Nottawasaga Valley Conservation Authority

NVCA Stormwater Technical Guide

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This document has been prepared by the Nottawasaga Valley Conservation Authority, in consultation with our 18 member municipalities, engineering consultant stakeholders and representative community groups. This document relies heavily on the work previously undertaken by the Toronto Region Conservation Authority (TRCA), Credit Valley Conservation (CVC), Lake Simcoe Region Conservation Authority (LSRCA) and Conservation Ontario, and we are thankful for their efforts.

This document may be updated as a result of additional NVCA technical guide chapters or changes in municipal and/or technical guidance. Please contact the NVCA Engineering Department prior to applying the information contained within this guide.

Publication Information

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Table of Contents

List of Tables

1 Introduction

1.1 Purpose of Guidelines

The purpose of these guidelines is to provide assistance to consulting firms and our municipal partners in the development and review of technical reports in support of new development. These guidelines are intended to work in conjunction with the NVCA Planning and Regulation Guidelines, the Ministry of the Environment Stormwater Management and Design Manual, and the Ministry of Natural Resources Natural Technical Guides.

These guidelines present procedures, computation methods, and input parameters that are commonly used and accepted by NVCA staff, however it is still the designer's responsibility to recommend and justify the most appropriate methods. If the designer determines that alternative procedures, computation methods, or parameters are required to best describe the development site, an explanation of the rationale must be provided to assist the Conservation Authority in their review.

Municipal guidelines should also be consulted as they may exceed the recommendations of the guidelines, policy and design documents referenced here.

1.2 Need for Stormwater Management

Stormwater, for the purpose of this document, refers to “rainfall and snowmelt that seeps into the ground or runs off the land into storm sewers, streams and lakes.” In an undeveloped condition, the hydrologic cycle includes multiple components such as infiltration, evaporation and evapotranspiration that occur due to the natural vegetated state of the land. Through development, the hydrologic cycle is modified as more impervious surfaces are introduced.

Impervious surfaces prevent water from infiltrating into the ground, thereby reducing the amount of vegetation available for evapotranspiration and causing increases in volume of runoff that enters directly into the receiving watercourse. As well, there is a more direct path between the impervious surface and the receiving watercourse, which results in a subsequent increase in peak flows.

Increased volume to the receiving watercourse can have multiple impacts to the watercourse such as a longer period of higher flows after rainfall events and longer periods of sustained erosion that may result in down-cutting or widening of the watercourse. As well, there is an impact to the water balance as volume is being lost from groundwater that may:

- be the source of base flow in the summer months;
- impact adjacent wetland communities by modifying the hydrologic system;
- contribute to a cold water discharge to support the aquatic ecosystem; and/or
- recharge the groundwater aquifers.

Increased peak flows to watercourses downstream of development will increase existing flooding hazards. An increase in flows will result in an increase of the existing erosive forces of water that form the watercourse. Increased erosive force can cause meander patterns to change and become more pronounced, thereby increasing the erosion hazards associated with a watercourse both in confined and unconfined systems.

With development applications there also comes a rise in pollutants that can impact water quality. This increase in pollutants is caused by human activity within developments, such as fertilizers, pool runoff, sand and road salts and other contaminants from vehicle traffic. These pollutants can cause serious impacts to downstream aquatic habitats and can also affect the recreational uses of watercourses and shoreline areas.

Stormwater management must be incorporated into the design of new development applications in order to address increased volume and peak flows and degraded water quality. Stormwater management is meant to counteract the changes to receiving systems by this shift in the hydrologic cycle.

1.3 Legislative Framework

The *Conservation Authorities Act* was legislated by the provincial government in 1946 in response to concerns expressed by agricultural, naturalist and sportsmen's groups that pointed out that much of the renewable natural resources of the province were in an 'unhealthy state' as a result of poor land, water and forestry practices during the 1930s and 1940s.The combined impacts of drought and deforestation led to extensive soil loss and flooding.

The Act provides Conservation Authorities with the mandate to "further the conservation, restoration, development and management of natural resources." With respect to this mandate, the NVCA reviews stormwater management reports in order to address concerns with the control of flooding, erosion, pollution and the conservation of land as a commenting agency to watershed municipalities.

The Provincial Policy Statement (2005) also notes that "*planning authorities shall protect, improve or restore the quality and quantity of water*" through a variety of measures. In relation to water, within Section 2.2.1, the policy identifies three measures that specifically relate to stormwater management:

- "maintaining linkages and related function among surface water features, ground water features, hydrologic functions and natural heritage features and areas;
- promoting efficient and sustainable use of water resources, including practices for water conservation and sustaining water quality; and
- ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces."

1.4 Purpose of Document

The NVCA Planning and Regulation Guidelines is intended to provide direction for the implementation of the policies for the Plan Input/Review and Regulation and Permitting programs as mandated by the *Planning Act* and the *Conservation Authorities Act*.

The Stormwater Management Technical Guide has been prepared to provide the technical information required to support applications and technical studies for development. These two documents complement each other, with the Planning and Regulation Guidelines providing the policy basis for development review and the Stormwater Management Technical Guide providing engineering guidance for technical submissions.

This document should be used in conjunction with the current MOE Stormwater Management Planning and Design Manual (SWMPDM). Other documents from other Conservation Authorities and agencies may also be referred to and are not duplicated in the NVCA guidelines.

The NVCA expectations for all stormwater management submissions are outlined in the following sections, which include a description of NVCA policies, guidance on approved methods and techniques, a summary of key hydrologic parameters and a summary of submission requirements.

1.5 Technical Disputes

Standards established by individual municipalities or within watershed/subwatershed studies that exceed the guidelines identified in this document are to be given precedence.

In the case of a disagreement between the technical information included in any reports submitted (as per the criteria in this technical guide) and the technical information contained within this guide, it is the designer/applicant's responsibility to provide references for the changed technical information and a justification for the change in the reports submitted to the NVCA.

Where the change has implications to the municipality in which the development is proposed or any off-site impacts, then the proposed change will be discussed with the appropriate municipal staff to confirm that the change does not impact the municipality.

If an agreement on the technical information to be utilized cannot be reached, a peer review will be undertaken by a third party agreed upon by NVCA staff and the designer/applicant at the expense of the applicant. Before proceeding to third-party peer review to resolve an outstanding issue, a dispute resolution meeting will be held with the applicant and her/his representatives and the appropriate NVCA staff including the CAO and/or Director of Engineering and other appropriate staff.

Disputes related to the issuance of permits will be handled by the *Procedures for the Implementation of Ontario Regulation 172/06*. Disputes related to *Planning Act* applications will be handled in accordance with the *Plan Review Communications and Issue Resolution Protocol* as laid out in the individual municipality's Partnership Agreement.

1.6 Transition of the Document

The requirements of this document will apply to all new development applications submitted and after the date of Board Approval.

The updated criteria contained within this document are not intended to reset the application review process of ongoing applications; however, opportunities may be proposed for the inclusion of some of the policies within this document based on a mutually acceptable arrangement or through advancing opportunities to enhance stormwater management where applicable.

1.7 Stormwater Management Design Criteria

Stormwater management plans should include an evaluation of the hydraulic, hydrologic, geomorphic, hydrogeologic and ecological conditions of a subject area. As well, they should be designed to address quantity, quality, erosion and water balance (including both groundwater recharge and water balance for natural features), as described in the following sections of this document and the other technical guides.

It is the applicant's responsibility to confirm with the NVCA and the appropriate approval agencies whether the criteria within this document are applicable at the time of application.

The NVCA strongly recommends that pre-consultation be undertaken with every development application to identify any site-specific concerns, existing site-specific studies, digital information the NVCA may be able to provide or study requirements additional to those listed in the sections of this report.

A summary of the general stormwater management criteria applicable to the NVCA jurisdiction is included in Table 1.1 below.

Table 1.1: Summary of stormwater management design criteria

Stormwater Management Design Criteria	Additional Information/ Comments
Stormwater Quantity ▪ Control post-development flows to pre-development levels for the 2- to 100-year storm events ▪ Safe conveyance of the Regulatory flow through the site	▪ Certain portions of the watershed adjacent to Georgian Bay may require a modified stormwater quantity control approach; please contact NVCA to determine if the development is located within these areas
Erosion ▪ At a minimum, retain 5 mm on site where conditions do not warrant additional studies ▪ If the site drains to a sensitive watercourse, then the proponent must complete a geomorphic assessment study to determine the site-appropriate erosion threshold ▪ For sites with stormwater management ponds, 25 mm 48-hour detention as a minimum will be required, depending on the results of the geomorphic assessment study	▪ Please refer to Appendix B of the TRCA or Appendix A of CVC Stormwater Management Criteria for further information on identifying sensitive watercourses
Stormwater Quality ▪ Enhanced level of protection as per the latest MOE SWMPDM is required ▪ Where applicable, mitigate potential thermal and bacteriological impacts; to minimize thermal impacts, preventative measures (e.g. low-impact development practices) and mitigation measures should be applied	▪ Refer to TRCA/CVC LID Guide (2010) for low-impact development design guidance ▪ Refer to CVC Study Report: Thermal Impacts of Urbanization including Preventative and Mitigation Techniques (2011)
Water Balance ▪ For Significant Groundwater Recharge Areas and Highly Vulnerable Aquifers, site-specific water balance analyses are required ▪ For sensitive ecological features (woodlands, wetlands, watercourses) maintain hydrologic regimes and hydroperiods	▪ Refer to Section 7.3 with respect to the specific requirements for the design of infiltration facilities ▪ Water balance guidance is provided in Section 6

2 Stormwater Management Planning

2.1 Natural Hazard Considerations

End-of-pipe stormwater management facilities are to be located outside of Regulatory floodplain and erosion hazard limits. Facilities will also not be accepted if located within the following:

- environmental features and associated buffers
- valley lands and associated setbacks

Subject to the above, in some instances stormwater management facilities may be located within the floodplain between the 100-year storm and the Regional storm flood limit subject to the following technical requirements:

- not located within the erosion hazard limit;
- no loss of floodplain storage;
- no hydraulic obstruction to flood flows;
- no negative impacts on the fluvial processes in the floodplain;
- the elevation of the permanent pool of the stormwater management facility is set above the 100-year flood elevation;
- outside of the areas listed above.

