E1 INTRODUCTION

Storm drainage system design includes the design of a minor system (storm sewers) and a major system (overland flow routes, stormwater management ponds, etc.).

The design of the storm drainage system (minor and major systems) shall be based on an accepted Stormwater Management Report, in accordance with the City of Markham's latest "Stormwater Management Guidelines" Standard Drawings, and Design Criteria discussed in this document.

Site plan (Industrial, Commercial, Condo, etc.) developments shall be designed in accordance with the on-site detention (OSD) requirements of the City of Markham "Design of On-Site Detention (OSD)' manual.

Stormwater management criteria (quality control, quantity control, erosion control and water balance) shall be in accordance with the City of Markham Stormwater Management Guidelines, as amended.

Storm drainage systems shall be designed on the basis of gravity flow under open channel conditions. Any variation from the Design Criteria, the use of pumping stations or siphons, and forcemains may only be considered on a case specific basis where other alternatives are not possible with the permission and approval from the Director of Engineering.

E2 STORM SEWER DESIGN

E2.1 Contributing Drainage Area

Storm sewers shall be designed to accommodate storm drainage from the proposed development as well as any contributing external areas. An external drainage plan showing the locations and the estimated flows shall be prepared.

E2.2 Design Flow Calculation

Storm sewers (minor system) shall be designed to accommodate a 5-Year design flow and shall operate without surcharge. Minor and major systems drainage analyses shall be provided in a report and this shall preferably be carried out using established computer models (e.g. PCSWM, OTTSWMM, etc.) accepted by the Director of Engineering.

Storm sewers shall be designed based on the Rational Method. The Stormwater Management Guidelines shall be referred to for further details and principles.

Rational Method

$$Q = KRCIA$$

Where:

Q = Design flow (m3 / sec)
K = Conversion factor (0.00278)
R = Return period factor
C = Runoff coefficient
I = Rainfall intensity (mm / hour)
A= Contributing drainage area (ha)

Runoff Coefficient (C)

The following runoff coefficient shall be used for the design purposes:

Area Types	Run-of-Coefficient (C)
Asphalt, Concrete, Roof Areas, Gravel Areas and Parking Lots	0.90
Grassed Areas	0.25
Parklands	0.40
Water Surfaces (e.g. Pond, Creeks, etc.)	1.00 [1]
Pond Blocks	0.60
Commercial	0.90
Industrial	0.90
Institutional (Schools and Churches)	0.75

Residential	
Single Family	0.65
Semi-detached	0.70
Row Housing, Town Houses	0.75
Apartments / Mix Used	0.85

NOTE: [1] Where water surfaces are deemed to be a significant portion of the contributing drainage area, the proponent has the opportunity to conduct a storage analysis to refine the runoff coefficient and the influence of the water surfaces on the capacity of the receiving system.

To calculate the corresponding Runoff Coefficient for existing development or where coefficients may be lower than standard values, the following formula may be used:

$$C = 0.25 (1 - i) + 0.9 i$$

Where,

C = Runoff Coefficient
i = Imperviousness Ratio
Supporting calculations demonstrating the calculated Imperviousness Ratio (i) must be provided.

Return Period Factor (R)

The following return period factor shall be used for design purposes:

Return Period	Return Period Factor (R)
Up to 10-Year	1.00
25-Year	1.10
50-Year	1.20
100-Year	1.25

Rainfall Intensity (I)

The intensity of rainfall shall be determined using the following equation:

$$\mathbf{I\ (mm\ /\ hr) = A\ /\ (T+B)^{C}}\ ,$$

Where,

T = Time of Concentration in minutes. The minimum initial time of concentration shall be 10 minutes.

The values of A, B and C for the various storms are as follows:

Return Period	A	B	C
2-Year Storm	651.63	3.75	0.80
5-Year Storm	1045.41	4.90	0.83
10-Year Storm	1331.42	5.26	0.84
25-Year Storm	1817.88	6.22	0.87
50-Year Storm	1918.97	6.00	0.86
100-Year Storm	2167.43	6.03	0.86

Contributing Drainage Area: Drainage systems shall be designed to accommodate all upstream drainage areas for interim and ultimate conditions, as determined by contour mapping and drainage plans.

Pre-Development: To calculate the initial time of concentration (T) for upstream, undeveloped lands, the following formulae may be used: Bransby Williams, HYMO / OTTHYMO, SCS Upland Method, Airport Formula, etc. The most appropriate method shall be determined at the discretion of the Director of Engineering.

Post-Development: To calculate the initial external time of concentration (T) for external lands that are scheduled for future development, a straight line shall be drawn from the furthest point within the watershed to the proposed inlet. The top 50.0 m shall have an initial T of 10 minutes and the remainder shall have a T as if the velocity in the sewer is 2.0 m / s. The summation of the two T's will give the future external time of concentration.

E3 SEWER CAPACITY

Manning's formula (see Section D) shall be used in determining the capacity of all storm sewers. The capacity of the sewer shall be determined on the basis of the pipe flowing full. Design flow calculations shall be completed on the City's Standard Format for Storm Sewer Design Sheets.

