32.4	43.7	44.6
1995	16.1	21.0	28.2	31.0	33.5	36.9	39.5	46.0	47.8
1996	5.7	9.1	13.2	14.9	15.3	16.8	29.4	47.1	59.8
1997	7.1	10.0	11.0	11.5	15.0	18.8	26.1	26.5	32.8
1998	6.1	10.2	12.0	12.8	14.5	15.6	17.5	30.2	40.2
2000	11.3	18.5	27.2	38.7	44.9	48.8	94.0	101.0	101.0
2001	9.8	10.0	10.6	14.1	15.3	15.3	20.4	24.0	35.8
2002	12.0	20.6	24.1	41.6	65.2	96.1	107.2	135.2	136.0
2003	5.8	11.1	14.7	18.3	19.8	23.2	28.1	33.7	39.2

NOTE:-99.9 INDICATES MSG DATA
DONNEES MANQUANTES

# YRS. ANNEES	35	35	35	36	36	36	36	36	36
MEAN MOYENNE	9.0	13.1	16.2	21.2	25.1	32.1	44.3	50.7	57.2
STD. DEV. ECART-TYPE	2.8	3.7	4.9	8.4	11.4	18.0	25.1	26.7	27.3
SKEW DISSYMETRIE	.77	.68	.90	1.23	1.52	1.83	2.07	2.23	1.86
KURTOSIS KURTOSIS	3.27	2.74	3.58	4.07	6.17	7.29	7.83	8.31	6.29

WARNING / AVERTISSEMENT
YEAR 1983 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1983 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 135.2   100 YEAR/ANNEE = 122.8

WARNING / AVERTISSEMENT
YEAR 1983 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 1983 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 141.1   100 YEAR/ANNEE = 134.3

WARNING / AVERTISSEMENT
YEAR 2002 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 2002 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 65.2   100 YEAR/ANNEE = 60.7

WARNING / AVERTISSEMENT
YEAR 2002 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 2002 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 96.1   100 YEAR/ANNEE = 88.5

WARNING / AVERTISSEMENT
YEAR 2002 HAD VALUE GREATER THAN 100 YEAR STORM.
EN 2002 L"INTENSITE DE LA PLUIE A DE PASSE
CELLE POUR UNE PERIODE DE RETOUR DE 100 ANS
DATA/LA VALEUR = 135.2   100 YEAR/ANNEE = 134.3

NOTE: -99.9 INDICATES LESS THAN 10 YEARS OF DATA AVAILABLE
INDIQUE MOINS DE 10 ANNEES DE DONNEES DISPONIBLES

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990
****

TABLE 2 STRATFORD MOE ONT 6148105

LATITUDE 4322 LONGITUDE 8100 ELEVATION/ALTITUDE 354 M
****

RETURN PERIOD RAINFALL AMOUNTS (MM)
PERIODE DE RETOUR QUANTITIES DE PLUIE (MM)

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS	# YEARS ANNEES
5 MIN	8.5	11.0	12.6	14.7	16.2	17.7	35
10 MIN	12.5	15.8	17.9	20.7	22.7	24.8	35
15 MIN	15.4	19.7	22.5	26.1	28.8	31.5	35
30 MIN	19.8	27.3	32.2	38.5	43.1	47.7	36
1 H	23.2	33.2	39.9	48.3	54.5	60.7	36
2 H	29.2	45.0	55.6	68.8	78.7	88.5	36
6 H	40.1	62.3	76.9	95.5	109.2	122.8	36
12 H	46.3	69.8	85.5	105.2	119.8	134.3	36
24 H	52.7	76.8	92.8	113.0	128.0	142.9	36

RETURN PERIOD RAINFALL RATES (MM/HR)-95% CONFIDENCE' LIMITS
INTENSITE DE LA PLUIE PAR PERIODE DE RETOUR (MM/H)-LIMITES DE CONFIANCE DE 95%

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS
5 MIN	102.1	131.6	151.2	175.9	194.2	212.4
	+/- 10.2	+/- 17.1	+/- 23.1	+/- 31.2	+/- 37.3	+/- 43.4
10 MIN	74.8	94.6	107.7	124.2	136.5	148.6
	+/- 6.8	+/- 11.4	+/- 15.5	+/- 20.9	+/- 24.9	+/- 29.1
15 MIN	61.5	78.7	90.2	104.5	115.2	125.8
	+/- 5.9	+/- 10.0	+/- 13.5	+/- 18.2	+/- 21.7	+/- 25.3
30 MIN	39.7	54.6	64.5	76.9	86.2	95.4
	+/- 5.1	+/- 8.5	+/- 11.5	+/- 15.5	+/- 18.6	+/- 21.6
1 H	23.2	33.2	39.9	48.3	54.5	60.7
	+/- 3.4	+/- 5.7	+/- 7.8	+/- 10.5	+/- 12.5	+/- 14.6
2 H	14.6	22.5	27.8	34.4	39.3	44.2
	+/- 2.7	+/- 4.5	+/- 6.1	+/- 8.3	+/- 9.9	+/- 11.5
6 H	6.7	10.4	12.8	15.9	18.2	20.5
	+/- 1.3	+/- 2.1	+/- 2.8	+/- 3.8	+/- 4.6	+/- 5.4
12 H	3.9	5.8	7.1	8.8	10.0	11.2
	+/- .7	+/- 1.1	+/- 1.5	+/- 2.0	+/- 2.4	+/- 2.8
24 H	2.2	3.2	3.9	4.7	5.3	6.0
	+/- .3	+/- .6	+/- .8	+/- 1.0	+/- 1.3	+/- 1.5

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

****

TABLE 3 STRATFORD MOE ONT 6148105

LATITUDE 4322 LONGITUDE 8100 ELEVATION/ALTITUDE 354 M

****

INTERPOLATION EQUATION / EQUATION D"INTERPOLATION: R = A * T ** B
R = RAINFALL RATE / INTENSITE DE LA PLUIE (MM /HR)
T = TIME IN HOURS / TEMPS EN HEURES

STATISTICS STATISTIQUES	2 YR ANS	5 YR ANS	10 YR ANS	25 YR ANS	50 YR ANS	100 YR ANS
MEAN OF R MOYENNE DE R	36.5	48.3	56.1	65.9	73.2	80.5
STD. DEV. R ECART-TYPE	35.7	45.0	51.2	59.0	64.9	70.7
STD. ERROR ERREUR STANDARD	8.0	10.2	11.8	14.0	15.6	17.3
COEFF. (A) COEFFICIENT (A)	22.0	30.8	36.5	43.7	49.1	54.4
EXPONENT (B) EXPOSANT (B)	-.690	-.656	-.642	-.629	-.623	-.617
MEAN % ERROR % D'ERREUR	7.6	10.1	11.1	12.0	12.7	13.2

SHORT DURATION RAINFALL INTENSITY-DURATION FREQUENCY DATA FOR- STRATFORD MOE ONT
DONNEES SUR L'INTENSITE,LA DUREE ET LA FREQUENCE DES CHUTES DE PLUIE DE COURTE DUREE A

GUMBEL-METHOD OF MOMENTS
METHODE DES MOMENTS

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD- 1966 - 2003 36 YEARS/AN
BASEES SUR LES DONNEES DU PLUVIOGRAPHES POUR LA PERIOD

PREPARED BY - PREPARE PAR LE

ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE - ENVIRONNEMENT CANADA

APPENDIX I

Erosion and Sediment Control

Table of Contents – Appendix I

List of Tables

I.1 EROSION AND SEDIMENT CONTROL - GENERAL

Construction activities disturb the typically vegetated cover of an area, exposing the underlying soil and increasing susceptibility to erosion. During a runoff-generating event (rainfall or snowmelt), soil particles become suspended in stormwater and are transported and deposited downstream, which can result in the sedimentation of lakes, rivers, and wetlands thereby affecting flood control and conveyance, fish habitat, navigation, water supplies, and recreational activities (MNR, 1987a).

Though the words "erosion" and "sediment" are almost universally used in tandem when discussing the requirement for control, the relative importance of each component and the implementation of measures to provide the control are different. For the purpose of this guideline, **erosion** is defined as the physical removal or detachment of soil materials. The subsequent transport and deposition of these detached particles (sediment) from the source location by the action of a mobile agent is referred to as **sedimentation**.

The transport of sediment overland and deposition into surrounding natural areas, including watercourses (fish habitat), woodlots and wetlands as well as adjacent private lands, needs to be prevented. The consequence of off-site movement of sediment from a construction site varies with the characteristics of the drainage pathways and the final area of deposition. In the case where the sediment is transported downstream through a watercourse, there can be significant negative affects to fish habitat, floodplains, water supplies, infrastructure, flood control, navigation and recreational activities.

Clearly, the best way to prevent sedimentation is to prevent erosion. This fundamental truth is the reason to understand the erosion potential of a site at every project stage. Appendix A lists the Ministry of Natural Resources Erosion Potential Reference Charts. In cases where the surrounding environmental features are sensitive, erosion control efforts should be effective and significantly constrain the approach to an undertaking including controlled vegetation clearing, which is usually conducted in phases and the utilization of unobtrusive construction methodologies. **Erosion prevention is the preferred mitigation measure for eliminating and/or reducing the potential for sedimentation**.

It is not the intent of this Appendix section to represent an exhaustive summary of E & SC philosophy and implementation, but rather to provide a basic reference source for common requirements evaluations, design information on the most commonly implemented measures, and typical inspection and monitoring protocols. Much of the information contained herein is taken directly or almost directly from the materials cited in the reference section, most notably the *Erosion and Sediment Control Guideline for Urban Construction* (GGHCA, December 2006).

I.2 EVALUATION OF EROSION POTENTIAL

Before selecting ESC practices, the erosion potential and sediment transport path must be evaluated. A methodical approach to assessing the potential for erosion and sedimentation from construction activities involves a number of screening evaluations. The following factors regarding the development site should be considered during the erosion potential evaluation:

- Soil Erodibility;
- Surface slope gradients;
- Length of slopes;
- Rainfall intensities; and,
- Runoff potential.

Table I1 classifies erodibility for the various soil types. The texture and drainage of the soil are considered when estimating its erodibility.

Table I1: Hierarchy of Soil Erodibility

Soil Type	Erodibility Classification	Soil Erodibility Rating
Silt	Most	High
Silt Loam		High
Loam		High
Silty Sand		High
Sandy Loam		Medium
Silty Clay Loam		Medium
Sandy Clay Loam		Medium
Silty Clay		Medium
Sandy Clay		Low
Clay		Low
Heavy Clay		Low
Loamy Sand		Low
Sand		Low
Poorly Graded Gravel		Low
Well Graded Gravel	Least	Low

Source: Adapted from Guidelines on Erosion and Sediment Control for Urban Construction Sites (MNR *et al.*,1987)

Table I2 shows erosion potential based on soil erodibility, ground slope, and slope length. The surface gradients are generally grouped into three classes: gentle (0 to 10 %), moderate (10 to 15%), and steep (> 15 %). Slope lengths are assessed as either moderate (under 30 m) or long (over 30 m).

Table I2: Erosion Potential for Graded Slopes

Slope Gradient	Soil Erodibility	Slope Length	
		< 30 m	> 30 m
< 2% Gentle Slope	Low	Low	Moderate
	Medium	Moderate	Moderate
	High	Moderate	High
2 – 10 % Moderate Slope	Low	Low	Moderate
	Medium	Moderate	High
	High	High	High
> 10 % Steep Slope	Low	Low	Moderate
	Medium	High	High
	High	High	High

Source: Adapted from Guidelines on Erosion and Sediment Control for Urban Construction Sites (MNR *et al.*,1987)

Table I3 shows erosion potential based on soil erodibility, channel slope, and slope length of channel.