The proponent should pre-consult with NVCA staff to determine the acceptability of the location and any other required design constraints.

2.2 Riparian Rights

Changes in a flow regime (peak flows, location, volume, duration, etc.) that could impact properties off site need to consider riparian rights of all impacted properties. It is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm (the greater of the 1:100-year design storm or Timmins storm event) through the development site to a sufficient outlet, such that no adverse impacts will be incurred on upstream and downstream landowners. A sufficient outlet typically constitutes a permanently flowing watercourse or lake. A public right-of-way may also provide sufficient outlet, provided the proponent has obtained written permission from the landowner. In the case of privately owned land, the proponent must obtain a legal right of discharge registered on title. Legal documentation, such as right of discharge and/or written permission to discharge into a public right of way, must be provided with the design submission.

2.3 Geotechnical Requirements

Prior to draft plan approval, the NVCA will require a geotechnical engineer's letter/report confirming the feasibility of the conceptual stormwater management design from a geotechnical perspective. This must include a test pit or borehole in the location of all stormwater management facilities including low-impact development locations.

The geotechnical report should address any side slope stability concerns, hazardous soils, berm construction (with the appropriate materials and compaction), specifications of a liner (if required), high groundwater table and/or bedrock issues. The purpose of this letter/report is to ensure that the parcel of land for the stormwater management facility is adequate, as it will be much more difficult to adjust the parcel size later in the planning process. In addition, it is required to confirm that the conceptual design for the stormwater management facility has been reviewed by a geotechnical engineer and that no geotechnical problems are obvious at this time.

Prior to final design approval, the NVCA will require a geotechnical engineer's letter/report confirming that the final design of the stormwater management facility and the operation and maintenance manual are acceptable from a geotechnical perspective. The review of the operation and maintenance manual should ensure that the proposed measures to maintain the facility will not cause damage to the proposed facilities.

2.3.1 Depth to Groundwater

Geotechnical samples, boreholes or test pits in support of infiltration systems should be extended to a depth between 2.5 to 5 metres or until bedrock or fully saturated conditions are reached. A minimum of 1.5 metres below the proposed infiltration stormwater management practices will be required for samples with respect to these facilities.

The determination of the location of the seasonably high groundwater level is recommended to be completed within the months of March, April and May, after the ground has thawed to account for the high groundwater table associated with the snowmelt event. A yearly record may be requested for infiltration practices by the NVCA and by certain municipalities. If data is not available or timing for testing does not meet the spring window, NVCA is prepared to work with the proponent to determine conservative assumptions as an alternative.

2.4 Stormwater Management Outfalls

The siting of stormwater management outfalls should be such as to minimize the impact to the natural environment. Disturbance to forested valley slopes and adjacent wooded or wetland habitats needs to be avoided and/or minimized to the extent possible. Levels of disturbance also need to consider any access roads required to maintain the outfall and outfall channel.

Storm pond outfalls require flow dissipation measures, such as plunge pools or equivalent, to reduce erosive velocities at the end-of-pipe. Discharge velocities should be reduced to allow for grass-lined meandering outfall swales. Pond outfall swales should be terminated away from the receiving watercourse, if possible, to avoid alteration to fish habitat on creek banks. If engineering requirements allow, additional flow spreaders or dissipaters should be employed at the end of the outlet swale to promote diffuse flow on the floodplain, to encourage some level of infiltration, evaporation or evapotranspiration prior to entering the watercourse.

If flow spreaders or equivalent are not feasible at the end of the outfall swale, then outlet channels should be vegetation-lined meandering swales that extend to the watercourse bank. Tree and shrub planting along the outfall channel is required, with densities sufficient to provide a closed canopy over the outlet swale. Infiltration trenches or additional measures may be required to minimize thermal impacts to receiving watercourses that are classified as coldwater resources.

Outfalls that require hard structures, such as headwalls or pipes, should be located outside of the 100-year erosion limit unless it is not technically feasible. If not technically feasible then the outfall should at least be located in an area where active erosion is not occurring.

Outfalls should be located as a minimum above the level of the 25-year flood limit and outside of the low flow channel to avoid disturbance to the watercourse.

2.5 Climate Change

Climate change can be defined in a number of different ways; for example, Environment Canada defines it as: "a long-term shift in weather conditions measured by changes in temperature, precipitation, wind, snow cover, and other indicators". Based on research carried out by Natural Resources Canada, there has been an increasing shift in the overall temperature of Canada by more than 1.3°C since 1948. Global climate models are predicting that this trend will increase to an average annual temperature of 2.7°C to 3.7°C by 2050.

2.5.1 Changes to Storm Events

With respect to stormwater management design, storm events in Ontario are becoming more severe and more powerful. From 2000 to 2005, 10 storms were experienced in Ontario alone that exceeded the 1:100-year probability storm event. These include a storm event in Peterborough in 2004 where 240 mm of rain fell over approximately 8 hours and caused $87 million in damage, and a 2005 storm event that hit Toronto with 175 mm of rain in less than an hour and caused $550 million in damage. To put this into perspective, the Timmins Storm event (which is the regional event for the NVCA jurisdiction) is modelled with a total rainfall runoff of 193 mm over a 12-hour period.

Climate change will also "affect the frequency, magnitude, location and duration of hydrological extremes" (TRCA, 2009). Climate change trends are such that the storm and flood events of today will continue the trend of escalating into the coming years and stormwater management facilities must be designed to deal with these concerns. Several studies for Southern Canada note trends "towards more heavy precipitation days, greater contributions to total precipitation from heavy events, and greater increases in the five day rainfall amounts in spring than in other seasons" (Bruce, 2008).

Based on the results of 16 climate models predicting 24-hour rainfall intensities, these rainfall intensities would increase by 6 percent per degree Celsius. With the projected temperature change of 3 to 4 degrees for Southern Ontario, including the NVCA jurisdiction, an increase of 18 to 24 percent in the 20-year 24-hour rainfall event could be expected.

Climate change can also be seen in the way that precipitation is falling. As shown in Table 2.1 there is a decrease in the amount of snowfall and an increase in the amount of precipitation that falls as rain. A change in the number of cold temperature days means less ice on Lake Huron and Georgian Bay, which will result in lower lake levels in the years to come.

Table 2.1: Seasonal precipitation trends in the Great Lakes/St. Lawrence region including Lake Huron

		Change in precipitation ÷ 10-year mean precipitation
Winter	Snow	-1.50 %
	Rain	2.60%
Spring	Snow	-3.8% *
	Rain	2.6% *
Summer	Snow	N/A
	Rain	+1.6 % *
Fall	Snow	-.10 %
	Rain	+2.9 % *

Ref: Mekis and Hogg, 1999

Note:
*	Significant Trend (1895–1995)

Precipitation patterns will change such that even though there is an increase in the amount of precipitation it will occur in more extreme storm events, exacerbating the problem of summer droughts. These droughts will become more frequent and result in longer dry periods.

Urban development within watersheds exacerbates this problem as it changes the capacity with which watersheds, through water balance, are able to slow runoff and ease flood flows (Conservation Ontario, 2009).

2.5.2 Adaptation

The NVCA, as well as organizations at all levels of government, are taking an adaptive approach to the uncertainty of climate change. The Province of Ontario defines adaptation as "the process societies go through in order to cope with an uncertain future". The NVCA recommends that, in the future, stormwater management might include some of the following to offset some of that uncertainty:

- Upsizing storm sewer designs to better handle the more extreme storm events;

- Low-impact development (LID) stormwater management features to allow more water to infiltrate back into the ground;
- Achieving a complete post- to pre-development water balance;
- Providing more tree cover within developments to promote evapotranspiration;
- Siting stormwater management facilities outside of the Regulatory Floodplain limit;
- Upsizing bridge and culvert capacity.

