SECTION C - STORM DRAINAGE AND STORMWATER MANAGEMENT

C1.00 STORM DRAINAGE POLICIES

The Town of Bradford West Gwillimbury has prepared a detailed set of design criteria and applicable parameters for the design of minor and major storm drainage facilities. These policies are to be adhered to in the production of all storm water control facilities.

C1.01 Planning, Policies and Design Criteria

The most current version of the following Ministry of the Environment (MOE), Lake Simcoe Region Conservation Authority (LSRCA) and Nottawasaga Valley Conservation Authority (NVCA) guidelines, policies and standards, apply to the design of storm drainage facilities in the Town of Bradford West Gwillimbury.

- Ministry of the Environment (i.e. Stormwater Management Planning and Design Manual, March 2003)
- Lake Simcoe Region Conservation Authority Watershed Development Policies
- NVCA Stormwater Technical Guide (December 2013)
- Technical Design Guidelines, Standards and Policies for Siltation and Erosion Control, Nottawasaga Valley Conservation Authority
- **or the most up-to-date version of the above, or any new documents issued by these agencies.**

Development proponents are also required to confirm design criteria and obtain approvals from any other relevant ministries or agencies (i.e. Ministry of Transportation, Ministry of Natural Resources, Department of Fisheries and Oceans, etc.). The most current version of Ontario Provincial Standard Drawings (OPSD) shall also apply to design and construction of storm drainage facilities as determined by the Town.

The planning and design of stormwater management (SWM) facilities shall be discussed with the Town and the appropriate Conservation Authority early in the planning process and shall focus on minimizing the number of pond facilities. Master servicing plans for the various Community Planning Areas layout the general location of all planned stormwater facilities. Water quality and quantity control in new development areas are to be provided in Town-owned municipal blocks. Proponents in these areas may consider providing on-site control (meeting Building Code requirements) however, credit for these facilities toward reducing municipal downstream municipal SWM facilities may be considered on a case by case basis.

Individual on-site SWM facilities are discouraged. In the case of infilling proposals, on-site SWM concepts may be considered by the Town in conjunction with any potential off-site storm drainage improvements.

The planning and design of each pond shall also focus on opportunities to integrate the pond with the surrounding topography and land uses. Ponds are to be created as public amenity features and are to be safe, significantly visible and accessible to

the general public. Opportunities for linkages through the use of trails to larger open space, floodplain areas or other SWM facilities are to be maximized.

The planning and design of SWM works is to have full regard for *riparian rights* of both upstream and downstream landowners. Any change in flow rates, or water levels that would occur as a result of the development, SWM drainage areas and/or in-stream works to neighboring private properties must be adequately addressed. Written permission from affected landowners must be sought in cases where acknowledged impacts are proposed and any governing legislation, in this regard, must be adhered to.

C1.02 Levels of Service

The level of service to be provided by the storm drainage infrastructure is listed in the following table, unless stipulated otherwise. The planning of access routes for emergency services (i.e. police, fire, and ambulance) may result in higher levels of service as determined by the Town.

Table 6: Levels of Service for Major and Minor Systems

Item	Level of Service	Comments
Storm Sewers	1:10 year storm	• use catchbasin inlet controls (as required), sized and located such that storm sewers do not surcharge
Hydraulic Grade Line	1:100 year storm	• no closer than 0.5m between 1:100 year storm hydraulic grade line and finished basement floor elevations
Major System	1:100 year storm	• large drainage areas may require classification as a floodplain using Regulatory storm criteria (LSRCA and NVCA) • overland flow cannot exceed width or flow capacity of right-of-way
Culverts	per MTO Directive B-100	• see Table 7 (following page)
Stormwater Management	1:100 year storm	• maximum level of control

Table 7: Level of Service for Bridges and Culverts (per MTO Directive B-100)

Road Classification	Up to 6m Span	Over 6m span
Urban Arterial Road	1:50 year	1:100 year
Rural Arterial Road Urban Collector Road	1:25 year	1:100 year
Local Road	1:10 year	1:25 year
Driveways	1:5 year	1:10 year

C2.00 STORMWATER MANAGEMENT

Stormwater ponds are required to meet provincial Stormwater Management (SWM) prerequisites as set out by MNR, MOE, the LSRCA and the NVCA. SWM pond locations, functions and design criteria shall be confirmed through consultation with the relevant Conservation Authority and the Town of Bradford West Gwillimbury. Where Stormwater Master Plans have been completed, the design criteria shall follow the approved Master Plan. End-of-pipe facilities are acceptable to the Town when the designs are safe, maintainable, integrated with the surrounding landscape, and aesthetically pleasing.

The Town concedes the overall design requirements to the most recent provincial direction, as is acceptable to the LSRCA and the NVCA. Exceptions to this are in circumstances that involve:

- matters of public safety and aesthetics
- maintenance requirements
- protecting the riparian rights of private landowners
- protection of municipal infrastructure and maintaining an acceptable level of protection to residents whose homes drain into a municipal drainage system
- conflicts with land use.

In these cases, the Town may invoke additional release rate stipulations and design requirements over and above those required by other agencies.

The Town requires integration of stormwater pond grading design with the surrounding landscape. The design is to consist of varied contour grading to ensure public safety, provide improved aesthetics, support of a variety of plantings and vegetation and provide passive recreational activities (i.e. walking trails, bike paths, vistas, etc.). Safety aspects must be given special consideration. This includes identifying the use of gentle slopes in areas where passive recreation takes place, an increasing density of appropriate plantings and vegetation on steeper slopes, handrails/guardrails at headwalls and placing signs which inform of the function and potential hazards of SWM ponds.