E4 FLOW VELOCITIES AND SLOPE

Flow velocities shall be determined using Manning's Equation.

For circular pipes, the minimum and maximum flowing full velocities shall be 0.60 m/s and 3.70 m/s respectively.

Full flow velocity, $V_{full} = 30.527 \times D^{2/3} \times S^{1/2}$ (for n = 0.013, D in meters)

$Q_{full} = 23.976 \times D^{8/3} \times S^{1/2}$ (for n = 0.013, D in meters)

Velocity change from one pipe to another in a maintenance hole shall not exceed 0.6 m / s for mainline sewers.

The first leg of all sewers shall have a minimum grade of 1.0% and a maximum grade of 3.0%.

The minimum grade of all sewers shall not be less than 0.3%.

E5 SEWER LAYOUT

E5.1 Location

Storm sewers shall be located as shown on the Standard Drawings. This standard location is generally 1.5 m offset from the centre line of the roadway. If sewers are in a common trench, the minimum horizontal separation between two sewers (barrel to barrel) shall be 1.0 m, as shown in the Standard Drawings.

E5.2 Sewer Alignment

Storm sewers shall be laid in a straight line between maintenance holes unless a radius pipe (675 mm and above) has been designed. Joint burial (common trenching) with sanitary sewers will be considered when supported by the recommendations of a Soil Report prepared by a Geotechnical Engineer.

E5.3 Clearances

A minimum barrel to barrel clearance of 0.5 m (horizontal clearance for parallel sewer and vertical clearance at crossing) for a sanitary sewer and a storm sewer shall be provided.

See Section G - Composite Utility Plans for the minimum clear separation between storm sewers and other utilities / sewers.

E5.4 Minimum Size

The minimum size for a storm sewer, excluding FDC sewer, shall be 300 mm.

E5.5 Changes in Pipe Size

No decrease of pipe size from a larger size upstream to a smaller size downstream shall be allowed regardless of the increase in grades. Exceptions may be made for stormwater management controls subject to acceptance by the Director of Engineering.

E5.6 Depth

Sewers shall be designed with a minimum cover of 2.50 m between the road centerline and the top of sewer elevation (O/D), allowing sufficient depth for foundation drains.

For industrial / commercial Subdivisions, a minimum depth less than 2.50 m may be considered provided that all tributary areas can be serviced.

A minimum cover of 1.2 m to the top of sewer shall be provided at all times for frost protection.

E5.7 Limits of Construction

Sewers shall be terminated with a maintenance hole at the Subdivision limits when external drainage areas are considered in the design. The design of the terminal maintenance holes must allow for possible future extension of the sewer.

Temporary sewer stubs (maximum length of one full pipe) may be permitted between the phases of a development at the discretion of the Director of Engineering.

E5.8 Clay/Collar Plugs

In order to prevent the migration of fines through granular pipe bedding, clay/collar plugs in bedding are required along the pipe at a minimum interval of 40.0 m.

E6 RADIUS PIPES

Radius pipe shall be allowed for storm sewers 675 mm diameter and larger. The minimum centre line radius allowable shall be in accordance with the minimum radii table as provided by the manufacturers.

E7 FORCEMAINS

Where forcemain is necessary and the City accepts its requirements on a case specific basis, the termination of forcemain shall be designed in accordance with the "MECP Design Guidelines For Sewage Works" as detailed below:

'The forcemain shall enter the receiving maintenance hole with a smooth flow transition to the gravity sewer system at a point not more than 0.30 m above the flow line. Corrosion protection shall be provided where corrosive conditions are anticipated due to septicity or other causes. The forcemain length shall be short to reduce dynamic head losses and the production of odours and corrosive gases at initial and design flows, respectively.'

E8 HYDRAULIC GRADE LINE ANALYSIS

A 100-Year Hydraulic Grade Line (HGL) analysis shall be performed and provided in a tabular format.

For Greenfield developments, the basement slab elevations shall be set minimum 0.5 m above the 100-Year (HGL) and shall be indicated on the Plan and Profile drawings.

For Infill developments, where HGL information is not readily available or determined, then the HGL shall be estimated to be minimum 1.8 m below the road centreline elevation, provided the municipal sewer is located at the standard 2.5 m depth. Therefore, the minimum basement slab elevation shall be set at maximum 1.3 m depth from the road centreline elevation. Sump pump shall be installed if the basement elevation is lower than 1.3 m from the centreline elevation of the road.

The minimum basement slab elevations shall be shown on all lots where HGL is above obvert of the pipe.

Inlet control devices (ICDs) shall only be used to control flow into the sewer to reduce 100-Year HGL.

Storm sewer calculations shall be completed on the design sheets as per the City's Standard Format (attached) and the final design sheets shall be stamped by a Professional Engineer and included in the Engineering Drawings.

E9 MAINTENANCE HOLES

Maintenance holes may be precast or poured / cast-in-place and shall be designed and constructed in accordance with the Standard Drawings and Ontario Provincial Standard Drawings and Specifications. Precast maintenance holes shall conform to CSA A257.4.