Based on the statistical information above, the NVCA recommends that all stormwater management facilities be designed to include an increase in precipitation. A number of jurisdictions have made specific changes to account guidelines to account for climate change. Some examples are below:

- The City of Barrie has increased intensity by 15% in their IDF curves.
- The City of London has increased the intensity in their IDF curves by 21%.
- The City of Ottawa required that 'stress test' is run on stormwater infrastructure by increasing rainfall 20% and seeing how the infrastructure responds.

The NVCA will continue to keep up-to-date on climate change adaptation across the industry and encourages municipalities and engineering consultants to include adaptation measures in design.

3 Stormwater Quantity

Stormwater quantity control is required in order to protect downstream properties from the increased flooding conditions from upstream development.

3.1 Stormwater Quantity Criteria

Every effort should be made to maintain existing watershed boundaries and drainage patterns. Pre-consultation is mandatory for any proposed shift in drainage boundaries. Quantity control facilities are to be designed in accordance with recommendations set out in the MOE's SWMPDM.

Unless specified otherwise by the municipality, the NVCA, a subwatershed study or fluvial geomorphic analysis, post-development peak flow rates must not exceed corresponding pre-development rates for the 1:2-year, 1:5-year, 1:10-year, 1:25-year, 1:50-year and 1:100-year design storm events. Both the 4-hour Chicago and 24-hour SCS Type II storms must be modelled for the specified storm events.

If there is a known deficiency in the downstream conveyance or an insufficient outlet, additional quantity control may be required (i.e. private property, undersized pipes). Any proposed increase in flood elevations must be contained on the subject property.

Safe conveyance of the Regulatory flows through the site to a sufficient outlet is required. The Regulatory flows are taken as the greater of the uncontrolled 100-year or Timmins flows through the development.

The use of infiltration measures designed as per Section 7.3 may be applied for quantity control volume and flow reductions only where local municipalities have accepted the use of these practices and have considered the long term operation and maintenance.

3.2 Hydraulic Modeling

If the site may impact the flood limit, hydraulic modeling must be provided as outlined in the NVCA Natural Hazard Technical Guide. The preferred hydraulic model is the U.S. Army Corps of Engineers' HEC-RAS in the most recent version of the software.

4 Erosion Control

Urban development will result in changes to the natural processes that define watercourses. Through changes in land use and stormwater management techniques, there is a change to the quantity of water – both flow and volume – applied to the watercourse, as well as a lack of sediments being transported to the watercourse. These changes to the natural processes of the watercourse can cause channel instability, as well as degraded water quality and aquatic habitats. There is also a risk with these systems that they could cause an increase in downstream bank erosion and channel migration, putting existing developments at risk.

Through the years, changes in hydrology and sediment loadings have resulted in:

- Stream bank widening and bank erosion: *stream channels enlarge to accommodate higher stormwater volumes and peak flows;*
- Streambed changes due to sedimentation: *channel erosion and sediment loading from urban construction lead to deposition of fine material in stream covering coarser materials with mud, silt and sand;*
- Stream downcutting: *another adjustment that occurs in response to flow increases in downcutting of the stream channel, which leads to a steepening of the stream profile or gradient, thus accelerating the erosion process;*
- Loss of riparian tree canopy: *the continued undercutting and failure of stream banks exposes tree roots that normally protect stream banks from erosion leading to uprooting of trees that causes further weakening of the structural integrity of the stream banks.*

4.1 Erosion Control Criteria

To deal with the issues resulting from additional volume of runoff produced as a result of urbanization, a minimum of the first 5 mm of rainfall should be retained on site. This requires Low-Impact-Development measures of sufficient size to store the volume of 5 mm across the entire development site. The volume of storage required should be calculated by multiplying the 5 mm depth over the entire area to be treated by the stormwater management treatment train. This could be done through infiltration, rainwater harvesting or evapotranspiration. In some sites the conditions make retention of 5mm impractical. For these site the NVCA encourages a 'best efforts' approach to try to meet this goal.

To deal with potential impacts of increased erosion in the receiving watercourses, the NVCA recommends that a rapid geomorphic assessment is completed for all development applications were the outlet is directly into a watercourse.

NVCA staff may remove the requirement of geomorphic assessments for altered systems (e.g. ditches, municipal drains); however, this can only occur through pre-consultation with appropriate technical staff to determine the level of impact to the receiving watercourse.

If a watercourse is deemed sensitive based on the criteria below, then a minimum of 48-hour detention is required for the 25 mm storm event. There may also be a need to increase the amount of volume retained on-site based on the results of the detailed geomorphic assessment.

4.1.1 Rapid Geomorphic Assessments

For technical guidance on the rapid geomorphic assessment requested, NVCA refers to the MOE SWMPDM and TRCA and CVC's Stormwater Management Criteria Documents dated August 2012. These guidelines require the assessment of four indicators:

- Aggradation (AI);
- Degradation (DI);
- Channel Widening (WI); and
- Planimetric Form Adjustment (PI).

Table C.1 of the MOE SWMPDM describes the geomorphic indicator required for each of these parameters. Additional indicators may be present and they can be included at the discretion of the assessor.

The total number observed is divided by the number of indicators present to produce a ratio value of between 0 and 1. Individual geomorphic indicators that cannot be assessed should not be included in the total number of indicators.

Two indices based on the above indicators will be required: overall stability index (SI) and individual index values.

The overall stability index is determined through the following equation:

$$SI = (AI + DI + WI + PI)/4$$

Table C.2 of the MOE SWMPDM uses this value to classify watercourses into three categories: in regime, transitionally or stressed, or in adjustment. If the value of the overall stability index is greater than 0.2, a detailed geomorphic assessment is required; however, due to the averaging of the four parameters the values can be skewed, in which case the NVCA will require an assessment of individual parameters as well.

Individual index values should be evaluated as values greater than 0.5 for AI, DI, WI or PI will also indicate that there may be an issue with the downstream receiving watercourse and will require a detailed geomorphic assessment.

4.1.2 Detailed Geomorphic Assessments

Detailed geomorphic assessments include defining erosion indices for specific watercourses. The indices are determined based on the following procedures, for which the CVC and TRCA Stormwater Management Criteria provide further information:

- Field measurement of channel geometry;
- Field measurement of sediment particle size;
- Desktop analysis of erosion thresholds;
- Continuous hydrologic modeling; and
- Determination of erosion indices.

The purpose of the detailed assessment is to develop the criteria for maintaining the natural channel function, which will require the design of the stormwater management treatment train to match the frequency of exceedance or cumulative effective work in the post-development condition. In systems where the SI value is already greater than 0.2 or an individual index is greater than 0.5, over control may be required to bring the watercourse back to equilibrium.

If stormwater management options cannot bring the receiving watercourse back into equilibrium than additional options must be discussed with the NVCA.

If more than one development is proposed within an Official Plan that outlets to the same watercourse, it is necessary to assess the cumulative impact of multiple developments with a combined detailed geomorphic assessment in order to determine the stormwater management control necessary to mitigate downstream erosion impacts.

5 Stormwater Quality

MOE sets criteria for stormwater quality control, as urban development will provide contaminants to downstream water resources. Table 5.1 includes a list of common contaminants from urban development.

Table 5.1: Stormwater and its sources

Stormwater Contaminants	Source
Suspended solids/sediment	Construction sites, roads, winter sanding
Nutrients (nitrogen and phosphorous)	Fertilizers, pet wastes, yard wastes
Metals	Cars
Oil/grease	Cars, leaks, spills
Bacteria	Pet wastes
Pesticides and herbicides	Yard and garden care
Heat (increased water temperature)	Exposure to air in warm season

The NVCA's objective in requiring a standard of stormwater quality is to protect the natural habitat downstream, which may be a source of drinking water, used for agriculture and/or provide aquatic habitats that support recreational activities such as fishing. The requirement for quality control is not only a concern of the NVCA but also of the Ministry of the Environment and the Department of Fisheries and Oceans through various acts and regulations.

5.1 Stormwater Quality Criteria

All stormwater management plans within the NVCA's jurisdiction are required to meet a minimum 80% TSS removal or an enhanced (Level 1) removal as referenced in the MOE SWMPD Manual.

5.1.1 Stormwater Nutrient Management

In 2006, the NVCA, the MOE and the Lake Simcoe Region Conservation Authority undertook assimilative capacity studies (ACS). The purpose was to identify concerns with growth pressures and the "already evident decline in water quality and ecosystem health" for both watersheds (ACS, 2006).

The generalized loading rates for the Nottawasaga River Watershed from the Greenland study are shown in Table 5.2. The assimilative capacity study notes that the Nottawasaga River receives an average annual load of 46.9 tonnes/year of phosphorous. Conversion of the Provincial Water Quality Objective (PWQO) of 0.03 mg/L to an annual loading for the Nottawasaga River would result in an average annual loading of 25.5 tonnes/year (Berger, 2006). Based on a comparison of these values the NVCA would require a phosphorous loading reduction of 46% across the watershed to meet a PWQO target for phosphorous. As well, 11 out of the 12 watersheds listed in Table 5.2 individually exceed the PWQO objective for phosphorous.