C2.01 Hydrology and Hydrologic Modeling

The most current rainfall data from the Toronto-Pearson meteorological station is to be used for design of storm drainage and SWM facilities. The Intensity-Duration-Frequency curves are provided in Appendix J – Design Storms, and the equations to calculate rainfall intensity are provided in Section 3.02.

The estimation of peak design flow rates can be done using the Modified Rational Method or computer model simulation. The Modified Rational Method is typically used to design storm sewers and estimate peak flow rates from small urban areas. Its application should be limited where the time of concentration (T_c) is less than approximately 30 minutes. Designers should consult the Conservation Authority

requirements, where applicable, to assist in determining the most appropriate method to calculate T_c.

In cases where undeveloped lands dictate the time of concentration used in Modified Rational Method design, the urban time of concentration (usually smaller) shall be used and the contributing rural area reduced to a factor of:

$(T_c \text{ urban} / T_c \text{ rural})^{0.5}$

Computer analyses are best suited to large urban areas, rural areas and designing municipal SWM facilities.

The minimum and maximum duration of design storms are 4 hours and 24 hours respectively. Hyetographs of the following design storms selected by the Town (distribution based on the Toronto-Pearson data and a 10 minute discretization) are provided in Appendix J – Design Storms:

- 24 hour SCS
- 4 hour Chicago distribution
- 24 hour Chicago distribution (where requested).

The Town, LSRCA or NVCA may request other design storm lengths and distributions for evaluation during the pre-consultation process.

The following are the A, B, C values for the Chicago Design Storms to be used in the equation:

Intensity = A / (t+B) ^C, as indicated in the following

Return Period	**2 Year**	**5 Year**	**10 Year**	**25 Year**	**50 Year**	**100 Year**
A	789.070	980.848	1118.790	1284.892	1405.794	1443.947
B	6.205	6.013	6.018	6.008	6.012	5.273
C	0.823	0.806	0.800	0.793	0.788	0.776

C2.02 Safety Features

The Town prefers not to unnecessarily require fencing around pond blocks, but instead to allow for casual public access. Accordingly, public safety must be kept paramount in the design of SWM facilities. Table 8 (following page) summarizes pond design criteria.

The Town may elect to require fencing along any residential lot that abuts stormwater facilities. However, fencing around the perimeter of pond blocks will only be considered by the Town when reviewing submissions where there are extenuating circumstances which prevent the above requirements from being met. Specific approval will be required from the Town for consideration of fenced facilities.

Where approval for fencing stormwater ponds is given by the Town, 1.5m high black vinyl-coated fencing, posts and hardware shall be used.

Should gates in fences be requested by private homeowners, the Town requires that a clause, prepared by the Town, be registered on title of the private property absolving the Town of all liability associated with having a gate installed in a fence bordering a Town-owned SWM facility. The Town will not be responsible for legal costs incurred for registering the clause on title of the property or for the cost of the gate installation. The Town may also require construction of the fence on the private property side of the property line.

Table 8: Pond Design Criteria

Permanent Pool	Maximum Slopes	6:1 for 0.5m drop in elevation below normal water level (NWL)
	Maximum Slopes	3:1 from 0.5m below NWL to bottom of pond
	Average Depth	1.0 to 2.0m
	Maximum Depth	2.5m
Extended Detention	Maximum Slopes	6:1 for 0.5m rise in elevation above NWL
	Maximum Slopes	5:1 to top of extended detention
	Maximum Depth	1.0m
Flood Storage	Maximum Slopes	4:1 above the maximum extended detention level up to 2m beyond the high water level (HWL)
	Maximum Depth	2.0m for combined Extended Detention and Flood Storage
Other	Maximum Slopes	3:1 from 2.0m beyond HWL as required
	Design of sediment forebays at each inlet to the pond, meeting MOE design guidelines in order to maximize sedimentation in the forebays.	
	A minimum 3.0m wide platform at a maximum cross-slope of 4% provided around the property boundary of the SWM block for the purposes of grass cutting.	
	A horizontal terrace of 3.0m required for continuous slope changes in elevation greater than 3.0m.	
	Freeboard to top of pond of 0.3m above the HWL (based on routing of Regional Storm flow). (HWL = maximum water level to convey the Regulatory event through pond)	
	Emergency overflow weir (to pass the Regulatory event) with capacity of no less than $0.1m^3/s/ha$.	
	Clay core berms with slope toe drains required if NWL is higher than surrounding grade.	

	Signage (as per BWG Standard Drawing C104) with one sign located on each side of the pond) shall be placed to educate and advise the public of the purpose, characteristics and dangers associated with the facility.
	Bollards or gates to discourage vehicular access to the maintenance road.
	Pond inlet and outlet pipes are to be equipped with grates per the OPSDs.
	Maintenance vehicle access roads suitable to support municipal equipment but also designed to support vegetation growth on the surface of the roadway.
	Berms constructed of suitable material, inspected by a geotechnical engineer and compacted to a minimum 95% Standard Proctor density.