Maintenance holes shall be placed at the upstream end of each line, changes in size and material, at pipe junctions, and at changes in grade and horizontal alignment. Self-Leveling frame and cover system, in accordance with standard drawing MS6A, are preferred and encouraged to be used for all maintenance holes within existing and future municipal roads/ROW. If these products are used, manufacturer's specification for installation and maintenance must be followed and included in Engineering detail drawings.

Self-Leveling frame and cover system, as per the manufacturer's specification, is not recommended where it is subject to repetitive heavy loading in landscaped areas (non-asphalt).

The use of modular adjustment units (precast or other materials) is only permitted if accepted by the Director of Engineering in writing, in accordance with standard drawing MS6B. In the event that modular adjustment units are used, they shall be fully wrapped with an approved waterproofing membrane ('Mel-rol' or approved equivalent). The waterproofing membrane shall extend over the top of the adjustment to form a gasket type seal on the underside of the frame.

All maintenance hole joints shall be watertight and wrapped with a waterproof membrane ('Mel-rol' or approved equivalent).

E9.1 Maintenance Hole Details

- Maintenance hole chamber openings shall be located on the side of the maintenance hole parallel to the flow for straight run maintenance holes, or on the upstream side of the maintenance hole at all junctions
- The change in the direction of flow in any maintenance hole shall not exceed 90^0
- The maximum change in direction of flow in maintenance holes, for sewer sizes over 1050 mm diameter, shall be 45° (see MS 9).
- Where maintenance hole depths exceed 5.0 m, safety grating as per the OPSD shall be incorporated into the maintenance hole. Safety grating shall not be more than 5.0 m apart. Whenever practical, a safety grating shall be located 0.5 m above the drop structure inlet pipe
- The obverts on the upstream side of maintenance holes shall not be lower than the obvert of the outlet pipe
- Where the difference in elevation between the obvert of the inlet and outlet pipes exceed 0.6 m, a drop structure shall be provided in accordance with the Standard Drawings
- Maintenance holes shall be benched to the obvert of the outlet pipe on a vertical projection from the spring line of the sewer
- Benching between the channel edge and the inside wall of the maintenance hole shall be a minimum of 250 mm in width
- Maintenance holes shall be located with a minimum of 1.5 m clearance away from the face of curb and / or any other service
- Bituminous/Denso seal tape shall be placed around rings and section joints of maintenance hole to seal and to prevent the migration of fines through the direct inflow
- Maintenance holes shall have rubber apron gripping the pipe

- If storm maintenance hole and sanitary maintenance hole are both located at islands or high ground areas, the top elevation of the storm maintenance hole shall be lower than the top elevation of the sanitary maintenance hole
- Pre-benched maintenance holes, as designed by the Ontario Concrete Pipe Association (OCPA) or equivalent, are acceptable.

E9.2 Location and Spacing

Maintenance holes shall be located at each change in alignment, grade or pipe material, at all pipe junctions, at the beginning or end of radius pipe sections and at intervals along the pipe to permit entry for maintenance to the sewer.

Maximum spacing of maintenance holes shall be:

- Sewers 600 mm or less in diameter 120 m
- Sewers 675 mm or greater in diameter 170 m

Where a non-standard maintenance hole configuration is required, it shall be designed with reinforced concrete. Such designs shall be detailed on the Engineering Drawings.

E9.3 Head Losses and Drops

Suitable drops shall be provided across maintenance holes to compensate for the loss in energy due to the change in flow velocity and for the difference in the depth of flow in the sewers. The change in velocity between the inlet and outlet pipes along mainline sewers shall not exceed 0.6 m / s.

Hydraulic calculations may be required for maintenance holes where, in the opinion of the Director of Engineering, there may be insufficient invert drop provided across any maintenance hole.

Regardless of the invert drop across a maintenance hole as required by calculations, obvert of the outlet pipe shall not be higher than obvert of the inlet pipe at any maintenance hole location.

The minimum drops across maintenance holes shall be as follows:

Change of Direction	Minimum Drop (m)
0°	0.02
1° to 45°	0.05
46° to 90°	0.08

The Consulting Engineer shall ensure that drops through maintenance holes are sufficient to accommodate hydraulic losses.

Where pipe sizes change at maintenance holes, the downstream sewer obverts should match the upstream obvert or be lower.

Drop structures shall be avoided, if possible. Drop structures shall be provided if drop is more than 0.6 m. Joints and gaskets shall conform to CSA B 182.1 and CSA B 182.2.

E9.4 Maintenance Hole Channel

For existing maintenance hole retrofit/repair, precast modular Fiberglass panels are required to be installed in the maintenance hole channel. The Fiberglass panels shall be configured to match the existing orientations found in individual maintenance holes. The selected Fibergalss panels shall be reviewed and approved by the Director of Environmental Services or their designate.