Table 5.2: Generalized loading rates to Nottawasaga Bay over the simulation period of 1996 to 2004

Watershed	Nitrogen (kg/yr)	Phosphorous (kg/yr)	Sediment (tonnes/yr)
Bear Creek	35788	863	702.2
Boyne River	170356	4893	5228.6
Coates Creek	89150	1056	702.9
Innisfil Creek	402867	7105	4895.3
Lower Nottawasaga	267564	5308	2479.4
Mad River	163376	4681	5062.5
Marl Creek	127997	1929	1784.1
Matheson Creek	157849	3090	1840.6
McIntyre Creek	169896	8205	2021.3
Pine River	98334	4050	3542.9
Upper Nottawasaga	151852	5200	8045.3
Willow Creek	24664	712	604.5
Total	1859693	47092	36910

As a minimum standard, the NVCA requires the matching of post-development phosphorous loads to pre-development levels. Based on the recommendations provided in this report, the NVCA would prefer all new development to achieve a 20% reduction from pre-development levels in phosphorous loadings. This reduction will be based on a best-efforts approach that may include LID, constructed wetlands, vegetative buffer strips and improved wastewater treatment.

5.1.2 Temperature Mitigation

As per the *Federal Fisheries Act*, elevated water temperatures are considered a deleterious substance. Urban development can exacerbate temperature issues, as the design of stormwater management end-of-pipe facilities specifically wet ponds can raise downstream water temperatures by as much as 5.1°C. Efforts to reduce the temperature of water leaving stormwater management facilities must be applied to facilities that outlet directly to coldwater or cool water fish habitats as identified in Table 5.3. Best management efforts will be considered for systems that are discharging to warm water habitats. Designs for stormwater management systems that discharge directly to coldwater habitats or other areas that contribute to cold water habitats should include:

- Pond configuration;
- Bottom-draw outlet;
- Subsurface trench outlet;
- Outlet channel design; and/or
- LID.

Additional guidance for thermal impact mitigation in stormwater management designs can be found in the MOE SWMPDM and in CVC's "Study Report: Thermal

Impacts of Urbanization including Preventative and Mitigation Techniques" (CVC, 2011).

Table 5.3: Fisheries habitat management objectives

Coldwater ▪ Lower Nottawasaga River between Klondike Park Road and the Wasaga Beach Wastewater Treatment Plant, including tributary streams ▪ McIntyre Creek ▪ Lamont Creek ▪ Warrington Creek ▪ Marl Creek ▪ Franks-Hood Creek ▪ Middle Nottawasaga ▪ Upper Nottawasaga ▪ Willow Creek with its Matheson Creek tributary and other tributaries entering the main branch between St. Vincent Street and the 9th Line of former Vespra ▪ Black Creek and its tributary streams ▪ Mad River and its tributary upstream from Simcoe County Road 10 ▪ Coates Creek and its tributary upstream of the New Lowell Reservoir ▪ Pine River ▪ Boyne River ▪ Innisfil Creek ▪ Pretty River ▪ Silver Creek ▪ Batteaux Creek ▪ Black Ash Creek ▪ Townline Creek ▪ Upper Reaches of Hog Creek ▪ Sturgeon River ▪ Coldwater River
Coolwater ▪ Sturgeon Creek ▪ Upper Swaley Creek
Warmwater ▪ Lower Nottawasaga River including Marl Lake, Jack's Lake and the warmwater tributary stream ▪ 2nd Line Municipal Drain including diverted flows from the Mad River ▪ Little Lake ▪ Willow Creek upstream of St. Vincent Street including upstream warmwater tributaries and downstream of the 9th Line of former Vespra ▪ Mad River and its tributary downstream from Simcoe County Road 10 ▪ Coates Creek and its tributary downstream of the New Lowell Reservoir ▪ Intermittent Georgian Bay Streams ▪ Orr Lake ▪ Wye River and its tributary streams ▪ Nottawasaga Bay ▪ Bass Lake ▪ North River and its tributaries

* Additional detail related to the status of NVCA watercourses Fisheries Habitat Management Objectives can be found in the Fisheries Management Plan

6 Water Balance

Urban development has impacted the hydrologic cycle of our watersheds by preventing natural infiltration into the ground and evapotranspiration from natural areas. End-of-pipe stormwater management measures also impact the hydrologic cycle by shifting the runoff from a site to a single point. Application of the water balance criteria as defined below is meant to prevent this shift in the hydrologic cycle, thereby protecting groundwater, base flows and natural heritage features such as wetlands and woodlots and reducing stream erosion.

These guidelines set out the requirements for managing the water balance in order to maintain ecological functions and characteristics and hydrological function of features that have been recommended for protection through an Official Plan designation, Watershed Plan, Subwatershed Study, NVSPA Assessment Report, Master Environmental Servicing Plan, Environmental Implementation Report, Environmental Impact Study or other similar study and/or in consultation with the Conservation Authority and municipality. In other areas with suitable soils, the water balance is also managed to sustain groundwater levels to protect base flows in watercourses and provide water sources for municipal and private wells and other permits to take water.

6.1 Wetlands

For wetlands and vernal pools, the overall objective is to manage the water balance in order to maintain the quantity (volume, timing, spatial distribution) of surface water and groundwater contributions that ensures the pre-development hydroperiod (seasonal pattern of water level fluctuation) of the wetland is protected. The proposed development must not cause changes to the hydroperiod that negatively impact the hydrological functions of the feature.

For vernal pools that are identified as being ecologically important, the NVCA and the municipality should be consulted prior to undertaking an evaluation to determine appropriate requirements. MNR must also be contacted if species at risk are known to use the vernal pool or any other wetland feature. Wildlife Scientific Collectors Authorizations (WSCAs) and *Endangered Species Act* (ESA) permits may be required where species at risk are known to occur.

6.2 Woodlands

For woodlands, the overall objective is to manage the water balance in order to maintain the volume, timing and spatial distribution of surface water and groundwater contributions that ensures that hydrological changes do not cause adverse effects on the form and/or function of the woodland.

6.3 Watercourses

For watercourses and headwater drainage features, the overall objective is to manage the water balance in order to maintain the quantity (volume, timing, spatial distribution) of surface water and groundwater contributions to ensure the duration, frequency, magnitude and rate of change of flow do not result in adverse effects.

6.4 Groundwater Recharge Areas

Important groundwater recharge areas include Significant Groundwater Recharge Areas (SGRA) as per the Source Water Protection Policies, and high- and medium-volume groundwater recharge areas as defined by soils with infiltration rates greater than or equal to 15 mm/hour.

Water balance limitations:
The NVCA recognizes that not all areas are suitable for recharge measures. Unsuitable conditions for recharge may include:

- Slopes >20% and contributing catchment area slopes >15%;
- Seasonally high water-table elevations that are within 1.0 metres of the bottom of a proposed recharge facility;
- Bedrock within 1 metre of the bottom of the proposed recharge facility;
- Soils with infiltration rates less than 15 mm/hour; underdrains may be required where infiltration is proposed in areas with soil infiltration rates less than 15 mm/hour;
- Locations within 250 metres of the boundary of a landfill site;
- Wetlands and associated hydric soils;
- Drinking water wells within 30 metres of the recharge facility;
- Land uses that may produce toxic chemicals that could contaminate the groundwater or other land uses where runoff containing toxic chemicals that cannot be adequately removed before infiltration.

The NVCA would not recommend any engineered recharge facilities where the above conditions are present at a site; however, the proponent should make every effort to maintain overall infiltration across the site based on the noted requirements.

6.5 Water Balance Equation

The physical properties of the landscape that determine the proportions of precipitation that partition into recharge/infiltration, evapotranspiration and runoff include:

- Soil permeability;
- Soil moisture;
- Depth to groundwater table;
- Slope; and
- Type of vegetation.

Water balance can be assessed based on the following equation using the information found in Section 3.2.3 in the MOE SWMPDM:

$$P = R + I + ET$$

Where:

P	= Precipitation
R	= Surface water runoff
I	= Infiltration/recharge
ET	= Evapotranspiration

Precipitation values should be based on the appropriate municipal standard or the closest Environment Canada rain gauge with appropriate years of record to the proposed development.

6.6 Water Balance Analysis Methodology

As with any development, the level of study and evaluation should be scoped relative to the size and significance of the proposed development through pre-consultation with the NVCA staff.

The methodology for undertaking a water balance will vary from site to site depending on the sensitivity of the features being protected, the size of the development and available site information. Terms of reference must be developed for the site and approved by the NVCA through pre-consultation before initiating the study.

Please refer to section 3.2.4 Water Balance Analysis of the Hydrogeological Assessment Submissions- Conservation Authority Guidelines to Support Development Applications dated June, 2013 for hydrogeological study requirements for water balance calculations.

In addition, the NVCA uses standardized methodology consistent within the GTA and therefore will evaluate the proposal using guidelines developed by other conservation authorities. Other water balance guidelines, such as the criteria developed by the CVC and the TRCA in their *Stormwater Management Criteria Documents* should be referred to. Other documents such as the *Water Budget Reference Manual, Ministry of Natural Resources* (2013) can also provide guidance.

7 Stormwater Management Practices

7.1 Oil/Grit Separators

The NVCA prefers that oil/grit separators be used as part of a multi-component approach to achieve enhanced quality control, provided they are sized in accordance with the recommendations set out by both the MOE SWMPDM and the manufacturer. At this time the NVCA relies on the manufacturer’s evaluation.

