1.0 INTRODUCTION

1.1 Purpose

The City of Kawartha Lakes storm drainage and stormwater management policies and design guidelines presented herein are intended as a guide to provide a solid engineering basis for storm drainage and stormwater management design, to establish uniform guidelines of minimum standards, and to improve processing of site plan and plan of subdivision applications for approval in the City. The development review process involves a number of review agencies each of which has guidelines, policies and criteria that should be followed when completing the storm drainage and stormwater management design for site plans and plans of subdivision. In an effort to maintain some consistency and to streamline the development review process, a review of guidelines, policies and criteria from various governing review agencies was completed while preparing the policies and guidelines included in this document. While best efforts were made to minimize discrepancies between the City's guidelines and those from various agencies, it was not possible to do so in all cases while meeting the City's requirements. Where a discrepancy between the policies and guidelines presented in this document and other agency guidelines exists, the policies and guidelines in this document will govern in completing the City's review of development applications. Otherwise, the guidelines, policies and criteria of other review agencies such as the LSRCA, ORCA, The Oak Ridges Moraine, KRCA and the MOE will govern. Technological or economical deviations which improve or maintain the quality of the design will be considered and must be approved by the City. Changes and revisions may be made to these policies and guidelines from time to time and it is the responsibility of the Developer or the Developer's Consulting Engineer to obtain and make use of the latest version available at the time of engineering design. This document does not provide guidance on the selection of storm drainage or management technologies required to meet specific drainage or environmental objectives.

1.2 Environmental and Municipal Land Use Planning

The Environmental and Municipal Land Use Planning Process has evolved over time to enable a streamlined review process and to ensure that qualified input and representation from the agencies, public and consultants is provided at the appropriate time. The following sections describe the Urban Drainage/Environmental Plans that are required at different stages of the overall planning process.

1.2.1 Watershed Plan

Planning at the watershed level has become an accepted practice, as it integrates resource management, land use planning and land management practices. The typical drainage area associated with a watershed plan is in the order of 1,000 km^2. The watershed consists of an area of land that drains to a major river, lake or stream and represents a complex ecosystem that is influenced by processes associated with the natural environment and human activities. The watershed plan addresses environmental issues associated with studies at the Official Plan level and sets the stage for determining the effects of existing and proposed land use practices on the resources within the watershed. Watershed plan recommendations typically identify at the macro level how land use changes should proceed while minimizing impacts to the watershed resources. Recommendations from the watershed plan are often used to focus and direct further investigations at the subwatershed level.

1.2.2 Subwatershed Plan

The existing environmental conditions within the subwatershed are identified and defined through a series of technical studies including surface water resources, hydrogeology, fluvial geomorphology, surface water quality, terrestrial resources and aquatic resources. Form, function and linkages of natural systems are identified and constraints to development are delineated based on establishing the environmental goals and objectives for the subwatershed. Alternative subwatershed management strategies are developed and evaluated to determine the preferred strategy to implement in terms of achieving the established goals and objectives. Based on the preferred alternative, recommendations are prepared that will specify areas for protection, restoration and/or enhancement. Regarding stormwater management, recommendations are typically made in terms of the level of controls required for water quality, erosion and quantity control (flood protection). Finally, a plan is proposed that will ensure that the recommendations are implemented. Environmentally sound land use designations and development policies are ensured as the information from the subwatershed plan is incorporated into the planning documents. The land area associated with a subwatershed plan is typically in the order of 50 km^2 to 200 km^2.

1.2.3 Master Drainage Plan

The Master Drainage or Environmental Management Plan takes the form of a variety of studies referred to as a Master Drainage Plan (MDP), Environmental Implementation Report (EIR), or Master Environmental Servicing Plan (MESP) and is typically carried out prior to consideration for Draft Plan Approval. This level of study typically deals with lands in the order of 2 km^2 to 10 km^2 in area; the details provided are sufficient to enable the preparation of block plans. The Master Drainage or Environmental Management Plan demonstrates how development can proceed in accordance with the requirements and criteria established in the Subwatershed Plan. Details provided in the plan include a review of existing information and existing environmental conditions, the establishment of constraint and opportunity mapping, and the development of a preferred environmental and stormwater management strategy for the lands within the plan study area. A sufficient level of detail is provided to enable the preparation of the preliminary or conceptual Stormwater Management Plan for all lands within the block plan.

1.2.4 Stormwater Management Plan (Preliminary/Conceptual Design)

The Stormwater Management Plan prepared at the preliminary or conceptual design stage is typically completed as a Preliminary SWM Report, a Functional SWM Report, or Functional Servicing Report (FSR). A Functional Servicing Report describes the proposed water supply, sanitary servicing, storm sewer drainage system, and stormwater quality and quantity control facilities and how the servicing and development will proceed in accordance with the Master Drainage or Environmental Management

Plan recommendations. A Preliminary or Functional SWM Report focuses on the storm drainage system and the proposed stormwater quality and control facilities alone without discussing the additional servicing. The Stormwater Management Plan at the preliminary/conceptual stage provides guidelines for the Draft Plan Approval process and lays the groundwork for the detailed design stage.

1.2.5 Stormwater Management Plan (Detailed Design)

The Stormwater Management Plan prepared at the detailed design stage is referred to as a Stormwater Management Report. The Stormwater Management Report provides details and supporting calculations associated with the detailed design of the minor and major drainage system and the required source, conveyance and end-of-pipe controls (i.e. SWM facilities) to achieve the criteria established in the *MOE's Stormwater Management, Planning and Design Manual.* The Stormwater Management Report is typically prepared following issuance of Draft Plan Conditions and is required for Plan of Subdivision Approval and Registration.

1.2.6 Municipal Class Environmental Assessment

The Municipal Class EA applies to municipal infrastructure projects including roads, water and wastewater projects. Depending on the potential environmental impact of projects undertaken by the municipality, the project is classified according to the following schedules that must be adhered to as part of the Municipal Class EA process:
Schedule A Generally includes normal or emergency operational and maintenance activities. The environmental effects of these activities are usually minimal and, therefore, these projects are pre-approved.
Schedule A+ These projects are pre-approved, however, the public is to be advised prior to project implementation. The manner in which the public is advised is to be determined by the proponent.
Schedule B Generally includes improvements and minor expansions to existing facilities. There is the potential for some adverse environmental impacts and, therefore, the proponent is required to proceed through a screening process including consultation with those who may be affected.
Schedule C Generally includes the construction of new facilities and major expansions to existing facilities. These projects proceed through the environmental assessment planning process outlined in the Municipal Class EA document (MEA, September 2007).

1.3 Format of Document

The document is organized into 9 sections with the intent to provide the reader with a comprehensive set of policies and guidelines regarding storm drainage and stormwater management design to be followed when submitting site plans and plans of subdivision to the City for approval.
Section 2 *- Legislation, Acts and Regulations* – This section provides a review of current legislation, acts and regulations that form the basis for most of the existing municipal, regional, provincial and federal guidelines, policies and criteria.
Section 3 *- Stormwater Drainage System Polices and Design Guidelines* – All of the municipal policies and design guidelines regarding the major and minor storm drainage system are provided in this section.

Section 4 - *Stormwater Management Policies and Design Guidelines* – The municipal policies and design guidelines regarding stormwater management are provided in this section including source, conveyance and end-of-pipe controls, planting guidelines and density requirements.
Section 5 - *Requirements for Erosion and Sediment Control During Construction* – This section provides the municipal requirements that must be followed when designing and implementing erosion and sediment control measures during construction.
Section 6 - *Assumption Protocol for Storm Sewers and Stormwater Management Ponds* – The protocol that must be followed when completing performance evaluations for storm sewers and SWM ponds is included in this section.
Section 7 - *Guidelines for Hydrologic and Hydraulic Analyses* – In this section a number of guidelines are provided for completing various hydrologic and hydraulic analyses including rainfall data, runoff and flow calculations, hydraulic calculations and water balance.
Section 8 - *Engineering Submission and Reporting Requirements (Drainage Designs / SWM Reports)* – An outline of the miscellaneous requirements for storm drainage and stormwater management details to be included in development submissions is provided in this section.
Section 9 - *References* – References for information cited and included in this document are provided in this section. *Appendices* – A collection of detailed information related to the municipal policies and guidelines is provided in a series of appendices at the back of this document.

2.0 LEGISLATION – ACTS AND REGULATIONS

Stormwater management policies and design guidelines provided in this document were developed based on legislation and acts for:

• Watercourses and Existing Infrastructure (i.e., Culverts and Bridges, Roads)
• Erosion and Sediment Control
• Flood Damage Control
• Pollution Prevention
• Fisheries

30 STORMWATER DRAINAGE SYSTEM POLICIES AND DESIGN GUIDELINES

This section discusses the policies and design guidelines applicable to the storm drainage system including foundation drains, the minor system (storm sewers), the major system (roads and swales), bridges and culverts, watercourses, and easements and buffers. When constructing on private property, construction materials and practices must be in accordance with the Ontario Building Code (OBC), the City of Kawartha Lakes Standards and the City's *Lot Grading Criteria and Drainage Control Procedures*.

3.1 Foundation Drain Collector Outlet System

Foundation drain collector systems shall be designed on the basis of a continuous flow rate of 0.075 liters per second per residential lot plus infiltration. The minimum foundation drain collector diameter shall be 200 mm. Material and bedding standards applicable to foundation drain collectors shall be in accordance with City of Kawartha Lakes Standard Drawings.

3.1.1 Foundation Drains

In order to minimize the flow rate from foundation drains, piezometer tests will be completed prior to design and construction to determine the seasonal high water level. Foundation elevations should then be set 0.5 m higher than the water table or as high as is practical. Where the anticipated flow from sump pumps will be considered a nuisance as deemed by the City, the City may request that Options 2 and 3 be implemented. Foundation drains shall have an accessible outlet for maintenance/cleanout. Foundation drains shall not be connected to the storm sewer system unless as identified in the options below. The City will allow for an approved outlet which could include the storm sewer system. The following alternatives are acceptable to the City:

1. *Option 1 – Sump pump with discharge of foundation drain flow to ground surface.*
Flow collecting in the foundation drain shall be pumped to the surface using a sump pump and then conveyed overland via lot drainage to the street or surface drain.

2. *Option 2 – Sump pump with discharge of foundation drain flow to storm sewer extension at surface or subsurface.*
Lots shall be constructed with a storm sewer extension extending from the storm sewer to the surface or subsurface adjacent to the building. Flow collecting in the foundation drain shall be pumped to the surface (or subsurface) using a sump pump and into the storm sewer extension and then conveyed to the storm sewer. A benefit of this configuration is the ability to discharge flow from foundation drains to the storm sewer while eliminating the risk of basement flooding and avoiding surface discharge and nuisance flooding.

3. *Option 3 – Gravity drain or sump pump with discharge to third pipe (foundation drain collector – FDC).*
A third pipe (FDC) shall be constructed in the right-of-way (ROW) to collect foundation drain flow by gravity (or using a sump pump if grades do not permit) and to convey the flow to a nearby watercourse or other acceptable receiving body. Similar to the option above, an FDC eliminates the risk of basement flooding and surface discharge and nuisance flooding.

4. *Option 4 – Sump pump discharge piping in boulevard (retrofit option only).*
In the event of overactive sump pump activity, a 150 mm diameter PVC DR-28 sewer may be installed, when so directed by the City, along the frontages of designated lots, with an offset of 0.6 m from back of curb. This sewer is to have a cleanout at the upstream end and is to outlet into the nearest catchbasin downstream. The depth of sewer is to be equal to the subdrain depth. The discharge piping shall not be directly connected to the foundation drains.

3.2 Minor System

Storm sewers shall be provided on all roads with curb and gutter. Storm sewers shall be designed to convey, as a minimum, the 1:5 year design storm.

3.2.1 Service Area

The drainage system shall be designed to accommodate all upstream drainage areas plus any external area tributary to the system for the existing, interim and ultimate development conditions, as determined by the delineation of topographic mapping derived from a topographic survey and the preparation of drainage plans.

3.2.2 Design Flow

Storm sewer systems with a drainage area ≤ 50 ha shall be designed to convey the 1:5 year (minimum) design storm using the Rational Method and the City's IDF regression equation for rainfall intensity unless otherwise approved or directed by the City. Storm sewer systems with a drainage area > 50 ha shall be designed using an approved computer program and verified with the Rational Method. The storm sewer design shall be based on the larger of the two flows calculated using the computer model and the Rational Method. Under no circumstances shall the storm system be designed in a surcharged condition. The design of the storm sewers shall be computed using the City of Kawartha Lake's Storm Sewer Design Sheet as provided in **Appendix A.**
All storm sewers shall be designed according to the Rational Formula where:

$$Q = \frac{(C)(i)(A)}{360}$$

where,

Q	= the design flow in (m^3/s)
C	= the site specific runoff coefficient
A	= the drainage area (ha)
I	= rainfall intensity (mm/hr)

The rainfall intensity shall be calculated in accordance with the following table and equation:

Table 3.1: Lindsay Infiltration IDF Curve Parameters

Parameter	Return period					
	2-Yr	**5-Yr**	**10-Yr**	**25-Yr**	**50-Yr**	**100-Yr**
A	808.793	1248.043	1486.840	1917.901	2141.858	2645.877
B	7.421	9.759	10.440	11.842	12.181	12.899
C	0.835	0.857	0.859	0.873	0.872	0.879

Rainfall Intensity, I (mm/hr) = A/(t+B)C, where t is time duration in minutes
Parameters based on rain gauge data for the period 1971 – 1990 for the Lindsay Filtration Plant Station #6164432

$$i = \frac{A}{(t_d + B)^C}$$

where,

i = the rainfall intensity (mm/hr)
t_d = the storm duration (minutes)
A, B, C = a function of the local intensity-duration data.

The storm duration is set to the time of concentration (i.e. the sewer inlet time plus the time of travel in the pipe or channel) for the total cumulative drainage area to the node of interest. The maximum inlet time for the first pipe of a storm sewer system is 10 minutes.

The runoff coefficient shall be calculated in accordance with the following table:

Table 3.2: Runoff Coefficients (Rational *C*) (5-yr to 10-yr) Based on Hydrologic Soil Group

Land Use	Runoff Coefficient "C"		
	A-AB	**B-BC**	**C-D**
Cultivated Land, 0 - 5% grade	0.22	0.35	0.55
Cultivated Land, 5 - 10% grade	0.30	0.45	0.60
Cultivated Land, 10 - 30% grade	0.40	0.65	0.70
Pasture Land, 0 - 5% grade	0.10	0.28	0.40
Pasture Land, 5 - 10% grade	0.15	0.35	0.45
Pasture Land, 10 - 30% grade	0.22	0.40	0.55
Woodlot or Cutover, 0 – 5% grade	0.08	0.25	0.35
Woodlot or Cutover, 5 - 10% grade	0.12	0.30	0.42
Woodlot or Cutover, 10 - 30% grade	0.18	0.35	0.52
Lakes and Wetlands	0.05	0.05	0.05
Impervious Area (i.e., buildings, roads, parking lots, etc.)	0.95	0.95	0.95
Gravel (not to be used for proposed parking or storage areas)	0.40	0.50	0.60
Residential – Single Family	0.30	0.40	0.50
Residential – Multiple (i.e., semi, townhouse, apartment)	0.50	0.60	0.70
Industrial – light	0.55	0.65	0.75
Industrial – heavy	0.65	0.75	0.85
Commercial	0.60	0.70	0.80
Unimproved Areas	0.10	0.20	0.30
Lawn, < 2% grade	0.05	0.11	0.17
Lawn, 2 - 7% grade	0.10	0.16	0.22
Lawn, > 7% grade	0.15	0.25	0.35

Adapted from Design Chart 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997)

An approximation of the runoff coefficient can be calculated based on the following relationship with:

$$c = (0.7)(TIMP) + 0.2$$

where,

c = the runoff coefficient
TIMP = total impervious fraction (dimensionless)

The runoff coefficient shall be adjusted for return period events greater than the 10-yr storm per the following table:

Table 3.3: Runoff Coefficient Adjustment for 25-yr to 100-yr Storms

Return Period Runoff	Coefficient "C"
25 years	C25 = 1.1*C5
50 years	C50 = 1.2*C5
100 years	C100 = 1.25*C5

Adapted from Design Chart 1.07, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997).
Note: When applying the runoff coefficient adjustment, the maximum C-value should not exceed 1.0.