E9.5 Pipe Head Losses Calculations

Pipe head losses shall be calculated using the following formula:

$$h_f = f\frac{L\,V^2}{D\,2g} \quad \text{or} \quad k\frac{V^2}{2g} \quad \text{or} \quad \frac{124.5\,n^2\,LV^2}{D^{4/3}\,2g}$$

Where h_f = Pipe head loss (m) (ie frictional loss through a pipe)

f = Darcy-Weisbach friction factor = $\frac{8\,g}{(1/n \times R^{1/6})^2}$

n = Manning's friction factor

L = Length of pipe (m)

V = Flow velocity (m / s)

R = Hydraulic radius (m)

D = Pipe diameter (m)

g = Acceleration of gravity (m / s^2)

k = Head loss coefficient ($f \times \frac{L}{D}$)

E9.6 Maintenance Hole Head Losses and Bend Losses Calculations

Maintenance Holes Head Losses

For losses through maintenance holes, the applicable k (head loss coefficient) varies with the structure and the type of junction.

In a straight-through maintenance hole with one incoming and one outgoing pipes, k = 0.05 and the resulting maintenance hole loss (h_m) is:

$$h_m = 0.05\frac{V_2^2}{2g} \quad \text{(m)}$$

Where V_2 = outflow velocity (m / s)

For a maintenance hole that has incoming and outgoing main pipes (i.e.: maintenance hole on mainline) with one or more lateral pipes, k is calculated based on the velocities of the mainline pipes only (not the laterals) and the angle of lateral pipes to the mainline. The head losses at maintenance holes are calculated as follows or as given in “Design and Construction of Urban Stormwater Management Systems” prepared by ASCE:

90^0 Lateral, $h_m = 0.75\frac{V_2^2}{2g}$ (m)

60^0 Lateral, $h_m = 0.65\frac{V_2^2}{2g}$ (m)

45^0 Lateral, $h_m = 0.50\frac{V_2^2}{2g}$ (m)

22.5^0 Lateral, $h_m = 0.25\frac{V_2^2}{2g}$ (m)

Bend Losses

Bend losses in pipes can be estimated by using the bend loss coefficients in conjunction with the established equations in hydraulic engineering practice.

Head losses applied at the beginning of bend (h_b) are as follows or as given in “Design and Construction of Urban Stormwater Management Systems” prepared by ASCE:

$$90^0 \text{ Bend, } h_b = 0.50 \frac{V_2^2}{2g} \text{ (m)}$$

$$60^0 \text{ Bend, } h_b = 0.43 \frac{V_2^2}{2g} \text{ (m)}$$

$$45^0 \text{ Bend, } h_b = 0.35 \frac{V_2^2}{2g} \text{ (m)}$$

$$22.5^0 \text{ Bend, } h_b = 0.20 \frac{V_2^2}{2g} \text{ (m)}$$

E10 SERVICE CONNECTIONS

For storm service connections, refer to Section M – Service Connections.

E11 BEDDING & PIPE SELECTION

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

All storm sewers shall conform to the requirements of the Canadian Standards Association.

E11.1 Bedding

The class of pipe and the type of bedding shall be selected to suit loading and proposed construction conditions.

All pipes attached to maintenance holes shall be supported from maintenance hole to first pipe joint as per OPSD 708.020.

Storm, Foundation Drain Collector (FDC), and Roof Drainage Collector (RDC) sewer bedding shall be as per OPSD-802.010 for flexible pipes and OPSD-802.030 Class ‘B’ for rigid circular pipes and OPSD-802.050 Class ‘B’ for rigid elliptical pipes unless otherwise specified by the Geotechnical Engineer.

Storm, Foundation Drain Collector (FDC), and Roof Drainage Collector (RDC) sewer bedding in water bearing sand and silt (wet trench condition) shall consist of minimum 20 mm crusher-run limestone as detailed in Engineering Drawings. The necessity for implementing these measures can be assessed at the time of trench excavation by a Geotechnical Engineer.

The width of trench at the top of the pipe shall be carefully controlled to ensure that the maximum trench width is not exceeded unless additional bedding or higher strength pipe is used (refer OPSS 514).

E11.2 Polyvinyl Chloride Pipe (PVC)

The maximum allowable deflected pipe diameter 7.5% of the base inside diameter of the pipe. Deformation gauge (Mandrel) test shall be required for all sewers prior to Acceptance.

For PVC pipe, the initial maximum allowable deflection of PVC pipe under load shall be in accordance with the pipe manufacturer's specifications. The pipe class shall be selected in accordance with the bedding type, depth of sewer, trench width, and soil conditions. The Consulting Engineer may be required to submit pipe loading calculations in support of their design. These calculations shall be based on the Modified Iowa Formula.

Storm sewers 375 mm in diameter or smaller shall be constructed either from PVC or concrete. Sewers 450 mm diameter and greater shall be concrete.

PVC gravity sewer and fittings shall conform to CSA B 182.1 or CSA B 182.2. The pipe shall have a maximum Standard Dimension Ratio (SDR) of 35 and a minimum pipe stiffness of 320 kPa. Storm sewers (mainline pipe) shall be green in colour while service connection pipe shall be white in colour.

Sewers, fittings, joints, and gaskets shall be fabricated in accordance with CSA B182.1, CSA B182.2 and CSA B182.4.

Maximum depth of cover for PVC gravity sewer pipes shall be in accordance with OPSD 806.040.