C2.03 Submission Requirements for SWM Design Reports

The following is a list of documentation which should be included within SWM design reports submitted to the Town of Bradford West Gwillimbury for review. These reports are submitted to support the final design of quality and/or quantity control facilities. These reports shall clearly identify how applicable recommendations from Master Servicing, Functional Servicing, Geotechnical, Environmental or Hydrogeological Reports have been incorporated into the final design of the facility.

a) Site Location Plan.

b) Existing and proposed catchment area plan which delineates internal/external drainage areas and labels areas and catchment reference numbers.

c) Engineering plans for stormwater facility which should identify the following:

- permanent, extended detention, highest water levels on plan view and include all ponding levels for various return periods in tabular form,
- section/details of major overland flow routes,
- section/details of maintenance access roads,
- section/details of erosion protection at inlet/outlet structure and on spillways,
- location of facility signage,
- borehole location and existing groundwater elevation,
- existing and proposed grading elevations and transition slopes,
- sediment forebay details including lining and separation berm,
- details of sediment drying area and/or by-pass pipe for cleaning purposes,
- section/details of inlet/outlet structures,
- fencing limits.

d) Landscaping/restoration plans and details.

e) Erosion and sediment control plans and details.

f) Excerpts from Master and Functional Studies which outline requirements for quantity/quality control and any facility design requirements.

g) Identify any deviations from the BWG Standard Drawings including an explanation based on site specific conditions.

h) Pre and post development hydrologic modeling schematic to illustrate all components of each model.

i) Table summarizing pre and post development catchment parameters (i.e. catchment number, area, percent impervious, CN value, etc.).

j) Table summarizing stage, storage and discharge characteristics of the facility.

k) Table summarizing pre and post development peak flows and storage volumes based on output from hydrologic modeling or comparison to volumes and target peak flows identified in Master and Functional Servicing Studies.

l) Table to summarize and compare required permanent pool and extended detention storage requirements to volumes provided in the facility.

m) Table to compare calculated 100-year hydraulic grade line elevations within storm sewer system to estimated underside of basement floor slab elevations.

n) Sample or supporting calculations for the following:

- extended detention drain-down time (hours),
- major system overland flow and velocity to confirm conveyance within R.O.W. and/or defined flow routes,
- 100-year hydraulic grade line to confirm basements will be protected,
- erosion control sizing and flow velocity at inlet/outlet structures and spillways,
- sediment forebay length and width in conformance with MOE manual, and estimate of required cleanout frequency,
- major system inlet grating sizing (assuming 50% blockage).

o) Hard and digital copies of input/output files from hydrologic modeling (digital files may be provided on diskette or via e-mail).

p) Identify erosion and sediment control methods to be implemented before, during, and after municipal servicing construction up to the end of servicing maintenance period, including schedule for implementation/decommissioning and maintenance requirements.

C2.04 Operations and Maintenance Manual

A SWM Facility Operations and Maintenance Manual is to be prepared for the Town by proponents of new SWM facilities. The manual is to describe how each facility operates and the short term and long term inspection and maintenance requirements of the facilities. Any collection system SWM components, such as oil and grit separators, infiltration galleries or infiltration trenches, etc. are to be included in the

manual. The manual is to focus on the expected frequency and method of maintenance that will be required in the following specific areas:

- Facility inspection/monitoring program (outline seasonal and annual tasks based on Master/Functional Studies or Draft Plan Approval Conditions)
- grass cutting
- weed control
- plantings
- trash removal
- sediment testing, removal and disposal.

The SWM facility Operations and Maintenance Manual is also to include cost estimates (including labour, equipment and materials) for the operations and activities described above.

Report Format

The SWM Design Report and the Operations and Maintenance Manual shall be separate documents, bound with front/back covers, the planning file number shall be included on the front covers. ARCH D size plans included within the reports shall be folded and included in the back of the report in appropriate sleeves. Once the reports have been reviewed and accepted by the Town, separate digital copies of the report shall be provided.

Operational & Maintenance Features

The SWM pond designs are to incorporate features that allow the Town to operate and maintain the facility. It is strongly recommended that the Design Engineer arrange a pre-consultation meeting with the Town once a preliminary pond design has been prepared in order to discuss maintenance operations and features, specifically clean-out procedures and sediment management and removal. These features include:

- Provide a primary maintenance access to the facility (minimum 8m in width between adjacent properties) suitable for municipal equipment but supports vegetation growth on the surface of the roadway.
- Maintenance vehicle access roads and turn-around areas at sediment forebays, outlet pools and control structures having a maximum gradient of 10%, minimum width of 4m, a minimum inside turning radius of 10m and including a 10m long loading platform at the forebay and outlet pool locations. Maintenance roads may be required to other locations with the pond block as determined by the Town. Maintenance roads should have maximum crossfall of 2%.
- All maintenance vehicle access roads construction shall be structurally designed to support municipal equipment and allow for vegetation growth on the surface of the roadway.
- Provision of a drain-down pipe leading from the permanent pool to a manhole with de-watering sump, if a gravity outlet is not available.