Table I3: Erosion Potential for Graded Conveyance Channels

Channel Gradient	Soil Erodibility	Slope Length	
		< 30 m	> 30 m
< 2% Gentle Slope	Low	Low	Moderate
	Medium	Moderate	Moderate
	High	Moderate	High
2 – 10 % Moderate Slope	Low	Low	Moderate
	Medium	Moderate	High
	High	High	High
> 10 % Steep Slope	Low	Low	Moderate
	Medium	High	High
	High	High	High

Source: Adapted from Guidelines on Erosion and Sediment Control for Urban Construction Sites (MNR *et al.*,1987)

Special attention must be given to critical areas within the proposed development that have the potential for serious erosion problems. For example, critical areas may include highly erodible soils, shorelines, human-made watercourses or ditches that outlet to a watercourse, and natural courses that may receive increased sediment-laden water

I.3 TYPICAL EROSION AND SEDIMENT CONTROLS PRACTICES

EROSION CONTROL PRACTICES

Erosion prevention is essential and is the most effective method in protecting downstream aquatic habitat during the construction process. Erosion controls involve minimizing the extent of disturbed areas by clearing only what needs to be cleared, preserving and protecting natural cover and immediately stabilizing disturbed areas. Some of the more commonly applied erosion prevention controls include:

- Vegetative Filter Strips
- Mechanical Seeding
- Terraseeding™
- Hydroseeding
- Top soiling
- Sodding
- Mulching
- Re-vegetative Systems
- Tree and Shrub Planting
- Erosion Control Matting / Blanket / Net (with Seed)
- Growth Media Erosion Control Blanket
- Lockdown™ Netting
- Buffer / Riparian Zone Preservation
- Surface Roughening (Scarification)
- Edge Saver™ System

The applicability of a given practice in a specific situation should be critically evaluated by the practitioner as part of the design process, with the most appropriate and effective approach selected. Guidance in the form of the definition and purpose of a given practice, and aspects to be considered concerning appropriateness of application, design, installation, and maintenance are provided within the literature, most notably the *Erosion and Sediment Control Guideline for Urban Construction* (GGHCA, December 2006).

SEDIMENT CONTROL PRACTICES

Despite best efforts at eliminating erosion in the first place, the resultant dislodging and movement of sediment through water and wind impacts is virtually inevitable. Control of the sediment represents the next barrier(s) of the multi barrier approach, requiring that measures be implemented when areas are continually disturbed and/or when a finite amount of time is required before vegetative practices can be employed and become fully effective. The design and selection of site specific sediment control measures are primarily governed by drainage area, length of upstream gradient/slopes, soil cover/type, construction schedule, and season in combination with cost and effectiveness.

Sediment controls are typically categorized into three sections including perimeter, settling, and filtration controls. In keeping with the multi barrier approach, a comprehensive ESC Plan incorporating all three types of sediment controls (in addition to erosion control measures) could be warranted based on the erosion potential assessment and sensitivity of the receiver.

A brief discussion of the three types of sediment controls are presented as follows. In all cases, the applicability of a given practice in a specific situation should be critically evaluated by the practitioner as part of the design process, with the most appropriate and effective approach selected. Guidance in the form of the definition and purpose of a given practice, and aspects to be considered concerning appropriateness of application, design, installation, and maintenance are provided within the literature, most notably the *Erosion and Sediment Control Guideline for Urban Construction* (GGHCA, December 2006).

Perimeter Controls

Perimeter controls, such as sediment control fences and temporary flow diversion swales and/or dykes, are implemented to protect adjacent areas down gradient from the construction site and/or divert sediment laden runoff away from unprotected/disturbed slopes and areas. Perimeter controls are also utilized to convey runoff from external drainage away from a construction site. Although some perimeter controls may provide some sedimentation, their main function is to prevent sediment laden runoff from encroaching onto adjacent undisturbed areas and/or unprotected slopes. Some of the more commonly used perimeter control measures include:

- Sediment / Silt Fence
- Interceptor Swale / Dyke
- SiltSoxx™
- Vehicle Tracking Control / Mud Mat
- Vehicle Wheel Washers
- Channel Soxx™

Settling Controls

Settling controls allow for a reduction in runoff velocity, resulting in the settlement of suspended soil particles from the sediment laden runoff. Extended detention and/or filtration sediment control measures will be needed to remove finer particles. Some of the more commonly used settling control measures include:

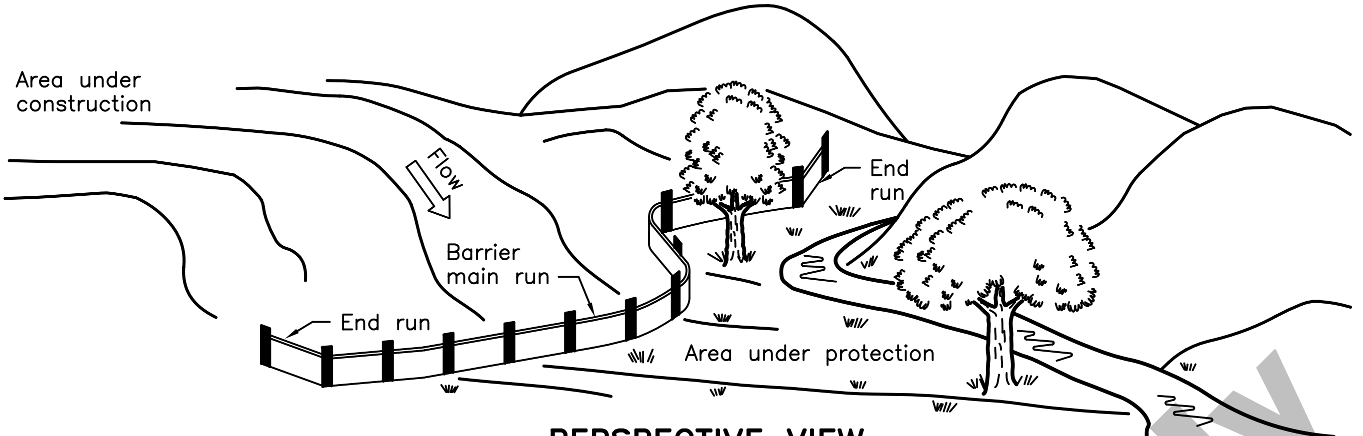
- Ditch / Swale Sediment Trap
- Sediment Traps
- Rock Check Dam
- Ditch Chexx™
- Filter Berms
- Straw / Wood Fibre Logs
- Straw Bales
- Sediment Control Ponds
- Storm Drain Outfall Protection
- Bulkheads within Storm Sewers

Filtration Controls

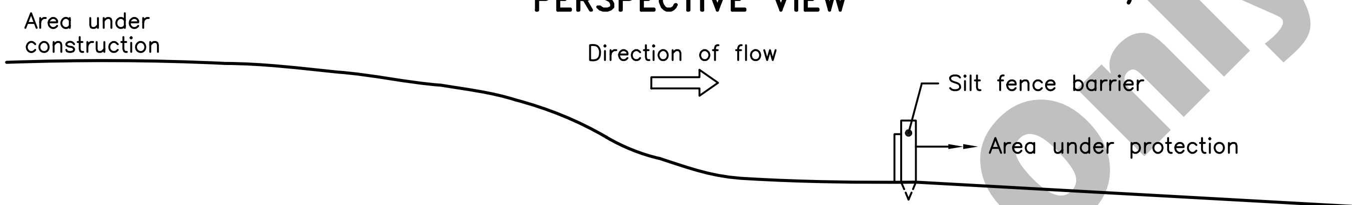
Filtration is the process in which sediment laden water passes through a porous media (e.g. geotextile, sand) consisting of small voids to trap the suspended sediment. The mechanism that makes each mitigation method effective must be understood when considering appropriate application of ESC measures. The number of barriers that may be required to trap sediment before it reaches the aquatic ecosystem will also determine the effectiveness of the mitigation methods. Some of the more commonly used filtration control measures include:

- Storm Drain Inlet Protection
- InletSoxx™
- Sediment Bags
- Filter Bags

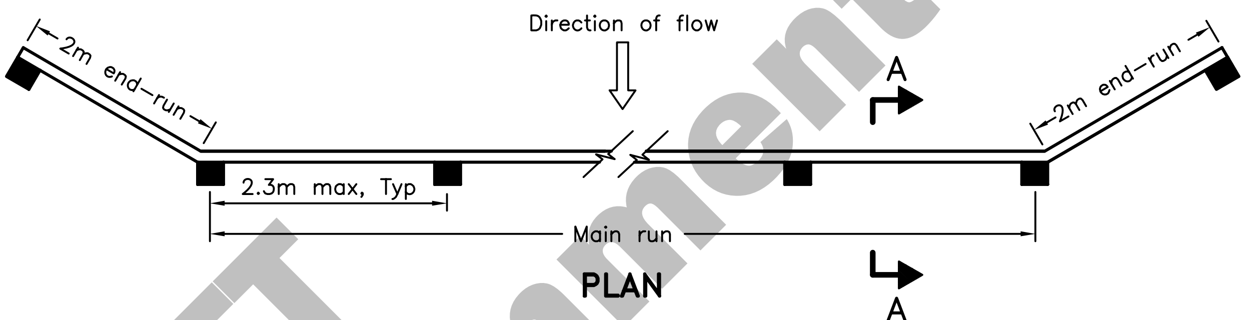
OPSD diagrams pertaining to the most common E & SC measures are included on the following pages.



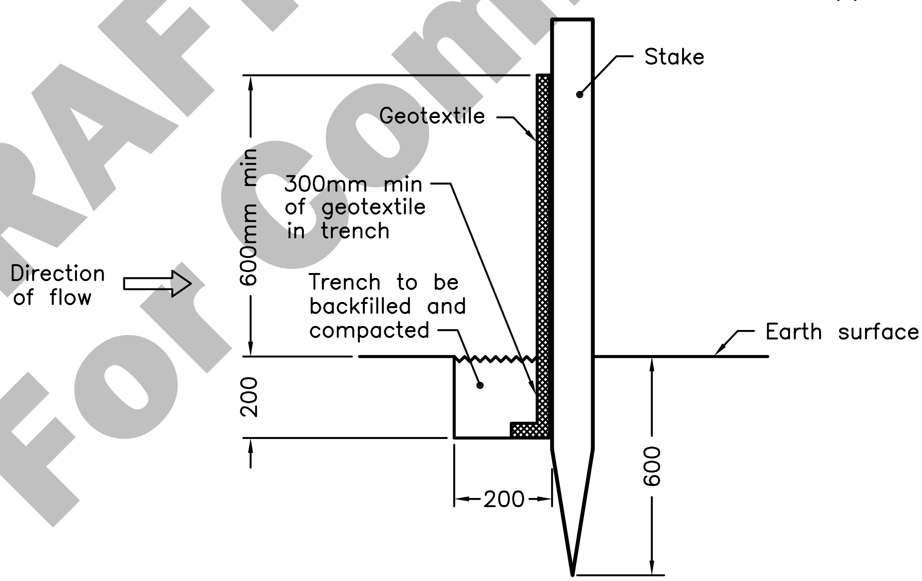
PERSPECTIVE VIEW



SECTION



PLAN

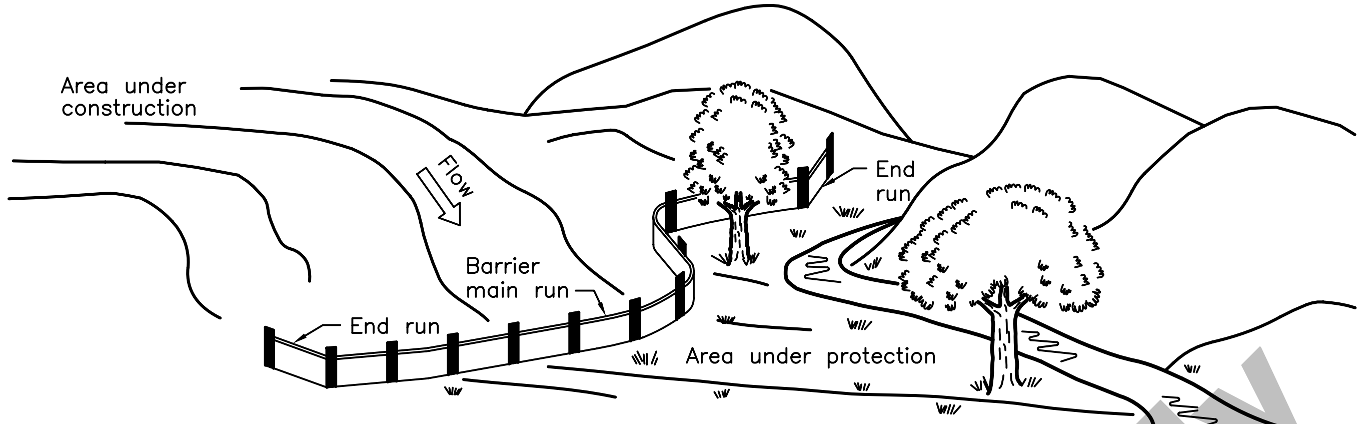


SECTION A–A

NOTE:

