EPCOR

VOLUME 3

DRAINAGE

VOL. 3-02

STORMWATER MANAGEMENT AND DESIGN MANUAL

FEBRUARY 2022

TERMS OF USE

The "City of Edmonton Design and Construction Standards Volume 3: Drainage", henceforth known as "Volume 3", is made available for use in the City of Edmonton effective as of February 28, 2022. Volume 3-02: Stormwater Management and Design Manual has been developed to establish standards and guidelines which align with EPCOR's expectations in the design and construction of drainage infrastructure within the City of Edmonton. Volume 3-02 is presented as accurate and complete as of the effective date and all care has been taken to confirm the accuracy of the information contain herein. The views expressed herein do not necessarily represent those of any individual contributor. No part of these standards absolves any user from the obligation to exercise their professional judgment and follow good practice. Should any user have questions as to the intent or accuracy of any specification or drawing herein, or concern that conflict may exist between the manufacture's or suppliers' recommended installation procedures and Volume 3-02, the user is advised to seek clarification by sending an email to DRENG@epcor.com.

Professional Engineer Seal	Permit to Practice	Responsible for Sections
PROFESSIONAL ENGINEER MOHAMMAD TARIQ ALBERTA Feb. 17, 2022 ID # 75190 Mohammad Tariq, P.Eng. Manager, Hydraulic Modelling EPCOR Water Services Inc.	PERMIT TO PRACTICE EPCOR WATER SERVICES INC. RM SIGNATURE: RM APEGA ID #: 47563 DATE: Feb. 18, 2022 PERMIT NUMBER: P006368 The Association of Professional Engineers and Geoscientists of Alberta (APEGA) Frank Fechner, P.Eng. Senior Manager, Operational Strategies EPCOR Water Services Inc.	1 – 2 Appendix A
PROFESSIONAL ENGINEER MATHEW T. LANGFORD ALBERTA February 18 2022 APEGA ID 86067 Mathew Langford, P.Eng. Manager, Stormwater Planning EPCOR Water Services Inc.	PERMIT TO PRACTICE EPCOR WATER SERVICES INC. RM SIGNATURE: Liliana Malesevic RM APEGA ID #: 68166 DATE: February 18 2022 PERMIT NUMBER: P006368 The Association of Professional Engineers and Geoscientists of Alberta (APEGA) Liliana Malesevic, P.Eng. Senior Manager, Stormwater Plan and Growth EPCOR Water Services Inc.	3 – 5
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Volume 3 in this update is split into six sub-volumes, as following tables, for easy reference and timely update of individual sub-volume to address industry requirements and technological advancements.

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1	1	Planning	December 2021
2	2	Planning Approval Process - General	December 2021
3	3	Planning and Design Studies	December 2021
4	4	Typical Area Master Plan Requirements	December 2021
5	5	Typical Neighbourhood Design Report Requirements	December 2021
6	6	Typical Requirements for Hydrogeotechnical Impact Assessments	December 2021
7	7	Sanitary Sewer - Policy, Goals and Objectives	December 2021
8	12	Storm Drainage System - Policy, Goals and Objectives	December 2021
Appendix A	Appendix G	Pump Station Decision Model	December 2021
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2	13	Tables of Runoff and Rainfall Information	February 2022
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4	16	Stormwater Management Facility Design	February 2022
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6	18	Lot Grading and Surface Drainage Design	December 2021
Appendix A	Appendix B	Computer Model Transfer Requirement Check List	December 2021
Vol. 3-03: Design Guidelines			
1	8	Sanitary Sewer Design Criteria	February 2022
2	14	Minor Conveyance System Design	December 2021
3	19	Sewers, Appurtenances and Structures	February 2022
4	20	Structural Design for Pipe	December 2021
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Appendix B	Appendix D	Guidelines for the Design and Installation of Rigid Gravity Sewer Pipe in the City of Edmonton	December 2021
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3.11.5 ii and iii	Appendix H	Appendix H: Outfall Structure Monitoring embedded in Sections 3.11.5 ii and iii	December 2021
Vol. 3-04: Pump Station and Forcemain Design Guidelines			
1	9	Sanitary Wastewater Pumping Systems	December 2021
2	10	General Design Requirements for Pump Stations	February 2022
3	11	Design of Sewage Forcemains	December 2021
Appendix A	Appendix A	Design Guidelines for Electrical and Control Systems for Wastewater Pump Stations	February 2022
2.13.2 ii and iii	Appendix F	Appendix F: Pumpwell Unit Confined Space Entry Fall Arrest and Rescue System updated and embedded in Sections 2.13.2 ii and iii	December 2021
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1	21	Detailed Engineering Drawings	December 2021
2	22	As-Built Drawing Requirements	February 2022
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5	02426	Pipe Jacking	December 2021
6	02427	Precast Concrete Tunnel Lining	December 2021
7	02435	Tunnel Liner Grouting	December 2021
8	02441	Microtunnelling	December 2021
9	02444	Shaft Construction	December 2021
10	02445	Bored Undercrossings	December 2021
11	02446	Horizontal Directional Drilling	December 2021
12	02531	Sewage Forcemains	December 2021
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16	02620	Subdrains	December 2021
17	02631	Manholes and Catch Basins	December 2021
18	02632	Drainage Manholes Frames and Covers	December 2021
19	02640	Corrugated Steel Pipe Culvert	December 2021
20	02645	Precast Concrete Box Sewers	December 2021
21	02952	Temporary Flow Control	December 2021
22	02953	Cleaning Sewers	December 2021
23	02954	Inspection of Sewers	December 2021
24	02955	Pipe Bursting	December 2021
25	02956	Joint Grouting Concrete Sewers	December 2021
26	02957	Relining Sewers	December 2021
27	02958	Leakage Testing of Sewers	December 2021
28	02959	Deflection Testing of Flexible Pipe	December 2021
29	03310	Concrete for Water and Drainage Structures	December 2021

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DR-02-04-01	-	Typical Davit Base, Guard Rail and Hatch Layout on Control Structure	November 2021
DR-02-05-01	7001	Bioretention Cleanouts	October 2021
DR-02-05-02	7003	Soil Cell Cleanouts	October 2021
DR-06-13-01	7980	Trench Bedding Types	October 2021
DR-06-13-02	7981	Concrete Pipe Butt Joint Detail	October 2021
DR-06-14-01	7063	Standard Riser Connections to Storm and Sanitary Sewers in Common Trench	October 2021
DR-06-17-01	7005	Standard 600 Catch Basin with Type 2A Grating and Frame	October 2021
DR-06-17-02	7006	Standard 600 Catch Basin with Type K-7 Grating and Frame	October 2021
DR-06-17-03	7007	Neck Section Details for Type 4A, 6B and 8 Grating and Frame	October 2021

New Drawing Number	Old Drawing Number	Description	Date
DR-06-17-04	7008	Neck Section Details for Type F-51 and K-7 Grating and Frame	October 2021
DR-06-17-05	7009	Standard 900 Catch Basin with Type DK-7 Grating and Frame	October 2021
DR-06-17-06	7010	Standard 900 Catch Basin with Type F-51 Grating and Frame with Side Inlet	October 2021
DR-06-17-07	7011	Standard 1200 CB Manhole with Type 6B or 8 Grating and Frame	October 2021
DR-06-17-08	7012	Standard 1200 CB Manhole with Type F-51 Grating and Frame with Side Inlet	October 2021
DR-06-17-09	7013	Standard 1200 Manhole for Piping up to 600mm Diameter with Type 6A Cover and Frame	October 2021
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DR-06-17-11	7020	Benching Detail for Standard 1200 Manhole	October 2021
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DR-06-17-13	7030	Grade Rings	October 2021
DR-06-17-14	7031	Rings/Tops	October 2021
DR-06-17-15	7032	Slab Tops for Standard 900 Catch Basin	October 2021
DR-06-17-16	7033	Slab Top for Standard 900 Catch Basin	October 2021
DR-06-17-17	7034	Slab Tops for Standard 1200mm Manhole	October 2021
DR-06-18-01	7040	Type 2A Two Piece Side Inlet Catch Basin Grating and Frame	October 2021
DR-06-18-02	7041	Type 4A Two Piece Side Inlet Catch Basin Manhole Grating and Frame	October 2021
DR-06-18-03	7042	Type 8 Catch Basin Manhole Grating and Frame	October 2021
DR-06-18-04	7043A/B	Type 6 Standard Manhole Frame, Cover and Round Catch Basin Cover	October 2021
DR-06-18-05	7043C	Type 6S Manhole Frame and Cover	October 2021
DR-06-18-06	7044	Type 80 Cover and Floating Type Manhole Frame	October 2021
DR-06-18-07	7045	Type K-7 and DK-7 Catch Basin Frame and Grating	October 2021
DR-06-18-08	7047	Type F-51 Three Piece Catch Basin Frame and Grating with Side Inlet	October 2021
DR-06-18-09	7048	Type F-51 Two Piece Curb Component Frame and Grating	October 2021
DR-06-18-10	7050	Type 41 Manhole Frame and Cover	October 2021
DR-06-18-11	7051	Type 6C Slotted Flat Cover to be used on Type 6 Frame for Air Release	October 2021
DR-06-19-01	7062	Culvert End Riprap	October 2021

The following is a list of revisions in **Vol. 3-02: Stormwater Management and Design Manual**.

Section	Changes	Date
4.2.2	New Section for rescue system requirement added and new typical drawing, DR-02-04-01, of the rescue system added in Vol. 3-06: Standard Drawings.	December 2021
2.4 to 2.7	Tables 2.4 to 2.8 updated based on rainfall data up to the year 2020.	February 2022
4 General	Updated the terminology through section 4 from “pond” to “SWMF” for consistency.	February 2022
4.5.1.iii	Adjusted wording to reflect that dry SWMFs are not actively discouraged.	February 2022
5 General	Updated wording and formatting throughout Section 5 to provide clarity.	February 2022
5.1 Site Planning Considerations	Added more site planning considerations: land use, imperviousness, contamination, connection to drainage system, integration with existing & future use of space, impacts to existing tree	February 2022

Section	Changes	Date
	plantings, future operations and maintenance of facility and surrounding infrastructure.	
5.2 Design Basis	Added 5.2.2 I/P ratio requirements.	February 2022
5.2.3	Design storm events changed from 2 year – 4 hour event and 5 year – 4 hour event to 1:5 year 4 hour event and 1:100 year 4 hour event, respectively.	February 2022
5.2.5	Added a requirement against sub-excavation below the bottom of a basement's slab and added a reference to Alberta HSE regulations and building codes.	February 2022
5.2.6	Added 5.2.6, a requirement to follow any applicable utility standards, and refer to CoE Vol 4 Water Design & Construction Standards for water utilities.	February 2022
5.3.4 Bioretention Garden Surface Geometry and Side Slope	Added ii, a recommendation that for areas adjacent to a sidewalk or a shared-use path, the bioretention garden should have a max side slope of 5:1.	February 2022
5.3.6, 5.4.6, 5.5.7 Media Layers	Added a specification that the mulch shall be non-floating, composed, a blend of fine and course bark, aged a minimum of 4-6 months. Also added that mulch is not required if sufficient ground cover is proposed. Removed the specific recommendation of cedar mulch.	February 2022
5.3.6, 5.4.6, 5.5.7 Media Layers	Changed filter layer washed rock size from "less than 13 mm" to "14 mm".	February 2022
5.4.1 Bioretention Basin Definition	Updated to include the definition of a bioswale.	February 2022
5.4.4 Surface Geometry and Side Slope	Added ii, a recommendation that for areas adjacent to a sidewalk or a shared-use path, the bioretention basin should have a max side slope of 5:1.	February 2022
5.4.4 Surface Geometry and Side Slope	Added iv, a requirement that bioswales should not have surface slopes greater than 3%, and if surface slope is above 1%, check dams are required.	February 2022
5.4.5 iv	Added parking lots to the list of areas in which LID facilities require filter strips at their inlets.	February 2022
5.4.6 Media Layers	Drainage layer changed from minimum 350 mm depth to 400 mm depth.	February 2022
5.5.1 Box Planter Definition	Added that box planters may or may not have a self-containing bottom.	February 2022
5.6.6 Soil Cell Distribution Pipe	Updated to reflect that the distribution pipe should be sloped at a minimum of 0.5% towards a CB or CB-style cleanout.	February 2022
5.6.11 General Considerations	Added the requirement that utility design should meet offsets from trees.	February 2022
5.7 Piping and Infrastructure Considerations	Section 5.7 was updated with additional information and figures to provide clarity.	February 2022
5.7.4	Added the recommendation that cleanout covers should be element resistant, resilient, and made of brass/iron/other durable material.	February 2022
5.7.5	Added that CB-style cleanouts may be considered as a piping line's CB if they are within 4 m of an accessible surface.	February 2022
5.7.5	Added vi), the requirement of 400 mm of straight pipe immediately exiting a CB or MH before there is a bend.	February 2022
5.7.9	Added requirements for perforated piping regarding geotextiles, aggregate sizing.	February 2022

Section	Changes	Date
5.7.12	Removed “beehive style trash rack” as a requirement for overflows in bioretention basins and box planters.	February 2022
5.7.12	Replaced “backflow preventer or check valve” with “flap gates” for preventing combined sewage from entering the LID facility. Also includes a specific requirement for Fontaine SERIES 60 with RMX mount or equivalent. Also includes that retrofits can use different flap gates, but installation procedures and maintenance guides must be provided.	February 2022
5.7.13	Added a requirement that underground enclosure boxes must be firmly embedded in soil and not within mulch.	February 2022
5.9.1 Vegetation Selection	Added “potential nuisances (i.e. pollen and aroma) in high traffic areas” to the list of considerations for species selection.	February 2022
5.9.1	Added that even if the provided plant list is used, the designers must still choose plants that are suitable for the location and the LID type.	February 2022
5.10 Drawing Requirements	Added 5.10.1 Design Stage Requirements, 5.10.1.1 Concept/Preliminary, Figure 5-10: LID Summary Table, 5.10.1.2 Detailed, 5.10.1.3 IFT/IFC, 5.1.10.4 As-Built, 5.10.3 Drawing Considerations.	February 2022
5.11 ii	Added the requirement that if an ESC plan is required, protection of LID facilities must be specifically addressed.	February 2022
5.11 viii	Added a requirement that wet soil should be allowed to dry before placement, and that soil should not be placed in wet, muddy, or frozen conditions.	February 2022
5.12.1	Added a recommendation that soil cells with trees should have a lower sand content to promote water retention.	February 2022
5.12.1	Table 5-4 LID Soil Media Specification: Values for each parameter have been changed, Cation Exchange Capacity requirement removed.	February 2022
5.12 LID Growing Soil Media Specifications	Added 5.12.2 Performance Based Standards.	February 2022
5.12	Added 5.12.3 Tree Root Package Soil.	February 2022
5.13.1 Soil Sampling and Analysis	Added the requirement that soil media analysis should be conducted w/ approval from the City/EPCOR prior to soil arriving on site and soil being placed in LID facility.	February 2022
5.13.1 Soil Sampling and Analysis	Added a requirement that soil that has been purchased premixed and pretested requires one test per stockpile.	February 2022
5.13.2 Compaction and Infiltration	Changed “Soil shall be placed in 300mm lifts” to “Soil shall be placed in 200mm to 300mm lifts”.	February 2022
5.13.2 Compaction and Infiltration	Added the requirement of one compaction test per lift, and Guelph Permeameter testing at varying depths post LID soil placement. Added requirement of hydraulic conductivity testing prior to placement of concrete or planting. Added requirement of Guelph Permeameter testing once per 1000m^2 or once per LID facility. Added requirement of Guelph Permeameter testing at FAC.	February 2022
5.13.2.1	Added 5.13.2.1 Additional Subgrade Compaction for Soil Cells.	February 2022
5.13.2.2	Added 5.13.2.2 Additional LID Inspections.	February 2022
Figure 5.2	Updated references. Cross section adjusted to be more consistent with the plan view.	February 2022
Figure 5.3	Updated references. Cross section adjusted to be more consistent with the plan view.	February 2022
Figure 5.4	Updated references.	February 2022
Figure 5.5	Updated references.	February 2022

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1.0 STORMWATER RUNOFF ANALYSIS

1.1 General Considerations

The hydrologic aspects of urban drainage, i.e. peak rates of runoff, volumes of runoff and time distribution of flow, most directly affect the potential success or failure of the resulting facility designs. These factors determine the basis for planning, design and eventual construction of the drainage facilities. Errors in the determination of any of these factors may result in undersizing the facilities, oversizing them and incurring unnecessary expenditures, or unbalanced designs exhibiting both of these characteristics. The design methodologies available are, however, capable only of defining approximations of the hydrologic parameters and in the interest of the public good, a conservative approach to all designs is warranted.

1.2 Commentary on Analytical Methods

Application of computer simulation methods is recommended for all final analyses and detailed designs. Utilization of the rational method should be restricted to preliminary design or to approximate estimates of peak flow rates. The rational method may also be used for the detailed design of minor drainage systems that drain areas of 65 ha or less. However, consultants are encouraged to apply computer modelling methods for the design of all drainage systems.

1.3 Design Basis - Rainfall/Level of Service

Refer to Section 8.0 - Vol. 3-01: Development Planning Procedure and Framework, for definition of the level-of-service requirements that establish the design basis for storm drainage system elements. In general, storm drainage system elements should be designed to accommodate runoff flow rates and volumes as in ***Table 1.1***.

Table 1.1: Design Basis for Minor/Major Drainage System

System Elements	Design Basis (rainfall return period)
Minor drainage system components servicing areas of 30 ha and less	5 years.
Minor drainage system trunk sewers servicing areas greater than 30 ha	5-year runoff rate plus 25%.
Major drainage system conveyance elements	100 years.
Major drainage system storage	Generally, designs are to be based on elements providing the volume equivalent of a 120 mm depth of water over the total catchment area. Designs are to be evaluated considering the most critical storage event as may result from selected design and historical rainfall events.

1.4 Rational Method

1.4.1 Application

The use of the rational method for final design calculations is to be limited to the design of minor storm drainage system components proposed to accommodate flows from catchments with an area of approximately 65 ha or smaller.

1.4.2 Estimating Runoff Flow Rates by the Rational Method

The rational formula for storm runoff is expressed as:

$$Q = \frac{CIA}{360}$$

where,

Q	=	discharge in m^3/s (design flow rate)
C	=	a dimensionless runoff coefficient
I	=	the average intensity of rainfall in mm/hr
A	=	the drainage area in ha

1.4.3 Runoff Coefficients

The runoff coefficient, C, is to be consistent with the imperviousness for the respective land use. For the purposes of this standard, imperviousness (imp) shall be expressed as a fraction equivalent to the ratio of impervious area to the total area. The following formula relates C and imp and is applicable for the determination of runoff coefficients for storm events with return periods of 10 years or less.

$$C = 0.95 \times \text{imp} + 0.1(1.0 - \text{imp})$$

1.4.4 Runoff coefficients may be calculated for site-specific conditions where details of ultimate site development are known. Otherwise, values of C are to be selected on the basis of zoning or general land uses from the respective tables, ***Table 2.1*** or ***Table 2.2***, provided at the end of this section. These values are to be applied only for determination of peak runoff rates for storms with return periods of 10 years or less.

1.4.5 For use of the rational method to determine peak rates of runoff due to storms with return periods greater than 10 years, the values of runoff coefficients are to be increased from those identified above, in accordance with ***Table 1.2***, up to a maximum value of 0.95:

Table 1.2: Runoff Coefficient Modification Factor

Design Return Period	Runoff Coefficient Modification
Above 10 year up to 25 year	multiply C by 1.1
Above 25 year up to 50 year	multiply C by 1.2
Above 50 year	multiply C by 1.25

1.4.6 Rainfall Design Intensity

i. The value of the design rainfall intensity, I, for the rational formula is selected from the appropriate intensity duration frequency (IDF) curve, with a duration chosen to coincide with the time of concentration, t_c. The time of concentration for runoff flow is the time required for runoff flow to become established and reach the design location from the furthest point within the contributing catchment area.

ii. Determination of t_c requires estimation of two components, the "inlet time" and "travel time".

iii. The inlet time is the time for flow from the extreme limits of the catchment to reach the first point of inflow into the defined conveyance system. It is dependent upon the imperviousness and the size of the catchment.

iv. The travel time is the length of time required for flow to travel within the conveyance system from the point of inflow to the design location.

1.4.7 Inlet Time Determination

Appropriate values for inlet time may be selected from ***Table 2.3*** at the end of this section. This specifies values with respect to imperviousness and size of the catchment.

1.4.8 Intensity-frequency-duration (IDF) curves

Rainfall IDF curves for the City of Edmonton for selected return frequency events are presented in tabular form in ***Table 2.4*** and ***Table 2.5*** at the end of this section.

1.5 Computer Simulation of Runoff

1.5.1 Application

All storm drainage conveyance system elements proposed to accommodate flows for servicing areas larger than 65 ha and all stormwater management storage facilities shall be designed using computer modelling techniques.

1.5.2 Methodology for Computer Simulations, Selection of Computer Models

i. Before commencing any computer modelling for purposes of AMP or neighbourhood design studies, the Developer or the Consultant shall obtain approval from EPCOR Drainage Services on the selection of the proposed computer models and version they plan to use. The selection and proper application of computer models is primarily the responsibility of developers and their consultants. It is necessary to use computer models which have the capability to generate hydrographs for a critical storm or series of storms and which can route these hydrographs through a network of conduits, surface channels and storage facilities.

ii. The DHI – Mike Urban (or Mouse) and Mike 21 models are recommended for use in the design of dual (major and minor) drainage systems.

iii. Storage facilities should be designed using reservoir routing techniques when discharges are permitted during an event. This is dependent on downstream conditions and constraints.

1.5.3 Modelling Procedures

i. The basic approach involves a coarse discretization (lumped area) of the basin based upon the latest available information, which may be a development proposal or area or neighbourhood structure plan.

ii. Runoff hydrographs are to be calculated from these lumped areas and used for pipe sizing, acknowledging the routing effects of the sewers. Post-development hydrographs are to be determined at key points of the trunk sewer and major systems for the 5, 10, 25, and 100-year design storms and for the most critical rare runoff event for the sizing of stormwater management storage facilities.

iii. Drainage systems which involve a number of interconnected ponds in series, or which have relatively restricted outlet flow capacity, require analysis for sequential storm events or modelling with a continuous rainfall record. At the detailed levels of design (NDR and beyond) the system inlets to the minor system must be designed to pass, without exceeding ponding depth allowances, runoff flows from the 1:5 year design runoff event. It must also be demonstrated that for events exceeding the 1:5 year design event, excess runoff volumes are accommodated by surface conveyance and ponding to depths not exceeding major event ponding depth allowances.

iv. The 4-h Chicago distribution hyetographs should be used for analysis of major and minor conveyance systems by computer simulation. When the design of stormwater management is involved, the 24-h Huff distribution design hydrographs should be used along with the “Multiple Event Time Series’” as recommended by EPCOR Drainage Services i.e.: yr1991 and/or yr2004.

v. See ***Appendix A*** for the computer model transfer requirement.

1.5.4 Watershed Data Preparation

When modelling portions of the watershed that have been developed previously, data preparation shall be based upon existing conditions. Data preparation for new areas shall be based upon the best available planning information.

1.5.5 Rainfall Data

Tabulated rainfall data are provided at the end of this section. These data, as applicable, shall be used for all computer modelling studies along with “Multiple Event Time Series’” and Long Duration Time Series’ which are available from One Water Planning.

1.5.6 Sensitivity Analysis

When using computer models, sensitivity work of the hydrological parameters shall be required to ensure proper calibration. Hydrological parameters should be discussed with “One Water Planning” personnel to ensure the values utilized are within acceptable ranges.

1.5.7 Presentation of Modelling Results

To obtain standardization in presentation of model results, planning reports shall include an appropriate section that indicate the following:

- type and version of computer model used;
- all parameters and specific simulation assumptions used;

- design storms used, to be clearly documented and plotted;
- volumetric runoff coefficient or total runoff obtained;
- peak flow versus area, plotted for each event studied; and
- peak flow/area versus time, plotted for each event studied.

2.0 TABLES OF RUNOFF AND RAINFALL INFORMATION

Table 2.1: Storm Runoff Coefficients and Imperviousness According to Zoning

Table 2.2: Storm Runoff Coefficients and Imperviousness According to Land Use

Table 2.3: Design Inlet Time (minutes) with Respect to Catchment Imperviousness and Size

Table 2.4: IDF Curves - Intensity Table (Summary table for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and 200-year curves.)

Table 2.5: IDF Curves - Intensity Table-Summary (Summary table for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and 200-year curves.)

Table 2.6: IDF Parameters

Table 2.7: Chicago Distribution (modified): 4-Hr Design Storm Data (mm/hr) (The 2-year, 5-year, 25-year, 50-year, 100-year and 200-year design storm hyetographs.)

Table 2.8: Huff Distribution (24-h duration storm, first quartile 50% probability). Design Storm for SWMF Drawdown Analysis Only

Table 2.9: Recorded Storm of July 14, 1937

Table 2.10: Recorded Storm of July 10 - 11, 1978

Table 2.11: Recorded Storm of July 2 & 3, 2004 (total of 135mm)

Table 2.12: Recorded Storm of July 12, 2012

2.1 Table 2.1: Storm Runoff Coefficients and Imperviousness According to Zoning

Zoning or Classification Designation Per Bylaw # 12800[1]	Runoff[2] Coefficient " C "	Imperviousness[3] " Imp " (%)
A, RR, AC	0.2	10 - 50
AP, Schools	0.3	10 - 50
RF1, RF2, RF3, RF4, RMH, AGU	0.5	40 - 65
MA, IH	0.5	40 - 70
RF5, RF6, RSL, RA7	0.65	40 - 90
RA8, US, PU	0.75	40 - 90
CNC, CSC, IB, IM, RA9, CB1, CHY, AGI, CO	0.9	40 - 100
CB2	0.95	70 - 100
RMX, CMS, DC1, DC2, DC3, DC4	*	40 - 100

[1] For zonings not shown in this table, the runoff coefficient "C" and the percentage of imperviousness "Imp%" shall be estimated by the designer.

[2] Minimum design values to be used without specific area analysis. To be used only for calculation of peak runoff rates by the rational method.

[3] Typical ranges based on land use bylaw site coverage limits and typical paving practice.

2.1.1 *Special districts

The storm runoff factor for special district zonings are to be the same as the factors for the land use designation which closest resembles the land use specified by the associated statutory plan overlay, or area structure plan, covering the parcel being assessed.

2.1.2 Zonings not shown above

For zonings not shown in ***Table 2.1***, the runoff coefficient "C" and the percentage of imperviousness Imp% shall be estimated by the designer.

2.2 Table 2.2: Storm Runoff Coefficients and Imperviousness According to Land Use

Land Use	Runoff Coefficient[1] "C"	Imperviousness "Imp"(%)
Asphalt, concrete, roof areas	0.95	90 - 100
Industrial, commercial	0.60	50 - 100
Single family residential	0.65	40 - 60
Predominant grassed areas, parkland	0.10	10 - 30

[1] Minimum values to be used without specific area analysis. To be used only for calculation of peak flow rates by the Rational Method.