- In order to facilitate sediment removal operations, either of the following may be proposed and are subject to review and approval of the overall approach to sediment management and removal:
  - provision of a sediment drying space for each forebay, suitable to contain the volume of sediment and water remaining in the forebay (after completing pond drain-down procedures) located adjacent to each sediment forebay and higher than the maximum extended detention water level, OR
  - provision of a pond by-pass sewer (sized based on the minor system design criteria) between the inlet and the outlet in order to divert incoming flows around the pond for the duration of clean-out operations (allows for sediment drying in-situ).
- The sediment drying space noted above is to be designed based on approximately 2.5m^2 per cubic metre of accumulated sediment and a maximum depth of 0.4m. A limited tile or under-drain system in the sediment drying area is required to promote de-watering.
- A minimum 3m wide platform at a maximum cross slope of 4% is to be provided around the property boundary of the stormwater block for the purposes of grass cutting.
- Use of a reverse-sloped control pipe, which reduces thermal impacts (wet pond application).
- Provision of flow control devices in manhole structures located in a berm for easy access, maintenance and cleaning as opposed to a vertical pipe structure located in the pond.
- Minimum orifice size of 75mm diameter. Use of a screened orifice plate or weir plate fixed to a permanent structure to achieve extended detention.
- A gate valve to enable the normal pond outlet to be closed in case of chemical spills.

C2.05 Retaining Walls and Structures

Any retaining wall or structure for stormwater ponds, headwalls, culverts, roadways or grade separations are to consist of pre-engineered, precast large stone or patterned concrete systems, as opposed to rip-rap or gabion baskets, and are to include an engineering drawing or shop drawing stamped by a registered professional engineer for any structure not covered under Ontario Provincial Standard Drawings. Building permits for the construction of retaining walls that fall into the category of designated structures within the scope of the Ontario Building Code are required.

The use of gabion baskets or rip-rap as a means for erosion control is subject to specific review and approval by the Town. All rip-rap, gabion structures or retaining wall systems are to include appropriate filter fabric, sub-drainage or weeping tile systems as recommended by manufacturers or design engineers.

C2.06 Landscaping

Landscaping shall be used to enhance the safety, aesthetics and functional aspects of stormwater ponds. Native, non-invasive trees, shrubs, and ground cover are required in a low maintenance landscape design. LSRCA or NVCA policies are to be consulted for a listing of acceptable planting species.

A detailed outline of landscaping requirements is provided in Section H-Landscaping.

A planting and landscaping plan prepared by a registered landscape architect is to be submitted to the Town and the applicable Conservation Authority for review and approval. The design is to ensure a minimum 3m separation from the edge of trails or walkways to trees or shrubs. The plan is to address the following objectives:

- provide shade to areas of the permanent pool (minimize thermal impacts)
- propose vegetation which has high nutrient up-take capability and is planted in shallow ponding areas in the extended detention zones
- provide outlooks or viewing features with space suitable for installation of benches and use of gravel paths to link viewing areas with local walkway or trail systems
- provide a low maintenance ground cover that minimizes the area to be mowed on a regular basis.

The Town requires the following minimum standards for trees and shrubs:

- deciduous trees – minimum 60mm diameter caliper
- coniferous trees – minimum 1.8m in height
- deciduous or coniferous shrubs – minimum 0.9m in height.

Where tree planting is required, the density of planting is to be such that there is a minimum of one tree per $50m^2$. The selection of shrub species and the proposed density of plantings shall be used to discourage public access where appropriate. These locations include areas of steeper slopes around the edge of the permanent pool and around retaining walls or headwalls.

The basis of Figure 1 is that 100% shrub density equals one shrub per m^2 and 25% density equals one shrub per $4m^2$. The purpose of the chart is not to encourage repetitive landscaping design, but to provide a guide for the relationship between planning densities and the relative pond side slope.

Figure 1

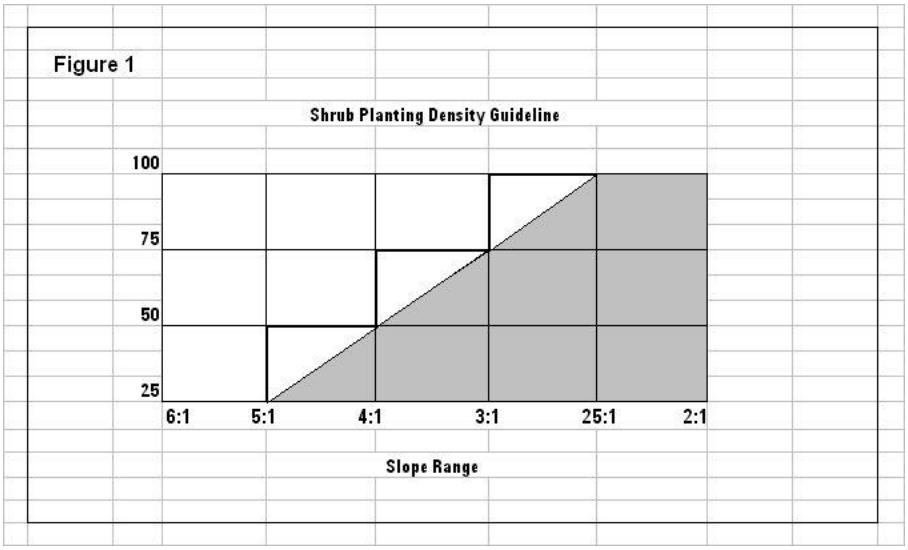


Figure 1
Shrub Planting Density Guideline
100
75
50
25
6:1
5:1
4:1
3:1
25:1
2:1
Slope Range

C3.00 STORMWATER CONVEYANCE

C3.01 General

Urban stormwater conveyance systems may include open channels and swales, storm sewers, manholes and catchbasins, roadways and road allowances. Downspouts and foundation / floor drains are not to be connected to storm sewers. The design of stormwater conveyance systems shall follow “dual drainage” principles, which consist of:

- the minor drainage system which conveys runoff from the 10-year return period storm
- the major drainage system which conveys runoff from storms greater than the 10-year return period up to the 1:100 year storm.