E11.3 High Density Poly Ethelene Pipe (HDPE) (375 mm or smaller)

HDPE pipe and fittings for storm sewers shall conform to CSA B 182.6 and a minimum pipe stiffness of 320 kPa. HDPE pipe shall have a light coloured interior to facilitate CCTV inspections. HDPE pipes may be used at the sole discretion of the Director of Engineering.

Maximum depth of cover for HDPE gravity sewer pipes shall be in accordance with OPSD 806.020 and 806.021.

E11.4 Rigid Pipe

The pipe class (use class 65-D as a minimum) shall be selected in accordance with the bedding type, depth of sewer material, trench width, and soil conditions. The Consulting Engineer may be required to submit pipe loading calculations in support of their design. These calculations shall be based on the Marston Formula.

Non-reinforced concrete sewers and fittings less than 300 mm in diameter shall be fabricated in accordance with CSA-A257.1, minimum Class 3 or latest amendment unless otherwise noted.

Reinforced concrete sewers and fittings 300 mm in diameter and greater shall be fabricated in accordance with CSA-A257.2 or latest amendment unless otherwise noted.

Joints and gaskets shall conform to CAN / CSA-A257.3.

All Tees and Wyes shall be pre-manufactured.

Maximum depth of cover for concrete pipes shall be in accordance with OPSD 807.010 and 807.050.

E11.5 Other Pipes

Any other sewer materials shall first be submitted to the Director of Engineering and can only be used if accepted by the Director of Engineering.

E12 CATCHBASIN REQUIREMENTS

E12.1 Catchbasins Types

Typical details for single, double, ditch inlet, and rear lot type catchbasins are shown in the Standard Drawings and O.P.S.D. Standards.

Catchbasins shall be precast and shall be designed and constructed in accordance with the Standard Drawings, O.P.S.D. and O.P.S.S. requirements.

Any special catchbasins and inlet structures proposed shall be fully designed and detailed by the Consulting Engineer in the Engineering Drawings for acceptance by the Director of Engineering.

All watermain shall be insulated at or near catchbasin locations in accordance with the City Standards (MS7).

Double catchbasins (DCB) shall be installed at the low point of any road where drainage is collected from two or more directions. Single catchbasins may be acceptable at low points approaching intersections where drainage is mostly from one direction.

Catchbasins in rear yards and other grassed areas such as parks shall not contain sumps.

Catchbasin Maintenance Holes (CBMH) are not accepted in main sewer line. However, a catchbasin maintenance hole may be accepted where it is connected to a catchbasin on the other side of the road where there is no main sewer line.

Where possible, roads designed with a curbside bicycle lane or collector roads where there is no conflict with watermain, curb inlet catch basin frames (OPSD 400.081) may be used with prior approvals of the Director of Engineering. In such a case, catch basin structures shall be located in the boulevard.

E12.2 Location and Spacing

Catchbasins shall be selected, located, and spaced in accordance with the conditions of design. The design of the catchbasin location and type shall take into consideration the lot areas, the lot grades, pavement widths, road grades, and intersection locations. No catchbasins shall be located in walkways.

Maximum spacing for catchbasins shall be as follows:

Road Grades	**Maximum Spacing**	
	Two Lane Road	**Four Lane Road**
0.7% to 4.0%	110 m	60 m
> 4.0% up to 6.0%	75 m	45 m

NOTE: *For cul-de-sacs, the distance shall be measured along the gutter.*

Catchbasins shall be located at the point of curvature on the upstream side of all curb returns and upstream of sidewalk crossings and walkways.

Catchbasins shall not be located within driveways, sidewalk, and walkway curb depressions unless the walkway block is within an overland flow block.

Rear lot catchbasins (RLCB) shall be located to drain a maximum of 0.1 ha or 4 rear yards, whichever is smaller.

E12.3 Catchbasin Leads

The minimum size and slope of catchbasin leads shall be:

Catch Basin Type	Minimum Connection Size (mm)	Minimum Grade (%)
Single Road CB	200	1.0
Double Road CB	300	1.0
Rear Lot CB	250	0.5

Catchbasins leads shall be connected to the storm sewer and not directly to maintenance holes.

Rear lot catchbasin leads shall be installed as follows:

- RLCB leads shall be constructed using 250 mm diameter PVC SDR-35 pipe and shall be within one lot, with the centre of the lead 0.50 m off the lot line
- Where the PVC RLCB lead goes between houses, 150 mm thick concrete slab shall be placed on top of the sand backfill cover within private property

E12.4 Frames and Grates

The frame and cover for catchbasins shall be as detailed in the Standard Drawings and O.P.S.D. Standards. In general, catchbasin grates shall be square flat grade type (OPSD 400.100, OPSD 400.110) for catchbasins located in roadway, parking or walkway areas.

Bird cage frames and covers, flat top frames and covers, or ditch inlet catchbasins shall be used for all parks and school grassed open areas, as required by the users (parks / schools). Beehive covers shall be used for rear lot catchbasins.

For all City's Park, OPSD 400.020 shall be used in consultation with the City's Parks Department.