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
LIGHT–DUTY SILT FENCE BARRIER		OPSD 219.110



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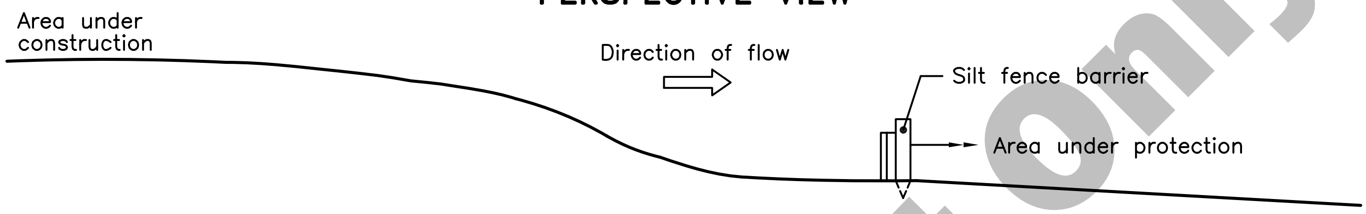

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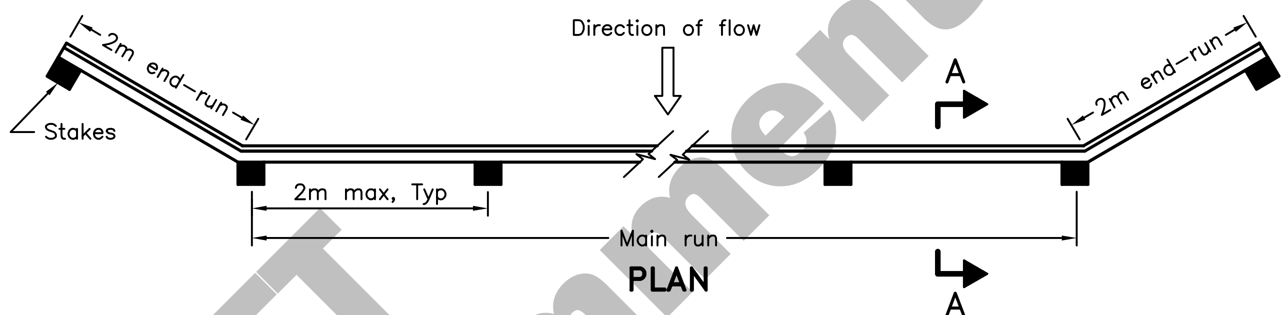

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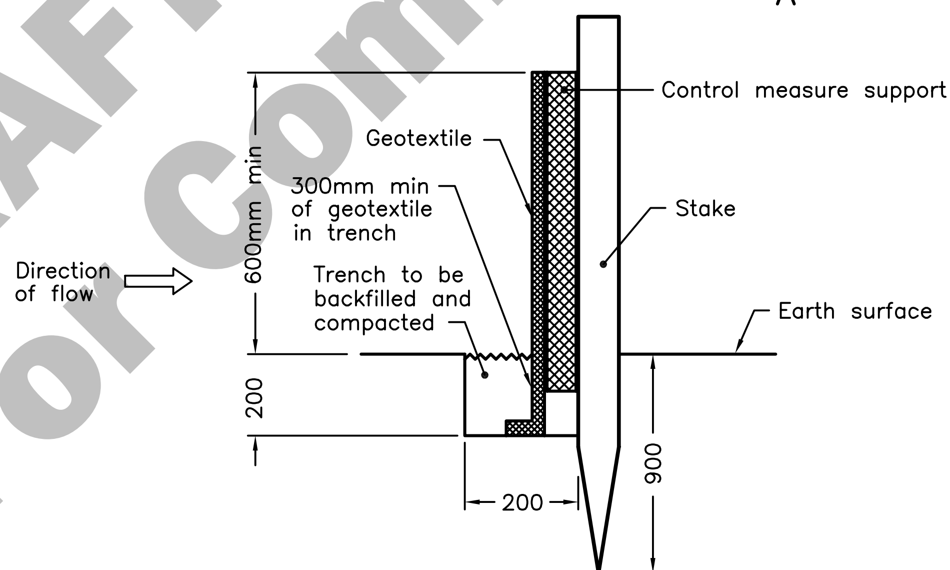
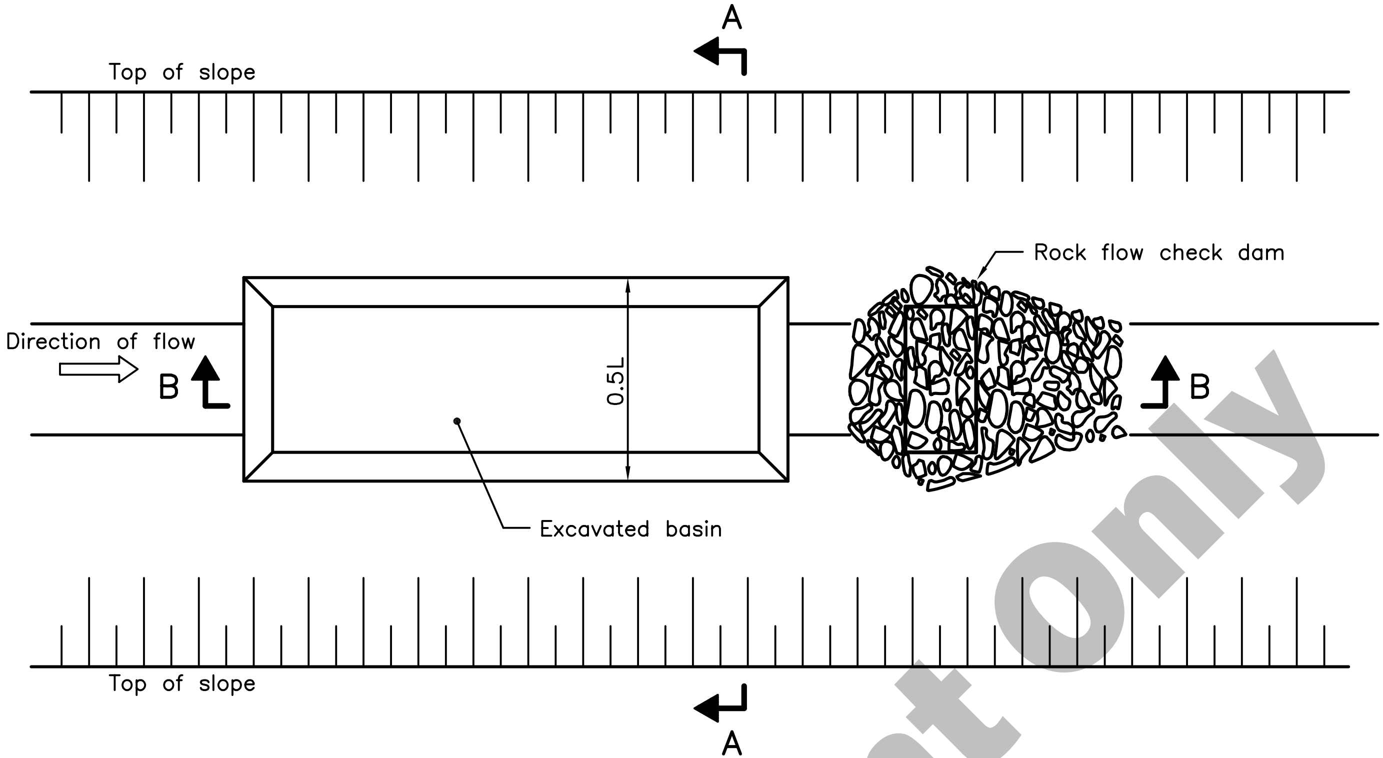


SECTION A-A

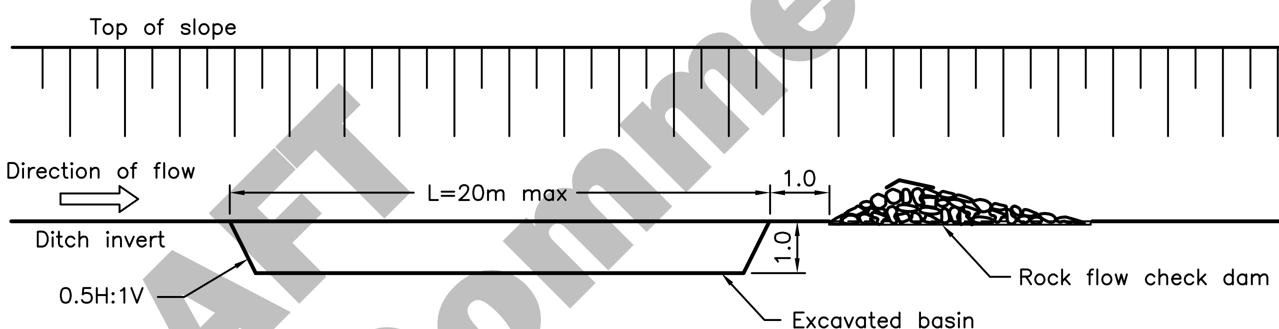
NOTE:

A All dimensions are in millimetres unless otherwise shown.

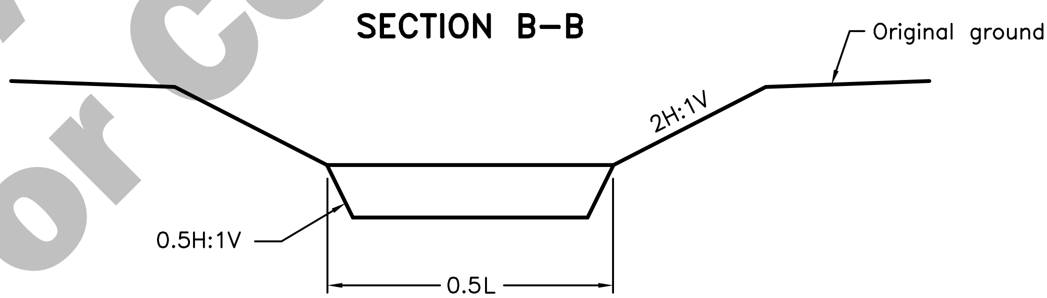
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
HEAVY-DUTY SILT FENCE BARRIER		**OPSD 219.130**