The design of the minor drainage system shall provide unsurcharged conditions up to the 1:10 year storm. The minor system design shall include capacity for connection of foundation drains or weeping tiles and the storm sewers shall be at an appropriate depth to provide connection to foundation drains. A hydraulic gradeline analysis shall be completed and submitted to the Town for review. Sufficient inlet control devices at appropriate locations shall be determined by the design engineer to ensure a sufficient level of protection is provided against potential basement flooding due to surcharge of the minor system during the 100-year storm event. The degree of protection is to be approved by the Town through a pre-design consultation. As an alternative to connecting foundation drains or weeping tiles to the storm sewer, a Foundation Drain Collector (FDC) sewer system may be considered by the Town. The use of sump pumps is not permitted, however, will be considered by the Town if they are deemed to be the only viable option available.

The design of the major system shall be such that runoff is conveyed within the boundaries of municipal road allowances, blocks or easements. A continuous overland flow route is to be identified on the engineering drainage plans.

C3.02 Minor Drainage System Design

The design of the storm sewers shall be computed on the Town's standard Storm Sewer Design Sheet, Appendix I and shall be included in the drawing set on ISO A1 (594mm x 841mm) sheets. All storm sewer minor system designs shall be based on a 10-year frequency unless otherwise directed by the Town.

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

$$Q = 2.778\ (ACi)$$

Where, Q = Run-off quantity in m^3 /sec.

A = Area in hectares (ha)

C = Runoff coefficient

i = Average rainfall intensity in mm/hr.

b) The value for rainfall intensity shall be calculated in accordance with the values as provided in Section C2.01. The equation for the 10-Year Storm is indicated as:

$$i = 1118.790/ (T+6.018)^{0.800}$$

c) Values for the run-off coefficient "C" are as follows:

Urban Roadways	0.90
Commercial areas	0.80
Industrial areas	0.75
Schools, churches, institutions	0.70
Apartments, townhouses, med. density	0.65
Single family residential	0.60
Estate residential	0.45
Parks, cemeteries, recreation	0.30

Where required, appropriate run-off coefficients may also be determined based on detailed calculations using the following values:

Sodded Area, under 7% slope	0.20
Sodded Area, over 7% slope	0.30
Impervious areas	0.95
Gravel areas	0.60
Roof areas	0.70-0.95
Bricked areas	0.85

d) The design for minor water courses, associated culverts and structures will be designed to a twenty-five (25) year storm frequency unless otherwise directed by the Town or Conservation Authority.

Manning's Formula

Designers shall reference Section C2.01 of the BWG Standard Drawings to establish an appropriate inlet time (typically minimum of 10 minutes in small urban areas).

Table 9 provides the relevant design parameters for the minor storm sewer drainage system. This table shall be used to determine the maximum and minimum designs for storm sewers. Although the Manning's formula is to be used as a basis for sewer design, the values listed in Table 9 will supersede the results of Manning's calculations where applicable.

Pipe Capacity

The sewers will be designed according to the Manning equation:

$$Q = \frac{1.00 \times R^{2/3} \times S^{1/2} \times A}{n}$$

and

$$V = \frac{1.00\ R^{2/3} \times S^{1/2}}{n}$$

Where: Q = flow (m^3/sec)

A = nominal cross-sectional area of the sewer (m^2)

R = hydraulic radius (m)

S = slope of pipe (m/m)

n = roughness coefficient as noted below

Roughness Coefficients

The roughness coefficients to be used for storm sewer pipes will be:

a) concrete pipe: n=0.013 for all sizes of pipes

b) PVC pipe: n=0.013 for all sizes of pipes

c) corrugated metal (culverts only): n=0.024 for all sizes of pipes.