Given that the direct connection of foundation drains to the storm sewer is not permitted, a detailed HGL analysis is typically not required unless deemed otherwise by the City due to special circumstances. Refer to **Section 7.3** for details regarding HGL analysis requirements.

The calculation of total percent impervious (TIMP) values for modeling shall be in accordance with **Section 7.2.5** (**Table 7.6**).

3.2.3 Pipe Capacity and Size

The storm sewer capacity shall be calculated using the Manning's equation assuming the pipe is flowing full as follows:

$$Q = \left[\frac{1}{n}\right] A(R)^{\frac{2}{3}} (S)^{\frac{1}{2}}$$

where,

Q = the pipe capacity (m3/s)
n = the Manning roughness value
R = the hydraulic radius (m)
S = the sewer pipe slope (m/m).

A maximum inlet time of 10 minutes shall be used for the first pipe of a storm sewer system.

The velocity of flow in the storm sewer (assuming pipe flowing full) shall be calculated as follows:

$$v = \left[\frac{Q}{A}\right]$$

where,

Q = flow in the pipe when flowing full (m3/s)
A = cross sectional area of the pipe (m2)

The appropriate roughness coefficients shall be used as identified in **Table 3.4**.
The minimum size for a storm sewer (within a street) shall be 300 mm in diameter. No decrease of pipe size from a larger size upstream to a smaller size downstream shall be allowed regardless of the increase in grade.

3.2.4 Roughness Coefficients

The following roughness coefficients shall be used for hydraulic calculations of storm sewers:

Table 3.4: Sewer Pipe Manning's Coefficient

Material	Manning's "n"
Concrete, PVC, Profile Rib Pipe	0.013
Corrugated Metal with 25% Paved Invert	0.021
Corrugated Metal 68 x 13 mm Corrugations	0.024

3.2.5 Flow Velocity

The minimum flow velocity in the storm sewer shall be 0.75 m/s (full flow conditions).

The maximum flow velocity in the storm sewer shall be 4.0 m/s (full flow conditions).

3.2.6 Minimum Slope

The minimum storm sewer slope shall be not less than 0.5% unless specifically approved by the Director of Engineering.

3.2.7 Sewer Alignment

The storm sewers shall be laid in a straight line between maintenance holes unless radius pipe has been designed.

3.2.8 Curved Sewers (radius pipe)

Curved pipe (radius pipe) shall be allowed for storm sewers 1200 mm in diameter and larger. The minimum center line radius allowable shall be in accordance with the minimum radii table as provided by the manufacturer.

3.2.9 Depth of Storm Sewers

A minimum 1.5 m cover below the centerline of road to obvert shall be provided for storm sewers. Under certain conditions where sufficient cover is not feasible, shallow insulated pipes may be permitted subject to review by the City.

3.2.10 Pipe Crossing and Clearance

A minimum clearance of 500 mm between the obvert of the sanitary sewer and the invert of the storm sewer shall be provided if the sanitary sewer connections are required to go under the storm sewer. The minimum horizontal clearance between the outside wall of the adjacent sewer pipes shall be 800 millimeters. On crescent roads or roads with numerous bends, the sewer position may generally follow the same relative side of the road allowance.

The minimum clearance from a sewer to a watermain shall be 2.5 m horizontally and 0.5 m vertically.

3.2.11 Sewer Bedding

The type and classification of the storm sewer pipe and the sewer bedding type shall be clearly indicated on all profile drawings for each sewer length.

Bedding type selection shall be based on the depth of sewer, sewer material, trench width and configuration and soil conditions. Pipe loading calculations shall accompany the design submission. Storm sewers shall be constructed with bedding as per the current Ontario Provincial Standard Drawings (OPSD) (Gran. “A” embedment material) for flexible pipes and Class B (Gran. “A” bedding material) for rigid pipe unless otherwise approved by the Director of Engineering.

All pipe bedding must conform to OPSD, maximum cover table. No flexible pipe sewers will be installed with a depth of cover greater than 6 m unless specifically approved by the Director of Engineering.

3.2.12 Joints

All concrete and PVC pipes shall have rubber gasket joints.

3.2.13 Maintenance Holes

Maintenance holes shall be provided at each top end or dead end of a sewer line, change in alignment, grade, material, and at all junctions except where radius pipe is used in sizes 1200 mm and larger.

Maintenance holes shall be located 3.0 m off the road centre line as per City Standards.

Maintenance holes shall be located, whenever possible, with a minimum of 1.5 m clearance away from the face of curb and/or any other service.

Full height benching within maintenance holes shall be completed per current OPSD.

The maximum maintenance hole spacing shall be 100 m for a pipe diameter less than 1200 mm and 150 m for pipe diameter 1200 mm or larger.

The maximum change in direction is 90 degrees for pipes 900 mm and smaller and 45 degrees for pipes over 900 mm.

The minimum allowances for hydraulic losses incurred at maintenance holes shall be as follows:

Table 3.5: Required Pipe Elevation Drop in Maintenance Holes

Change in Direction	Minimum Required Drops
0 degrees	30 mm
>0 – 45 degrees	80 mm
46 – 90 degrees	150 mm

Where the difference in elevation between the obvert of the inlet and outlet pipes exceed 0.9 m, a drop structure shall be designed in accordance with current City standards. Obverts of inlet pipes shall not be lower than obverts of outlet pipes.

3.2.14 Catch Basins

Catch basins shall be located upstream of pedestrian crossings, at street intersections such as to avoid driveways, sidewalks, and walkways and, where possible, to outlet into maintenance holes.

Type:

The single (CB), double (DCB) and rear lot (RLCB) type of catch basin shall be designed based on OPSD. Any proposed special catch basins and inlet structures must be approved by the City.

Due to maintenance issues, RLCB’s are typically not permitted by the City except when other options are not feasible. Wherever possible, site grading should be designed in such a way that RLCB’s are not required.

Capacity Design:

DCB’s are to be installed at the low point of any road where drainage is collected from 2 or more directions. CB’s may be acceptable at low points approaching intersections where drainage is mostly from one direction.

The maximum spacing shall be in accordance with the following:

Table 3.6: CB Spacing

Road Pavement Width	Slope	Maximum Spacing
≥10 m	> 4.5%	60 m
	≤ 4.5%	75 m
< 10m	> 4.5%	75 m
	≤ 4.5%	90 m

The maximum drainage area for any catchbasin shall be 2000 m^2 of paved area or 5000 m^2 of grassed area.
Additional catch basins may be required at road intersections, elbows, and cul-de-sacs to facilitate satisfactory drainage.

Leads:

The lead size for catch basins shall be as follows:

- 250 mm diameter with a 2% minimum slope for single CB's
- 300 mm diameter with a 2% minimum slope for DCB's; and
- 250 mm diameter with a minimum 0.5 % slope for RLCB's.

ICDs

Inlet control devices (ICD's) shall be installed where the inlet capacity must be regulated. Inlet Control Devices such as orifice plates or other flow control devices are to be permanently attached to the storm structure in parking lots.

3.2.15 Sewer Materials, Catch Basin and Maintenance Hole Types

Sewer Material Specifications:

Polyvinyl Chloride (PVC) specifications: can be used for either residential or industrial use conforming to CSA Standard B182.1, ASTM D3034 for pipe size 100 millimeter to 150 millimeter diameters, CSA Standard B182.2, ASTM D3034 for pipe size 200 millimeter to 375 millimeter diameter and CSA Standard 182.4, ASTM F-794 for pipe size greater than 450 millimeter diameter or current edition only as approved by the City.

Concrete Pipe specifications: complying with CSA Standard A257.1 (concrete sewer, storm drain and culvert pipe), CSA Standard A257.2 (reinforced concrete culvert storm drain and sewer pipe), and CSA Standard A257.3 (joints for concrete sewer and culvert pipe using flexible water tight rubber gaskets), ASTM C14, C76, C655.

<u>Profile Rib Pipe specifications:</u> For 250 mm to 450 mm (inclusive), pipe to be manufactured to the latest edition of CSA Standard B-182.2 (ASTM Specification F-794) with rubber gasketed bell and spigot joints. Pipe and fittings shall have a maximum Standard Dimension Ratio of 35 (SDR-35) and a minimum pipe stiffness of 320 kPa, or higher strength as may be required by the design.

Maintenance Hole Material and Type:

The minimum size for a MH shall be 1200 mm in diameter or 1200 mm x 1200 mm precast or poured in place concrete with precast or poured concrete bases in accordance with the OPSD drawings.

Catch Basin Material and Types:

Catch basin design shall be per the OPSD standard drawings using precast or poured in place concrete.

3.2.16 Storm Sewer Connections

The connection of sanitary sewers and foundation drains to the storm sewer is *strictly prohibited.* Options for foundation drain discharge are provided in **Section 3.1**.

3.3 Major System

The major system shall be designed to safely convey flow in excess of the minor system including the larger of the 100-yr storm and Regional Timmins Storm via streets, open channels, storm sewers, walkways, and approved drainage easements to a safe outlet without flooding private property.

3.3.1 Drainage Area

The drainage area shall include all upstream drainage areas for the interim and ultimate conditions including any external area tributary to the system, as determined by suitable topographic mapping, site survey, and drainage plans.

3.3.2 External Drainage

All external tributary areas not accounted for in adjacent storm drainage areas, as well as other areas which may become tributary due to re-grading, shall be included in the site drainage plans.

3.3.3 Design Flow

The major system shall be designed to safely convey the Regulatory storm (*i.e.* larger of the 100-yr or Timmins) (less minor system flow) through the road network without flooding private property and/or drainage easements.

3.3.4 Lot Grading and Drainage

The minimum lot grading around houses and buildings shall be 2%. The minimum grades for side lot swales and rear lot swales shall be 2%. All grading design shall be completed in accordance with the governing guidelines which are currently documented in the City’s Lot Grading and Drainage Guidelines. Where applicable, side and rear lot swales shall be located on the low side of the property line.

3.3.5 Overland Flow Routes

An overland flow route must be established to safely convey runoff from the Regulatory storm (in excess of the design capacity of the minor system) within the road right-of-way or easements to the nearest major open channel.

3.3.6 Roughness Coefficients

The tables below should be consulted in completing channel and overland flow calculations. The equation for Manning’s Overland flow (assuming a wide plane with shallow flows such that R is approximately equal to the channel bottom width) is:

$$q_o = \left[\frac{1}{n}\right](S_o)^{\frac{1}{2}}(y_o)^{\frac{5}{3}}$$

where,

Q_o = the overland flow per unit width of overland flow (m3/s/m)
n = the Manning roughness value for overland flow
S_o = the average overland flow slope (m/m)
Y_o = the mean depth of overland flow (m).

The Manning’s equation for channel flow is:

$$Q = \left[\frac{1}{n}\right](A)(R)^{\frac{2}{3}}(S_o)^{\frac{1}{2}}$$

where,

Q = the channel flow (m3/s)
n = the Manning roughness value for channel routing
R = the hydraulic radius (area/wetted perimeter)(m)
S_o = the channel slope (m/m).

and

$$V = \left[\frac{1}{n}\right](R)^{\frac{2}{3}}(S)^{\frac{1}{2}}$$

where,

V = the channel velocity (m/s)
n = the Manning roughness value for channel routing
R = the hydraulic radius (area/wetted perimeter)(m)
S_o = the channel slope (m/m).

Table 3.7: Manning's Roughness Coefficients - for Channel Routing

Location	Cover	Manning's "n"
	Woods	0.080 - 0.120
Over bank	Meadows	0.055 – 0.070
	Lawns	0.035 - 0.050
	Natural	0.030 – 0.080
	Grass	0.030 - 0.050
	Natural Rock	0.030
	Armour Stone	0.025
Channel	Concrete/asphalt	0.015
	Articulated Block e.g. Terrafix	0.020
	Gabions	0.025
	Wood	0.015
	Corrugated Steel Pipe - 3"x1"	0.024
	Structural Plate Corrugated Steel Pipe - 6"x2"	0.032

Adapted from Design Chart 2.01, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997)

Table 3.8: Manning's Roughness Coefficients - for Overland Flow

Cover	Manning's "n"
Impervious Areas	0.013
Woods	
---- with light underbrush	0.400
---- with dense underbrush	0.800
Lawn	
---- short grass	0.150
---- dense grass	0.240
Agriculture	0.050-0.170

Adapted from Soil Conservation Service, Urban Hydrology for Small Watersheds, U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division, Technical Release 55, June 1986

3.3.7 Roads

Road grading must direct flows from the right-of-way to a safe outlet at specified low points. Outlets can be walkways or open sections of road leading to open spaces or river valleys. Roads may be used for major system overland flow conveyance during the Regulatory (*i.e.* the larger of the 100-yr storm and Timmins) storm subject to the following depth constraints:

Table 3.9: Maximum Allowable Flow Depth for Centre Line for Roads

Location	Maximum Ponding Depth
Local Road	0.20 m above crown of road
Collector and Industrial Road	0.10 m above crown of road
Arterial Roads	Single lane to remain open

3.3.8 Channels

Overland flow channels shall be designed to convey the Regulatory storm peak flow without flooding adjacent private properties. Appropriate stabilization shall be provided to protect against velocity conditions experienced during the Regulatory storm and calculations shall be provided to the City for review and approval. The maximum velocities during the 1:5 year and Regulatory storms shall be 1.5 m/s and 2.5 m/s, respectively for sod lined channels. Channels expected to experience higher flow velocities shall be stabilized using other measures approved by the City, such as soil reinforcement or stone lining. Calculations, using the Maximum Permissible Tractive Force method (*MTO Drainage Management Manual*, Section 5), shall be provided to the City and Conservation Authority for review.

3.3.9 Total Capture Inlets

Total capture inlet grates shall be sized with a minimum 2.0 factor of safety (*i.e.* assume 50% blockage). Inlet grates shall be designed as per OPS drawings.

3.3.10 Conveyance of Flow from Road to SWM Facility or Channel

The Consultant must demonstrate that overland flows during the Regulatory storm can be safely conveyed from the road allowance to a SWM facility or open channel without flooding adjacent private properties. Overland flows may be routed as follows:

- Overland flow may be routed over the curb and boulevard. The Consultant must demonstrate that sufficient hydraulic capacity exists using the broad-crested weir equation. The flow route from the boulevard into the SWM facility or open channel must be stabilized to prevent slope erosion.
- Overland flow must be contained within publicly owned lands.
- Overland flow must be captured and piped at the major system low point(s) on the roadway unless the Consultant can demonstrate that the flow can be conveyed by other means to the satisfaction of the City.
- The Consultant must demonstrate that the inlet grates required to capture the major system flow have sufficient hydraulic capacity assuming 50% bar area and blockage of opening.

3.3.11 Outfall Channels

<u>*General*</u>

The following general principles are to be applied when designing storm sewer or FDC outfalls to a natural watercourse:

- Headwall designs shall conform to OPSD. Pipes 900 mm in diameter or greater shall be complemented by armourstone wing walls. Headwall grates, as per OPSD, shall be specified for all headwalls.
- Outfall inverts are to be located at or above the 1:2 year storm flood level in the receiving watercourse.

- Headwalls shall be protected by a 1200 mm height black vinyl chainlink fence and the posts shall be cored into the concrete headwall and/or armourstone wing walls.
- All exposed concrete faces and surface treatment shall conform to City Standards
- All outfalls to a watercourse require a permit from the Conservation Authority.

Hydraulics
The following hydraulic considerations are to be incorporated to all outfall channel designs:

- To minimize erosion, outfall channels shall be extended from the headwall to the natural watercourse. The outfall channel shall be designed, where possible, such that flow in the outlet channel is tangential to the flow in the natural watercourse at the confluence. The outfall channel shall tie into the natural watercourse at or above the natural water level in the watercourse.
- Discharge onto steep slopes is not permitted.
- Outfall channels shall be designed to withstand the erosive forces experienced under the design storm event. Calculations, using the Maximum Permissible Tractive Force method (*MTO Drainage Management Manual*, Section 5), shall be provided to the City and Conservation Authority for review.
- Tailwater impacts of the natural watercourse shall be accounted for in the design of the outfall channel, control structures and upstream storm sewer/FDC systems.