E12.5 Inlet / Outlet Structures

An inlet structure (super catchbasin) may be used where more substantial drainage areas shall be drained into a storm sewer system. Where additional inlet capacity is required, inlet structures shall be designed specifically for the required application. Inlet grating sizing shall be designed assuming 50% blockage.

Inlet structure grates shall generally consist of inclined parallel bars or rods set in a plane at approximately 45^0 with the top away from the direction of flow. For super catchbasins grate and frame, refer to MS11. Grate sizing and capacity calculations shall be included in the design to show that the opening has sufficient capacity to accommodate the incoming flow.

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

Storm sewer headwalls shall be constructed in accordance with the OPSD Standards. All headwalls shall be equipped with a grating over the outlet end of the pipe and a 1.2 m chain-link fence across the top of the headwall and along its sides for the protection of the public.

Directional change shall be accomplished within the sewer upstream of the outfall in order to minimize erosion within the watercourse.

Erosion protection shall be indicated on the Engineering Drawings and shall be dependent upon the velocity of the flow in the storm sewer outlet, the soil conditions, the flow in the existing watercourse and site conditions. Materials shall be selected based upon the recommendations in an accepted Stormwater Management Report. Erosion protection calculations shall be provided.

E13 ROOF LEADERS AND FOUNDATION DRAINS

E13.1 Roof Leaders

Roof leaders shall be discharged onto splash pads directing water away from house and towards drainage swales and shall not render any sidewalk impassable. No roof leader connection shall be allowed directly to a storm sewer or a sanitary sewer.

E13.2 Foundation Drain

Foundation drains shall be connected by gravity to the storm sewer system provided that the elevation of the bottom of the basement floor slab is at least 1.0 m above the elevations of the storm sewer obvert at that point or minimum 0.5 m above the 100-Year HGL elevation.

E13.3 Foundation Drain Collector (FDC) or Roof Drainage Collector (RDC)

A “Third Pipe” system (FDC or RDC) shall be considered where warranted by flat grades and minimal available outfall depth at the discretion of the Director of Engineering.

Minimum size for the third pipe system shall be 200 mm.

The minimum cover for third pipe system shall be 1.5m from the top of ground to obvert of pipe.

Calculations shall be provided supporting recommended pipe sizes.

Separate maintenance holes are required, not combined with any other system.

Third Pipe system shall not be laid on top of main Storm Sewers. Appropriate horizontal clearance shall be provided to ensure proper maintenance of both the systems.

FDC shall be designed on the basis of continuous flow rate of 0.10 l / s per residential (typical lot size of upto 400 m^2) lot plus infiltration or actual measured groundwater flow. For commercials / condominiums and other uses, FDC shall be designed based on actual measured groundwater flow and potential need.

E13.4 Sump Pumps

Where the above provisions for gravity connection of foundation drains cannot be met, a sump pump system shall be installed in the building and discharge to the storm sewer connection or to the surface, in accordance with the Ontario Building Code and considering the specific site situation. The sump pump shall be maintained by the property owner.

All lots / blocks requiring sump pumps shall be identified clearly in the Storm Drainage Plans and Engineering Drawings for Subdivisions.

The proposed location of the sump pump discharge, including sump pump details, shall be shown on the Site Grading Plan for Site Plans.

Where sump pump discharge is not connected to a sewer, extensions shall be provided to discharge water on to a pre-cast concrete splash pad graded away from the building/foundation and adjacent properties. Splash pad shall be minimum 600 mm x 600 mm in size and placed in a manner that will prevent soil erosion and not render any sidewalk impassable. In no case, sump pump discharge can create ponding or erosion on the Lot or adjacent properties or the City’s rights-of-way.

E14 OVERLAND FLOW

Overland flow routes shall be designed to convey flows in excess of the capacity of the minor storm sewer system. Overland flow routes shall be continuous either within the road right-of-way or by walkways to the nearest outlet, such as river, stormwater management pond, etc.

Maximum depth of flow shall be 250 mm in accordance with the City of Markham Stormwater Management Guidelines.

Where super catchbasins are to be installed to capture the major overland flow, the catchbasin inlet capacity shall be designed considering 50% blockage.

Where major flow (100-Year) is required to be captured in storm sewer through catchbasins, an unobstructed emergency flow route must be provided at this location to cater for events beyond 100-Year. The emergency flow route shall be designed with proper erosion protection works to safely convey 100-Year flow considering no attenuation. The Director of Engineering, at his discretion, may require an easement / block to be dedicated to the City for emergency flow route.

E14.1 Inlet Control Device (ICD)

Should the Consulting Engineer requires to use ICDs to control the ingress of runoff into the minor system, the ICDs shall be sized and spaced to limit runoff in excess of 5-Year.

Catchbasins shall be equipped with IPEX Inlet Control or approved equivalent where shown on plan / profile drawings.