2.3 Table 2.3: Design Inlet Time (minutes) with Respect to Catchment Imperviousness and Size

Imperviousness (%) / Catchment Area (A)	30	50	> 70
A = 8 ha or less	8	8	5
8 ha < A < 40 ha	9.2	9.2	6
A = 40 ha or more	10.4	10.4	7.25

2.4 Table 2.4: IDF Curves - Intensity Table

Edmonton 11 Rain Gauges Upper Bound - IDF Period: 1984-2020
Maximum Years of Record = 37
IDF Intensity (mm/hr)

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
5		67.84	91.53	109.85	135.00	155.14	178.49	204.34
6		63.13	85.94	103.63	127.77	146.95	169.28	194.46
7		59.12	81.08	98.15	121.36	139.70	161.11	185.63
8		55.67	76.81	93.30	115.64	133.22	153.81	177.68
9		52.65	73.03	88.96	110.50	127.40	147.23	170.47
10		49.99	69.66	85.06	105.86	122.13	141.26	163.92
11		47.63	66.62	81.53	101.63	117.34	135.84	157.92
12		45.51	63.88	78.32	97.77	112.96	130.87	152.40
13		43.60	61.38	75.38	94.23	108.94	126.31	147.32
14		41.87	59.10	72.68	90.97	105.23	122.10	142.61
15	0.25	40.29	57.01	70.20	87.96	101.80	118.20	138.24
16		38.84	55.08	67.90	85.16	98.63	114.58	134.17
17		37.52	53.29	65.76	82.56	95.67	111.21	130.37
18		36.29	51.63	63.78	80.13	92.90	108.06	126.80
19		35.15	50.09	61.92	77.86	90.32	105.11	123.46
20		34.09	48.65	60.18	75.74	87.89	102.34	120.32
21		33.11	47.31	58.56	73.73	85.61	99.73	117.35
22		32.19	46.04	57.02	71.85	83.46	97.27	114.55
23		31.33	44.85	55.58	70.07	81.44	94.95	111.90
24		30.52	43.74	54.22	68.39	79.52	92.76	109.39
25		29.75	42.68	52.93	66.80	77.70	90.68	107.00
26		29.03	41.68	51.71	65.29	75.98	88.70	104.74
27		28.35	40.73	50.55	63.86	74.34	86.83	102.58
28		27.71	39.83	49.45	62.49	72.78	85.04	100.52
29		27.10	38.98	48.41	61.19	71.30	83.33	98.56
30	0.5	26.52	38.17	47.41	59.95	69.88	81.70	96.68
31		25.97	37.39	46.46	58.77	68.53	80.15	94.89
32		25.44	36.65	45.55	57.64	67.23	78.66	93.17
33		24.94	35.95	44.68	56.55	65.99	77.24	91.52
34		24.46	35.27	43.85	55.52	64.80	75.87	89.93
35		24.00	34.63	43.05	54.52	63.66	74.56	88.41
36		23.57	34.01	42.29	53.56	62.57	73.30	86.95
37		23.15	33.41	41.55	52.65	61.52	72.09	85.54
38		22.74	32.84	40.84	51.76	60.50	70.92	84.19
39		22.36	32.29	40.16	50.91	59.53	69.80	82.88
40		21.99	31.76	39.51	50.09	58.59	68.71	81.62
41		21.63	31.26	38.88	49.30	57.68	67.67	80.41

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
42		21.29	30.77	38.27	48.54	56.81	66.66	79.23
43		20.95	30.29	37.69	47.81	55.96	65.69	78.09
44		20.63	29.84	37.12	47.10	55.15	64.74	77.00
45	0.75	20.33	29.40	36.57	46.41	54.36	63.83	75.93
46		20.03	28.97	36.04	45.74	53.60	62.95	74.90
47		19.74	28.56	35.53	45.10	52.86	62.10	73.90
48		19.46	28.16	35.04	44.48	52.14	61.27	72.94
49		19.19	27.77	34.56	43.87	51.45	60.47	72.00
50		18.93	27.40	34.09	43.29	50.77	59.69	71.09
51		18.68	27.04	33.64	42.72	50.12	58.94	70.20
52		18.44	26.69	33.20	42.17	49.49	58.20	69.34
53		18.20	26.35	32.78	41.64	48.87	57.49	68.51
54		17.97	26.02	32.36	41.12	48.27	56.80	67.70
55		17.75	25.69	31.96	40.61	47.69	56.12	66.91
56		17.53	25.38	31.57	40.12	47.12	55.47	66.14
57		17.32	25.08	31.19	39.64	46.57	54.83	65.39
58		17.11	24.78	30.83	39.17	46.04	54.21	64.66
59		16.91	24.49	30.47	38.72	45.52	53.61	63.95
60	1.0	16.72	24.21	30.12	38.28	45.01	53.02	63.25
61		16.53	23.94	29.78	37.85	44.51	52.44	62.58
62		16.35	23.68	29.44	37.43	44.03	51.88	61.92
63		16.17	23.42	29.12	37.02	43.56	51.34	61.28
64		15.99	23.16	28.80	36.62	43.10	50.80	60.65
65		15.82	22.92	28.50	36.24	42.65	50.28	60.03
66		15.66	22.68	28.20	35.86	42.21	49.77	59.44
67		15.49	22.44	27.90	35.48	41.78	49.28	58.85
68		15.33	22.21	27.62	35.12	41.36	48.79	58.28
69		15.18	21.99	27.34	34.77	40.96	48.32	57.72
70		15.03	21.77	27.06	34.42	40.56	47.85	57.17
71		14.88	21.56	26.80	34.08	40.17	47.40	56.64
72		14.74	21.35	26.54	33.75	39.78	46.96	56.11
73		14.60	21.15	26.28	33.43	39.41	46.52	55.60
74		14.46	20.95	26.03	33.11	39.04	46.10	55.10
75	1.25	14.32	20.75	25.79	32.80	38.69	45.68	54.61
76		14.19	20.56	25.55	32.50	38.34	45.28	54.13
77		14.06	20.37	25.31	32.20	37.99	44.88	53.66
78		13.94	20.19	25.08	31.91	37.66	44.49	53.19
79		13.81	20.01	24.86	31.63	37.33	44.10	52.74
80		13.69	19.83	24.64	31.35	37.00	43.73	52.30
81		13.57	19.66	24.42	31.08	36.69	43.36	51.86
82		13.46	19.49	24.21	30.81	36.38	43.00	51.44

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
83		13.34	19.33	24.00	30.55	36.07	42.64	51.02
84		13.23	19.16	23.80	30.29	35.78	42.30	50.61
85		13.12	19.01	23.60	30.03	35.48	41.96	50.20
86		13.02	18.85	23.40	29.79	35.19	41.62	49.81
87		12.91	18.70	23.21	29.54	34.91	41.29	49.42
88		12.81	18.55	23.02	29.30	34.64	40.97	49.04
89		12.71	18.40	22.84	29.07	34.36	40.65	48.66
90	1.5	12.61	18.25	22.66	28.84	34.10	40.34	48.29
120	2	10.28	14.86	18.40	23.44	27.82	33.03	39.60
180	3	7.68	11.07	13.65	17.38	20.76	24.75	29.73
240	4	6.23	8.96	11.00	14.00	16.80	20.09	24.17
300	5	5.30	7.59	9.30	11.83	14.24	17.07	20.54
360	6	4.64	6.63	8.09	10.29	12.43	14.93	17.97
420	7	4.14	5.91	7.20	9.15	11.07	13.33	16.05
480	8	3.75	5.35	6.50	8.26	10.02	12.07	14.54
540	9	3.44	4.89	5.94	7.54	9.17	11.06	13.33
600	10	3.18	4.52	5.48	6.96	8.47	10.23	12.33
660	11	2.97	4.21	5.09	6.46	7.88	9.53	11.48
720	12	2.78	3.94	4.76	6.04	7.38	8.93	10.76
780	13	2.62	3.71	4.48	5.68	6.94	8.41	10.14
840	14	2.48	3.51	4.23	5.36	6.56	7.96	9.60
900	15	2.36	3.33	4.01	5.09	6.23	7.56	9.11
960	16	2.25	3.17	3.82	4.84	5.93	7.20	8.69
1020	17	2.15	3.03	3.64	4.62	5.67	6.89	8.30
1080	18	2.06	2.90	3.48	4.42	5.42	6.60	7.95
1140	19	1.98	2.79	3.34	4.23	5.21	6.34	7.64
1200	20	1.91	2.68	3.21	4.07	5.01	6.10	7.35
1260	21	1.84	2.58	3.09	3.92	4.82	5.88	7.09
1320	22	1.78	2.50	2.98	3.78	4.66	5.68	6.85
1380	23	1.72	2.41	2.88	3.65	4.50	5.49	6.62
1440	24	1.67	2.34	2.79	3.53	4.36	5.32	6.41

2.5 Table 2.5: IDF Curves - Intensity Table-Summary

Edmonton 11 Rain Gauges Upper Bound - IDF Period: 1984-2020
Maximum Years of Record = 37
IDF Intensity (mm/hr)

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
5	0.083	67.84	91.53	109.85	135.00	155.14	178.49	204.34
10	0.167	49.99	69.66	85.06	105.86	122.13	141.26	163.92
15	0.250	40.29	57.01	70.20	87.96	101.80	118.20	138.24
20	0.333	34.09	48.65	60.18	75.74	87.89	102.34	120.32
25	0.417	29.75	42.68	52.93	66.80	77.70	90.68	107.00
30	0.500	26.52	38.17	47.41	59.95	69.88	81.70	96.68
35	0.583	24.00	34.63	43.05	54.52	63.66	74.56	88.41
40	0.667	21.99	31.76	39.51	50.09	58.59	68.71	81.62
45	0.750	20.33	29.40	36.57	46.41	54.36	63.83	75.93
50	0.833	18.93	27.40	34.09	43.29	50.77	59.69	71.09
55	0.917	17.75	25.69	31.96	40.61	47.69	56.12	66.91
60	1	16.72	24.21	30.12	38.28	45.01	53.02	63.25
120	2	10.28	14.86	18.40	23.44	27.82	33.03	39.60
180	3	7.68	11.07	13.65	17.38	20.76	24.75	29.73
240	4	6.23	8.96	11.00	14.00	16.80	20.09	24.17
360	6	4.64	6.63	8.09	10.29	12.43	14.93	17.97
720	12	2.78	3.94	4.76	6.04	7.38	8.93	10.76
1440	24	1.67	2.34	2.79	3.53	4.36	5.32	6.41

Table 2.6: IDF Parameters

Rate=$a(t+c)^b$	Return Frequency						
Parameters	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
a (t in min)	370.26	587.05	798.40	1044.56	1145.99	1290.08	1554.16
b	-0.74	-0.76	-0.78	-0.78	-0.77	-0.75	-0.75
c (min)	4.83	6.56	7.83	8.70	8.63	8.76	9.73

2.6 Table 2.7: Chicago Distribution (modified[1]): 4-Hr Design Storm Data (mm/hr)

Edmonton 11 Rain Gauges Upper Bound, IDF-Period: 1984-2020
Maximum Years of Record = 37
Chicago Type Distribution - Design Storm (5-Minute Increment)

Time (min)	Return Frequency						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
0	0	0	0	0	0	0	0
5	1.74	2.40	2.80	3.54	4.51	5.61	6.83
10	1.83	2.53	2.96	3.75	4.77	5.93	7.22
15	1.94	2.68	3.15	3.99	5.06	6.29	7.66
20	2.06	2.86	3.36	4.27	5.40	6.71	8.17
25	2.20	3.07	3.62	4.59	5.80	7.20	8.77
30	2.37	3.31	3.91	4.98	6.28	7.77	9.48
35	2.56	3.60	4.28	5.44	6.85	8.47	10.33
40	2.80	3.95	4.72	6.02	7.55	9.31	11.37
45	3.10	4.40	5.28	6.75	8.43	10.38	12.68
50	3.49	4.98	6.01	7.70	9.58	11.77	14.39
55	4.01	5.77	7.01	9.01	11.15	13.65	16.71
60	4.75	6.90	8.46	10.90	13.41	16.35	20.03
65	5.90	8.67	10.75	13.89	16.95	20.57	25.22
70	7.94	11.85	14.90	19.32	23.32	28.09	34.43
75	12.75	19.33	24.62	31.95	37.96	45.21	55.12
80	48.81	67.94	82.93	103.19	119.09	137.78	159.90
85	48.81	67.94	82.93	103.19	119.09	137.78	159.90
90	23.24	35.13	44.74	57.49	67.24	79.03	94.93
95	14.67	22.31	28.48	36.93	43.70	51.90	63.14
100	10.82	16.35	20.76	26.97	32.21	38.53	47.11
105	8.64	12.95	16.33	21.19	25.50	30.66	37.57
110	7.24	10.76	13.47	17.45	21.14	25.52	31.29
115	6.26	9.23	11.48	14.85	18.08	21.90	26.86
120	5.53	8.10	10.02	12.94	15.82	19.23	23.57
125	4.97	7.24	8.90	11.48	14.09	17.17	21.04
130	4.53	6.55	8.02	10.32	12.72	15.53	19.02
135	4.16	6.00	7.31	9.39	11.61	14.20	17.38
140	3.86	5.54	6.72	8.62	10.69	13.10	16.03
145	3.60	5.15	6.22	7.98	9.91	12.17	14.88
150	3.38	4.82	5.80	7.43	9.25	11.37	13.90
155	3.19	4.53	5.44	6.96	8.68	10.68	13.05
160	3.02	4.28	5.12	6.54	8.18	10.08	12.31
165	2.87	4.05	4.84	6.18	7.74	9.55	11.66
170	2.74	3.86	4.60	5.86	7.35	9.08	11.08

[1] Instantaneous Peak Averaged out

Time (min)	Return Frequency						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
175	2.62	3.68	4.37	5.57	7.00	8.66	10.56
180	2.51	3.52	4.18	5.32	6.69	8.28	10.09
185	2.41	3.37	4.00	5.08	6.41	7.93	9.67
190	2.32	3.24	3.83	4.87	6.15	7.62	9.28
195	2.24	3.12	3.68	4.68	5.91	7.33	8.93
200	2.16	3.01	3.55	4.50	5.70	7.07	8.61
205	2.09	2.91	3.42	4.34	5.50	6.82	8.31
210	2.03	2.81	3.31	4.19	5.31	6.60	8.04
215	1.97	2.73	3.20	4.05	5.14	6.39	7.78
220	1.91	2.64	3.10	3.92	4.98	6.20	7.54
225	1.86	2.57	3.00	3.80	4.83	6.02	7.32
230	1.81	2.50	2.92	3.69	4.70	5.85	7.11
235	1.76	2.43	2.83	3.59	4.57	5.69	6.92
240	1.72	2.37	2.76	3.49	4.44	5.54	6.74

2.7 Table 2.8: Huff Distribution

Design Storm for SWMF Drawdown Analysis Only
Edmonton 11 Rain Gauges Upper Bound, IDF-Period: 1984-2020
Maximum Years of Record = 37
Storm Duration = 24 hours
Huff Distribution (First-Quartile 50% Probability), mm/hr

Time		Return Frequency						
Mins.	Hrs.	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
0	0	0	0	0	0	0	0	0
15		0.30	0.42	0.50	0.63	0.78	0.95	1.15
30		0.60	0.84	1.00	1.27	1.56	1.91	2.30
45		0.90	1.26	1.50	1.90	2.34	2.86	3.45
60	1	1.20	1.67	2.00	2.53	3.12	3.81	4.60
75		1.59	2.23	2.66	3.37	4.16	5.08	6.12
90		2.39	3.34	3.99	5.05	6.23	7.60	9.17
105		3.18	4.45	5.32	6.73	8.30	10.13	12.22
120	2	3.97	5.56	6.64	8.41	10.37	12.66	15.26
135		4.76	6.67	7.97	10.08	12.44	15.18	18.31
150		5.30	7.42	8.86	11.21	13.84	16.88	20.36
165		5.44	7.62	9.10	11.52	14.22	17.35	20.92
180	3	5.59	7.83	9.35	11.83	14.60	17.82	21.49
195		5.73	8.03	9.59	12.14	14.98	18.28	22.05
210		5.88	8.24	9.84	12.45	15.37	18.75	22.61
225		5.79	8.11	9.68	12.26	15.13	18.45	22.25
240	4	5.54	7.76	9.26	11.73	14.47	17.66	21.29
255		5.29	7.41	8.85	11.20	13.82	16.86	20.33
270		5.04	7.06	8.43	10.67	13.16	16.06	19.37
285		4.79	6.71	8.01	10.14	12.51	15.26	18.41
300	5	4.54	6.36	7.60	9.62	11.87	14.48	17.47
315		4.30	6.02	7.19	9.10	11.24	13.71	16.53
330		4.06	5.68	6.79	8.59	10.60	12.93	15.60
345		3.81	5.34	6.38	8.07	9.96	12.16	14.66
360	6	3.57	5.00	5.97	7.56	9.33	11.38	13.72
375		3.35	4.69	5.60	7.09	8.75	10.67	12.87
390		3.13	4.38	5.23	6.62	8.17	9.96	12.01
405		2.90	4.07	4.86	6.15	7.58	9.25	11.16
420	7	2.68	3.75	4.48	5.67	7.00	8.54	10.30
435		2.47	3.46	4.13	5.23	6.46	7.88	9.50
450		2.32	3.25	3.88	4.91	6.06	7.39	8.91
465		2.17	3.03	3.62	4.59	5.66	6.90	8.33
480	8	2.01	2.82	3.37	4.26	5.26	6.42	7.74
495		1.86	2.61	3.11	3.94	4.86	5.93	7.15
510		1.74	2.44	2.92	3.69	4.56	5.56	6.70
525		1.68	2.35	2.81	3.56	4.39	5.36	6.46
540	9	1.62	2.27	2.71	3.43	4.23	5.16	6.22
555		1.56	2.18	2.60	3.29	4.06	4.96	5.98
570		1.49	2.09	2.50	3.16	3.90	4.76	5.74
585		1.43	2.00	2.39	3.03	3.74	4.56	5.50
600	10	1.37	1.92	2.29	2.90	3.57	4.36	5.26
615		1.31	1.83	2.18	2.76	3.41	4.16	5.02
630		1.24	1.74	2.08	2.63	3.25	3.96	4.78
645		1.18	1.65	1.97	2.50	3.08	3.76	4.54
660	11	1.12	1.57	1.88	2.38	2.94	3.58	4.32

Time		Return Frequency						
Mins.	Hrs.	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
675		1.07	1.50	1.79	2.26	2.79	3.40	4.10
690		1.01	1.42	1.69	2.14	2.64	3.23	3.89
705		0.96	1.34	1.60	2.02	2.50	3.05	3.68
720	12	0.90	1.26	1.51	1.91	2.35	2.87	3.46
735		0.87	1.22	1.46	1.85	2.28	2.78	3.36
750		0.85	1.18	1.41	1.79	2.21	2.69	3.25
765		0.82	1.14	1.37	1.73	2.14	2.61	3.14
780	13	0.79	1.11	1.32	1.67	2.06	2.52	3.04
795		0.76	1.07	1.27	1.61	1.99	2.42	2.92
810		0.73	1.02	1.21	1.54	1.90	2.31	2.79
825		0.69	0.97	1.16	1.46	1.81	2.20	2.66
840	14	0.66	0.92	1.10	1.39	1.71	2.09	2.52
855		0.62	0.87	1.04	1.32	1.62	1.98	2.39
870		0.60	0.84	1.00	1.27	1.56	1.91	2.30
885		0.59	0.83	0.99	1.25	1.54	1.88	2.27
900	15	0.58	0.82	0.98	1.24	1.53	1.86	2.24
915		0.58	0.81	0.97	1.22	1.51	1.84	2.22
930		0.57	0.80	0.95	1.21	1.49	1.82	2.19
945		0.56	0.79	0.94	1.19	1.47	1.79	2.16
960	16	0.56	0.78	0.93	1.18	1.45	1.77	2.14
975		0.55	0.77	0.92	1.16	1.43	1.75	2.11
990		0.54	0.76	0.91	1.15	1.42	1.73	2.08
1005		0.54	0.75	0.90	1.13	1.40	1.71	2.06
1020	17	0.53	0.74	0.88	1.12	1.38	1.68	2.03
1035		0.52	0.73	0.87	1.10	1.36	1.66	2.00
1050		0.51	0.72	0.86	1.09	1.34	1.64	1.98
1065		0.51	0.71	0.85	1.07	1.33	1.62	1.95
1080	18	0.50	0.70	0.84	1.06	1.31	1.60	1.92
1095		0.49	0.69	0.83	1.04	1.29	1.57	1.90
1110		0.49	0.68	0.81	1.03	1.27	1.55	1.87
1125		0.48	0.67	0.80	1.02	1.25	1.53	1.84
1140	19	0.47	0.66	0.79	1.00	1.24	1.51	1.82
1155		0.46	0.65	0.78	0.98	1.21	1.48	1.79
1170		0.45	0.63	0.75	0.95	1.18	1.44	1.73
1185		0.44	0.61	0.73	0.92	1.14	1.39	1.68
1200	20	0.42	0.59	0.71	0.89	1.10	1.35	1.62
1215		0.41	0.57	0.68	0.87	1.07	1.30	1.57
1230		0.39	0.55	0.66	0.84	1.03	1.26	1.52
1245		0.38	0.53	0.64	0.81	1.00	1.21	1.46
1260	21	0.37	0.51	0.61	0.78	0.96	1.17	1.41
1275		0.35	0.49	0.59	0.75	0.92	1.13	1.36
1290		0.34	0.48	0.57	0.72	0.89	1.08	1.30
1305		0.33	0.46	0.54	0.69	0.85	1.04	1.25
1320	22	0.31	0.44	0.52	0.66	0.81	0.99	1.20
1335		0.30	0.42	0.50	0.63	0.78	0.95	1.14
1350		0.28	0.40	0.47	0.60	0.74	0.90	1.09
1365		0.27	0.38	0.45	0.57	0.70	0.86	1.04
1380	23	0.26	0.36	0.43	0.54	0.67	0.82	0.98
1395		0.24	0.34	0.40	0.51	0.63	0.77	0.93
1410		0.23	0.32	0.38	0.48	0.60	0.73	0.88
1425		0.21	0.30	0.36	0.45	0.56	0.68	0.82
1440	24	0.20	0.28	0.33	0.42	0.52	0.64	0.77

2.8 Table 2.9: Recorded Storm of July 14, 1937

Municipal Airport Rain Gauge

Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h
July 14		12.00	2.50	**July 15**		12.15	1.80
0.00	0.50	12.15	2.50	0.00	4.30	12.30	1.80
0.15	0.50	12.30	2.50	0.15	4.30	12.45	1.80
0.30	0.50	12.45	2.50	0.30	4.30	13.00	0.50
0.45	0.50	13.00	1.50	0.45	4.30	13.15	0.50
1.00	0.00	13.15	1.50	1.00	2.80	13.30	0.50
1.15	0.00	13.30	1.50	1.15	2.80	13.45	0.50
1.30	0.00	13.45	1.50	1.30	2.80	14.00	0.00
1.45	0.00	14.00	0.50	1.45	2.80	14.15	0.00
2.00	0.00	14.15	0.50	2.00	2.80	14.30	0.00
2.15	0.00	14.30	0.50	2.15	2.80	14.45	0.00
2.30	0.00	14.45	0.50	2.30	2.80	15.00	0.50
2.45	0.00	15.00	0.50	2.45	2.80	15.15	0.50
3.00	4.00	15.15	0.50	3.00	2.80	15.30	0.50
3.15	4.00	15.30	0.50	3.15	2.80	15.45	0.50
3.30	4.00	15.45	0.50	3.30	2.80	16.00	2.80
3.45	4.00	16.00	1.00	3.45	2.80	16.15	2.80
4.00	4.10	16.15	1.00	4.00	5.30	16.30	2.80
4.15	4.10	16.30	1.00	4.15	5.30	16.45	2.80
4.30	4.10	16.45	1.00	4.30	5.30	17.00	1.50
4.45	4.10	17.00	0.50	4.45	5.30	17.15	1.50
5.00	1.00	17.15	0.50	5.00	6.10	17.30	1.50
5.15	1.00	17.30	0.50	5.15	6.10	17.45	1.50
5.30	1.00	17.45	0.50	5.30	6.10	18.00	1.00
5.45	1.00	18.00	0.50	5.45	6.10	18.15	1.00
6.00	4.60	18.15	0.50	6.00	6.40	18.30	1.00
6.15	4.60	18.30	0.50	6.15	6.40	18.45	1.00
6.30	4.60	18.45	0.50	6.30	6.40	19.00	0.50
6.45	4.60	19.00	0.50	6.45	6.40	19.15	0.50
7.00	15.50	19.15	0.50	7.00	5.10	19.30	0.50
7.15	15.50	19.30	0.50	7.15	5.10	19.45	0.50
7.30	15.50	19.45	0.50	7.30	5.10	20.00	0.00
7.45	15.00	20.00	0.50	7.45	5.10	20.15	0.00
8.00	18.50	20.15	0.50	8.00	3.30	20.30	0.00
8.15	18.50	20.30	0.50	8.15	3.30	20.45	0.00
8.30	18.50	20.45	0.50	8.30	3.30	21.00	1.00
8.45	18.50	21.00	1.30	8.45	3.30	21.15	1.00
9.00	15.50	21.15	1.30	9.00	6.40	21.30	1.00
9.15	15.50	21.30	1.30	9.15	6.40	21.45	1.00

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
Minutes	mm/h	Minutes	mm/h	Minutes	mm/h	Minutes	mm/h
9.30	15.50	21.45	1.30	9.30	6.40	22.00	0.50
9.45	15.50	22.00	5.10	9.45	6.40	22.15	0.50
10.00	7.40	22.15	5.10	10.15	5.30	22.30	0.50
10.15	7.40	22.30	5.10	10.30	5.30	22.45	0.50
10.30	7.40	22.45	5.10	10.45	5.30	23.00	0.00
10.45	7.40	23.00	5.10	11.00	2.30	23.15	0.00
11.00	2.30	23.15	3.80	11.15	2.30	23.30	0.00
11.15	2.30	23.30	3.80	11.30	2.30	23.45	0.00
11.30	2.30	23.45	3.80	11.45	2.30		
11.45	2.30			12.00	1.80		

2.9 Table 2.10: Recorded Storm of July 10 - 11, 1978

Municipal Airport Rain Gauge

Time	Intensity mm/h	Time	Intensity mm/h	Time	Intensity mm/h	Time	Intensity mm/h
July 10		1:00		6:15		11:30	105.60
20:00		1:05		6:20		11:35	88.80
20:05		1:10		6:25		11:40	55.20
20:10	7.20	1:15		6:30		11:45	33.60
20:15	24.00	1:20		6:35		11:50	26.40
20:20	21.60	1:25		6:40		11:55	28.80
20:25	2.40	1:30		6:45		12:00	9.60
20:30		1:35		6:50		12:05	16.80
20:35		1:40		6:55		12:10	48.00
20:40		1:45	21.60	7:00		12:15	33.60
20:45		1:50	79.20	7:05		12:20	16.80
20:50		1:55	74.40	7:10		12:25	4.80
20:55		2:00	21.60	7:15	2.40	12:30	7.20
21:00		2:05		7:20		12:35	14.40
21:05		2:10		7:25		12:40	9.60
21:10		2:15		7:30		12:45	9.60
21:15		2:20		7:35		12:50	4.80
21:20		2:25		7:40		12:55	2.40
21:25		2:30		7:45		13:00	4.80
21:30		2:35		7:50		13:05	4.80
21:35		2:40		7:55		13:10	4.80
21:40		2:45		8:00		13:15	9.80
21:45		2:50		8:05		13:20	4.80
21:50		2:55		8:10		13:25	2.40
21:55		3:00		8:15		13:30	2.40
22:00		3:05		8:20		13:35	4.80
22:05		3:10		8:25		13:40	
22:10		3:15		8:30		13:45	2.40
22:15	38.40	3:20		8:35		13:50	
22:20	14.40	3:25		8:40		13:55	
22:25	4.80	3:30		8:45	2.40	14:00	4.80
22:30	4.80	3:35		8:50	9.60	14:05	9.60
22:35	4.80	3:40		8:55	19.20	14:10	2.40
22:40	19.20	3:45		9:00	12.00	14:15	2.40
22:45	7.20	3:50		9:05	9.60	14:20	
22:50	2.40	3:55		9:10	12.00	14:25	
22:55		4:00		9:15	19.20	14:30	
23:00	2.40	4:05		9:20	14.40	14:35	
23:05	2.40	4:10		9:25	9.60	14:40	

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
	mm/h		mm/h		mm/h		mm/h
23:10	4.80	4:15		9:30	16.80	14:45	
23:15	28.80	4:20		9:35	9.60	14:50	
23:20	9.60	4:25		9:40	2.40	14:55	
23:25	2.40	4:30		9:45	2.40	15:00	
23:30		4:35		9:50	24.00	15:05	4.80
23:35		4:40		9:55	14.40	15:10	7.20
23:40		4:45		10:00	9.60	15:15	
23:45		4:50		10:05	38.40	15:20	
23:50		4:55		10:10	21.60	15:25	2.40
23:55		5:00		10:15	12.00	15:30	
24:00		5:05		10:20	43.20	15:35	
July 11		5:10		10:25	4.80	15:40	2.40
0:00		5:15		10:30	9.60	15:45	
0:05		5:20		10:35	9.60	15:50	
0:10		5:25		10:40	21.60	15:55	
0:15		5:30		10:45	16.80	16:00	
0:20		5:35		10:50	43.20	16:05	
0:25		5:40		10:55	7.20	16:10	
0:30		5:45		11:00	2.40	16:15	
0:35		5:50		11:05	21.60	16:20	4.80
0:40		5:55		11:10	14.40	16:25	2.40
0:45		6:00		11:15	36.00		
0:50		6:05		11:20	72.00		
0:55		6:10		11:25	40.80		

2.10 Table 2.11: Recorded Storm of July 2 & 3, 2004 (total of 135mm)

Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h
July 02		22:25	52.8	4:50	4.8	11:20	0
16:00	0	22:30	40.8	4:55	0	11:25	2.4
16:05	0	22:35	19.2	5:00	0	11:30	0
16:10	0	22:40	7.2	5:05	0	11:35	2.4
16:15	0	22:45	4.8	5:10	0	11:40	0
16:20	0	22:50	4.8	5:15	2.4	11:45	2.4
16:25	0	22:55	2.4	5:20	0	11:50	2.4
16:30	7.2	23:00	4.8	5:25	0	11:55	0
16:35	33.6	23:05	2.4	5:30	0	12:00	0
16:40	21.6	23:10	0	5:35	0	12:05	2.4
16:45	21.6	23:15	0	5:40	2.4	12:10	0
16:50	16.8	23:20	0	5:45	2.4	12:15	2.4
16:55	0	23:25	0	5:50	4.8	12:20	2.4
17:00	9.6	23:30	0	5:55	2.4	12:25	0
17:05	0	23:35	0	6:00	4.8	12:30	2.4
17:10	2.4	23:40	0	6:05	9.6	12:35	2.4
17:15	2.4	23:45	0	6:10	2.4	12:40	2.4
17:20	12	23:50	0	6:15	2.4	12:45	0
17:25	45.6	23:55	0	6:20	2.4	12:50	2.4
17:30	26.4	**July 03**		6:25	2.4	12:55	0
17:35	9.6	0:00	0	6:30	0	13:00	2.4
17:40	7.2	0:05	0	6:35	4.8	13:05	0
17:45	7.2	0:10	0	6:40	2.4	13:10	2.4
17:50	4.8	0:15	4.8	6:45	2.4	13:15	0
17:55	7.2	0:20	2.4	6:50	2.4	13:20	4.8
18:00	2.4	0:25	0	6:55	2.4	13:25	2.4
18:05	2.4	0:30	2.4	7:00	2.4	13:30	2.4
18:10	2.4	0:35	0	7:05	2.4	13:35	2.4
18:15	0	0:40	4.8	7:10	0	13:40	2.4
18:20	2.4	0:45	2.4	7:15	0	13:45	2.4
18:25	0	0:50	2.4	7:20	4.8	13:50	4.8
18:30	0	0:55	4.8	7:25	0	13:55	2.4
18:35	0	1:00	4.8	7:30	2.4	14:00	2.4
18:40	2.4	1:05	4.8	7:35	2.4	14:05	2.4
18:45	0	1:10	2.4	7:40	2.4	14:10	2.4
18:50	0	1:15	0	7:45	2.4	14:15	2.4
18:55	0	1:20	4.8	7:50	4.8	14:20	0
19:00	0	1:25	2.4	7:55	2.4	14:25	2.4
19:05	0	1:30	0	8:00	0	14:30	0
19:10	0	1:35	2.4	8:05	2.4	14:35	4.8

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
Minutes	mm/h	Minutes	mm/h	Minutes	mm/h	Minutes	mm/h
19:15	0	1:40	2.4	8:10	4.8	14:40	4.8
19:20	0	1:45	0	8:15	4.8	14:45	4.8
19:25	0	1:50	2.4	8:20	2.4	14:50	2.4
19:30	0	1:55	0	8:25	0	14:55	2.4
19:35	0	2:00	4.8	8:30	2.4	15:00	4.8
19:40	0	2:05	2.4	8:35	2.4	15:05	2.4
19:45	0	2:10	2.4	8:40	2.4	15:10	2.4
19:50	0	2:15	2.4	8:45	0	15:15	2.4
19:55	0	2:20	4.8	8:50	2.4	15:20	2.4
20:00	0	2:25	2.4	8:55	0	15:25	2.4
20:05	0	2:30	0	9:00	2.4	15:30	2.4
20:10	0	2:35	2.4	9:05	2.4	15:35	0
20:15	0	2:40	2.4	9:10	0	15:40	2.4
20:20	0	2:45	7.2	9:15	2.4	15:45	0
20:25	0	2:50	4.8	9:20	2.4	15:50	2.4
20:30	0	2:55	4.8	9:25	2.4	15:55	0
20:35	0	3:00	4.8	9:30	2.4	16:00	0
20:40	0	3:05	2.4	9:35	4.8	16:05	0
20:45	0	3:10	7.2	9:40	2.4	16:10	2.4
20:50	0	3:15	4.8	9:45	2.4	16:15	0
20:55	0	3:20	2.4	9:50	7.2	16:20	0
21:00	0	3:25	9.6	9:55	4.8	16:25	0
21:05	0	3:30	2.4	10:00	4.8	16:30	0
21:10	0	3:35	7.2	10:05	2.4	16:35	0
21:15	0	3:40	4.8	10:10	2.4	16:40	0
21:20	0	3:45	2.4	10:15	4.8	16:45	0
21:25	0	3:50	4.8	10:20	0	16:50	0
21:30	0	3:55	2.4	10:25	2.4	16:55	0
21:35	0	4:00	2.4	10:30	2.4	17:00	0
21:40	4.8	4:05	0	10:35	0	17:05	0
21:45	33.6	4:10	2.4	10:40	2.4	17:10	0
21:50	72	4:15	0	10:45	0	17:15	0
21:55	129.6	4:20	4.8	10:50	0	17:20	0
22:00	103.2	4:25	2.4	10:55	2.4	17:25	0
22:05	127.2	4:30	2.4	11:00	0	17:30	0
22:10	158.4	4:35	2.4	11:05	2.4	17:35	0
22:15	100.8	4:40	0	11:10	2.4	17:40	0
22:20	64.8	4:45	0	11:15	0	17:45	0

2.11 Table 2.12: Recorded Storm of July 12, 2012

12-Jul-12	Intensity (mm/h)
2:45	0.00
2:50	28.80
2:55	43.20
3:00	48.00
3:05	18.00
3:10	93.60
3:15	110.40
3:20	52.80
3:25	55.20
3:30	20.40
3:35	39.60
3:40	25.20
3:45	15.60
3:50	4.80
3:55	10.80
4:00	18.00
4:05	8.40
4:10	3.60
4:15	0.00

3.0 MAJOR CONVEYANCE SYSTEM DESIGN

Section ***3.0*** outlines the requirements and considerations which apply to the detailed design of the conveyance elements, surface flow routes and ponding locations, of major drainage systems, which carry flows not intercepted by or beyond the capacity of the minor drainage system.