3.4 Bridges and Culverts

Culverts and bridges crossing arterial roads must be designed to prevent overtopping during the 100-yr storm. Under certain circumstances the City may request protection from overtopping for the Regional storm. In addition, bridges and culverts shall be designed so there is no increase in the Regulatory flood conditions of the watercourse.

All culverts shall be supplied with headwall end protection constructed of interlocking wall systems, concrete, armour stone or other material approved by the City.

Corrugated Steel Pipe (CSP) Culvert Specifications

- All CSP to be Aluminized (Type 2) pipe in accordance with CSA Standard G.401.
- For 150 mm to 600 mm (inclusive), pipe to be manufactured with the profile dimensions 68 mm x 13 mm with a minimum wall thickness of 1.6 mm.
- For 700 mm to 1000 mm (inclusive), pipe to be manufactured with the profile dimensions 68 mm x 13 mm with a minimum wall thickness of 2.0 mm.
- For 1200 mm to 2400 mm (inclusive), pipe to be manufactured with the profile dimensions 125 mm x 26 mm with a minimum wall thickness of 2.0 mm.
- For 2700 mm to 3000 mm (inclusive), pipe to be manufactured with the profile dimensions 125 mm x 26 mm with a minimum wall thickness of 2.8 mm.

- For 3300 mm and larger, pipe to be manufactured with the profile dimensions 125 mm x 26 mm with a minimum wall thickness of 3.5 mm.
- All CSP to be manufactured with Annular Corrugated ends to allow for a variety of joints to be utilized for standard pipes and pipe-arches. Three recommended and approved types of coupler are the Hugger band, the Annular corrugated standard bolt and angle coupler, and the Dimpled coupling band.

3.4.1 Road Crossings

For local roads, the maximum allowable overflow depth over the gutter elevation shall be 300 mm and must not cause damage to private property. Road crossing culverts shall be a minimum of 600 mm (2.0 mm CSP gauge) in diameter with headwall.

3.4.2 Roadside Ditches and Culverts

When designing a rural road cross section, the design of roadside ditches shall consider the following:

- Ditch inverts shall be located a minimum of 0.15 m and a maximum of 0.50 m below the roadway subgrade elevation. Where the minimum of 0.15 m cannot be met, a ditch subdrain will be required and shall outlet to the ditch once the minimum depth criterion is met.
- The minimum and maximum ditch gradients shall be 2.0% (wherever possible) and 6.0%, respectively.
- Ditch protection shall consist of 200 mm topsoil and staked sod on the side slopes and bottom of the ditch.
  In the event that the 1:5 year storm velocity in the ditch exceeds 1.5 m/s, or the Regulatory storm velocity exceeds 2.5 m/s, the ditches shall be stabilized using other measures approved by the City such as soil reinforcement or stone lining.
- All roadside ditches shall transport runoff to a safe outlet, such as a stormwater management facility or natural watercourse, approved by the City.

The design of culverts shall consider the following:

- Entrance or driveway culverts must have a minimum size of 450 mm (1.6 mm CSP gauge) with appropriate end treatment and be sized to convey the 10-yr event (minimum) without overtopping unless otherwise directed by the City.
- A minimum of 300 mm cover shall be provided at the edge of the shoulders.
- End protection shall be provided on all driveway culverts, including metal aprons, concrete, pressure treated timbers, concrete headwalls or precast stones.

3.4.3 Design Flow Capacity

The following design flood frequency shall apply to road crossings unless otherwise directed by the City. Culverts and road elevations shall be designed accordingly to meet the flood design guidelines.

Table 3.10: Flow Design Guidelines for Road Crossing

Road Classification	Design Flood Frequency
Arterial	1:100 Year
0	Regional (Timmins) – if directed by the City
Collector	1:50 Year
Urban Local	1:50 Year
Rural Local	1:25 Year
Temporary	Detour 1:10 Year
Driveway	1:10 Year

Modified from MTO Directive B-100 and the Highway Drainage Design Standards (MTO, Jan 2008).

3.4.4 Headwalls / Endwalls

Headwall and endwall structures shall conform to the current OPSD and City Standards and be included on the engineering drawings. The details provided shall include the existing topography, proposed grading and the works necessary to protect against erosion.

3.4.5 Fish Passage

Requirements for flow and hydraulic calculations regarding fish passage for bridges and culverts shall be completed in accordance with the Federal Department of Fisheries requirements and the MTO Drainage Management Manual and subject to review by the Conservation Authority. Perched culverts are typically not permitted if they will introduce a barrier to fish movement. Open bottom culverts shall be utilized where possible.

3.4.6 Erosion Protection

Armour stone, river stone and/or concrete shall be provided at all inlets and outlets to protect against erosion of the watercourse and provide embankment stability. The maximum allowable target channel velocity shall be in accordance with the MTO Drainage Management Manual (Section 5). Subject to City approval, gabions may be permitted in certain settings (e.g., industrial). Gabions are not permitted in or adjacent to watercourses and other bodies of water.

3.5 Watercourses

Watercourses and associated flood plains shall be capable of handling the Regulatory flood run-off as determined by the Conservation Authority.

3.5.1 Existing Watercourses

Existing water courses shall be left in their natural state as much as possible.

3.5.2 Natural Channel Design

The criteria for natural channel design shall be determined on a site-specific basis and shall be consistent with accepted natural channel design principles such as those provided in the *Adaptive Management of Stream Corridors in Ontario* (MNR, 2002).

A natural channel shall be designed to have a baseflow channel, a 2-yr conveyance channel and an adjacent floodplain in accordance with natural channel principles. The channel shall be designed for the Regulatory flood runoff with approved lined material within the baseflow and 2-yr conveyance channel and with slopes vegetated to the satisfaction of the City. Maximum side slope shall not exceed 4:1 (H:V).

3.6 Blocks

The minimum width of blocks for municipal storm sewers shall be 6.0 metres.

Sewers in between or in the rear yard of houses are to be concrete encased for the full length of the lot and to the back of the street curb.

3.7 General Maintenance Requirements

In order to ensure the optimal and long term continued operation of the storm drainage system prior to assumption and following assumption, it is important that the storm drainage system be regularly maintained. Some of the key components of an effective maintenance program include:

- Regular street sweeping and catch basin cleaning.
- Regular inspections of the storm sewer system including inlet grates and catch basins and periodic flushing and cleaning as required.
- Regular inspections of the overland drainage system including ditches, culverts and bridges and the removal of accumulated sediment and debris as required.
- Regular inspections of total capture inlet grates and the removal of debris as required.
- Regular inspections of storm drainage system components for structural degradation and repair or replacement of degraded components as required.

4.0 STORMWATER MANAGEMENT POLICIES AND DESIGN GUIDELINES

This section describes the stormwater management policies and design guidelines regarding environmental protection and flood and erosion control. This section provides guidance on the design of stormwater management facilities as they may be applied to traditional urban design, urban design concepts employing principles of low impact development (LID) and redevelopment as infill. The stormwater management guidelines to be applied to proposed site plans are dependent upon the drainage area associated with the proposed development.

4.1 Environmental Protection Guidelines

4.1.1 Water Quality and Erosion Control

All new SWM facilities shall provide as a minimum the Enhanced level of protection as specified in the *Stormwater Management Planning and Design Manual* (MOE, 2003). This may not apply to infill developments and the redevelopment of one or more properties if the applicant can demonstrate to the satisfaction of the Director (MOE) that it is impractical to achieve the Enhanced level of protection. In addition, it shall be demonstrated that through an evaluation of anticipated changes in phosphorus loadings between pre-development and post-development conditions how the phosphorus loadings shall be minimized.

Unless otherwise directed by the City or Conservation Authority, or unless otherwise indicated in an approved master drainage plan or watershed plan, developments ≥ 5 ha in drainage area shall require erosion control measures to be implemented whereby the 25 mm 4 hr Chicago storm shall be stored and released over a minimum 24 hour period. Proposed developments < 5 ha may require erosion control measures, depending upon the type of protection provided in any downstream facilities and the potential for downstream erosion. The erosion control requirements for proposed development sites < 5 ha shall be confirmed with the City and Conservation Authority.

4.1.2 Quantity Control (Flood Protection)

Post-to-pre quantity control shall be provided unless otherwise directed by the City or Conservation Authority, or unless otherwise indicated in an approved master drainage plan or watershed plan.

4.1.3 Water Balance

All new developments with a contributing drainage area > 5 ha shall provide post-to-pre infiltration on-site where soils permit and unless otherwise established at the secondary plan stage. The water balance requirements apply to the property limit of the development and do not necessarily need to be achieved on a lot-by-lot basis (*i.e.* "communal" infiltration facilities that service multiple lots may be acceptable). Sites ≤ 5 ha (*e.g.* site plans or infill sites) shall minimize any anticipated changes in the water balance between pre-development and post-development conditions and shall provide a minimum infiltration equivalent to the first 5 mm of any given rainfall event.

4.1.4 Flow Diversions

Unless approved by the City and the Conservation Authority, the re-direction of flow between drainage basins is not permitted.

4.1.5 Receiving Watercourses

It shall be a general requirement that all watercourses remain in their natural state and that base flow and velocity be maintained. Any alterations required must take into consideration the form and function of the watercourse, including requirements to convey water and sediment, and the provision of aquatic habitats.

4.1.6 Wetlands

As per regulations made under the Conservation Authorities Act, proposed development within a wetland is not permitted. Development within a portion of the adjacent buffer area may be permitted subject to an approved Environmental Impact Study.

4.2 Flood and Erosion Protection Guidelines

4.2.1 Flood Standards for River Systems

The flood plain shall be defined as the limit of the water surface elevation associated with the larger of the 100-year or the Regional storm. For purposes of flood plain mapping and associated hydrology models the Timmins storm shall be the Regional storm. As per regulations made under the Conservation Authorities Act, proposed development within the maximum extent of the flood plain is not permitted, with certain exceptions.

4.2.2 Flood Hazard Limits for Lakes

The flood hazard limit for lakes within the City limits shall be defined as the 100 year flood level.

4.2.3 Flood Proofing of Buildings

Should approval be granted by the City and Conservation Authority for development or re-development of buildings within the flood plain, the minimum opening elevation into a structure shall be 500 mm greater than the regulatory flood elevation.

4.2.4 Stormwater Management Facilities

The construction of new SWM facilities within the 100-yr flood plain is not permitted. The construction of new SWM facilities within the Regional flood plain is only permitted by the City and Conservation Authorities if it can be demonstrated that there will be no impacts to the Regional water surface elevation or floodplain storage upstream and downstream of the proposed facility and no other reasonable options are available. On-line SWM ponds are not permitted by the City or Conservation Authorities. Existing on-line flow attenuation areas behind railroad/road embankments may be considered at the discretion of the Director of Engineering or Conservation Authority.

4.2.5 Retrofit of SWM Facilities

The retrofit of SWM facilities is permitted to enhance the current level of treatment provided, subject to review by the City, Conservation Authority and MOE. Subject to feasibility, the retrofit design shall provide the Enhanced level of protection for water quality per the SWMPD Manual (MOE, 2003). The Enhanced level of protection may not apply to the retrofit of existing SWM facilities if the applicant can demonstrate to the satisfaction of the City, Conservation Authority, and Director (MOE) that it is impractical to achieve the Enhanced level of protection. Typically, the extent of improvements for a pond retrofit is restricted by space limitations (i.e. the pond block cannot usually be expanded due to surrounding development). As such, an analysis of needs and priorities should be completed prior to the retrofit to determine the best allocation of available volume in terms of water quality, erosion, and quantity control to maximize the overall benefit.

4.2.6 Erosion and Sediment Control

Measures shall be implemented to minimize the impact of erosion and sediments from sites to receiving watercourses. Control measures during construction shall be designed in accordance with the City of Kawartha Lakes Site Alteration By-Law and the *Erosion and Sediment Control Guidelines for Urban Construction* (GGHA CA’s, 2006).

In accordance with the governing guidelines, which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003), and the NVCA guidelines, and until further erosion studies are completed, erosion control measures must be implemented for stormwater management facilities, requiring the 25 mm 4-hr Chicago storm be stored and released over a 24-hr period.

4.3 Site Plans and Infill Developments (Drainage Area < 5 ha)

Proposed developments with drainage areas less than 5 ha, such as site plans and infill development, shall require the design of water quality and quantity controls based on the existing or proposed quality and quantity facilities provided downstream of the site. Four scenarios have been identified that describe the level of water quality and quantity control provided downstream of the site and are presented below.

4.3.1 Scenario A – Both Quality and Quantity Controls Provided Downstream

Scenario A defines the case where downstream quality and quantity control facilities are in place or are proposed that service the proposed development site. Depending on the design of the major and minor system downstream of the proposed development, additional on-site quantity controls may be required. The steps identified below shall be followed when completing a site plan or infill development classified as Scenario A.

Step 1 – Review Minor System Design Capacity (≤ 5 Year Event)

The previously approved storm sewer design sheets and storm drainage plans shall be reviewed and compared with the design parameters (i.e. runoff coefficient and contributing drainage area) for the proposed site to confirm that sufficient residual capacity is provided to safely convey the 5-yr design flow from the site. If the proposed 5-yr design flow does not exceed the previously approved design flow from the site by more than 5%, then no additional on-site quantity controls are required. If the proposed 5-yr design flow exceeds the previously approved design flow by more than 5%, then the consultant shall complete one of the following options:

Option 1 – it shall be demonstrated that the there is sufficient residual capacity in the minor system to safely convey the 5-yr flow from the site. The consultant shall assess the ability of the downstream facility to accommodate any additional storm runoff and to maintain the same level of quality and quantity control.

Option 2 – on-site quantity controls (e.g. rooftop, parking, landscape storage and outlet controls) shall be provided for the proposed development such that the 5-year peak flow is reduced to the previously approved peak flow from the site. On-site quantity controls shall adhere to the guidelines provided in **Sections 4.5** and **4.6**.

Step 2 – Review Major System Design Capacity and Flow Route (Regulatory Event)

It shall be demonstrated that the major system flow from the proposed site will be safely conveyed to a previously identified existing R.O.W. or other defined flow route within City property or easement. Drainage to the major system outlet shall not exceed 0.3 m in depth and velocities shall not exceed 0.65 m/s.

Where it is not feasible to safely convey the Regulatory flow from the proposed site to a previously identified overland flow route, an alternate flow route shall be identified within City lands or easement adjacent to the proposed property that is acceptable to the City.

Should there be no feasible overland flow route that is acceptable to the City, or as an alternative to the above option, quantity storage (e.g. rooftop, parking, landscape storage and outlet controls) shall be provided on the proposed site to attenuate the Regulatory peak flow to the capacity of the minor system. On-site quantity controls shall adhere to the guidelines provided in **Section 4.5**.

The proposed major system design for the development site must be designed to convey any existing external flows or future external drainage as identified in approved master drainage or other studies.

Step 3 - Water Quality Treatment Requirements

The current level of water quality protection afforded by the downstream controls shall be reviewed to confirm that the Enhanced level of protection per the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003) is provided for the proposed development site. Should it be determined that the required level of water quality control is provided, then no additional water quality controls are required on-site. Should it be determined that the required level of control is not achieved and it is feasible to provide the Enhanced level of protection on-site, then on-site controls shall be provided that achieve the requisite level of water quality protection. If it is not possible to comply with the Enhanced level design standard due to on-site limitations, it must be demonstrated to the satisfaction of the City and the Conservation Authority that the most effective measures possible have been incorporated in the overall design of on-site water quality treatment.

Proposed developments that have the potential for contaminant spills as stipulated by the City shall require the installation of an appropriate end-of-pipe treatment such as an oil grit separator.

Step 4 – Confirm Erosion Control Requirements for the Site

Depending upon the type of protection provided in any downstream facilities and the potential for erosion issues along the downstream conveyance route to a Lake, erosion controls may be required on-site. Erosion and sediment control requirements for the proposed development site shall be confirmed with the City and Conservation Authority. Otherwise, the minimum control requirement shall be the runoff associated with the 25 mm 4-hr Chicago storm released over 24 hours. In order to protect or maintain the stability of receiving watercourses under special circumstances, the City and/or Conservation Authority may identify the need for and request a detailed erosion control analysis. Detailed watercourse erosion analyses may be based on continuous modeling and/or field based analyses to determine critical flow thresholds. Field based analyses must be completed by a qualified fluvial geomorphologist. If it can be demonstrated that the required level of erosion control is not feasible due to on-site limitations, then a reduced level of protection may be acceptable, subject to review and approval by the City and Conservation Authority.