Velocity

Minimum = 0.9m/s
Maximum = 4.0m/s

Slope

Minimum = 0.5%

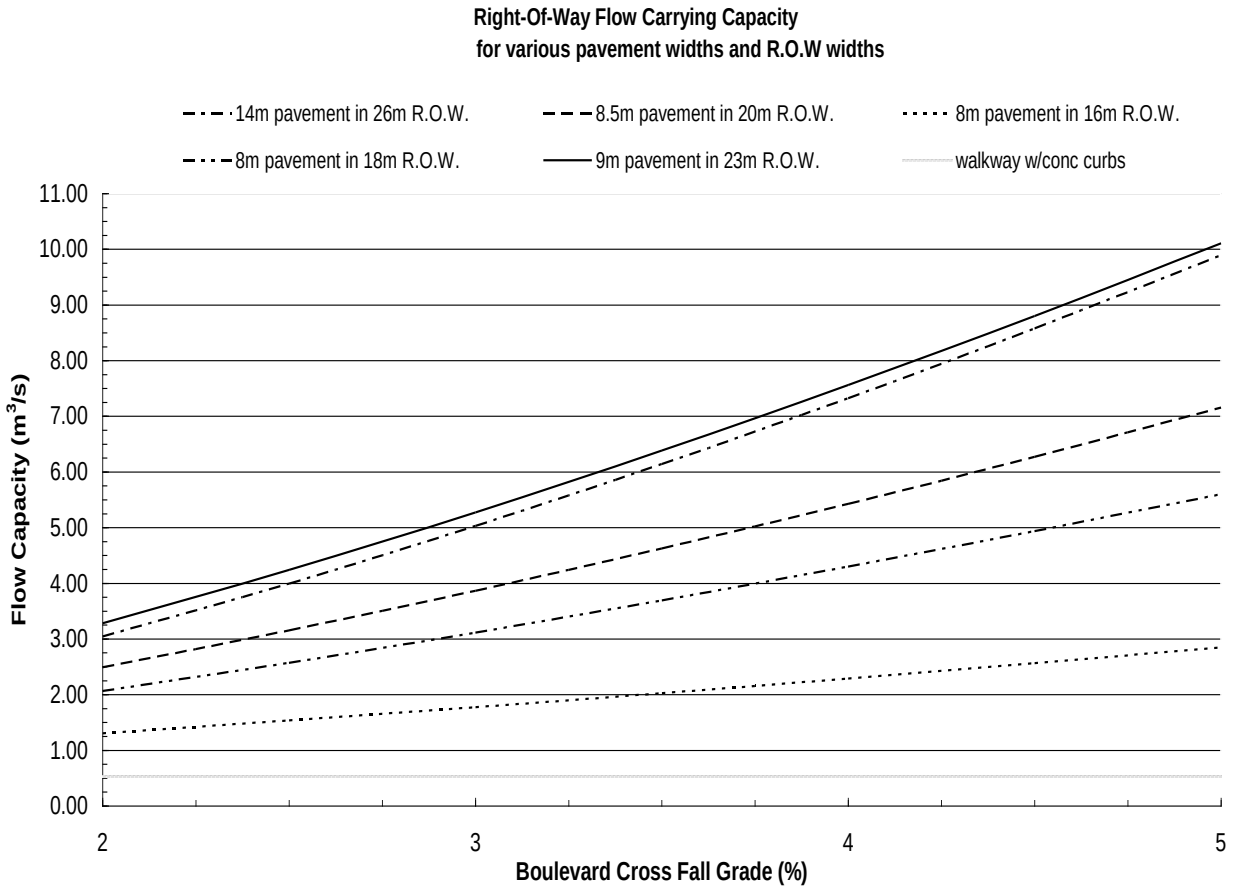
C3.03 Major Drainage System Design

A continuous overland flow drainage route is to be identified on the engineering drawings and grading plans. The extent of any overland ponding at low points is also to be shown on the grading plans. The maximum allowable depth of flow where vehicle or pedestrian traffic takes place or may be expected is 0.30m. Any inlet grating associated with the major drainage system is to include a 50% blockage factor in its design.

Overland flow from public property onto swales on private property must be limited to no more than $0.1m^3$/s, or a drainage area of 1ha, whichever is smaller. Otherwise, overland flow must be limited to road rights-of-way, walkways and easements, free of fences and other impediments to flow.

Figure 2 provides the maximum road allowance carrying capacity for overland flow for various pavement and road allowance widths. This table shall be used to confirm the capacity of the overland conveyance system relative to the expected design flows.

Figure 2


Right-Of-Way Flow Carrying Capacity
for various pavement widths and R.O.W widths
14m pavement in 26m R.O.W.
8.5m pavement in 20m R.O.W.
8m pavement in 16m R.O.W.
8m pavement in 18m R.O.W.
9m pavement in 23m R.O.W.
walkway w/conc curbs
Flow Capacity (m3/s)
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2
3
4
5
Boulevard Cross Fall Grade (%)

C4.00 STORM SEWER PIPE DESIGN

All storm drainage infrastructure, including sewers, manholes, catchbasins, etc., are to conform to the design standards outlined herein. Should any provincial standards (i.e. MOE) exceed the BWG Standard Drawings, those provincial standards shall dictate.

Ditch inlet grate capacities are to be checked against design flows.

Storm laterals are to be provided for foundation drain connections. The use of sump pumps is not permitted, but will be considered by the Town if they are deemed to be the only viable option available. The storm sewer system shall be designed such that a sufficient level of protection is provided against surcharging of weeper tiles resulting in potential basement flooding. The level of protection through the appropriate design and placement of catchbasin inlet control devices shall be approved by the Town. The Town may consider a Foundation Drain Collector (FDC) sewer in place of storm lateral connections to the storm sewer system. The FDC sewer system shall have a free outlet above the 100-year storm level.

Culvert capacity shall be checked against inlet and outlet control hydraulics and the potential effects of backwater to upstream properties.

Connection of residential roof leaders to the storm sewer system is not permitted and shall be directed overland.

Maximum capacity of any pipe shall not exceed 90%.

C4.01 Minimum Pipe Sizes

The minimum size for a storm sewer main shall be 300mm in diameter. The minimum size for rear lot catchbasin leads is 250mm.

The minimum size for entrance culverts shall be 400mm and the minimum size for road crossing culverts shall be 450mm.

C4.02 Location

The storm sewers shall be located as shown on the standard Town road cross section drawings. This standard location shall be generally 1.75m south or west of the centreline of the road allowance. Any sewers which are situated in off-road locations, shall be contained within easements. Such easements shall comply with the requirements noted under Appendix B.

C4.03 Sewer Alignment

All storm sewers shall be laid in a straight line between manholes unless radial pipe is required. All pipe grades are to comply with the values provided in Table 9. The minimum pipe depth shall be 2.7m except where servicing details permit the minimum frost depth (1.2m) to be used. The minimum diameter for radial pipes, where approved, shall be 900mm.