3.1 Surface Drainage on Public Rights-of-Way - Major System

Public rights-of-way, including roadways, alleys, utility lots and walkways, serve as components of the runoff conveyance system to collect runoff water from adjacent lands and convey it to the inlets of the minor drainage system. They also function as the surface flow conveyance elements of the major drainage system.

3.1.1 Level of Service

i. As stated in Section 8.0 - Vol. 3-01: Development Planning Procedure and Framework, rights-of-way for roadways, walkways and other public purposes shall be graded to provide a continuous surface drainage system to accommodate flows from rainfall events of greater intensity than the 1:5 year event and convey these flows to appropriate safe points of escape or storage.

ii. The level-of-service requirements for the major system include provision of a level of protection against surface flooding and property damage for the 1:100 year return frequency design storm. Through control of roadway and other surface elevations, designs should be such that maximum flow ponding surface elevations are generally 0.35 m or more below the lowest anticipated finished ground elevations at buildings on adjacent properties. An overflow must be provided from all sags or depressions such that there will be a freeboard of at least 150 mm above the overflow elevation to the proposed ground surface elevation at adjacent buildings and the maximum depth of ponding is limited to 350 mm.

3.1.2 Flow Capacity of Streets

The theoretical street carrying capacity can be calculated using modified Manning's formula with an "n" value applicable to the actual boundary conditions encountered. Recommended values are n = 0.013 for roadway and n = 0.05 for grassed boulevards.

3.2 Swales

A swale is a shallow sloped linear depression for conveyance of surface runoff.

3.2.1 Use of swales on public rights-of-way

Swales may be used on public rights-of-way, including easements, for the collection and conveyance of major and minor runoff to appropriate points of interception or release. Swales on public rights-of-way, except easements, should not to be provided with concrete flow channels or hard surface treatments, except where such measures are required to address flow velocity or erosion concerns.

3.2.2 Use of swales on private property for drainage of other lands

The use of swales crossing private properties for collection of runoff and drainage control is not permitted unless proper justification is produced and documented indicating that no other alternative is feasible. If the Engineer approves use of such swales they are to be covered by easements in favour of EPCOR, to the satisfaction of the Engineer.

Refer to Section ***6.0***, Lot Grading and Surface Drainage Design, for details of the design and application of public use swales on private property.

3.3 Representation of the Major Conveyance System

i. The nature and detail of the major conveyance system is to be shown on the overall storm drainage basin schematic within the detailed engineering drawings for subdivision developments and on lot grading plans required for such developments or pursuant to other requirements or regulations.

ii. Information shown is to include the direction of surface flows on roadways, other rights-of-way and all surface flow routes, areas subject to ponding and depths of ponding, elevations of overflow points from local depressions and details of channel cross sections.

iii. Where significant major system flows are expected to discharge or overflow to a watercourse, ravine, environmental reserve area, etc., the rate and projected frequency of such flows is to be noted on the overall storm drainage basin schematic and the lot grading plan.

iv. For properties adjacent to SWMFs, requirements for appropriate control of elevations for buildings are to be noted on the associated lot grading plans.

4.0 STORMWATER MANAGEMENT FACILITY DESIGN

This section identifies the general design parameters and specific requirements, including safety features that must be considered and addressed in the planning and design of SWMFs.

4.1 Basis for Detailed Design

4.1.1 Level of Service

SWMFs shall be designed to satisfy the level-of-service requirements for major system storage elements as stated in Section 8.0 - Vol. 3-01: Development Planning Procedure and Framework. The requirements for hydraulic performance for SWMFs including storage capacity, outlet restrictions, bypass and drawdown rates and other basic design parameters such as elevations and design water levels are required to be specifically defined and documented in the NDR for the respective development area.

4.1.2 Geotechnical Considerations

Special geotechnical investigations to address issues related to the design of all constructed wetlands, wet ponds and dry ponds are to be undertaken as part of the planning and design studies and are a prerequisite to the final design of such facilities.

4.1.3 Erosion and Sediment Control

A project specific ESC Plan shall be included with the engineering drawings. The Plan shall build on the ESC Strategy and be developed according to the checklist presented in the ESC Guidelines.

4.1.4 Staged Construction - Standards for Interim Facilities

When stormwater management storage facilities are to be implemented in stages, the standards applicable to the design and construction of the interim facilities are to be generally in accordance with the standards set out herein for permanent facilities of that type. For example, where an interim dry pond facility is proposed as a preliminary stage in the implementation of a wet pond, it shall be designed and constructed in accordance with the criteria and standards applicable to a permanent dry pond. Any proposal for application of alternative standards requires special approval. In all staged construction, erosion and sediment control shall be an important aspect to be adequately addressed in the design.

4.1.5 Storage Alternatives

The review of SWMF alternatives should include the storage methods described in this subsection. The optimum number and location of SWMFs must be determined bearing in mind the major/minor system concept. A combination of the various types of facilities should be considered to select a cost-effective drainage system that minimizes flooding and erosion and maximizes water quality improvement. Constructed wetlands or wet ponds should be used as the final treatment process prior to discharging to the receiving watercourse.

i. Retention storage

Retention storage collects and stores storm runoff for a significant period and releases it after the storm runoff has ended. Retention storage is often associated with "wet reservoirs," more commonly referred to as "wet ponds".

ii. Constructed wetlands

Constructed stormwater wetlands are human-made systems, designed, constructed and operated to emulate natural wetlands or many of their biological processes. They are generally shallow impoundments, planted with emergent rooted vegetation or colonized naturally by volunteer plant species. Water is the primary factor controlling the environment and associated plant and animal life. The water storage, filtering capacity and biological processes in wetlands can improve the quality of stormwater discharge. They may be designed as single or multiple cell compartments to allow redistribution of flows, maintenance of plant communities and flexibility in operation. Multiple cell wetlands may be designed as a series of cells or as parallel cells.

iii. Detention storage

Detention storage or “dry ponds” are commonly used to provide storage in urban drainage works. When the inflow is large enough, the proper functioning of flow controls on the outlet from the system restricts the outflow to a rate much less than the inflow and causes the excess to be temporarily detained in the storage element.

iv. Upstream storage

The storage of water close to the points of rainfall occurrence is referred to as upstream storage. This may be retention or detention storage and usually consists of rooftop ponding, parking lot ponding, property line swale ponding and small ponds in green areas. Although this method lends itself well to planned unit development, it may only be applicable when suitable and effective means are established to ensure that both implementation and long-term operating and maintenance responsibilities are met by property owners.

v. Downstream storage

Water stored downstream of the area where the rainfall occurs is downstream storage. It may be of either the retention or detention types.

vi. Offstream storage

A minor conveyance system may conduct low flows directly to an outlet, but have restricted outlet capacity or flow control elements that allow only peak flows to be routed to a SWMF for storage.

This form of storage is usually termed "offstream" or "off-line" storage. The storage may incorporate depressed open areas, reservoirs and low lying recreation fields.

vii. Channel storage (blue-green storage)

Slow-flow channels with wide bottoms provide channel storage as an inherent part of their hydraulic characteristics. As the channel fills to transport water it is also storing water.

viii. Onstream storage

Onstream storage is achieved through the construction of an embankment across a channel so that a storage facility is formed. Spillway considerations are important to pass large floods exceeding the design runoff.

4.2 Design Requirements Common to Stormwater Management Facilities

4.2.1 Outflow Control Works

i. The outlet from a stormwater management storage system must incorporate appropriate means for control of outflow, to limit the rate of discharges as prescribed in the NDR. In addition the outlet works must include provisions for operational flexibility and to address unintentional blockage of the outlet and the possible need to either stop outflow or increase the rate of outflow.

ii. Outflow Control Gate

Each storage facility shall be provided with a slide gate or similar means to stop the discharge of water from the facility. Gates and hardware used shall be constructed of corrosion resistant material such as stainless steel or marine grade aluminum or approved equivalent or better.

iii. Outlet Control Bypass and Rapid Drawdown Provisions

- The outlet works of each storage facility are to include the means to permit bypassing of the control element and discharge at an increased rate, as may be required to drawdown water levels at the facility more rapidly than the controlled rate would allow. Refer also to ***4.7.8*** in regard to provisions for draining wet storage facilities.
- These provisions may require that outlet connecting sewers be sized with capacity in excess of that defined as the normal controlled outlet rate. An assessment of downstream system capacities, considering conditions during and subsequent to rainfall events, is necessary to define the constraints in this regard, including the impact of discharges from other stormwater management systems that may be operating in parallel.
- In any case, the means should be provided to permit discharge from storage facilities at the maximum rate of flow that the downstream system can accommodate after storm runoff peak flows have passed and the flows from other contributing areas have decreased or ended. The rate of discharge to be provided for rapid drawdown purposes is to be sufficient to restore the availability of storage capacity above NWL to accommodate subsequent runoff events within a reasonable time frame. To achieve this purpose, drawdown rates should satisfy the relationship in ***Table 4.1***.

Table 4.1: Drawdown Time and Available Volume of Wet Pond between NWL and HWL

Time after commencing drawdown from design full level	Available volume between design HWL and NWL
24 h	Volume equivalent to runoff from 1:5 year storm
48 h	Volume equivalent to runoff from 1:25 year storm
96 h	90% of total storage volume above NWL

4.2.2 Rescue system eg. davit base, grab bar, guard rail, hatch, and swing gate on control structures must be installed per typical drawing DR-02-04-01 Vol. 3-06: Standard Drawings.

4.3 Emergency Overflow Provisions

Where feasible an emergency overflow spillway is to be incorporated in the facility design. The designer is to identify the probable frequency of operation of the emergency spillway. Where provision of an emergency spillway or overflow route is found to be unfeasible, the design is to include an analysis of the impact of overtopping the storage facility and the probable frequency of occurrence of overtopping. Both analyses should consider the possible consequences of blockage of the system outlet or overloading due to consecutive runoff events, such that the storage capacity of the facility may be partially or completely unavailable at the beginning of a runoff event.

4.4 Operation and Maintenance Manual

i. As part of the responsibility for design of a stormwater management storage facility the designer shall prepare and provide an O&M Manual for the facility.

ii. One hardcopy of the O&M manual is to be provided in a piano hinged binder with 65 mm spine bound heavy weight fabricord as well as a searchable and organized PDF version following the standard requirements for the O&M manual. Draft O&M manual is to be provided to EPCOR Private Development Section and EPCOR Drainage Operations a minimum of two weeks prior to CCC inspection and the final version of the O&M manual is to be provided prior to approval of a CCC. If any material changes are done between CCC and FAC, updated O&M manual shall be delivered as soon as practicable after material changes and before FAC application. The manual shall include complete equipment manufacturer's operation, maintenance, service and repair instructions and complete parts lists for any mechanized and/or electrical equipment incorporated in the design.

iii. The O&M manual is to include, at minimum, the following information:

- A copy of the approved engineering drawings relating to the SWMF and appurtenances, updated to "As-Built";
- A completed SWMF Data Summary Form;
- Schematic diagrams of the inlet and outlet arrangements, connections to and arrangement of upstream and downstream systems, including all controls, shutoff valves, bypasses, overflows and any other operation or control features;
- Location plans for all operating devices and controls, access points and routes, planned overflow routes, or likely point of overtopping when the design containment volume is exceeded;
- Head Discharge and Stage Discharge Curves with clear relationships of the stages to surrounding features;
- Stage-discharge relationships for receiving storm sewers or channels downstream of the storage outlet, with indication of backwater effects which may restrict the outflow or which shall be considered in the operation of the facilities outlet controls;
- An outline of the normally expected operational requirements for the facility;
- An outline of emergency operating requirements under possible abnormal situations;
- The O&M manual shall include a simplified schematic and description for quick reference (a “user-friendly drawing”) indicating operations modes, bypass considerations, basin area, etc.

4.5 Signage for Safety and Public Information

4.5.1 Signage for Safety

SWMFs shall include mounting provisions for adequate signage to warn of anticipated water level fluctuations and markers indicating the design high water level. Safety signs are required at all access points and strategic locations at a spacing of not more than 200 m between signs. Warning signs are provided by EPCOR Drainage Services and must be requested by the Developer as early as practicable. The Contractor’s or the Developer’s information should be written on signage until CCC is issued. Refer to ***Figure 4.1***. Signs promoting public education are encouraged.

Figure 4.1: Wet SWMF Standard Safety Sign Example

4.5.2 Public Information

The Developer is required to inform the general public by means of signage and brochures that the facility is for stormwater management. It is the responsibility of the Developer to provide an educational brochure on SWMFs during the marketing of an area that includes a wet or dry SWMF. The purpose of the brochure is to educate residents about:

- The specific function of wet SWMFs;
- The water quality inherent with the function of the facility and the impact of water quality resulting from different land uses and landscaping practices (which directly feeds into the storm sewer system);
- Design high water level;
- Recreational use is not permitted.

The Developer is responsible for installation at least one interpretive signage showing schematic map of how storm flow gets in and out of a SWMF, high water level, its main function as a retention facility, water quality inherent with the function, naturalization and other relevant information as it fits to a specific facility.

4.6 Engineering Drawing Requirements

The engineering drawings for any SWMF are to include the following information, in addition to the physical dimensions:

- Stage-Storage Volume and Stage-Area Curves and tables of the values;
- The High Water Level (HWL) design event basis;

- Elevations at SWMF Bottom, Normal Water Level (NWL), 5 Year, 25 Year, 100 Year Level and HWL;
- Storage Volumes at NWL, 5 Year, 25 Year, 100 Year Level, HWL, and freeboard level;
- Area at SWMF Bottom, NWL, 5 Year, 25 Year, 100 Year, HWL, and freeboard level;
- Freeboard elevation;
- Notation indicating the lowest allowable building opening elevation for lots abutting the wet SWMF;
- SWMF and forebay depth at NWL, 5 Year Level, 25 Year, 100 Year Level and HWL;
- Length of shoreline at NWL, 5 Year Level, 25 Year, 100 Year, and HWL;
- SWMF and forebay area in ha at NWL, 5 Year, 25 Year, 100 Year Level and HWL;
- Contributing basin size in ha;
- Measurements to locate submerged inlet(s), outlet(s) and sediment traps referenced to identifiable, permanent features which are not submerged at NWL.

4.7 Design Details for Wet SWMFs

4.7.1 Land Dedication and Easement Requirements for Wet SWMFs

i. The requirement for dedication of land on which a wet SWMF is to be situated should be in accordance with the City's current policy.

ii. The area of land which would be covered by water when the wet SWMF level is at its HWL should be designated as a "Public Utility Lot." This designation should also apply to all rights-of-way for access to and protection of inlets, outlets and flow control facilities, and maintenance access routes to the wet SWMF.

iii. A restrictive covenant shall be placed upon lots abutting the wet SWMF to control lot development so as not to compromise design requirements of the wet SWMF and ensure that an adequate freeboard is maintained.

4.7.2 Minimum Wet SWMF Size

When a choice is necessary between using one larger wet SWMF as an alternative to two or more smaller facilities, one of which would have a wet SWMF surface area of less than 2 ha at normal water level, then one wet SWMF is to be used. This is to discourage proliferation of large numbers of small wet SWMFs and higher maintenance costs.

4.7.3 Side Slopes

i. Side slopes requirements are to be generally as shown in ***Figure 4.2***.

ii. Areas normally or infrequently covered by water, from the design high water level down to a point 1.0 m below the normal water level, shall have a maximum slope of 7 horizontal and 1 vertical (7H:1V). This is to include all overflow areas.

iii. A slope of 3H:1V shall be used from the 1.0 m depth point (below normal water level) to the SWMF bottom. This is to minimize the area of shallow water when the wet SWMF is at normal water level, to discourage the growth of unwanted vegetation.

iv. Where confined space or extremes of topography dictate, limited areas within overflow areas located on Public Utility and Walkway lots may be graded with a slope of 5H:1V. Proposals to amend the slope requirements are approved by the Engineer on a site specific basis.

4.7.4 Minimum Depth and Width

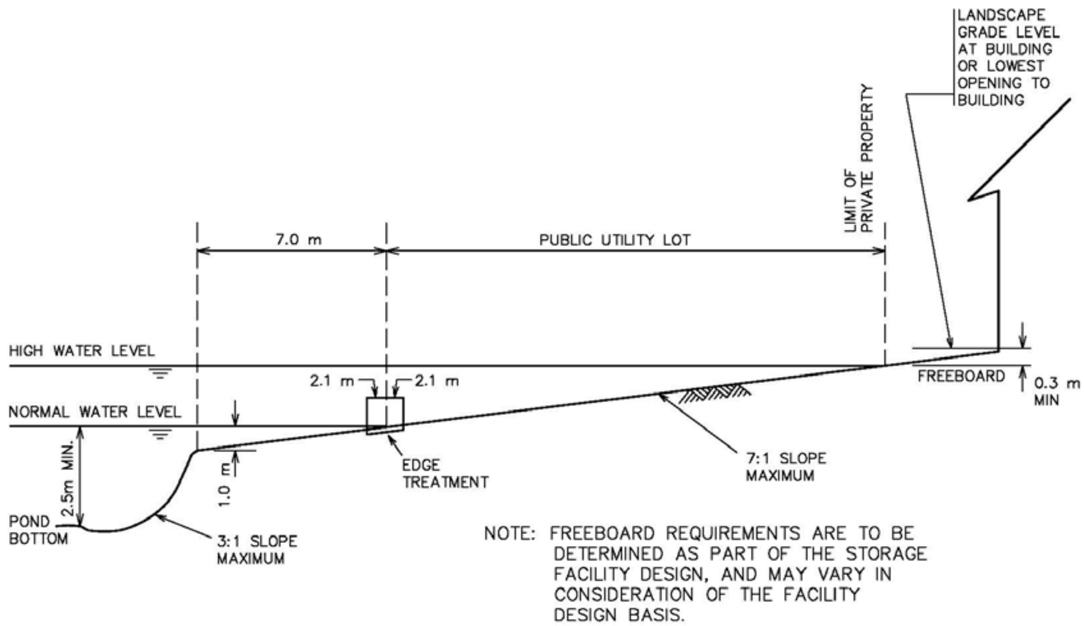

Figure 4.2: Recommended Cross Section of a Wet SWMF

The minimum depth from NWL to wet SWMF bottom (beyond the side slope area) shall be 2.5 m. Refer to ***Figure 4.2***. Provide a channel with a 3.0 m bottom width at a depth of no less than 1.0 m between the forebays, permanent pool and outlet pools.

4.7.5 Wet SWMF Bottom Material

i. For areas where the ground water table is below the NWL, the wet SWMF bottom and side slopes are to be composed of impervious material with a suitably low permeability (e.g. with a permeability coefficient in the order of 1 x 10^{-6} cm/s).

ii. For areas where the ground water table is expected to be near or above the NWL, the wet SWMF bottom may be of a pervious material as dictated by geotechnical considerations.

4.7.6 Circulation Requirements

Narrow and/or dead bay areas where floating debris may accumulate are to be avoided. Inlets and outlets should be located to maximize detention time and circulation within the wet SWMF water body.

4.7.7 Inlet and Outlet Requirements

i. Submergence of inlets and outlets

Inlets and outlets are to be fully submerged, with the crown of the pipe at least 1.0 m below normal water level. Inlet and outlet pipe inverts are to be a minimum 100 mm above the wet SWMF bottom.

ii. Provision for free outfall from inlets to wet SWMFs

The invert elevation of the inlet pipe(s) to the first manhole upstream from the wet SWMF shall be at or above the normal water level of the wet SWMF to avoid deposition of sediments in the inlet to the wet SWMF. To avoid backwater effects in the upstream sewers the obvert of the inlet sewer at the first manhole upstream from the wet SWMF shall be at or above the wet SWMF level for the 1:5 year storm. A drop structure upstream from the wet SWMF is generally be required to achieve this. Inlet and outlet control calculations are required to verify the mode of operation of the inlets.

iii. Separation of inlets and outlets

The inlet and outlet shall be physically separated and be located at the perimeter of the facility. The inlet and outlet should be distanced as far as possible from each other to avoid hydraulic short-circuiting. Settlement time of particles shall be less than the travel time for water in a wet SWMF. Water quality improvement design calculations must be submitted as part of the engineering drawings.

iv. Provisions for water level measurement

To permit direct measurement of water level in the wet SWMF, a manhole is to be provided and hydraulically connected to the wet SWMF.

v. Inlet and outlet foundation should be designed to provide adequate support to the structures (either through Class A bedding or piles)

4.7.8 Provisions for Lowering Wet SWMF Level

The provision of the means to drain the wet SWMF completely by gravity drainage is desirable. The incorporation of this provision with the outlet control bypass should be considered, whenever feasible, refer to ***4.2.1 iii***. Where a gravity drain is not feasible, provisions are to be made in association with the outlet works or otherwise, so that mobile pumping equipment may be used to lower the wet SWMF level.

4.8 Sediment Removal Provisions

i. The wet SWMF design shall include an approved sedimentation removal process for control of heavy solids that may be washed to the wet SWMF during the development of the contributing basin.

ii. Sediment basins shall be provided at all inlet locations for use after completion of the subdivision development.

4.9 Wet SWMF Edge Treatment

i. Edge treatment or shore protection is required and shall be compatible with the adjacent land use. The treatment used shall meet criteria for low maintenance, safety and ease of access to the water's edge.

ii. The edge treatment is to cover the ground surfaces exposed by a wet SWMF level decrease to 0.3 m below the NWL and covered by a wet SWMF level increase to 0.3 m above the NWL (refer to ***Figure 4.2***) and shall be adequate to prevent erosion of the wet SWMF edge due to wave action. The typical edge treatment shall be a 250 mm deep layer of well graded washed rock, 75 mm minimum size, underlain with a woven polypropylene geotextile fabric.

iii. The designer is encouraged to propose alternate edge treatments that exceed this minimum standard. The final selection of edge treatment is subject to the approval of the Engineer.

4.10 Maintenance Access Requirements

All-weather asphalted vehicle access must be provided to all wet SWMF outlet controls and works. An all-weather vehicle access route shall also be provided to the edge of all wet SWMFs suitable to carry maintenance vehicles and for use as a boat launch point. The access shall be a minimum of 3.0 m wide, extend into the wet SWMF to a point where the normal water depth is 1.0 m and be accessible from a public road right-of-way. It must also be designed to allow for proper drainage to avoid any ponding/icing issues. Sharp bends are to be avoided and it shall have a straight run of 12 m or more leading to the wet SWMF edge, to permit a straight run in for launching of boats and weed harvesting equipment. Boat launch ramp alignment shall be constructed to avoid conflict between inlet/outlet and boat. A curved transitional area between the maintenance pathway and boat ramp is required to allow for the entry and exit of maintenance equipment.

4.11 Landscaping Requirements

Landscaping of areas bounding the wet SWMF is to be part of the wet SWMF construction requirement, and plans shall be submitted as part of the engineering drawings. This shall include all proposed public lands comprising the wet SWMF and all easement areas, including areas from the wet SWMF edge treatment to the limit of inundation when the wet SWMF is filled to the design high water level (refer to ***Figure 4.2***). The minimum requirement for landscaping shall be as specified in the City of Edmonton Design and Construction Standards, Volume 5: Landscaping. The design intent for landscaping within a SWMF is to create a physical and a visual barrier discouraging direct access to the waterline. In order to mitigate public safety risks, a variety of design features and safety measures are required for site-specific landscape design around SWMFs:

- Fencing is required along the property lines of residential, commercial, industrial or institutional lands where they border a wet SWMF.
- Fencing is also required in instances where safety sensitive public and private facilities (schools, playgrounds, daycares, senior/nursing homes etc.) are directly adjacent to wet SWMF (no buffer i.e. road).
- Proper railings are required on any vertical (retaining) walls or inlet outlet structures where fall hazards exist.

4.12 Design Details for Constructed Wetlands

4.12.1 For details refer to ***Figure 4.3:*** Schematic Diagram of a Constructed Wetland and to ***Table 4.3***: Summary Guide for the Design of Constructed Wetlands

4.12.2 Land dedication and easement requirements for constructed wetlands

i. The land required for the constructed wetland is to be dedicated to EPCOR Water Services Inc.

ii. It is not a part of the municipal reserve provided by the Developer to the City.

iii. It is not part of an environmental reserve.

iv. Generally, the area of land which would be covered by water when the water level is at the most critical design storm event level, high water level, is to be designated as a “Public Utility Lot.” This designation also applies to all rights-of-way for access to and protection of inlets, outlets and flow control facilities, and for maintenance access routes to the wetland.

v. Lots abutting the constructed wetland are allowed provided that there are areas around the wetland that are open for maintenance access routes to the wetland and secondary uses to the public (refer to Sections ***4.12.20*** and ***4.12.21***).

vi. A restrictive covenant is to be placed upon lots abutting the constructed wetland to control lot development so as not to compromise the design requirements of the SWMF and ensure that an adequate freeboard is maintained. Where overland overflow is available, a minimum of 0.3 m freeboard above HWL is acceptable. Otherwise, a minimum of 0.5 m is required.

4.12.3 Suspended Solids Removal

The minimum design requirement for total suspended solids removal is 85% of particle size 75 µm or greater, as recommended by AEP, April 2001. Constructed wetlands are considered to be the most effective treatment for sediment control and it is expected that this recommended criteria for reduction of total suspended solids is achieved. Refer to Section ***4.12.12 i*** .

4.12.4 Wetland Drainage Area

i. A minimum drainage area of 5 ha is required to generate constant or periodic flow to the constructed wetland.

ii. The smallest practical drainage area is considered to be 20 ha. For drainage areas between 5 and 20 ha in size, the City may approve the use of constructed wetlands on a site-specific basis.

iii. To determine that a permanent pool can be maintained in a constructed wetland, hydrological studies are to be conducted using the size and characteristic of the drainage area.

iv. The City prefers that fewer, larger wetlands be constructed rather than a series of smaller constructed wetlands.

v. The Developer is required to implement the ESC Plan during development in the drainage area to minimize sediment loading to the forebay and wetland during the construction phase of the project and during the staged construction of the SWMF.

4.12.5 Wetland Soil Characteristics

i. For wetland deep water areas, low soil permeability of 10^{-7} m/s is recommended to maintain a permanent pool of water and minimize exfiltration. Compacted sandy clays and silty clay loams may be suitable provided that documented geotechnical testing demonstrates low soil permeability.

ii. Wetland vegetative zones can be constructed using soils from recently displaced wetlands, sterilized topsoil, or peat from within the drainage basin or region. A layer of 10 cm to 30 cm of soil shall be spread over the vegetation zones of the constructed wetland. Planting should be done in this soil over the 2 years following construction.

4.12.6 Wetland Vegetation

i. After construction and placement of soil the entire vegetation area shall be planted with species that are tolerant to wide ranges of water elevations, salinity, temperature and pH as the pioneer colonizer to quickly establish a protective canopy and rigorous root development to stabilize the soil.

ii. In the spring of the year following construction the entire vegetation zone shall be overseeded with legumes and wild flowers. Also, at approximately the same time, the area above NWL shall be planted with 50% of the woody species agreed upon as noted in Section ***4.12.7***. Plants shall be selected for tolerance to flooding and oxygen-reduced environments.

iii. One year after completion of construction a stable mixture of water tolerant grasses shall be in place.

iv. In the spring of the second year following construction the non-surviving woody plants shall be replaced and the remaining 50% of the woody plants shall be planted.

v. Two years after completion of construction a diverse population of water tolerant grasses, native grasses, wild flowers, and water tolerant woody plants shall have taken root.

vi. Manipulation of water levels may be used to control plant species and maintain plant diversity.

vii. Harvesting emergent vegetation is not recommended.

4.12.7 Upland vegetation in the extended detention storage area around the wetland

i. Requirements for screening the constructed wetlands, between NWL and HWL, from adjacent land uses and for visual aesthetics shall be agreed by the Developer and the City.

ii. A mow strip of a minimum of 2.0 m shall extend from the public utility lot boundary towards the constructed wetland NWL. This is to act as a safety bench and weed barrier to prevent root invasion of adjacent properties by Poplar and Aspen species.

4.12.8 Wetland Water Depth

i. Use a variety of water depths, 0.1 m to 0.6 m with an average permanent water depth of 0.3 m, to encourage emergent vegetation.

ii. Deep water areas, i.e. greater than 2 m, are to be limited to less than 25% of wetland surface area.

iii. Water level fluctuation in excess of 1 m above NWL should be infrequent to prevent killing of the vegetation.

4.12.9 Wetland Surface Area

i. The surface area of the constructed wetland shall be a minimum of one ha at the NWL.

ii. The wetland surface area is typically about 3% to 5% of the drainage area.

4.12.10 Wetland Volume

To achieve suspended solids removal for the highest level of protection, it is required to provide 80 m^3 of dead storage volume per ha for a drainage area 35% impervious. For an area 85% impervious, a dead storage volume of 140 m^3 per ha of drainage area is required.

4.12.11 Length to Width Ratio

i. The minimum ratio should provide an effective flow path length at low flow that is three times the relative wetland width in order to increase the residence time.

ii. Incoming water should be well distributed throughout the land and be conveyed as sheet flow to optimize treatment.

4.12.12 Forebay

i. A forebay is required at each major inlet, to trap suspended solids before stormwater enters the constructed wetland.

ii. A major inlet is one that provides greater than 10% of the total storm inflow to the wetland.

iii. A forebay is to be between 2.4 m to 3.0 m deep for major inlets.

iv. Provide maintenance access at forebays to permit removal of sediments.

v. Runoff leaving the forebay should pass through shallow areas of emergent vegetation.

vi. Side slopes shall be a maximum of 7H:1V along accessible areas around open and deep water areas at the forebay.

4.12.13 Permanent Pool at the Outlet

i. The permanent pool requires a depth of 2.4 m to 3.0 m. Size can be variable depending on the wetland's configuration.

ii. Side slopes shall be a maximum of 7H:1V along accessible areas around open and deep water areas at the permanent pool.

4.12.14 Inlet and outlet

i. Inlets are to discharge to a forebay.

ii. A variable water level control structure is required on the outlets for maintenance and water management purposes and to assist with the establishment and management of vegetation. The control structure should be capable of maintaining water levels between 0.5 m below NWL and 0.5 m above NWL. Variable water level control should be obtained through the manipulation of stop logs or similar overflow devises.

iii. Inlets and outlets should be located to avoid short-circuiting and maximize the flow path.

iv. The maximum depth in the inlet and outlet areas is restricted to 3.0 m.

v. Inlets and outlets are to be fully submerged, with the crown of the pipe at least 1.0 m below NWL. Inlet and outlet pipe inverts are to be a minimum of 100 mm above the bottom.

vi. Provide reinforced grassed maintenance access, with a minimum width of 3 m, to forebay and permanent pool to allow for sediment removal.

4.12.15 Grading

i. Slopes shall be 5H:1V or flatter to support larger areas of wetland vegetation. Terraced slopes are acceptable.

ii. A 2 m wide shallow marsh bench around the wetlands at NWL with a 10H:1V slope and the use of terraced grading is recommended to improve public safety.

iii. Side slopes around the accessible deep areas in sediment forebay and permanent pool areas shall be a maximum of 7H:1V.

iv. The 2 m wide mow strip shall have a side slope of either 7H:1V at accessible deep water areas or 5H:1V in other areas around the wetland.

4.12.16 Outflow Control

The quickest drawdown time shall be 24 hours for a 1:2 year storm to facilitate settling. For the most critical storm event, 90% of the total active storage volume shall have a drawdown time of 96 hours.

Table 4.2: Drawdown Time and Available Volume of Constructed Wetland between NWL and HWL

Time After Commencing Drawdown from Full Level at HWL	Available Volume Between HWL and NWL
≥ 24 hours	Volume equivalent to runoff from 1:2 year storm
48 hours	Volume equivalent to runoff from 1:5 year storm
≤ 96 hours	90% of total storage volume above NWL

4.12.17 Floatables, Oil and Grease

To trap floatable materials, oil and grease, inlets and outlets are to be below normal water level.

4.12.18 Maintenance

i. The Developer is required to provide an O&M manual.

ii. Maintenance and warranty period shall be two years from CCC issuance.

iii. Removal of accumulated sediment during construction from forebays is required prior to issuance of the FAC.

iv. Sediment traps are to be cleaned during the maintenance period.

v. Sediment removal is required when forebay and permanent pool volumes are reduced by greater than 25%.

vi. Replace or adjust plantings and manage nuisance species during the maintenance period.

vii. During the maintenance period, the facility shall be inspected at least twice each year to determine vegetation distribution and the preservation of design depth. These inspection reports shall be submitted when applying for FAC.

viii. In future years, wetland vegetation regeneration should be possible by lowering the water level in the fall season using the control structure.

4.12.19 Monitoring

i. The Developer shall monitor stormwater quality. If required by EPCOR, effluent from the permanent pool shall be sampled and tested for the following parameters: TSS, TP, NH_3, BOD and faecal coliforms each year during the maintenance period and the data provided to EPCOR.

ii. The Developer shall also monitor wetland and upland vegetation and take any corrective action required during the maintenance period.

iii. At the end of the maintenance period, before the issuance of the FAC, the Developer shall ensure that at least 75% of the grass cover and 30% of the non-grass emergent vegetation around the wetland's edge has established given normal seasonal conditions. A vegetation survey by a qualified professional shall be submitted to the City.

4.12.20 Recreational Uses

Planting strategies should deter direct public access to the wetland so as to avoid disturbance of the wetland fauna and to protect the public from the hazards of the SWMF.

4.12.21 Access

Access is required to all inlets and outlets for maintenance, operation of water control structures, removal of debris and litter and vegetation management. Access from arterial roads and freeways should be avoided where possible due to safety concerns of maintenance staff.

4.12.22 Fencing

i. The Developer is required to use natural solutions such as grading and planting strategies to provide safety features for the wetland, inlets and outlets.

ii. The Developer shall provide a fence at the public utility lot boundary with openings for maintenance and public access to trails.

4.12.23 Wildlife

At the discretion of the City and the Developer the design may incorporate features that either encourage or discourage wildlife.

4.12.24 Mosquito Control

The Developer shall include design features that minimize mosquitoes in a constructed wetlands facility. Features can include system design and vegetation management that would preclude stagnant backwaters and shading of the water surface, providing habitat for purple martin, swallows, baitfish, dragon flies, bats and other predators.

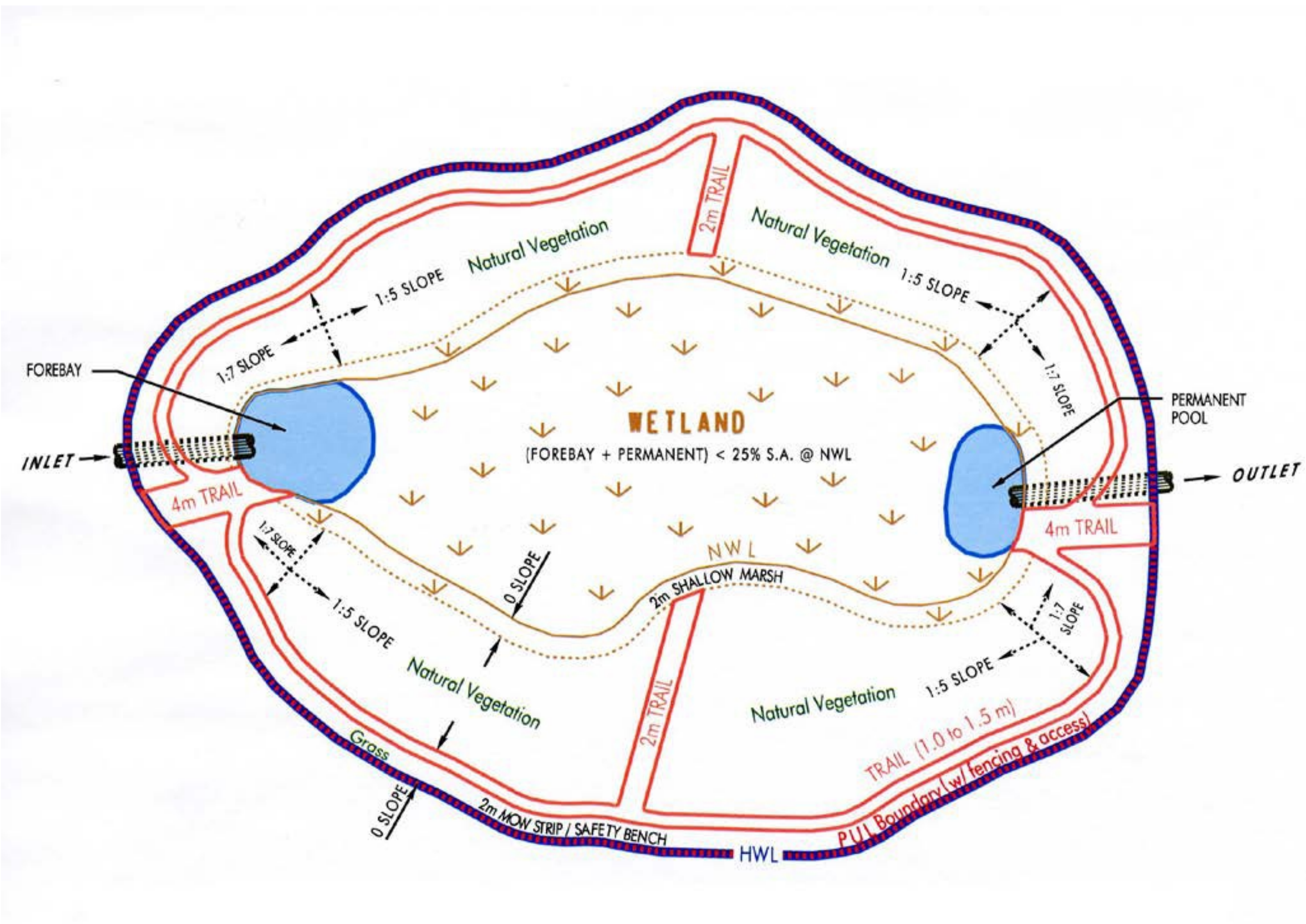

Figure 4.3: Schematic Diagram of a Constructed Wetland

Table 4.3: Summary Guide for the Design of Constructed Wetlands

Design Element	Design Objective	Minimum Criteria	Recommended Criteria
Level of Service/ Volumetric Sizing	To provide appropriate level of protection and adequate volume for quantity (retention) and quality (treatment).	Most critical storm event design and 85% TSS removal of particle size 75µm or greater for water quality. Provide 80 m^3 of dead storage volume per ha for a drainage area 35% impervious. For an area 85% impervious provide a dead storage volume of 140 m^3 per ha of drainage.	
Land Dedication	To apply appropriate designation for specific areas within the wetlands facility	Public Utility Lot - area covered by water at the most critical design storm event; not part of municipal reserve, nor part of area's natural history, nor part of environmental reserve.	
Drainage Area	Maintain the sustainability of the wetlands, provide constant and or periodic flows and prevent stagnant and long periods of dry conditions.	Minimum of 5 ha.	20 ha;
Wetland Surface Area Number of Wetlands	 To provide higher and consistent contaminant removal.	Minimum of 1 ha at NWL. A series of small wetlands offering higher treatment capability can be provided.	 Fewer, larger wetlands preferred.
Soil Characteristics	To maintain a permanent pool of water by minimizing exfiltration.	For wetland deep water areas, 10^{-7} m/s soil permeability; sandy clays and silty clay loams may be suitable when compacted. Construct wetland vegetation zones using soils from displaced wetlands, sterilized topsoil or peat, to a depth of 10-30 cm of the bottom of the wetland.	
Wetland Vegetation Upland Vegetation	Stormwater quality treatment. For public safety. To act as safety bench and also weed barrier to prevent root invasion of adjacent properties by Poplar and Aspen species. To provide aesthetic buffer to adjacent lands.	Plant diverse species within one year after construction; use soils from displaced wetlands or topsoil or peat to a depth of 10-30 cm of the bottom of the wetland. A 2 m wide shallow marsh area around the wetland at NWL. Screening requirements between NWL and the most critical design storm event to be agreed between the Developer and City. A mow strip, minimum 2 m wide, extending from HWL to NWL.	
Water Quality	To provide stormwater treatment	TSS removal is 85% of particle size 75 µm or greater.	
Sediment Forebay (inlet)	To provide sediment removal as pre-treatment and have the ability to re-direct incoming flows as sheet flow with a submerged inlet structure.	Required for major inlets. Depth: 2.4 m to 3.0 m. Total deep surface areas < 25% of wetland surface area. Side slopes: maximum 7 horizontal to 1 vertical (7H:1V) around the area.	
Forebay Length to Width Ratio	Maximize flow path and minimize short-circuiting.	Minimum of 2:1 measured along flow path.	
Permanent Pool (outlet)	To provide a submerged outlet structure and have the ability to regulate water levels.	Depth: 2.4 m to 3.0 m. Total deep areas < 25% of wetland area. Side slopes: maximum of 7H:1V around the area.	
Active Storage Detention Time	To enhance treatment and suspended solids settling.	Drawdown time: ≥ 24 hrs for volume equivalent to runoff from a 1:2 storm; 48 hrs for volume equivalent to runoff from a 1:5 storm; ≤ 96 hours for 90% of total active storage volume above NWL. Dead storage: 80 m^3 of storage volume/ha for a drainage area 35% impervious. 140 m^3 storage volume/ha for a drainage area 85% impervious.	

Design Element	Design Objective	Minimum Criteria	Recommended Criteria
Length to Width Ratio	To maximize flow path and minimize short-circuiting. Provide longer contact time over the surface area of the marsh. Optimize treatment capability.	Effective flow path length to be 3 times the relative wetland width. Incoming water should be well distributed throughout the land and conveyed as sheet flow after the forebay.	
Wetland Depth	To encourage emergent vegetation.	Variety of water depths: 0.1 m - 0.6 m. Average depth: 0.3 m. Deep water areas, >2 m, only in forebay and permanent pool. Water fluctuation in excess of 1 m above NWL should be infrequent.	
Recreational Uses	Public amenity and safety.	A trail may be provided beside the mow strip between NWL and the private property boundary. Planting strategies should deter direct access of public to wetlands.	
Side Slopes	To provide drainage and ensure safety along deep open water. To provide erosion control and accessibility for maintenance.	5H:1V along all edges except at accessible deep water areas in forebay and permanent pool areas where shall be 7H:1V. Terraced slopes are acceptable. The 2 m wide shallow marsh area at the NWL boundary shall be 10H:1V slope.	
Access	For maintenance and operation of water control structures, litter and debris removal and vegetation management.	Required at all inlets and outlets.	
Inlet	Safety and maintenance.	Maximum depth: 3 m. Distanced far away from outlet to avoid short-circuiting of flow. Fully submerged: crown 1.0 m below NWL; invert 100 mm above bottom.	
Outlet	Safety, maintenance and assistance in plant species management.	Use variable water level control structures to regulate water levels between 0.5 m below NWL and 0.5 m above NWL. Maximum depth: 3 m. Distanced far away from inlet to avoid short-circuiting of flow. Fully submerged: crown 1.0 m below normal water level; invert 100 mm above bottom.	
Maintenance Vehicle Access	Access for equipment.	Width: 4 m.	
Fencing	Safety.	Use natural solutions such as grading and planting strategies. Developer should provide fencing around the PUL with openings for maintenance and public access to trails.	
Signage	Safety and public information.	Can use signage and brochures.	
Erosion and Sediment Control	Implement appropriate erosion and sediment controls during development in the drainage area during the construction phase and during the staged-construction of wetland.		
Wildlife	At the discretion of the Developer and the City.		
Mosquitoes	Incorporation of design features that minimize mosquitoes.		
Floatables, Oil and Grease	To trap floatables, oil and grease.	Inlets and outlets are to be below NWL.	

Design Element	Design Objective	Minimum Criteria	Recommended Criteria
Maintenance	To properly operate and maintain constructed wetland; to optimize treatment.	Maintenance and warranty period shall be 2 years from the date of the CCC. Developer to provide an operations and maintenance manual. Replacing and or adjusting plantings, managing nuisance species and cleaning sediment traps are required. Inspect at least twice each year. Sediment removal required when sediment loading reduces forebay and permanent pool volumes by greater than 25%. Provide reinforced grassed maintenance access to forebay and permanent pool, 4 m minimum width.	
Monitoring	To monitor, make necessary corrective actions, and compile data on the use of constructed wetland as a SWMF.	Developer to monitor stormwater quality during the maintenance period. Developer to monitor wetland and upland vegetation and take corrective actions when necessary during the maintenance period. Before issuance of the FAC, the Developer shall ensure that at least 75% of the grass and 30% of the emergent vegetation around the wetland's edge has established. A vegetation survey by a qualified professional shall be submitted to the City.	

4.13 Design Standards for Dry SWMFs

4.13.1 Land Dedication for Dry SWMFs

i. Dry SWMFs to be operated by EPCOR Drainage Services are to be located within public utility lots that encompass all lands subject to inundation at the 5 year design high water level.

ii. Lands subject to inundation for larger storm events, to the limit of inundation for the design maximum event, are to be either:

- included within the Public Utility lots, or
- privately owned land covered by an easement in favour of EPCOR Water Services Inc. to permit the encroachment of water onto the property and restrict development in areas subject to inundation.

iii. A restrictive covenant is to be registered on the titles of lots abutting the dry SWMF onto which ponded water will encroach in order to control lot development below HWL so as not to compromise the dry SWMF design requirements. This will also ensure that an adequate freeboard is maintained.

4.13.2 Frequency of Operation

i. All dry SWMFs shall be off-line storage areas designed to temporarily detain excess runoff and reduce the peak outflow rates to the downstream system.

ii. Designs that propose containment of runoff due to events more frequent than 1:2 years are to include special provisions to facilitate clean up, i.e. paved bottom areas or having a slope of 2% to the outlet to prevent ponding.

4.13.3 Depth of Ponding

The maximum live storage limit in a dry SWMF is 3.0 m measured from the invert elevation of the outlet pipe.

4.13.4 Dry SWMF Bottom Grading and Drainage

The dry SWMF shall be graded to properly drain all areas after its operation. The SWMF bottom shall have a minimum slope of 0.7% and a slope of 1.0% or greater is recommended where feasible. Lateral slopes shall be 1.0% or greater. French drains or similar may be required where it is anticipated that these slopes may not properly drain the dry SWMF bottom, or where dictated by multiple use or other special considerations.

4.13.5 Side Slopes

Side slopes subject to inundation upon filling of the dry SWMF shall have a maximum slope of 7H:1V within private property and a maximum slope of 5H:1V within public property.

4.13.6 Landscaping

Landscaping of dry SWMFs is to be considered part of the construction and plans shall be submitted with the engineering drawings. The minimum requirement for landscaping of dry SWMFs shall be as specified in the City of Edmonton Design and Construction Standards, Volume 5: Landscaping.

4.13.7 Inlets and Outlets

i. All inlet and outlet structures associated with dry SWMFs shall have grates provided over their openings to restrict access and prevent entry into sewers by children or other persons. A maximum clear bar spacing of 100 mm shall be used for gratings.

ii. Grated outlet structures are to be designed with a hydraulic capacity of at least twice the required capacity to allow for possible plugging. Further, the arrangement of the structures and the location of the grating shall be such that the velocity of the flow passing through the grating does not exceed 1.0 m/s. Appropriate fencing and guard-rails are to be provided to restrict access and reduce the hazard presented by headwalls and wing walls.

iii. The inlet and outlet should be physically separated around the perimeter of the dry SWMF. The inlet and outlet should be distanced as far as possible from each other to avoid hydraulic short-circuiting.

5.0 LID FACILITY DESIGN

5.1 Site Planning Considerations

Integration of Low Impact Development (LID) into site planning is the key to applying LID facilities holistically. This means strategically placing them with considerations of site grading and soil conditions and satisfying various setbacks from buildings, utilities and road infrastructure. The following should be considered when siting an LID facility:

- Site drainage patterns, topography, and grading;
- Catchment characteristics such as area, land use, and imperviousness; LID facilities should not be sited in areas with high contamination potential such as gas stations;
- LID facility layout and footprint;
- Connection to the drainage system (if applicable);
- Underlying soil permeability if applicable and load-bearing capacity;
- Clearance to groundwater table;
- Buffers and setbacks;
- Utility conflicts;
- Integration with the existing/proposed use of space (i.e. streetscaping, impacts to pedestrian movements, etc.) including future use of space;
- Impacts to existing tree plantings;
- Cost implications of system configuration and size; and
- Future operations & maintenance of the facility and surrounding infrastructure.

For large developments that require an Area Master Plan (AMP), an inventory of the physical attributes including a hydrogeotechnical impact assessment and environmental impact assessment is provided as part of the AMP. The AMP and relevant studies (as well as those preceding them as per the Volume 3 Drainage Design and Construction Standards - Vol. 3-01: Development Planning Procedure and Framework) should provide an understanding of the relationship between shallow groundwater and local surface water resources. The AMP should explore the potential of incorporating LID as a best management practice (BMP) for stormwater management. LID should not be viewed as a redundant system, but as a necessary part of the integrated stormwater management system that helps to meet the environmental objectives. Prior to proceeding with LID for large developments the following information must be gathered:

- Proximity to nearby building foundations and roadway infrastructure, and likelihood of a perched water table. The investigation depth is dependent upon site conditions such as presence of sensitive receptors (e.g. surface water bodies) and slopes.
- Interaction between groundwater and surface water near watercourses and in the vicinity of wetlands and marshes to assess slope stability and aid in protecting natural areas from poor-quality runoff and alteration of natural surface water-ground water interactions.
- Potential slope stability issues.
- The direction and rate of groundwater flow (hydraulic gradient and hydraulic conductivity).
- The potential vertical hydraulic conductivity of the soil above the water table (e.g., expected infiltration rates and percolation rates) and horizontal hydraulic conductivity of saturated soils if bioretention gardens are proposed.

Local geotechnical data must be reviewed for smaller infill and redevelopment sites – this can be through previous reports from nearby sites or municipal projects, or can be collected during foundation/other site excavation. The following must be considered prior to construction of LID on a smaller site, however does not need to be field verified.

- Proximity to nearby building foundations and roadway infrastructure, and likelihood of a perched water table.
- Interaction between groundwater and surface water near watercourses and in the vicinity of wetlands and marshes to assess slope stability and aid in protecting natural areas from poor-quality runoff and alteration of natural surface water-ground water interactions.
- Potential slope stability issues.
- Groundwater levels, particularly the seasonally high water level.

The following features must be identified and assessed for all developments (large or small) including:

- The distribution of surficial geological materials and soil types within the development.
- The topography, hydrology (surface watercourses, and storage features, if any) and hydrogeology (groundwater characteristics) including;
  - Watercourses, wetlands, and marshes;
  - Areas of potential groundwater and surface water interaction;
  - Recharge and discharge areas; and
  - The probable depth, direction and rate of groundwater flow (estimated at the reconnaissance or desktop level of planning).
- The geotechnical hazard areas including areas of geological hazards, abandoned coal mines or geotechnical instability of slopes including identifying preliminary setbacks.

5.2 Design Basis

5.2.1 LID facilities shall be designed to retain and store a minimum of 18 mm of rain from their contributing impervious catchment area. The impervious area includes paved surfaces, roofs, and surfaces that do not allow infiltration of water.

5.2.2 The I/P ratio shall not exceed 50:1 where I is the impervious area of the contributing drainage area and P is the surface area of the LID facility. The I/P ratio should be 10:1 or lower for catchment areas having a high sediment or winter salt load. An I/P ratio of 20:1 is common and may be used for roads and parking areas with a lower sediment load, e.g., smaller roads and parking areas and those that do not receive winter sanding loads.

5.2.3 Design storm events for piping infrastructure and maximum surface ponding are the 1:5 year 4 hour event and 1:100 year 4 hour event, respectively.

5.2.4 LID facilities must not be located on top of bank lands. LID facilities should be located at a minimum distance of 50 m from the top of bank or as specified in the geotechnical engineering assessment for the subject lands. If site restrictions for LID facilities are not specifically addressed in the geotechnical report for the subject lands, the location of LID facilities must follow the "Water Feature" setback requirements as identified in the neighbourhood ASP and associated geotechnical engineering assessment.

5.2.5 A minimum setback of 3.0 m from buildings is recommended; however LID facilities must be located a minimum setback of 1.0 m from buildings. An impermeable membrane must be placed within the slopes excavation on the side of the LID adjacent to the foundation and must extend at least half-way through the LID facility. Sub-excavation must not extend below the bottom of the basement's slab and all Alberta Health, Safety and Environment regulations and building codes must be followed. Where this setback and/or these controls are not possible, site specific analysis and a signed and stamped design by a qualified professional is required.

- Impermeable membranes must be linear low-density polyethylene (LLDPE) 20-mil following the minimum specifications identified in ***Table 5.1***. Subgrade should be smooth and devoid of rocks, lumps, depressions and others that may affect the liner's integrity. The membrane should be installed following the manufacturer's specifications.

Table 5.1: LLDPE 20-MIL Minimum Specifications

Property	Test	Frequency	Unit	Value
Thickness (min. avg.)	ASTM D-5199	Per roll	mm (in)	0.50
Sheet Density	ASTM D-1505	90,000 kg (200,000	g/ml	0.939
Carbon Black Content	ASTM D-1603	20,000 kg (45,000 lb)	%	2.0 - 3.0
Tensile Strength at	ASTM D-6693	9,000 kg (20,000 lb)	N/mm (lb/in)	13 (76)
Elongation at Break	ASTM D-6693	9,000 kg (20,000 lb)	%	700
Tear Resistance	ASTM D-1004	20,000 kg (45,000 lb)	N (lb)	50 (11)
Puncture Resistance	ASTM D-4833	20,000 kg (45,000 lb)	N (lb)	124 (28)

- Waterproofing membranes may also be applied to the building walls at sites with nearby LID facilities. Use of both impermeable membranes and waterproofing membranes can further reduce setback distances.
- If an impermeable membrane is required for a facility, the designer should consider this when determining plant selection.

5.2.6 The required offsets from utilities vary and are set by the utilities themselves, if applicable utility standards should be followed or utilities should be consulted prior to installing LID facilities over or in proximity to utilities. Proximity to water utilities are covered extensively in the City of Edmonton Volume 4 Water Design & Construction Standards.

5.2.7 Depth to the seasonally high groundwater below the LID facility invert (bottom of the drainage layer) should be no less than 1.0 m to prevent groundwater intrusion. Groundwater levels will fluctuate seasonally and in response to climatic conditions.

- If the distance from the base of the proposed LID to the water table is less than 1.0 m, fluctuations in groundwater should be monitored for at least a year in the field by installing a borehole/monitoring well as directed by a qualified geotechnical professional when the area is near proposed grade. If groundwater levels are monitored for a year, 0.6 m would be the minimum acceptable separation.
- If a detailed field assessment is not feasible, existing records should be reviewed and indicate that groundwater levels are 1.0 m below the LID facility.
- Adjustments to these buffer distances may be considered if a signed and stamped geotechnical

assessment and design has been completed. The design must consider potential lift of the underdrain system, and must use controls that limit/stop the movement of groundwater into the LID system.

5.2.8 For large developments a geotechnical assessment that includes soil type classification and groundwater evaluation is required across the developed site before selecting and implementing the LID facilities. In addition, hydraulic conductivity testing is required for facilities which lack an underdrain system (bioretention gardens), and which drain exclusively to groundwater. LID facilities with an underdrain system (bioretention basins, box planters and soil cells) can be located over any soil type including high plastic clays (CH).

The following is a guide to field work for large developments, but will vary based on the location, size, number and type of LID facility(s), and complexity of the development area.

- Drilling a network of shallow boreholes placed at approximately 200 m centres to evaluate the potential variation in soil conditions within the development. For a development area of less than 1 ha, one borehole or excavation pit is required. The extent of this effort will largely depend on what information is already available.
- Visual classification of soil types (textures) from soil samples collected during drilling using the Unified Soil Classification System (USCS). The first 3.0 m of depth for LID facility assessments is the most critical soils information to obtain.
- Conducting standard penetration tests (SPTs) to identify zones of changing soil strength and consistency in terms of loose and consolidated soil. These tests aid in defining low permeability barriers that may inhibit infiltration capacity of native soil and suggest certain LID facilities over others.
- Installing a borehole or excavation pit in the area of the LID for some local design information. Larger areas and areas of complex surficial geology may require additional investigation to evaluate groundwater depth.
- Depth to groundwater across the site must be calculated using borehole data. To undertake surface infiltration estimates, use of the following methods: the double ring, the Guelph Permeameter, or the Modified Phillips Dunne permeameter method, provided consideration is given to the specific site conditions and the suitability of each method's application.

A design report supported by construction drawings (see ***Table 5.3*** for requirements) must be submitted for large developments. A qualified professional must stamp the reports and drawings.

- If applicable, the construction details of the geosynthetics used should include hydraulic conductivity and thickness (either as a hydraulic conductivity to achieve designed infiltration rates to support runoff targets, or the hydraulic conductivity required to minimize infiltration, depending upon the criteria that best satisfies the LID objective(s)).
- If a synthetic liner will be used to minimize infiltration, the specifications of the liner material must be provided and supported by the manufacturer's detailed specifications. Recommendations on how to protect the liner from damage during construction and long-term maintenance requirements, if any, shall be provided.
- An assessment of the designed infiltration rates of the infiltration areas and underdrains, and the methods for verifying that these infiltration rates will be achieved post-construction.
- An analysis of the stability of the LID side slopes and surrounding area based on soil type(s) found if applicable.
- Analysis of the impact of percolation and underdrains on the water table, including the potential for impact on roadway infrastructure.
- Recommendations on monitoring and maintenance requirements.
- Test results to demonstrate that permeability between soil media/subgrade drains and the surrounding native soil will promote downward drainage for facilities that are designed for infiltration into native soils.

5.3 Bioretention Garden Design

5.3.1 Definition

Bioretention gardens are a type of LID facility with a shallow depression. On the surface, bioretention gardens may appear similar to flower / shrub beds, however bioretention gardens utilize the specified LID Soil Media (Section ***5.12***) and vegetation to capture and treat rainwater and are located at the low point of a landscape. They use vegetation and specialized soil media to filter and retain stormwater and provide stormwater management by promoting absorption, evapotranspiration, and interception. Bioretention gardens have no underdrain. They consist of pre-treatment, a flow entrance, ponding area, plant materials, soil media, and structural storage layers. Structural storage layers are any man-made component that aids in the storage of water such as a storage tank/pipe, storm chamber, or soil cell structure; this list is not exhaustive and other man-made components could be utilized. A structural man-made storage layer/component is an essential component of bioretention gardens.

Bioretention gardens are at much higher risk of freezing and should have natural underlying permeability rates of greater than 15 mm/hr (hydraulic conductivity greater than $4x10^{-4}$ cm/s) unless designed as a closed system which stores runoff i.e. the structural man-made storage component does not allow infiltration into the native soils. High plastic (CH) soils have permeability less than 15 mm/hr and are susceptible to changes in volume upon changes in moisture content. There is a possibility of swelling if the moisture content of these soils is increased due to saturation and low infiltration rates, and swelling of 50 mm or more is possible in localized areas. This could lift and damage adjacent road and sidewalks. In-situ analysis with the Guelph Permeameter (combined reservoir two head) method using shallow uncased wells up to 1.0 m deep is an alternative to a full geotechnical investigation with conventional monitoring wells and hydraulic conductivity testing.

If a facility does not have a structural man-made storage layer/component it would be classified as a rain garden; for rain garden design guidance refer to the City of Edmonton *Low Impact Development - Best Management Practices Design Guide*.

5.3.2 Sizing Requirements

i. The contributing impervious catchment area is less than 2 ha.

ii. Retain runoff volume through ponding and surface infiltration for 18 mm of rain from its contributing impervious catchment area.

iii. Show that the high water level (HWL) during the 100-year, 4-hour design event does not compromise adjacent structures, i.e. drainage away from the facility is sufficient.

iv. Duration of ponded water following a design event (see Section ***5.2***) should be less than 48 hours.

v. See Section **5.2.2** for I/P ratios.

vi. Ponding depth within the bioretention garden is a maximum of 200 mm.

5.3.3 Surface Flow Velocity to prevent erosion

i. Maximum 0.3 m/s in planted areas

ii. Maximum 0.9 m/s in mulched zones

5.3.4 Surface Geometry and Side Slope

i. Flat bottom, with a recommended minimum length/width ratio of 2:1, as applicable. If a bioretention garden is irregularly shaped it should be designed to allow water infiltration throughout the bioretention garden.

ii. For areas immediately adjacent to a sidewalk or shared-use path, the preferred maximum side slope of the bioretention garden is 5:1 (H:V), and the maximum allowable side slope is 3:1 (H:V).

iii. For all other areas the preferred maximum side slope of the bioretention garden is 4:1 (H:V); the maximum allowable side slope is 3:1 (H:V). This only applies to the facility itself, and slopes outside of the facility must meet the requirements of its own land use.

5.3.5 Inlet

i. 0.5 m to 3 m grass filter buffer for non-point source inlets or erosion control at point source inlets, this could also include a filter spreader. Point source inlets can be installed above or below ground with an energy dissipater. Energy dissipaters may include (but are not limited to) rocks, or a drop/ramp between the pavement and grass.

ii. Filter strips to buffer salt impacts are required for collector and arterial roadways, and parking lots. Filter strips are recommended to be 3-5 m in width which may include the sidewalk, if applicable.

5.3.6 Media Layers

i. If a mulch layer is used, the mulch shall be long, fibrous non-floatable organic mulch. Non-floating mulch should be composted and a blend of fine and coarse bark and must be aged a minimum of 4-6 months. The depth of the mulch during establishment should be 80 mm or as determined by the designer. A compostable netting may be used to stabilize mulch during establishment of vegetation. Mulch is not required if sufficient ground cover is proposed.

ii. The LID growing soil media shall meet the specifications in Section ***5.12***. The minimum depth is 300 mm.

iii. The filter layer is 100 mm depth with 14 mm washed rock with less than 0.1% silt. If used, the granular filter layer around the facility should have a minimum thickness of 100 mm with 14 mm washed rock and less than 0.1% silt. Where situations permit, a greater depth may be applied.

iv. The storage layer must have a man-made structural layer/component that aids in the storage of water (see Section ***5.3.1*** for additional details).

5.3.7 Geotextile

i. Non-woven geotextiles are NOT recommended within LID facilities between media layers; if space and design allow, using granular filter layers to limit sediment transport is preferred.

ii. If geotextile is used for filtration or sidewall coverage, it should be woven monofilament or non-woven needle punched fabrics. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. Geotextile fabric may be placed along the sides of the LID facilities to help direct the water flow downward and to reduce lateral flows if sand seams exist.

iii. If geotextile must be used within the LID to control transport of sediments, the permeability rate should be higher than that of the soil or 3 $m^3/min/m^2$ (75 $gal/min/ft^2$), whichever is greater.

5.3.8 Buffer

i. The facility base must be at least 0.6 m to 1.0 m above the seasonally high groundwater table (see Section ***5.2.7*** for additional details). If required (i.e. if facility is not a closed system and relies on natural infiltration), groundwater mounding calculations must be conducted to ensure mounded groundwater will not affect nearby structures or features.

ii. Horizontal buffers are 3.0 m from building foundations, or closer with the use of engineering controls and as approved by a geotechnical professional (see Section ***5.2.5*** for additional details).

iii. Provide a buffer of at least 0.5 m from sidewalks and 0.6 m from Shared Use Pathways.

Figure 5.1 shows an example of a typical bioretention garden layout, and is for illustrative purposes only, it does not depict every detail that may be required for successful construction, operations, and maintenance. These figures are one variation of the many scenarios that exist and any scenario that meets the requirements of the standards can be proposed. The man-made storage layer/component depicted in ***Figure 5.1*** is simply a placeholder, and actual requirements of the layer are described in Section ***5.3.1.***

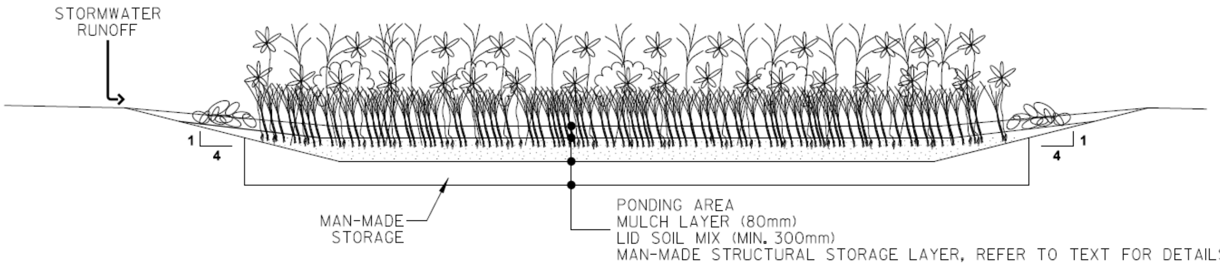

Figure 5.1: Bioretention Garden Cross Section

5.4 Bioretention Basin Design

5.4.1 Definition

A bioretention basin is a type of LID facility that relies on vegetation, specialized soil media and a storage layer to infiltrate, filter, detain, and retain stormwater runoff. Bioretention basins provide stormwater management by promoting absorption, evapotranspiration, and interception. Bioretention basins consist of pre-treatment, flow entrance/inlet, ponding area, plant materials, LID soil media, filter layer, storage layer, underdrain, and overflow outlet.

A bioswale is a type of linear bioretention LID with a small slope to convey water. In order to be considered a bioretention facility, a bioswale requires a minimum of 400 mm of LID soil (reduced from the typical 500 mm minimum), an underdrain connecting to the storm sewer and the surface slope must not be greater than 3%. If the surface slope is 1% or greater, check dams must be used.

5.4.2 Sizing Requirements

i. The contributing impervious catchment area is less than 4 ha.

ii. Retain runoff volume through ponding and surface infiltration for a minimum of 18 mm from the contributing impervious catchment area.

iii. Show that the HWL during the 100-year, 4-hour design event does not compromise adjacent structures, i.e. drainage away from the facility is sufficient.

iv. Duration of ponded water following a design event (see Section ***5.2***) should be less than 48 hours.

vii. See Section **5.2.2** for I/P ratios.

v. Ponding depth within the bioretention basin is a maximum of 350 mm.

5.4.3 Surface Flow Velocity to Prevent Erosion

i. Maximum 0.3 m/s in planted areas;

ii. Maximum 0.9 m/s in mulched zones

5.4.4 Surface Geometry and Side Slope

i. Flat bottom, with a recommended minimum length / width ratio of 2:1 as applicable. If a bioretention basin is irregularly shaped it should be designed to allow water infiltration throughout the bioretention basin.

ii. For areas immediately adjacent to a sidewalk or shared-use path, the preferred maximum side slope of the bioretention basin is 5:1 (H:V), and the maximum allowable side slope is 3:1 (H:V).

iii. For all other areas the preferred side slope of the bioretention basin is 4:1 (H:V); the maximum allowable side slope is 3:1. This only applies to the facility itself, and slopes outside of the facility must meet the requirements of its own land use.

iv. For bioswales surface slopes must not be greater than 3%. If the surface slope is 1% or greater, check dams must be used.

5.4.5 Inlet

i. Inlets may include (but are not limited to) curb cuts, CBs, filter strips, flow spreaders, curb cuts with grates or sidewalk grates. Sidewalk grates may only be used in certain applications after other options have been evaluated. If sidewalk grates are to be used they must have firm, stable, slip resistant, and heel-friendly covers; care must be taken to ensure the grates are level with the existing sidewalk.

ii. 0.5 m to 3 m grass filter buffers for non-point source inlets or erosion control at point source inlets are recommended. Erosion control and/or energy dissipation must be appropriate to the type of inlet, anticipated inflow, and the location. Erosion control and energy dissipation methods chosen must be permanent and control erosion throughout the life of the bioretention basin.

iii. Point source inlets can be installed above or below ground with an energy dissipater. Energy dissipaters may include (but are not limited to) rocks, or a drop/ramp between the pavement and grass.

iv. Filter strips to buffer salt impacts are required as follows: 3-5 m width along collectors (may include sidewalk), parking lots, and arterials (if necessary).

v. Pre-treatment is required to capture large particles and debris and prevent the spread of sediments on the surface of the bioretention basin.

vi. Inlets must be situated to allow for maintenance of both the inlet and the erosion control/energy dissipater (if applicable). Inlets should not be situated directly adjacent to overflows to encourage water movement throughout the LID. Proximity of inlets to potential obstructions should be minimized to reduce inlet blockage.

5.4.6 Media Layers

i. If a mulch layer is used, the mulch shall be long, fibrous non-floatable organic mulch. Non-floating mulch should be composted and a blend of fine and coarse bark and must be aged a minimum of 4-6 months. The depth of the mulch during establishment should be 80 mm or as determined by the designer. A compostable netting may be used to stabilize mulch during establishment of vegetation. Mulch is not required if sufficient ground cover is proposed.

ii. The LID growing soil media shall meet the specification in Section ***5.12***. The minimum depth is 500 mm unless it is not feasible due to site constraints.

iii. The filter layer is 100 mm depth with 14 mm washed rock with less than 0.1% silt. If used, the granular filter layer around the facility should have a minimum thickness of 100 mm with 14 mm washed rock and less than 0.1% silt. Where situations permit, a greater depth may be applied.

iv. The drainage layer is a minimum of 400 mm in depth with 25 mm - 40 mm angular crushed rock containing less than 0.1% silt.

5.4.7 Geotextile

i. Non-woven geotextiles are NOT recommended within LID facilities; if space and design allow, using granular filter layers to limit sediment transport is preferred.

ii. If geotextile is used for filtration or sidewall coverage, it should be woven monofilament or non-woven needle punched fabrics. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. Geotextile fabric may be placed along the sides of the LID facilities to help direct the water flow downward and to reduce lateral flows if sand seams exist.

iii. If geotextile must be used within the LID to control transport of sediments, the permeability rate should be higher than that of the soil or 3 $m^3/min/m^2$ (75 $gal/min/ft^2$), whichever is greater.

5.4.8 Underdrain Perforated Pipe

i. All Piping and Infrastructure Considerations in Section ***5.7*** must be followed.

5.4.9 Buffer

i. The facility base must be at least 0.6 m to 1 m above the seasonally high groundwater table (see

Section ***5.2.7*** for additional details).

ii. Horizontal buffers are 3.0 m from building foundations, or closer with the use of engineering controls and as approved by a geotechnical professional (see Section ***5.2.5*** for additional details).

Figure 5.2 shows plan and profile views of a typical bioretention basin layout with curb cut inlets, and are for illustrative purposes only, they do not depict every detail that may be required for successful construction, operations, and maintenance. Another common method of surface water capture are catch basin inlets as shown in ***Figure 5.3***. These figures are two variations of the many scenarios that exist and any scenario that meets the requirements of the standards can be proposed.

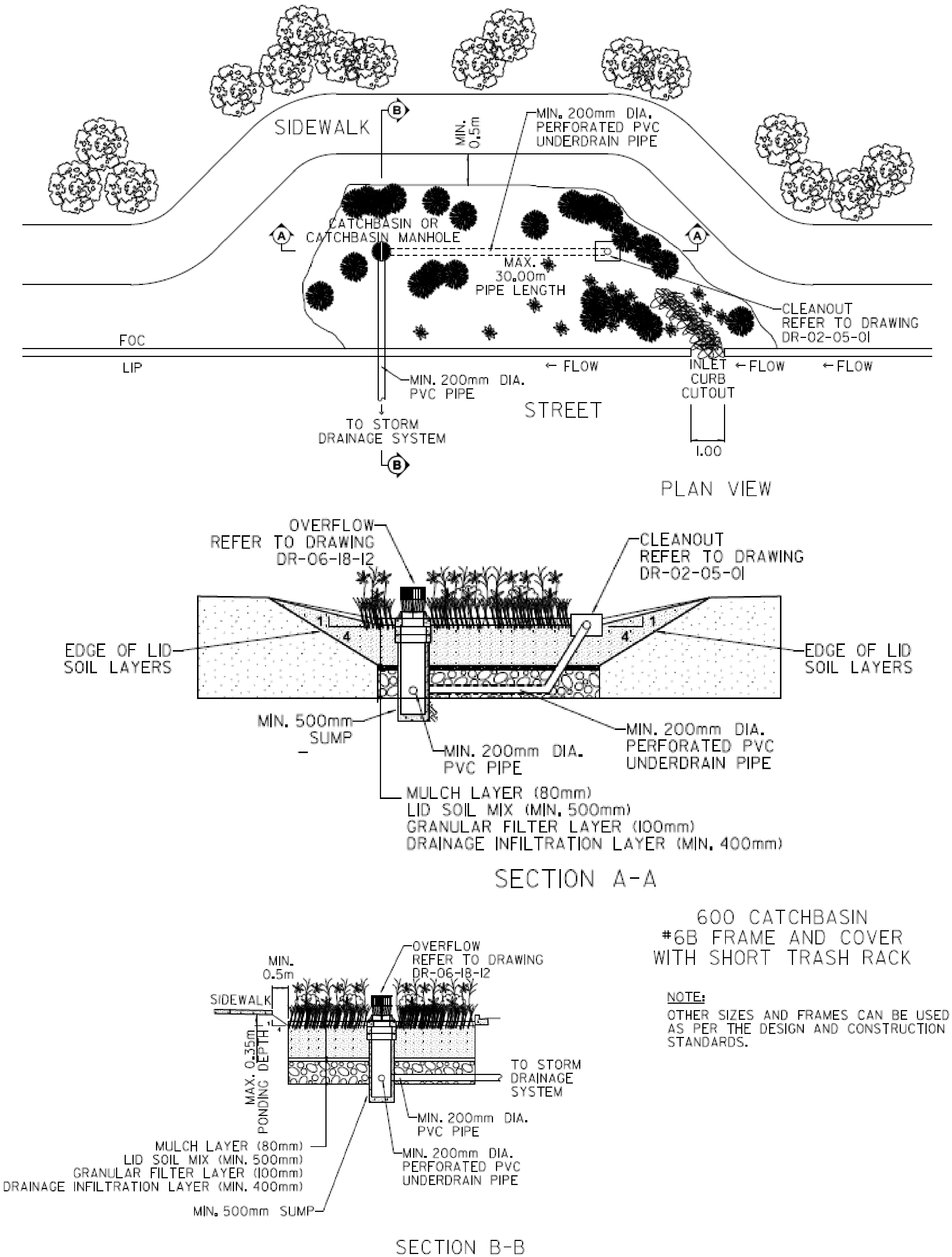

Figure 5.2: Bioretention Basin Plan View and Cross Sections

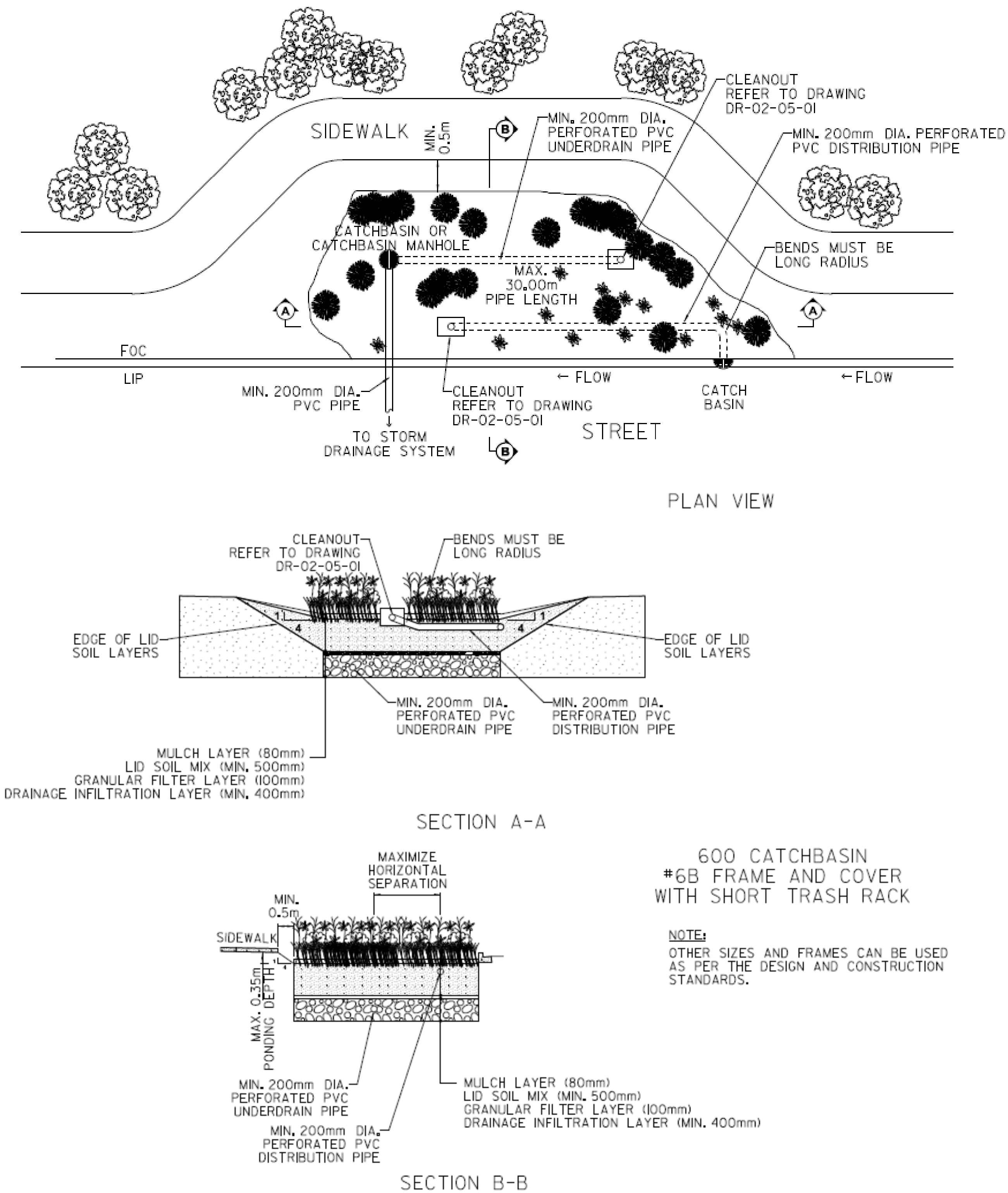

Figure 5.3: Bioretention Basin with Catch Basin Inlet Plan View and Cross Sections

5.5 Box Planter Design

5.5.1 Definition

Similar to bioretention basins, box planters use vegetation and specialized soil media to filter and retain stormwater and provide stormwater management by promoting absorption, evapotranspiration, and interception; however box planters are contained within a box-like structure. Box planters are ideal for areas with small footprints such as downtown as they have smaller footprints (vertical sides) and can be located close to buildings. Box planters can be raised, level with the surrounding area, or depressed below ground. Box planters contain an underdrain pipe and may or may not have a self-containing bottom.

5.5.2 Sizing Requirements

i. The contributing catchment area is less than 0.5 ha.

ii. Retain runoff volume through ponding and surface infiltration for 18 mm of rain from its contributing impervious catchment area.

iii. Show that the high water level (HWL) during the 100-year, 4-hour design event does not compromise adjacent structures, i.e. drainage away from the facility is sufficient.

iv. Duration of ponded water following the design event (see Section ***5.2.3***) should be less than 48 hours.

v. See Section **5.2.2** for I/P ratios.

vi. Ponding depth is a maximum of 350 mm.

5.5.3 Surface Flow Velocity to Prevent Erosion

i. Maximum 0.3 m/s in planted areas.

ii. Maximum 0.9 m/s in mulched zones, to prevent erosion.

5.5.4 Planter Material

i. Stone, concrete, brick, clay, or plastic are acceptable materials for the contained planters.

5.5.5 Surface Geometry and Surface Slopes

i. The width of the box planter must be greater than or equal to 450 mm.

ii. Surface slopes less than 0.5%.

5.5.6 Inlet

i. Erosion control and energy dissipaters at inlets. Energy dissipaters may include (but are not limited to) rocks, a downspout impact baffle, or a drop/ramp between the pavement and grass.

ii. Inlets may include (but are not limited to) curb cuts, curb cuts with grates, roof leaders, CBs, or concrete flow spreaders.

iii. Pre-treatment may be required to capture large particles and debris and prevent the spread of sediments on the surface of the box planter.

5.5.7 Media Layers

i. If a mulch layer is used, the mulch shall be long, fibrous non-floatable organic mulch. Non-floating mulch should be composted and a blend of fine and coarse bark and must be aged a minimum of 4-6 months. The depth of the mulch during establishment should be 80 mm or as determined by the designer. A compostable netting may be used to stabilize mulch during establishment of vegetation. Mulch is not required if sufficient ground cover is proposed.

ii. The LID growing soil media shall meet the specification in Section ***5.12***. The minimum depth is 500 mm unless it is not feasible due to site constraints.

iii. The filter layer is 100 mm depth with 14 mm washed rock with less than 0.1% silt. If used, the granular filter layer around the facility should have a minimum thickness of 100 mm with 14 mm washed rock and less than 0.1% silt. Where situations permit, a greater depth may be applied.

iv. The drainage layer is a minimum of 400 mm in depth with 25 mm - 40 mm angular crushed rock containing less than 0.1% silt.

5.5.8 Geotextile

i. Non-woven geotextiles are NOT recommended within LID facilities; if space and design allow, using granular filter layers to limit sediment transport is preferred.

ii. If geotextile is used for filtration or sidewall coverage, it should be woven monofilament or non-woven needle punched fabrics. Woven slit film and non-woven heat bonded fabrics should not be used as they are prone to clogging. Geotextile fabric may be placed along the sides of the LID facilities to help direct the water flow downward and to reduce lateral flows if sand seams exist.

iii. If geotextile must be used within the LID to control transport of sediments, the permeability rate should be higher than that of the soil or 3 $m^3/min/m^2$ (75 $gal/min/ft^2$), whichever is greater.

5.5.9 Underdrain Pipe

i. All piping and infrastructure considerations in Section ***5.7*** must be followed.

5.5.10 Buffer

i. The facility base must be at least 0.6 m to 1 m above the seasonally high groundwater table (see Section ***5.2.7*** for additional details).

ii. Horizontal buffers are 3 m from building foundations, or closer with the use of engineering controls and as approved by a geotechnical professional (see Section ***5.2.5*** for additional details). Box planters may be placed adjacent to buildings with engineering controls approved by a geotechnical professional.

Figure 5.4 shows plan and profile views of a typical box planter layout, and are for illustrative purposes only, they do not depict every detail that may be required for successful construction, operations, and maintenance. These views show the inlet from a curb cut; however these figures are one variation of the many scenarios that exist and any scenario that meets the requirements of the standards can be proposed.

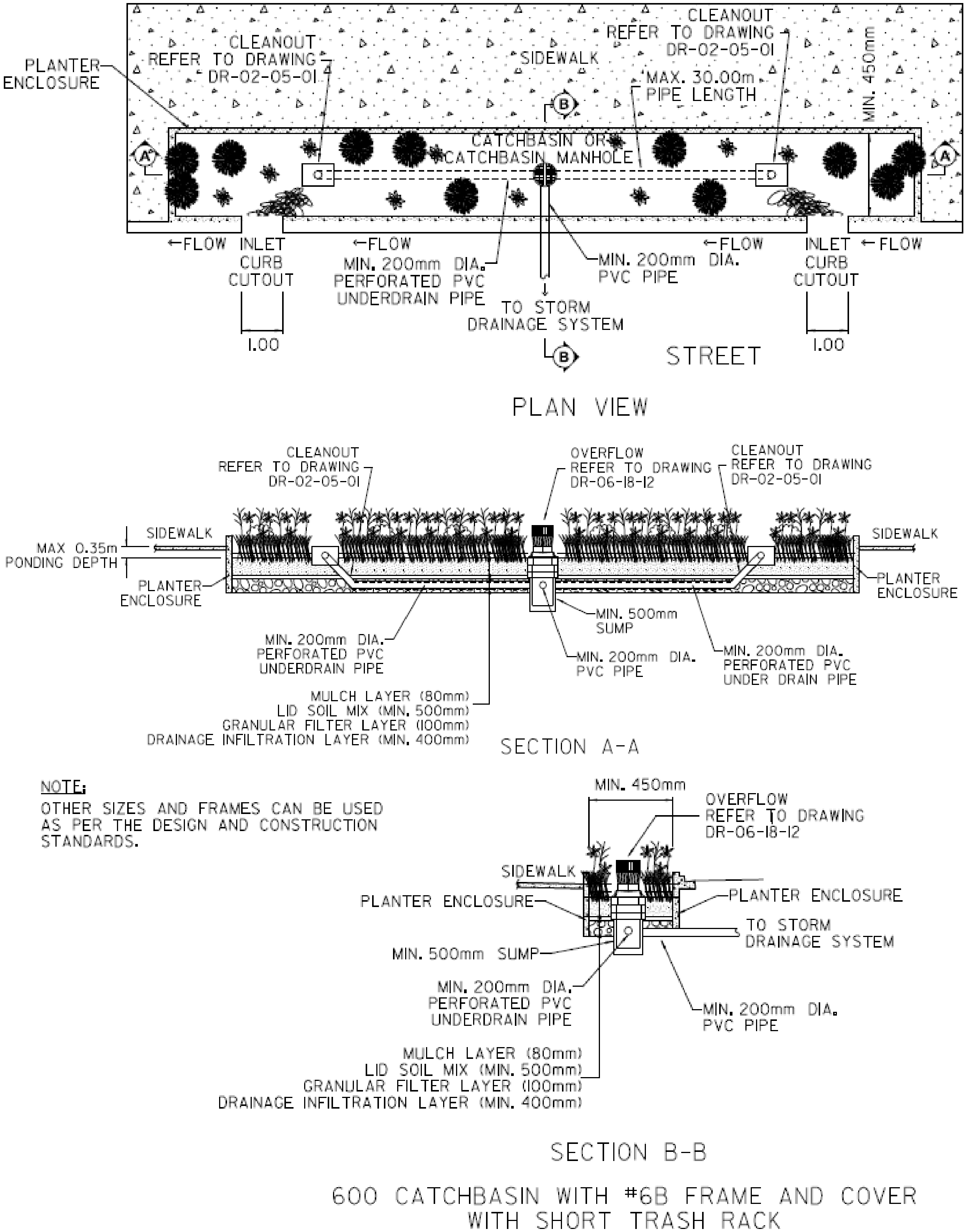

Figure 5.4: Box Planter Plan View and Cross Sections

5.6 Soil Cell Design

5.6.1 Definition

Soil cells provide structural support for sidewalks and roadways while allowing space for specialized soil media to facilitate tree rooting and provide stormwater management by promoting absorption, transpiration, and interception. Stormwater can be directed into the soil cell system through a CB with pre-treatment, roof drain connection, or overland flow through a curb cut.

5.6.2 Sizing Requirements

i. Duration of ponded water following the design event (see Section ***5.2.3***) should be less than 48 hours, if applicable.

ii. Retain runoff volume through ponding and surface infiltration for a minimum of 18 mm, soil cells can also retain additional volume captured during large events.

iii. Show that the HWL during the 100-year 4 hour design events does not compromise adjacent structures.

iv. Meet minimum soil volumes required for trees by the City of Edmonton Volume 5 Landscape Design and Construction Standard.

5.6.3 Geometry and Loading

i. Installed to the size and dimensions of the structural cell module chosen.

ii. Structural cell modules and corresponding pavement (asphalt, concrete, etc.) must be able to handle required loads (typically of the largest vehicle that would be driving over the soil cell), loading must be reviewed and approved by a structural engineer or following manufacturers' specifications. Note: different products may have different load capacities and testing protocols, protocols should be checked for relevance in local jurisdictions.

5.6.4 Inlet

i. Inlets may include (but are not limited to) CBs, roof leaders, trench drains, curb cuts, or pre-treatment devices.

ii. An energy dissipater should be provided if the water flows directly onto the surface of the system. Energy dissipaters may include (but are not limited to) rocks, a downspout impact baffle, or a drop/ramp between the pavement and the soil cell.

5.6.5 Media Layer

i. LID growing soil media shall meet the specifications in Section ***5.12***.

ii. The structural cell module type selected will dictate the media layers required and their corresponding depths and volumes; manufacturer's specifications and recommendations must be followed. Note: soil and media specifications may differ depending on the purpose of the structural cell module. Soil and media must be designed for stormwater retention and detention and to allow tree root growth.

5.6.6 Distribution Pipe

i. A minimum diameter 200 mm perforated PVC distribution pipe shall be installed as per one of the following specifications:

   a) sloped at 0.5% towards a CB or CB-style clean-out;

   b) a level pipe set below the CB inlet; or

   c) as per manufacturer's specifications.

ii. All Piping and Infrastructure Considerations in Section ***5.7*** must be followed.

5.6.7 Underdrain Pipe

i. A minimum diameter 200 mm perforated PVC underdrain pipe shall be installed within an aggregate blanket that extends the length of the pipe or as per manufacturer's specifications.

ii. The underdrain pipe must slope towards the catch basin/manhole.

iii. All Piping and Infrastructure Considerations in Section ***5.7*** must be followed.

5.6.8 Subbase and Subgrade

i. Subbase and subgrade must be prepared and/or installed as per manufacturer specifications and with consultation and approval of a geotechnical engineer.

ii. The native soil subbase must be compacted to a minimum of 95% Standard Proctor density to support the system load unless a geotechnical engineer has indicated another compaction level.

iii. In certain situations manufacturers may require different soils, materials, or geotextiles immediately adjacent to or within the soil cell installation; all manufacturer's specifications/ recommendations must be followed unless approved by a qualified engineering professional.

5.6.9 Buffer

i. The facility base must be at least 0.6 m to 1.0 m above the seasonally high groundwater table (see Section ***5.2.7*** for additional details) unless approved by a qualified engineering professional.

ii. Horizontal buffers are 3 m from building foundations, or closer with the use of engineering controls and as approved by a geotechnical professional (see Section ***5.2.5*** for additional details).

5.6.10 Backfill Material (Adjacent to Soil Cells)

The backfill material adjacent to the soil cell installation must be clean, compactable, coarse-grained (gravel) fill with less than 30% fines, or as per manufacturer's specifications/ recommendations. Backfill material must be free of organic material, trash and other debris, and free of materials toxic to plant growth. Backfill material should be compacted and placed as per the manufacturer's specifications.

Note, in certain situations manufacturers may require different soils, materials, or geotextiles immediately adjacent to or within the soil cell installation; all manufacturer's specifications/ recommendations must be followed unless approved by a qualified engineering professional.

5.6.11 General Considerations

i. The structural systems must meet the requirements of the Complete Streets Design and Construction Standards for roadways, sidewalks, walkways, paths and/or trails.

ii. The soil cells must be designed and tested for the purpose of growing tree roots, and stormwater filtering, detention, and retention.

iii. Soil cells must be able to be installed to allow installation of utilities through the soil cells, if necessary. Installation of utilities through the spaces within the soil cell frames must be approved by the utility owner/operator. All utility lines installed through the soil cells must be secured and braced within the frames. Where utility lines require that the space between cells is larger than 150 mm, bridging must be designed. Utility design must meet offsets from trees.

iv. Geogrid shall be net-shaped woven polyester fabric with PVC coating; inert to biological degradation; resistant to naturally occurring chemicals, alkalis, and acids; and used to provide a stabilizing force within the soil structure. Geogrid must meet the soil cell manufacturer's specifications.

v. Geotextile shall be composed of high tenacity polypropylene yarns which are woven into a network such that the yarns retain their relative position; be inert to biological degradation; and resistant to naturally encountered chemicals, alkalis, and acids. Geotextiles must meet the soil cell manufacturer's specifications.

vi. If a root barrier is required, the root barrier shall prevent root penetration. The root barrier shall be made of an impermeable and ribbed geotextile. The root barrier must be installed the full depth of the soil cells and as needed around utilities or other obstructions through the soil cells. Root barriers must be continuous or interlocking.

vii. Follow the manufacturer's instructions for installation including locations of drainage lines, utilities, geogrid, geotextile, subgrade preparation, paving, and system layout.

viii. In areas of potential change or expansion, an empty conduit should be installed to facilitate ease of future utility installation.

Figure 5.5 shows plan and profile views of a typical soil cell (with trees) layout, and are for illustrative purposes only, they do not depict every detail that may be required for successful construction, operations, and maintenance. These views show the inlet from a CB; however these figures are one variation of the many scenarios that exist and any scenario that meets the requirements of the standards can be proposed.

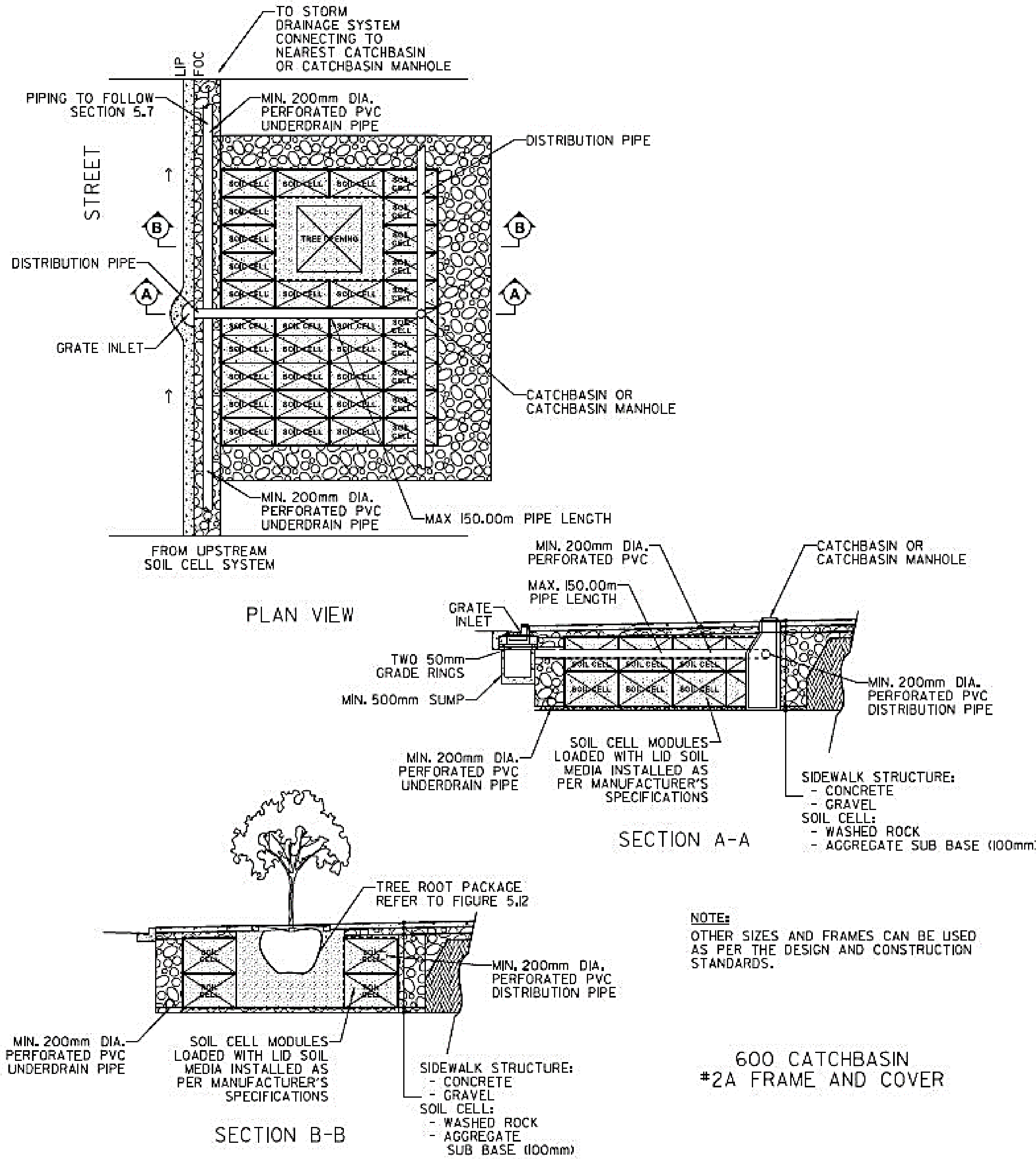

Figure 5.5: Soil Cell Plan View and Cross Section

5.7 Piping and Infrastructure Considerations

5.7.1 All piping must be smooth, rigid, PVC pipe with a minimum 200 mm diameter. This applies to distribution piping, underdrain piping, leads, and cleanouts to surface.

5.7.2 If underdrain piping does not require a cleanout at the upstream end (below minimum lengths and bends/junctions as listed below) it must be capped. Perforated distribution piping must either be capped or come to surface as a cleanout. Piping cannot be capped with any type of fabric, and filter fabric should not be placed inside the piping.

5.7.3 Where bends are required, the maximum angle of bends allowed shall be the long radius type of either 22.5°, 45° or 90°, multiple long radius bends may be used to create a steeper incline for cleanouts but must include a minimum length of 400 mm of straight pipe between bends.

5.7.4 Cleanouts may come to surface at an angle or vertically when provided with a single long radius 90 degree bend (minimum radius of 1200 mm). Cleanouts must contain either an underground enclosure box or an element resistant cover when they come to surface. Covers must only be used for vertical cleanouts that breach a hard surface. Covers must be element resistant, resilient and made of brass, iron or other durable material. When an underground enclosure box is to be used for an angled pipe the box must be installed so that the pipe breaks the surface at the box edge closest to the LID facility. See Standards Drawings DR-02-05-01 and DR-02-05-02 in Vol. 3-06: Construction Specifications and Standards Drawings.

5.7.5 If in-line cleanouts are to be used they must be installed with a Y-junction. In-line cleanouts are not preferred and should only be utilized if no other configuration is feasible.

Each separate piping line must include a manhole or CB to allow for cleaning/flushing of the pipe. CB-style cleanouts may also count as a piping lines' CB if they're within 4 m of an accessible surface (see vii below). The following must also be adhered to, see ***Figure 5.6*** for clarifications.

i. The maximum permitted spacing between a manhole or CB and the next manhole or CB is 150 m.

ii. The maximum amount of bends on a piping line is 90°. If more bends are required, a manhole, CB or CB manhole is required before the next section of piping.

iii. The maximum permitted spacing between cleanouts or a cleanout access point (such as a manhole or CB) is 150 m if there are no bends in that section of pipe. If bends are required between the cleanout and cleanout access point, the maximum permitted spacing is 30 m.

iv. If junctions are to be used both piping lines must contain a cleanout and a CB following the spacing outlined above.

v. See Figure 5.6 for example layouts.

vi. There must be 400 mm of straight pipe immediately exiting a CB or MH before there is a bend.

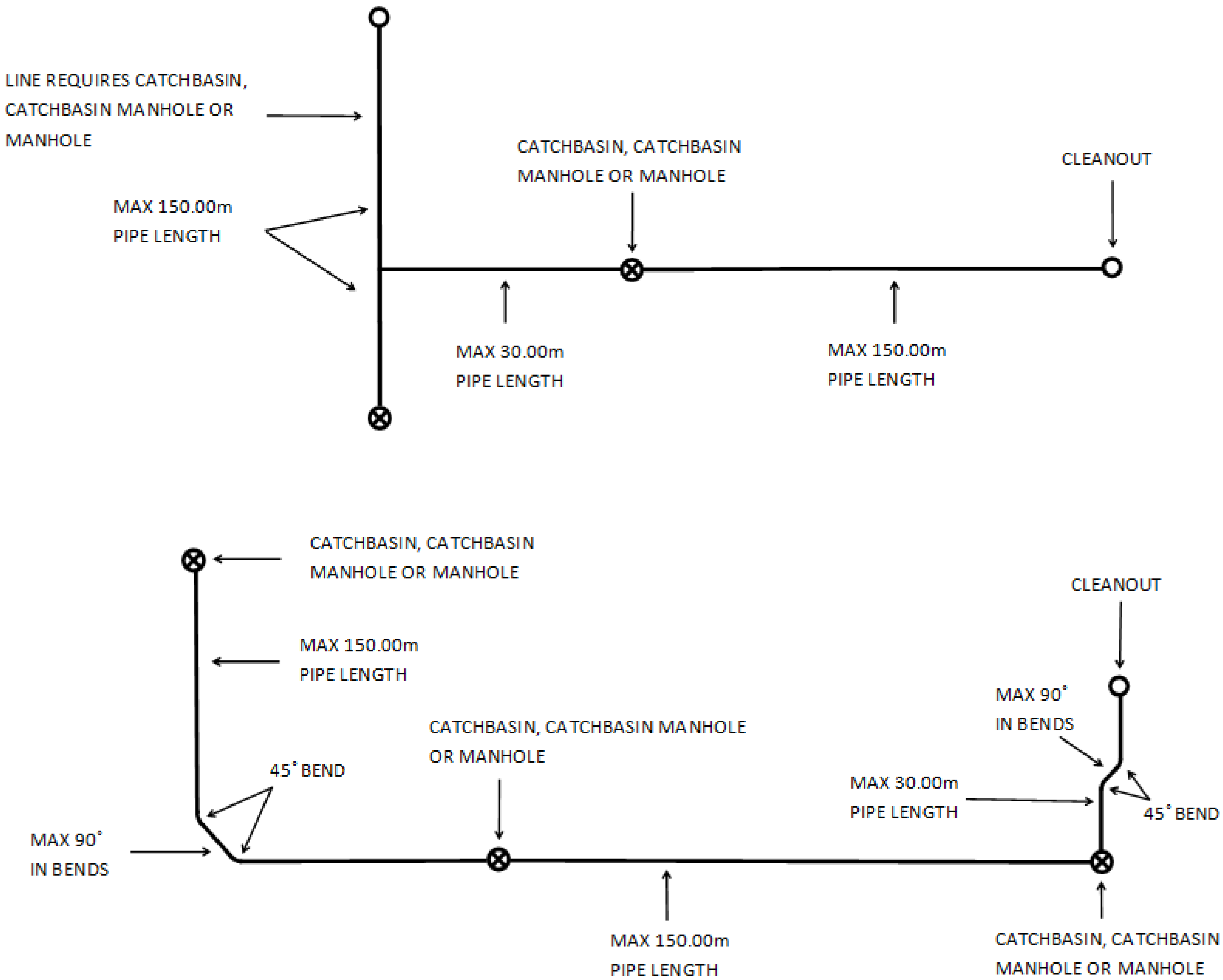

Figure 5.6: Piping Spacing

5.7.6 If a CB (or any access point with a sump) is utilized as the primary cleanout location, the CB must be located within 4 m of a surface kept to emergency access standards, suitable for the use of a vehicle the size of a City of Edmonton fire truck. If feasible, all access points with sumps should be located within 4 m of a surface kept to emergency access standards.

5.7.7 If the minimum required pipe grade is not feasible the following shall apply:

- Piping should be sloped towards the manhole or CB to facilitate drainage of the pipe and allow for proper cleaning/flushing.
- If the sloped pipe would affect the functionality of the LID or is not feasible due to existing infrastructure and grades; piping extending from a manhole or CB must be flat.

5.7.8 If stub ends are to be used, they must be reinforced using a stainless steel or galvanized steel cap with a concrete thrust block, approved equivalent or an approved restrained end cap.

5.7.9 Perforated piping must be placed within an aggregate layer. The aggregate layer must be thick enough to protect the soil media from flushing/cleaning operations. Perforated piping must not be installed with the geotextile immediately adjacent to the pipe due to clogging concerns. The aggregate should be sized to ensure it does not fall into the perforated holes. A typical embedment for perforated distribution piping is shown in ***Figure 5.7.*** The embedment shape can be square or circular, this is simply a depiction of one possibility.

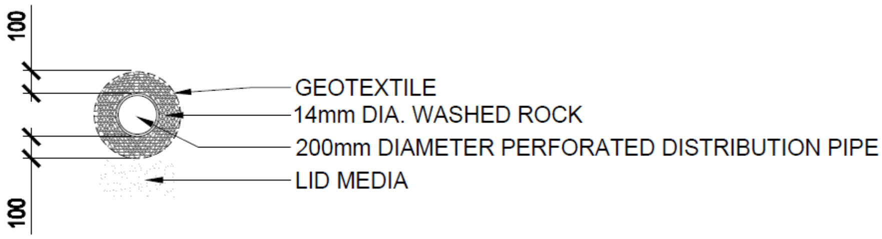

Figure 5.7: Typical Perforated Distribution Embedment

5.7.10 Pipe perforations are to be spaced 125 mm apart and the orientation of the perforations is specified in ***Figure 5.8*** below. If the pipe is to be used for a specific purpose such as storage, other perforation configurations can be specified by the designer to meet required performance objectives.

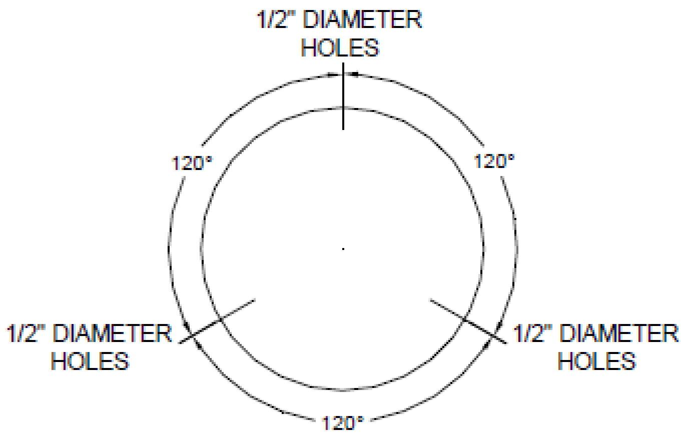

Figure 5.8: Pipe Perforations

5.7.11 LID inlets and outlets utilizing manhole and CBs must meet the frame, cover and barrel size requirements in the Volume 3 Drainage Drawing and Construction Standards. Barrel heights may be adjusted to better suit the LID, however sump requirements must be followed. The specific manhole or CB configuration can be chosen based on the LID facility and the location it is to be installed. For distribution piping only, the grade ring requirement can be reduced to use two-50 mm grade rings. If minimum depths of piping cannot be met due to other restrictions such as groundwater table or LID design this must be indicated in the project-specific drawings and details. If any piping protrudes into the CB or manhole it must not protrude more than 50 mm; if there are multiple pipes protruding into the CB or manhole they must be flush with the barrel. If piping/devices must protrude into the barrel of the CB or manhole a larger barrel size may be required.

5.7.12 If bioretention basins and box planters contain an overflow, a short trash rack should be installed. Please contact Drainage Engineering at DRENG@epcor.com for the short trash rack drawing. Overflow structures must be accessible for maintenance after vegetation has been established. Overflows must be positioned away from inlets, preferably near the middle of the LID facility to encourage water movement and infiltration. If surcharging from the combined sewer system is a possibility flap gates must be installed on the system to prevent combined sewage from entering the LID facility. If flap gates are used, they must be Fontaine SERIES 60 with an RMX mount or equivalent installed on a 1200 mm manhole or catch basin manhole to allow for maintenance and repair of the device. For retrofits a different flap gate including specifications, installation procedures, and maintenance guides must be provided. A smaller diameter CB may be considered if the entire device can be removed and reinstalled from grade for maintenance.

5.7.13 Underground enclosure boxes (including junction boxes and valve boxes) and caps must be labelled appropriately. Underground enclosures boxes or caps should be installed to protect infrastructure coming to surface such as cleanouts. Underground enclosure boxes must be firmly embedded within the LID soil media and not within the mulch to ensure sufficient stability to anchor the box. Underground enclosure boxes and caps must be designed and installed to meet any loadings relative to their location. LID boxes and caps must be engraved with "LID". Cleanouts and underground enclosure boxes must be clear of trees, buildings, or permanent obstructions within 1.0 m of the cleanout location (small vegetation is acceptable). If due to site constraints a 1.0 m radius around the cleanout is not possible, a minimum of 180° of clear space is required.

5.8 Cold Climate Design Considerations

5.8.1 De-icing salt loadings to LID facilities should not exceed 1000 mg/L during winter months to avoid salt induced injury to vegetation and soils. LID facilities that will receive higher loadings must be designed with salt tolerant species, highly permeable soils, and underdrains.

5.8.2 Locate snow storage areas away from LID facilities unless vegetation and soil structure is specifically designed to accommodate snow storage. Snow loading calculations must be completed for snow storage areas to ensure the weight of the snow will not affect the soil compaction or cause pipe deformations. Boulevards and other areas can sometimes be used for snow storage, these areas should be designed accordingly. Salt tolerant, non-woody vegetation are recommended for areas that may be used for snow storage. Loading calculations and corresponding design must be signed and stamped by a qualified professional. LID is not recommended for use at dedicated snow storage facilities (i.e. sites that store a large amount of snow from multiple sites).

5.8.3 Size curb cut inlets to prevent blockage by ice and snow during spring runoff. See ***Figure 5.9*** below for a typical concrete curb opening approved by the City of Edmonton. Other curb openings may be accepted by the City of Edmonton.

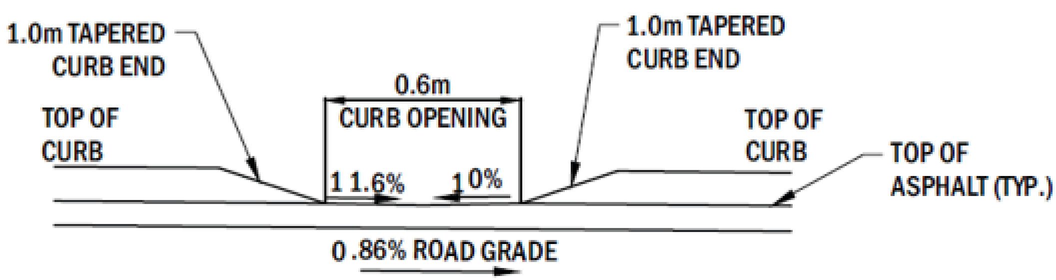

Figure 5.9: Typical Curb Cut Opening

5.9 Vegetation Selection

5.9.1 Select plant varieties that will thrive on the site conditions and that grow well together. Species selection should consider:

- Soil permeability and periodic inundation of the soil;
- LID soil media type (as per Sections ***5.12***)
- Tolerance of seasonal salt loadings depending on facility location;
- Pollutant uptake capacity;
- Maintenance needs, including mowing and pruning;
- Sight lines for facilities on or near roadways;
- Site use, for example in high traffic pedestrian areas plants with an odour may not be appropriate;
- Reduction of water and fertilizer needs after establishment;
- Potential nuisances (i.e. pollen and aroma) in high traffic areas; and
- Resistance to pests.

Recommended native species for LID are listed in ***Table 5.2*** below. This table is limited to native material only; this list is not fully comprehensive and there are many plants, both native and non-native, that will function in LID facilities that are not represented here. ***Table 5.2*** is provided for guidance and outlines some of the characteristics and principles of plant selection that we look for when designing LID facilities but, designers have the ability to provide exceptions and expansions to the list. If utilizing the list, designers must still choose plants that are suitable for the location and LID type.

5.9.2 Native species are recommended to be used where possible as native species typically facilitate further ongoing infiltration through development of root structures and are more resistant to changing weather patterns and climate change. Recommended plant species have been included in ***Table 5.2***, however, vegetation selected for specific LID facilities is still governed by the City of Edmonton Design and Construction Standards, Volume 5: Landscaping and must meet these requirements. Note all recommended plant species may not be suitable for every situation, for example LID facilities near roadways have size restrictions to maintain sight lines.

5.9.3 For soil cells ONLY, a drought tolerant, minimal maintenance blend of grasses can be used over top of the soil cells. This configuration can be used for mature neighbourhood retrofits. Trees and shrubs should be used where possible, to encourage stormwater uptake and ongoing infiltration through development of root structures. ***Table 5.2*** lists very few trees suitable for soil cells as native species may not be ideal for soil cells in urban environments. A mix of ornamental and native tree species is encouraged for soil cells if possible. Trees selected are still governed by the City of Edmonton Design and Construction Standards, Volume 5: Landscaping and must meet these requirements

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Table 5.2: Recommended Native Plant Species for LID Facilities in Edmonton, Alberta

Common Name	Scientific Name	Plant Type	Establishment Method	Wetland Indicator Status	Drought Tolerance	Salt Tolerance	Soil Moisture	Soil Preference	Succession	Mature Spread (cm)	Mature Height (cm)	Sunlight Preference	Additional Information
Water Sedge	*Carex aquatilis*	Aquatic	Seed	OBL	Low	Low	Moist - Wet	Sand, Clay, Loam	Decreaser		100 - 200	Part Shade - Full Sun	Can be mat forming, in loose or dense colonies.
Golden Sedge	*Carex aurea*	Aquatic	Seed or Live Plant Material	OBL	Low	Low	Moist - Wet	Sand, Loam	Decreaser	60-90	35	Part Shade - Full Sun	Minimum root depth 20 cm; Thrives in shallow water.
Bebb's Sedge	*Carex bebbii*	Aquatic	Seed	OBL	Medium	Medium	Moist - Wet	Sand, Clay, Loam	Increaser	30	30	Full Sun	Forms clumps; Does most of its growing in the spring.
Beaked Sedge	*Carex utriculata*	Aquatic	Seed or Live Plant Material	OBL	Medium	Low	Moist - Wet	Clay, Loam	Increaser		50 -100	Full Sun	Spreads by rhizomes to form clumps.
Common Spike Rush	*Eleocharis palustris*	Aquatic	Seed	OBL	Low	Low	Moist	Sand, Clay	Increaser	30-60	60-100	Part Shade - Full Sun	Mat forming.
Baltic Rush	*Juncus balticus*	Aquatic	Seed or Live Plant Material	OBL	Low	High	Moist - Wet	Sand, Clay, Loam	Increaser	90	30-90	Part Shade - Full Sun	Important nitrogen fixer and has thick rhizomes that bind the soil together.
Small Leaved Pussytoes	*Antennaria parvifolia*	Forb	Live Plant Material	UPL	High	Medium	Dry - Moist	Sand, Clay, Loam	Increaser	30-50	10-15	Full Sun	Responds negatively to severe fires, if conducting controlled burns wet large patches to ensure they remain in the planting.
Yarrow	*Achillea millefolium*	Forb	Live Plant Material	FACU	High	Medium	Dry - Moist	Sand, Loam	Increaser	60	30-90	Full Sun	Spreads by rhizomes which can become aggressive under ideal conditions.
Giant Hyssop	*Agastache foeniculum*	Forb	Seed or Live Plant Material	FAC	Medium	Medium	Moist	Sand	Increaser	150-300	45-90	Part Shade - Full Sun	Self-seeds readily.
Canada Anemone	*Anemone canadensis*	Forb	Live Plant Material	FACW	Medium	Medium	Moist	Sand, Clay, Loam	Increaser	60-75	30-60	Part Shade - Full Sun	Can spread aggressively; Creates uniform ground cover.
Rosy Pussytoes	*Antennaria rosea*	Forb	Live Plant Material	UPL	High	Medium	Dry - Moist	Sand, Clay, Loam	Increaser	30-50	10-30	Part Shade - Full Sun	Responds negatively to severe fires, when conducting controlled burns wet large patches to ensure they remain in the planting.
Meadow Arnica	*Arnica chamissonis*	Forb	Seed or Live Plant Material	FACW	Low - Medium	Low	Moist	Sand, Loam	Increaser	50-100	45-70	Part Shade - Full Sun	Has shallow roots and it is very easy to dig out unwanted plants; Sow the seeds in late fall or late spring directly into the garden; Local availability may be an issue.
Heart-leaved Arnica	*Arnica cordifolia*	Forb	Seed or Live Plant Material	NI	Low	Low	Dry - Moist	Sand, Clay, Loam	Increaser	20-60	20-60	Full Shade - Part Shade	Has low resistance to consistent foot traffic.
Shining Arnica	Arnica fulgens	Forb	Seed or Live Plant Material	UPL	Low - Medium	Low	Moist	Sand, Clay, Loam	Increaser	50-100	50	Part Shade - Full Sun	Sow in fall or stratify to break dormancy; Local availability may be an issue.
Dwarf Milkweed	*Asclepias ovalifolia*	Forb	Seed or Live Plant Material	NI	High	Medium	Dry - Moist	Sand, Loam	Increaser	20-50	20-50	Full Shade - Full Sun	Plant contains latex, a common allergen, so gloves should be worn when handling.
Showy Milkweed	*Asclepias speciosa*	Forb	Seed or Live Plant Material	FAC	Low	Low	Dry - Moist	Sand, Clay, Loam	Increaser	45-150	45-150	Part Shade - Full Sun	Plant contains latex, a common allergen, so gloves should be worn when handling.
Bunchberry	*Cornus canadensis*	Forb	Live Plant Material	FACU	Low	Low	Moist	Sand, Clay, Loam	Increaser	30-60	10-20	Full Shade - Full Sun	Spreads evenly and quickly creating continuous ground cover.
Mountain Shooting Star	*Dodecatheon conjugens*	Forb	Seed	FACU	High	Medium	Moist	Sand, Loam	Decreaser	10-15	20-25	Part Shade - Full Sun	Short-lived perennial.
Tufted Fleabane	*Erigeron caespitosus*	Forb	Seed	NI	High	Medium	Dry	Sand, Loam	Increaser	15-45	10-30	Full Sun	Spreads by short rhizomes and seed with a moderate to fast growth habit.
Smooth Fleabane	*Erigeron glabellus*	Forb	Seed	FACW	High		Dry - Moist	Sand, Loam	Increaser	30-45	30-45	Part Shade - Full Sun	A low maintenance perennial with an upright spreading growth habit.
Wild Strawberry	*Fragaria virginiana*	Forb	Live Plant Material	FACU	Medium	Medium	Dry - Moist	Sand, Loam	Increaser	15-20	15-20	Part Shade - Full Sun	Plants spread horizontally and reproduce through stolons to create a ground cover.
Northern Bedstraw	*Galium boreale*	Forb	Seed or Live Plant Material	FACU	Medium	Low	Dry - Moist	Sand, Loam	Increaser	30-45	60-90	Part Shade - Full Sun	Spreads by seed and rhizomes; ideal for soil stabilization.

Common Name	Scientific Name	Plant Type	Establishment Method	Wetland Indicator Status	Drought Tolerance	Salt Tolerance	Soil Moisture	Soil Preference	Succession	Mature Spread (cm)	Mature Height (cm)	Sunlight Preference	Additional Information
Gumweed	*Grindelia squarrosa*	Forb	Seed or Live Plant Material	UPL	High	High	Dry	Sand, Clay, Loam	Increaser	30-60	20-60	Full Sun	Can be weedy; Plants may be pruned or mowed back to prevent excessive spreading; Plant is biennial and short-lived.
Beautiful Sunflower	*Helianthus pauciflorus*	Forb	Seed or Live Plant Material	NI	High	High	Dry	Sand	Increaser	60	15-35	Part Shade - Full Sun	Plants exude allelopathic chemicals that inhibit the growth of young plants nearby.
Meadow Blazingstar	*Liatris ligulistylis*	Forb	Seed or Live Plant Material	FAC	High	Medium	Dry - Moist	Sand	Increaser	20-40	45-70	Full Sun	Seeds are large and wind dispersed; Collecting and reseeding into the desired area will increase establishment.
Blue Flax	*Linum lewisii*	Forb	Seed	NI	High	Low	Dry - Moist	Sand, Loam	Stable	50-90	30-90	Full Sun	Short-lived perennial; Can become weedy if there is little competition.
Ostrich Fern	*Matteuccia struthiopteris*	Forb	Live Plant Material	FACW	Low	Low	Moist	Sand, Loam	Increaser	100-200	100-200	Full Shade - Part Shade	Clump forming and can become aggressive under ideal conditions.
Wild Mint	*Mentha arvensis*	Forb	Live Plant Material	FACW	Low	Low	Moist - Wet	Clay, Loam	Increaser	100	20-75	Full Shade - Full Sun	Can spread aggressively under ideal conditions; Resistant to browsing from deer; Can be mat forming.
Tall Bluebells	*Mertensia paniculata*	Forb	Seed	FAC	Low	Low	Moist - Wet	Sand, Clay, Loam	Increaser	45	20-80	Full Shade - Part Shade	Regenerates from thick rhizomes.
Wild Bergamot	*Monarda fistulosa*	Forb	Seed or Live Plant Material	FACU	High	Medium - High	Dry - Moist	Sand, Clay, Loam	Increaser	60-90	60-90	Full Sun	Requires occasional maintenance, can spread to form clumps and self seed.
Yellow Coneflower	*Ratibida columnifera*	Forb	Seed	NI	High	Low	Dry - Moist	Sand, Loam	Increaser	30-45	30-90	Full Sun	Will readily self-seed.
Canada Goldenrod	*Solidago canadensis*	Forb	Seed or Live Plant Material	FACU	Medium	Low	Dry - Moist	Sand, Clay, Loam	Increaser	50-100	50-100	Part Shade - Full Sun	Can be aggressive under ideal conditions.
Prairie Goldenrod	*Solidago missouriensis*	Forb	Seed	FACU	Low	Low	Dry - Moist	Sand, Clay, Loam	increaser	30-60	45-90	Part Shade - Full Sun	Spreads by rhizomes and seeds with a moderate to fast growth habit, can become aggressive.
Sticky Goldenrod	*Solidago simplex*	Forb	Seed	FACU	Low	Low	Dry - Moist	Sand, Loam	Increaser	30-45	20-45	Full Sun	Could be used in smaller spaces; can be controlled by deadheading.
Smooth Aster	*Symphyotrichum laeve*	Forb	Seed or Live Plant Material	FACU	Medium	Medium	Dry - Moist	Clay, Loam	Decreaser	30-90	30-90	Part Shade - Full Sun	Can directly seed into plantings, seeds do not require either scarification or stratification.
Purple Stemmed Aster	*Symphyotrichum puniceum*	Forb	Seed or Live Plant Material	OBL	Medium	Medium	Moist - Wet	Clay, Loam	Increaser	60-90	60-150	Full Sun	Can spread rapidly and form large colonies in moist - wet areas.
Heart-leaved Alexanders	*Zizia aptera*	Forb	Live Plant Material	FAC	Medium	Medium	Dry - Moist	Sand, Clay, Loam	Decreaser	45-60	45-90	Part Shade - Full Sun	Low maintenance perennial.
Indian Ricegrass	*Achnatherum hymenoides (Oryzopsis hymenoides)*	Grass	Seed	FACU	High	Medium	Dry - Moist	Sand, Clay, Loam	Stable		25-70	Full Sun	Seeds must be pretreated to break dormancy.
Awned Wheatgrass	*Agropyron subsecundum*	Grass	Seed	FACU	Medium	Low	Dry - Moist	Loam	Decreaser		50-100	Part Shade - Full Sun	Self-seeds, some tillering.
Blue Grama	*Bouteloua gracilis*	Grass	Seed	UPL	High	Medium	Dry	Sand, Clay, Loam	Increaser	45-60	30-35	Full Sun	Tolerates moderate to heavy foot traffic.
Marsh Reed Grass	*Calamagrostis canadensis*	Grass	Seed	OBL	Medium	Medium	Moist - Wet	Sand, Clay, Loam	Decreaser	100-150	100-200	Full Sun	Rhizomes can be pruned in the spring to limit spread.
Tufted Hairgrass	*Deschampsia caespitosa*	Grass	Live Plant Material	FACW	High	Low	Moist	Sand, Clay, Loam	Stable	30	40	Full sun	A clump forming perennial that can provide erosion control with its deep rhizomes.
Canada Wildrye	*Elymus canadensis*	Grass	Seed	FAC	High	High	Dry - Moist	Sand, Clay, Loam	Decreaser	60-90	100-150	Part Shade - Full Sun	Lives 4-5 years, reseeds easily on bare soil.

Common Name	Scientific Name	Plant Type	Establishment Method	Wetland Indicator Status	Drought Tolerance	Salt Tolerance	Soil Moisture	Soil Preference	Succession	Mature Spread (cm)	Mature Height (cm)	Sunlight Preference	Additional Information
Rocky Mountain Fescue	*Festuca saximontana*	Grass	Seed or Live Plant Material	NI	High	High	Dry - Moist	Sand, Loam	Increaser		20-25	Part Shade - Full Sun	Does well in disturbed or polluted areas but does not tolerate heavy foot traffic.
Tall Manna Grass	*Glyceria grandis*	Grass	Seed	OBL	Low	Low	Wet	Clay, Loam	Decreaser		25-60	Full Sun	Spreads by thick rhizomes and stolons; suitable for erosion control.
Sweetgrass	*Hierochloe odorata*	Grass	Live Plant Material	FACW	Low	High	Moist - Wet	Sand, Clay, Loam	Increaser	60	30-60	Part Shade - Full Sun	One of the four sacred plants to Metis and Indigenous people; It grows much better from rhizomes than from seed, and may triple in size within one year.
Junegrass	*Koeleria macrantha*	Grass	Seed or Live Plant Material	FACU	High	Low	Dry - Moist	Sand, Loam	Increaser	30-60	30-60	Full Sun	Seedlings are weak and do not survive moderate to high foot traffic.
Fowl Bluegrass	*Poa palustris*	Grass	Seed	FACW	Low	Low	Moist	Clay, Loam	Decreaser		150	Part Shade	Requires a minimum root depth of 30 cm.
False Melic Grass	*Schizachne purpurascens*	Grass	Seed	FACU	Medium	Low	Dry - Moist	Sand	Decreaser	10-15	40-80	Full Shade - Part Shade	Prefers shadier spots than most grasses making it suitable for treed areas.
Little Bluestem	*Schizachyrium scoparium*	Grass	Seed or Live Plant Material	FACU	High	Medium - High	Dry - Moist	Sand	Increaser	45-60	30-70	Full Sun	Requires burning or mowing with thatch removal every 3-5 years.
Needle and Thread Grass	*Stipa comata*	Grass	Seed	UPL	High	Low	Dry	Sand, Loam	Decreaser	30	40-60	Part Shade - Full Sun	Requires >254 mm of annual precipitation but grows in areas with less; Provides stabilization from erosion; Seed heads are potentially problematic for pet owners in residential areas.
Green Alder	*Alnus viridis*	Shrub	Seed or Live Plant Material	FAC	Low	Low	Moist	Sand, Loam	Increaser		300	Part Shade - Full Sun	Clearance from lowest branches to the ground can be up to 100 cm at maturity
Saskatoon Serviceberry	*Amelanchier alnifolia*	Shrub	Live Plant Material	FACU	Low - Medium	Low	Dry - Moist	Sand, Loam	Decreaser	200-300	300-400	Full Sun	No clearance under the lowest branches could impedes sightlines; Species is a decreaser without proper maintenance.
Bog Birch	*Betula pumila*	Shrub	Live Plant Material	OBL	Low	Low	Moist - Wet	Sand, Loam	Increaser	200-300	100-300	Part Shade - Full Sun	Low maintenance, minimal suckering and has a fast growth rate.
Red Osier Dogwood	*Cornus sericea*	Shrub	Live Plant Material	FACW	Medium	High	Dry - Moist	Sand, Clay, Loam	Increaser	300	300	Part Shade - Full Sun	Low maintenance, may require light pruning.
Beaked Hazelnut	*Corylus cornuta*	Shrub	Live Plant Material	UPL	Medium	Low	Dry - Moist	Sand, Loam	Stable	100-200	100-200	Part Shade - Full Sun	Controlled burn will kill the above ground portion of the shrub, but it readily resprouts.
Castlegar Hawthorn	*Crataegus chrysocarpa*	Shrub	Live Plant Material	FACU	Medium	Medium	Moist - Wet	Loam	Decreaser	400	500	Part Shade - Full Sun	Does not require any significant pruning to maintain its shape; Can be planted to stabilize banks, preventing wind and water erosion.
American Silverberry	*Elaeagnus commutata*	Shrub	Live Plant Material	UPL	High	High	Dry - Moist	Sand, Clay, Loam	Increaser	300	200-400	Full Sun	Recovers slowly from severe fire.
Wolf Willow	*Elaeagnus commutata*	Shrub	Live Plant Material	UPL	High	Medium	Dry - Moist	Clay, Loam	Increaser	200-400	200-400	Full Sun	Readily suckers, thicket forming.
Twinberry Honeysuckle	*Lonicera involucrata*	Shrub	Live Plant Material	FACU	Medium	Low	Moist	Clay, Loam	Increaser	150	300	Part Shade - Full Sun	Naturalizes through self-seeding and can form colonies overtime.
Shrubby Cinquefoil	*Potentilla fruticosa*	Shrub	Live Plant Material	FACW	High	Medium	Dry - Wet	Sand, Clay, Loam	Increaser	50-100	100-150	Part Shade - Full Sun	May require the removal of die back every spring.
Fire Cherry, Pin Cherry	*Prunus pensylvanica*	Shrub	Live Plant Material	FACU	Medium - High	Medium	Dry - Moist	Sand, Clay, Loam	Decreaser	200-300	200-500	Full Sun	Clearance from lowest branches to the ground can be up to 120 cm at maturity, without pruning.
Golden Currant	*Ribes aureum*	Shrub	Live Plant Material	FACU	High	Low	Dry - Moist	Sand, Clay, Loam	Increaser	60-200	100-300	Part Shade - Full Sun	Plant may sucker under ideal conditions.
Wild Rose	*Rosa acicularis*	Shrub	Live Plant Material	FACU	Low	Low	Dry - Moist	Clay, Loam	Increaser	100	100	Part Shade - Full Sun	Requires occasional maintenance and upkeep, best pruned in late winter.

Common Name	Scientific Name	Plant Type	Establishment Method	Wetland Indicator Status	Drought Tolerance	Salt Tolerance	Soil Moisture	Soil Preference	Succession	Mature Spread (cm)	Mature Height (cm)	Sunlight Preference	Additional Information
Beaked Willow	*Salix bebbiana*	Shrub	Live Plant Material	FACW	Low	Low	Moist - Wet	Sand, Clay, Loam	Increaser	100-600	300-1000	Part Shade - Full Sun	Short-lived and fast-growing; Susceptible to insect, disease, and wind damage.
Hoary Willow	*Salix candida*	Shrub	Live Plant Material	OBL	Low	Low	Moist - Wet	Sand, Clay, Loam	Increaser	50-100	50-100	Part Shade - Full Sun	Short-lived and fast-growing; Susceptible to insect, disease, and wind damage.
Under-green Willow	*Salix commutata*	Shrub	Live Plant Material	OBL	Low	Low	Moist - Wet	Sand, Loam	Increaser	50-150	300	Part Shade - Full Sun	Little maintenance required.
Pussy willow	*Salix discolor*	Shrub	Live Plant Material	FACW	Medium	Medium	Wet	Sand, Clay, Loam	Increaser	100-300	200-300	Part Shade - Full Sun	Branches will need maintenance annually.
Drrummond's Willow	*Salix drummondiana*	Shrub	Live Plant Material	FACW	Low	Low	Moist - Wet	Sand, Clay, Loam	Increaser	100-300	200-400	Part Shade - Full Sun	Plant can sucker profusely.
Sandbar Willow	*Salix exigua*	Shrub	Live Plant Material	FACW	Medium	Low	Moist - Wet	Sand, Loam	Increaser	250-400	400-700	Part Shade - Full Sun	Plant can sucker profusely.
Gray leaf Willow	*Salix glauca*	Shrub	Live Plant Material	FACW	Low	Low	Moist - Wet	Clay, Loam	Increaser	200-300	120-200	Part Shade - Full Sun	Plant can sucker profusely.
Shining Willow	*Salix lucida*	Shrub	Live Plant Material	FACW	Low	Low	Moist - Wet	Clay, Loam	Increaser	500-600	500-600	Part Shade - Full Sun	Aggressive roots can exploit soil moisture; Fast-growing, short-lived, and prone to disease and insect damage.
Yellow Willow	*Salix lutea*	Shrub	Live Plant Material	FACW	Low	Low	Moist	Sand, Clay, Loam	Increaser	300	300-600	Full Sun	Fast growing; Some maintenance required.
Meadow Willow	*Salix petiolaris*	Shrub	Live Plant Material	OBL	Medium	Low	Dry - Moist	Sand, Clay, Loam	Increaser	300	300	Part Shade - Full Sun	Low maintenance; Forms dense spreading tidy clumps; Is good for erosion control.
Silver Buffaloberry	*Shepherdia argentea*	Shrub	Live Plant Material	UPL	Medium	High	Dry - Moist	Sand, Loam	Increaser	300	400	Full Sun	Tolerates the poor soils and does well in dry or alkaline situations; Low maintenance and extremely cold- and drought-tolerant.
Canada Buffaloberry	*Shepherdia canadensis*	Shrub	Live Plant Material	FACU	High	Medium	Dry - Moist	Sand, Loam	Increaser	200-300	100-200	Full Shade - Full Sun	Low maintenance. Extremely cold- and drought-tolerant.
White Meadow Sweet	*Spiraea alba*	Shrub	Live Plant Material	FACW	Low	Low	Moist - Wet	Sand, Clay, Loam	Increaser	50-150	100-200	Part Shade - Full Sun	Can sucker under ideal conditions. Remove spent flower clusters to promote additional bloom.
Snowberry	*Symphoricarpos albus*	Shrub	Live Plant Material	UPL	High	Medium	Dry - Moist	Sand, Clay, Loam	Increaser	100-200	100-200	Part Shade - Full Sun	Plants can sucker, prune as needed.
High-bush Cranberry	*Viburnum edule*	Shrub	Live Plant Material	FACW	Low	Low	Moist	Sand, Clay, Loam	Decreaser	200-400	200-300	Part Shade - Full Sun	Thicket forming.
White Birch	*Betula papyrifera*	Tree	Live Plant Material	FACU	Low	Medium	Moist	Sand, Clay, Loam	Increaser	600	1200	Full Sun	A short-lived tree and shade intolerant. Not suitable for a soil cell.
Tamarak Larch	*Larix laricina*	Tree	Live Plant Material	FACW	Low	Low	Moist - Wet	Sand, Loam	Increaser	300	1200	Full Sun	Tree has a shallow root system. Not suitable for a soil cell.
White Spruce	*Picea glauca*	Tree	Live Plant Material	FACU	Medium	Low	Moist	Clay, Loam	Stable	300-600	1000-2000	Full Sun	Clearance from lowest branches to the ground can be up 150 cm at maturity, without pruning. Not suitable for a soil cell.
Lodgepole Pine	*Pinus contorta*	Tree	Live Plant Material	FACU	High	Medium	Dry	Sand, Loam	Increaser	600	3000	Full Sun	Clearance from lowest branches to the ground can be up to 300 cm at maturity, without pruning. Not suitable for a soil cell.
Balsam Poplar	*Populus balsamifera*	Tree	Live Plant Material	FACW	Low	Low	Moist	Sand, Clay, Loam	Increaser	1000	2500	Full Sun	A high maintenance tree that can become invasive. Not suitable for a soil cell.
Trembling Aspen	*Populus tremuloides*	Tree	Live Plant Material	FAC	Low	Medium	Dry - Wet	Sand, Clay, Loam	Increaser	500	1500	Part Shade - Full Sun	Can be an aggressive invader under ideal conditions. Not suitable for a soil cell.
Bur Oak	*Quercus macrocarpa*	Tree	Live Plant Material	FAC	High	Medium - High	Dry - Wet	Sand, Clay, Loam	Stable	1800-2500	1800-2500	Full Sun	Clearance from lowest branches to the ground can be up to 300 cm at maturity, without pruning.

Thatch removal may be required every 3 - 5 years, determined by condition of planting

5.10 Drawing Requirements

5.10.1 Design Stage Requirements

Drawing requirements for all stages of design are outlined below. All LID facilities must be labelled as LID.

i. Concept/Preliminary

- Completed LID Summary Table (see ***Figure 5.10***)
- Plan view of facility locations and catchments with cadastral
- Proposed locations of distribution/subdrain piping and tie into drainage system, including all pipe bends and fittings. All bends must be labelled and drawn to scale.
- Existing constraints for each LID facility

Drainage Area	LID Type	Location Where Runoff Enters to LID	Catchment Area, m^2	Catchment Imperviousness, %	Runoff Volume for Design Rainfall, m^3	LID Surface Area, m^2	LID Capacity, m^3
1	e.g. Bioretention Basin		4315	90%	67	300	75
2	e.g. Soil Cell		2000		31		28
		Sum	6315		98		103

Figure 5.10: LID Summary Table

ii. Detailed

- All requirements outlined in ***Table 5.3***: Drawing Detail Requirements.
- Reference to an LID Soil Testing Plan in the Contract Documents, or a clearly laid out plan on the drawing set
- A separate drawing for each LID facility is expected

a) Utility Drawings

- Extent of LID facility
- Proposed locations of distribution/subdrain piping, cleanouts (including all pipe bends and fittings, all bends must be labelled and drawn to scale), tie ins, and CBs/ CB Manholes
- Flow direction through LID facility and overland drainage route
- Grading in the LID facility and catchment area (if applicable)
- Existing utilities including invert elevations
- Landscaping is not to be shown on utility drawings unless it is the location of existing trees, shrubs, etc. to be maintained.
- Distances to any utilities in proximity to the LID facility or its associated piping and drainage infrastructure.

b) Details

- Applicable cleanout details from the standards
- Slope and invert elevation of distribution pipe and underdrain pipe
- Pipe perforations
- Pipe embedment
- Soil cell installation layout and placement of piping within soil cells (if applicable)

- Profile of highest point of distribution and subdrain piping within soil cells (if applicable)
- Inlet and outlet (as applicable) type and location, including a detail, tie-ins, and surface flow velocities, if applicable
- Inline or overflow CB, spillway or other water conveyance details (as applicable)
- Profile of all LID infrastructure tie-ins to existing or proposed drainage infrastructure

c) Landscape

- Separate planting plans must be included with every LID plan
- Vegetation maturity, species and quantity summary table
- General layout of distribution and underdrain piping (and other potential utility conflicts) should be shown to gauge proximity to mature plants and trees. Landscaping is not to be shown on utility drawings with the exception of existing trees, shrubs etc. that may conflict with the work.

iii. IFT/IFC

- Changes required to detailed drawings as noted during detailed drawing review.
- Specifications and Special Provisions for LID to be standalone documents.

iv. As-Built

- All requirements outlined under Utility Drawings and Details in Section ***5.10.1 ii***, as well as all requirements in Section ***5.10.1 iii***
- Completed LID Summary Table, including hydraulic conductivity (see ***Figure 5.11***)

Drainage Area	LID Type	Location Where Runoff Enters to LID	Catchment Area, m^2	Catchment Imperviousness, %	Runoff Volume for Design Rainfall, m^3	LID Surface Area, m^2	LID Capacity, m^3	Average Hydraulic Conductivity (from Guelph Permeameter), mm/hr
1	e.g. Bioretention Basin		4315	90%	67	300	75	
2	e.g. Soil Cell		2000		31		28	
		Sum	6315		98		103	-

Figure 5.11: As-Built LID Summary Table

- LID Calculator spreadsheet attached to the as-built drawings as a PDF
- Coordinates of all cleanouts, including the depth at which they were installed
- Clear distinction between perforated and non-perforated pipes
- Clear distinction between old and new infrastructure

5.10.2 Required plan view, detail, and profile view drawing details are listed in ***Table 5.3*** below. All drawing packages are required to have a drawing index.

Table 5.3: Drawing Detail Requirements

Parameter	Plan	Detail	Profile	Description
Summary Table from LID Calculator	x			Include the summary table from the LID calculator which identifies LID Type, Location, Catchment Area (m^2) and imperviousness (%), Runoff Volume for 18 mm (m^3), and LID Capacity (m^3) and surface area (m^2) see ***Figure 5.10***.

Parameter	Plan	Detail	Profile	Description
Location	x			Areal extent shown on plan view (bump-outs, municipal reserves, private lots, parks, road ROW, utilities)
Surface area	x			Outlined on plan view drawings, size of surface area of LID facility
Type	x		x	The type of LID (using the four definitions outlined above in Sections ***5.3, 5.4, 5.5, 5.6***) or definitions as per the City of Edmonton *Low Impact Development - Best Management Practices Design Guide*.
Inlet	x	x	x	Shown on plan view and typical detail provided (curb cut, flow spreader, ribbon curb, pre-treatment, CB, etc.)
Slopes (if applicable)	x		x	Side slopes of the LID facilities as well as slope of ground adjacent to LID facility. Grades within the LID facility must be noted.
Materials	x	x	x	Material specifications including depths/thickness and volumes required (LID soil media, filter layer, drainage layer), depth/thickness, hydraulic conductivity, porosity, SPDD as required, and any other material such as geotextiles or soil cells that may be required. Piping size and specifications. There should be at least one profile view outlining all layers and materials within the LID facility, including pipe locations and lengths.
Vegetation	x	x		Planting plan and vegetation details (species, mature density, succession plan)
Outlet	x	x	x	Underdrain specification & slope, spill elevation, CB type and grate, weir type and location, inlet control device and overflow details. A site-specific detail.
Catchment	x			Delineated catchment area directed to LID facility, size of catchment area and impervious portion
Flow Arrows	x			From contributing area, into LID facility, and overflow route(s)
Water Depth	x		x	Ponding depth and extent of inundation and water surface elevation during design storm(s) and maximum prior to spill. Water depths for all design storms identified in Section ***5.2*** must be shown.
Erosion Control/ Energy Dissipation	x	x		Outlined location on plan view (inlet, outlet if overland spill) and details, this should include both temporary and permanent measures. Temporary measures include use of rock socks.
Cleanouts	x	x	x	Detailed with all piping details, including cleanout type and dimensions of cleanout boxes
Location of surrounding sewer systems	x			Location(s) shown on plan view. Sewer system type (i.e., sanitary, stormwater or combined) must be specified. Services should also be shown.

5.10.3 Drawing Considerations

For clarity and ease of review the following drawing aspects should be considered:

- Ensuring that the distinction between non-perforated and perforated pipe is clearly defined and labelled. Different line styles should be used for each type of piping line. Lengths of piping lines and direction of slope should be clearly labelled.
- For LID infrastructure/utility drawings, removing backgrounds, hatching, and plant species from drawing in order for piping layout, inlets and outlets to be unobstructed. If existing utilities are shown be sure they are greyed out but still visible.
- Increasing piping lineweight or using colour when pipes in plan view are close to other lines to ensure piping layout is clear.

- Utility offsets should be shown on the drawings (see section ***5.2.6*** for further details).

5.11 Construction Considerations

Project specifications and special provisions should consider the following regarding construction of the LID facility and placement of the soil mix:

i. Construction execution planning should give careful consideration to the sequencing and traffic flow of activities at and around the LID facility to minimize disturbance of the LID site.

ii. The LID facility(s) should be isolated from runoff and sedimentation from the impervious catchment area until vegetation is established and ready to provide treatment as per design. This can be achieved by physically blocking flow with a barrier, using sacrificial sod or geotextiles for ESC control, or installing the LID facility after construction around the site has been completed. This is especially important in highly saline areas such as snow storage areas or adjacent to arterial roadways. If the LID facility cannot be isolated from runoff and sedimentation ESC measure for the catchment must be put into place and thought should be taken to using plantings instead of seed. If an ESC plan is required, protection of the LID facilities must be specifically addressed.

iii. The subsoil, LID growing soil media, filter layer, and granular drainage layer should be inspected by qualified personnel prior to backfill.

iv. If infiltration is part of the stormwater management mechanism for the LID, subgrade excavation should be performed by suitable equipment and construction practices that will minimize compaction to the infiltration area. The use of excavators reaching in from outside the infiltration footprint is preferred. If excavation must be carried out within the footprint, light weight, low ground-contact pressure equipment should be used. In this case, tests should be carried out to ensure the subgrade infiltrations rates meet that of the design prior to backfilling or installation of geotextiles. Tilling operations may be necessary should infiltration tests indicate excessive compaction of the area.

v. If infiltration is part of the stormwater management mechanism for the LID surface of the subgrade may require scarification to provide proper bonding and transition between materials.

vi. The granular drainage layer and granular filter layer should be placed uniformly in 300 mm lifts.

vii. Soil, compost, and/or other amendments should be uniformly mixed prior to placement. Care should be taken to avoid compacting the mixture during the mixing process. For further information on acceptable soil amendment see the City of Edmonton's Volume 5 - Topsoil Specification 02910.

viii. Soil mix should be placed uniformly in 200 mm to 300 mm lifts. Each lift should be water consolidated or compacted using a suitable method as per design specifications. Wet soil should be allowed to dry prior to placement. Soil should not be placed in wet, muddy or frozen conditions.

5.11.1 Safety Factor

When completing hydraulic simulations or calculations utilizing hydraulic conductivity, a minimum safety factor of 2 must be used for the hydraulic conductivity to account for variability in soil and clogging. For example for a soil with a hydraulic conductivity of 40 mm/hour, hydraulic simulations and calculations should be completed using a hydraulic conductivity of 20 mm/hour.

5.11.2 General Inlet and Outlet Considerations

LID facility design should consider the following regarding inlets and outlets:

i. The location of the inlets and outlets must be situated to allow water to fully flow through and percolate into the LID Soil Media.

ii. The overflow outlet must be situated near the center of the LID, between the inlet and the outlet to maximize water flow through the LID Soil Media. If the overflow outlet is located near the inlet flow may short circuit the system and flow directly into the overflow.

iii. Thought should be given to the type of erosion/flow control utilized at the inlets and outlets and the permanence of the installation.

iv. Inlets, outlets, and overflows must be accessible for operations and maintenance. Care should be taken during vegetation selection to ensure that all will still be accessible at peak vegetation size.

5.12 LID Growing Soil Media Specifications

The LID soil media must meet the requirements in Section ***5.12*** or the performance-based standards outlined in Section ***5.12.2*** If performance-based standards are chosen, the designer must prove the standards can be met with their design.

5.12.1 Texture and Property

The LID soil media specification in ***Table 5.4*** provides a range of values for each parameter. It is at the discretion of the engineer and the landscape architect to determine the exact value and whether any additional tolerances are allowed outside the standard ranges for a specific project. If ranges outside those listed below are chosen, the design basis must shift to the performance-based standards in Section ***5.12.2.***

For soil cells with trees a more specific media specification is highly recommended to be specified with a lower sand content. Trees often require additional water and a high sand content may hinder a soil's ability to retain water. For trees in soil cells only, a lower organic matter content may be specified by the project designer.

Table 5.4: LID Soil Media Specification

Parameter	Values
Texture classification	Loamy Sand; Sandy Loam
Sand sized particles, larger than 0.05 mm diameter and smaller than 2 mm diameter	60% – 80%
Silt	10% – 25%
Clay	5% - 15%
Silt and clay combined	Maximum 40%
Organic matter	5% – 10%
pH value	6-8
Available Phosphorus	10 -50 ppm
Saturated Hydraulic conductivity, at soils specified compaction and moisture	Minimum 40 mm/hr

Notes: All % are in dry weight.

Sand: Sand sized particles shall have a well-graded distribution with a coefficient of uniformity between 4 and 6. Sand shall be free from clay balls and other extraneous materials.

Compost: The use of compost is to enhance soil permeability and water holding capacity, and to provide the right amount of organics and nutrient for plant growth. Compost should be the City-certified for landscape use as per the City of Edmonton Landscape Standard Topsoil Section 02910.

Woodchips: A small amount of woodchips can be utilized to increase pore space within the LID soil mix to help plant establishment; however all other parameters listed must still be met. Woodchips must be smaller than 50 mm in length.

5.12.2 Performance-Based Standards

If a soil mix other than that specified in ***Table 5.4*** is used the LID facility must be able to retain and store a minimum of 18 mm of rain from the LID facilities impervious catchment area and drain the corresponding standing water within 48 hours. The HWL during the 100-year 4 hour design event must not compromise adjacent structures. Surface storage, and soil mix shall not allow water from the 18 mm of rain to drain directly into the stormwater system, as this will not provide storage or improvements in water quality.

Alternate soil mixes may be used for any of the layers (mulch layer, growing media, granular filter layer, or drainage infiltration layer) however layers must still meet their respective purposes and the overall performance-based standard. The drainage infiltration (storage) layer must be able to withstand flushing as per Section ***5.7*** Piping and Infrastructure Considerations and must provide adequate support for the specified piping.

Different soil mixes may be used for different areas of the LID facility (i.e. slopes vs. bottoms) if required to promote varied vegetation growth.

If LID facilities are constructed in series, the performance based standards will apply as one facility; that is the facilities working in tandem must be able to retain a minimum of 18 mm and drain the corresponding standing water within 48 hours; each individual LID facility does not need to meet these requirements. If LID facilities are constructed in series, the space between LID facilities must be constructed to facilitate water flow. Spaces between LID facilities should be minimized to discourage use of space as access or crossing locations.

5.12.3 Tree Root Package Soil

The tree root package (that comes with the tree) may contain different soil, however soil media throughout the remainder of the soil cell system must be consistent with the LID Soil Media (Section ***5.12***). ***Figure 5.12*** shows a profile view of a typical tree root package within a soil cell and is for illustrative purposes only, it does not depict every detail that may be required for successful construction, operations, and maintenance. Soil volumes for trees must still meet soil volumes as per the City of Edmonton Design and Construction Standards, Volume 5: Landscaping.

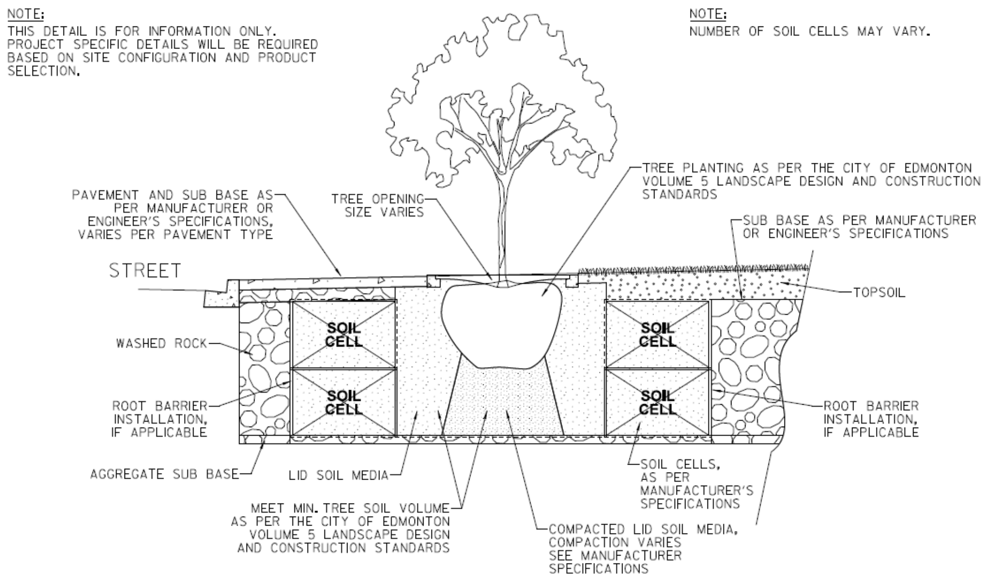

Figure 5.12: Typical Tree Root Package

5.13 Testing Requirements

5.13.1 Soil Sampling and Analysis

Soil media analysis shall be conducted and the results shall be approved by the City/EPCOR prior to:

- soil arriving on site; and
- soil being placed in LID facility

Analyses conducted shall include the following:

- Texture classification by a qualified professional;
- Grain size classification (sieve and/or hydrometer) (%);
- Organic matter (Loss on ignition);
- pH
- Available Phosphorus

Onsite stockpile testing for texture classification, grain size classification and organic matter parameters for LID soil mix that is not purchased premixed and pretested shall follow the Sampling Requirements as outlined in the City of Edmonton Volume 5 - Topsoil Specification 02910. Soil that has been purchased premixed and pretested requires one test per stockpile. Testing for pH, phosphorus and cation exchange capacity is one test per stockpile regardless if the soil is purchased premixed and pretested.

Additional analyses may be requested on a project-specific basis. In the case that written approval is given by the City/EPCOR to the Consultant or Contractor, as applicable, the City reserves the right to conduct in-situ testing after CCC and prior to FAC on the LID soil mix. If these test results show the soil does not meet the parameters in Section ***5.12.1***, and that there is no reasonable wear and tear or adjacent activity that could have altered the soil since it was placed such that is does not meet the requirements set in Section ***5.12.1****,* the City/EPCOR can, at its discretion, require the Developer, Consultant or Contractor, as applicable, to amend or replace the soil to meet the requirements.

5.13.2 LID Soil Compaction and Infiltration

Compaction for the LID soil media is recommended to be specified at a minimum 75%-85% Standard Proctor density depending on the soil type to be used; unless further compaction is required for structural purposes. Soil shall be placed in 200 mm to 30 mm lifts; unless otherwise specified by the designer. Where substrate infiltration is slow (<15 mm/hr) an underdrain must be installed.

During LID soil placement one of the following tests shall be completed:

- One compaction test per lift
- Guelph Permeameter testing at varying depths post LID soil placement

Prior to the placement of concrete or planting, saturated hydraulic conductivity testing must be completed. Guelph Permeameter testing must be conducted once per 1000 m^2 or once per LID facility, in facilities smaller than 100 m in length. For each Guelph Permeameter test conducted, an additional test at an adjacent location should be completed for QA/QC purposes. As per the Guelph Permeameter testing manual to ensure accuracy of the test with a highly permeable soil, the test shall use the two head method with combined reservoirs.

At FAC, Guelph Permeameter testing must be conducted once per 1000 m^2 of LID facility or once per LID facility in facilities smaller than 100 m in length; this is not required for facilities with an impervious surface such as concrete or asphalt on top. For each Guelph Permeameter test conducted, an additional test at an adjacent location shall be completed for QA/QC purposes. This is recorded for record purposes only and will not require soil amendment or replacement if results fail.

Soils with a high organic content should still be lightly compacted to reduce settlement of the soil and LID facility.

When limiting compaction, care must be taken to follow the Construction Considerations located in

Section ***5.11.***

i. Additional Subgrade Compaction for Soil Cells

Subgrade and granular base compaction shall be completed prior to soil cell placement to 95% of Standard Proctor density.

ii. Additional LID Inspections

All pipes within LID facilities must be CCTV'ed as per the Volume 3 Drainage Design and Construction Standards. CCTV requirements are located in Vol. 3-06: Construction Specifications Section 23 – Inspection of Sewers.

6.0 LOT GRADING AND SURFACE DRAINAGE DESIGN

This section outlines the requirements and considerations that apply to the detailed design of lot grading plans. Note: City of Edmonton provides this service. Subdivision Engineering Plans which includes Lot Grading Plans submitted by Private Developers and Engineers are reviewed and approved by City of Edmonton, Development Services, Development Engineering and Drawing Review. Lot Grading Certificates and inspections on Private Property are submitted by Owners, Home Builders, Grading Contractors or Landscapers are reviewed, inspected and enforced by the City of Edmonton, Development Services, Lot Grading.

6.1 Lot Grading on Private Property

6.1.1 Level of Service

The level-of-service requirements for lot grading include provision of protection against surface flooding and property damage for the 1:100 year return frequency design storm. Through control of surface elevations, designs should be such that maximum flow or ponding surface elevations are 150 mm below the lowest anticipated finished ground elevations at buildings. An overflow route or sufficient ponding volume must be provided from or at all sags or depressions to provide for this 150 mm freeboard with the maximum depth of ponding is limited to 350 mm.

6.1.2 Intent and Application of Lot Grading Plans

i. The establishment of a lot grading plan is one of the principal means for establishing a critical component of the major drainage system. The lot grading plan is a specific requirement within the detailed Engineering Drawings for a subdivision under the terms of a standard servicing agreement. Lot grading plans are required for most property developments involving building construction or surface improvements and may be a requirement of a development permit or pursuant to requirements of bylaws, regulations, other approvals or agreements.

ii. Site grading shall ensure proper drainage (lot grading) and control stormwater runoff of individual private properties or establish an effective surface runoff system for a whole development area. A lot grading plan establishes the drainage relationship between adjacent properties and its approval is an effective basis for the control of grading of the properties.

iii. The lot grading plan shall be suitable for use as a tool to control surface drainage and control stormwater runoff through the development process and thereafter. The lot grading plan is approved by the City of Edmonton, Development Services, Development Engineering and Drawing Review Unit to establish the "Lot Grading Plan" pursuant to the Drainage Bylaw No. 18093. Lot Grading Plans specify design elevations, surface gradients, lot types, swale locations, and any other related drainage related information (e.g. Site Servicing, Easements, Restrictive Covenants) required for lot grading. The lot grading plan may be enforced by the City, initially to implement the approved grading and then to have the grading maintained by the property owner to prevent or correct obstruction of flow routes and excessive or recurrent ponding of water around buildings.

iv. Refer to the Lot Grading Guidelines, published by the City of Edmonton, Development Services, Lot Grading, for an outline of the mechanisms for establishment and control of lot grading and for drawings showing typical standard grading patterns for unit residential, multi-family residential and commercial / industrial properties. These guidelines are available from City of Edmonton, Development Services, Lot Grading web page www.edmonton.ca/lotgrading.

iv. General considerations in the establishment of Lot Grading Plans

- In the design of lot grading plans, the designer must achieve a proper relationship and balance between the street elevation, building grade elevation, surrounding development and existing topography.
- The implications of required noise attenuation berms and other elevation controlling features are to be fully addressed by the designer. It is also important to ensure that the lot grading design and the anticipated house or building designs are complementary. Reverse slope driveways and other features that would be likely to capture runoff or fail to drain during major rainfall events or snow melt should be discouraged.
- The Developer must ensure that builders are informed of any potential problems or restrictions respecting building design, lot grading and site servicing. The lot grading plan is used as one of the principle means by which this information is communicated.

6.2 Lot Grading Design Requirements

6.2.1 Details of Grading Within Lots

Refer to ***Figure 6.1*** and ***Figure 6.2*** for typical lot grading details for various standard drainage arrangements for detached residential developments. Also refer to the Lot Grading Guidelines, published by the City of Edmonton, Development Services, Lot Grading, for drawings showing typical standard grading patterns for unit residential, multi-family residential and commercial/industrial properties. These guidelines are available from the City of Edmonton's web page www.edmonton.ca/lotgrading.

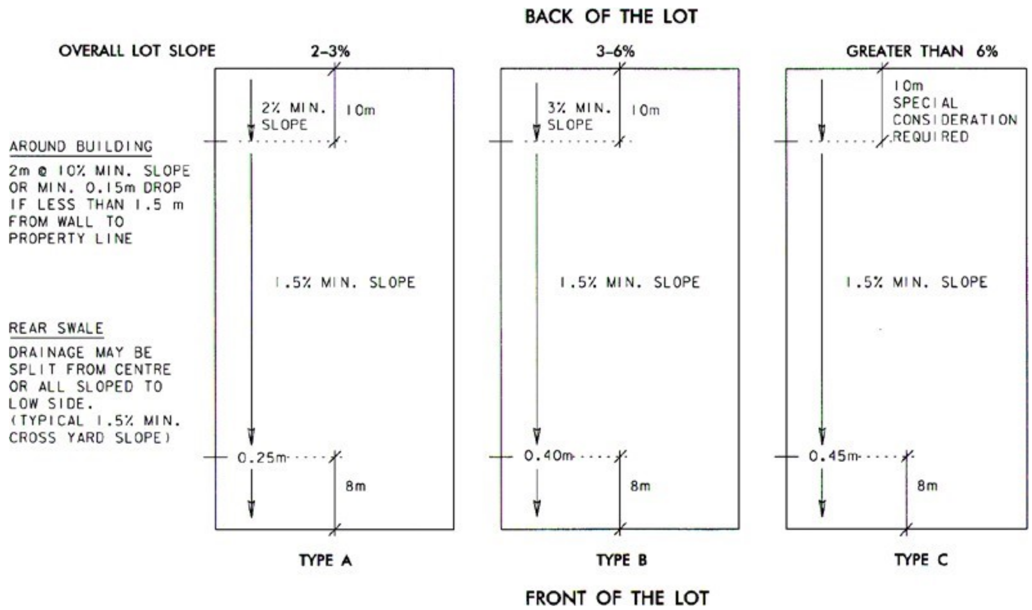

Figure 6.1: Typical Lot Grading Details – Rear to Front Drainage

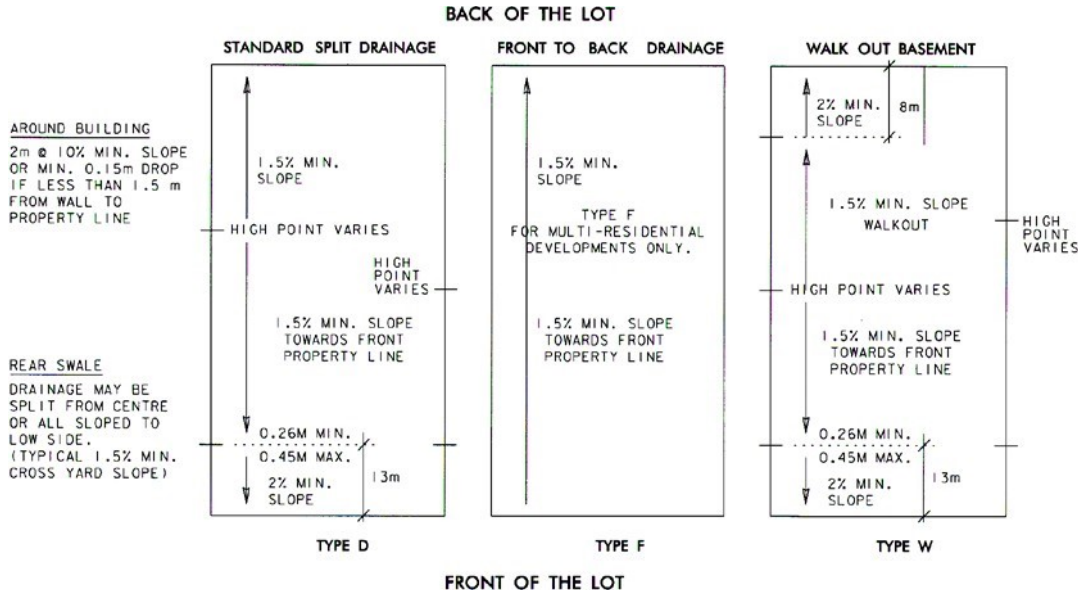

Figure 6.2: Typical Lot Grading Details – Split/Front to Back Drainage

6.2.2 Special Requirement for Multi-plex Development

For multi-plex developments comprised of three or more units with separate fee simple titles for each unit, specific lot grading requirements apply.

i. For multi-plex developments where cross lot surface drainage is required to provide a drainage path for the rear yards, a private to private easement and restrictive covenant document is required to be registered on all the lots. The easement and restrictive covenant document shall be registered to cover all the lots within a continuous block.

ii. Each individually titled lot must be provided with a separate storm service to accommodate roof leader connections and sump pump discharge connections.

iii. All roof leaders for each dwelling unit shall be connected to the storm sewer service for that lot. No roof leaders are permitted to discharge to the ground surface.

iv. Roof leader drainage from accessory buildings such as garages must also be connected to the storm sewer service of the individual lot or directed to discharge to the rear alley.

v. In situations where the rear yards of a titled lot cannot surface drain directly to a public Right-of-Way and cross lot surface drainage is required the following Lot Grading Plan requirements apply:

- The Lot Grading Plan must clearly establish and define the drainage path on any downstream lot that is required to convey surface runoff from an upstream lot. This requires that an additional lot grade elevation be provided on the Lot Grading plan at the center of that lot along the defined flow path (see typical multi-plex lot grading detail in ***Figure 6.3***).
- The minimum slope along the cross-lot swale shall be 1.5%. The flow path shall be clearly illustrated using a flow arrow on the Lot Grading Plan.
- Specific notes must be provided on the Lot Grading Plan to indicate the requirement for the private to private easement and restrictive covenant document to be registered on all the lots.

6.2.3 Establishment of Grade Elevations at Buildings

The finished grade elevations at buildings are basically established by following the Alberta Building Codes, Part 9 – Housing and Small Buildings https://www.alberta.ca/building-codes-and-standards.aspx. The Alberta Land Surveyor, Engineer, Architect, or other applicant for a building permit sets the elevation. The relative surface elevations must allow for the slope of the ground adjacent to the building to be at a minimum of 10% for a distance of 2.0 m or to the property line, on all sides of the house, with the slope directing drainage away from the building and then for reasonable slopes in the order of 1.5% to 2.0% from all points within the property to the property boundary at which the drainage may escape.

6.2.4 Overall Slopes for Property Grading

Property line elevations are to be established such that lots have a minimum overall slope of 2.0%, from the high point to the front or back property lines for split drainage situations, or between the higher and lower, front and rear property lines with through drainage. The minimum grade (2%) should normally be exceeded if topography allows.

6.2.5 Overall Drainage Arrangement

i. Lots abutting a public right-of-way at front and rear

ii. Split drainage or through drainage (front to rear or rear to front drainage) is allowed when a lot is located such that there is a road, alley, or public right-of-way at both the front and back of the lot.

iii. Alleyless subdivisions (properties with no alley)

iv. Rear to front drainage is preferred in alleyless subdivisions. Split drainage in alleyless subdivisions is permitted only if all of the following conditions are met:

- it is not feasible to achieve rear-to-front drainage due to extreme natural topography;
- the receiving downstream lot has an overall grade of 3.0% or more;
- there is no concentration of flow from upstream lots to downstream lots;
- only one lot drains to another lot;
- runoff from the roof of the upstream lot is directed to a storm service or the upstream lot's grading is designed with the ridge as close to the rear property line as possible.

In situations where split drainage may be problematic due to the above conditions not being met, the use of a swale for the interception of split drainage and its conveyance directly to a public right of way is permitted.

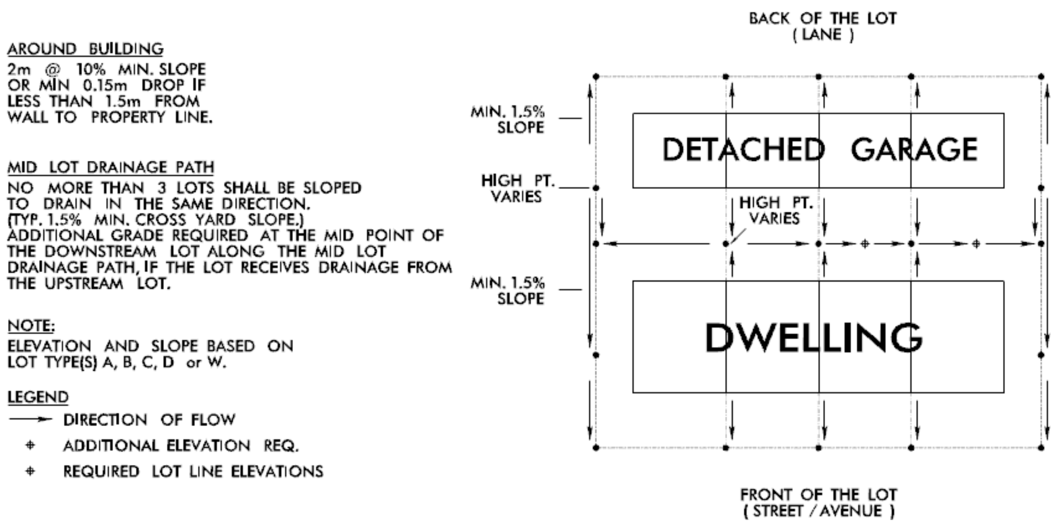

Figure 6.3: Typical Multiplex Lot Grading Details

6.3 Use of Swales

6.3.1 A swale is a shallow sloped linear depression for conveyance of surface runoff. The use of swales crossing numerous properties for collection of runoff and drainage control is not permitted unless justification is produced and documented to the satisfaction of the Engineer, indicating that no other alternative is feasible.

6.3.2 If the Engineer approves a swale to drain numerous properties, it shall be covered by an easement in favour of EPCOR Water Services Inc., to the satisfaction of the Engineer.

6.3.3 For private development projects, the servicing agreement may identify swales as a separate improvement and therefore they would have their own construction completion certificates. Otherwise, the swales shall be completed as part of, and as a prerequisite to the issuance of the construction completion certificate for sewers.

6.3.4 Detail Requirements for Swales

When swales crossing several properties cannot reasonably be avoided, then the following requirements shall be satisfied:

i. Grass swales serving lots on one side only
   - Location: Rear of upstream lot in a 2.0 m easement
   - Cross Section: V-shape, 150 mm minimum depth and 4H:1V maximum side slope
   - Longitudinal slope: 1.5% minimum

ii. Grass swales serving lots on both sides
   - Location: Common rear property line as centre of a 4.0 m easement.
   - Cross-section: Trapezoidal with 1.0 m bottom, 150 mm minimum depth and 4H:1V maximum slope.
   - Longitudinal slope: 1.5% minimum

iii. Grass swales with concrete gutter (swale), serving lots on one or both sides
   - Location: Upstream lot with the gutter preferably centred on the 2.0 m easement.
   - Cross-section of gutter: V-shape, 75 mm to 150 mm deep, 500 mm to 610 mm wide with 4H:1V maximum slope. 100 mm minimum thickness with 3-10 M longitudinal bars and 3.0 m spaced control joints.
   - Longitudinal slope: 0.75% minimum.
   - Note: alternate design considerations with respect to minimum slope requirements for swales is considered when swales are located within existing developments or at locations where infill development is proposed.

iv. Other Parameters and Requirements
   - Capacity: Contain the 1:5 year storm flow within the concrete gutter and the 1:100 year storm major flow within the easement.
   - Interception: Provide a CB upstream of a walkway to intercept the 1:5 year storm flow. Limit the depth of ponding to 150 mm with 5H:1V maximum side slope all around the CB cover.
   - No. of lots draining to swale – Depending on the concrete gutter and swale capacities, and the CB’s 1:5 year storm flow inlet capacity.
   - Bends: Bends greater that 45° shall be avoided, and no bend greater than 90° shall be allowed. When 45° bend is exceeded, provide a 1.0 minimum centreline radius and adequate curbing to contain the design flows within the gutter and easement.
   - Conveyance: The grading of the boulevard and sidewalk shall be such that the major flow is not allowed to flow down the sidewalk.
   - Erosion and sediment control: Grass swales preferably shall be sodded, or at the least, shall be topsoiled and seeded, Interim measures shall be provided to protect exposed surfaces from erosion until the grass cover is established.
   - Swales that convey flows from more than two lots must not be routed along the side yard of a single family or duplex residential lot.

- Future swale extensions shall be identified and evaluated to ensure that anticipated constraints and capacities are addressed.
- Details: Show on the Lot Grading Plan, the cross-section, inverts, slopes and lot grades along the swale.
- Calculations for the swale's minor and major flow capacities shall be submitted with the engineering drawings.

6.4 Content of Lot Grading Plans

Lot grading plans required as part of the detailed engineering drawings for development servicing agreements and as surface drainage plans necessary pursuant to other requirements or regulations are to include the following items of information:

6.4.1 Legal Descriptions

The general legal designation for all existing and proposed lots including lot and block numbers and plan numbers when established.

6.4.2 Predevelopment Topography

Existing contours within the subdivision and extending into the adjacent lands, at a maximum 0.5 m interval and flow patterns on adjacent lands.

6.4.3 Representation of the Major Conveyance System

i. The nature and detail of the major conveyance system is to be shown on the lot grading plan, including all major drainage flow directions, overland flow depth or profile on ROW for 1:5 year and 1:100 year design storm events, ponding areas and the extent and maximum depth of ponding anticipated for a 1:100 year return frequency rainfall event. The overall major drainage flow route is to be clearly defined and designated with prominent arrows (refer to Section ***3.3***).

ii. Information shown is generally to include the direction of surface flows on all surfaces, elevations of overflow points from local depressions and details of channel cross sections.

iii. Where significant major system flows are expected to discharge or overflow to a watercourse, ravine or environmental reserve area, the rate and projected frequency of such flows is to be noted on the lot grading plan.

6.4.4 Surface Slopes of Roadways and other Surfaces

Proposed roadway and other surface grades with arrows indicating the direction of flow.

6.4.5 Property Boundary Elevations

Proposed or existing elevations along the boundaries of the subdivision and design elevations at all lot corners and changes of surface slope along property boundaries.

6.4.6 Lot Drainage Pattern

The direction of surface drainage for each lot is to be identified, to indicate whether split drainage or through drainage is contemplated. Proposed surface drainage for abutting future development lands is to be shown to the extent that it will impact on the subject lands.

6.4.7 Lot Grading Details

Typical detail diagrams of the various types of lot grading arrangements, which normally conforms to the figures provided within the Lot Grading Guidelines, are to be used, identifying for each lot which typical detail applies. When more than one sheet is required for the lot grading plan, each sheet is to show the typical details which apply.

6.4.8 Roof Drain Provisions

i. Roof drain connections are proposed:

Where storm sewer service connections are provided to each lot and/or roof drain downspouts are intended or required to be connected to a storm sewer service, the proposed servicing and connection requirements are to be noted on the lot grading plan.

ii. Surface discharge of roof drains is proposed:

- Only when supported by the conclusions of the geotechnical investigations applicable to the development site.
- Where storm sewer service connections are not provided to each lot and/or roof drain downspouts are not to be connected to a storm service, and roof leaders' discharge do not drain from one lot to another, provisions to carry and discharge roof drain flows away from the building foundation and to control erosion at the discharge point are required. A downspout extension or splash pad, provided by the house builder / owner, is recommended at each roof downspout location.

6.4.9 Foundation Drainage Details

Show in the lot grading plan the requirement of foundation drain service (for weeping tile flows only), and storm service, when required (for weeping tile and roof leader flows), for all new detached, semi-detached, duplex and multiplex residential units. The plan should also identify the need to use a sump pump discharging to a downpipe connected to the foundation drain service. Alternately, a gravity connection may be an option provided the grade allows it, and the consultant identifies no constraints or restrictions. For a gravity connection, a backwater valve and a cleanout should be installed downstream of the weeping tiles, in an accessible location. The legend indicating the different types of sewer service shall be as follows.

CL LOT ON PL	Single / Dual Service
	Existing Service
	Water, Sanitary and Foundation Drain Service
Θ	Water, Sanitary and Storm Service
	(Foundation Drains and Roof Leaders)

6.4.10 Swale Details

When the use of swales is included in the design, the lot grading plan is to show locations, easement requirements, slopes, cross sections and construction details for the swales.

6.4.11 Provisions for Properties Abutting SWMFs

For lots backing onto SWMFs (owned and operated by EPCOR), the lowest permitted building opening elevations are to be above the ultimate design high water level for the facility by at least 300 mm if the facility has an emergency overflow provided at the high water level, or by at least 500 mm if such an overflow is not provided. Building footings shall also be at least 150 mm above the normal (permanent) water level of wet storage facilities. Lot Grading Plans are to include appropriate notation of the requirements to establish building elevations accordingly. This notation and the specific requirements for building elevations and the grading of the property are to be consistent with the requirements set out in easements and restrictive covenants to be registered against the affected properties (refer to Section ***6.4.12***).

6.4.12 Easements and Restrictive Covenants

Requirements and locations for all easements and restrictive covenants related to drainage provisions and development restrictions associated with the drainage of the property are to be shown and identified on the lot grading plan. This is to include without limitation:

i. Easements and restrictive covenants relating to SWMFs;

ii. Restrictive covenants relating to top of bank lot development restrictions and servicing requirements;

i. Other easements or restrictive covenants to contain requirements or limitations of development with respect to drainage or sewer servicing as may apply to the subject lands.

Appendix A

Computer Model Transfer Checklist

Computer Model Transfer Checklist

1.1 New Models

1.1.1 The Model

- DHI Models, e.g. Mike Urban, Mike Flood, etc. (Version Mike Urban 2019)
- Operating environment- e.g. Windows 10

1.1.2 Model Facts Sheet

- # of nodes/links, e.g. combined, sanitary, storm sewers (regular and dummy connections)
- # of stormwater management facilities and RTCs.
- # of open and natural channels.
- # of special hydraulic elements: weirs, orifices, pump stations.
- Total study area (in ha) and # of sewersheds/catchments

1.1.3 Overall Maps (in MicroStation or equivalent format)

- Location map and catchments or sewershed delineation maps
    - o In MicroStation or AutoCAD format c/w "GIS" shape file of catchment areas. Shape file to have 3 attributes: Catchment Name, Inlet Node and Drainage Area.
- Schematic maps of Sanitary and Storm collection Systems
- Special structure details

1.1.4 Basic Model Setup

- List of assumptions and boundary conditions

1.1.5 Hydrological Data

- Major inflow source, e.g. rainfall, design storms, inflow hydrograph, etc.
- Population for domestic flow components
- Landuse and surface runoff parameters for what year?
- Digital Elevation Map/lidar
- Impervious classification
- I/I components, etc.
- Rainfall and storm event analysis

1.1.6 Hydraulic Parameters

- Closed conduit cross-sections, connectivity, diversions, etc.
- Open channels and natural creeks cross-section and profile data.
- Rating curves: Pump stations, storage nodes, equivalent channel for storm detention ponds.
- Control set points, etc.

1.1.7 Simulations and Results

- Model calibrations, verifications: Flow monitoring data analysis
- Include all result files, runoff and hydraulic and include the Summary HTM for each.
- Grade Line Factor (GLF), Theoretical Loading Factor (TLF), Hydraulic Condition Ratings (HCR) calculations
- Conclusions, recommendations and implementation plan

1.1.8 Files

- Final report, presentation and all supporting files such as tables, charts and maps. Format: Searchable PDF format, MicroStation, Microsoft Office, etc.
- Model input and output files (organized index list with descriptions)
- Where coupled models are used, the database submission should include the separated minor and major system models as well as the final model, e.g. 1D-1D and 2D-1D coupled models
- Include all result files
- Detailed scenario descriptions. What is included in each and why?
- Other items

1.2 Models supplied by EPCOR to the Consultants for projects (and returned to EPCOR after project completion)

1.2.1 The Model

- DHI Models, e.g. Mike Urban, Mike Flood, etc. (Mike Urban 2019)
- Operating environment- e.g. Windows 10

1.2.2 Model Facts Sheet

- Details of any changes to the model elements such as pipes, manholes and other structures.

1.2.3 Overall Maps (in MicroStation or equivalent format)

- Sketches of any upgrades and/or changes to the model elements

1.2.4 Basic Model Setup

- List of assumptions and boundary conditions and details of any changes to the boundary conditions or assumptions

1.2.5 Hydrological Data

- Details of any changes to the hydrological data such as rainfall, design storms, inflow hydrograph, population for domestic flow components, landuse and surface runoff parameters and/or I/I components, etc.

1.2.6 Hydraulic Parameters

- Details of any changes to closed conduit cross-sections, connectivity, diversions, open channels and natural creeks cross-section and profile data; Rating curves: Pump stations, storage nodes, equivalent channel for storm detention ponds and/or Control set points, etc.

1.2.7 Simulations and Results

- Model calibrations, verifications: Flow monitoring data analysis
- Grade Line Factor (GLF), Theoretical Loading Factor (TLF), Hydraulic Condition Ratings (HCR) calculations.
- Conclusions, recommendations and implementation plan

1.2.8 Files

- Final report, presentation and all supporting files such as tables, charts and maps. Format: Searchable PDF format, MicroStation, Microsoft Office, etc.
- Where coupled models are used, the database submission should include the separated minor and major system models as well as the final model, e.g. 1D-1D and 2D-1D coupled models
- Model input and output files (organized index list with descriptions)
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