The NVCA notes that there may be a requirement for OGS units to be placed in situations where a multi-component approach is not feasible; pre-consultation with the NVCA and the municipality should be undertaken prior to the stand-alone use of this treatment option.

It is not recommended to rely on oil/grit separators for quality control for plans of subdivision because of the limited storage capacity and high maintenance requirements of these systems.

NOTE: *The NVCA will be updating this section on oil/grit separators in the near future based on work currently being undertaken by the TRCA; please contact NVCA engineering staff prior to the use of these devices to clarify if there are any changes to this section pending.*

7.2 Low Impact Development

The NVCA supports the use of low-impact development (LID) using best management practices as part of a treatment train approach to achieve both quantity and enhanced water quality control. LID techniques may include but are not limited to:

- green roofs
- bioretention swales
- soak-away pits
- filter strips
- permeable pavement
- grass channel
- dry swales

Design of LID stormwater management facilities should be based on requirements from the Ministry of the Environment's *"Stormwater Management Planning and Design Manual* and the design guidelines as set out in the CVC/TRCA's *"Low Impact Development Stormwater Management Manual"* dated 2010. A copy of this document is available on the Credit Valley Conservation Authority's website.

The use of any of the above LID methods should be discussed with NVCA staff and the municipality prior to any planning submission to determine any site-specific design requirements that may differ from previously mentioned guideline documents.

7.3 Infiltration

The NVCA promotes the use of infiltration systems to support the natural hydrologic cycle for stormwater runoff from the site. This helps maintain groundwater recharge, provides additional water quality treatment and reduces the volume of runoff from the site that may cause erosion downstream.

Infiltration-based controls include:

- Reduced grading to allow greater ponding of stormwater and natural infiltration;
- Directing roof leaders to rear yard ponding areas, soak-away pits or to cisterns or rain barrels;
- Sump pumping foundation drains to rear yard ponding areas;

- Infiltration trenches;
- Grassed swales;
- Pervious pipe systems;
- Vegetated filter strips; and
- Stream and valley corridor buffer strips.

Concentrated infiltration of stormwater collected from larger areas will not match the characteristics of distributed infiltration that occurred under pre-development conditions. The natural hydrologic cycle can be maintained to the greatest extent possible by implementing lot level, conveyance and end-of-pipe controls help to optimize the volume of runoff that can be infiltrated.

7.3.1 Infiltration Criteria

Infiltration technologies can achieve water quality enhancement; however, stormwater containing high concentrations of suspended solids tends to clog these controls. Further, infiltration of contaminated water can impair groundwater quality. Therefore, these measures are ideally suited to the infiltration of relatively clean stormwater such as stormwater from rooftops, which contains only atmospheric contaminants or foundation drainage.

If the quality of the stormwater is such that there may be a problem with clogging in the system or degradation of groundwater quality, pre-treatment is required. Infiltration controls are not appropriate for applications with the potential for highly contaminated stormwater (e.g., industrial land uses).

Infiltration systems that operate at the surface such as vegetated filter strips, surface infiltration trenches, wet swales and enhanced grass swales are primarily effective for stormwater quality treatment and should not be designed to provide quantity control due to winter frozen ground conditions.

Infiltration systems that operate below the frost level such as pervious pipe systems, subsurface infiltration trenches and pervious catch basins are effective for stormwater quality and quantity control. These systems continue to operate all year round.

Design of infiltration systems should be based on the criteria outlined in the MOE SWMPDM and the CVC/TRCA's *"Low Impact Development Stormwater Management Manual"* as noted in Section 7.2 of this document. The rate of infiltration used in the design of these systems should be based on the parameter determined through the guidance provided in Section 7.3.2. Areas where the infiltration rate is determined to be lower than 15 mm/hour may still be able to function if a strong groundwater gradient is present.

Infiltration practices should be designed to fully drain the 25 mm 4-hour storm runoff volume within 48 hours.

The understanding and design of infiltration LIDs is a rapidly advancing area of stormwater management. The NVCA welcomes new ideas and new understandings of the science of LIDs that designers and bring to projects in the NVCA. Pre-consultation is always recommended.

7.3.2 Infiltration Rate

The infiltration rate of a soil must be measured/determined on site.

Infiltration methods that are proposed to be included in the design of the stormwater management treatment train as best management practices (BMP) for the development will require a geotechnical report that includes the following:

- Testing using a Guelph permeameter or a double ring infiltrometer test, as these tests calculate a saturated hydraulic conductivity in the vertical direction only. If borehole permeameter and percolation tests are used then the calculation for how these have been adjusted for vertical flow will be required.
- Testing should be completed at the base of the proposed infiltration measure and within 1.5 metres below the base for every soil horizon encountered.
- Testing should occur within the same period as the seasonably high groundwater measurements. Testing should not occur during a precipitation event, within 24 hours of a significant rainfall event (>15 mm depth) or when temperatures are below freezing.

Hydraulic conductivity and percolation time must be converted to infiltration rate for the purposes of designing infiltration measures. The conversion is provided in Table 7.1.

Table 7.1: Approximate relationships between hydraulic conductivity, percolation time and infiltration rate

Hydraulic Conductivity, K_{fs} (cm/second)	**Percolation Time, T (minutes/cm)**	**Infiltration Rate, 1/T (mm/hour)**
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Ref: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario.

7.3.2.1 Infiltration Systems Factor of Safety

As noted in the MOE SWMPDM, a correction factor is required for facilities designed to operate in winter conditions. In addition to winter conditions, a safety correction to infiltration rates should also consider: potential reductions in soil permeability due to compaction or smearing during construction, gradual accumulation of fine sediments over the life-span of the LID and uncertainty in measured values when less permeable soil horizons exist within 1.5 metres below the proposed bottom elevation of the BMP. The safety factor that should be applied is selected from Table 7.2 below.

Table 7.2: Safety factor for calculating design infiltration rates

Ratio of Mean Measured Infiltration Rates[1]	Safety Correction Factor[2]
≤1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

Ref: Wisconsin Department of Natural Resources. 2004. Conservation Practice Standards. Site Evaluation for Stormwater Infiltration (1002). Madison, WI.

Notes:

1. Ratio is determined by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the geometric mean measured infiltration rate of the least permeable soil horizon within 1.5 metres below the proposed bottom elevation of the BMP.
2. The design infiltration rate is calculated by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the safety correction factor.

7.4 Requirements for Rooftop and Parking Lot Storage

The NVCA does not recommend the use of rooftop and parking lot storage for stormwater management because of the potential for flood damage and because the continual functioning of such devices cannot be guaranteed.

Typically, design ponding values do not accurately represent anticipated ponding depths or flooding frequencies, as the design does not consider impacts of partially blocked grates and outlets or localized rainfall patterns such as short duration, intense rainfall bursts typical of summer thunderstorms. Since vehicles may be flooded, with water entering the passenger compartment at depths of less than 0.3 metres, the use of parking lot storage represents a significant liability risk. Similarly, the retention of stormwater on rooftops increases the potential for property damage. Many member municipalities have specific policies relating to rooftop storage that could further limit or prohibit its use.

Where other options for stormwater management practices exist, it is the preference of the NVCA that alternatives to parking lot and rooftop storage be used. NVCA staff will not approve developments incorporating parking lot or rooftop storage without consultation and acceptance from the municipality. Should parking lot and rooftop storage at the subject site be supported, we will require that the following conditions be met:

- The developer must provide written acknowledgement that he/she is aware of the potential liabilities associated with parking lot and rooftop controls and that he/she will not hold the NVCA liable for any damages related to the installation, operation, modification or removal of proposed parking lot or rooftop controls.

- Parking lot and rooftop storage devices should be registered on title to be binding on subsequent site owners as part of the Site Plan Agreement to ensure they cannot be removed or altered during future site alterations without the provision of adequate alternative storage, as approved by the municipality and Conservation Authority. The following clauses should be included in the site plan agreement:
    - The site owner is responsible for all liability related to the proposed parking lot and rooftop controls, including all damages resulting from the designed operating conditions and any downstream damages resulting from removal, modification or lack of maintenance to on-site controls;
    - On-site controls are to be maintained in accordance with the Maintenance Manual.
- The site owner must obtain written approval from both the NVCA and Municipality prior to permitting any removal or modification to approved parking lot or roof top controls.

7.4.1 Specific Design Requirements for Parking Lot Storage

- Parking lot storage must be controlled by pipe size reductions within the storm sewer network and not through the use of orifice plate restrictors to a minimum size of 75 mm.
- Surface ponding is only allowable during storm events greater than the 1:5-year design storm.
- The maximum allowable ponding depth within the parking lot is to be limited to 0.3 metres; however, maximum ponding depths of 0.2 metres are preferred.
- The 100-year ponding elevation and storage volume provided at each ponding location must be shown on the design drawings.
- An emergency overflow system and overland flow route must be provided to allow all runoff exceeding the 100-year storage to be safely routed from the site to a suitable outlet. (ie. municipal R.O.W.) This flow route must be shown on an engineering plan.

7.4.2 Specific Design Requirements for Rooftop Storage

- The type of control to be installed (i.e., product name and manufacturer);
- The number and placement of proposed drains and weirs;
- Product specifications showing design release rates for each structure;
- The total release rate and detained volume for the roof;
- Wherever possible, tamper-proof structures are to be selected;
- An emergency weir overflow should be provided at the maximum design water elevation.

8 Maintenance Requirements

One of the purposes of stormwater management facilities is to prevent sediment from being released to downstream watercourses. This sediment builds up within the facilities and must be removed or the efficiency with which the facility operates will be diminished.

8.1 Sediment Loadings

LSRCA has recently completed a study within their watershed as to the conditions of their stormwater management ponds with respect to maintenance and sediment loads. Of the 77 end-of-pipe enhanced level designed facilities included in their study, only 36 were still operating at an enhanced water quality level as of 2010 (LSRCA, 2011). In total, 56 of the total 98 facilities were operating at a lower efficiency than designed and 12 were providing no permanent pool volume or were operating below 40% TSS removal rate (LSRCA, 2011). It also seems that there is not a trend with respect to the effective life of a facility based on age and the removal efficiencies.

As such, the cost analysis for maintenance of the stormwater management facilities required by municipalities may need to be modified to reflect the higher level of maintenance required.

Table 8.1: Pond age compared with dropped levels of efficiency

	Dropped 1 Level	Dropped 2 Level	Dropped 3 Level	Filled / No Quality
# of ponds	22	13	1	7
Youngest pond (years)	6	6		10
Oldest pond (years)	15	20		20
Median age	9.5	10	15	14
Outliers/incomplete design information	5	3		5

8.2 Operation and Maintenance Documentation

As described in the previous section, it is very important that stormwater management facilities be maintained regularly, otherwise they will not function optimally or may even cease to function. To assist municipalities with future maintenance of these facilities, a stand-alone operation and maintenance (O & M) document will be required to accompany the design of the stormwater management facility prior to final approval by the NVCA.

The MOE SWMPDM provides guidelines on operation, maintenance and monitoring of stormwater management facilities. Stormwater management cleanouts should be completed during a time period where no rainfall is predicted in the timeframe for which the cleanout needs to be undertaken.

In addition to these requirements, NVCA will request that a section of the O & M be included to discuss how future sediment clean-outs will be undertaken. This should identify the location for where cleanouts of the forebay and main cell will be completed from, how the pond will be drawn down, the type of equipment to be used, the location of the sediment drying area if one has been provided and any special operation considerations that must be utilized such as by-pass piping or valves. These procedures must be reviewed by a geotechnical engineer along with the final design of the pond to identify if the maintenance works will impact the overall function and stability of the stormwater management facility.

With an oil/grit separator, it is recommended that a separate maintenance manual be provided and approved by the municipality, to highlight standard operating conditions and maintenance schedule and guide the site owner through recommended maintenance requirements for all aspects of the stormwater management system.

9 Stormwater Management Facility Modelling Requirements

9.1 NVCA Approved Software

Modeling should be completed using the most current version of the computer software.

Table 9.1: Computer model recommendations

Application	Recommended Software
Hydrology (Single Event) ▪ Event based hydrologic modelling to establish flow rates and design of peak reduction and attenuation facilities	Visual Otthymo SWMHYMO PCSWMM MIDUSS QUALHYMO
Hydrology (Continuous Simulation) ▪ Continuous hydrologic modelling to calibrate flow rates and utilize long term hydrometric and meteorological data ▪ Evaluation of erosion potential	PCSWMM QUALHYMO
Hydraulics ▪ Hydraulic modeling of watercourses to evaluate flood limits and design of hydraulic structures	HEC-RAS
Water Balance ▪ Continuous hydrologic simulation utilizing long term hydrometric and meteorological data	PCSWMM QUALHYMO

9.2 Sub-Catchment Delineation – Internal & External Drainage Areas

Drainage boundaries should be determined based on field reconnaissance supplemented by site-specific survey, topographic maps and aerial photo interpretation.

Sources must be provided for all topographic information used in the analysis. If multiple topographic mapping sources are used then the datum of the sources must be modified to be congruent. If a datum adjustment is completed, the methodology and the points used must be included in the submission.

Reference information should include: map title, author, publisher, scale, publishing date and flown date or surveyor name and survey date. Watershed points of interest must be included in the discretization scheme.

9.3 Storage Volume

The calculation of the storage volume required for a stormwater management pond is based on the values and the type of pond provided in Table 3.2 of the MOE SWMPDM. This table provides storage volumes for all of the protection levels and type of stormwater management ponds for 35%, 55%, 70% and 85% imperviousness.

The MOE SWMPDM states that for percent impervious values below 35%, the required volumes should be determined through extrapolation, and for impervious values that fall between the values provided in Table 3.2 the values can be obtained through interpolation.

The NVCA recommends that the following equations be used to determine the storage volume required for enhanced water quality treatment for percent impervious values above and below 55%.

For percent impervious values above 55%, the following equation should be used with coefficient values taken from Table 9.2 for the specific type of pond.

$$y=(a*b+c*x^d)/(b+x^d)$$

Table 9.2: Equation coefficients for percent imperviousness greater than 55%

	A	**B**	**C**	**D**
Infiltration	17.80922	5103.677	301.4291	1.365602
Wetlands	22.17357	363.4705	1025.393	0.869978
Hybrid wet pond/wetland	-4.36139	86.6503	470.3615	0.931958
Wet pond	-38.0839	58.24687	978.8003	0.706798

For percent impervious values below 55%, the following equation should be used with coefficient values taken from Table 9.3 for the specific type of pond.

$$y=mx+b$$

Table 9.3: Equation coefficients for percent imperviousness less than 55%

	A	B
Infiltration	16.25	0.25
Wetlands	36.25	1.25
Hybrid Wet Pond/Wetland	40	2
Wet Pond	52.5	2.5

9.4 Modified Rational Method

The NVCA allows the use of the modified rational method for catchments that are less than 5 hectares as long as the following parameters are met:

- That there is no routing of catchments through other catchments to the outlet (e.g. rooftop to parking lot);
- The site doesn't include more than one catchment; and,
- That the standard method approved by the NVCA (included below) is met, or that sufficient information is provided about the method used to determine that it is better suited to calculating the volume required.

The NVCA guideline equation for the modified rational method is taken from "ASCE Manuals and Reports on Engineering Practice No. 28, Hydrology Handbook," Second Edition, Copyright 1996, ISBN 0-7844-0138-1, pp. 580-581, and is based upon using trapezoidal hydrographs.

$$V_p = Q_p \cdot D - Q_o\left[\frac{D + t_c}{2}\right]$$

Where:
V_p is the pond volume
Q_p is the runoff peak for that duration
Q_o is the maximum allowable discharge from the area.
D is the duration of rainfall

9.5 Precipitation

Both the 4-hour Chicago and the 24-hour SCS Type II design storm distributions should be modelled to demonstrate peak flow control and calculate required storage volumes. Rainfall amounts should be based on the IDF curves for the precipitation station outlined in the municipality's stormwater management standards, or in the case where there is not a municipal standard the NVCA recommends that the most geographically similar IDF station is used.

The rainfall time step should be equal to 1/5 of the smallest basin time to peak.

9.6 Hydrograph Computation

NVCA standard values/approaches should be used in the calculation of curve numbers, runoff coefficients (rational C), initial abstraction, time of concentration, overland flow lengths, Manning roughness coefficients and orifice coefficients. These values are available in Section 10: Hydrologic Parameters. Consultants can use values outside of the range of NVCA values with proper justification and reference.

Area weighted calculation based on land use and soil type are required for curve numbers, initial abstraction and runoff coefficients.

As the regional storm for the NVCA jurisdiction is the Timmins Storm (1961), all CN values are to be provided as CN (II) conditions for all storm events.

CALIB*HYD routines must be used for all modeling completed using HYMO based models as some of the standard values applied in the DESIGN*HYD analysis do not meet NVCA standards.

9.7 Imperviousness

An accurate estimate of the percentage of imperviousness is very important, as the model is sensitive to this parameter. The parameter will affect the proposed stormwater management volumes and consequently the land requirements and the size of the stormwater management block. OTTHYMO uses two parameters for imperviousness: the Total Imperviousness Percentage (TIMP) and the Directly Connected Imperviousness Percentage (XIMP). TIMP is the ratio of the impervious area to the total area. XIMP is the ratio of the impervious area that is directly connected to the conveyance system to the total area.

9.8 Channel Routing

Sufficient channel routing should be incorporated into the hydrologic model. Rating curves and travel times used in channel routing shall be determined by preliminary hydraulic calculations of the backwater profile or by procedures available in the approved hydrologic model.

Hydrographs should be combined before being routed through watercourse reaches. Cross-sections required for the hydrologic model routing procedure must be obtained from the most recent digital elevation models or preferably from field surveys. Please refer to Section 3.1 of the NVCA Natural Hazards Technical Guide for the procedure for correction of aerial topography information to survey.

Cross-sections shall be extended sufficiently to ensure that flows do not exceed the range of the travel timetable.