4.3.2 Scenario B – Quantity Controls Provided Downstream but No Quality Controls

Scenario B defines the case where quantity facilities are in place or are proposed downstream of the proposed development site, however, no existing or proposed quality facilities are in place. As such, on-site quality controls shall be required. Depending on the design of the major and minor system downstream of the proposed development, additional on-site quantity controls may be required. The steps identified below shall be followed when completing a site plan or infill development classified as Scenario B.

Step 1 – Review Minor System Design Capacity (≤ 5 Year Event)

Refer to **Section 4.3.1** (Step 1).

Step 2 – Review Major System Design Capacity and Flow Route (Regulatory Event)

Refer to **Section 4.3.1** (Step 2).

Step 3 – Water Quality Treatment Requirements

On-site water quality controls shall be provided that achieve the Enhanced level of protection per the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003). If it is not possible to comply with the Enhanced level design standard due to on-site limitations, it must be demonstrated to the satisfaction of the City and the Conservation Authority that the most effective measures possible have been incorporated in the overall design of on-site water quality treatment. Proposed developments that have the potential for contaminant spills as stipulated by the City shall require the installation of an appropriate end-of-pipe treatment such as an oil grit separator.

Step 4 – Confirm Erosion Control Requirements for the Site

Refer to **Section 4.3.1** (Step 4).

4.3.3 Scenario C – Quality Controls Provided Downstream but No Quantity Controls

Scenario C defines the case where quality facilities are in place or are proposed downstream of the proposed development site, however, no existing or proposed quantity facilities are in place. Subject to discussions with the City regarding any potential downstream drainage or other issues and depending on the design of the major and minor system downstream of the proposed development, additional on-site quantity controls may be required. The steps identified below shall be followed when completing a site plan or infill development classified as Scenario C.

Step1 - Consultation with City

In the case where downstream quantity controls are not provided or previously required, a consultation with the City is required to determine if on-site quantity controls are required due to downstream drainage or other issues. Subject to clearance by the City in this regard, the following steps shall be taken in completing the site design. Should clearance not be obtained, on-site quantity controls shall be provided per discussions and agreement with the City and Conservation Authority.

Step 2 – Review Minor System Design Capacity (≤ 5 Year Event)

Refer to **Section 4.3.1** (Step 1).

Step 3 – Review Major System Design Capacity and Flow Route (Regulatory Event)

Refer to **Section 4.3.1** (Step 2).

Step 4 - Water Quality Treatment Requirements

Refer to **Section 4.3.1** (Step 3).

Step 5 – Confirm Erosion Control Requirements for the Site

Refer to **Section 4.3.1** (Step 4).

4.3.4 Scenario D – No Quality or Quantity Controls Downstream of Site

Scenario D defines the case where there are no existing or proposed quality or quantity control facilities in place downstream of the proposed development site. Subject to discussions with the City regarding any potential downstream drainage or other issues and depending on the design of the major and minor system downstream of the proposed development, additional on-site quantity controls may be required. Subject to feasibility, on-site water quality controls that meet the Enhanced level of protection shall be provided. The steps identified below shall be followed when completing a site plan or infill development classified as Scenario D.

Step1 - Consultation with City

In the case where downstream quantity controls are not provided or previously required, a consultation with the City is required to determine if on-site quantity controls are required due to downstream drainage or other issues. Subject to clearance by the City in this regard, the following steps shall be taken in completing the site design. Should clearance not be obtained, on-site quantity controls shall be provided per discussions and agreement with the City and Conservation Authority.

Step 2 – Review Minor System Design Capacity (≤ 5 Year Event)

Refer to **Section 4.3.1** (Step 1).

Step 3 – Review Major System Design Capacity and Flow Route (Regulatory Event)

Refer to **Section 4.3.1** (Step 2).

Step 4 - Water Quality Treatment Requirements

Refer to **Section 4.3.2** (Step 3).
Step 5 – Confirm Erosion Control Requirements for the Site

Refer to **Section 4.3.1** (Step 4).

4.3.5 Interim Facilities

In cases where the proposed downstream quality and quantity control facilities have not yet been constructed, the construction of interim site controls may be considered by the City if it can be demonstrated that an acceptable level of control will be provided. The construction of any such interim facilities shall be in accordance with the applicable municipal and provincial guidelines.

4.3.6 Uncontrolled Sewershed Outfalls

Under exceptional circumstances for very small catchments (<0.5 ha) where it is not possible to provide end-of-pipe water quality (incl. oil/grit separators), erosion and quantity controls, measures should be implemented at the sewer outfall to minimize impacts regarding water quality and erosion. Such measures could include, for example, a stilling basin with cattail plantings.

4.4 Developments ≥ 5 ha

Proposed developments with drainage areas greater than or equal to 5 ha shall require the design of water quality/erosion and quantity control facilities (i.e. wet pond, constructed wetland or hybrid wet pond / constructed wetland) as described in **Section 4.7** of this document.

4.5 Source and Conveyance Controls

The following source and conveyance controls are acceptable for use within the City of Kawartha lakes:

- Roof leaders directed to pervious areas
- Rooftop storage
- Green Roofs
- Parking lot storage
- Permeable pavements
- Rainfall harvesting
- Oil / grit separators (for lots ≤ 2 ha)
- Underground storage
- Infiltration trenches
- Soakaway pits
- Grassed swales
- Vegetated filter strips

- Natural channels
- Sand filters
- Roadside ditches (industrial areas only)

The following source and conveyance controls are not permitted for use within the City of Kawartha lakes:

- Rear lot ponding
- Pervious pipe systems (for untreated runoff)
- Pervious catchbasin (for untreated runoff or with exfiltration pit located underneath the CB)

With the exception of the municipal-specific guidelines identified in the sections below, the guidelines for the design of source and conveyance controls shall be in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003) as a minimum requirement. In some cases, additional policies and guidelines per the KRCA's *Development Review Guidelines* may also apply.

4.5.1 Roof Leaders

Roof leaders should be directed to front or rear yard pervious (grassed) areas wherever possible to promote infiltration and shall not discharge to impervious areas directly connected to the storm sewer (e.g. driveways, parking areas) unless there is no other feasible option. Roof leaders shall discharge to the ground surface via splash pads or extension pipes and flows shall be directed a minimum of 0.6 m away from buildings such as to prevent ponding or seepage into the weeping tile. Roof leader outlet locations shall be identified on the lot development plan.

4.5.2 Rooftop Storage

Flat roofs may be used to store runoff to reduce peak flow rates to storm sewer systems to mitigate the need for downstream storm sewer size increases. Per the *SWMPD Manual* (MOE, 2003), rooftop storage can typically store 50 mm to 80 mm of runoff subject to the roof loading design. Detention time is typically between 12 to 24 hours. Supporting calculations and design drawings must be provided to indicate the following:

- The total number and location of proposed roof drains and emergency overflow weirs
- The type of control device proposed (i.e. product name and manufacturer). Tamper proof devices are preferred where feasible (provision of shop drawings required).
- The City's current policy indicates a maximum flow rate of 42 L/s/ha of roof area.
- Product specifications (i.e. design release rates for identified control devices)
- Emergency overflow weirs shall be provided at the maximum design water level elevation.
- The maximum ponding depth, storage volume, and drawdown time for roof top storage during the 2-yr through 100-yr design storms

Within the jurisdiction of the Conservation Authorities, additional guidelines may also apply (e.g. roof top control devices may require registration on title as part of the Site Plan Agreement and/or Subdivision Agreement).

4.5.3 Parking Lot Storage

Parking lots may be used to store runoff to reduce peak flow rates to storm sewer systems. The maximum ponding depth shall be 300 mm and grading shall be between 0.5% and 5%. The outlet flow may be regulated through the use of permanently attached orifice plates (ICD's). The 5-yr and 100-yr ponding elevations and storage volume at each ponding location must be included on the design drawings. In addition, Regulatory storm overland flow routes are also to be indicated on the drawings. Within the jurisdiction of the Conservation Authorities, additional guidelines may also apply (e.g. parking lot control devices may require registration on title as part of the Site Plan Agreement and/or Subdivision Agreement).

4.5.4 Rear Lot Ponding Areas

Rear lot ponding or other areas of extended ponding on residential lots is not permitted.

4.5.5 Permeable Pavements

Permeable pavements are encouraged for use to reduce runoff and promote infiltration. The reduction in runoff achieved will vary based on the product used and the identified manufacturer's specifications. The City does not permit a reduction in runoff coefficient for permeable pavements (i.e. standard c-value for asphalt shall be used) for peak flow, conveyance and storage calculations.

4.5.6 Rainfall Harvesting

Rainfall harvesting facilities may be used to temporally store runoff for future use (e.g. rain barrel for watering the lawn). An overflow by-pass shall be provided at a minimum distance of 0.6 m from the foundation wall.

4.5.7 Oil / Grit Separators

Subject to approval by the City and governing Conservation Authority, designated approved oil/grit separators may be installed on small sites ≤ 2 ha where a water quality control pond/wetland is not feasible. For developments on sites > 2 ha, oil/grit separators are only permitted as a pre-treatment in the treatment train approach in conjunction with other stormwater management options approved by the City.

When completing sizing calculations for oil/grit separators, the following guidelines shall apply:

- For special sites such as cement, aggregate, or other such manufacturing facilities that may contribute a much higher proportion of very fine or coarse particles. In such cases, a site specific particle size distribution must be determined and used in sizing calculations to ensure that the Enhanced Level of treatment is achieved.

- For sites that exhibit unstable wash-off characteristics, such as construction sites or sites with material storage, special design considerations must be addressed and supporting calculations provided to demonstrate that the Enhanced Level of treatment is achieved.

The owner is responsible for maintaining and repairing oil/grit separators installed on private property. Operation and maintenance requirements for oil/grit separators shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the device as designed is achieved as per the Certificate of Approval/Environmental Compliance Approval, if applicable.

4.5.8 Underground Storage and/or Infiltration

Underground storage may be used where surface SWM storage is not feasible or the volume is not adequate (subject to acceptable geotechnical and hydrogeological investigations in support of the approach). If the underground storage facility is designed for infiltration of road or parking lot runoff, a pretreatment structure shall be provided. The outlet structure shall be designed to meet the SWM control requirements. Any such facilities shall be readily accessible for any required maintenance activities. Operation and maintenance requirements for underground storage facilities shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the facility as designed is achieved.

4.5.9 Infiltration Trenches

Infiltration trenches are permitted and encouraged for use in the City to promote infiltration of runoff (subject to acceptable geotechnical and hydrogeological investigations in support of the approach). The maximum draw down time should be less than 48 hours, soils permitting. Longer drawdown times may be permitted where soils exhibit lower percolation rates. Infiltration trenches shall be located a minimum of 5.0 m from buildings with basements to avoid infiltration to drainage tiles and sump pumps. Operation and maintenance requirements for infiltration trenches shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the facility as designed is achieved.

4.5.10 Soakaway Pits

A soakaway pit is typically connected to the roof leader of a single house and may be used to store runoff and promote infiltration (subject to acceptable geotechnical and hydrogeological investigations in support of the approach). The maximum draw down time should be less than 48 hours, soils permitting. Longer drawdown times may be permitted where soils exhibit lower percolation rates. Soakaway pits shall be located a minimum of 5.0 m from buildings with basements to avoid infiltration to drainage tiles and sump pumps. Operation and maintenance requirements for soakaway pits shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the unit as designed is achieved.

4.5.11 Pervious Pipe Systems

Subject to the City's review, pervious pipe systems may be used to store stormwater and promote infiltration for *treated* runoff only (subject to acceptable geotechnical and hydrogeological investigations in support of the approach). Operation and maintenance requirements for pervious pipe systems shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the system as designed is achieved.

4.5.12 Grassed Swales

The use of grassed swales for extended detention by impoundment of water on residential lots is not permitted by the City. Grassed swales are permitted as a means to promote infiltration, but must be free flowing and designed primarily to convey runoff from the lot without any ponding with a minimum slope of 2%.

4.5.13 Natural Channels

Natural channels are designed to convey the overland flow and may also be used as a flow filter and to temporally detain storm runoff, in particular where the overland flow route uses an extended linear open space area.

4.5.14 Sand Filters

Sand filters may be used to treat stormwater from roads or parking lots prior to discharge to infiltration facilities in order to prevent clogging of the voids within the storage media and to polish the runoff prior to infiltration. Operation and maintenance requirements for sand filters shall be identified in the SWM report for the site and shall be implemented by the owner to ensure that the continued performance of the system as designed is achieved.

4.5.15 Roadside Ditches

Similar to natural channels, roadside ditches may be used as a flow filter and storm runoff detention area subject to flow conveyance design requirements and a minimum slope of 2%.

4.6 End-of-Pipe Controls

End-of-pipe control facilities shall provide the required quantity and quality control in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003), unless otherwise specified below by the City.

4.6.1 Wet Pond with Extended Detention

Wet ponds are typically the preferred end-of-pipe control facility for large drainage areas. Wet ponds shall be designed in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003) (Section 4.6.2), unless otherwise specified in the City's guidelines provided in **Section 4.7**.

4.6.2 Wetland with Extended Detention

A constructed wetland is an acceptable stand-alone end-of-pipe control facility. Constructed wetlands shall be designed in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design*

Manual (MOE, 2003) (Section 4.6.3), unless otherwise specified in the City's guidelines provided in **Section 4.7**.

4.6.3 Hybrid Wet Pond / Wetland with Extended Detention

A wet pond / constructed wetland hybrid is an acceptable stand-alone end-of-pipe control facility. Hybrid wet ponds / constructed wetlands shall be designed in accordance with the governing guidelines which are currently documented in the Stormwater Management Planning and Design Manual (MOE, 2003) (Section 4.6.4), unless otherwise specified in the City's guidelines provided in **Section 4.7**.

4.6.4 Dry Pond with Extended Detention

Dry ponds shall not be permitted as a stand-alone treatment system. Dry ponds may be used as a part of a treatment train approach provided that the Enhanced level of water quality treatment is achieved.

4.6.5 Infiltration Basin

In general, infiltration basins shall not be accepted as a stand-alone end-of-pipe facility, unless as part of a treatment train approach or as an additional feature. Infiltration basins shall not be permitted for drainage areas > 5 ha.

4.7 Stormwater Management Facilities (Wet Ponds and Wetlands)

It is required by law that all new SWM facilities shall be designed to meet the Enhanced level of protection per the *SWMPD Manual* (MOE, 2003). Stormwater management facilities shall be designed per the *SWMPD Manual* (MOE, 2003) as a minimum requirement unless otherwise specified in this document. An Operation and Maintenance Manual for the SWM facility shall be submitted to the City for the site and shall be implemented by the owner to ensure that the continued performance of the facility as designed is achieved.

4.7.1 Length to Width Ratio

The SWM facility length to width ratio shall be designed in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003) (Table 4.6 and 4.7).

4.7.2 Grading (Side slope)

Grading within SWM facilities shall be designed in accordance with *Stormwater Management Planning and Design Manual (MOE, 2003)*. Retaining walls are not permitted in the pond block.

4.7.3 Water Levels

Water levels within SWM facilities shall be designed in accordance with *Stormwater Management Planning and Design Manual (MOE, 2003).*

4.7.4 Permanent Pool, Quality and Quantity Storage Requirements

The SWM pond sizing, including the permanent pool volume, quality and quantity volume shall be designed in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual*

(MOE, 2003). The erosion control volume shall consist of the 25 mm 4-hr Chicago storm runoff volume released over 24 hours. Where feasible, a drawdown pipe with a control valve shall be included to drain the facility by gravity for maintenance.

4.7.5 Forebay

The forebay, including dispersion length, minimum required bottom width and forebay berm, shall be designed in accordance with the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003). A berm shall be constructed with a forebay spillway invert at the NWL with appropriate erosion protection to enable, as a minimum, the flow of the water quality event (25 mm event) without overtopping any other part of the forebay into the main cell of the facility. The minimum top width of the berm shall be 1.0 m. A dewatering sump shall be installed in the forebay to enable the drawdown of the permanent pool for maintenance and sediment removal. Where feasible, the forebay sump shall be connected to the pond outlet structure with a control valve to drain by gravity. Where draining by gravity is not feasible, a dewatering sump shall be included and drained by pump.