C4.04 Pipe Crossings

All sewers and connections shall have a minimum horizontal separation of 2.5m, where running parallel, and a vertical clearance at crossings of 0.5m from all watermains and appurtenances. A minimum clearance of 0.25m shall be provided between the outside of pipes barrels at all points of sewer crossings. In any event, the minimum separation distance requirements shall comply with the current MOE policy.

In cases where the storm sewer crosses a recent utility trench at an elevation higher than the elevation of the utility, a support system shall be designed to prevent settlements of the storm sewer, or alternatively the utility trench is to be excavated and backfilled with compacted crushed stone or concrete to adequately support the storm sewer. When the storm sewer passes under an existing utility, adequate support shall be constructed to prevent damage to that utility.

C4.06 Pipe Bedding and Backfill

The class of pipe and the type of bedding shall be selected to suit loading and proposed construction conditions. Details and types of bedding and backfill are illustrated in OPSD 802.01 and 802.03.

Fill beneath sewers is to be approved native fill compacted to 95% Standard Proctor as directed by a geotechnical engineer.

C5.00 MANHOLES

C5.01 Location

Manholes shall be located at each change in alignment, grade or pipe material, at all pipe junctions and at intervals along the pipe to permit entry for maintenance of the sewer.

C5.02 Maximum Spacing of Manholes

Spacing of manholes shall be in accordance with the following table:

Table 9: Manhole Spacing

Pipe Diameter	Desirable Spacing	Maximum Allowable Spacing
300mm to 750mm inclusive	100m	120m
825mm to 1200mm inclusive	120m	150m
1350mm to 1800mm inclusive	150m	240m
Over 1800 mm	210m	240m

C5.03 Manhole Types

All manholes are to be supplied as precast concrete structures. The type, size and depth of all maintenance holes shall be indicated on the Plan & Profile engineering drawings. The minimum sized maintenance hole is to be 1200mm in diameter. The standard manhole details as shown on OPSS 407 and OPSD 701.010 shall be used for manholes.

In cases where the standard drawings are not applicable, the manholes shall be individually designed and detailed.

Precast manholes shall conform to CSA A257.4 specifications.

C5.04 Manhole Design

a) Safety gratings shall be provided in all manholes in accordance with OPSS 407 and OPSD 400.010 and 400.230 when the depth of the manhole exceeds 5.0m.

b) When the difference in elevation between the invert of the inlet and outlet pipes exceeds 0.9m, an internal drop structure shall be placed on the inlet pipe, as per OPSD 1003.030 or 1003.031.

c) All storm sewer manholes shall be benched in accordance with OPSS 407 and OPSD 701.021.

C5.05 Grades for Manhole Frames and Covers

All manholes located within the travelled portion of a roadway shall have the rim elevation set flush to the base course of asphalt. A maximum of 3 concrete modular rings to a maximum total thickness of 300mm shall be permitted on manholes in new subdivisions. The concreting and setting of the frame and cover shall be in

accordance with the details on the OPSD. Prior to the placement of the surface course asphalt the manhole frame shall be adjusted to the finished grade of asphalt using concrete modular rings. Steel and/or plastic adjusting rings will not be permitted.

C5.06 Head Losses Through Manholes

Suitable drops shall be provided across all manholes to compensate for the loss of energy due to the change in flow velocity and for the difference in the depth of flow in the sewers.

The minimum drops across manholes shall be as follows:

Change of Direction	Minimum Drop
Straight Run	0.030m
1 to 45 degrees	0.060m
46 to 90 degrees	0.090m

C6.00 CATCHBASINS

C6.01 Location and Spacing

Catchbasins shall be generally located upstream of sidewalk crossings at intersections and at a spacing in accordance with the Table 11 (below). Double catchbasins shall normally be required when the catchbasin intercepts flow from more than one direction.

The maximum allowable drainage path to a catchbasin is as follows:

Table 10: Maximum Catchbasin Spacing

Pavement Width	Maximum Spacing
8.0m-8.5m	90m
9.0m to 12.0m	80m
14.0m	60m

Where the road grade exceeds 5%, the maximum spacing is to be reduced to 75% of the above distances.

Rear lot catchbasins and connections shall be located as outlined in the lot grading criteria.

C6.02 Catchbasin Types

Catchbasins must be of the precast type as shown on OPSD 705.010 or 705.020.

Catchbasin inlet control devices are to be PVC with diamond-shaped orifices and bolted to the inside wall of catchbasins. Special catchbasins and inlet structures shall be fully designed and detailed by the Consulting Engineer.

C6.03 Catchbasin Connections

All catchbasin connections are to have a minimum of 1.2m cover over the pipe barrel.

Type Of Connection	Minimum Size Of Connection	Minimum Grade
Single Catchbasin	250mm	1.0%
Double Catchbasin	300mm	1.0%
Rear Lot Catchbasin	250mm	1.0%

C6.04 Catchbasin Frame and Grate

The frame and grate for catchbasins shall conform to OPSD 400.100. In general, “bike-proof” catchbasin grates shall be used in the roadway or walkway areas. Frames shall be set to finished grade and ramped with asphalt until the top course of asphalt is placed.

In cases where catchbasin inlet capacity is a special consideration, grates may be proposed which provide increased capture of stormwater and are suitable for traffic loading, subject to the Town's review and approval.

C6.05 Rear Lot Catchbasins

Rear lot catchbasins shall be located entirely within one lot and shall have a pyramidal type style frame and grate as per OPSD 400.120.

Sewer pipe in the easement is to be concrete encased from the street line to the catchbasin, with the pipe located on the common lot line between dwellings. House footings are to be extended to below the level of the sewer adjacent to the dwelling. All in accordance with Appendix B.