ICD ratings shall be as follows (assumes 950 mm depth to orifice centerline, plus 250 mm maximum ponding at curb; total 1,200 mm head):

- Type ‘A’ 19.8 l / s
- Type ‘B’ 28.3 l / s
- Type ‘C’ 36.8 l / s

E15 STORMWATER MANAGEMENT

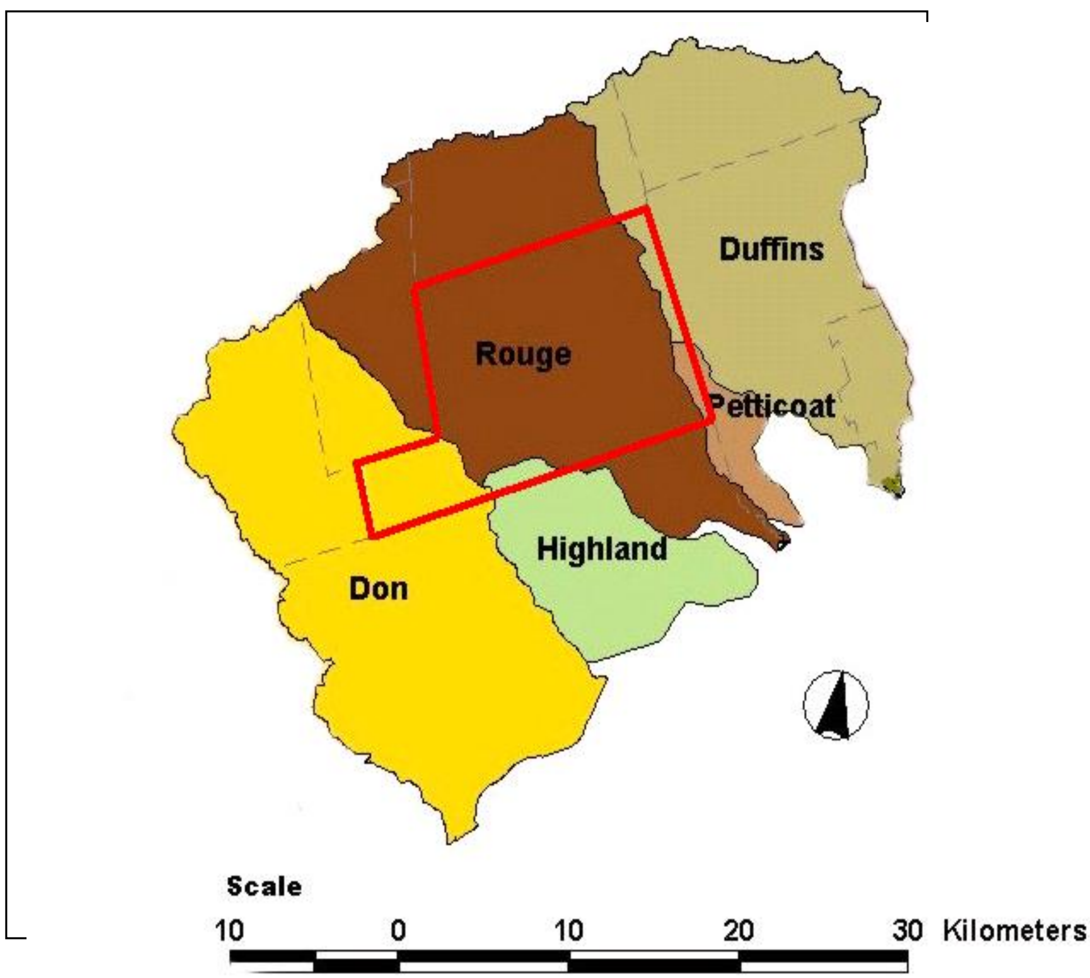
In general, the City of Markham's "**Stormwater Management Guidelines - October 2016"** or any subsequent revision accepted by the Director of Engineering and the Ministry of Environment and Climate Change's (MECP's) "**Stormwater Management Planning and Design Manual - March 2003"**, as amended, shall be followed in planning and designing of stormwater management system.

All proposed stormwater ponds and their appurtenances shall be located on the City owned lands. Overland flows from stormwater ponds shall generally be contained on the City owned lands and not traverse private properties. If these requirements cannot be met due to unique site constraints, the Owner/Engineer must raise it very early in the review process and approval from the Director of Engineering, in consultation with the City Solicitor, will be required.

E16 WATERSHED FLOOD CONTROL CRITERIA

This section details the watershed flood control criteria related to the Rouge River, Don River, Highland Creek, Duffins Creek, and Petticoat Creek Watersheds in the City of Markham (Figure 1). The following criteria are intended to manage riverine-based flood risks related to design flows that affect flood hazards along watercourses and at watercourse crossings. Please refer to the TRCA 2012 Criteria Document, as amended.

Figure 1



E17 GUIDELINES FOR DEWATERING APPLICATIONS (INTERIM POLICY)

E17.1 Permanent Dewatering

The City generally does not support permanent dewatering. The Owner is encouraged to explore other options to avoid permanent dewatering. In the event, that permanent dewatering is the only option (to be confirmed by a structural engineer and a hydrogeologist), a hydrogeological report must be submitted to the City justifying the need for permanent dewatering. The report should address the quality and quality of water, receiving sewer and its capacity, and impacts on surrounding natural environmental including potential settlement to City infrastructures or private properties including proposed mitigation measures.