PLAN



SECTION B–B

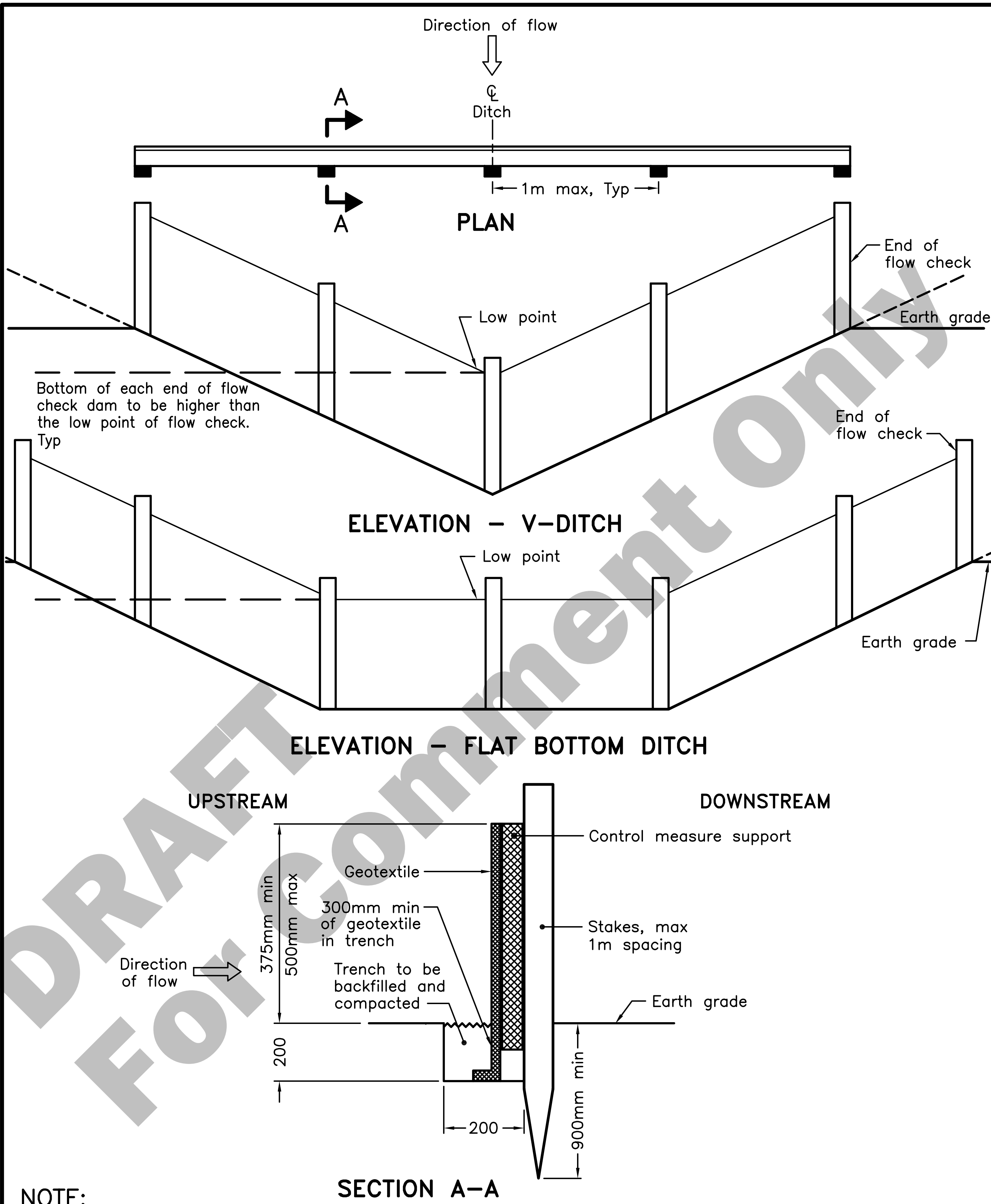


SECTION A–A

NOTES:

A Ditch cross–section upstream or downstream of sediment trap may be flat bottom or V–shaped. Flat bottom shown.
B This OPSD to be read in conjuction with OPSD 219.210 or 219.211.
C All dimensions are in metres unless otherwise shown.

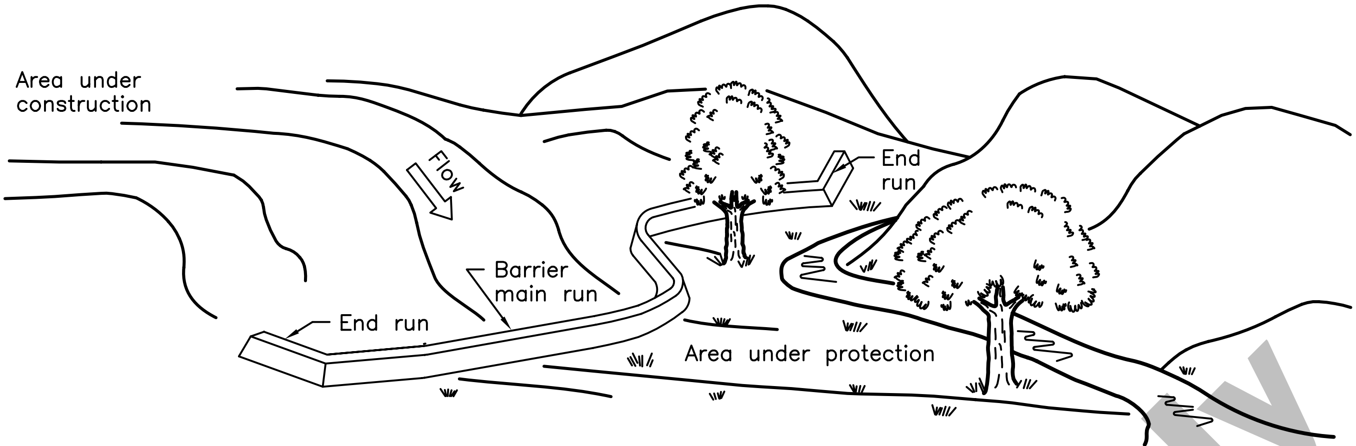
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
EXCAVATED SEDIMENT TRAP IN DITCH	**OPSD 219.220**	



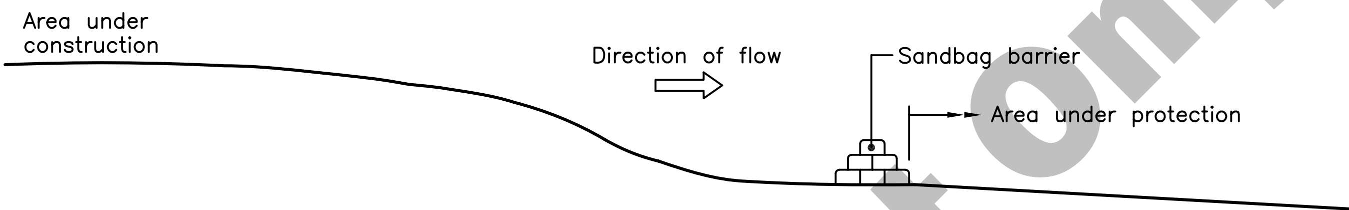
NOTE:

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
SILT FENCE FLOW CHECK DAM		
	OPSD 219.190	



PERSPECTIVE VIEW



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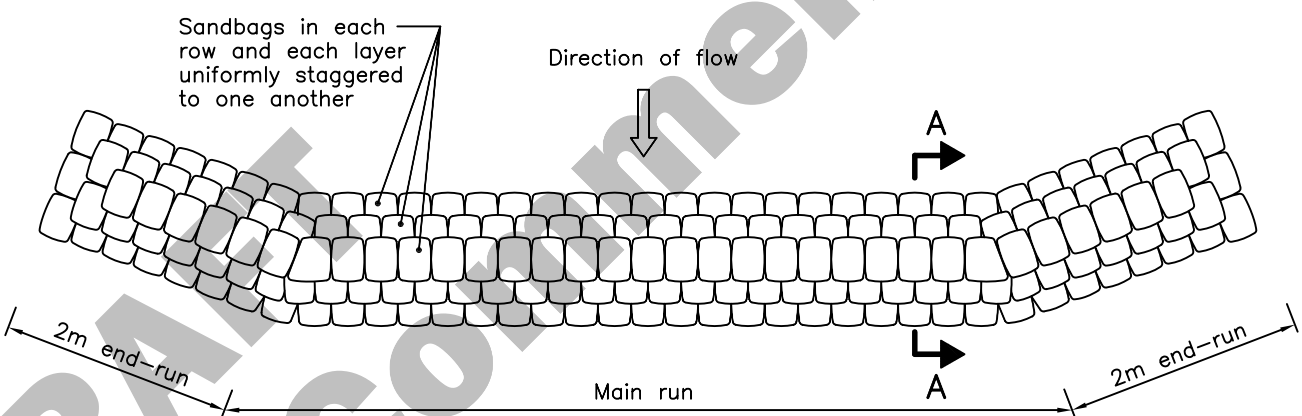

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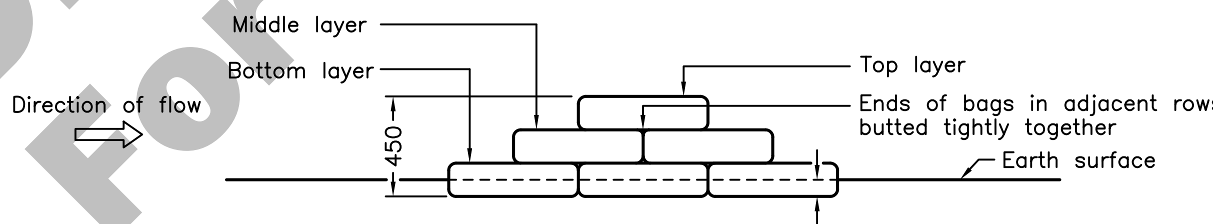
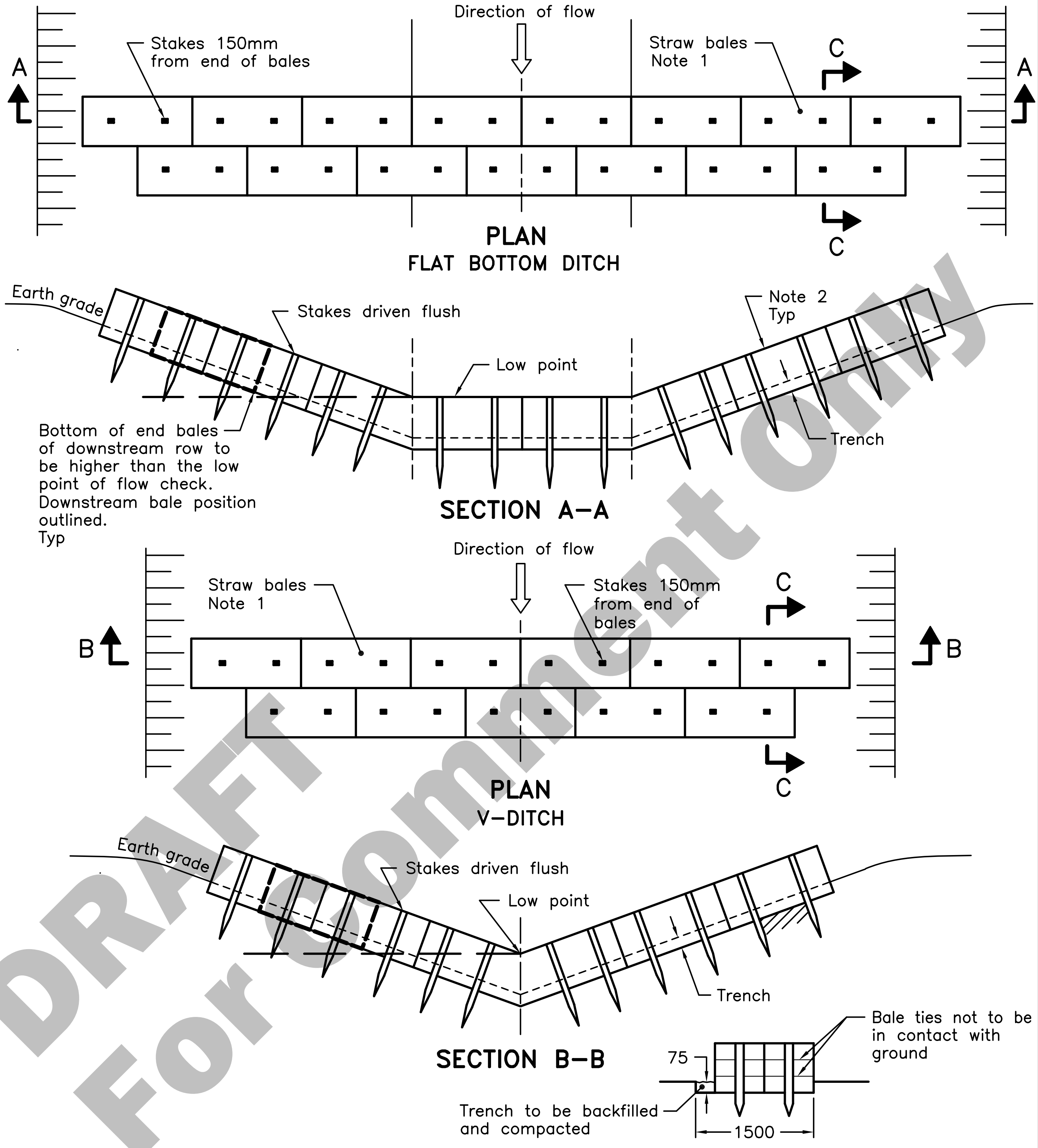


SECTION A–A

NOTE:

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
SANDBAG BARRIER		
	OPSD 219.150	



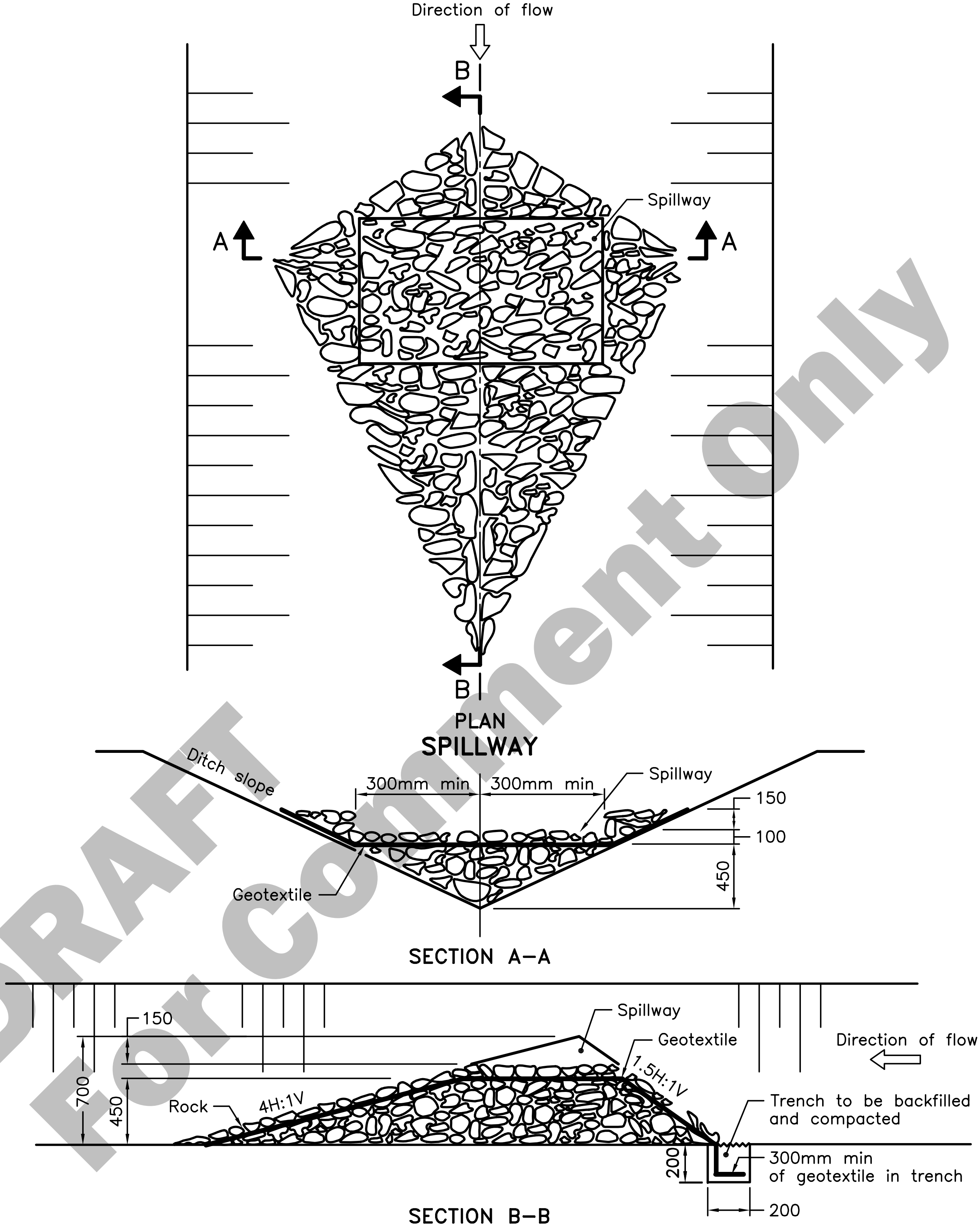
SECTION C–C

NOTES:

1 Number of bales varies to suit ditch.
2 Straw bales to be butted tightly against adjoining bales and shaped to conform to the sides of the ditch to prevent water flow through barrier.

A All dimensions are in millimetres unless otherwise shown.

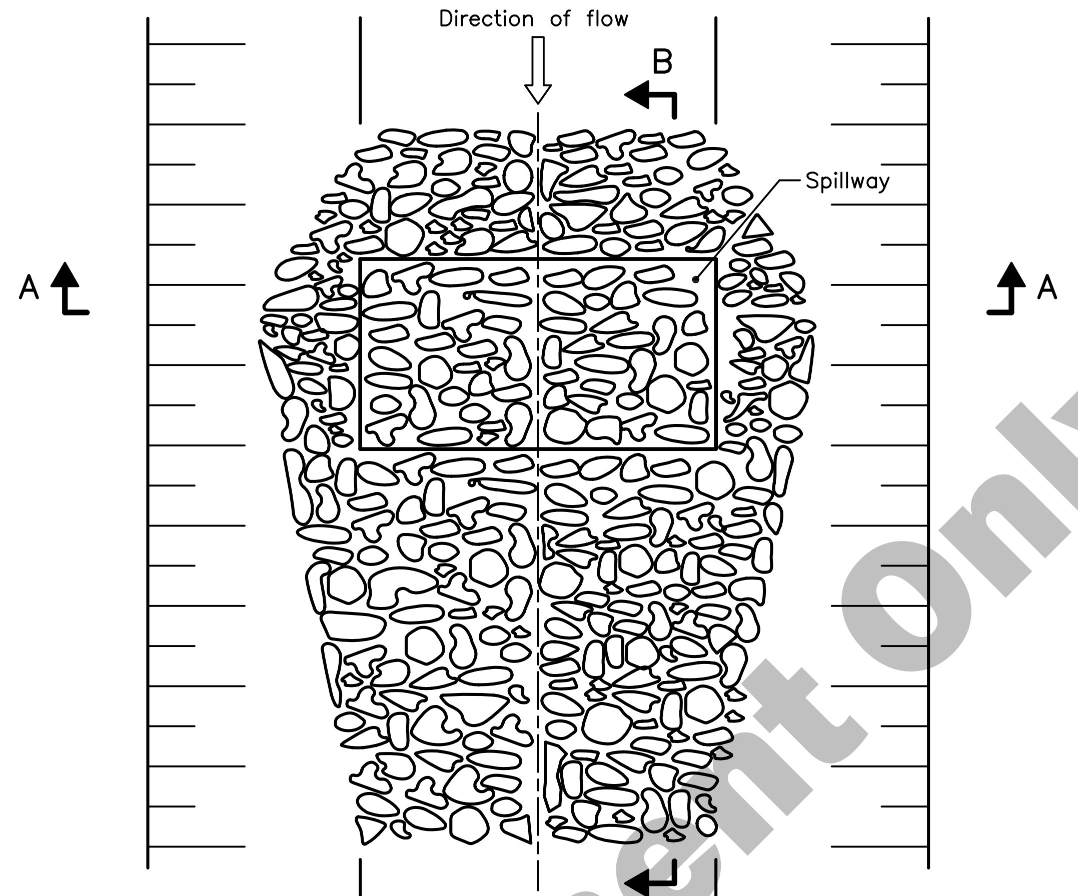
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
STRAW BALE FLOW CHECK DAM		OPSD 219.180



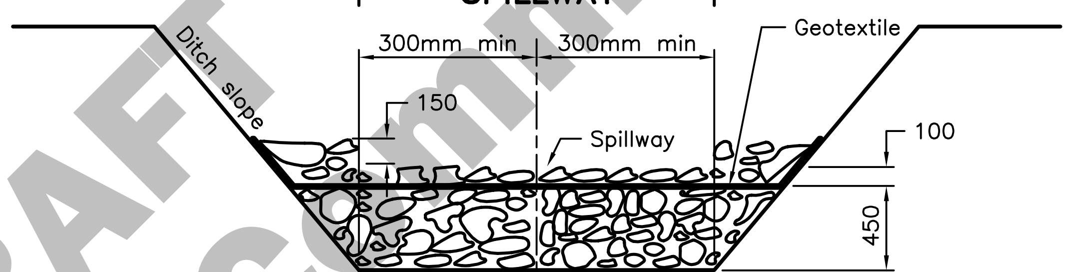
NOTE:

A All dimensions are in millimetres unless otherwise shown.

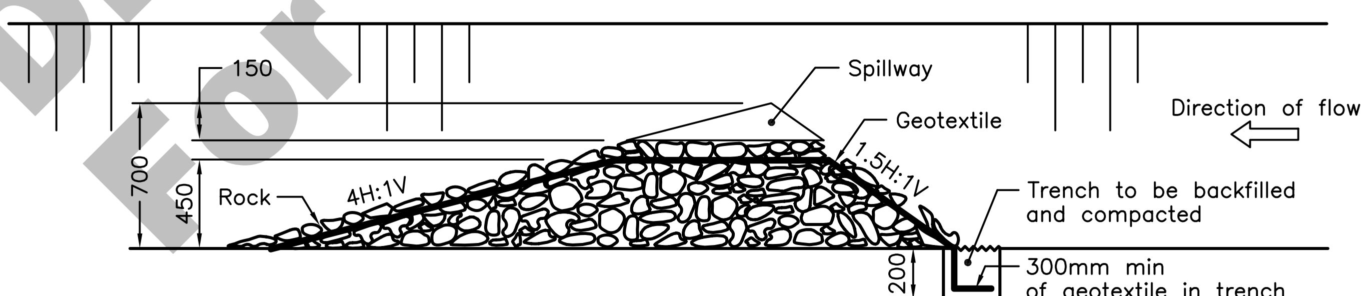
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
ROCK FLOW CHECK DAM V–DITCH		OPSD 219.210



PLAN
SPILLWAY



SECTION A–A

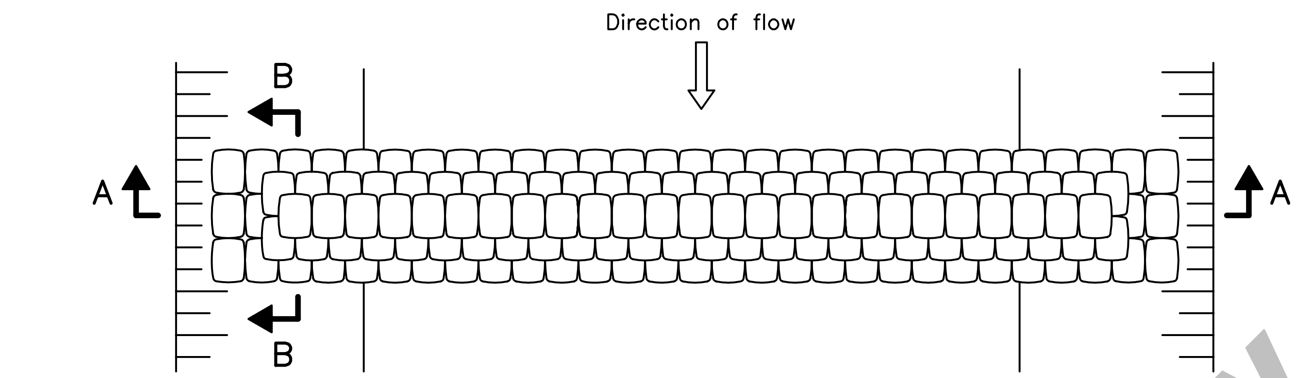


SECTION B–B

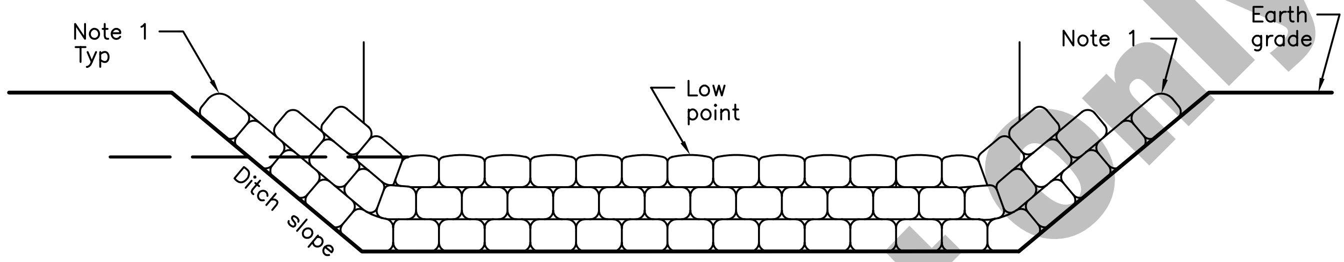
NOTE:

A All dimensions are in millimetres unless otherwise shown.