Unless it can be demonstrated by a geotechnical engineer that the bearing capacity of the native soils on the bottom of the forebay is sufficient to support maintenance machinery for the removal of sediment, the bottom of the forebay shall be lined with 300 mm of 50 mm diameter crusher run rock, or as recommended by a geotechnical engineer. Unstable native soils may warrant the use of geotextile lining under the rock. The forebay lining shall be certified by a geotechnical engineer to provide sufficient bearing capacity to support maintenance equipment during sediment removal assuming that the forebay is dewatered prior to maintenance activities.

4.7.6 Freeboard

A 0.3 m freeboard is required above the *maximum routed water level* under the Regional Storm. For Regional control ponds (i.e., ponds intended to provide post-to-pre control for the Regional event), the maximum routed water level will equal the maximum water level to control the storm. For 100 year control ponds (i.e., ponds intended to provide post to-pre control for the 100 year event), the maximum routed water level will equal the maximum water level required for the pond to convey the Regional Storm through the pond. This assumes that the Regional outflow rate is not limited to pre-development levels.

4.7.7 Berming

Berms around wetlands and wet ponds shall be designed with a minimum top width of 2.0 m (where trails and access roads are not located) with a 3:1 maximum side slope on the outside. The core of the berms shall be constructed with engineered fill on the basis of the recommendations of a licensed geotechnical engineer. Topsoil is not permitted for berm construction except as a dressing to support vegetation on the top of the core. For pond berms exceeding 2.0 m in height, the berm must be designed by a qualified professional engineer in accordance with the *Ontario Dam Safety Guidelines*.

4.7.8 Sediment Drying Area

A sediment drying area shall be provided, where feasible, as follows:

- Sized for a minimum of 10 years of sediment accumulation.
- Sized assuming a maximum sediment height of 1.5 m and sediment slope of 10:1.
- Located at or above the predicted 2 year water level and near the maintenance access road.
- Setback a minimum of 6.0 m away from all property lines.

Temporary sediment drying areas may be provided on adjacent parks and within road allowances with drainage directed back to the facility subject to approval by the City.

4.7.9 Maintenance Access Roadway

Maintenance access roads are required to all inlets, outlet structures, sediment forebays, and sediment drying areas (if applicable) within the SWM facilities. Where feasible, two access points shall be provided from the municipal road allowance such that the access road is looped to key hydraulic features. In situations where this is not practical, dead end access roads shall be designed with a hammerhead turning area consisting of a minimum hammerhead width of 17.0 m and a 12.0 m centerline turning radius.

The maintenance access road shall consist of a minimum 300 mm of compacted granular “A” (or as recommended by a geotechnical engineer) with a surface treatment consisting of 50 mm topsoil and Native Seed Mixture. The access roads shall provide for all-weather ingress and egress with a minimum width of 5.0 m and a maximum grade of 8%. Curves on all access roads shall have a maximum centerline radius of 12.0 m.

Where the access road enters the forebay below the NWL, the forebay ramp shall be constructed consistent with the lining of the bottom of the forebay or as recommended by a geotechnical engineer. Ramp access should favour “green” solutions.

4.7.10 Fencing

Fencing shall be installed where the SWM facilities abut private lots unless maximum slopes of 6:1 are provided. Where required, fencing shall be installed as per City of Kawartha Lakes standards.

4.7.11 Aesthetics

The SWM facilities shall be constructed with acceptable building materials (e.g., no gabions) that are not unsightly. A landscape plan shall be prepared as per **Section 4.8**. SWM facilities shall be integrated with parks and trails where feasible.

4.7.12 Warning Signage

Warning signs shall be clearly visible and erected at all access points to the SWM facility. Warning signs shall be supplied and installed by the developer and designed in accordance with City requirements and by-laws.

4.7.13 Inlet Structures

Inlet structures shall be installed with the invert set to the NWL or higher. Submerged inlets shall only be permitted if the obvert of the pipe lies below the maximum anticipated thickness of ice. Suitable erosion control and energy dissipation treatment shall be provided at all inlets to the pond. Headwalls and safety grating shall be installed at all inlets per OPSD. SWM pond inlet elevations are to be designed such that the 1:5 year storm design sewer capacity as per the storm sewer design sheet is maintained and not reduced due to tailwater conditions.

4.7.14 Outlet Control Structures

Outlet control structures shall be designed with flow regulating devices (e.g. orifice) to control the flow and pond drawdown time. Outlet structures are to be designed in a safe and aesthetic manner with the majority of the structure contained within the berm. A perforated riser should be installed at the intake associated with the bottom draw pipe connected to the outlet control structure. A maintenance draw down pipe with valve shall be installed where feasible to enable the dewatering of the pond for maintenance activities such as sediment removal. Suitable erosion control and energy dissipation treatment shall be provided at the pond outfall where it discharges to the receiving body. The sizing of rip rap or river stone at the outfall shall be based on appropriate erosive velocity calculations. The outlet structure should be designed to operate under free-flowing conditions where feasible. The return period water surface elevations of the receiving body must be determined and verified to ensure the proper operation of the outlet structure. Where it is not feasible to operate the outlet structure under free-flowing conditions, appropriate submergence calculations must be completed to ensure that the outlet structure is sized correctly. When a temporary SWM facility is required and approved by the City a temporary outlet structure shall be designed. Temporary SWM facilities shall remain in place until the ultimate downstream controls have been constructed to the satisfaction of the City. The maintenance, operation and full decommissioning of temporary SWM facilities shall be the sole responsibility of the land owner and such responsibility shall be reflected in the site plan or subdivision agreements.

4.7.15 Emergency Spillway

All SWM facilities shall be designed with an emergency spillway. The emergency spillway shall be designed to convey the larger of the unrouted 1:100 year or the Regional peak flow with the invert of the spillway set, as a minimum, at the 100-yr controlled water level (or Regional controlled water level for ponds where Regional control may be required). A freeboard of 0.3 m shall be provided above the maximum routed water level under the Regional storm. The spillway shall be treated for erosion protection that is adequately designed to withstand the erosive velocity associated with the uncontrolled governing flow. The erosion protection shall be integrated with a natural vegetated surface treatment that is aesthetically pleasing. Spillway side slopes shall not be steeper than 3:1 and shall be no steeper than 8% when incorporated into the access road. The spillway shall not be located directly above the outlet control structure and a minimum clearance of 3.0 m shall be provided.

4.7.16 Major System Overland Flow Routes

The major system overland flow route to the SWM facilities shall be designed to safely convey the Regulatory (*i.e.* the larger of the 100-yr storm and Regional Timmins) overland flow. Should the overland flow route to the SWM facility consist of the access road and path, then the flow depth shall not exceed 0.30 m or a velocity of 0.65 m/s. Where feasible, the overland flow should not be directed into the forebay to avoid the re-suspension of settled sediments.

4.7.17 Anti-seepage Collars

Anti-seepage collars shall be installed on all outlet pipes or as directed by a geotechnical engineer.

4.7.18 Existing Groundwater Elevation

The bottom of the SWM pond shall be a minimum of 1.0 m above the seasonal high GWL unless it can be demonstrated by a hydrogeologist to the satisfaction of the City that there will be no impact to groundwater elevation and groundwater quality. Otherwise, if it is not feasible to maintain the required separation distance, a suitable liner shall be installed based on consultation with a hydrogeologist.

4.7.19 Fire Use

In certain locations of the City, and subject to review by the City, it may be desirable to utilize the SWM pond as a source of water for fire use by incorporating a dry hydrant design. The design must meet the requirements of the Ontario Building Code for dry hydrants which is currently in accordance with FPA 1142, *Water Supplies for Suburban and Rural Fire Fighting*.

4.7.20 West Nile Virus

Reasonable measures should be incorporated in the design of wet ponds and wetlands to minimize the proliferation of mosquitoes and the potential spread of the West Nile virus and to reduce the need to apply larvicide. Such measures, which focus on creating habitat less suitable for mosquito breeding and survival, include the following (adapted from *TRCA Innovative Stormwater Management Workshop*, Culex Environmental, May 2008):

- *Encourage a plant-dominated state as opposed to an algae-dominated state* – A plant-dominated state (i.e. lots of submerged and floating-leaved aquatic plants) provides habitat for predators whereas an algae dominated state is less favourable for predators and more favourable for mosquitoes with increased availability of nutrients and turbidity as a food source and warmer water. In addition, mosquito larvae tend to avoid submerged and floating-leaved plants.

- *Introduce predators* – Along with a plant-dominated state introduce predators that feed on mosquito eggs and larvae, such as: grazing invertebrates (e.g. snails, Mayfly larvae, Chironomids), neustonic insects (e.g. water striders, water boatmen, whirligig beetles), benthic invertebrates (e.g. flatworms, leeches, Asellus, shrimps), three-spined sticklebacks, fathead minnows, dragonfly nymphs, water beetles, Alderfly larvae, and frogs and toads. In addition, bird and bat houses should be erected to encourage the nesting of bats and birds such as swallows and purple martins which rely on flying insects including mosquitoes as their primary food source.

- *Maximize water depths* – Where possible, the minimum depth of water within the permanent pool should be 1 m or greater.

4.7.21 Thermal Impacts

When discharging to a watercourse identified as a cold water fishery, mitigation measures such as shoreline planting, shading by trees, bottom draw outlet pipes from deeper pools, or cooling trenches shall be implemented to minimize thermal loading to the receiving watercourse.

4.7.22 Trails

Pedestrian circulation trails shall be incorporated into SWM facilities where public safety has been fully addressed in terms of access, side slopes and fencing requirements. The feasibility of connections to adjacent neighbourhood parks, recreation areas and existing trail networks is to be explored as part of the initial pond submission plans to the satisfaction of the City.

4.7.23 Maintenance and Inspections Protocol

An operation and maintenance manual shall be prepared that identifies on-going operation protocol and maintenance issues including, but not limited to, the following:

- The procedure for draining the forebay during required maintenance
- The method for sediment removal from the forebay
- The annual sediment loading rate and the estimated sediment accumulation in the facility
- The sediment clean-out frequency
- The inspection procedures and frequency of inspections
- A description of the pond features and pond operating characteristics
- A monitoring program plan for periodic water quality sampling for SWM works

4.7.24 In-fill Development and Re-development

All new SWM facilities shall provide Enhanced level of water quality protection. For infill and re-development sites where it can be demonstrated that the Enhanced level of protection is not feasible, a reduced level of protection may be acceptable subject to approval by the Director (MOE) and the City.

4.8 Stormwater Management Facility Planting Guidelines

The following section outlines the specific design criteria and planting requirements which are to be followed within stormwater management (SWM) facilities and/or wetlands within the City of Kawartha Lakes. These criteria are in addition to the minimum standards outlined within the MOE's *Stormwater Management, Planning and Design Manual* and planting standards for the KRCA. Landscaped areas shall consist of native species only as per the *Native Plant Species in Ontario* (Riley, 1989). If a development is located within an area where an overall SWM planning study (*i.e.*

Environmental Impact Study, Ministry of the Environment Special Provisions) is available, the design criteria and recommendations as specified in the appropriate study must also be followed where specific direction is given.

4.8.1 Planting Zones

1. SUBMERGENT (*Deep Water*) – Water depth 0.5m to 2.0m
    - Planting is to consist of a combination of both floating and submergent species.
    - Planting must include at least (3) three species each of robust, broadleaf and narrow leaf plant varieties.

2. AQUATIC FRINGE (*Shallow Water*) – Water depth 0.0m to 0.5m
    - Planting is to consist of a combination of both floating and submergent species.
    - Planting must include at least (4) four species each of robust, broadleaf and narrow leaf plant varieties.

3. SHORELINE FRINGE (*Extended Detention*) – 1.0m (horizontal) from the permanent pool elevation
    - Plantings zone appropriate wetland species must include perennial sedges, rushes and wild flowers in combination with shrubs and wetland seed mix.
    - The shoreline fringe is subject to fluctuations in water levels which will result in regular flooding and therefore plant selections must be flood tolerant.

4. FLOOD FRINGE – 2.0m (horizontal) from the limit of the shoreline fringe limit or to the 100 year flood level (whichever is greater)
    - Plantings must include a diverse variety of no less than (4) four flood tolerant species each of shrubs, deciduous trees and coniferous trees.
    - Trees and shrubs within the flood fringe will provide canopy structure to mitigate thermal effects on water temperature.
    - Herbaceous plant material may be provided by the use of an approved wet meadow seed mix which will be applied in combination with an annual rye nurse crop.

5. UPLAND – includes all areas outside the 3.0m flood fringe
    - Plantings will include a minimum of (5) five species each of drought tolerant deciduous and coniferous trees and shrubs.
    - Upland planting is intended to provide visual screening, aesthetic appeal, wind blockage and shading to mitigate thermal effects on water temperature.
    - Provide a minimum 1.5m buffer between plantings and any structures such as maintenance roads and drying areas and fencing which abuts residentially zoned property.

4.8.2 Planting Guidelines

AQUATICS (*Submergent and Aquatic Fringe*)

- Spacing requirements for aquatics in plug form is 5 units per m2.
- Spacing requirements for aquatics in 100cm potted form is 4 units per m2.
- Spacing requirements for aquatics in 150cm potted form is 3 units per m2.
- Cattails (*Typha spp.*) will be planted as interim perimeter vegetation in sediment forebays to increase sediment trapping. The use of this material will not limit maintenance access and it is acceptable that this material will be removed during dredging operations.
- Other aquatic species will not to be placed within the forebays as they would be less likely to re-colonize after dredging operations.
- Plant material must be comprised of 100% native stock.
- Protection from geese and other water foul may be required during initial aquatic plant installations.
- Aquatic fringe plant installations should be installed (1) full growing season after that of both the shoreline and flood fringe or at such time as a complete vegetative buffer is established around the pond perimeter as deterrence to geese.

TERRESTRIAL (*Shoreline Fringe, Flood Fringe and Upland*)

- Do not utilize plant material which has been removed or harvested from natural wetlands or roadsides as they may contain invasive or non-native species.
- Plant material must be comprised of 100% native stock.
- Plant shrubs in groupings of no less than 15 units to promote both colonization and spreading.
- Shrubs are to be no less than 60cm height (*container grown stock only*).
- Deciduous trees within the flood fringe are to be no less than 60mm caliper stock.
- Deciduous trees within the upland may utilize a combination of caliper material and whip stock where caliper trees are planted based on a rate of 1 unit per 25m2. Whip stock is to be installed at a rate of 6.25 units per 25m2.
- Coniferous material well be no less than 2000mm in height where height is measured from the top of the root ball to the first whorl (*does not include the leader*).
- Where applicable, shrubs, deciduous trees and coniferous trees are to be installed in accordance to current City of Kawartha Lakes Standards.
- Rodent protection will be installed around the base of all deciduous trees.
- Bio-engineering (*e.g. live staking*) should be implemented on steep slopes in conjunction with other stabilization methods. Live staking will not be considered for use against density calculations for plant material.

4.8.3 Topsoil

- Topsoil must meet the current Ontario Provincial Standard Specification No.570 (OPSS-570).
- Topsoil will be laboratory tested and the subsequent findings forwarded to Parks Planning and Development for approval prior to placement of topsoil.
- Testing must demonstrate that topsoil has sufficient organic and nutrient content and is suitable for sustaining plant material which is to be placed into the pond and/or wetland.
- Soil amendments required as a result of laboratory testing must be completed prior to or during the placement of topsoil in accordance with laboratory findings and amendment requirements.
- Provide topsoil at a minimum depth of 0.45m to a maximum depth of 1.0m beginning at the permanent pool elevation and including all terrestrial planting areas.
- Provide topsoil at a minimum depth of 0.35m from the permanent pool elevation to 1.0m (horizontal) into the pond. The remaining pond area is to receive a minimum topsoil depth of 0.2m.
- Stabilize topsoil after placement prior to the installation of woody plant material. In the event that erosion control blankets are utilized in combination to approved seed mixes for stabilization purposes, the netting and blanket material will be 100% bio-degradable. Photo-degradable plastic or plastic netting is not permitted for stabilization products.
- If topsoil stabilizations cannot be completed within (1) one construction year's growing season, the topsoil should not be placed until the following spring. In this event, sediment controls must be in place to prevent erosion of stockpiled materials.

4.8.5 Seeding

- All seed mixes are to be placed in combination with an annual rye nurse crop and will be applied at a rate of 12kg per hectare.
- All upland areas are to be seeded using a 'City of Kawartha Lakes Native Seed Mix' applied at a rate of 20kg per hectare.
- Shoreline Fringe and Flood Fringe areas are to be seeded using an approved 'Wet Meadow' or seasonally flooded annual/perennial seed mix which are to be applied at a rate of 20kg per hectare.
- Seed application is to follow directly after topsoil placement in order to establish vegetative cover quickly for stabilization of topsoil.
- Erosion control blankets are to be placed over top of seeded areas immediately after application where required.
- Contractor will insure 100% coverage and establishment within the stormwater facility throughout the warranty period.

4.8.6 Guarantee Period

- All aquatics, perennials, trees and shrubs are to be guaranteed for a period of not less than one year from the beginning of the general maintenance period.

- If aquatics, perennials, trees and/or shrubs are found dead, diseased, missing or are deemed to be unhealthy within the guarantee period the defective plants are to be replaced and re-guaranteed for an additional two years.

4.8.7 Monitoring and Maintenance

- Vegetation monitoring plans and schedules are required with all landscape plan submissions which will include monitoring of the performance and effectiveness of interim measures (e.g. nurse crops) and monitoring of plant health during droughts.
- Monitoring reports for will be provided to the City of Barrie from the time of the initial plant installations until the end of the guarantee period. Inspections are to take place during September of each year and are to be provided to the City of Kawartha Lakes no later than October 15_{th} of each year.
- Mulch saucers should be placed and maintained around the base of trees to retain water.
- Watering activities should continue for the first two years after planting.

4.9 Emerging Technologies

The City of Kawartha Lakes will consider the use of emerging technologies for stormwater management. Some existing emerging technologies that have demonstrated an ability to provide water quality and quantity benefits include the following:

- Greenroofs (vegetated roofs)
- Subsurface infiltration tanks
- Infiltration drainfields
- Subsurface infiltration beds
- Phosphorus removal technologies
- Phoslock
- Low Impact Development (LID)

Due to the nature of emerging technologies, there is typically a lack of available monitoring data or design guidelines. As such, it is incumbent upon the proponent or Consulting Engineer to provide complete supporting calculations when submitting stormwater management designs utilizing emerging technologies. A preconsultation meeting with the City and governing Conservation Authority to discuss the use of emerging technologies is recommended to review the proposed design and to establish any specific requirements. All submissions employing stormwater management designs with emerging technologies will be reviewed by the City and other review agencies on a site-by-site basis.

4.10 General Maintenance Requirements

In order to ensure the optimal and long term continued operation of the source and conveyance controls and end-of-pipe controls for stormwater management prior to and following assumption (where applicable), it is important that the stormwater management controls be regularly maintained. Some of the key components of an effective maintenance program include:

- Regular cleaning of source and conveyance controls, and inspections to identify clogging (e.g. permeable pavements, infiltration trenches), sediment/oil accumulation (e.g. oil/grit separators), and structural failure in need of maintenance.
- Regular inspections and maintenance of end-of-pipe controls (e.g. wet ponds, constructed wetlands, hybrid ponds) as outlined in the operation and maintenance manual prepared for each facility.
- Provide and maintain a log book noting all maintenance activities.

5.0 REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION

The SWM report shall include the list of items below in terms of controlling erosion and the transport of sediment into natural watercourses during construction. However, since the list is intended to cover a broad range of development proposals, portions of the submission list may not be applicable for all development proposals.

- Erosion and Sediment Control Plans
- Erosion and Sediment Control Phasing
- Worksite Isolation Plan for In-stream Construction
- Spill Control and Response Plan
- De-watering plan
- Storm Drain Outfall Protection
- Storm Drain Inlet Protection
- Seeding/Sodding
- Sediment/Silt Control Fence
- Interception/Diversion Swales and Dykes
- Vehicle Tracking Control/Mud Mats
- Sediment Traps
- Rock Check Dams
- Temporary Sediment Control Ponds/Basins
- Topsoil Stockpiles
- Construction Access Mud Mats
- Restoration

The design of erosion and sediment control measures shall be in accordance with the City of Kawartha Lakes Site Alteration By-Law and permit requirements as well as the *Erosion and Sediment Control Guideline for Urban Construction* (December, 2006) and with applicable City of Kawartha Lakes standards.

6.0 ASSUMPTION PROTOCOL FOR STORM SEWERS AND SWM PONDS

6.1 Performance Evaluation of Storm Sewer Prior to Assumption

Prior to assumption of the storm sewer by the City, the following protocol shall be followed to ensure that the storm sewer system is operating per the design:

- A survey shall be completed for the storm sewer including maintenance holes and as-constructed drawings shall be prepared.
- The storm sewer design sheets shall be revised as required to verify adequate design capacity.
- A video inspection of the storm sewer including maintenance holes shall be undertaken by the developer/owner with City staff in attendance to identify any deficiencies (including damages). A digital and hardcopy record of the video inspection along with written certification from the developer's consulting engineer confirming that the storm system has been constructed as per the approved design drawings and approved plans must also be provided.
- A deformation test (PEGG Test) shall be completed on all PVC storm pipe to identify pipe sections that may require replacement. Pipe sections that do not allow the "pig" to pass freely shall be replaced.
- The storm sewer and catchbasins shall be thoroughly flushed and cleaned to remove all sediments as required.
- All inspections shall be conducted in compliance with the Occupational Health and Safety Act (OHSA) (e.g. confined space entry protocol).

6.2 Performance Monitoring of SWM Ponds Prior to Assumption

All new SWM facilities shall undergo a 1 year performance monitoring evaluation and shall meet the design requirement to the satisfaction of the City. Prior to assumption, the performance evaluation shall include, as a minimum requirement, the following items:

- Complete inspection and verification of hydraulic structure design, dimensions and elevations.
- Bathymetry to determine the volume of sediment accumulation within the facility.
- Water quality (phosphorus) monitoring.
- Plant monitoring as per **Section 4.8.7**.
- Provide and maintain a log book noting all inspection and monitoring activities

6.3 SWM Pond Assumption Protocol

Prior to assumption of any SWM facilities by the City, the following steps shall be taken:

- Complete a pond performance evaluation.
- Complete inspection of facilities.
- Bathymetry, including removal, testing, and safely disposing of any accumulated sediments at a suitable offsite location, if required.
- As-constructed survey of SWM pond block and all key pond elements and hydraulic structures.

- Written clearance from a Landscape Architect that all pond plantings are as approved on the design drawings and are established. Pond plantings must be shown to be healthy and complete. Any dead, diseased or missing material must be replaced prior to assumption inspection.

6.4 Lot Grading

Lot grading shall conform to current City guidelines.

7.0 GUIDELINES FOR HYDROLOGIC AND HYDRAULIC ANALYSES

The guidelines in this section provide some direction for completing hydrologic and hydraulic studies for submission to and review by the City of Kawartha Lakes. Prior to undertaking hydrology and hydraulic modeling work, the City of Kawartha Lakes Engineering Department shall be contacted to confirm the use of an approved and appropriate software package.

7.1 Rainfall Data

7.1.1 City of Kawartha Lakes IDF Curves

Table 7.1: Lindsay Filtration Plant IDF Curve Parameters

Parameter	Return period					
	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
A	808.793	1248.043	1486.840	1917.901	2141.858	2645.877
B	7.421	9.759	10.440	11.842	12.181	12.899
C	0.835	0.857	0.859	0.873	0.872	0.879

Rainfall Intensity, I (mm/hr) = A/(t+B)C, where t is time duration in minutes

Based on a review of the literature, the IDF intensity values for Lindsay Filtration Plant were increased by 15% before calculating a, b, c values to account for climate change.

7.1.2 Return Period Design Storms and Regional Storm

1: 2 year, 1:5 year, 1:10 year, 1:25 year, 1:50 year, 1:100 year and the Regional Storms shall be applied for quantity control and the 25 mm 4-hour Chicago storm shall be applied for erosion control as required. In order to determine the critical design storms, the SCS Type II (6-hr, 12-hr and 24-hr durations) and the 4-hour Chicago storm distributions for the 1:2 year through 1:100 year return period shall be applied.

Unless otherwise directed by the City, Regional Timmins Storm shall be applied throughout the City as the Regional storm for the sizing of municipal infrastructure associated with storm drainage and stormwater management.

7.1.3 Probable Maximum Rainfall (PMR)

The probable maximum rainfall (PMR) is defined as the largest precipitation event that can be reasonably expected to occur over a selected basin. Hydrological/hydraulic calculations using the PMR may be required and/or requested by the City or Conservation Authority under special circumstances where the risk of catastrophic loss of life is deemed to outweigh the cost of implementing a more stringent design criterion using the PMR.

7.1.4 Snowmelt and Winter Precipitation

During the winter months the occurrence of rainfall is typically less intense than during the summer. However, due to frozen ground conditions that result in lower infiltration rates and in conjunction with snowmelt, significant runoff volume and flow rates are possible that may exceed that resulting from summer storms. Based on previous studies, the rain plus snowmelt design event can exceed the summer design rainfall event for long duration storms (i.e. the 24 hour or 48 hour event). Given the limited size of the watersheds within the City, it is unlikely that an analysis of snowmelt and winter precipitation would be required, however, the City may request such an analysis under certain circumstances (*e.g.* areas with severe spring flooding) where there is deemed to be a high risk to public safety.

7.2 Runoff and Flow Calculations

7.2.1 Rational Method

The rational method shall be used for the design of storm sewers and conveyance infrastructure within the proposed development for drainage areas ≤ 50 ha. Storm sewers and conveyance infrastructure with a drainage area > 50 ha shall be designed using a computer model approved by the City and verified with the rational method.

Regarding flow control calculations (*e.g.* SWM facility), the rational method can be used for small (≤ 5 ha) sites. Otherwise, an approved hydrologic model shall be used.

When the rational method is used, the minor storm sewer system design shall be based on a 5 year return frequency unless otherwise directed by the City. The design of the storm sewers shall be computed using the City of Kawartha Lakes Storm Sewer Design Sheet as provided in **Appendix A**.

All storm sewers shall be designed according to the rational formula where:

$$Q = \frac{(C)(i)(A)}{360}$$

where,

Q	= the design flow (m^3/s)
C	= the site specific runoff coefficient
A	= the drainage area (ha)
i	= rainfall intensity (mm/hr)

The average rainfall intensity shall be calculated in accordance with **Table 7.1** using the following equation:

$$I = \frac{A}{(T_c + B)^C}$$

where,

I = average rainfall intensity (mm/hr)
A,B,C = the IDF equation coefficients (dimensionless)
T_c = the time of concentration (min)

where T (in minutes) is the sewer pipe inlet time plus the time of travel in a closed conduit or open channel to the design point. The first leg of a storm sewer system shall be designed using an initial time of concentration or inlet time of 10 minutes.

7.2.2 Hydrologic Computer Programs

Some of the hydrologic programs supported by the City include Visual OTTHYMO (VO2), SWMHYMO, and PCSWMM.NET. Prior consultation with the City should be completed to ensure that the selected software is acceptable to the municipality if proposing to use a program other than those noted above.

Single Event Models

Event based hydrologic programs, including Visual OTTHYMO (VO2), SWMHYMO, and PCSWMM.NET can be used to simulate peak flows associated with different return period design storms.

Continuous Models

Continuous hydrology programs, including PCSWMM.NET and SWMHYMO can be used to simulate flows associated with actual continuous rainfall data.

Model Calibration and Verification

Hydrology models shall be calibrated and verified for runoff volume, peak flow, and timing when reasonably feasible or if requested by the City and suitable flow data and precipitation data is available. Calibration parameters such as CN should be adjusted to AMCII conditions (average soil moisture) for calibrated event based models. When it is not feasible to calibrate the hydrology model, the critical physical parameters (e.g., CN numbers, Imperviousness, Average Slope and Time to Peak) shall be derived from the guidelines and the best available information such as watershed plans or master drainage plans. A sensitivity analysis should be completed for uncalibrated models since small changes in parameter values can often result in significant changes in model results.

Channel and Reservoir Routing

The rating curves and travel times used in channel routing and reservoir routing shall be determined by preliminary hydraulic calculations of the backwater profile or by procedures available in the approved hydrologic model. Sufficient channel routing should be incorporated into the hydrologic model. The routing computation time step must be relative to the smallest channel section, and at a maximum equal to the hydrograph time step.

Antecedent Moisture Conditions

The antecedent moisture conditions used for hydrologic modeling, including the selection of CN values shall be AMCII (average moisture condition). When the last 12 hours of the Hurricane Hazel storm is used for modeling (as is common practice), the AMCIII condition shall be used to account for saturated soil conditions due to the previous 36 hours of rainfall associated with the event. A conversion table for CN values under different antecedent moisture conditions is provided in **Appendix B**.

7.2.3 Flow Through Hydraulic Structures

The following table provides a list of acceptable coefficients for free flowing hydraulic structures such as weirs, orifices and spillways. The associated flow equations for common structures are as follows:

Sharp Crested Weir with End Contractions

$$Q = C(L - 0.2H)(H)^{\frac{3}{2}}$$

where,

Q = flow rate (m3/s)
H = head on the weir (m)
L = crest length of the weir (m)
C = weir coefficient.

Sharp Crested Weir Without End Contractions and Broad-crested Weir

$$Q = (C)(L)(H)^{\frac{3}{2}}$$

where,

Q = flow rate (m^3/s)
H = head on the weir (m)
L = crest length of the weir (m)

C = weir coefficient.

Orifice and Orifice Tube

$$Q = (C)(A)\sqrt{2g\Delta h}$$

where,

Q = flow rate (m^3/s)
Δh = differential head measured from the centroid of the orifice (m)
g = acceleration due to gravity (m/s^2)
C = coefficient of discharge. The coefficient for an orifice tube (C=0.80) is valid for a short tube

where the tube length is approx. equal to 2.5 times the orifice diameter.

Table 7.2: Weir and Orifice Coefficients

Application	C
Orifice	0.63
Orifice Tube	0.80
Sharp Crested Weir	1.837
Broad Crested Weir (SWMP and dam spillway)	1.7
Broad Crested Weir (road crossing)	1.5

Adapted from NVCA Development Review Guidelines (April 2006)

Time of Concentration and Time to Peak

Airport Formula

The Airport formula should be used when the composite runoff coefficient for the catchment is < 0.40. The Airport formula is defined as follows:

$$t_c = \frac{3.26(1.1 - C)(L)^{0.5}}{{S_w}^{0.33}}$$

where,

t_c = time of concentration (minutes)
C = runoff coefficient
S_w = watershed slope (%) calculated as per MTO methodology (*MTO Drainage Management Manual*, 1997)
L = watershed length (m) calculated as per MTO methodology (*MTO Drainage Management Manual*, 1997)

Bransby Williams Formula

The Bransby-Williams formula should be used when the composite runoff coefficient for the catchment is > 0.40.

$$t_c = \frac{(0.057)(L)}{(S_w)^{0.2}(A)^{0.1}}$$

where,

t_c = time of concentration (minutes)
A = watershed area (ha)
S_w = watershed slope (%) calculated as per MTO methodology (*MTO Drainage Management Manual*, 1997)
L = watershed length (m) calculated as per MTO methodology (*MTO Drainage Management Manual*, 1997)

Uplands Method

The Uplands Method is appropriate when the flow path consists of a number of different land covers. The average overland flow velocity is determined for a catchment based on the catchment slope and land cover type. The individual travel time for each land cover is summed to obtain the total travel time. The velocity used in the Uplands Method is calculated as follows:

$$V = (C_u)(S)^{0.5}$$

where,

V = average overland flow velocity (m/s)
C_u = V/S0.5 (Uplands coefficient)
S = average slope (m/m)

And the Uplands coefficient for different land covers is defined in the following table:

Table 7.3: Uplands Coefficients for Different Land Covers

Land Cover	Cu (V/S^0.5)
Forest with heavy ground litter meadow (overland flow)	0.6
Fallow or minimum tillage cultivation (overland flow)	1.5
Short grass pasture and lawns (overland flow)	2.3
Cultivated straight row (overland flow)	2.7
Nearly bare ground (overland flow)	3.0
Grassed waterway (ditch)	4.6
Paved areas (sheet flow) and shallow gutter flow	6.1

Source: modified from Figure 3.11, American Iron and Steel Institute, "Modern Sewer Design: Canadian Edition," Corrugated Steel Pipe Institute, 1996 and Stormwater Conveyance Modeling and Design, Haestad Methods, First Edition, 2003.