The routing computation time step must be relative to the shortest channel section and at a maximum equal to the hydrograph time step. Selected Manning's roughness parameters must be in accordance with the values/approaches set out in Section 10 Hydrologic Parameters.

9.9 Reservoir Routing

9.9.1 Orifice

When calculating orifice discharge, the orifice equation is only to be applied for water levels above the centroid of the orifice. Flows for water levels below the orifice centroid should be calculated using the weir equation.

Q_w = 1.65([(pi*(D^2)/4)(2*$\cos^{-1}$[(((D/2)-d)/(D/2))*(180/pi)]/360)-((D/2-d)(Dd-d^2)$^{0.5}$)]/d)$d^{1.5}$

Where:
Q_w is weir flow (m^3/s)
D is orifice diameter (m)
d is depth of flow above the invert (m)

Where routing is applied, the technical report should discuss the method of routing used and assumptions made in determining routed flows.

The discharge coefficients of 0.63 and 0.8 are recommended for orifice plates and orifice tubes, respectively.

9.9.2 Rectangular Broad Crested Weir

Rectangular broad crested weirs used in the determination of the stage-storage-discharge relationship of a stormwater management pond should use the following equation:

$$Q = CLH^{3/2}$$

Where:
Q is Discharge (m^3/s)
C is the discharge coefficient
L is the weir length (m)
H is the head (m)

The discharge coefficient for a rectangular broad crested weir can be determined using the following equation:

$$C = (-1.04E+04 + 3.42E+06x)/(1+2.13E+06x-2.35E+05x^2)$$

Where:
X is equal to head divided by the downstream length of the weir (H/L)

This equation is valid until H/L is equal to 0.6, then the discharge coefficient is equal to 1.705.

This equation was derived from applying a line of best fit to the following chart taken from "Hydraulic Structures," C.D.Smith, University of Saskatchewan, Copyright 1995, ISBN 0-199-029288, pp.11-12 to 11-15.

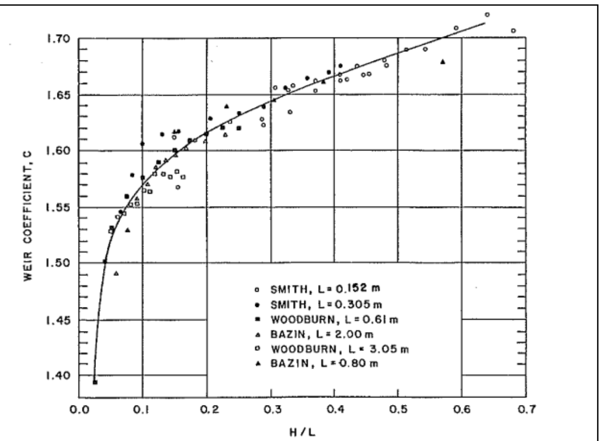

Figure 11. Weir Coefficient for Rectangular Broad Crested Weir

9.9.3 Trapezoidal Broad Crested Weir (Emergency Spillways)

Emergency spillways from stormwater management ponds that have side slopes should be modelled as trapezoidal broad crested weirs whose discharge is determined by the combined discharge of representative triangular and rectangular broad crested weirs. The equation and coefficient for the rectangular broad crested weir is provided in the previous section. The equation for a triangular broad crested weir is:

$$Q = CH^{5/2}\mathrm{Tan}(\theta/2)$$

Where:
Q is discharge (m^3/s)
C is the discharge coefficient
H is the head (m)
θ is the included angle at the apex of the triangle (Radians)

The discharge coefficient for a triangular broad crested weir can be determined using the following equation:

$$C = (-1.01E-05 + 1.44E+02x)/(1+1.15E+02x-4.77x^2)$$

Where:
X is equal to head divided by the downstream length of the weir (H/L)

This equation is valid until H/L is equal to 0.6, then the discharge coefficient is equal to 1.268.

This equation was derived by applying a line of best fit to the following chart taken from "Hydraulic Structures," C.D.Smith, University of Saskatchewan, Copyright 1995, ISBN 0-199-029288, pp.11-15 to 11-18.

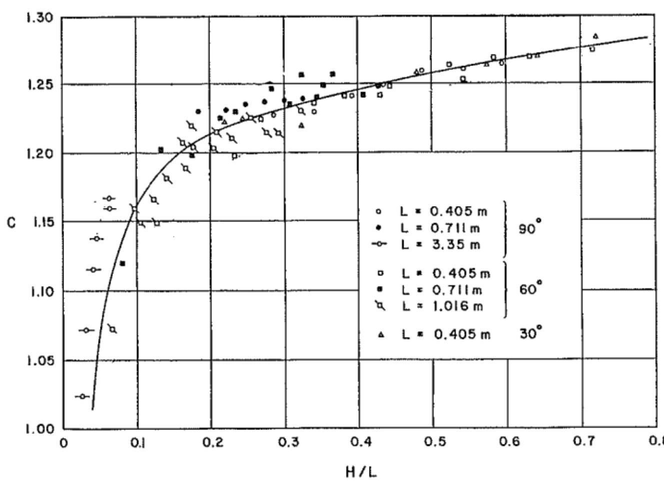

Figure 13. C vs H/L for a Triangular Broad Crested Weir

10 Hydrologic Parameters

10.1 SCS Curve Numbers

Table 10.1: SCS curve numbers

	Hydrologic Soil Group						
Cover	**A**	**AB**	**B**	**BC**	**C**	**CD**	**D**
Wetlands/lakes /SWMFs	50	50	50	50	50	50	50
Woods	32	46	60	67	73	76	79
Meadows	38	51	65	71	76	79	81
Pasture/lawn	49	59	69	74	79	82	84
Cultivated	62	68	74	78	82	84	86
Impervious areas	100	100	100	100	100	100	100

Ref: Adapted from Design Chart 1.09, Ontario Ministry of Transportation, "MTO Drainage Management Manual," MTO. (1997)

Notes:

- Table 10.1 represents AMCII conditions and is not applicable to frozen soils or to the period where snowmelt contributes to runoff.
- CN values should be used as given above. The NVCA does not support the use of CN* based on the Paul Wisner Method.

10.2 Initial Abstraction/Depression Storage

Table 10.2: Initial abstraction/depression storage

Cover	Depth (mm)
Woods	10
Pasture/Meadow	8
Cultivated	7
Lawns	5
Wetland	12/16
Impervious areas	2

Ref: UNESCO, Manual on Drainage in Urbanized Areas, 1987.

Notes:

- The representative area method should be used to calculate the IA value for catchment areas.

10.3 Horton Method Parameters

Table 10.3: Horton method parameters

Soil Group	Minimum Infiltration Rate (mm/hr)	Maximum Infiltration Rate (mm/hr)
A	25	250
B	13	200
C	5	125
D	3	75

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

The infiltration rate is an exponential decay equation. The decay parameter indicates how fast the maximum infiltration rate will decay to the minimum infiltration rate. ILLUDAS uses a value of 2 hours while the SWMM 5 Manual suggests typical values range between 2 and 7 hours. A larger value indicates a greater soil storage capacity.

10.4 Green and Ampt Method Parameters

Table 10.4: Green and Ampt method parameters

Soil texture class	Porosity ϕ	Wetting front soil suction head S_f, cm	Saturated hydraulic conductivity* K_s, cm/h
Sand	0.437 (0.374-0.500)	4.95 (0.97-25.36)	23.56
Loamy sand	0.437 (0.363-0.506)	6.13 (1.35-27.94)	5.98
Sandy loam	0.453 (0.351-0.555)	11.01 (2.67-45.47)	2.18
Loam	0.463 (0.375-0.551)	8.89 (1.33-59.38)	1.32
Silt loam	0.501 (0.420-0.582)	16.68 (2.92-95.39)	0.68
Sandy clay loam	0.398 (0.332-0.464)	21.85 (4.42-108.0)	0.30
Clay loam	0.464 (0.409-0.519)	20.88 (4.79-91.10)	0.20
Silty clay loam	0.471 (0.418-0.524)	27.30 (5.67-131.50)	0.20
Sandy clay	0.430 (0.370-0.490)	23.90 (4.08-140.2)	0.12
Silty clay	0.479 (0.425-0.533)	29.22 (6.13-139.4)	0.10
Clay	0.475 (0.427-0.523)	31.63 (6.39-156.5)	0.06

*K_s can be modified to obtain the Green-Ampt K. For bare ground conditions K can be taken as $k_s/2$.

Ref: Rawls, W.J., Gish, T.J., Brakensiek, D.L. and D.L. Shirmohammadi, A. (1993) from ASCE Hydrology Handbook, page 108.

10.5 Runoff Coefficients

Table 10.5: Runoff coefficient (Rational C) for urban catchments

Land Use		Runoff Coefficient Min	Max
Pavement	asphalt or concrete brick	0.8 0.7	0.95 0.85
Gravel roads and shoulders		0.4	0.6
Roofs		0.7	0.95
Business*	downtown neighbourhood light heavy	0.7 0.5 0.5 0.6	0.95 0.7 0.8 0.9
Residential*	single family urban multiple, detached multiple, attached suburban	0.3 0.4 0.6 0.25	0.5 0.6 0.75 0.4
Industrial*	light heavy	0.5 0.6	0.8 0.9
Apartments*		0.5	0.7
Parks, cemeteries*		0.1	0.25
Playgrounds (unpaved)*		0.2	0.35
Railroad yards*		0.2	0.35
Unimproved areas*		0.1	0.3
Lawns	sandy soil		
	flat, to 2% average, 2 to 7% steep, over 7%	0.05 0.1 0.15	0.1 0.15 0.2
	clayey soil		
	flat, to 2% average, 2 to 7% steep, over 7%	0.13 0.18 0.25	0.17 0.22 0.35

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

Notes:

- *Only to be used during preliminary design calculations.
- As per MTO Manual, increase coefficients for the 1:25-year storm by 1.1, the 1:50-year design storm by 1.2 and the 1:100-year design storm by 1.25 (to a maximum value of 1.0).
- Proposed gravel parking and storage areas must be modeled as asphalt.
- Minimum values should be used for catchments with slopes less than 2% and maximum values used for catchments with slopes greater than 7%. For all catchments with slopes between 2 and 7% a weighted average should be used to determine the appropriate value.

Table 10.6: Runoff coefficient (Rational C) for rural catchments

Land Use & Topography	Soil Texture		
	Open Sand Loam (A-AB)	**Loam or Silt Loam (B-BC)**	**Clay Loam or Clay (C-CD-D)**
Cultivated			
Flat 0- 5% Slopes Rolling 5 - 10% Slopes Hilly 10 - 30% Slopes	0.22 0.3 0.4	0.35 0.45 0.65	0.55 0.6 0.7
Pasture/Meadows			
Flat 0- 5% Slopes Rolling 5 - 10% Slopes Hilly 10 - 30% Slopes	0.1 0.15 0.22	0.28 0.35 0.4	0.4 0.45 0.55
Woodland or Cutover			
Flat 0- 5% Slopes Rolling 5 - 10% Slopes Hilly 10 - 30% Slopes	0.08 0.12 0.18	0.25 0.3 0.35	0.35 0.42 0.52
Bare Rock	Coverage		
	30%	50%	70%
Flat 0- 5% Slopes Rolling 5 - 10% Slopes Hilly 10 - 30% Slopes	0.4 0.5 0.55	0.55 0.65 0.7	0.75 0.8 0.85
Lakes and Wetlands	0.05		

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

10.6 Time of Concentration

Hydrograph time of concentration should be calculated as per the MTO manual and should be based on the Airport Method for catchments with a runoff coefficient less than 0.40 or the Bransby-Williams Equation for catchments with a runoff coefficient greater than 0.40 (based on the weighted catchment C).

The Upland method may be more appropriate for certain topography and the NVCA will allow for the use of this method in place of the MTO specified method; however, the use of the Upland method will require justification to be provided by the consultant as to its usage. Please note that sketches identifying Upland travel paths and land use must be included with the submission if this method is used.

Time to peak should be calculated as $t_p = 0.67\ t_{c,}$ where t_c is time of concentration.

The number of linear reservoirs for the NASHYD command shall equal 3 unless calibration results indicate otherwise.

The hydrograph computation time step [D(T)] should be equal to 1/5 of the basin time to peak, i.e., D(T) = 0.2 x Tp and equal to the rainfall time step. The NVCA recognizes the limits of the Visual OTTHYMO model and allows for minimum values of one minute time steps to be used for the Chicago storm events and two minute time steps to be used for the SCS storm events.

Airport Equation To be used if "C" value is less than or equal to 0.4

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

Where: t_c = time of concentration, minutes
C = runoff coefficient
L = watershed length, m
S_w = watershed slope, %

Bransby-Williams Formula To be used if "C" value is greater than 0.4

$$t_c = 0.057 * L * S_w^{-0.2} * A^{-0.1}$$

where: t_c = time of concentration, minutes
L = watershed length, m
S_w = watershed slope, %
A = watershed area, ha

Ref: MTO, Drainage Management Manual, page 28, Chapter 8, 1997

Uplands Method

Table 10.7: $V/(S^{0.5})$ relationship for various land covers

Land Cover	$V/(S^{0.5})$
Forest with heavy ground litter, hay meadow	0.6
Trash fallow or minimum tillage cultivation	1.5
Short grass pasture	2.3
Cultivated, straight row	2.7
Nearly bare soil, untilled	3
Grassed waterway (ditch)	4.6
Paved areas; small upland gullies	6.1

$$\text{Travel Time} = \text{Travel Length} / [\text{Slope}^{0.5} * V/(S^{0.5})]$$

Where:
S = slope, m/m
t_c = sum of travel times for each land use

Ref: Figure 3.11: Velocities for Upland Method for Estimating Travel Time for Overland Flow, American Iron and Steel Institute, "Modern Sewer Design: Canadian Edition," Corrugated Steel Pipe Institute. (1996)

Notes:

- Travel times must be calculated individually for each land use and must be calculated along the longest continuous travel path

10.7 Overland Flow Lengths for STANDHYD

Pervious Areas

A typical value for urban pervious areas is 40 m, the depth of a residential lot.

Impervious Areas

The overland flow length for un-calibrated watersheds can be calculated using the following equation:

$$LGI = (A / 1.5)^{0.5}$$

Where: A = subcatchment area, m^2
LGI = overland flow length, m

10.8 Subcatchment Width

$$\text{Subcatchment Width} = (2 S_k) * L$$

L = length of main drainage channel, m
S_k = skew factor = (A_2 - A_1) / A_t
A_2 = largest area to one side of the channel, ha
A_1 = area to the other side of the channel, ha
A_t = total basin area, ha

Ref: US EPA, SWMM Version 4, Users Manual, August 1988

11 Development Submission Requirements

Technical reports are to be prepared such that the entire work can be recreated by any qualified person without the need to refer to any additional material. As such, if the submission refers to previously completed and approved reports, the referenced sections of those reports must be included in the appendix of the submission. Further, any qualified person must be able to recognize and understand all of the methods, approaches, basic data and rationale used in the calculations.

With the exception of copywritten or proprietary models, equations should be given for all provided calculations. Calculations are to be provided in paper and digital form. All formulas and values used by the program must be clearly identified on the paper copy. This is requested so that the reports will be reproducible in the future if our guidelines were to be modified.

The NVCA must receive a complete set of drawings outlining all of the proposed works. Engineering plans and drawings must be signed and sealed by a Professional Engineer licensed by the Professional Engineers of Ontario.

11.1 Preliminary Design

Preliminary Design is required for subdivisions to determine the general layout of the subdivision and that the blocks set aside for stormwater management are appropriately sized; therefore, there are specific requirements that need to be addressed at the draft plan stage of the development process.

All of the natural hazards (flood, erosion, hazardous soils) need to be addressed and the lot fabric designated so that none of the proposed lots fall within the natural hazard areas. As well, the stormwater management pond must be located above the regulatory floodplain elevation, unless pre-consultation was undertaken to allow for the pond to be located in the regional floodplain but above the 100-year flood elevation and outside of any erosion hazards.

If the property is located in an area of a spill zone, the submission must demonstrate that the spill can safely be conveyed through the site without impacting any of the proposed private lots proposed in the subdivision. It must also be demonstrated that the development as proposed will not have a negative impact on any adjacent properties.

Major submission information for stormwater management sizing that needs to be included during preliminary design are:

- Modeling of pre- and post-development scenarios of a general pond design to confirm that the stormwater management block(s) size is adequate;
- A look at preliminary grades for the stormwater management design; this should consider groundwater conditions, elevations at the proposed outlet(s), flooding elevations in the area and grades of overland flow routes;
- Confirmation that the outlet from the development is suitable; if the outlet is across private land then the NVCA will require written confirmation from the affected land owner.

A geotechnical engineer should review the conceptual design and provide a preliminary geotechnical report that assures that the conceptual design is feasible from a geotechnical perspective.

11.2 Detailed Design

Detailed design submissions should deal with the finer details of the preliminary design submission, such as:

- An operation and maintenance manual for the stormwater management facility;

- Erosion and sediment control plans for the construction of the subdivision;
- Modeling of pre- and post-development scenarios of a detailed pond design including the final pond side slopes and outlet configuration to confirm that the stormwater management block(s) size is adequate;
- Modelling inputs based on actual lot densities proposed for the subdivision;
- Detailed grading plans showing the overland flow routes to the outlet;
- A written statement from a geotechnical engineer confirming that the detailed design of the stormwater management facility and the procedures outlined in the operation and maintenance manual meet current geotechnical standards and are suitable from a geotechnical perspective.

11.3 Site Plans

Site plans are generally required of commercial sites and single site developments that require stormwater management, such as high density residential. The process by which site plans are reviewed is a combination of the preliminary and detailed design submission associated with subdivision developments; therefore, all of the details listed in Sections 11.1 and 11.2 are required. There are some specific requirements that typically only apply to site plans for rooftop and parking lot storage. The use of these methods within developments undergoing the preliminary and detailed design submissions must be identified and approved through pre-consultation with the NVCA.