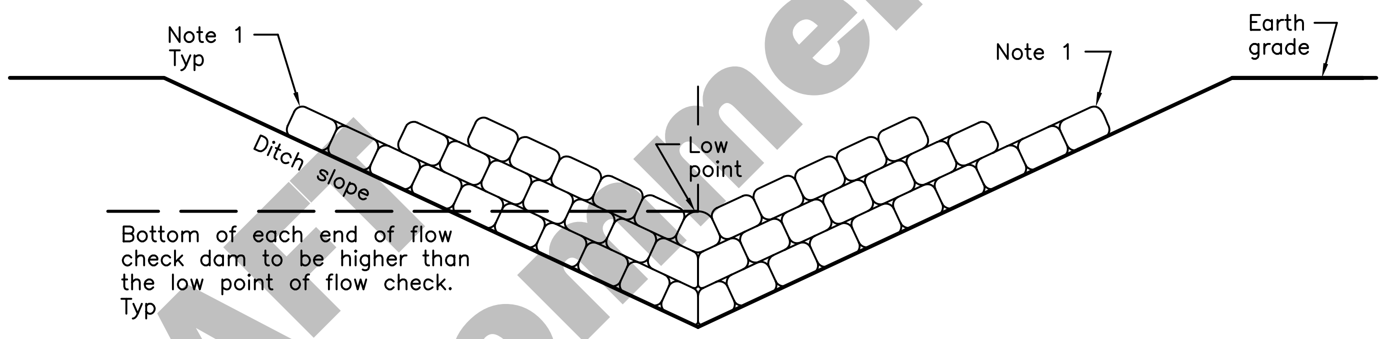
ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
ROCK FLOW CHECK DAM FLAT BOTTOM DITCH		
	OPSD 219.211	



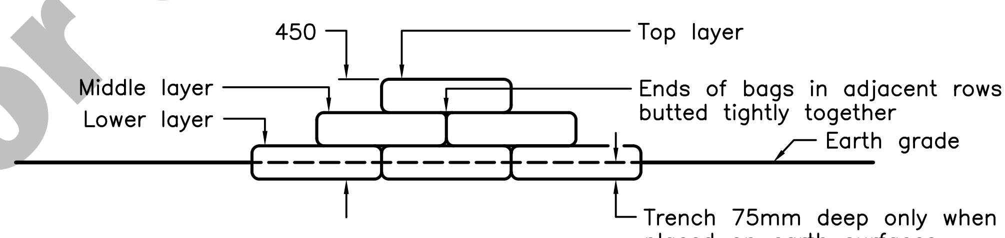
PLAN



SECTION A–A
FLAT BOTTOM DITCH



SECTION A–A
V–DITCH



SECTION B–B

NOTES:

1 Sufficient sandbags are to be placed to prevent end scouring.

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2006	Rev 1
SANDBAG FLOW CHECK DAM		OPSD 219.200

I.4 INSPECTIONS AND MONITORING

The environmental plans developed for an undertaking commonly provides a level of monitoring or supervision suitable for the sensitivity of the surrounding environment, the scale of a project and the expected time frames. Specific monitoring requirements are provided with the environmental approvals and permits, which are undertaken as a measure of compliance. The intention of this monitoring is to provide environmental protection, and compliance with all applicable legislation while contributing to the overall success of a project. This generally includes a number of inspections prior to the start of an undertaking to document the pre-disturbance conditions, and to ensure that the erosion and sediment control plan is initiated at the start of the project. Often, post construction monitoring is required to ensure the restoration, stabilization, and required monitoring of constructed features/habitats is established.

As a basis of monitoring an undertaking, it is essential to ensure that the erosion and sediment control measures are properly installed, well maintained and functioning as intended on a daily basis. The scrutiny placed on erosion and sediment control measures is applied by many parties involved in the project including environmental monitors, contractors, site inspectors and the Contract Administrator. The ESC plan should provide the framework for the inspection, maintenance including the need for repair, and record-keeping procedures during all stage of construction. The effectiveness of the ESC Plan depends directly on the frequency the ESC measures are inspected and what actions are taken to address any failures that may occur with the measures. A timely response by the contractor to any noted deficiencies is critical for demonstrating due diligence in compliance with regulatory requirements. As such, a regular inspection program should be planned and implemented to determine when ESC measures need maintenance and/or repair. Documentation of all inspections should be kept on site for a minimum of one (1) year after the development is substantially completed.

An Environmental Monitor (EM) can be retained by the project owner, the contractor or in some cases regulatory agencies and interested third parties. The role of the EM is to assure project construction activities comply with the environmental provisions defined in the project approvals, Authorizations and permits. It is important to note that an EM has no power to enforce compliance with any environmental laws. Environmental monitoring also offers a level of quality control and assurance not unlike other engineering inspectors retained for a project to ensure design standards are met. The EM is expected to provide timely and relevant advice in regards to the environmental management of a site, construction timing and methodologies. The EM should strive to remain neutral and independent in order to assess compliance of all project parties and allow for the accurate reporting of non-compliance events to the regulatory agencies.

An effective inspection program should include the following:

1. Identification of Personnel: Names and contact information of project members assigned to each task as well as agency/enforcement contacts. A communication protocol should also be developed to ensure effective reporting and compliance.

2. Details and locations of the environmental constraints for an undertaking including maps, reports, approvals and permits. Specific attention should be directed to timing restrictions and reporting requirements.

3. Construction drawings detailing the erosion and sediment controls installed which is updated through the construction period. Erosion and Sediment Control Guideline – December 2006

4. High risk areas should be identified on these drawings and routinely evaluated. Greater frequency of monitoring requirements may be required for areas and protection measures immediately adjacent to soil stockpiles, excavations, dewatering locations, protected features/areas, and locations where site runoff discharges into a receiving watercourse, water body, or municipal sewer system.

5. Inspection schedule: This should include inspection times, areas, and person(s) responsible for the inspections. A ‘walk-through’ inspection of the construction site should be undertaken in anticipation of large storm events (or a series of rainfall and/or snowmelt days) that could potentially yield significant runoff volumes The regular inspections should occur during all construction stages and should be based on at a minimum the requirements identified in the permits and approvals. Commonly this frequency is:
   - on a weekly basis;
   - after every rainfall event;
   - after significant snowmelt events; and,
   - daily during extended rain or snowmelt periods.

6. During inactive construction periods, where the site is left alone for 30 days or longer, a monthly inspection should be conducted.

7. All damaged ESC measures should be repaired and/or replacement within 48 hours of the inspection.

A sample inspection and monitoring sheet is included on the following pages.

EROSION AND SEDIMENT CONTROL INSPECTION REPORT

PROJECT: ______ INSPECTOR: ______ CURRENT ______ Weekly

PRIME ______ QUALIFICATIONS: ______ LAST MAJOR RAIN: ______ Rainfall Event

PROJECT NUMBER: ______ INSPECTION ______ PERMIT NUMBER: ______ Other

SITE AREA: ______ DISTURBED ______ RECEIVING WATER: ______

Reason for Inspection: ______ (weekly, rainfall, or other) Rainfall (mm): ______ Other Reason: ______

INSPECTION OF BEST MANAGEMENT PRACTICES

NOTES: ANY "CONTROL PRACTICE EFFECTIVE" BOX CHECKED 'N' OR "MAINTENANCE/MODIFICATION NEEDED" BOX CHECKED 'Y' MUST HAVE COMMENTS AND RECOMMENDED IMPROVEMENTS NOTED. ANY MODIFICATIONS MUST BE SKETCHED AND DESCRIBED ON THE BACK. DATES AND INITIALS ON THE DRAWING MUST BE INCLUDED WITH THE POLLUTION PREVENTION PLAN. TO COMPLETE THIS FORM, THE DATE IMPLEMENTED AND ACTUAL WORK SECTION MUST BE COMPLETED AND INTIALED BY THE OPERATOR PERFORMING THE WORK.

BEST MANAGEMENT PRACTICE	CONTROL			MAINTENANCE/				Action Items	Photos	DATE IMPLEMENTED
	Yes	No	N/A	Yes	Week #	No	N/A			
Erosion Prevention										
Vegetative Filter Strips	☐	☐	☐	☐		☐	☐		Photo	
Seeding	☐	☐	☐	☐		☐	☐		Photo	
Top soiling	☐	☐	☐	☐		☐	☐		Photo	
Sodding	☐	☐	☐	☐		☐	☐		Photo	
Mulching	☐	☐	☐	☐		☐	☐		Photo	
Riprap	☐	☐	☐	☐		☐	☐		Photo	
Re-vegetative Systems	☐	☐	☐	☐		☐	☐		Photo	
Tree and Shrub Planting	☐	☐	☐	☐		☐	☐		Photo	
Growth Media Erosion Control blankets/mats	☐	☐	☐	☐		☐	☐		Photo	
Netting	☐	☐	☐	☐		☐	☐		Photo	
Plastic sheeting	☐	☐	☐	☐		☐	☐		Photo	
Buffer/Riparian Zone Preservation	☐	☐	☐	☐		☐	☐		Photo	

BEST MANAGEMENT PRACTICE	CONTROL Yes	CONTROL No	CONTROL N/A	MAINTENANCE/ Yes	Week #	No	N/A	Action Items	Photos
Erosion Prevention (continued)									
Surface Roughening (Scarification)	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Dust control	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Other____________	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Other___________	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Slopes and stockpiles									
Stabilization of slopes and stockpiles	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Erosion Control Mats/Blankets/Netting	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Diversion dikes	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Compost biofilters	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Silt fencing	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Filter berms	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Straw logs	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Straw bales	☐	☐	☐	☐	____	☐	☐	____	Photo ____
Other_______________	☐	☐	☐	☐	____	☐	☐	____	Photo

BEST MANAGEMENT PRACTICE	CONTROL Yes	CONTROL No	CONTROL N/A	MAINTENANCE/ Yes	MAINTENANCE/ Week #	MAINTENANCE/ No	MAINTENANCE/ N/A	Action Items	Photos
Swales and channels									
Stabilization of swales and channels	☐	☐	☐	☐	______	☐	☐	______	Photo
Interceptor swales/diversion dikes	☐	☐	☐	☐	______	☐	☐	______	Photo
Compost biofilters	☐	☐	☐	☐	______	☐	☐	______	Photo
Check dams	☐	☐	☐	☐	______	☐	☐	______	Photo
Filter berms	☐	☐	☐	☐	______	☐	☐	______	Photo
Straw/Wood Fibre Logs	☐	☐	☐	☐	______	☐	☐	______	Photo
Straw Bales	☐	☐	☐	☐	______	☐	☐	______	Photo
Other__________________	☐	☐	☐	☐	______	☐	☐	______	Photo
Other__________________	☐	☐	☐	☐	______	☐	☐	______	Photo
Storm Drain Inlets									
Compost biofilters	☐	☐	☐	☐	______	☐	☐	______	Photo
Organic or inorganic berms	☐	☐	☐	☐	______	☐	☐	______	Photo
Geotextile fabric filters	☐	☐	☐	☐	______	☐	☐	______	Photo
Other__________________	☐	☐	☐	☐	______	☐	☐	______	Photo

BEST MANAGEMENT PRACTICE	CONTROL Yes	No	N/A	MAINTENANCE/ Yes	Week #	No	N/A	Action Items	Photos
Sediment Traps and Basins									
Stabilization of embankments	☐	☐	☐	☐	____	☐	☐	____________	Photo
Sediment traps	☐	☐	☐	☐	____	☐	☐	____________	Photo
Rock check dams used with sediment traps	☐	☐	☐	☐	____	☐	☐	____________	Photo
Pond/basin (check inlet, forebay, outlet, emergency spillway)	☐	☐	☐	☐	____	☐	☐	____________	Photo
Other__________________	☐	☐	☐	☐	____	☐	☐	____________	Photo
Other	☐	☐	☐	☐	____	☐	☐	____________	Photo
Perimeter devices									
Silt fencing	☐	☐	☐	☐	____	☐	☐	____________	Photo
Compost biofilters	☐	☐	☐	☐	____	☐	☐	____________	Photo
Filter berms	☐	☐	☐	☐	____	☐	☐	____________	Photo
Interceptor swales and dikes	☐	☐	☐	☐	____	☐	☐	____________	Photo
Vegetative filter strips	☐	☐	☐	☐	____	☐	☐	____________	Photo
Mud mats	☐	☐	☐	☐	____	☐	☐	____________	Photo
Vehicle wheel washers	☐	☐	☐	☐	____	☐	☐	____________	Photo
Straw bales/logs (**note:** cannot be used alone at perimeter)	☐	☐	☐	☐	____	☐	☐	____________	Photo
Other__________________	☐	☐	☐	☐		☐	☐	____________	Photo

Title ______________________

______________________ Signature of Inspector

______________________ Date

I.5 EROSION & SEDIMENT CONTROL LITERATURE REFERENCES

Substantial literature pertaining to the practice of erosion and sediment control exists - a Google search of the exact phrase "erosion and sediment control" identified almost 13,000 "hits" within Canada alone! Some of the more common reference documents providing additional guidance in the theory and practice of Erosion and Sediment Control include:

- Greater Golden Horseshoe Conservation Authorities (December 2006), *Erosion and Sediment Control Guideline for Urban Construction*. Available for download at: http://www.trca.on.ca/Website/TRCA/Graphics.nsf/Graphics/planning_permits_pdf_escg/$file/H_ESCGUC.pdf
- Greater Golden Horseshoe Conservation Authorities (December 2006), *Erosion and Sediment Control Inspection Guide*. Available for download at: http://www.sustainabletechnologies.ca/ (not a direct link to document – search site as required)
- Ontario Ministry of Transportation (February 2007). *Environmental Guide for Erosion and Sediment Control During Highway Construction Projects*. Download available at: http://www.raqsa.mto.gov.on.ca/techpubs/eps.nsf/epswv/$searchForm?SearchView (not a direct link to document – search site as required)
- Greenland International Consulting Inc. and The Toronto and Region Conservation Authority (April 2001). *Urban Construction Sediment Control* Strategy. Download available at: http://www.trca.on.ca/ (not a direct link to document – search site as required)
- Transportation Association of Canada (TAC), 2005, *National Guide to Erosion and Sediment Control on Roadway Projects*. Document ordering details at: http://www.tac-atc.ca/english/pdf/erosion-puborder.pdf
- Chilibeck, B.G. Chislett and G. Norris, Province of British Columbia Ministry of Environment, Lands and Parks, 1993.. *Land Development Guidelines for the Protection of Aquatic Habitat.* Document available for download at: http://www.dfo-mpo.gc.ca/Library/165353.pdf

APPENDIX J

Useful SWM Design Information

Table of Contents – Appendix J

List of Tables

J.1 USEFUL SWM DESIGN REFERENCE INFORMATION

There are a variety of design parameters that are routinely referred to within the hydrologic and hydraulic analysis associated with most SWM designs. In that this Policy and Technical Guidelines document is intend to serve as a resource for SWM practitioners within the watershed and technical reviewers, a selection of such information is included herein.

The Tables included on the following pages have been inserted verbatim from the previous version of the Policy document, issued in 1994, and from the MTO Drainage Management Manual (Design Charts) (1997)

TABLE 4.7

HYDROLOGIC SOIL GROUPS FOR PRINCIPAL SOIL TEXTURES IN ABCA WATERSHED

Soils Series	Map Symbol	Soil Texture	Hyd. Soil Group
Berrien	Bes	sl	AB
Blackwell	Blac	C	C
Bookton	Bos	sl	AB
Brady	Bysl	sl	AB
Brisbane	Brl	l	B
Brookston	Bs	sil	C
Burford	Bul	l	AB
Donnybrook	Dos	si	AB
Dumfries	Dl	l	AB
Eastport	ETS	s	A
Fox	Fxsl	sl	AB
Gilford	Gil	l	B
Granby	Grsl	sl	B
Harriston	Hl	l	BC
Harriston	Hs	sil	BC
Huron	Hus	sil	BC
Huron	Huc	cl	C or D
Huron	Huc	c	D
Listowel	Li	l	B/BC
Listowel	Ls	sil	BC
Muck	M	m	B
Parkhill	Pal	l	BC
Parkhill	Pas	sil	BC
Perth	Ps	sil	C
Perth	Pc	cl	CD
Perth	Pc	c	CD
Plainfield	Pds	s	A
Toledo	Ts	sil	BC
Toledo	Toc	c	C

Key to abbreviations: c - clay; f - fine; g - gravel; l - loam; ma - marl; m - muck; p - peat; r - rock; s - sand; si - silt.

TABLE 4.8
RUNOFF CURVE NUMBERS

Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious).		81	88	91	93
Residential:[3]					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

1/ For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

2/ Good cover is protected from grazing and litter and brush cover soil.

3/ Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

4/ The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

5/ In some warmer climates of the country a curve number of 95 may be used.

Table 4.9 Design Criteria for Conveyance

Facility	Typical Criteria	Agency Responsible
Minor Drainage System (Piped)	1:2 to 1:10 yr.	Municipality
Roadside Ditches	1:5 to 1:100 yr.	Municipality ABCA
Major System	1:100 yr. to Regional Storm	ABCA
Road Crossings	1:2 yr. to Regional Storm (see MTO criteria below)	Municipality ABCA MTO
Watercourses	Regulatory Event	ABCA
MTO Criteria		
Road	Minor System	Major System
Freeway Urban Arterial	1:10 yr.	1:100 yr. or Regional Storm, whichever is greater
Rural Arterial	1:2 to 1:5 yr.	1:100-yr. or Regional Storm, whichever is greater
Local Road	1:2 yr.	1:100-yr. or Regional Storm, whichever is greater
Depressed Roadways (subways, etc.)	1:10 to 1:25 yr.	--
Bridge deck drains	1:10 yr.	--

TABLE 4.10

Roughness Coefficient 'n' for Manning Formula

Type and Description of Conduits	n Values* Min.	Design	Max.
CHANNELS, LINED			
Asphaltic concrete, machine placed ..		0.014	
Asphalt, exposed prefabricated		0.015	
Concrete	0.012	0.015	0.018
Concrete, rubble	0.017		0.030
Metal, smooth (flumes)	0.011		0.015
Metal, corrugated	0.021	0.024	0.026
Plastic	0.012		0.014
Shotcrete	0.016		0.017
Wood, planed (flumes)	0.010	0.012	0.015
Wood, unplaned (flumes)	0.011	0.013	0.015
CHANNELS, EARTH			
Earth bottom, rubble sides	0.028	0.032	0.035
Drainage ditches, large, no vegetation:			
(a) less than 0.8 m hydraulic radius	0.040		0.045
(b) 0.8-1.2 m hydraulic radius	0.035		0.040
(c) 1.2-1.5 m hydraulic radius	0.030		0.035
(d) more than 1.5 m hydraulic radius	0.025		0.030
Small drainage ditches	0.035	0.040	0.040
Stony bed, weeds on bank	0.025	0.035	0.040
Straight and uniform	0.017	0.0225	0.025
Winding, sluggish	0.0225	0.025	0.030
CHANNELS, VEGETATED (GRASSED WATERWAYS)			
Dense, uniform stands of green vegetation more than 250 mm long			
(a) Bermuda grass	0.04		0.20
(b) Kudzu	0.07		0.23
(c) Lespedeza, common	0.047		0.095
DENSE, UNIFORM STANDS OF GREEN VEGETATION CUT TO A LENGTH LESS THAN 60 mm			
(a) Bermuda grass, short	0.034		0.11
(b) Kudzu	0.045		0.16
(c) Lespedeza	0.023		0.05
Sorghum, 1 m rows	0.04		0.15
Wheat, mature poor	0.08		0.15

TABLE 4.10 (cont'd)

Type and Description of Conduits	n Values* Min.	Design	Max.
NATURAL STREAMS			
(a) Clean, straight bank, full stage, no rifts or deep pools	0.025		0.033
(b) Same as (a) but some weeds and stones	0.030		0.040
(c) Winding, some pools and shoals, clean	0.035		0.050
(d) Same as (c), lower stages, more inefficient slopes and sections	0.040		0.055
(e) Same as (c), some weeds and stones	0.033		0.045
(f) Same as (d) stony sections	0.045		0.060
(g) Sluggish river reaches, rather weedy or with very deep pools	0.050		0.080
(h) Very weedy reaches	0.075		0.150
PIPE			
Asbestos cement		0.009	
Cast iron, coated	0.011	0.013	0.014
Cast iron, uncoated	0.012		0.015
Clay or concrete drain tile (100-300 mm)	0.010	0.0108	0.020
Concrete	0.010	0.014	0.017
Metal, corrugated	0.021	0.025	0.0255
Steel, riveted and spiral	0.013	0.016	0.017
Vitrified sewer pipe	0.010	0.014	0.017
Wood stave	0.010	0.013	
Wrought iron, black	0.012		0.015
Wrought iron, galvanized	0.013	0.016	0.017

*Note: The 'n' values in this table give satisfactory results when used in the Kutter formula on projects of the size usually carried out under the Drainage Act, 1980.

Design Chart 1.03: Hurricane Hazel

	Depth (mm)	Depth (inches)	Percent of 12 hour
First 36 hours	73	2.90	
37th hour	6	.25	3
38th hour	4	.17	2
39th hour	6	.25	3
40th hour	13	.50	6
41st hour	17	.66	8
42nd hour	13	.50	6
43rd hour	23	.91	11
44th hour	13	.50	6
45th hour	13	.50	6
46th hour	53	2.08	25
47th hour	38	1.49	18
48th hour	13	.50	6
	285	11.21	100

Drainage Area (km^2)	Percentage
0 to 25	100.0
26 to 45	99.2
46 to 65	98.2
66 to 90	97.1
91 to 115	96.3
116 to 140	95.4
141 to 165	94.8
166 to 195	94.2
196 to 220	93.5
221 to 245	92.7
246 to 270	92.0
271 to 450	89.4
451 to 575	86.7
576 to 700	84.0
701 to 850	82.4
851 to 1000	80.8
1001 to 1200	79.3
1201 to 1500	76.6
1501 to 1700	74.4
1701 to 2000	73.3
2001 to 2200	71.7
2201 to 2500	70.2
2501 to 2700	69.0
2701 to 4500	64.4
4501 to 6000	61.4
6001 to 7000	58.9
7001 to 8000	57.4

Source: Ministry of Transportation, MTO (1989)

Design Chart 1.05: SCS Type II Distribution

6 hour			12 hour			24 hour		
Time end'g, hour	F_{inc} (%)	F_{cum} (%)	Time end'g, hour	F_{inc} (%)	F_{cum} (%)	Time end'g, hour	F_{inc} (%)	F_{cum} (%)
0	0	0	0	0	0	0	0	0
0.5	2	2	2	5	5	2	2.2	2.2
1	3	5	3	3	8	4	2.6	4.8
1.5	3	8	3.5	2	10	6	3.2	8.0
2	5	13	4	2	12	7	-	-
2.5	6	19	4.5	3	15	8	4.0	12.0
2.75	15	34	5	4	19	8.5	-	-
3	39	73	5.5	6	25	9	2.7	14.7
3.5	11	84	5.75	12	37	9.5	1.6	16.3
4	5	89	6	33	70	9.75	-	-
4.5	4	93	6.5	9	79	10	1.8	18.1
5	3	96	7	4	83	10.5	2.3	20.4
6	4	100	7.5	3	86	11	3.1	23.5
			8	3	89	11.5	4.8	28.3
			10	7	96	11.75	10.4	38.7
			12	4	100	12	27.6	66.3
						12.5	7.2	73.5
						13	3.7	77.2
						13.5	0.7	77.9
						14	4.1	82.0
						16	6.0	88.0
						20	7.2	95.2
						24	4.8	100

Source: Ministry of Natural Resources - MNR (1986)

Design Chart 1.07: Runoff Coefficients

- Urban for 5 to 10-Year Storms

Land Use		Runoff Coefficient	
		Min.	Max.
Pavement	- asphalt or concrete	0.80	0.95
	- brick	0.70	0.85
Gravel roads and shoulders		0.40	0.60
Roofs		0.70	0.95
Business	- downtown	0.70	0.95
	- neighbourhood	0.50	0.70
	- light	0.50	0.80
	- heavy	0.60	0.90
Residential	- single family urban	0.30	0.50
	- multiple, detached	0.40	0.60
	- multiple, attached	0.60	0.75
	- suburban	0.25	0.40
Industrial	- light	0.50	0.80
	- heavy	0.60	0.90
Apartments		0.50	0.70
Parks, cemeteries		0.10	0.25
Playgrounds (unpaved)		0.20	0.35
Railroad yards		0.20	0.35
Unimproved areas		0.10	0.30
Lawns	- Sandy soil		
	- flat, to 2%	0.05	0.10
	- average, 2 to 7%	0.10	0.15
	- steep, over 7%	0.15	0.20
	- Clayey soil		
	- flat, to 2%	0.13	0.17
	- average, 2 to 7%	0.18	0.22
	- steep, over 7%	0.25	0.35

For flat or permeable surfaces, use the lower values. For steeper or more impervious surfaces, use the higher values. For return period of more than 10 years, increase above values as 25-year - add 10%, 50-year - add 20%, 100-year - add 25%.

The coefficients listed above are for unfrozen ground.

Design Chart 1.07: Runoff Coefficients (Continued)

- Rural

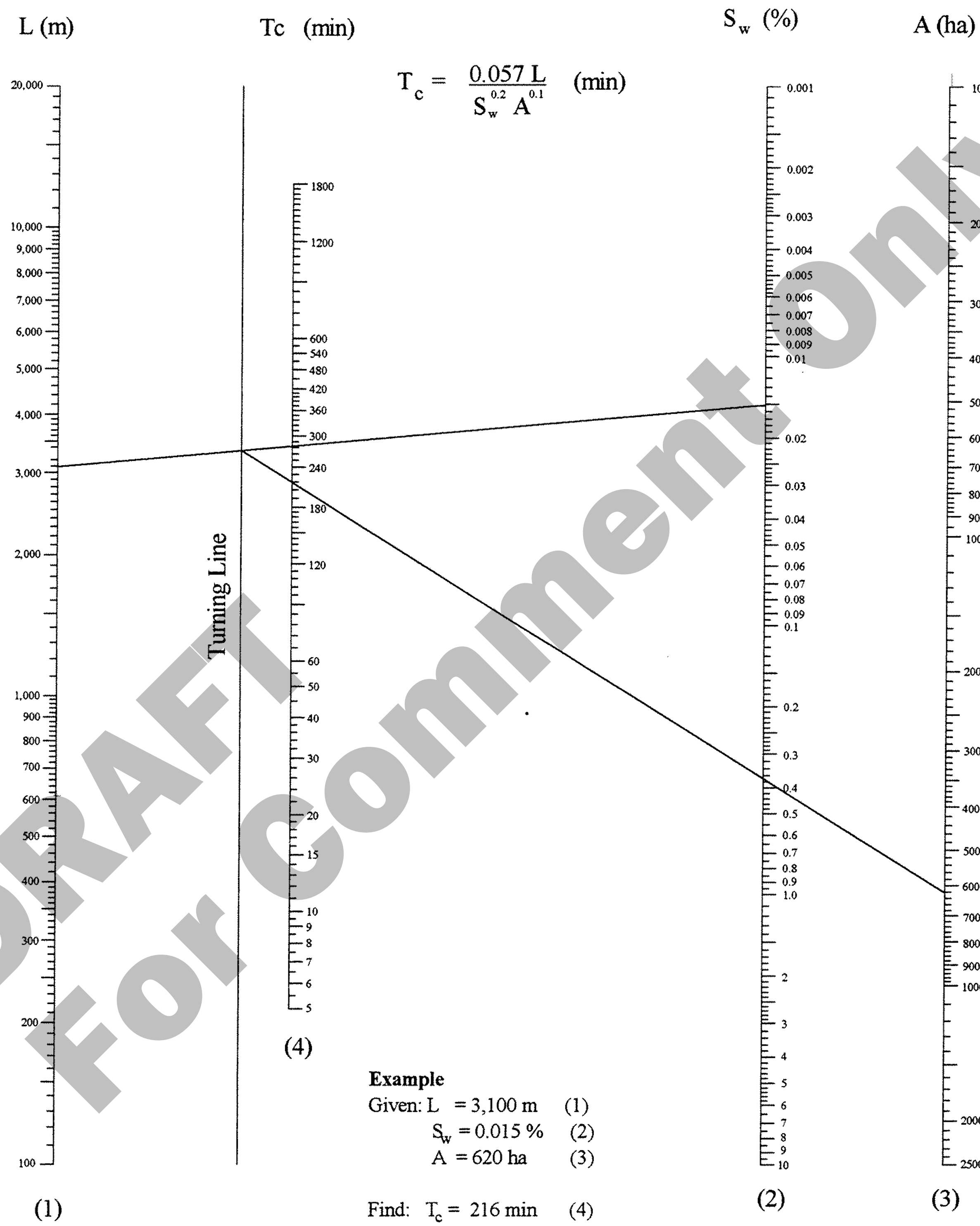
Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED			
Flat 0 - 5% Slopes	0.22	0.35	0.55
Rolling 5 - 10% Slopes	0.30	0.45	0.60
Hilly 10- 30% Slopes	0.40	0.65	0.70
PASTURE			
Flat 0 - 5% Slopes	0.10	0.28	0.40
Rolling 5 - 10% Slopes	0.15	0.35	0.45
Hilly 10- 30% Slopes	0.22	0.40	0.55
WOODLAND OR CUTOVER			
Flat 0 - 5% Slopes	0.08	0.25	0.35
Rolling 5 - 10% Slopes	0.12	0.30	0.42
Hilly 10- 30% Slopes	0.18	0.35	0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes	0.40	0.55	0.75
Rolling 5 - 10% Slopes	0.50	0.65	0.80
Hilly 10- 30% Slopes	0.55	0.70	0.85
LAKES AND WETLANDS	0.05		

[2] Terrain Slopes

[3] Interpolate for other values of % imperviousness

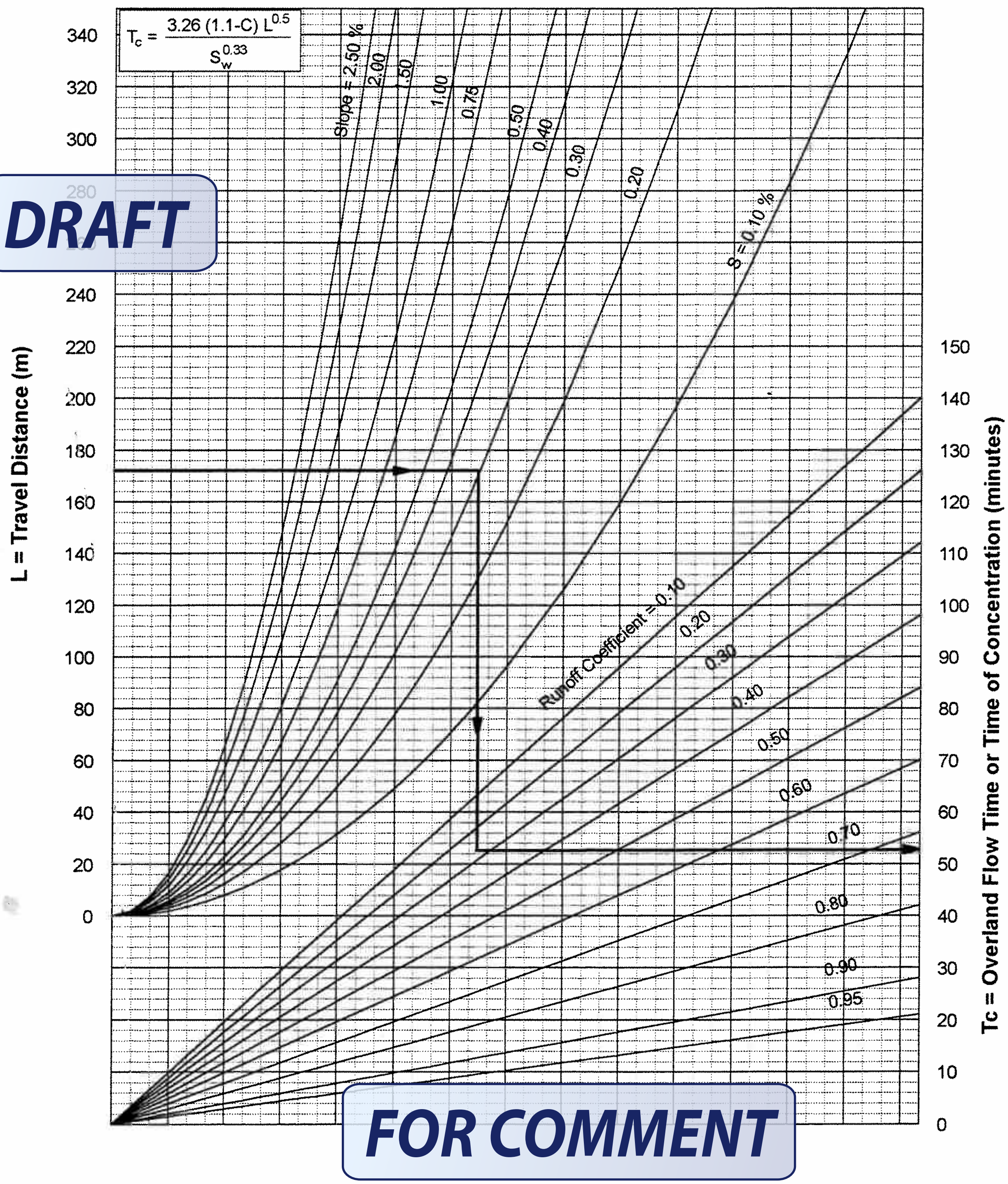
Sources: American Society of Civil Engineers - ASCE (1960)
U.S. Department of Agriculture (1972)

Design Chart 1.11: Time of Concentration - Bransby Williams Method



Source: French R., et al (1974)

Design Chart 1.12: Time of Concentration - Airport Method



Source: U.S. Department of Transportation (1970)

Design Chart 1.13: Infiltration Parameters

Horton Equation - Typical Values

		Minimum Infiltration Rate (mm/hr)	Maximum* Infiltration Rate (mm/hr)
Soil Group	A	25	250
	B	13	200
	C	5	125
	D	5	75

Decay Parameter 2 hr^{-1}

*Dry Soil Conditions

Green-Ampt Method - Typical Values

		IMD (mm/mm)	S_u (mm)	K_s (mm/hr)
Soil Group	A (sand)	0.34	100	25
	B (silt loam)	0.32	300	13
	C (sand clay loam)	0.26	250	5
	D (clay)	0.21	180	3

Source: M.L. Terstriep and J.B. Stall (1974)
U.S. EPA (1989)