The time to peak should be calculated based on the following formula:

$$T_p = 0.67(t_c)$$

where,

T_p = time to peak (hours)
T_c = time of concentration (minutes)

7.2.4 Dual Drainage Analysis

Dual drainage analysis programs (*e.g.* PCSWMM.NET) shall be used to generate the inflow captured by the minor system during the design storm for the major system and HGL analysis, if the major system and HGL analysis design event is larger than the minor system design storm.

7.2.5 Calculation of Model Parameters

Model parameters shall be site specific, area weighted if required, and provided with the design documents. Soils information shall be obtained from on-site soil testing (*e.g.* borehole data) or soil survey mapping (*e.g. Soil Survey of Victoria County*).

Table 7.4: Curve Numbers for Selected Land Uses

Land Use Description	Hydrologic Soil Group (AMC II)						
	A	**AB**	**B**	**BC**	**C**	**CD**	**D**
Cultivated Land (Fallow)	77	82	86	89	91	93	94
[2]**Cultivated Land** (Row Crops)							
---- without agricultural BMPs	72	77	81	85	88	90	91
---- [3]with agricultural BMPs	62	67	71	75	78	80	81
[4]**Cultivated Land** (Small Grain)							
---- without agricultural BMPs	65	71	76	80	84	86	88
---- with agricultural BMPs	59	65	70	74	78	80	81
[5]**Cultivated Land** (Close-seeded Legumes or Rotation Meadow)							
---- without agricultural BMPs	66	72	77	81	85	87	89
---- with agricultural BMPs	51	59	67	72	76	78	80
Pasture or Range Land							
---- [6]poor condition	68	74	79	83	86	88	89
---- [7]good condition	39	50	61	68	74	77	80
Meadow							
---- good condition	30	44	58	65	71	75	78
Wooded or Forest Land							
---- [8]poor cover	45	56	66	72	77	80	83
---- [9]good cover	25	40	55	63	70	74	77

Open Spaces Lawns, Parks, Golf Courses, Cemeteries							
---- good condition (≥75% grass coverage)	39	50	61	68	74	77	80
---- fair condition (50% - 75% grass coverage)	49	59	69	74	79	82	84
Commercial and Business Areas (~85% impervious)	89	91	92	93	94	95	95
Industrial Areas (~72% impervious)	81	85	88	90	91	92	93
[10]**Residential Areas**							
---- ≤ 1/8 acre lot size (~65% impervious)	77	81	85	88	90	91	92
---- 1/4 acre lot size (~38% impervious)	61	68	75	79	83	85	87
---- 1/3 acre lot size (~30% impervious)	57	65	72	77	81	84	86
---- ½ acre lot size (~25% impervious)	54	62	70	75	80	83	85
---- 1 acre lot size (~20% impervious)	51	60	68	74	79	82	84
Paved Parking Lots, Roofs, Driveways	98	98	98	98	98	98	98
Streets and Roads							
---- paved with curb and storm sewer connection	98	98	98	98	98	98	98
---- gravel	76	81	85	87	89	90	91
---- dirt	72	77	82	85	87	88	89
[11]**Open Water Bodies** (Lakes, Wetlands, Ponds)	100	100	100	100	100	100	100

1 -- Adapted from U.S. Soil Conservation Service National Engineering Handbook (1972), MTC Drainage Manual Chapter B (1984), MTO Drainage Management Manual (1997).
2 -- Includes row crops such as soybeans, corn, sorghum hay, peanut, potato, etc.
3 -- Includes agricultural best management practices (BMPs) such as contouring and terracing.
4 -- Includes small grain crops such as winter wheat, spring wheat, durham wheat, barley, oats, rye, etc.
5 -- Includes close-seeded legumes such as alfalfa, timothy grass, grass hay, etc.
6 -- Poor condition is defined as heavily grazed, no mulch, or has plant cover on less than 50% of the area.
7 -- Good condition is defined as lightly grazed, more than 75% of the area has plant cover.
8 -- Poor cover is defined as heavily grazed or regularly burned so that litter, small trees and brush are regularly destroyed.
9 -- Good cover is defined as protected from grazing so that litter and shrubs cover the soil.
10 -- Curve numbers are calculated assuming that roof leaders are connected to the driveway and/or road with a minimum of additional infiltration.
11 – When a number of water bodies within a large multi-land use catchment is modeled, a CN value of 50 may be applied to the water bodies in calculating the area-weighted CN value. When isolating a water body and modeling as a separate

catchment, then a CN value of 100 should be used and the catchment is typically routed through a reservoir.

Table 7.5: Initial Abstraction / Depression Storage

Cover	Depth (mm)
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious areas	2

Adapted from UNESCO, Manual on Drainage in Urbanized Areas, 1987

Total Imperviousness (TIMP) and Directly Connected Imperviousness (XIMP)

Table 7.6 outlines typical parameter values that should be applied at the preliminary/conceptual design stage. The TIMP and XIMP values at the high end of the range given in **Table 7.6** shall be used at the preliminary/conceptual design stage. Adjustment of parameter values will be considered and accepted by the City at the functional and detailed design stage subject to the submission of relevant engineering calculations from the consulting engineer to justify the revision of these parameters.

Table 7.6: Typical Impervious Values by Land Use

Land Use	Total Impervious Percentage (TIMP)	**Directly Connected** Impervious Percentage (XIMP)
Estate Residential (> ¾ acre lot);	11% - 30%	8% - 20%
Low Density Residential (1/3 to ¾ acre lot)	18% - 50%	15% - 35%
Medium Density Residential (1/10 to ¼ acre lot)	35% - 60%	20% - 45%
High Density Residential (<1/10 acre lot)	60% - 75%	35% - 60%
Institutional (e.g. school religious centre)	45% - 75%	40% - 60%
Industrial	70% - 85%	65% - 80%
Commercial / Business	80% - 95%	80% - 95%
Park	0% - 5%	0% - 3%

Adapted from *Stormwater Management Pond Requirements*, City of London, 2005; Visual OTTHYMO Reference Manual, 2001; and review of typical site plans.

An approximation of the total impervious fraction (TIMP) can be calculated using the following formula:

$$TIMP = \frac{C - 0.2}{0.7}$$

where,

TIMP = total impervious fraction (dimensionless)
C = runoff coefficient

<u>Infiltration</u>

Infiltration is the movement of water from the ground surface into the soil. The most widely used methods for calculating infiltration include the SCS Curve Number Method, Horton's Method, and the Green-Ampt Method (*MTO Drainage Management Manual*, 1997)

SCS Curve Number Method

The SCS Curve Number Method is most appropriate for rural and natural basins.

$$Q = \frac{(P - I_a)^2}{(P + S - I_a)}$$

where,

Q = runoff depth (mm)
P = precipitation (mm)
S = soil storage capacity (mm) = (25400/CN) – 254 (mm)
CN = curve number based on vegetative cover and hydrologic soil group (A, B,C, and D)
I_a = initial abstraction (mm)

CN ≤ 70 IA = 0.075(S)
70 < CN ≤ 80 IA = 0.10(S)
80 < CN ≤ 90 IA = 0.15(S)
CN > 90 IA = 0.2(S)
(Visual OTTHYMO Reference Manual, Version 2.0, July 2002)

Horton Infiltration Method

The Horton Infiltration Method is widely accepted for use within small urban catchments in areas without much soil variability. The Horton Infiltration Method is not ideally suited for use in rural and natural basins due to the large variation in soil and land cover types typically encountered. The Horton Infiltration Method is not recommended for storm durations ≥d12 hours as predicted flows are sometimes erroneous (VO2 Reference Manual, July 2002).

$$f_t = f_\infty + (f_o - f_\infty)(e)^{-kt}$$

If $i < f_t$ then $f = i$

where,

f_t = infiltration rate (mm/hr)
f_∞ = minimum infiltration rate (mm/hr)
f_o = maximum infiltration rate (mm/hr)
e = natural logarithm
k = decay coefficient (1/hr)
t = time from beginning of precipitation (hr)
i = rainfall intensity (mm/hr)

The following table provides typical parameter values used in the Horton Infiltration Method.

Table 7.7: Typical Parameter Values for Horton Infiltration Method

Parameter	HSG A	HSG B	HSG C	HSG D
fo (mm/hr) (dry soil conditions)	250	200	125	75
f∞ (mm/hr)	25	13	5	3
k (1/hr)	2	2	2	2

Source: M.L. Terstriep and J.B. Stall, Illinois Urban Drainage Area Simulator (ILLUDAS) Illinois State Water Survey Urbana, 1979.

Green-Ampt Infiltration Method

The Green-Ampt Infiltration Method has been used in Canada for both agricultural and urban watersheds.

When F < Fs, f = i

When F > Fs

$$f_p = K_s\left[1 + \frac{(S_u)(IMD)}{F}\right]$$

where,

F = cumulative infiltration volume (mm)
F_s = cumulative infiltration volume required to cause surface saturation (mm)

$$F_s = \frac{(S_u)(IMD)}{{}^{i}/_{K_s} - 1}$$ when i > Ks

F_s = no calculation when i < Ks
f = infiltration rate (mm/hr)
f_p = infiltration capacity (mm/hr)
i = rainfall intensity (mm/hr)

Ks = saturated hydraulic conductivity (mm/hr)
Su = average capillary suction at the wetting front (mm)
IMD = initial moisture deficit for the event (mm/mm)

The following table provides typical parameter values used in the Green-Ampt Method.

Table 7.8: Typical Parameter Values for Green-Ampt Infiltration Method Various Hydrologic Soil Groups (HSG)

Parameter	HSG A	HSG B	HSG C	HSG D
IMD (mm/mm)	0.34	0.32	0.26	0.21
S_u (mm)	100	300	250	180
K_s (mm/hr)	25	13	5	3

Source: Design Chart 1.13, MTO Drainage Management Manual, 1997

7.3 Hydraulic Calculations

7.3.1 Minor System Hydraulic Calculations and HGL Analysis

Head losses in storm sewers occur as a result of friction losses and form losses (minor losses). Friction losses are the result of shear stress between the moving fluid and the boundary material. Form losses are the result of abrupt transitions due to the geometry of maintenance holes, bends, expansions and contractions. Where an HGL analysis is required, a spreadsheet or equivalent method using computer modeling (*e.g.* PCSWMM.NET) shall be used that includes design information including storm sewer sizes, lengths and inverts, tailwater elevations, flow, and velocities to calculate the losses that will occur through the storm sewer system. The use of any modeling software other than those noted in this document (see **Section 7.2.2**) requires prior consultation with and approval by the City. When completing spreadsheet calculations, head losses through the storm sewer system shall be calculated using Bernoulli's equation of head loss in the form of:

$$h = \frac{kV^2}{2g}$$

where,

h = head loss (m)
k = loss coefficient (dimensionless)
V = average pipe flow velocity (m/s)
g = gravitational constant, (9.81 m/s^2)

For the frictional component of the losses through the pipe, the k coefficient becomes:

$$k = \frac{fL}{D}$$

where,

k = loss coefficient (dimensionless)
f = friction factor (dimensionless)
L = length of storm sewer (m)
D = actual diameter of the pipe (m)

The friction factor is defined by:

$$f = 124\frac{n^2}{d^{1/3}}$$

where,

f = friction factor (dimensionless)
n = Mannings n (dimensionless)
d = actual diameter of the pipe (m)

Head losses through maintenance holes shall be calculated using Bernoulli's equation of head loss, as outlined above, with an appropriate value of k consistent with the type of junction (*Design and Construction of Urban Stormwater Management Systems*, ASCE, 1992, p.146 – 159).

For a straight through maintenance hole, with one incoming and one outgoing pipe, the loss shall be calculated as follows:

$$h_{MH} = 0.50\frac{V_{d^2}}{2g}$$

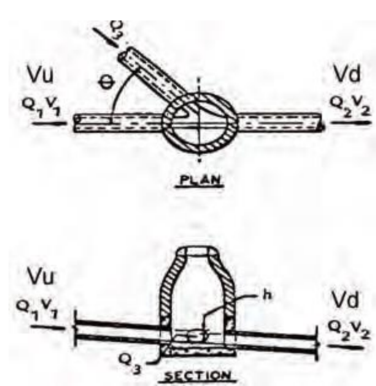
where,

h_{MH} = head loss through the maintenance hole (m)
0.05 = loss coefficient, k (dimensionless)
V_d = average pipe flow velocity in the downstream sewer (m/s)
g = gravitational constant, (9.81 m/s^2)

For a junction maintenance hole, with an incoming pipe, outgoing pipe and one or more laterals, the loss shall be calculated based on the velocities in the main branch sewers and the angle of the lateral sewer to the main branch as follows:

15° lateral: $h_{MH} = \frac{{V_d}^2}{2g} - 0.85\frac{{V_u}^u}{2g}$

22.5° lateral: $h_{MH} = \frac{{V_d}^2}{2g} - 0.75\frac{{V_u}^u}{2g}$



30° lateral: $h_{MH} = \frac{V_d{}^2}{2g} - 0.65\frac{V_u{}^u}{2g}$

45° lateral: $h_{MH} = \frac{V_d{}^2}{2g} - 0.50\frac{V_u{}^u}{2g}$

60° lateral: $h_{MH} = \frac{V_d{}^2}{2g} - 0.35\frac{V_u{}^u}{2g}$

90° lateral: $h_{MH} = \frac{V_d{}^2}{2g} - 0.25\frac{V_u{}^u}{2g}$

where,

hMH = head loss through the maintenance hole (m)
V_d = average pipe flow velocity in the downstream main branch sewer (m/s)
V_u = average pipe flow velocity in the upstream main branch sewer (m/s)
g = gravitational constant, (9.81 m/s^2)

For a maintenance hole, with an incoming and outgoing pipe benched through 90°, the loss shall be calculated based on the radius of curvature of the benching as follows:

Radius = the diameter of the pipe: $h_{MH} = 0.50\frac{V_d{}^2}{2g}$

Radius = 2 to 8 times the diameter of the pipe: $h_{MH} = 0.25\frac{V_d{}^2}{2g}$

Radius = 8 to 20 times the diameter of the pipe: $h_{MH} = 0.40\frac{V_d{}^2}{2g}$

where,

h_{MH} = head loss through the maintenance hole (m)
V_d = average pipe flow velocity in the downstream sewer (m/s)
g = gravitational constant, (9.81 m/s2)

7.3.2 Culvert / Bridge Hydraulic Analysis

Bridge and culvert calculations should be completed by computer programs such as CulvertMaster and HEC-RAS or SWMM. CulvertMaster is suitable for completing capacity and headwater elevation calculations for culverts while HEC-RAS is more appropriate for completing similar hydraulic calculations associated with bridges. When completing hydraulic analyses with HEC-RAS, the location of cross sections and modeling conventions should be in accordance with the HEC-RAS User Manual and Reference Manual.

7.3.3 Erosion and Erosion Mitigation Analyses

Erosion studies shall be based on an appropriate level of analysis to demonstrate the extent of unmitigated and mitigated erosion control criteria.

The MTO maximum permissible velocity method is acceptable for simple design needs, such as inlet/outlet, culvert erosion protection (see Section 5, *MTO Drainage Management Manual*, 1997).

For downstream erosion assessments within watercourses, a more detailed erosion analysis, including fluvial geomorphology and continuous modeling may be required at the discretion of the City and/or Conservation Authority.

7.3.4 Floodline Analysis

Floodline studies must be completed using a current version of HEC-RAS and the approved peak flows. Acceptable Manning's roughness values for routing calculations are provided in **Section 3, Table 3.7 and Table 3.8**. The use of any modeling software other than those noted in this document requires prior consultation with and approval by the City.

7.4 Water Balance

Water balance calculations shall be completed and provided per the methodology in the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003).

Infiltration facilities shall be provided to mitigate the water balance deficit. The infiltration facilities shall be designed based on soil percolation rates, local rainfall data, and maximum allowable detention time. The infiltration facilities shall conform to the governing guidelines which are currently documented in the *Stormwater Management Planning and Design Manual* (MOE, 2003) unless otherwise specified in the City's guidelines.

Where poor soils exist (i.e., soil percolation rate < 15 mm/hour), the detention time within the proposed infiltration facilities may be extended beyond 48 hours subject to approval by the City and Conservation Authority.

A suitable overflow bypass shall be provided for all infiltration facilities.

7.4.1 New Subdivisions

Infiltration facilities for large new development sites shall be designed to ensure that the annual infiltration volume for the post-development condition matches the volume for the pre-development condition. An overflow bypass shall be provided for the infiltration facilities.

7.4.2 Infill or Re-developments

Infiltration facilities for small infill or re-developments (< 5ha) shall be designed to minimize any anticipated changes in the water balance between pre-development and post-development conditions and to infiltrate as a minimum the first 5 mm rainfall volume from the subject development.

8.0 ENGINEERING SUBMISSION REPORTING REQUIREMENTS (DRAINAGE DESIGNS / SWM REPORTS)

A complete submission package must be delivered to the City for detailed engineering review of Stormwater Management Plans for both the conceptual/preliminary design stage and the detailed design stage. Submissions at the conceptual/preliminary design stage will consist of a Preliminary SWM Report, Functional SWM Report, or Functional Servicing Report. Submissions at the detailed design stage will consist of a Stormwater Management Report. The specific content requirements for the two types of Stormwater Management Plan submissions is provided below. However, as the list is intended to cover a broad range of development proposals, some of the items may not be applicable for infill development or small site plans. Exemptions may be made on a site-by-site basis, through pre-consultation with the City.

In general, printed and digital copies of the Stormwater Management Plan must be submitted with each development proposal. Digital copies are to be submitted in original format, and include report text, drawings and appendices, as well as the full set of engineering drawings (for detailed design). The report must be signed and sealed by a Licensed Professional Engineer of Ontario and include, as a minimum, the items outlined below.

8.1 Submissions to External Agencies

Submissions shall be made to the following external agencies as required.

- **Kawartha Region Conservation Authority (KRCA).** The KRCA is typically circulated on all applications that potentially impact the ecological resources and the quality and quantity of stormwater runoff and baseflow to watercourses within the jurisdiction of the KRCA. The KRCA jurisdiction corresponds to Zone 1 as delineated on the Flood Hazard Criteria Zones figure provided in **Appendix B**.
- **Lake Simcoe Region Conservation Authority (LSRCA).** The LSRCA jurisdiction corresponds to Zone 2 as delineated on the Flood Hazard Criteria Zones figure provided in **Appendix B**.
- **Otonabee Region Conservation Authority (ORCA).** The ORCA jurisdiction corresponds to Zone 3 as delineated on the Flood Hazard Criteria Zones figure provided in **Appendix B**.
- **Ministry of Environment (MOE) District and Approvals offices.** The MOE is typically circulated on applications for which a Certificate of Approval (C of A)/Environmental Compliance Approval (ECA) is required for municipal and private water and sewage works such as SWM facilities.
- **Ministry of Natural Resources (MNR).** The MNR is typically circulated on applications in which a permit is required under the *Lakes and Rivers Improvement Act* for construction within a watercourse.

- **<u>Ministry of Transportation (MTO).</u>** The MTO is typically circulated on applications in which provincial roads / highways under the authority of the MTO may be directly or indirectly impacted by the proposed works (400 m each side). For example, proposed development adjacent provincial roads / highways that may impact future expansion of travel corridors or may impact flows under MTO culverts or level of flood protection, typically require MTO review and approval.
- As directed by the City of Kawartha Lakes Engineering Department

8.2 Reporting Requirements for a Stormwater Management Plan (Conceptual / Preliminary Design)

8.2.1 Background Information

- 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 / historical land use.
- Reference for the topographic information used to determine internal and external catchment areas under existing and proposed conditions as well as references for soils, and water surface elevations (WSEL's) adjacent the site and downstream of any proposed outfalls or SWM facility outlet structures.
- Relevant recommendations and requirements from a Master Drainage Plan must be summarized for the site.
- Information related to the Class Environmental Assessment process must be included, if applicable.
- A copy of the Draft Plan must be provided.

8.2.2 Storm Drainage Areas

- Pre-development conditions must be indicated including: internal and external catchment areas and catchment I.D.'s, and drainage patterns for the site and applicable external lands.
- Post development conditions must be provided including: internal and external catchment areas and catchment I.D.'s, and major and minor flow routes for the site and relevant external lands. All external flows must be identified.

8.2.3 Stormwater Management Targets / Objectives and Design Criteria

- Conceptual/Preliminary SWM reports should identify how applicable recommendations from Master Drainage Plans, geotechnical and hydrogeological reports have been incorporated into the design.
- Outline the SWM design criteria being applied in the report. This should include criteria for water quality, erosion and quantity control as well as infiltration (water balance).

8.2.4 Storm Drainage System Design

- A conceptual storm sewer design must be provided to ensure sufficient sewer slope and pipe cover. Major overland flow paths should be indicated and any capacity restriction should be identified.

- Any interim servicing conditions should be identified.
- The routing of any external flows through the site must be identified.

8.2.5 Stormwater Management Facility Design

- Pre-development conditions must be indicated including: hydrologic parameters used for modeling, and predevelopment peak flow rates for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr year design storms for the critical storm distribution and duration (i.e. must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.
- Post development conditions must be provided including: hydrologic parameters used for modeling, and post development peak flow rates for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr year design storms for the critical storm distribution and duration (i.e. must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.
- Any requirements for thermal mitigation measures must be identified and conceptually described for any proposed SWM facilities.
- The water balance methodology must be provided along with input parameters, summary of results, and the requirements and concepts for any proposed infiltration measures.
- It must be demonstrated conceptually that sufficient measures can be provided to meet the required level of water quality control per the established criteria.
- It must be demonstrated conceptually that sufficient measures can be provided to achieve the required level of erosion control per the established criteria including an evaluation of anticipated changes in phosphorus loadings from pre-development to post-development conditions and how loadings will be minimized.

8.2.6 Erosion and Sediment Control During Construction

- Requirements and concepts for erosion and sediment control measures during construction are to comply with the City of Kawartha Lakes *Fill By-law ###* and should be identified in the design drawing package.

8.2.7 SWM Facility Inspection and Maintenance Requirements

- A detailed manual of required inspection requirements and maintenance requirements to ensure that the SWM facilities will continue to operate as designed must be provided.

8.2.8 Primary Tables

- Stage vs. Discharge and Storage Table (if required) – The table should include, as a minimum, all points used in the reservoir routing command.
- SWM facility operation characteristics table must be provided for the conceptual level of detail, including pond bottom, normal water level (NWL), extended detention WL, high water level (HWL) and incremental and cumulative storage volumes. A conceptual storage-discharge rating curve table must be included.
- A comparison of Predevelopment, Uncontrolled Post Development and Controlled Post Development Flows Table – showing peak flows for the Regional

and 2-yr through 100-yr design storm events at significant points of interest throughout the catchment area.
- Comparison of pre-development, unmitigated post-development and mitigated post-development water balance volumes and infiltration volumes.

8.2.9 Primary Figures and Drawings

- Site Location Plan.
- Draft Plan.
- Hazard Area Mapping (if applicable).
- Pre-development internal and external catchment areas and catchment I.D.'s on a topographic base showing existing land use and drainage patterns.
- 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.
- Conceptual drawings and siting of any proposed SWM facilities, including location of inlet, outlet and spillway. NWL and HWL must be indicated on the conceptual drawings.
- Conceptual siting and details for any proposed infiltration measures.
- Conceptual siting and details for any proposed thermal mitigation measures.
- Full set of **folded** Engineering Conceptual / Preliminary Design Drawings, signed and sealed by a licensed Professional Engineer of Ontario.

8.2.10 Supporting Hydrology and Hydraulics Calculations and Modeling Details and Output

- Printed copies of the model schematics and hydrologic modeling, including input and detailed output files for the 2-yr through 100-yr return period events (*i.e.* must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II distributions), 25 mm 4 hour Chicago quality storm, and Timmins storm for existing and future land uses as required.
- Digital copies of all modeling are to be included with the report. 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 2-yr through 100-yr design storm events. Digital files are to include both pre and post-development scenarios.
- 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 intensityduration-frequency values for the 2-yr through 100-yr return periods. Any other relevant design storm values not specified above should also be included. Tables and calculations should be provided in digital format.
- Table should be provided comparing the pre and post development peak flows for different storm distributions and durations for the site and required storage volumes to determine the critical storm to be used.
- Soil Characteristics Table – Listing the areal distribution of each soil type (expressed as a %) within every subcatchment.
- 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.

- Model input parameters, i.e., CN, IA, Tc, % imperviousness, etc. calculations.
- Incremental and cumulative volume calculations for the stormwater management facility.
- Drawdown time calculations for SWM facility (if applicable).
- Water balance calculations showing post-to-pre infiltration volume analysis and an evaluation demonstrating how phosphorus loadings from the site will be minimized.
- Pre and post-development watershed modeling schematics reflecting the model subcatchment I.D.'s and catchment areas.

8.2.11 Stand Alone Reports

- Geotechnical Report providing borehole information, including existing groundwater conditions, for the site and proposed pond block (if applicable)
- Environmental reports (e.g. fisheries impacts, hydrogeology, fluvial geomorphology), if applicable.

8.3 Reporting Requirements for a Stormwater Management Plan (Detailed Design)

8.3.1 Background Information

- 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 / historical land use.
- Reference for the topographic information using the City of Kawartha Lakes horizontal and vertical control monuments used to determine internal and external catchment areas under existing and proposed conditions as well as references for soils, and water surface elevations (WSEL's) adjacent the site and downstream of any proposed outfalls or SWM facility outlet structures.
- Information related to the Class Environmental Assessment process must be included, if applicable.

8.3.2 Storm Drainage Areas

- Pre-development conditions must be indicated including: internal and external catchment areas and catchment I.D.s, and drainage patterns for the site and applicable external lands.
- Post development conditions must be provided including: internal and external catchment areas and catchment I.D.s, and major and minor flow routes for the site and relevant external lands.

8.3.3 Stormwater Management Targets / Objectives and Design Criteria

- SWM reports should identify how applicable recommendations from Master Drainage Plans, geotechnical and hydrogeological reports have been incorporated into the design.

- Outline the SWM design criteria being applied in the report. This should include criteria for water quality, erosion and quantity control as well as infiltration (water balance).

8.3.4 Storm Drainage System Design

- It must be shown that the site provides safe conveyance of both the minor storm and 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 protected outlet constitutes: a permanently flowing watercourse or lake; a public right of way (provided the proponent has obtained written permission to discharge storm flows from the land owner); or in the case of privately owned lands, a legal right of discharge registered on title.
- Any interim servicing conditions should be identified.

8.3.5 Stormwater Management Facility Design

- Pre-development conditions must be indicated including: hydrologic parameters used for modeling, and pre-development peak flow rates for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr year design storms for the critical storm distribution and duration (i.e. must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.
- Post development conditions must be provided including: hydrologic parameters used for modeling, and post development peak flow rates for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr year design storms for the critical storm distribution and duration (i.e. must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II distributions) and the Regional Storm Event for each sub catchment.
- The WSEL's adjacent the site and downstream of the SWM facility outlet structure must be indicated to ensure the appropriate hydraulic calculations should backwater conditions exist.
- If required, thermal mitigation measures must be clearly identified and described for any proposed SWM facilities.
- The water balance methodology must be provided along with input parameters, summary of results, proposed siting, and functioning of any proposed infiltration measures.
- It must be demonstrated that sufficient measures are provided to meet the required level of water quality control per the established guidelines including an evaluation of anticipated changes in phosphorus loadings from pre-development to post-development conditions and how loadings will be minimized.
- It must be demonstrated that sufficient measures are provided to achieve the required level of erosion control per the established guidelines.

8.3.6 Erosion and Sediment Control During Construction

- Description of proposed erosion and sediment control measures to be in place before, during and after municipal servicing construction up to the end of the servicing maintenance period, including schedule for implementing/decommissioning and maintenance requirements.

8.3.7 SWM Facility Inspection and Maintenance Requirements

- Description of proposed inspection requirements and maintenance activities to ensure that the SWM facilities will continue to operate as designed. A schedule and frequency of maintenance activities is required.

8.3.8 Primary Tables

- Stage vs. Discharge and Storage Table (if required) – The table should include, as a minimum, all points used in the reservoir routing command.
- Existing and proposed runoff coefficients for each catchment.
- SWM Facility Operation Characteristics and Summary of Significant SWMF Features Table(s) – These include type of facility, contributing drainage area, lumped catchment imperviousness ratio, permanent pool, extended detention and quantity control volumes, as well as elevations for base of pond, base of forebay, normal water level, active storage and quantity control design high water level, Regional and 100-yr 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, and total draw down time required for the extended detention volume.
- Comparison of Predevelopment, Uncontrolled Post Development and Controlled Post Development Flows Table – showing peak flows for the Regional and 2-yr through 100-yr design storm events at significant points of interest throughout the catchment area.
- Comparison of pre-development, unmitigated post-development and mitigated post-development water balance volumes and infiltration volumes.

8.3.9 Primary Figures and Drawings

- Site Location Plan.
- Pre-development internal and external catchment areas and catchment I.D.'s on a topographic base showing existing land use and drainage patterns.
- 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.
- Siting and details for any proposed infiltration measures.
- Siting and details for any proposed thermal mitigation measures.
- Full set of **folded** Engineering Detailed Design Drawings, signed and sealed by a licensed Professional
- Engineer of Ontario

8.3.10 Supporting Hydrology and Hydraulics Calculations and Modeling Details and Output

- Calculations demonstrating that all storm outlets have sufficient energy dissipation and/or erosion protection based on calculated erosive velocities at each outlet.
- Storm sewer design sheets must be provided.
- Printed and digital copies of the model schematics and hydrologic modeling, including input and detailed output files for the 2-yr through 100-yr return period events (*i.e.* must look at both 4 hour Chicago and 6, 12 and 24 hour SCS Type II

distributions), 25 mm 4 hour Chicago quality storm, and Timmins storm for existing and future land uses as required.

- Digital copies (on DVD or CD) of all modeling are to be included with the report. 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 2-yr through 100-yr design storm events. Digital files are to include both pre and post-development scenarios.
- 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 2-yr through 100-yr return periods. Any other relevant design storm values not specified above should also be included. Tables and calculations should be provided in digital format.
- Table should be provided comparing the pre and post-development peak flows for different storm distributions and durations for the site and required storage volumes to determine the critical storm to be used.
- Soil Characteristics Table – Listing the areal distribution of each soil type (expressed as a %) within every subcatchment.
- 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.
- Model input parameters, i.e., CN, IA, Tc, % imperviousness, etc. calculations.
- Conveyance capacity calculations for the major system flow path.
- Stage-Storage-Discharge spreadsheet with hydraulic calculations for any proposed outlet control structures (Note: Calculation equations, coefficients, and design values for all hydraulic structures should be clearly identified).
- Incremental and cumulative volume calculations for the stormwater management facility.
- Sizing of emergency spillway (if applicable) for Regulatory flows.
- Drawdown time calculations for SWM facility (if applicable).
- Sizing of erosion control structures.
- Water balance calculations showing post-to-pre infiltration volume analysis.
- Calculations demonstrating that any proposed infiltration measures will provide the required infiltration volumes for the site and an evaluation demonstrating how phosphorus loadings from the site will be minimized.
- Dual drainage and hydraulic grade line calculations (if applicable).
- Tailwater elevations must be indicated for the outlet of any storm sewer and/or proposed SWM facility to demonstrate that any backwater conditions have been properly accounted for in the hydraulic design of the conveyance structures.
- Pre and post-development watershed modeling schematics reflecting the model subcatchment I.D.'s and catchment areas.
- Pre and post-development hydrograph plots for all significant points of interest.

8.3.11 Stand Alone Reports

- Operation and Maintenance Manual including a monitoring program plan for stormwater management facilities indicating how the facility will be monitored including water quality on a periodic basis.
- Geotechnical Engineering Report providing borehole information for the site and proposed pond block (if applicable) and certifying geotechnical feasibility of any stormwater management facilities and identifying any liner requirements for proposed SWM facilities.
- Environmental reports (e.g. fisheries impacts, hydrogeology, fluvial geomorphology), if applicable.
- Reports shall be submitted in paper and PDF format.

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