C7.00 INLETS, OUTFALLS AND SPECIAL STRUCTURES

Inlet and outfall structures, including headwalls shall be in accordance with the OPS Drawings and Specifications. Said structures are to be designed and detailed by a Structural Engineer whenever required.

Grates will be provided on all inlet and outlet structures and shall be designed and detailed when standard drawings are not appropriate. In general, inlet grates will consist of inclined parallel bars or rods set in a plane slope approximately 450mm away from and in the direction of the flow. Outlet grates will consist of horizontal bars or rods. Spacing of bars or rods shall not exceed 150mm clear. All metal parts will be adequately protected against rusting.

All drainage works will require sediment control during construction periods, and permanent installations may be required. Facilities shall be located for easy access by maintenance vehicles, and sediment shall be removed whenever the storage volume is reduced to 40% of required volume.

All drainage works shall be designed to control erosion and the impairment of water quality on receiving streams as a result of urban storm water run-off.

C7.01 Inlets

Inlet structures must be fully designed and detailed on the Engineering Drawings. Inlet grates shall generally consist of inclined parallel bars or rods set in a plane at approximately 18 degrees with the top away from the flow.

Gabions, rip-rap or concrete shall be provided at all inlets to protect against erosion and to channel flow to the inlet structure.

Precaution must be taken in the design of grating for structures to minimize the risk of entanglement or entrapment of a person.

C7.02 Outlets

The OPSD 804.030 standard headwall shall be used for all storm sewers up to 1200mm in diameter. For sewers over 1200mm in diameter, the headwall shall be individually designed. All headwalls shall be equipped with a grating over the outlet as per OPSD 804.050.

Gabions, rip-rap, concrete or other erosion protection shall be provided at all outlets to prevent erosion of the watercourse and the area adjacent to the headwall.

C7.03 Safety Railings

Safety railings, in the form of a 1.2m high continuous galvanized tubular railing shall be provided along the top of all headwalls 0.9m in height or greater. Railings may also be required along shorter headwalls where a risk to pedestrian safety has been identified. The site specific conditions must be reviewed in determining the requirement for safety railings and must have due regard to public health and safety.

C8.00 SERVICE CONNECTIONS

C8.01 Residential

Pipe material shall be P.V.C. SDR28, and be white in color and placed in accordance with BWG Standard Drawings C101 and C102. All storm services shall be double services where possible with a 150x100x100 wye connection at the property line.

Typically, a minimum cover of 2.7m (from future road grade) is required to the top outside edge of the pipe barrel for the storm and sanitary sewers, respectively. However, where specifically approved by the Town, minimum frost cover may be provided on storm sewers where servicing limitations exist.

Risers are to be used when sewers exceed a depth of 4.5m (to invert). Risers are to be brought to within 2.7m of center line grade.

C8.02 Industrial / Commercial / Institutional

Storm service connections for industrial, commercial or institutional will be considered on an individual basis. Non-standard locations are subject to the Town's approval and must be detailed on the plan and profile and utility coordination plans.

The service connections for industrial, commercial or institutional areas shall be sized individually according to the intended use. The minimum size of service pipe shall be 200mm in diameter. The minimum grade is to be 2%. The minimum cover at the street line shall be of sufficient depth to permit servicing of buildings by gravity, wherever possible.

Storm service connections to industrial, commercial or institutional blocks shall require the installation of an inspection maintenance hole located on private property immediately adjacent to the property line.

C9.00 TESTING

C9.01 Deflection Test

A deflection test shall be performed on all sewers constructed using flexible (i.e. PVC, etc) material. Said testing shall be generally in conformance with OPSS 410, except that the average inside diameter of the pipe shall used for the required calculation of the mandrel sizing (where the average inside diameter is as specified by the pipe manufacturer).

A suitably designed device shall be pulled manually through the pipe not sooner than 30 days after completion of the installation and backfilling operations. The device shall be provided as described by OPSS 410. The allowable pipe deflection shall be as follows:

Pipes 100mm to 750mm	7.5% of the average inside dia.
Pipes greater than 750mm	5.0% of the average inside dia.

The device to be used shall have a minimum length in accordance with the following:

Nominal Pipe Size (mm)	Length (mm)
150	100
200	150
250	200
300	250
375	300
450	350

C9.02 Video Record

All newly constructed storm sewers shall be T.V inspected upon satisfactory completion of all other testing, prior to the municipality's issuance of Preliminary Acceptance of the works. All sewer lines being inspected must be flushed immediately prior to the commencement of the inspection.

A permanent record in colour DVD video form shall be supplied, illustrating a continuous record of the sewer installations, service connection, manholes, etc. A report identifying any unusual or substandard conditions shall also be submitted. All CCTV work shall be performed with a camera equipped with a full-swivel head capable of examining lateral connections, manhole interiors and other key features of the sewer installation.

The Town will require certification from the Developer's Consulting Engineer that they have reviewed the videos and have found the sewers to be acceptable and free of all defects. Any deficiencies should be clearly identified in the Engineer's letter and confirmation that all deficiencies have been rectified must be included with the certification.

The CCTV inspection shall be carried out by an operator certified by NAAPI (or equivalent, to the satisfaction of the Town) and shall be carried out in accordance with OPSS 409.

All video records, reports and data provided from these inspections shall become the property of the Town.

An additional video inspection and record will be required prior to “Final Assumption”.