If the report identifies any potential settlement and if required by Environmental Engineering, Development Engineer will forward a copy of the hydrogeological report to Buildings staff for their reference that the report has identified potential settlement due to dewatering activities required to construct the building(s). The Owner will be required to submit pre-construction photos and CCTV of the municipal infrastructure identified in the report as potentially susceptible to settlement due to de-watering activities for the purposes of having a record of the state of the City's infrastructure prior to the commencement of any dewatering activities.

E17.2 Temporary Dewatering

Temporary Dewatering during the construction periods will be permitted. For temporary dewatering, a Temporary Dewatering Discharge Application must be submitted to Environmental Engineering (EE) with the required applicable fees. The Application will be processed in accordance with the current practices and will be subject to the following conditions:

1) The Geotechnical Engineer or Hydrogeologist shall complete a field test pit, borehole test or a hydrogeological study to determine the actual pumping rate that will occur during the construction periods.

2) A report, duly signed and stamped by a qualified Geotechnical Engineer / Hydrogeologist, shall be submitted to the City to include at a minimum the following information:
   a) Water quality test results, in compliance with City's Sewer Use By-law, and expected pumping rate and ZOI
   b) Identify any impact on adjacent wells and natural environmental features (e.g. watercourse, wetland, wood lot, etc.) and its Mitigation Plan
   c) State any impacts from temporary dewatering and how it will be mitigated during and after completion of the dewatering work. Appropriate parameter threshold values, target levels, and mitigation strategies for the project will be developed and can be incorporated into an Environmental Impact Assessment (EIA) study
   d) Provide a plan showing the discharge locations, flow rate, discharge duration, storm capacity if discharging to a storm sewer, water quality control measures, etc. Approvals must be obtained from the appropriate City's department and if required, York Region before discharging to any outlet
   e) Discharge water quality must be sampled and conform with applicable City's By-laws
   f) Environmental Mitigation Plan, if required, conforming to the accepted EIA report

3) If the test pumping indicates that the temporary pumping rate is over 50,000 l/d, an MECP's Permit-To-Take Water (PTTW) is required, copy of which shall be submitted to the City before construction starts. No PTTW is required if the pumping rate is below 50,000 l / d, but a report as identified above will be required.

4) Discharge application must be made to the appropriate City's Department and if required to the Region of York (ROY) as well. A written approval shall be obtained before discharging the water to any outlet.

E18 MECP'S ENVIRONMENTAL COMPLIANCE APPROVALS

MECP's Environmental Compliance Approvals (ECA) for Municipal Sewage Works and Stormwater Management Facilities are required prior to starting any servicing at site. The sumbission shall be reviewed by the City under the Transfer of Review program.

Any application that does not fall under the Transfer of Review program, shall be a direct submission to the MECP by the Proponent. The Proponent is advised to contact the City staff, before making any formal submission.

Refer to Engineering Submissions Required Documents (Annex 1) for details.

STORM SEWER DESIGN (5-YR)

PROJECT NAME ______________________________

SHEET NO: ______________________
JOB NO: ______________________
DATE: ______________________
CONSULTANT: ______________________
AMANDA NUMBER: ______________

Design Return Period = 5 Yrs, n = 0.013

Rainfall Intensity 'I' = A/(t + B)^c
A =
B =
C =
Starting 't' = 10 min

Location			Runoff				Rainfall Intensity I (mm/hr)	Cumm Flow (m³/s)	Pipe Data			Full Capacity (m³/s)	Full Velocity (m/s)	Qact/Qcap	Time (Entry 10 min.)	
Street Name	Manhole No. From	Manhole No. To	Area(A) (ha)	(R)	(A x R)	Cumm (A x R)			Length (m)	Diameter (mm)	Slope (%)				Sect. (min)	Accum. (min)

Notes	Prepared By:	

STORM SEWER DESIGN / HYDRAULIC GRADE LINE (HGL) ANALYSIS (100-YR)

PROJECT NAME ________________________________

SHEET NO: ______________________
JOB NO: ______________________
DATE: ______________________
CONSULTANT: ______________________
AMANDA NUMBER: ______________

Design Return Period = 100 Yrs, n = 0.013

Rainfall Intensity 'I' = A/(t + B)^c
A =
B =
C =
Starting 't' = 10 min

Location			Runoff				Rainfall Intensity	Cumm Flow	Pipe Data					Full Capacity	Full Velocity	Time (Entry 10 Min.)		Flow	Hydraulic Grade Line Analysis					
	Manhole No.		Area(A)	(R)	(A x R)	Cumm	I		Length	Diameter	Slope					Sect.	Accum.	(Act/Full)	U/S	D/S	Surcharging (m)	Basement	U/S HGL less	Verification
Street Name	From	To	(ha)			(A x R)	(mm/hr)	(m^3/s)	(m)	(mm)	(%)			(m^3/s)	(m/s)	(min)	(min)		HGL (m)	HGL (m)	Above U/S Obv.	Elevation (m)	Basement Ele(m)	

Notes:

Prepared By: