VOLUME 3

DRAINAGE

VOL. 3-02

STORMWATER MANAGEMENT AND DESIGN MANUAL

APRIL 2025

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 August 2025. 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 contained 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
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LIST OF REVISIONS

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

Section	Changes
	Deleted the tables of Vol 3-01, 3-02, 3-03, 3-04, 3-05, and 3-06 which showed the description of each sub-volume when split Volume 3 in 2021.
Vol. 3-02 wide	Bulleted lists are converted to numbered list for easy reference of the sections.
Vol. 3-02 wide	Replaced “manhole(s)” with “maintenance hole(s)”, “MH” is still used for the abbreviation of “maintenance hole”.
Vol. 3-02 wide	Replaced “EPCOR Drainage Services” with “EPCOR Water Services”.
1.2	Section heading changed from “Commentary on Analytical Methods” to “Analytical Methods”. Rearranged sentences in the paragraph and deleted “However, consultants are encouraged to apply computer modelling methods for the design of all drainage systems.”
1.5.2.ii	“Mike Urban (or Mouse) and Mike 21” updated to “Mike+”.
1.5.3.i	Added “The kinematic wave model (ModB) should be used for hydrologic routing.” in the last sentence.
1.5.7	“…planning reports…” updated to “…reports…”
2.4 to 2.8	Values in Tables 2.4 to 2.8 updated considering three decimal IDF parameters.
2.11	Deleted Table 2.12: Recorded Storm of July 12, 2012.
3.3 ii	“... depths of ponding…” updated to “... depths and duration of ponding…”.
Section 4 wide	Updated organization, wording, and formatting throughout Section 4.0 to provide clarity.
4.1	Added sections for: - Flood protection - Environmental objectives - Safety - Recreation - Costs - Topography
4.2.1 4.2.2	Added planning and design phase information of SWMFs in the Area Master Plan and Neighborhood Design Report.
4.2.3	Added section for SWMF Count
4.2.4	Added to Detailed Engineering Drawings: - Stage-volume and stage-area curves and tables from pond bottom to freeboard - The HWL design event basis - Contours showing elevations at 2- and 10-years level - Storage volumes at side slope changes and least at every 0.5 m, 2-, and 10-year level - Storage areas at pond bottom, at side slope changes or at least at every 0.5 m, at 2- and 10-year level - Notation indicating the lowest allowable building opening elevation and bottom of footing elevation for lots abutting the wet pond (if applicable) - SWMF and forebay depth at the 2-year level - Outflow control details and hydraulic control operation logic - Location, dimensions, and details of shared paths, maintenance access, furniture, and other amenities - Landscaping details - Permanent erosion and sediment control measures.
4.3.1	Updated definitions for SWMF types and removed definitions for different types of storage. Added SWMF type figures: Figure 4.1, Figure 4.2, and Figure 4.3.
4.3.2	Added section for SWMF Type Selection.
4.4	Added sections regarding: - Regulatory requirements - Water Level Monitoring - Trails - Furniture and Public Amenities - Warranty Period
4.4.3	Consolidated and updated land dedication sections across all SWMF types.

Section	Changes
4.4.4	Updated section to include requirements for freeboard.
4.4.6.iv	Added requirement for control panels to have a cooling fan and to place in a shaded location.
4.4.6.v	Added outflow control gates require a non-rising stem and gates are to have manual grease lines.
4.4.6.viii	Add control structures must have 3 chambers. Added Figure 4.4: Control Structure - Plan View.
4.4.6.ix	Added control structure shall be above the 1:100 year design event.
4.4.7	Updated requirements for water level monitoring to include water level monitoring for all SWMF types.
4.4.8	Added 30 tonnes rating and 15.1 m turning radius for maintenance access.
4.4.10	Updated the section to provide clarity on when fencing is required. Added requirement permitting gate access from private properties to SWMFs at the discretion of EPCOR.
4.4.12	Shared-use path shall be at or above the 1:25 year design event. Shared-use path placement is subject to approval by the City and EPCOR.
4.4.13.ii	Tree roots shall not compromise the effectiveness of the clay liner.
4.4.14	Furniture and public amenities shall be at or above the 1:25 year design event. Updated enhanced amenities requirements.
4.4.15.ii	Removed requirement for hard-copy O&M manual (electronic only is required).
4.4.15.iii	Added requirements for the user-friendly document.
4.4.16	Added section regarding warranty period for SMWFs.
4.4.17.i	Added verification for no invasive species and pests present at the SWMF at FAC.
4.4.17.ii	Added verification the NWL of a wet SWMF established at least for one season.
4.4.18	Updated requirements for interim SWMFs.
4.5.1	Updated section on sizing of naturalized wet ponds. Includes standards for both new and legacy AMPs and NDRs.
4.5.4	Added requirements for naturalized wet ponds to be relatively oval shaped.
4.5.5.i	Added grates shall not be installed on submerged inlets or outlets.
4.5.7.i	Removed recommendation of washed rock as an acceptable edge treatment.
4.5.8	Updated maintenance access requirements. Added Figure 4.6: Boat Ramp Cross Section.
4.5.10.iii	Added requirement of a geotechnical engineer inspecting the SWMF in the field following excavation.
4.5	Added Figure 4.7: Schematic Diagram of a Naturalized Wet Pond. Updated Figure 4.8: Recommended Cross Section of a Naturalized Wet Pond (previously Figure 4.2).
4.6.1	Updated section on sizing of constructed wetlands. Includes standards for both new and legacy AMPs and NDRs.
4.6.4	Added requirements for constructed wetlands to be relatively oval shaped.
4.6.11.iii	Added requirement of a geotechnical engineer inspecting the SWMF in the field following excavation.
4.6	Updated Figure 4.9: Schematic Diagram of a Constructed Wetland (previously Figure 4.3). Added Figure 4.10: Recommended Sections of a Constructed Wetland.
4.7.1	Updated section on sizing of dry ponds.
4.7.2.i	Updated minimum bottom slope of dry ponds from 0.7% to 1.5%.
4.7.3.i	Changed allowable live storage depth to 1.5 m. If live storage is to be greater than 1.5 m then more safety measures are required.
4.7.4	Added requirements and recommendations for shape of dry ponds.
4.7.5.iii	Clarified requirements for inlet and outlet for in-line dry ponds.
4.7.6	Added drawdown time table (Table 4.3) for dry ponds.

Section	Changes
4.7.8	Added section for signage identifying inlets, outlets, and shallow pipes to prevent heavy equipment from driving over shallow pipes or snow piling near inlets/outlets.
4.7	Added Figure 4.11: Schematic Diagram of an Off-Line Dry Pond, Figure 4.12: Schematic of an In-Line Dry Pond, and Figure 4.13: Recommended Cross Section of a Dry Pond.
Changes below in Section 5 are in the Addendum to City of Edmonton Design and Construction Standards, Volume 3-02: Stormwater Management and Design Manual, **Section 5.0 LID Facility Design** published in August 2023.	
Section 5 wide	Changed the wording from “man-made” to “engineered” for the whole Section 5.
Section 5 wide	Changed the wording from “manhole” to “maintenance hole” for the whole Section 5.
Section 5 wide	Changed the wording from “subdrain” to “underdrain” for the whole Section 5.
Section 5 wide	Changed wording from “geotechnical professional” to “qualified professional” for the whole Section 5.
Section 5 wide	Updated figure numbers after the addition/deletions of figures in Section 5.
Section 5 wide	Changed to allow for pre-treatment to be optional.
5.1	Changed section numbering/formatting to match the rest of the document.
5.2.5	Changed the impermeable membrane direction to defer to a qualified professional’s direction. Deleted “minimum” for the 3.0 m setback from buildings as it is just a recommended value. Also added that the minimum setback from buildings is “with engineering controls”.
5.2.8.iv	Statement on plantings changed to promote the use of low maintenance plantings.
5.2.10	Added “Trees may be installed within LID facilities; however, ensure that any hard infrastructure, such as maintenance hole covers and cleanouts, is accessible and located outside the tree canopy, if possible. If soil volumes are sufficient, trees are encouraged to be installed within soil cells as long as they do not affect operation and maintenance of the LID facility. Soil volumes are outlined within the City of Edmonton’s Design and Construction Standards Volume 5: Landscape. For existing public trees, setbacks and permits are required as per the City of Edmonton’s public tree bylaw; all setbacks should be followed unless approved by a City of Edmonton Urban Forester.”
5.2.11	Added “If LID facilities are being planned within the River Valley Area Redevelopment Plan, in a natural area or within an ecological network care must be taken to ensure that proper design considerations are taken into account. The ecological plans for that area should be consulted to ensure proper planning and integration of LID facilities into the natural area. Integration may include but is not limited to different construction practices, proper Erosion and Sediment Control (ESC), and study of the hydrological regime and water quality in the area (e.g., if LIDs are being used to replenish groundwater or feed natural waterbodies and planting plans, then monitoring of LIDs in these areas may be required).”
5.3	Updated Figure 5.1.
5.3.1.i	Added “overflow outlets” to list of bioretention garden components.
5.3.1.iii	Changed the BMP guide ownership reference from the City of Edmonton to EPCOR.
5.3.2.iv	Deleted the sentence “EPCOR’s LID Calculator can be utilized to demonstrate this if required.”
5.3.5.iii	Added overflow outlet direction.
5.3.6.iii	Deleted sentence “Where the situation permits, a greater depth may be applied.” Also added descriptor “angular” for filter layer rock.
5.3.7	Deleted Sections 5.3.7.i and 5.3.7.iii and deleted geotextile use for “filtration” in Section 5.3.7.ii.
5.4	Updated Figures 5.2 and Figure 5.3.
5.4.5.vii	Added overflow outlet direction.
5.4.6.iii	Deleted redundant sentence.
5.4.6.iii	Deleted sentence “Where the situation permits, a greater depth may be applied.” Also added descriptor “angular” for filter layer rock.
5.4.7	Deleted Sections 5.4.7.i and 5.4.7.iii and deleted geotextile use for “filtration” in Section 5.4.7.ii.
5.5	Updated Figure 5.4.
5.5.2.iv	“18 mm design event” replaced with “design event”.
5.5.6.i/iv/v	Added paragraphs on inlets/outlets.
5.5.7.iii	Redundant sentence was deleted.

Section	Changes
5.5.7.iii	Deleted sentence “Where the situation permits, a greater depth may be applied.” Also added descriptor “angular” for filter layer rock.
5.5.8	Deleted Sections 5.5.8.i and 5.5.8.iii and deleted geotextile use for “filtration” in Section 5.5.8.ii.
5.6	Updated Figure 5.5.
5.6.2.i	“18 mm design event” replaced with “design event”.
5.6.5.iii	Deleted redundant first sentence. Deleted sentence “Where the situation permits, a greater depth may be applied.” Added descriptor “angular” for filter layer rock.
5.6.6.i	Changed minimum diameter of pipe from 200 mm to 150 mm.
5.6.7.i	Changed minimum diameter of pipe from 200 mm to 150 mm.
5.6.11.vi	Updated sentence on root barriers and the distribution of stormwater.
5.7	Updated Figure 5.6.
5.7.1.i	Added sentence about how absorbent landscaping is shallower than other LID types.
5.7.5.iv	Added overflow outlet direction.
5.7.6.ii	Added “Must have a minimum 300 mm, preferably 600 mm of rolled and compacted sod, flush with hard surface adjacent to sidewalks and curbs”
5.7.7.ii	Added example of adjacent structures. Added sentence “If setbacks cannot be achieved, impermeable liners may be considered to protect adjacent structures.”
5.8	Changed section formatting (Roman Numerals to Section Numbers) to match the rest of the document
5.8.1	Updated the minimum pipe size from 200 mm to 150 mm.
5.8.3	Added that underdrains must connect to a CB/CBMH.
5.8.4	Added the minimum radius for long radius bends.
5.8.5	Added information on underground enclosure boxes and bend dimensions. Moved minimum radius of 90 degree bends to Section 5.8.4.
5.8	Added Figure 5.7 & Figure 5.8 for cleanouts.
5.8.6	Added sentences “Wye fittings are not allowed.” and “S-bends are not to be used and bends should not be used back to back to gain elevation in a short span.”
5.8.7	Changed description of infrastructure from MH to a barrel cleanout with sump.
5.8.7.i/ii	Updated section to include distances for 150 mm pipe and edited for clarity.
5.8.7.iv	Updated section for clarity.
5.8.7	Updated Figures 5.9, 5.10, 5.11, and 5.12.
5.8.8	Changed description of infrastructure from CB to barrel cleanout with sump.
5.8.9	Added minimum pipe grade of 0.5%.
5.8.9.i	Changed description of infrastructure from MH to barrel cleanout with sump.
5.8.9.ii	Changed “CB/CBMH must be flat” to “CB/CBMH may be flat”.
5.8.10.i	Deleted “A stainless steel or galvanized steel cap with a concrete thrust block or approved restrained end cap.”
5.8.11	Deleted “distribution” from figure description since the updated Figure 5.10 shows typical embedment for both distribution and underdrain perforated pipe.
5.8.12	Changed perforated pipe hole spacing to a maximum of 125mm.
5.8.15/5.8.16	Replaced “a short trash rack” with “an approved beehive/dome grate compatible with existing approved frames” and deleted reference to the Standards Drawings. Split the section to 5.8.16 for flap gate requirement.
5.9	Added new section. Moved old 5.10.3 from Cold Climate Design Considerations section to new Section 5.9.1 and moved old 5.13.4 from Construction Considerations section to new Section 5.9.2.
5.10	Added LID educational sign information and specifications. Adjusted wording to direct the use of the different signs and to articulate when signs may be necessary. Added direction on sign height.
5.13.1.i	Changed old Figure 5.13 to Table 5.4 and added columns for Design Rainfall Depth (mm) and LID Capacity/Runoff Volume (%). Also changed the example values for the table.

Section	Changes
5.13.1.iv	Changed old Figure 5.14 to Table 5.5 and added columns for Design Rainfall Depth (mm) and LID Capacity/Runoff Volume (%). Also changed the example values for the table.
5.13.3.i.e	Added "Aggregate around distribution pipes should be drawn to scale in section views to ensure that there is sufficient soil depth between the distribution pipe embedment and the filter rock layer."
5.13.3.ii	Placed drafting standards list into Table 5.7 for clearer presentation. Replaced images for clarity and uniformity.
5.15.1	Updated upper available phosphorus limit to 60 ppm in Table 5.8.
5.16.2.ii.e	Added " If Guelph testing fails specifications the Contractor can request alternate testing at their cost."
5.16.2.ii.f	Added "For facilities with a soil depth of 300 mm or less, Guelph Permeameter testing is not required."
5.16.2.vi	Added "minimum" in front of 95%.
6.2.5	Added requirements for lot grading design in case more than one lot drains to another lot downstream. Reworded the fourth bullet of 6.2.5 ii from "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." to "all the upstream lots shall have roof runoff directed to a storm service and the grading of each lot is designed with the ridge as close as possible to the rear property line."
6.3.2	Added the word "public" to the swale.
6.3	Added Figure 6.4: Lot Grading - More than One Typical D Lots Drain to Downstream Type B Lot and Figure 6.5: Lot Grading Detail - More than One Typical D Lots Drain to Downstream Type B Lot. Added 6.3.3 in regard to the private swale that is to be owned and maintained by private landowners and the required agreements such as easement and restrictive covenant triggered under 6.2.5 ii.
6.3.5	Added iv - for grass swale details on downstream Type B Lot that is servicing more than one split Type D Lots upstream.
6.3.5	iv is revised to read as v resulted as per the updates for Section 6.0 Lot Grading.
Appendix A: Computer Model Transfer Checklist.	
1.1.1	"DHI Models, e.g. Mike Urban, Mike Flood, etc. (Mike Urban 2019)" replaced with "DHI Models (Mike+), CHI Models (PC-SWMM) (current version)". "Windows 10" replaced with "Windows 11".
1.1.3	"In MicroStation or AutoCAD format c/w "GIS"" replaced with "GIS". "Sanitary" replaced with "Combined".
1.1.7	Deleted "Grade Line Factor (GLF), Theoretical Loading Factor (TLF), Hydraulic Condition Ratings (HCR) calculations". Deleted "Conclusions, recommendations and implementation plan".
1.1.8	"Microstation" replaced with "GIS shape file". "items" replaced with "relevant information".
1.2.1	"DHI Models, e.g. Mike Urban, Mike Flood, etc. (Mike Urban 2019)" replaced with "DHI Models (Mike+), CHI Models (PC-SWMM) (current version)". "Windows 10" replaced with "Windows 11".
1.2.3	Deleted "(in MicroStation or equivalent format)".
1.2.7	Deleted "Grade Line Factor (GLF), Theoretical Loading Factor (TLF), Hydraulic Condition Ratings (HCR) calculations". Deleted "Conclusions, recommendations and implementation plan".
1.2.8	"Microstation" replaced with "GIS shape file". "items" replaced with "relevant information".
Sections referenced below are from the Section 4.0 of Vol. 3-02: Stormwater Management and Design Manual published in February 2022.	
4.1.5	Removed definitions, with the exception of Naturalized Wet Ponds, Constructed Wetlands, and Dry Ponds.
4.4.ii	Removal of hardcopy O&M manual in a piano hinged binder with 65 mm spine. Instead an electronic PDF version is accepted.

Section	Changes
4.7.1	Removed "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." Removed "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."
4.12.2	Removed: - "The land required for the constructed wetland is to be dedicated to EPCOR Water Services Inc." - "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)." - "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."
4.12.17	Removed "To trap floatable materials, oil and grease, inlets and outlets are to be below normal water level."
4.13.1	Removed from Land Dedication for Dry Ponds, "Lands subject to inundation for larger storm events, to the limit of inundation for the design maximum event, are to be either: 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." Removed "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	Removed "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."

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

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 Analytical Methods

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. Application of computer simulation methods is recommended for all final analyses and detailed designs. Refer to Section ***1.5.1***.

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.

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

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*** in Section ***2.0***. 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*** in Section ***2.3***. 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*** in Section ***2.0***.

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 Water 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+ 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. The kinematic wave model (ModB) should be used for hydrologic routing.

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 Water Services i.e.: 1937, 1978 and/or 2004.

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 in Section ***2.0***. 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 EPCOR Water Services.

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 EPCOR Water Services, 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, reports shall include an appropriate section that indicate the following:

i. Type and version of computer model used;

ii. All parameters and specific simulation assumptions used;

iii. Design storms used, to be clearly documented and plotted;

iv. Volumetric runoff coefficient or total runoff obtained;

v. Peak flow versus area, plotted for each event studied;

vi. Peak flow/area versus time, plotted for each event studied.

2.0 TABLES OF RUNOFF AND RAINFALL INFORMATION

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

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 135 mm)

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

Zoning or Classification Designation Per Bylaw # 20001[1]	Zoning Category/Description Per Bylaw # 20001	Runoff[2] Coefficient " C "
RVSA, NA	River Valley	0.2
PS, PSN	Open Spaces/Civic Services	0.3[3]
AG, FD, RR	Agricultural/Rural Residential	0.3
UF	Urban Facilities	0.6
RS, RSF	Residential (Low Density)	0.65 or 0.7[4]
RSM, RM, RL	Residential (High Density)	0.7 or 0.75[4]
CN, MUN	Neighbourhood Commercial/Mixed Use	0.8 to 0.9[5]
CB, CG, MU	Commercial/Mixed Use	0.85 to 0.95[5]
BE, IH, IM	Industrial	0.85 to 0.95[5]

[1] For zonings not shown in this table, the runoff coefficient “C” and the percentage of imperviousness area shall be estimated by the designer and runoff coefficient determined in consultation with EPCOR.
[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] Runoff coefficient is valid for Open Spaces with minimal hard surfacing. Open Spaces that will have plaza areas or significant allocations for hard-surfaced sports fields must have a runoff coefficient assigned based on a percentage of impervious area estimated by the designer.
[4] Lower value may be used when the catchment area considers the lot only. Higher value must be used when the calculation includes the road ROW frontage and backage.
[5] Lower value may be used for developments incorporating landscaped areas (boulevards, islands, etc.) into the parking lot design.

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 percentage of imperviousness, Imp (%), shall be estimated by the designer and runoff coefficient be determined in consultation with EPCOR.

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

Catchment Area (A)	Imperviousness (%)		
	30	50	> 70
A ≤ 8 ha	8	8	5
8 ha < A < 40 ha	9.2	9.2	6
A ≥ 40 ha	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		67.77	91.63	109.91	134.89	154.95	178.71	204.47
6		63.06	86.03	103.68	127.66	146.77	169.50	194.59
7		59.05	81.17	98.21	121.26	139.52	161.32	185.76
8		55.60	76.90	93.36	115.54	133.04	154.01	177.80
9		52.58	73.12	89.02	110.41	127.22	147.43	170.60
10		49.93	69.74	85.11	105.76	121.96	141.46	164.04
11		47.56	66.71	81.58	101.54	117.17	136.03	158.03
12		45.45	63.96	78.37	97.68	112.79	131.06	152.52
13		43.54	61.46	75.43	94.15	108.78	126.49	147.43
14		41.81	59.18	72.73	90.89	105.08	122.27	142.72
15	0.25	40.23	57.08	70.24	87.87	101.65	118.37	138.35
16		38.79	55.15	67.94	85.08	98.48	114.75	134.28
17		37.46	53.37	65.81	82.48	95.52	111.37	130.47
18		36.23	51.71	63.82	80.05	92.76	108.22	126.91
19		35.10	50.17	61.96	77.79	90.18	105.27	123.56
20		34.04	48.72	60.23	75.66	87.75	102.50	120.42
21		33.06	47.38	58.60	73.66	85.48	99.89	117.45
22		32.14	46.11	57.06	71.78	83.33	97.43	114.65

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
23		31.28	44.92	55.62	70.00	81.30	95.11	112.00
24		30.47	43.80	54.26	68.32	79.39	92.91	109.48
25		29.71	42.74	52.97	66.73	77.57	90.83	107.10
26		28.99	41.74	51.75	65.22	75.85	88.85	104.83
27		28.31	40.80	50.59	63.79	74.22	86.97	102.67
28		27.66	39.90	49.49	62.42	72.66	85.18	100.61
29		27.05	39.04	48.44	61.13	71.18	83.47	98.65
30	0.5	26.47	38.23	47.45	59.89	69.76	81.84	96.77
31		25.92	37.45	46.49	58.70	68.41	80.29	94.97
32		25.40	36.71	45.59	57.57	67.11	78.80	93.25
33		24.90	36.01	44.72	56.49	65.88	77.37	91.60
34		24.42	35.33	43.88	55.45	64.69	76.00	90.02
35		23.96	34.68	43.08	54.46	63.55	74.69	88.50
36		23.53	34.06	42.32	53.50	62.46	73.43	87.03
37		23.11	33.47	41.58	52.59	61.40	72.21	85.63
38		22.70	32.90	40.88	51.70	60.39	71.05	84.27
39		22.32	32.35	40.20	50.85	59.42	69.92	82.96
40		21.95	31.82	39.54	50.04	58.48	68.84	81.70
41		21.59	31.31	38.91	49.25	57.58	67.79	80.48
42		21.25	30.82	38.30	48.49	56.70	66.78	79.31
43		20.92	30.35	37.72	47.75	55.86	65.81	78.17
44		20.60	29.89	37.15	47.04	55.05	64.86	77.07
45	0.75	20.29	29.45	36.60	46.35	54.26	63.95	76.01
46		19.99	29.02	36.07	45.69	53.49	63.07	74.98
47		19.70	28.61	35.56	45.05	52.76	62.22	73.98
48		19.43	28.21	35.07	44.42	52.04	61.39	73.01
49		19.16	27.82	34.59	43.82	51.35	60.58	72.07
50		18.90	27.45	34.12	43.24	50.68	59.81	71.16
51		18.65	27.09	33.67	42.67	50.02	59.05	70.27
52		18.40	26.74	33.23	42.12	49.39	58.31	69.41
53		18.16	26.39	32.80	41.58	48.78	57.60	68.58
54		17.93	26.06	32.39	41.06	48.18	56.91	67.77
55		17.71	25.74	31.99	40.56	47.60	56.23	66.97
56		17.49	25.43	31.60	40.07	47.03	55.58	66.21
57		17.28	25.12	31.22	39.59	46.48	54.94	65.46
58		17.08	24.83	30.85	39.13	45.95	54.32	64.73
59		16.88	24.54	30.49	38.67	45.43	53.71	64.01
60	1	16.69	24.26	30.14	38.23	44.92	53.12	63.32
61		16.50	23.99	29.80	37.80	44.42	52.55	62.64
62		16.31	23.72	29.47	37.38	43.94	51.99	61.99
63		16.13	23.46	29.15	36.98	43.47	51.44	61.34

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
64		15.96	23.21	28.83	36.58	43.01	50.90	60.71
65		15.79	22.96	28.52	36.19	42.56	50.38	60.10
66		15.62	22.72	28.22	35.81	42.12	49.87	59.50
67		15.46	22.49	27.93	35.44	41.70	49.38	58.91
68		15.30	22.26	27.64	35.08	41.28	48.89	58.34
69		15.15	22.03	27.36	34.72	40.87	48.42	57.78
70		15.00	21.81	27.09	34.38	40.47	47.95	57.24
71		14.85	21.60	26.82	34.04	40.08	47.50	56.70
72		14.71	21.39	26.56	33.71	39.70	47.05	56.18
73		14.57	21.19	26.30	33.39	39.33	46.62	55.66
74		14.43	20.99	26.05	33.07	38.96	46.19	55.16
75	1.25	14.30	20.79	25.81	32.76	38.61	45.78	54.67
76		14.16	20.60	25.57	32.46	38.26	45.37	54.19
77		14.04	20.41	25.34	32.16	37.91	44.97	53.72
78		13.91	20.23	25.11	31.87	37.58	44.58	53.25
79		13.79	20.05	24.88	31.59	37.25	44.20	52.80
80		13.66	19.87	24.66	31.31	36.93	43.82	52.36
81		13.55	19.70	24.44	31.03	36.61	43.45	51.92
82		13.43	19.53	24.23	30.77	36.30	43.09	51.49
83		13.32	19.37	24.02	30.50	36.00	42.73	51.07
84		13.20	19.20	23.82	30.25	35.70	42.39	50.66
85		13.10	19.04	23.62	29.99	35.41	42.05	50.26
86		12.99	18.89	23.43	29.75	35.12	41.71	49.86
87		12.88	18.73	23.23	29.50	34.84	41.38	49.47
88		12.78	18.58	23.05	29.26	34.56	41.06	49.09
89		12.68	18.44	22.86	29.03	34.29	40.74	48.72
90	1.5	12.58	18.29	22.68	28.80	34.02	40.43	48.35
120	2	10.26	14.90	18.42	23.40	27.76	33.10	39.65
180	3	7.66	11.10	13.66	17.35	20.70	24.81	29.77
240	4	6.22	8.98	11.01	13.98	16.76	20.15	24.20
300	5	5.28	7.61	9.31	11.81	14.20	17.12	20.57
360	6	4.62	6.64	8.10	10.28	12.39	14.97	18.00
420	7	4.13	5.92	7.21	9.13	11.04	13.36	16.07
480	8	3.74	5.36	6.51	8.24	9.99	12.11	14.56
540	9	3.43	4.91	5.95	7.53	9.14	11.09	13.35
600	10	3.18	4.53	5.49	6.94	8.44	10.26	12.35
660	11	2.96	4.22	5.10	6.45	7.85	9.56	11.50
720	12	2.78	3.95	4.77	6.03	7.35	8.96	10.78
780	13	2.62	3.72	4.48	5.67	6.92	8.44	10.16
840	14	2.48	3.52	4.24	5.35	6.54	7.99	9.61
900	15	2.35	3.34	4.02	5.08	6.21	7.58	9.13

Time		Return Frequency						
Minutes	Hours	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
960	16	2.24	3.18	3.82	4.83	5.91	7.23	8.70
1020	17	2.15	3.04	3.65	4.61	5.65	6.91	8.32
1080	18	2.06	2.91	3.49	4.41	5.41	6.62	7.97
1140	19	1.98	2.80	3.35	4.23	5.19	6.36	7.65
1200	20	1.90	2.69	3.22	4.06	4.99	6.12	7.36
1260	21	1.84	2.59	3.10	3.91	4.81	5.90	7.10
1320	22	1.77	2.50	2.99	3.77	4.64	5.70	6.86
1380	23	1.72	2.42	2.89	3.64	4.49	5.51	6.63
1440	24	1.66	2.34	2.79	3.52	4.34	5.34	6.43

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	67.77	91.63	109.91	134.89	154.95	178.71	204.47
10	0.167	49.93	69.74	85.11	105.76	121.96	141.46	164.04
15	0.250	40.23	57.08	70.24	87.87	101.65	118.37	138.35
20	0.333	34.04	48.72	60.23	75.66	87.75	102.50	120.42
25	0.417	29.71	42.74	52.97	66.73	77.57	90.83	107.10
30	0.500	26.47	38.23	47.45	59.89	69.76	81.84	96.77
35	0.583	23.96	34.68	43.08	54.46	63.55	74.69	88.50
40	0.667	21.95	31.82	39.54	50.04	58.48	68.84	81.70
45	0.750	20.29	29.45	36.60	46.35	54.26	63.95	76.01
50	0.833	18.90	27.45	34.12	43.24	50.68	59.81	71.16
55	0.917	17.71	25.74	31.99	40.56	47.60	56.23	66.97
60	1	16.69	24.26	30.14	38.23	44.92	53.12	63.32
120	2	10.26	14.90	18.42	23.40	27.76	33.10	39.65
180	3	7.66	11.10	13.66	17.35	20.70	24.81	29.77
240	4	6.22	8.98	11.01	13.98	16.76	20.15	24.20
360	6	4.62	6.64	8.10	10.28	12.39	14.97	18.00
720	12	2.78	3.95	4.77	6.03	7.35	8.96	10.78
1440	24	1.66	2.34	2.79	3.52	4.34	5.34	6.43

2.6 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)	370.264	587.050	798.399	1044.556	1145.985	1290.076	1554.160
b	-0.743	-0.759	-0.777	-0.782	-0.766	-0.754	-0.754
c (min)	4.831	6.555	7.834	8.701	8.629	8.758	9.732

2.7 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	48.75	68.03	82.98	103.10	118.92	137.97	160.01
85	48.75	68.03	82.98	103.10	118.92	137.97	160.01
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
175	2.62	3.68	4.37	5.57	7.00	8.66	10.56

[1] Instantaneous Peak Averaged out

Time (min)	Return Frequency						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
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

2.8 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	0.96	1.15
30		0.60	0.84	1.00	1.26	1.56	1.91	2.30
45		0.89	1.26	1.50	1.89	2.33	2.87	3.45
60	1	1.19	1.68	2.00	2.53	3.11	3.82	4.60
75		1.59	2.24	2.67	3.37	4.15	5.10	6.14
90		2.38	3.35	4.00	5.04	6.21	7.63	9.19
105		3.17	4.47	5.32	6.71	8.28	10.17	12.24
120	2	3.96	5.58	6.65	8.39	10.34	12.70	15.29
135		4.75	6.69	7.98	10.06	12.40	15.23	18.34
150		5.28	7.44	8.87	11.19	13.79	16.94	20.40
165		5.42	7.65	9.12	11.50	14.17	17.41	20.96
180	3	5.57	7.85	9.36	11.81	14.55	17.88	21.52
195		5.71	8.06	9.61	12.11	14.93	18.34	22.09
210		5.86	8.26	9.85	12.42	15.31	18.81	22.65
225		5.77	8.13	9.70	12.23	15.07	18.52	22.30
240	4	5.52	7.78	9.28	11.70	14.42	17.72	21.33
255		5.27	7.43	8.86	11.17	13.77	16.92	20.37
270		5.02	7.08	8.44	10.64	13.12	16.12	19.40
285		4.77	6.73	8.02	10.11	12.47	15.31	18.44
300	5	4.53	6.38	7.61	9.60	11.83	14.53	17.50
315		4.29	6.04	7.20	9.08	11.20	13.75	16.56
330		4.04	5.70	6.80	8.57	10.56	12.98	15.62
345		3.80	5.36	6.39	8.06	9.93	12.20	14.69
360	6	3.56	5.02	5.98	7.54	9.30	11.42	13.75
375		3.34	4.70	5.61	7.07	8.72	10.71	12.89

Time		Return Frequency						
Mins.	Hrs.	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
390		3.11	4.39	5.24	6.60	8.14	10.00	12.04
405		2.89	4.08	4.86	6.13	7.56	9.28	11.18
420	7	2.67	3.77	4.49	5.66	6.98	8.57	10.32
435		2.46	3.47	4.14	5.22	6.44	7.91	9.52
450		2.31	3.26	3.88	4.90	6.04	7.42	8.93
465		2.16	3.04	3.63	4.58	5.64	6.93	8.34
480	8	2.01	2.83	3.37	4.25	5.24	6.44	7.75
495		1.85	2.61	3.12	3.93	4.84	5.95	7.16
510		1.74	2.45	2.92	3.68	4.54	5.58	6.71
525		1.67	2.36	2.82	3.55	4.38	5.38	6.47
540	9	1.61	2.27	2.71	3.42	4.21	5.18	6.23
555		1.55	2.19	2.61	3.29	4.05	4.98	5.99
570		1.49	2.10	2.50	3.15	3.89	4.78	5.75
585		1.43	2.01	2.40	3.02	3.72	4.58	5.51
600	10	1.36	1.92	2.29	2.89	3.56	4.38	5.27
615		1.30	1.83	2.19	2.76	3.40	4.18	5.03
630		1.24	1.75	2.08	2.63	3.24	3.98	4.79
645		1.18	1.66	1.98	2.49	3.07	3.78	4.55
660	11	1.12	1.58	1.88	2.37	2.92	3.59	4.33
675		1.06	1.50	1.79	2.26	2.78	3.42	4.11
690		1.01	1.42	1.70	2.14	2.64	3.24	3.90
705		0.95	1.34	1.60	2.02	2.49	3.06	3.68
720	12	0.90	1.27	1.51	1.90	2.35	2.88	3.47
735		0.87	1.23	1.46	1.84	2.27	2.79	3.36
750		0.84	1.19	1.42	1.79	2.20	2.70	3.26
765		0.81	1.15	1.37	1.73	2.13	2.61	3.15
780	13	0.79	1.11	1.32	1.67	2.06	2.53	3.04
795		0.76	1.07	1.27	1.61	1.98	2.43	2.93
810		0.72	1.02	1.22	1.53	1.89	2.32	2.79
825		0.69	0.97	1.16	1.46	1.80	2.21	2.66
840	14	0.65	0.92	1.10	1.39	1.71	2.10	2.53
855		0.62	0.87	1.04	1.31	1.62	1.99	2.39
870		0.60	0.84	1.00	1.26	1.56	1.91	2.30
885		0.59	0.83	0.99	1.25	1.54	1.89	2.28
900	15	0.58	0.82	0.98	1.23	1.52	1.87	2.25
915		0.57	0.81	0.97	1.22	1.50	1.85	2.22
930		0.57	0.80	0.95	1.20	1.48	1.82	2.20
945		0.56	0.79	0.94	1.19	1.47	1.80	2.17
960	16	0.55	0.78	0.93	1.17	1.45	1.78	2.14
975		0.55	0.77	0.92	1.16	1.43	1.76	2.11
990		0.54	0.76	0.91	1.15	1.41	1.73	2.09
1005		0.53	0.75	0.90	1.13	1.39	1.71	2.06
1020	17	0.53	0.74	0.89	1.12	1.38	1.69	2.03
1035		0.52	0.73	0.87	1.10	1.36	1.67	2.01
1050		0.51	0.72	0.86	1.09	1.34	1.65	1.98
1065		0.51	0.71	0.85	1.07	1.32	1.62	1.95
1080	18	0.50	0.70	0.84	1.06	1.30	1.60	1.93
1095		0.49	0.69	0.83	1.04	1.29	1.58	1.90
1110		0.48	0.68	0.82	1.03	1.27	1.56	1.87
1125		0.48	0.67	0.80	1.01	1.25	1.53	1.85
1140	19	0.47	0.66	0.79	1.00	1.23	1.51	1.82
1155		0.46	0.65	0.78	0.98	1.21	1.49	1.79

Time		Return Frequency						
Mins.	Hrs.	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
1170		0.45	0.63	0.75	0.95	1.17	1.44	1.73
1185		0.44	0.61	0.73	0.92	1.14	1.40	1.68
1200	20	0.42	0.59	0.71	0.89	1.10	1.35	1.63
1215		0.41	0.57	0.68	0.86	1.06	1.31	1.57
1230		0.39	0.55	0.66	0.83	1.03	1.26	1.52
1245		0.38	0.54	0.64	0.80	0.99	1.22	1.47
1260	21	0.37	0.52	0.61	0.78	0.96	1.17	1.41
1275		0.35	0.50	0.59	0.75	0.92	1.13	1.36
1290		0.34	0.48	0.57	0.72	0.88	1.09	1.31
1305		0.32	0.46	0.54	0.69	0.85	1.04	1.25
1320	22	0.31	0.44	0.52	0.66	0.81	1.00	1.20
1335		0.30	0.42	0.50	0.63	0.77	0.95	1.15
1350		0.28	0.40	0.48	0.60	0.74	0.91	1.09
1365		0.27	0.38	0.45	0.57	0.70	0.86	1.04
1380	23	0.25	0.36	0.43	0.54	0.67	0.82	0.99
1395		0.24	0.34	0.41	0.51	0.63	0.77	0.93
1410		0.23	0.32	0.38	0.48	0.59	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	0.34	0.42	0.52	0.64	0.77

2.9 Table 2.9: Recorded Storm of July 14, 1937

Municipal Airport Rain Gauge

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
Minutes	mm/h	Minutes	mm/h	Minutes	mm/h	Minutes	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

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
Minutes	mm/h	Minutes	mm/h	Minutes	mm/h	Minutes	mm/h
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
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		

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

Municipal Airport Rain Gauge

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
	mm/h		mm/h		mm/h		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

Time	Intensity mm/h	Time	Intensity mm/h	Time	Intensity mm/h	Time	Intensity mm/h
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	
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	

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
	mm/h		mm/h		mm/h		mm/h
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		

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

Time	Intensity	Time	Intensity	Time	Intensity	Time	Intensity
Minutes	mm/h	Minutes	mm/h	Minutes	mm/h	Minutes	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

Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h
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
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

Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h	Time Minutes	Intensity mm/h
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

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 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 and durations 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 Stormwater Management Facilities (SWMFs).

4.1 General Principles, Objectives, Considerations

SWMFs receive stormwater from the minor system as well as from overland drainage sources. They have a multitude of important functions in the urban environment. SWMFs provide flood protection during large storm events and improvements to stormwater quality. In addition, SWMFs also serve to sequester carbon in soils and vegetation, add aesthetic value to a neighbourhood, provide passive recreation opportunities, and support ecological function and biodiversity, among other functions. SWMFs play a vital role in keeping property, the public, and communities safe. Therefore, the proper planning, design, construction, operation, and maintenance of these facilities is essential. In order to achieve these objectives, SWMFs shall adhere to all standards as outlined in this document. For further information, refer to Section 1.3 - Vol. 3-05: Statutory Requirements for Approvals by Other Authorities.

4.1.1 Flood Protection

SWMFs protect the public and property from flooding by storing stormwater during large storms and discharging it at a controlled rate back into the downstream sewer system, creek, or river, following the storm events. Urban development increases the proportion of impervious land area and thereby increases the volume of runoff generated when compared to pre-development conditions. Due to the volume of stormwater generated during large storm events, the minor drainage system that is designed for only 1:5 year design storm event can easily be overwhelmed, resulting in overland flooding and basement back-ups.

Starting in the 1980s, neighbourhoods in Edmonton were typically designed to direct stormwater to a SWMF in order to prevent flooding and provide many environmental benefits.

4.1.2 Environmental Objectives

SWMFs protect surrounding water bodies and wetlands from the impacts of erosion, urban pollutants, pathogens, and flooding. Urban stormwater can be high in suspended solids, metals, salts, nutrients, hydrocarbons, and bacteria, which can negatively affect receiving water courses. SWMFs disperse water, slow flow velocity, and cause sediment to be deposited by gravity. Metals and nutrients that are adsorbed to sediment particles are also deposited, resulting in stormwater quality improvements. Having a wet SWMF (naturalized wet pond, constructed wetland) for water quality improvements is important to maintaining the water quality in receiving water courses such as the North Saskatchewan River (NSR) and urban streams. Vegetation within SWMFs can improve water quality through pollutant and nutrient uptake.

Controlling the magnitude and discharge of stormwater helps to reduce erosion of the beds and shores of receiving waterbodies/watercourses. The banks of the NSR and its tributaries are vulnerable to erosion, particularly near outfalls where stormwater is discharged. This highlights the importance of best management practices for controlling discharge rates and reducing the volume of stormwater generated. Further, increases in sediment from stormwater may result in deteriorated water supplies and negatively affect aquatic habitat.

SWMFs help to promote biodiversity in urban settings. Wet SMWFs provide habitat for songbirds, waterfowl, native plants, invertebrates, and amphibians. Biodiversity should be encouraged through the selection of native plant species and naturalization.

SWMFs also help to mitigate urban heat island effects, and vegetation within SWMFs helps to capture greenhouse gasses.

4.1.3 Safety

i. Any interaction humans have with waterbodies can be considered a risk with potential significant consequences, and therefore, safety is crucial when planning and designing SWMFs. This includes Dry ponds, which do not typically contain water, but can rapidly fill during extreme rain events. Adherence to this Standard is important to ensuring the safety of the public, Operations & Maintenance (O&M) staff, property, and the environment. Failure to do so could result in property and environmental damage, injury, or death.

ii. A multi-barrier approach shall be used to limit and manage public access to SWMFs. Measures can include aquatic vegetation, upland vegetation, fencing, signage, public education, and strategically locating SWMFs in neighbourhoods. Where practical, SWMFs should be located away from schools, playgrounds, daycares, and other facilities where vulnerable persons may be present. Where this is not practical, measures should be considered to limit and discourage direct access, such as fencing, railings, or other equivalent barriers. Wet SWMF should have continuous, dense, and woody vegetation along the entire shoreline, with transitional vegetation at all boat launches to limit shoreline accessibility.

iii. The safety of O&M staff shall be a leading consideration when planning and designing SWMFs and their related components. At minimum, the design shall adhere to Occupational Health & Safety regulations, in addition to any other safety requirements outlined in these Standards.

4.1.4 Recreation

i. The primary purpose of SWMFs is to manage stormwater quantity and quality. SWMFs can also provide residents with recreational opportunities in their neighbourhoods, however, there are risks associated with these activities.

ii. Swimming, wading, fishing, sail boarding, water skiing, kayaking, scuba diving, any use of inner tubes or small inflatables, and boating (motorized and non-motorized) is prohibited for all SWMFs. Contact with stormwater in the facilities can cause skin irritation, and ingestion of stormwater can cause illness to humans and pets. Winter activities such as ice skating, cross-country skiing, and tobogganing on SWMFs is also prohibited, as the ice thickness is not monitored.

iii. Activities that are permitted include but are not limited to bird watching and photography from safe locations. Bicycle riding, walking, and jogging are permitted on designated paths and trails.

Outdoor picnicking is allowed in designated areas.

iv. Dry ponds are commonly utilized as multi-purpose facilities; however, they may require additional signage, monitoring, or other measures to prevent access during storm events when the dry pond begins to fill.

4.1.5 Costs

Both short-term capital costs and long-term operation and maintenance costs must be considered during the planning and design of SWMFs. A primary consideration must be to minimize the long-term operation and maintenance cost. For example, when a choice is available to use one larger SWMF as an alternative to two or more smaller SWMFs, then one larger SWMF shall be used, as a larger number of SWMFs results in increased operation and maintenance costs, which are ultimately borne, by citizens and utility rate payers.

4.1.6 Topography

The natural topography of a development or catchment area must be considered when planning SWMFs. Efforts should be made to locate SWMFs in naturally occurring, pre-development low points within the catchment area to aid in drainage and to take advantage of emergency overland spillways.

4.2 Planning & Design Phases

In addition to any requirements and guidelines set out in Volume 3-01 or elsewhere in these Standards, the following items related to SWMFs must be addressed during the phases of planning and design.

4.2.1 Area Master Plan (AMP)

The AMP is prepared in conjunction with the Area Structure Plan (ASP) and must specify and justify the approximate size and general location of SWMFs within the area. The 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, erosion, and operation and maintenance costs, while maximizing water quality improvement. Opportunities should be explored to safely integrate SWMFs into the community to provide recreational, educational, and aesthetic value. The AMP must demonstrate that the elevations of the proposed SWMFs will function along with the other aspects of the area's storm drainage system. The type of each SWMF within the AMP area should be identified (refer to Section ***4.3***), though there can be flexibility to change SWMF type at the NDR stage where sufficient justification exists. Refer to Section 4.0 - Vol. 3-01: Typical Area Master Plan Requirements for more information.

4.2.2 Neighbourhood Design Report (NDR)

i. The NDR is prepared in conjunction with the Neighbourhood Structure Plan (NSP) and refines servicing concepts established in the AMP/ASP. The requirements for hydraulic performance for SWMFs including storage capacity, outlet rate of flow/discharge 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.

ii. The NDR proposes methods and procedures for overcoming all constraints identified in the AMP. The NDR will identify all constraints to the implementation of the facilities, including financial, design, topographical, hydrogeotechnical, and construction approvals. Refer to Section 5.0 - Vol. 3-01: Typical Neighbourhood Design Report Requirements for more information.

iii. The NDR provides more information to make informed decisions about land-use for the neighbourhood. Relating to SWMFs, the NDR should include:

   a. Type of SWMF;
   b. Size (ha) at the NWL;
   c. Size (ha) of PUL;
   d. Contributing basin size (ha);

e. Required storage volume and available storage volume;

f. Profile of the SWMF with NWL, 1:25 Year and 100 Year HWL of design event, and freeboard;

g. Verification that the historical events (i.e. 1937, 1978, 2004) are within freeboard;

h. Drawdown times;

i. Control structure details and appurtenances;

j. Allowable release rate (both per hectare and total flow);

k. Estimated construction costs.

4.2.3 SWMF Count

i. When the number and types of SWMFs are being determined for an area during the AMP/ASP phase, NDR/NSP phase, or otherwise, a small number of large facilities should be targeted as opposed to a larger number of small facilities. This will encourage efficient use of land and discourage the proliferation of unnecessarily large numbers of SWMFs.

ii. The number of wet SWMFs for an area should be one (1) wet SWMF per quarter section of land (approximately 64.7 ha), excluding any lands that do not contribute storm flows to the drainage system (primarily creeks/environmental reserve areas). For example:

   a. Example ASP gross land area = 1,302 ha

   b. Example Non-contributing area (creek) = 20 ha

   c. Net drainage area calculation = 1,302 ha - 20 ha = 1,282 ha = 19.8 quarter sections

   d. Maximum number of wet SWMFs calculation = 19

   Each quarter section of land within the area does not necessarily need to contain a SWMF, nor does it necessarily need to contain only one SWMF. A given quarter section may contain more or less than one wet SWMF, provided that the overall area being planned contains an aggregate number of wet SWMFs of less than, or equal to, one per quarter section.

   Planners and designers are encouraged to further reduce the number of wet SWMFs where practical. This can typically be achieved by increasing facility size/capacity (thus decreasing the number of SWMFs required), or through the use of dry ponds.

iii. Areas that have an existing AMP/ASP, NDR/NSP, or otherwise, where the number and type of SWMFs has already been determined and approved, are not subject to the requirements outlined in Section ***4.2.3.ii***. These areas are considered exempt from the requirements of Section ***4.2.3 .ii***, and shall follow the requirements set out in Sections ***4.4*** to ***4.7*** as applicable. In the event that a previously approved stormwater management plan for an area is being changed or updated, EPCOR shall have the right to apply the requirements of Section ***4.2.3.ii*** during the change or update, acting reasonably.

4.2.4 Detailed Engineering Drawings

The detailed engineering drawings for any SWMF are to include the following information:

i. Physical dimensions of the facility;

ii. Stage-Volume Curve, Stage-Area Curve, Drawdown Curve (showing SWMF filling up during the storm event and post event activity, identifying the period of time where the pond has its 90% storage capacity restored), Outlet Discharge Curve, and tables of the values, including data and structures from pond bottom up to the freeboard;

iii. The HWL design event basis;

iv. Liner material type, boundary line, and elevation, if required;

v. Contours showing elevations at SWMF bottom or low points, side slope changes, Normal Water

Level (NWL), 2 Year, 5 Year, 10 Year, 25 Year, 100 Year Level/HWL, and freeboard;

vi. Storage volumes at side slope changes or at least at every 0.5 m between bottom and NWL, NWL, 2 Year, 5 Year, 10 Year, 25 Year, 100 Year Level, HWL, and freeboard level;

vii. Water surface area at SWMF bottom, side slope changes or at least at every 0.5 m, NWL, 2 Year, 5 Year, 10 Year, 25 Year, 100 Year Level, HWL, and freeboard level;

viii. Notation indicating the lowest allowable building opening elevation and bottom of footing elevation for lots abutting the wet pond (if applicable);

ix. SWMF and forebay depth at NWL, 2 Year, 5 Year, 10 Year, 25 Year, 100 Year Level/HWL, and freeboard;

x. Hydraulic control operation logic and details for outflow control gate, rapid drawdown provisions, bypass mechanism, discharge stop or flow control mechanisms, control medium (orifice, weir), gate and hardware;

xi. Contributing basin delineated and size in ha indicated;

xii. Measurements to locate submerged inlet(s), outlet(s), and sediment traps referenced to identifiable, permanent features which are not submerged at NWL;

xiii. Location, dimensions, and details of shared-use path(s), maintenance access, boat ramps, furniture, and other amenities;

xiv. Landscaping details;

xv. Permanent erosion and sediment control measures.

4.2.5 Erosion and Sediment Control

A project specific Erosion and Sediment Control (ESC) Plan shall be included with the ESC report. The Plan shall build on the ESC Strategy and be developed according to the checklist presented in the ESC Guidelines. The Plan to address project specific temporary and permanent ESC measures.

4.2.6 Geotechnical Considerations

Special geotechnical investigations to address issues related to the design of all SWMFs are to be undertaken as part of the planning and design studies and are a prerequisite to the final design of such facilities.

4.3 SWMF Types and Selection Criteria

4.3.1 SWMF Types

i. **Naturalized Wet Pond**: A naturalized wet pond is an impoundment area created by an embankment or through excavation of a depression. The purpose of naturalized wet ponds is to temporarily store stormwater runoff, to promote the removal of sediment, and to reduce urban contaminants reaching water bodies. As a wet facility, naturalized wet ponds are designed to store water up to the normal water level (NWL) year-round. Following rainfall events, stored stormwater above the NWL will be discharged at a controlled rate to decrease downstream flooding and erosion. Naturalized wet ponds use gravity and biological processes to achieve water quality enhancement targets. Naturalized wet ponds are mostly consists of deep pools (≥ 2.5m in depth) and emergent vegetation around the perimeter, with naturalized vegetation in the uplands.

Figure 4.1: Naturalized Wet Pond (Fountain Lake)

ii. **Constructed Wetland**: A constructed wetland is a shallow impoundment area created by constructing an embankment or through excavation of a depression, planted with emergent rooted vegetation or colonized naturally by volunteer plant species. The purpose of constructed wetlands is to temporarily store stormwater runoff, to promote the removal of sediment, and to reduce urban contaminants reaching water bodies. As a wet facility, constructed wetlands are designed to store water up to the normal water level year-round. Following rainfall events, stored stormwater above the NWL will be discharged at a controlled rate to decrease downstream flooding and erosion. Constructed wetlands use gravity and biological processes to achieve water quality enhancement targets. Constructed wetlands are dominated by shallow areas (0.1 - 0.6 m; average 0.3 m in depth) with a small portion being deeper pools, and typically have emergent vegetation throughout the wetland, with naturalized vegetation in the uplands.

Figure 4.2: Constructed Wetland (Ebbers Facility #1)

iii. **Dry Pond**: A dry pond is an impoundment area constructed by an embankment or through excavating a pit. The purpose of dry ponds is to temporarily detain stormwater runoff. As a dry facility, dry ponds are designed to only store water following large storm events and should be designed to empty completely between storm events. Following a rainfall event, dry ponds discharge stored stormwater at a controlled rate to prevent downstream flooding and erosion. Dry ponds should have downstream water quality improvement infrastructure such as a wet SWMF or other approved stormwater quality improvement infrastructure before discharging into a water body. Dry ponds may require additional signage and monitoring. Additional recreation facilities, such as sports fields, may be incorporated into dry ponds at the discretion of EPCOR and the City of Edmonton.

Figure 4.3: Dry Pond (Steinhauer Park)

iv. Other SWMF types and technologies may be considered on a case-by-case basis.

4.3.2 SWMF Type Selection

i. The type of SWMFs for an area shall be determined in conjunction with the preparation and approval of the AMP, NDR, or other applicable servicing study. Refer to Sections ***4.2.1*** and ***4.2.2***.

ii. When a wet SWMF is required, naturalized wet ponds that meet the criteria outlined in Section ***4.5*** are preferred from an O&M perspective.

iii. Constructed wetlands that meet the criteria outlined in Section ***4.6*** may be used at the discretion of the Developer, or if required in order to meet Provincial requirements related to water quality or lost wetland areas.

iv. Dry ponds are recommended where the requirements for wet facilities cannot be met, or at the discretion of the Developer. Dry ponds are also recommended in similar situations where smaller wet facilities have been used in the past, as Dry ponds can be incorporated into open spaces or recreational use areas. Important considerations when planning and designing Dry ponds are as follows:

a. Dry ponds should be used when the size or shape requirements for naturalized wet ponds and constructed wetlands cannot be met.

b. A wet facility downstream of a dry pond or an approved stormwater quality improvement alternative can be considered, prior to discharge to the receiving watercourse, in order to meet stormwater quality objectives.

c. In order to manage front-ending costs and allow for flexible development staging, Planners may consider an area stormwater design where many smaller dry ponds feed into a single large downstream wet facility.

d. Low impact development (LID) is recommended in conjunction with dry ponds to help meet flood protection and stormwater quality objectives.

v. A system of SWMFs, prior to outfall to a receiving natural water body, must be able to meet the minimum design requirement for total suspended solids removal of 85% of particle size 75 µm or greater, as recommended by Alberta Environment, April 2001.

vi. EPCOR encourages innovative solutions which meet the objectives for flood protection and stormwater quality improvements. Solutions outside the scope of these Standards will be assessed on a case-by-case basis.

4.4 Requirements Common to Stormwater Management Facilities

4.4.1 SWMF 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: Storm Drainage System – Policy, Goals and Objectives. 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 (or equivalent) for the respective development area.

4.4.2 Regulatory Requirements

Prior to construction, all SWMFs require the appropriate authorization and registration with Alberta Environment and Protected Areas pursuant to the Environmental Protection and Enhancement Act (EPEA) and the Water Act. The Developer is responsible for preparing and submitting the required information to the City for review and sign-off on behalf of EPCOR, prior to the consultant submitting the final registration package and supporting documentation to Alberta Environment and Protected Areas.

4.4.3 Land Dedication

i. The land required for SWMFs shall be designated as a Public Utility Lot (PUL), at minimum, up to the area of land which would be covered by water when the water level is at the freeboard elevation. Additionally, any land required for inlets, outlets, flow control facilities, and other SWMF components shall be designated as a PUL, including any maintenance access routes to the SWMF and its related components.

ii. Land required for SWMFs shall not form part of the municipal reserve or environmental reserve lands provided by the Developer to the City.

4.4.4 Emergency Overland Route and Freeboard

i. 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 facility 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.

ii. The design of SWMFs, which are provided with an emergency overflow to a safe outlet, shall include a minimum freeboard provision of 0.5 m above the design 1:100 year HWL. In the absence of a sufficient emergency overflow, the freeboard provided shall be at least 1.0 m. The historical events (i.e. 1937, 1978, 2004) shall be within the freeboard.

4.4.5 Circulation

Narrow and/or dead bay areas where floating debris may accumulate are to be avoided. Inlets and outlets shall be located to maximize detention time and circulation.

4.4.6 Inlets and Outlets

i. Inlets and outlets shall include a concrete flared end section and rip-rap to prevent erosion.

ii. Inlet and outlet foundations should be designed to provide adequate support to the structures (either through Class A bedding or piles) as recommended by the designer.

iii. The outlet from a SWMF must incorporate appropriate means for control of outflow to limit the rate of discharge 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.

iv. Control Panels

   a. All cabinets shall be fitted with a fan to circulate ambient air through the cabinet to prevent overheating of components. The fans shall have removable filters to prevent debris from entering the cabinet, be temperature controlled, and have the exhaust opening as far as practical from the intake.

   b. Cabinets should be placed to prevent exposure to direct, mid-day sun. Shading can be provided by placement of trees or by shade panels.

v. Outflow Control Gate

   a. Each SWMF shall include 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 316 stainless steel, marine grade aluminum, or an approved equivalent or better.

   b. The outflow control gate shall have a non-rising stem.

   c. Gates are to have manual grease lines, with grease ports clearly marked and accessible.

vi. Outlet Control Bypass and Rapid Drawdown Provisions

   a. The outlet works of each SWMF 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 Sections ***4.5.6*** and ***4.6.7*** in regard to provisions for draining wet SWMFs.

   b. 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.

   c. In any case, the means should be provided to permit discharge from SWMFs 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 specified in Sections ***4.5.6***, ***4.6.7***, and ***4.7.6***.

vii. Davit bases, guard rails, grab bars, hatches, steps, handrails, and other safety improvements for control structures shall be designed and constructed in accordance with drawing DR-02-04-01 found in Volume 3-06: Standard Drawings. Also refer to OH&S fall protection standards. Individual project conditions to be considered in the design, as the referenced detail is typical, and may not address all the safety improvements.

viii. Control structures shall have three chambers which can accommodate a water level control gate, drawdown (bypass gate) and flow control orifice/weir (gate) to ensure that maintenance can be performed on control gates and to aid in SWMF drawdown.

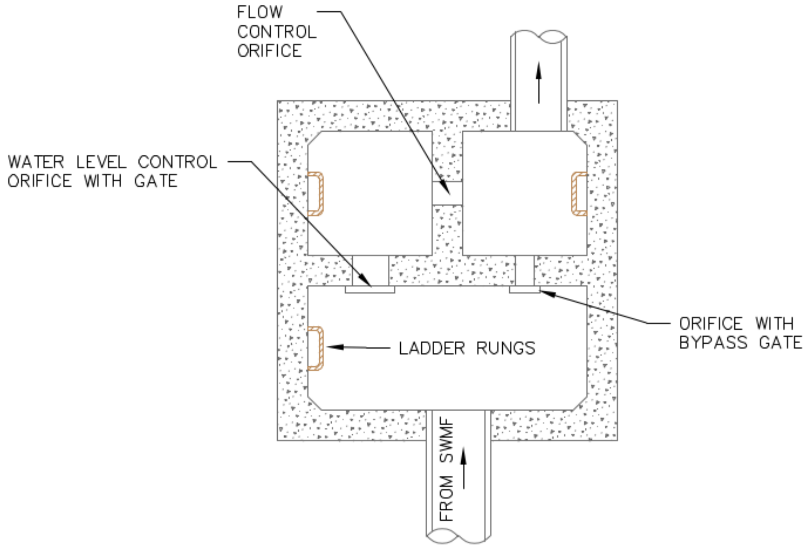


Figure 4.4: Typical Control Structure – Plan View

ix. Control structures must be located such that the top of the structure is located above the design 1:100 year HWL.

4.4.7 Water Level Monitoring

Water level monitoring devices are required for all SWMFs. The level monitoring device shall be installed at the SWMF control structure and must be accessible for maintenance. The monitoring device shall have the ability to measure water levels throughout the full depth of the control structure (above and below NWL). Other locations may be considered if sufficient justification exists. Radar level sensors are preferred, while other types will be considered where radar is found to be unfeasible. Level monitoring devices shall measure water level at real time and be connected to EPCOR's SCADA system.

4.4.8 Maintenance Access Requirements

For all SWMFs, all-weather (asphalt or concrete) vehicle access must be provided to the outlet control structure. The access shall be a minimum of 3.0 m wide and be rated for 30 tonnes. The minimum turning radius for maintenance accesses shall be 15.1 m. Turning movement details may be required for acute angled accesses. Alignments with angles less than 45° are to be avoided. Throughway provisions or a turnaround must be provided to allow safe access and egress at the site. Access alignment must avoid conflict with landscaping, furniture, and other public amenities, and must be at least 3 meters from City trees. Maintenance access with respect to public roadways is subject to review and approval by both EPCOR and the City. Specific additional access requirements for each SWMF type can be found below in Sections ***4.5.8*** (naturalized wet ponds) and ***4.6.9*** (constructed wetlands).

4.4.9 Signage

i. Signage for Safety

All 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 Water Services and must be requested by the Developer as early as practicable. The Contractor's or the Developer's information should be posted on a sticker on the signage until CCC is issued. Refer to ***Figure 4.5***.

Figure 4.5: SWMF Standard Safety Sign Examples

ii. 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 any area that includes a SWMF. The purpose of the brochure is to educate residents about:

a. The specific function of SWMFs;

b. 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);

c. Design High Water Level;

d. Recreational use on, in, or near the water or ice is not permitted;

e. Release of invasive species, such as goldfish or other, is illegal and dangerous to the natural ecosystem.

It is also recommended that the Developer includes this information on their website.

iii. The Developer is responsible for installation at least one interpretive signage showing a 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.

4.4.10 Fencing

i. In order to mitigate public safety risks, and to delineate the boundary between a SWMF and adjacent properties, fencing is required along the property lines of any privately titled lands where they border a SWMF. The fencing shall be fully located on the private side of the property line between the titled lands and the SWMF lot. This fencing shall be 1.2 m minimum in height.

ii. Fencing may be required at the discretion of EPCOR and the City in safety-sensitive locations (adjacent to schools, playgrounds, daycares, senior/nursing homes, etc.) where buffers are inadequate or not possible.

iii. Fencing may be required in areas where the SWMF is directly adjacent to a road right of way or park site at the discretion of EPCOR and the City.

iv. Fencing materials and construction shall adhere to requirements outlined in the City of Edmonton Design and Construction Standards, Volume 5: Landscape.

v. Private gate access to the SWMF, from backyards or other private property, is permitted at the discretion of EPCOR.

4.4.11 Railings

Proper railings, which at a minimum meet all OH&S regulations, must be installed on all vertical (retaining) walls and inlet/outlet structures.

4.4.12 Shared-Use Paths

Shared use paths must be located at or above the 1:25 year event elevation for the SWMF. Safe and controlled locations for access closer to the water (such as viewing plazas with railings) will be considered on a case-by-case basis. Shared use path configuration and locations are subject to review and approval by both EPCOR and the City and shall follow the City of Edmonton Design and Construction Standards, Volume 2: Complete Streets.

4.4.13 Landscaping

i. Landscaping of areas bounding the facility is to be part of the facility construction requirements, and landscaping plans shall be submitted as part of the engineering drawings. This shall include all proposed public lands comprising the SWMF and all easement areas if applicable. The minimum requirements for landscaping shall be as specified in the City of Edmonton Design and Construction Standards, Volume 5: Landscape. The design intent for landscaping within a SWMF is to create a physical and visual barrier discouraging direct public access to the waterline, and to enhance ecological habitat and water quality. In order to mitigate public safety risks, a variety of design features and safety measures are required for site-specific landscape design around SWMFs.

ii. Tree roots have a potential to compromise the effectiveness of the pond bottom/clay liner, and trees must not be planted in areas where liners reach. The engineering/landscape drawings must clearly indicate the boundary of liners within the SWMF in relation to trees.

4.4.14 Furniture and Public Amenities

i. Furniture and public amenities which are not critical to the drainage function of a SWMF, such as trails, benches, plazas, statues, viewing areas, entry features, or anything else that may attract and promote people to visit a SWMF, must be located at or above the 1:25 year event elevation for the SWMF. Furniture and amenities below the 1:100 year event elevation should be anchored or equivalent to ensure it is kept in place during larger storm events.

ii. Enhanced amenities will be considered on a case-by-case basis, provided they do not affect safety or operations. In most cases, EPCOR will not own or maintain the enhanced amenities. They are typically to be maintained by either the Developer, Homeowners Association, or the City through an agreement with the EPCOR.

iii. Bridges and viewing plazas located directly over water bodies are not permitted.

iv. Refer to the City of Edmonton Design and Construction Standards, Volume 5: Landscape.

4.4.15 Operation and Maintenance (O&M) Manual

i. As part of the responsibility for design of a SWMF, the designer shall prepare and provide an O&M manual for the facility.

ii. The O&M manual is to be a searchable and organized PDF document following the standard requirements outlined below. A draft O&M manual is to be provided to EPCOR 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 the CCC. If any material changes are made between CCC and FAC, an updated O&M manual shall be delivered as soon as practicable after the material changes are made, and before FAC application.

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

a. A copy of the approved engineering drawings relating to the SWMF and appurtenances, updated to "As-Built";

b. A completed SWMF Data Summary Form;

c. 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;

d. 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;

e. Head Discharge and Stage Discharge Curves with clear relationships of the stages to surrounding features;

f. 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;

g. An outline of the normally expected operational requirements for the facility;

h. An outline of emergency operating requirements under possible abnormal situations;

i. Complete equipment manufacturer's operation, maintenance, service, and repair instructions;

j. Complete parts lists for any mechanized and/or electrical equipment incorporated in the design;

k. The contractor shall prepare a user-friendly document, which includes a brief description of functions, how the system operates, bypass considerations, plan/section drawings and key structures of a stormwater management facility. Plan/section drawings shall clearly indicate inlets, outlets, control structure, orifice/weir, level monitor, gate and gate operation details, etc. It should also show key parameters including elevations, flow directions, applicable sizes (diameter/lengths/widths/height), and others as necessary;

l. In situations where the control structure for a wet SWMF does not have the ability to adjust the water level in accordance with Sections ***4.5.5.iv***, ***4.6.6.viii***, or ***4.6.6.ix***, whichever is applicable, the O&M manual shall include a pumping plan schematic indicating where stormwater from the SWMF can be pumped to, without re-entering the SWMF.

4.4.16 Warranty Period

The warranty period for SWMFs shall be a minimum of two years. A longer warranty period may be required, at the discretion of EPCOR and the City, for designs that do not meet the requirements outlined in these Standards, or in other unique circumstances where a longer period of time is required to demonstrate the proper functioning of a SWMF.

4.4.17 CCC and FAC

i. The Developer shall verify no invasive species and pests present at the SWMF at FAC through assessment done by third party specialist. If invasive species and pests are detected prior to FAC, the Developer is responsible for the control and removal.

ii. The Developer shall verify the NWL of a wet SWMF established at least for one season (e.g. April to September) before CCC inspection. The control gate needs to be in the position of normal operation to maintain NWL and at CCC inspection the NWL shall be marked by stakes to be verified by the inspector.

4.4.18 Interim SWMFs

i. When an interim SWMF is being implemented (i.e. the SWMF is not currently being designed and constructed to its ultimate size, location, configuration, type, etc.), the SWMF should be designed in accordance with the Standards set out herein for ultimate facilities of that type, and ownership, operation and maintenance of the SWMF shall be transferred to EPCOR through the CCC and FAC process on a case-by-case basis. Critical items that can affect safety, operation and maintenance, or performance of the SWMF must be included in interim SWMFs, including but not limited to items such as inlets, outlets, control structures, grass and other erosion and sediment controls throughout the facility, adequate storage volume, water quality attenuation, proper flow circulation, side slopes, maintenance access, and fencing. Inlets, outlets, and control structures of interim SWMFs shall be constructed to its ultimate SWMFs. Invasive and noxious weeds must be managed to avoid spread to adjacent lands.

ii. Interim SWMFs may be located within an easement, as opposed to a PUL, provided that the land is dedicated as a PUL when the facility is upgraded to its ultimate size, location, configuration, and type in the future.

4.5 Design Details for Naturalized Wet Ponds

4.5.1 Size

i. The facility size for naturalized wet ponds shall be in accordance with the approved AMP, NDR, or other applicable servicing study, and shall accommodate the 1:100 year storm event plus freeboard (refer to Section ***4.4.4.ii***).

ii. Planners and designers should take reasonable steps to ensure that the water surface area at NWL is 2.0 ha or larger. In the event that a naturalized wet pond is approved with an area of less than 1.0 ha, the designer and the Developer shall design and implement additional measures to address the potential for issues such as anaerobic conditions, algae, and odour, to the satisfaction of EPCOR. These measures may include additional aquatic and upland vegetation and minimizing shallow areas and flow short-circuiting. An additional warranty period may also be required in order to sufficiently demonstrate that the additional measures are effective. Alternatively, a dry pond is recommended when a smaller facility is warranted.

4.5.2 Grading & Side Slopes

i. Areas from the design freeboard down to 1.0 m below the NWL shall have a maximum slope of 7 horizontal to 1 vertical (7H:1V), including any overflow areas. Refer to ***Figure 4.8***. Side slopes may be reduced if required by geotechnical conditions. The Geotechnical Engineer of Record shall verify that the design side slope angles provide a suitable factor of safety for slope stability.

ii. A slope of 3H:1V shall be used from the 1.0 m depth point (below the NWL) to the pond bottom. This is to minimize the area of shallow water when the wet pond is at NWL, and to discourage the growth of unwanted vegetation. Refer to ***Figure 4.8***.

iii. 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.

4.5.3 Depth

The minimum depth from NWL to pond bottom (beyond the side slope area) shall be 2.5 m. Refer to ***Figure 4.8***.

4.5.4 Shape

The shape of naturalized wet ponds should be relatively oval, although other shapes may be used provided that flow length and water quality improvement are maximized, while avoiding dead storage areas/stagnation and flow short-circuiting. The SWMF length must be 3 to 5 times the width.

4.5.5 Inlets and Outlets

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 the NWL. Inlet and outlet pipe inverts are to be a minimum 100 mm above the wet pond bottom. Grates shall not be installed on submerged inlets and outlets.

ii. Provision for free outfall from inlets:

The invert elevation of the inlet pipe(s) at the first maintenance hole upstream from the facility shall be at or above the NWL to avoid deposition of sediments in the inlet. To avoid backwater effects in the upstream sewers, the obvert of the inlet sewer at the first maintenance hole upstream from the facility shall be at or above the design water level for the 1:5 year storm. A drop structure upstream from the facility 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 distanced as far as possible from each other to avoid hydraulic short-circuiting. In general, the inlet and outlet should be located on opposite sides along the perimeter of the facility, which may require design revisions to grading of adjacent roads and upstream and downstream storm sewers. The settlement time of particles shall be less than the travel time for water in the facility. Water quality improvement design calculations must be submitted in conjunction with submission of the engineering drawings.

iv. Provisions to drain the facility completely by gravity through operation of the outlet control should be provided whenever feasible (refer to Section ***4.4.6***). 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 water level as needed.

v. 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 control gates.

4.5.6 Drawdown/Detention Time

To facilitate particle settling, the quickest drawdown time shall be 24 hours for a 1:5 year storm. For the most critical storm event, 90% of the total active storage volume shall have a maximum drawdown time of 96 hours in order to restore the availability of storage capacity within a reasonable time frame, and to minimize safety risks.

Table 4.1: Drawdown Time and Available Volume between NWL and HWL for Naturalized Wet Ponds

Time After Commencing Drawdown from HWL	Available Volume Between HWL and NWL
≥ 24 hours	Volume equivalent to runoff from 1:5 year storm
48 hours	Volume equivalent to runoff from 1:25 year storm
≤ 96 hours	90% of required storage volume above NWL

4.5.7 Edge Treatment

i. Edge treatment/shore protection is required and shall be compatible with the adjacent land use. The treatment used shall meet criteria for low maintenance, safety, and preventing public access to the water's edge. Native plantings are recommended (cattails, bulrushes, longer grasses, etc.) and should be able to tolerate fluctuations in water level throughout the year. Other forms of edge treatment will be considered on a case-by-case basis. Washed rock or rip-rap is no longer a recommended edge treatment for naturalized wet ponds.

ii. The edge treatment is to cover the ground surfaces within 0.3 m elevation above and below the NWL (0.6 m total) and shall be adequate to prevent erosion of the edge due to wave action.

4.5.8 Maintenance Access

In addition to the maintenance requirements listed in Section ***4.4.8***, an all-weather vehicle access route shall also be provided to the water's edge suitable to carry maintenance vehicles and for use as a boat launch point. The access shall:

i. Be a minimum of 3.0 m wide;

ii. Be aligned to avoid conflict between inlets/outlets and boat ramp;

iii. Be designed to avoid sharp bends, and provide a curved transition area between the main SWMF access/trail and boat ramp to allow for entry and exit of maintenance equipment;

iv. Have a straight run of 12 m or more leading to the water's edge for launching of boats and weed harvesting equipment;

v. Extend into the water to an elevation 1.0 m below NWL;

vi. Be constructed from turfstone from the main SWMF access/trail to an elevation 1.0 m above NWL;

vii. Be constructed from precast concrete boat ramp segments from 1.0 m above NWL to 1.0 m below NWL;

viii. Be designed and constructed to allow for proper drainage to avoid ponding/icing issues;

ix. Be planted with transitional vegetation to limit public accessibility to the shoreline.

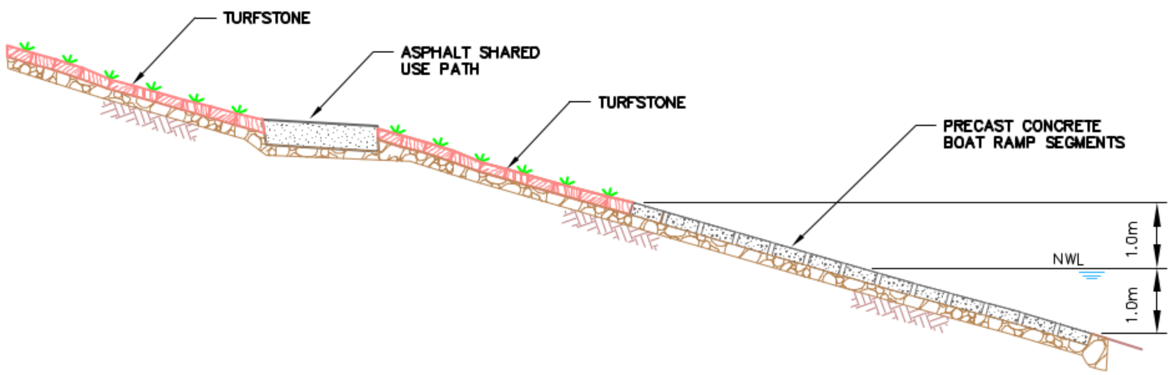


Figure 4.6: Boat Ramp Cross Section

4.5.9 Landscaping

Landscaping for naturalized wet ponds shall follow the City of Edmonton Design and Construction Standards, Volume 5: Landscape.

4.5.10 Soil Characteristics

i. For areas where the ground water table is below the NWL, the wet pond 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 pond bottom may be of a pervious material as dictated by geotechnical report recommendations.

iii. A geotechnical engineer must inspect the SWMF in the field following excavation to evaluate the presence of coal seams or sand, verify if a clay liner is needed, and determine the extent and specifications of the liner required as per the geotechnical report recommendations. At the time of CCC for the SWMF, a letter authenticated by a Professional Engineer is required confirming that a geotechnical engineer was present at the time of SWMF construction to ensure that the work on the clay liner and pond bottom was carried out in accordance with the geotechnical report recommendations.

4.5.11 Sediment Control and Removal

i. The 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.

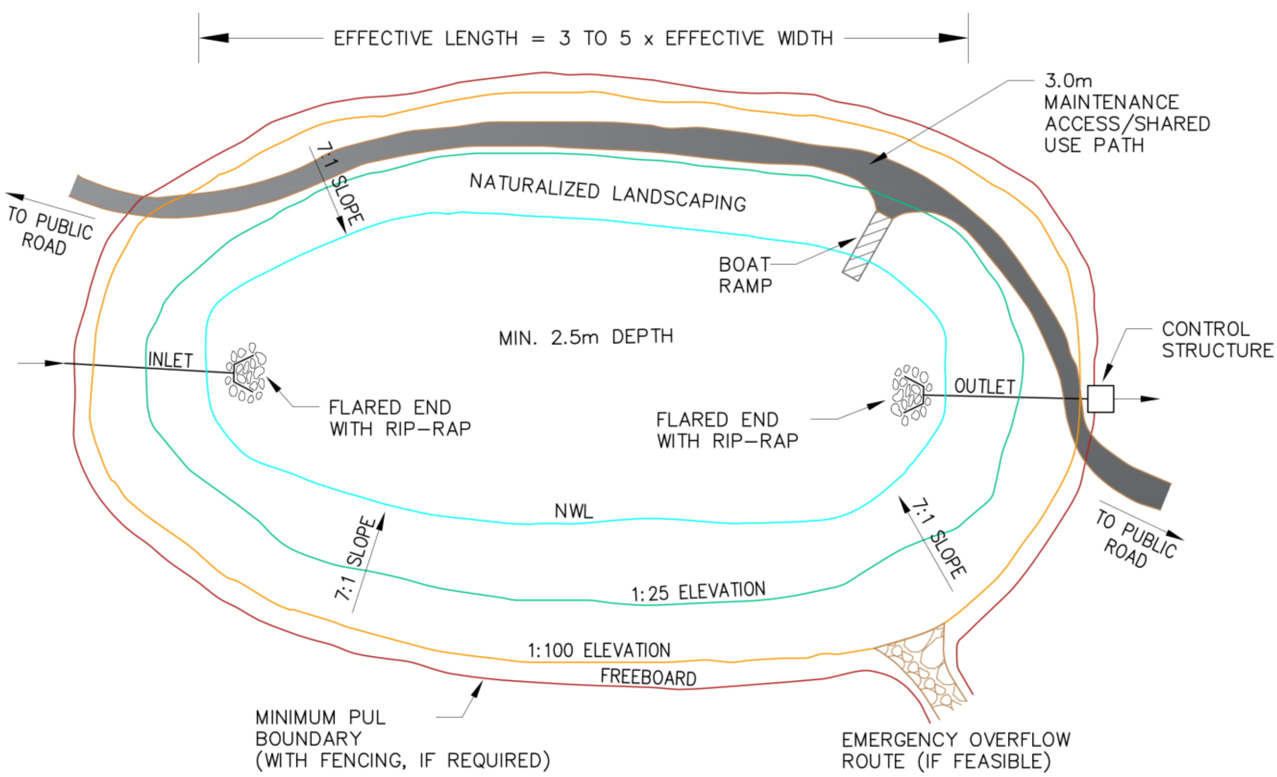


Figure 4.7: Schematic Diagram - Naturalized Wet Pond

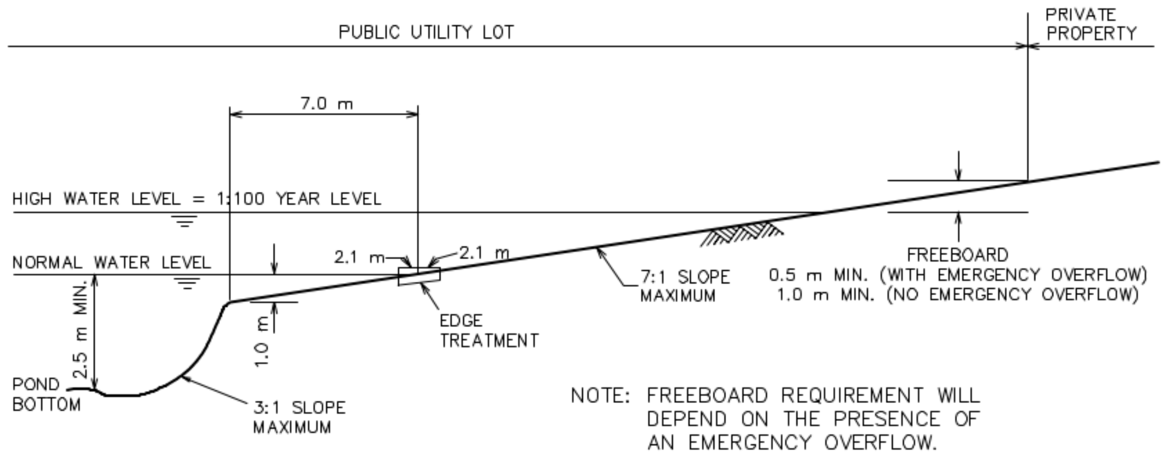


Figure 4.8: Recommended Cross Section - Naturalized Wet Pond

4.6 Design Details for Constructed Wetlands

4.6.1 Size

i. The facility size for constructed wetlands shall be in accordance with the approved AMP, NDR, or other applicable servicing study, and shall accommodate the 1:100 year storm event plus freeboard.

ii. Planners and designers should take reasonable steps to ensure that the water surface area at NWL is 1.0 ha or larger. In the event that a constructed wetland is approved with an area of less than 1.0 ha, the designer and the Developer shall design and implement additional measures to address the potential for issues such as anaerobic conditions, algae, and odour, to the satisfaction of EPCOR. These measures may include additional aquatic and upland vegetation and minimizing shallow areas and flow short-circuiting. An additional warranty period may also be required in order to sufficiently demonstrate that the additional measures are effective. Alternatively, a dry pond is recommended when a smaller facility is warranted.

iii. The wetland surface area should typically be approximately 3% to 5% of the drainage area.

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

4.6.2 Grading & Side Slopes

i. Side slopes adjacent to the shallow areas of the facility (0.1 m to 0.6 m normal water depth) shall be 5H:1V or flatter to support larger areas of wetland vegetation. Terraced slopes are acceptable. Side slopes shall be flatter if required by geotechnical conditions. The Geotechnical Engineer of Record shall verify that the design side slope angles provide a suitable factor of safety for slope stability.

ii. Side slopes adjacent to the accessible deep areas at the sediment forebay and permanent pools at the outlet shall be a maximum of 7H:1V.

iii. 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.

4.6.3 Depth

i. A variety of water depths is required throughout the facility, ranging from 0.1 m to 0.6 m, with an average permanent water depth of 0.3 m, to encourage emergent vegetation. Forebays and permanent pools are to be deeper, as outlined in Section ***4.6.6***.

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

iii. A deeper channel is recommended with a 3.0 m bottom width at a depth of no less than 1.0 m between any forebays, permanent pools, and outlet pools.

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

4.6.4 Shape

The shape of constructed wetlands should be relatively oval, although other shapes may be used provided that flow length and water quality improvement are maximized, while avoiding dead storage areas/stagnation and flow short-circuiting. In order to increase the residence time, the effective flow path length at low flow must be at least three times the relative wetland width. Incoming water should be well distributed throughout the land and be conveyed as sheet flow to optimize treatment.

4.6.5 Drainage Area

i. In order to generate constant or periodic flow to the constructed wetland, the smallest practical drainage area is considered to be 20 ha. A constructed wetland servicing an area smaller than 20 ha, but larger than 5 ha, may be considered on a case-by-case basis provided that other preferred options, such as a dry pond or LID, have been exhausted and are found to be unfeasible.

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

4.6.6 Inlets and Outlets

i. Major inlets shall discharge to a forebay in order to trap suspended solids before stormwater enters the constructed wetland. Inlets shall not be contradicting each other and the forebay shall have enough suspended solids settling capacity. A major inlet is one that provides greater than 10% of the total storm inflow to the constructed wetland.

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

iii. A permanent pool is required at the outlet to provide a submerged outlet structure and have the ability to regulate water levels in the facility.

iv. Forebays at inlets and the permanent pools at outlets are to be between 2.4 m to 3.0 m deep.

v. 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 the NWL. Inlet and outlet pipe inverts are to be a minimum 100 mm above the constructed wetland bottom. Grates shall not be installed on submerged inlets and outlets.

vi. Provision for free outfall from inlets:

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

vii. Separation of inlets and outlets:

The inlet and outlet shall be physically separated and distanced as far as possible from each other to avoid hydraulic short-circuiting. In general, the inlet and outlet should be located on opposite sides along the perimeter of the facility, which may require design revisions to grading of adjacent roads and upstream and downstream storm sewers. The settlement time of particles shall be less than the travel time for water in the facility. Water quality improvement design calculations must be submitted in conjunction with submission of the engineering drawings.

viii. 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 at least between 0.5 m below NWL and 0.5 m above NWL. Variable water level control should be obtained through the manipulation of control gates.

ix. Provisions to drain the facility completely by gravity through operation of the outlet control should be provided whenever feasible (refer to Section ***4.4.6***). 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 water level as needed.

4.6.7 Drawdown/Detention Time

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 in order to restore the availability of storage capacity within a reasonable time frame, and to minimize safety risks.

Table 4.2: Drawdown Time and Available Volume between NWL and HWL for Constructed Wetlands

Time After Commencing Drawdown from 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 required storage volume above NWL

4.6.8 Edge Treatment

i. Edge treatment/shore protection is required and shall be compatible with the adjacent land use. The treatment used shall meet criteria for low maintenance, safety, and preventing public access to the water's edge. Native plantings are recommended (cattails, bulrushes, longer grasses, etc.) and should be able to tolerate fluctuations in water level throughout the year. Other forms of edge treatment will be considered on a case-by-case basis.

ii. The edge treatment is to cover the ground surfaces within 0.3 m elevation above and below the NWL (0.6 m total) and shall be adequate to prevent erosion of the edge due to wave action.

4.6.9 Maintenance Access

In addition to the maintenance requirements listed in Section ***4.4.8***, all-weather vehicle access routes shall also be provided to the water's edge at the forebay and permanent pool suitable to carry maintenance vehicles and for use as a boat launch point. The accesses shall:

i. Be a minimum of 3.0 m wide;

ii. Be aligned to avoid conflict between inlets/outlets and boat;

iii. Be designed to avoid sharp bends, and provide a curved transition area between the main SWMF access/trail and boat ramp to allow for entry and exit of maintenance equipment;

iv. Have a straight run of 12 m or more leading to the water's edge for launching of boats and weed harvesting equipment;

v. Extend into the water to an elevation 1.0 m below NWL;

vi. Be constructed from turfstone from the main SWMF access/trail to an elevation 1.0 m above NWL;

vii. Be constructed from precast concrete boat ramp segments from 1.0 m above NWL to 1.0 m below NWL;

viii. Be designed and constructed to allow for proper drainage to avoid ponding/icing issues;

ix. Be planted with transitional vegetation to limit public accessibility to the shoreline.

Refer to ***Figure 4.6***.

If a deeper channel (≥ 3.0 m width and ≥ 1.0 m depth) is provided between the forebay and permanent pool such that a maintenance boat can access all parts of the SWMF, then only one (1) boat ramp is required, either at the forebay or permanent pool.

4.6.10 Landscaping

In addition to the landscaping provisions outlined in Section ***4.4.13***:

i. Planting strategies should deter direct public access to the wetland to avoid disturbance of the wetland fauna and to protect the public from the hazards of the SWMF. The Developer is required to use natural solutions such as grading and planting strategies to provide safety features for the wetland, inlet(s), and outlet(s). Refer to Section ***4.1.3.ii*** for shoreline accessibility limitation requirement.

ii. 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/EPCOR.

iii. Trees must not be planted below the 1:2 year flood level. Mulches must not be used below 1:5 year flood level to minimize washing away of mulches during more frequent storm events. Planting trees above the 1:2 year flood level but below the 1:5 year level is subject to the approval of the City of Edmonton Parks (refer to the City of Edmonton Design and Construction Standards, Volume 5: Landscape).

iv. After construction and placement of soil, the facility 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.

v. In the spring of the year following construction, the facility shall be overseeded with legumes and wild flowers. In addition, at approximately the same time, the area above NWL shall be planted with 50% of the woody species agreed upon as noted in Section ***4.6.10.ii***. Plants shall be selected for tolerance to flooding and oxygen-reduced environments.

vi. One year after completion of construction, a stable mixture of naturalized, water tolerant grasses shall be in place, as approved by the City of Edmonton and EPCOR. Refer to the City of Edmonton Design and Construction Standards, Volume 5: Landscape for list of approved native grass seed.

vii. 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.

viii. 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.

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

x. Harvesting emergent vegetation is not recommended.

4.6.11 Soil Characteristics

i. For 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.

iii. A geotechnical engineer must inspect the SWMF in the field following excavation to evaluate the presence of coal seams or sand, verify if a clay liner is needed, and determine the extent and specifications of the liner required as per the geotechnical report recommendations. At the time of CCC for the SWMF, a letter authenticated and validated by a Professional Engineer is required confirming that a geotechnical engineer was present at the time of SWMF construction to ensure that the work on the clay liner and pond bottom was carried out in accordance with the geotechnical report recommendations.

4.6.12 Water Quality

The minimum design requirement for total suspended solids removal is 85% of particle size 75 µm or greater, as recommended by Alberta Environment, 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.

4.6.13 Monitoring

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

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

iii. At the end of the warranty 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.

4.6.14 Maintenance

i. The Developer is required to provide an O&M manual meeting the requirements in Section ***4.4.15***.

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

iii. Sediment traps are to be cleaned during the warranty period.

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

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.

vi. The Developer may be required to replace or adjust plantings and manage nuisance species during the warranty period.

vii. During the warranty period, the facility shall be inspected at least twice each year to determine vegetation distribution and the preservation of design depth. Inspection reports shall be prepared and 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.

4.6.15 Wildlife

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

4.6.16 Mosquito Control

The Developer shall include design features that minimize mosquitoes in the facility such as vegetation management that would preclude stagnant backwaters, shading of the water surface, and providing habitat for purple martin, swallows, baitfish, dragonflies, bats, and other predators.

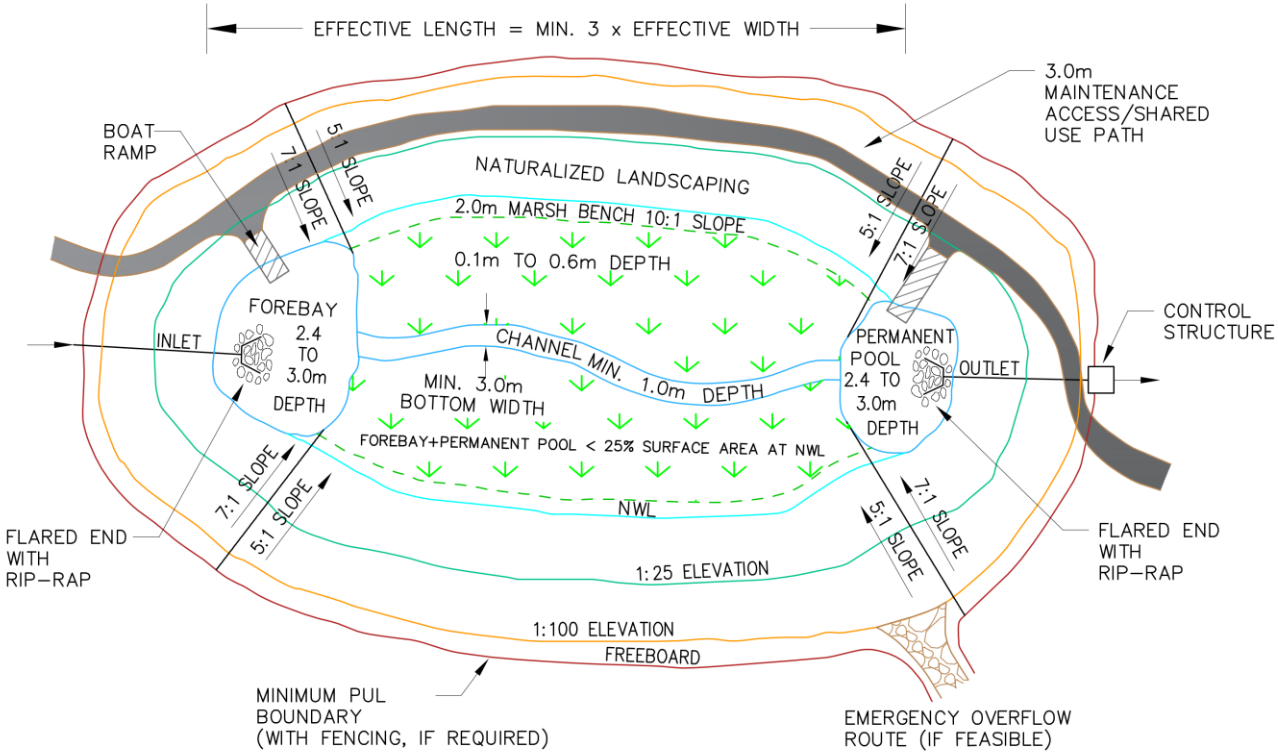


Figure 4.9: Schematic Diagram - Constructed Wetland

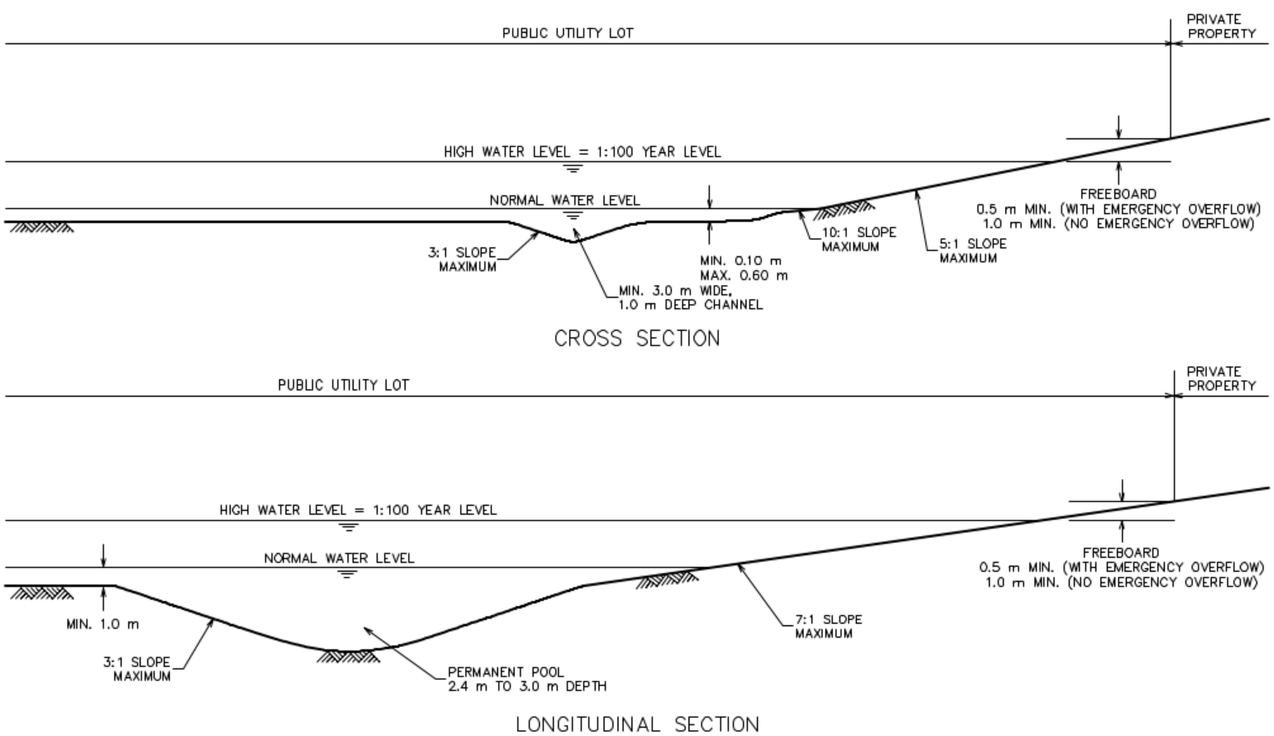


Figure 4.10: Recommended Sections - Constructed Wetland

4.7 Design Details for Dry Ponds

4.7.1 Size

i. The facility size for dry ponds shall be in accordance with the approved AMP, NDR, or other applicable servicing study, and shall accommodate the 1:100 year storm event plus freeboard.

ii. In general, dry ponds are preferred over wet SWMFs in situations where a small facility is warranted. The water surface area at HWL for dry ponds shall be 0.5 ha or larger, and the contributing drainage area shall be 5 ha or larger.

4.7.2 Grading and Side Slopes

i. Dry pond shall be graded to properly drain all areas after its operation. Designs that propose containment of runoff due to events more frequent than 1:2 years are to include special provisions to facilitate clean up, such as sloping the pond bottom at 2% grade from inlet to outlet. The SWMF bottom shall have a minimum slope of 1.5%; however, a grade of 2% is preferred. Lateral slopes shall be 1.0% or greater. French drains/perforated pipe drains or similar may be required where it is anticipated that these slopes may not properly drain the dry pond bottom or where dictated by multiple use or other special considerations.

ii. Side slopes of dry ponds shall be a maximum of 5H:1V. Side slopes shall be flatter if required by geotechnical conditions. The Geotechnical Engineer of Record shall verify that the design side slope angles provide a suitable factor of safety for slope stability.

4.7.3 Depth

i. The live storage water depth in a dry pond should be limited to 1.5 m, measured from the invert elevation of the outlet pipe to the HWL.

ii. If the live storage is to be greater than 1.5 m, then additional safety measures are required such as additional fencing, signage, or increased monitoring when the pond is holding water. In any event, the live storage water depth shall not exceed 3.0 m.

4.7.4 Shape

The shape of dry ponds can vary depending on factors such as configuration and availability of land, dual uses (recreation facilities/sports fields), compatibility with adjacent land uses, and whether the facility is in-line or offline (refer to ***Figure 4.11*** and ***Figure 4.12***). In-line dry ponds should generally be shaped similar to wet facilities, with a high length to width ratio in order to maximize the flow path and detention time, and to avoid flow short circuiting.

4.7.5 Inlets and Outlets

i. All inlet and outlet structures associated with dry ponds shall include concrete flared end sections and rip-rap to prevent erosion or buried box structures. Grates shall be provided over their openings to restrict access and to 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 guardrails, which at a minimum meet all OH&S regulations, must be provided to restrict access and reduce the hazards presented by headwalls and wing walls.

iii. For in-line dry ponds (refer to ***Figure 4.12***), the inlet and outlet should be physically separated around the perimeter of the dry pond. The inlet and outlet should be distanced as far as possible from each other to provide the longest possible flow path and to avoid hydraulic short circuiting.

4.7.6 Drawdown/Detention Time

The quickest drawdown time shall be 24 hours for a 1:5 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 in order to restore the availability of storage capacity within a reasonable time frame, and to minimize safety risks.

Table 4.3: Drawdown Time and Available Volume between Pond Bottom and HWL for Dry Ponds

Time After Commencing Drawdown from HWL	Available Volume Between HWL and Pond Bottom
≥ 24 hours	Volume equivalent to runoff from 1:5 year storm
48 hours	Volume equivalent to runoff from 1:25 year storm
≤ 96 hours	90% of required storage volume

4.7.7 Landscaping

Landscaping for dry ponds shall follow the City of Edmonton Design and Construction Standards, Volume 5: Landscape.

4.7.8 Signage

Signage shall be provided to indicate inlet and/or outlet structures and shallow pipes. Signage shall be placed to prevent heavy equipment from damaging pipes and prevent snow from being piled on inlets/outlets.

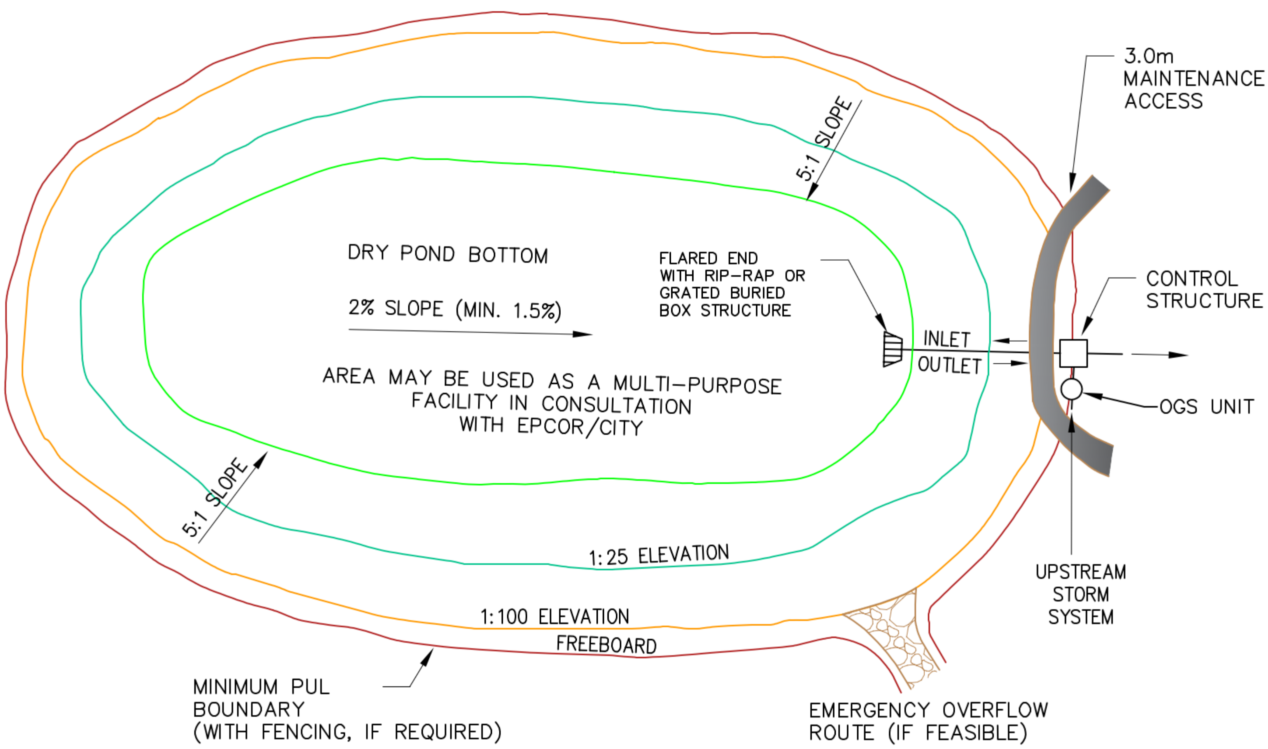


Figure 4.11: Schematic Diagram - Off-Line Dry Pond

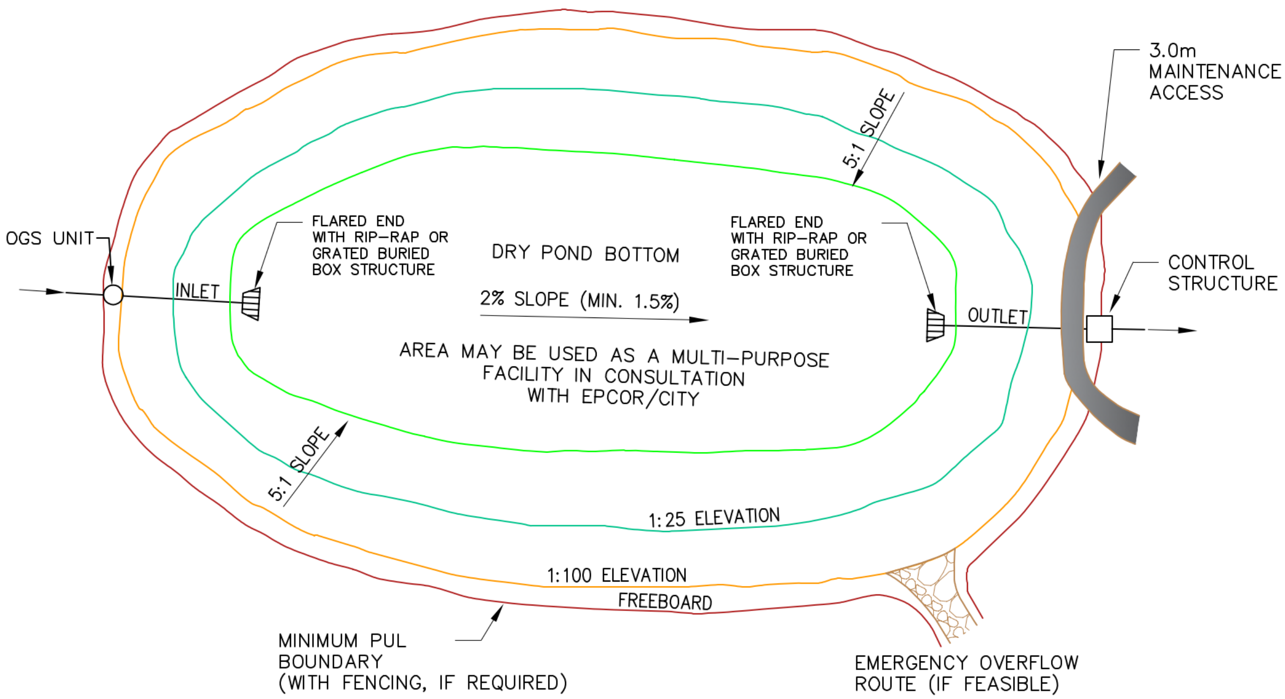


Figure 4.12: Schematic Diagram - In-Line Dry Pond

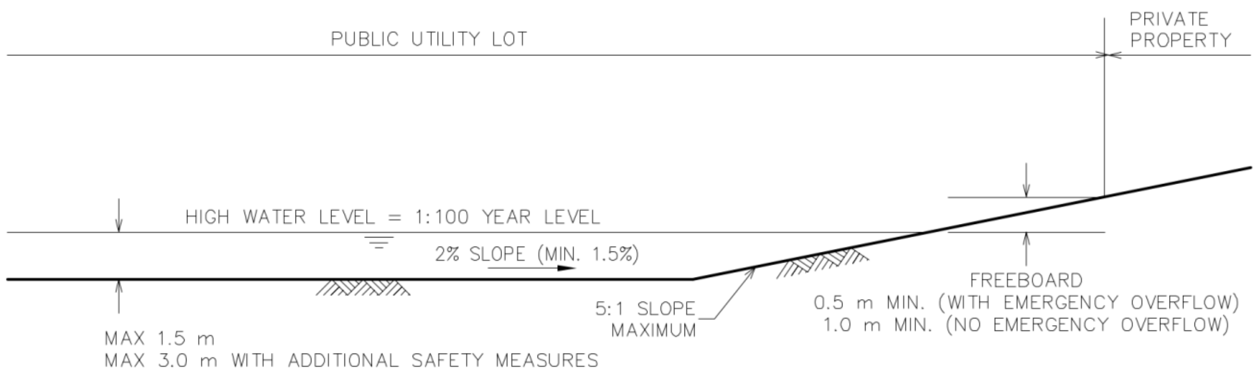


Figure 4.13: Recommended Cross Section - Dry Pond

5.0 LID FACILITY DESIGN

Unless otherwise specified in this section, all requirements of Volume 3 must be followed for LID design and LID construction. Modifications that are accepted for LID projects only are outlined in this section.

5.1 Site Planning Considerations

5.1.1 Integration of 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:

i. Site drainage patterns, topography, and grading;

ii. 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;

iii. LID facility layout and footprint;

iv. Connection to the drainage system (if applicable);

v. Underlying soil permeability and load-bearing capacity;

vi. Clearance to groundwater table;

vii. Buffers and setbacks;

viii. Utility conflicts;

ix. Integration with the existing/proposed use of space (i.e. streetscaping, impacts to pedestrian movements, etc.) including future use of space;

x. Impacts to existing tree plantings;

xi. Cost implications of system configuration and size; and

xii. Future operations and maintenance of the facility and surrounding infrastructure.

5.1.2 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 Low Impact Development (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:

i. 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.

ii. 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.

iii. Potential slope stability issues.

iv. The direction and rate of groundwater flow (hydraulic gradient and hydraulic conductivity).

v. 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.

5.1.3 Local geotechnical data should 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.

i. Proximity to nearby building foundations and roadway infrastructure, and likelihood of a perched water table.

ii. 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.

iii. Potential slope stability issues.

iv. Groundwater levels, particularly the seasonally high water level.

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

i. The distribution of surficial geological materials and soil types within the development.

ii. The topography, hydrology (surface watercourses, and storage features, if any) and hydrogeology (groundwater characteristics) including;

   a. Watercourses, wetlands, and marshes;

   b. Areas of potential groundwater and surface water interaction;

   c. Recharge and discharge areas; and

   d. The probable depth, direction, and rate of groundwater flow (estimated at the reconnaissance or desktop level of planning).

iii. 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 setback of 3.0 m from buildings is recommended; however, LID facilities must be located a minimum setback of 1.0 m from buildings with engineering controls. Engineering controls, such as an impermeable membrane must be placed as per the direction of a qualified professional. 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.

5.2.6 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. Membrane installation must follow manufacturer instructions.

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 (0.01969)
Sheet Density	ASTM D-1505	90,000 kg (200,000lb)	g/ml	0.939
Carbon Black Content	ASTM D-1603 (3)	20,000 kg (45,000 lb)	%	2.0 - 3.0
Tensile Strength at Break	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)

i. Waterproofing membranes could 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.

ii. If an impermeable membrane is required for a facility, the designer should consider this when determining plant selection.

5.2.7 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 Design and Construction Standards, Volume 4: Water.

5.2.8 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.

i. If the distance from the base of the proposed LID to the water table is suspected to be less than 1.0 m, LID designs must be modified to limit groundwater interactions with the LID facility. To accept this variance, LID designs must be authenticated by a qualified professional.

ii. Alternatively, fluctuations in groundwater could be monitored for at least a year in the field by installing a borehole/monitoring well as directed by a qualified 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. To accept this variance LID designs and plans for management of groundwater must be authenticated by a qualified professional.

iii. Trees are not permitted in LID’s that are constructed less than 1.0 m above the water table. Tree selection should be appropriate for the design of the LID and not all trees are suitable even with a minimum 1.0 m buffer.

iv. Plants should be appropriate for the design of the LID, including but not limited to depth to groundwater and LID capacity. Plants should be low maintenance plantings. Traditional turf sod should not be used unless the area is a boulevard that will be maintained by an adjacent homeowner or commercial business owner. Naturalized sod that does not require mowing is acceptable.

5.2.9 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. A design report outlining geotechnical characteristics of the development should be prepared and authenticated by a qualified professional.

i. 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.

ii. 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.

iii. 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.

iv. 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.

v. 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.

vi. 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)).

vii. 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.

viii. 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.

ix. An analysis of the stability of the LID side slopes and surrounding area based on soil type(s) found if applicable.

x. Analysis of the impact of percolation and underdrains on the water table, including the potential for impact on roadway infrastructure.

xi. Recommendations on monitoring and maintenance requirements.

xii. 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.

5.2.10 Trees may be installed within LID facilities; however, ensure that any hard infrastructure, such as maintenance hole covers and cleanouts, is accessible and located outside the tree canopy, if possible. If soil volumes are sufficient, trees are encouraged to be installed within soil cells as long as they do not affect operation and maintenance of the LID facility. Soil volumes are outlined within the City of Edmonton Design and Construction Standards, Volume 5: Landscape. For existing public trees, setbacks and permits are required as per the City of Edmonton's public tree bylaw; all setbacks should be followed unless approved by a City of Edmonton Urban Forester.

5.2.11 If LID facilities are being planned within the River Valley Area Redevelopment Plan, in a natural area or within an ecological network care must be taken to ensure that proper design considerations are taken into account. The ecological plans for that area should be consulted to ensure proper planning and integration of LID facilities into the natural area. Integration may include but is not limited to different construction practices, proper Erosion and Sediment Control (ESC), and study of the hydrological regime and water quality in the area (e.g., if LIDs are being used to replenish groundwater or feed natural waterbodies and planting plans, then monitoring of LIDs in these areas may be required).

5.3 Bioretention Garden Design

5.3.1 Definition

i. 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 (refer to Section ***5.15***) 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 may consist of pre-treatment, a flow entrance/inlet, ponding area, plant materials, soil media, structural storage layers, and an overflow outlet. Structural storage layers are any engineered 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 engineered components could be utilized. An engineered storage layer/component is a requirement of bioretention gardens.

ii. 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 engineered 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.

iii. If a facility does not have an engineered storage layer/component it would be classified as a rain garden; for rain garden design guidance refer to EPCOR's *Low Impact Development - Best Management Practices Design Guide*.

5.3.2 Sizing Requirements

i. The contributing impervious catchment area is less than 20,000 m^2 (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. Refer to Section ***5.2.3***.

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 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/Outlet

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.

iii. An overflow outlet is required to control the ponding level. Erosion control and energy dissipation may be required around the overflow outlet. Outlet flows must be directed away from private property and away from nearby buildings.

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, 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 ***5.15***. The minimum depth is 300 mm.

iii. The granular filter layer within the facility must be a minimum thickness of 100 mm with 14 mm angular washed rock and less than 0.1% silt.

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

5.3.7 Geotextile

If geotextile is used for 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.

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 ***5.2.8*** for additional details). If required (i.e. if the 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 qualified 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 engineered 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.***

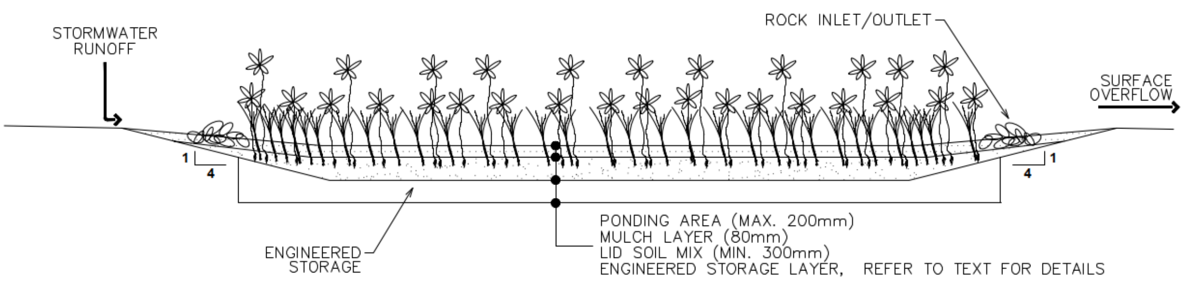


Figure 5.1: Bioretention Garden Cross Section

5.4 Bioretention Basin Design

5.4.1 Definition

i. 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 may consist of pre-treatment, flow entrance/inlet, ponding area, plant materials, LID soil media, filter layer, storage layer, underdrain, and overflow outlet.

ii. 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 40,000 m^2 (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. Refer to Section ***5.2.3***.

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 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 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/Outlet

i. Inlets/outlets 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 may be required to capture large particles and debris and prevent the spread of sediments on the surface of the bioretention basin.

vi. Inlets/outlets must be situated to allow for maintenance of both the inlet/outlet 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/outlets to potential obstructions should be minimized to reduce blockage.

vii. An overflow outlet is required to control the ponding level. Erosion control and energy dissipation may be required around the overflow outlet. Outlet flows must be directed away from private property and away from nearby buildings.

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, 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 ***5.15***. The minimum depth is 500 mm unless it is not feasible due to site constraints.

iii. The granular filter layer within the facility should have a minimum thickness of 100 mm with 14 mm angular washed rock and less than 0.1% silt.

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

5.4.7 Geotextile

If geotextile is used for 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.

5.4.8 Underdrain Perforated Pipe

All Piping and Infrastructure Considerations in Section ***5.8*** 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 ***5.2.8*** 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 qualified professional (see Section ***5.2.5*** for additional details).

Figure 5.2 shows plan and cross-section 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 is 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. Please note the figures may not show details required to meet other aspects of the City of Edmonton Design and Construction Standards such as membranes, filter fabric or clay caps.

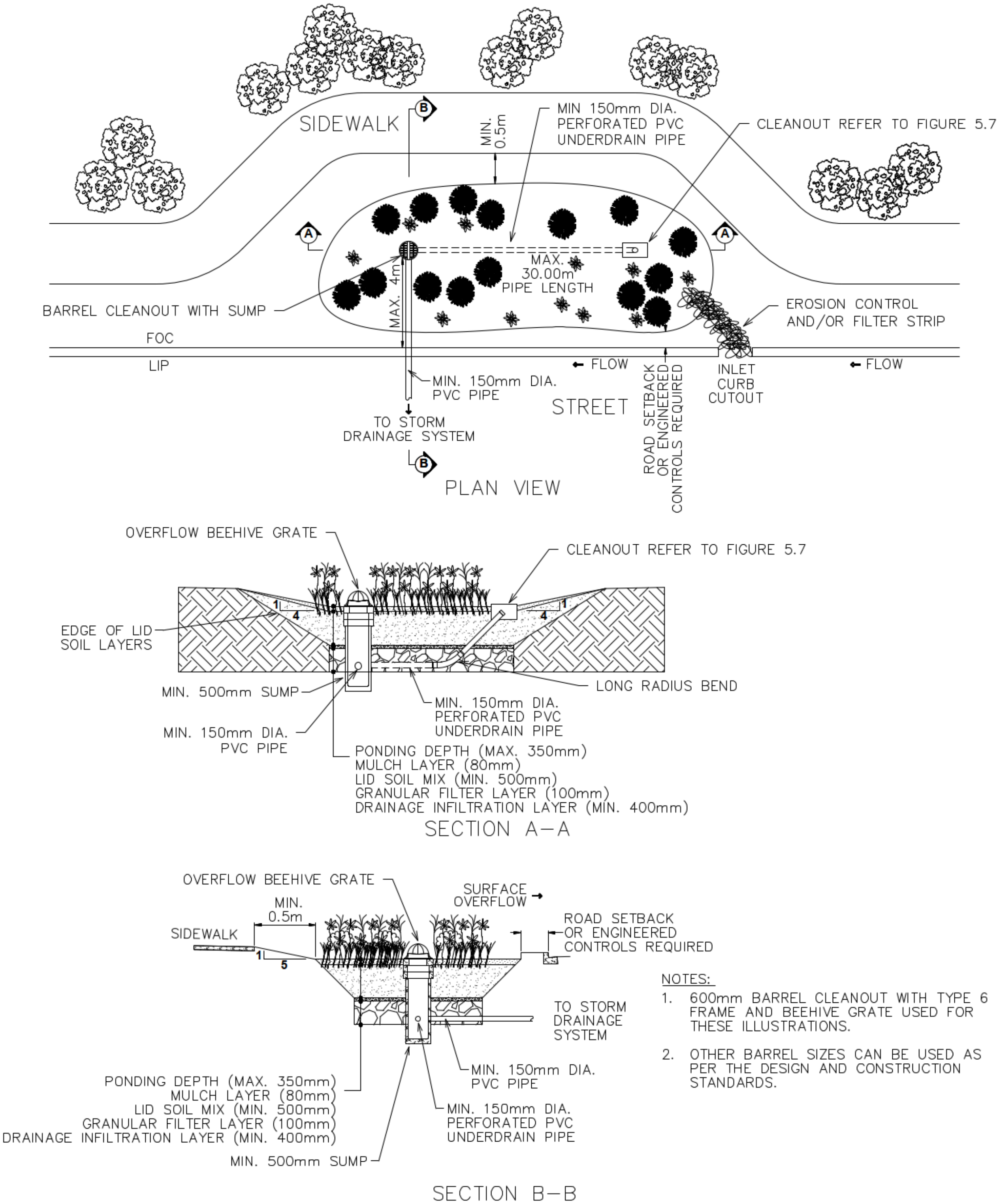


Figure 5.2: Bioretention Basin with Curb Cut Inlet – Plan View and Cross Sections

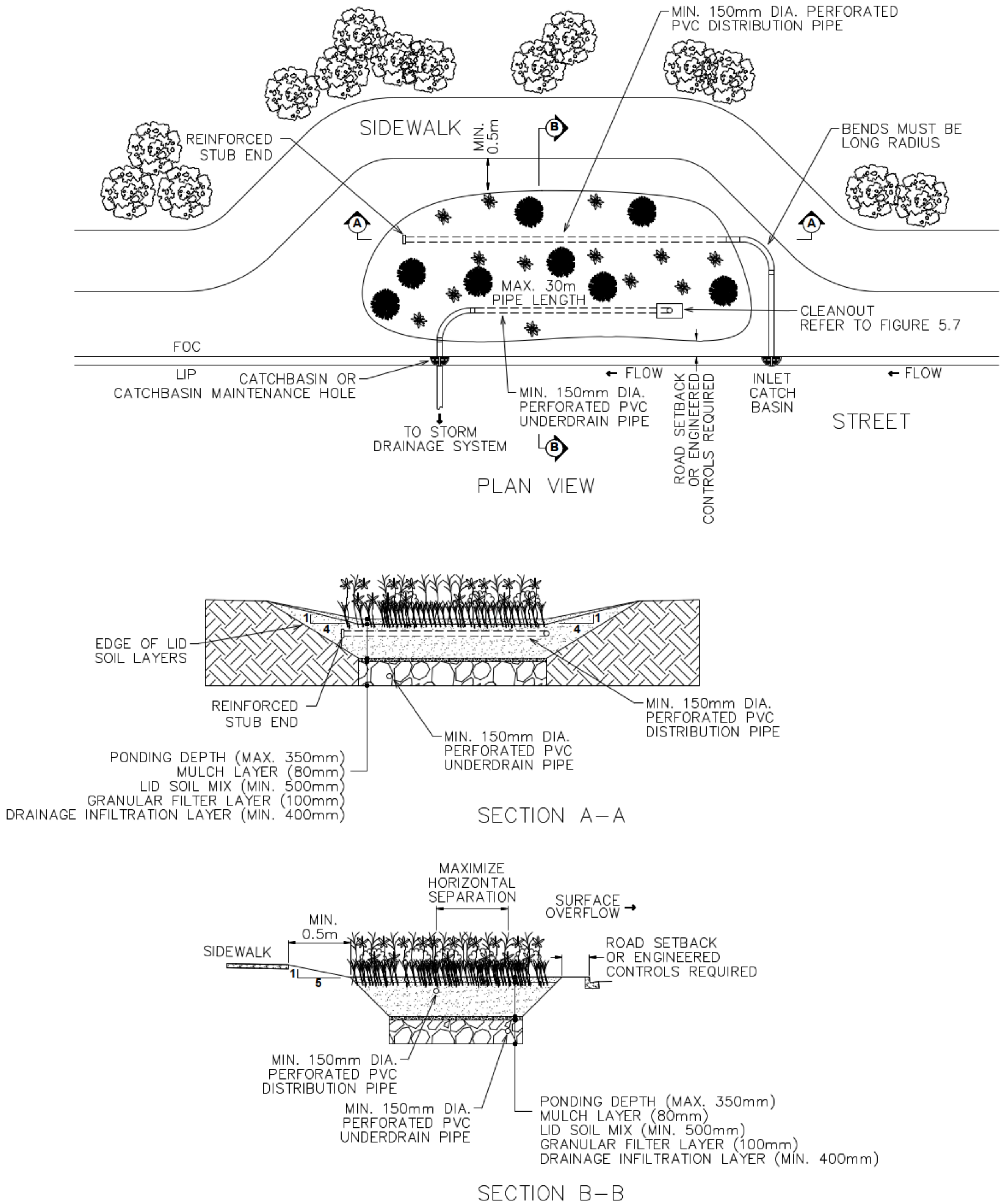


Figure 5.3: Bioretention Basin with Catch Basin Inlet – Plan View and Cross Sections

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 5,000 m^2 (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. Refer to Section ***5.2.3***.

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 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

5.5.4 Planter Material

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/Outlet

i. Inlets/outlets may include (but are not limited to) roof leaders, CBs, flow spreaders, curb cuts, 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. Erosion control and energy dissipaters at inlets may be required. Energy dissipaters may include (but are not limited to) rocks, a downspout impact baffle, or a drop/ramp between the pavement and grass.

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.

iv. Inlets/outlets must be situated to allow for maintenance of both the inlet/outlet 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/outlets to potential obstructions should be minimized to reduce blockage.

v. An overflow outlet is required to control the ponding level. Erosion control and energy dissipation may be required around the overflow outlet. Outlet flows must be directed away from private property and away from nearby buildings.

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, 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 ***5.15***. The minimum depth is 500 mm unless it is not feasible due to site constraints.

iii. The granular filter layer within the facility should have a minimum thickness of 100 mm with 14 mm angular washed rock and less than 0.1% silt.

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

5.5.8 Geotextile

If geotextile is used for 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.

5.5.9 Underdrain Pipe

All piping and infrastructure considerations in Section ***5.8*** 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 ***5.2.8*** 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 qualified professional (see Section ***5.2.5*** for additional details). Box planters may be placed adjacent to buildings with engineering controls approved by a qualified professional.

Figure 5.4 shows plan and cross-section 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.

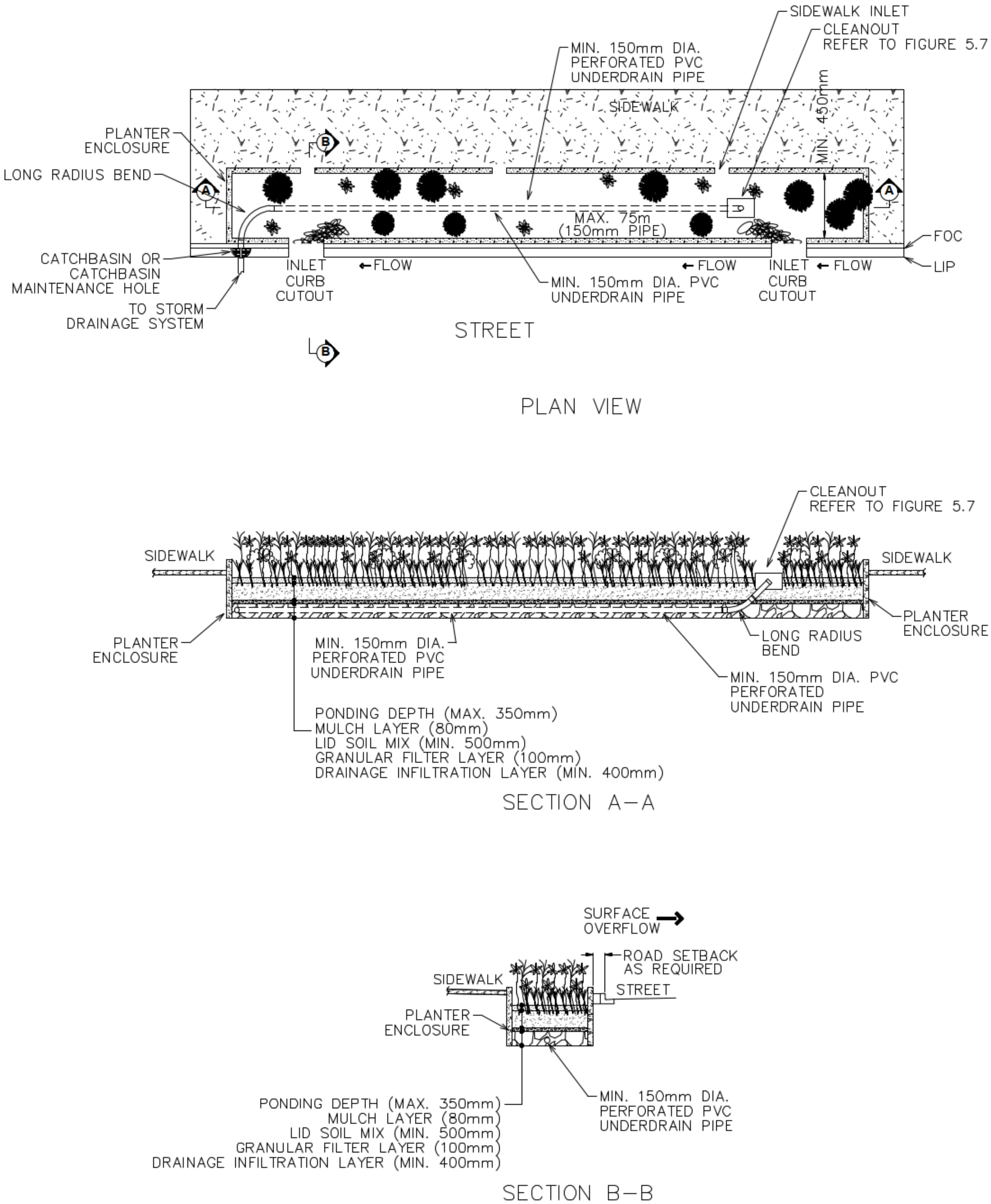


Figure 5.4: Box Planter Plan View and Cross Sections

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, roof drain connection, or overland flow through a curb cut.

5.6.2 Sizing Requirements

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

ii. Retain runoff volume through ponding and surface infiltration for a minimum of 18 mm from the impervious catchment area, 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. Refer to Section ***5.2.3***.

iv. Meet minimum soil volumes required for trees as per the City of Edmonton Design and Construction Standards, Volume 5: Landscape.

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, private roof leaders (cannot be directly connected into the LID and must enter a sump or CB prior), 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 ***5.15***.

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.

iii. The granular filter layer within the facility should have a minimum thickness of 100 mm with 14 mm angular washed rock and less than 0.1% silt.

iv. If used, the drainage layer is a minimum of 400 mm in depth with 25 mm - 40 mm angular washed rock containing less than 0.1% silt.

5.6.6 Distribution Pipe

i. A minimum diameter 150 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 barrel cleanout;

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

c. as per manufacturer's specifications.

ii. All Piping and Infrastructure Considerations in Section ***5.8*** must be followed.

5.6.7 Underdrain Pipe

i. A minimum diameter 150 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/maintenance hole.

iii. All Piping and Infrastructure Considerations in Section ***5.8*** 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 ***5.2.8*** 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 qualified 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 for roadways, sidewalks, walkways, paths and/or trails as per the City of Edmonton Design and Construction Standards, Volume 2: Complete Streets.

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 and must not impede the distribution of stormwater throughout the LID.

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: Soil Cell Plan View and Cross Sections shows 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.

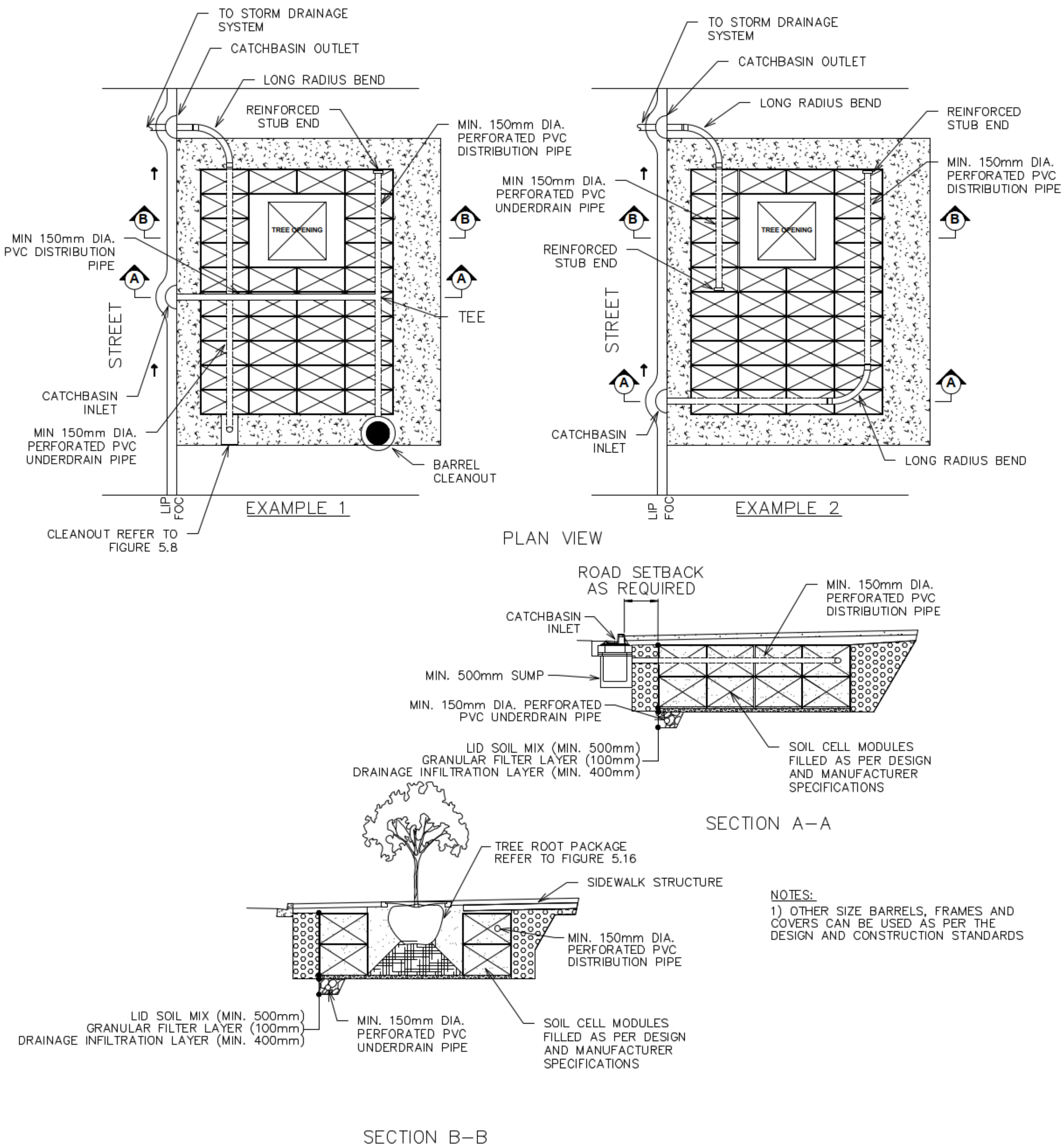


Figure 5.5: Soil Cell Plan View and Cross Sections

5.7 Absorbent Landscaping Design

5.7.1 Definition

i. Absorbent landscaping is an LID type that incorporates a shallow depression planted with both drought and saturation tolerant vegetation to collect surface flow. These facilities are graded to overflow directly into other LID facilities, or into the storm system. Unlike other LID facilities, absorbent landscaping does not typically include underdrains and has shallower soil and a shallower depression than a typical bioretention. Plant selection is pivotal to the success of absorbent landscaping facilities and establishing a well-developed root system cannot be understated.

ii. Absorbent Landscaping is being trialled within Edmonton and discussions with EPCOR Drainage should be initiated prior to moving forward with design of absorbent landscaping for any specific site or area.

5.7.2 Sizing Requirements

See Section **5.2.2** for I/P ratios. Considering that absorbent landscaping facilities often have I/P ratios between 5/1 and 20/1, a different planting approach may be applied for different impervious intensities. See ***Table 5.2*** for typical planting approaches and media depth for each range of I/P.

Table 5.2: Absorbent Landscaping I/P Ratios

I/P Ratio	Recommended Growing Media Depth	Recommended Planting Approach
< 5/1	300-600 mm	No restrictions: trees (as long as soil volume requirements are met), shrubs, etc.
5/1 to 10/1	300 mm	Fescue sod or naturalized grasses
10/1 to 20/1	300 mm	Naturalized fescue sod, sedges, or wet meadow grasses
> 20/1	300 mm	Naturalized wet meadow grasses or sedges

5.7.3 Surface Flow Velocity to Prevent Erosion

i. Maximum 0.3 m/s in planted areas

ii. Maximum 0.9 m/s in mulched zones

5.7.4 Surface Geometry and Side Slope

Includes a depression of 25-50 mm. If the facility is irregularly shaped it should be designed to allow water infiltration throughout the facility

5.7.5 Inlet/Outlet

i. Adequate erosion control or energy dissipation based on site is required at inlets/outlets. 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/outlets may include (but are not limited to) curb cuts, curb cuts with grates, or roof leaders with energy dissipation.

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

iv. An overflow outlet, such as a dual purpose inlet/outlet curb cut, is required to control the ponding level. Erosion control and energy dissipation may be required around the overflow outlet. Outlet flows must be directed away from private property and away from nearby buildings.

5.7.6 Media Layers

i. Fescue sod blend or seed mix is recommended with Kentucky blue grass sod as an alternative.

ii. Must have a minimum 300 mm, preferably 600 mm of rolled and compacted sod, flush with hard surface adjacent to sidewalks and curbs

iii. The LID growing soil media shall meet the specification in Section ***5.15***. The minimum depth is 300 mm.

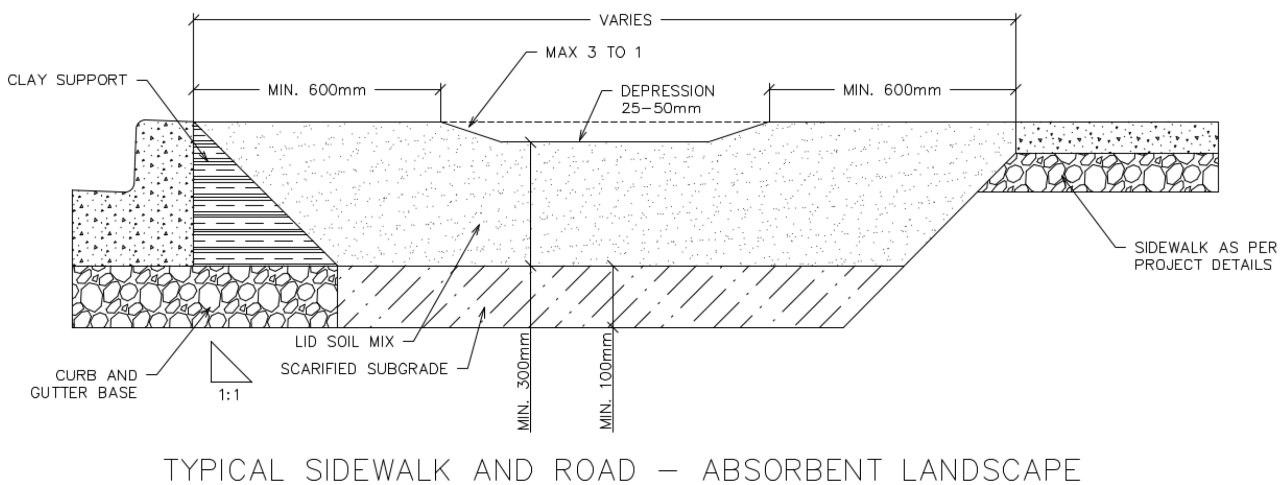
iv. Sub soil to be scarified a minimum of 100 mm unless it is not feasible due to site constraints.

5.7.7 Buffer

i. The facility base must be at least 0.6 m to 1 m above the seasonally high groundwater table (see Section ***5.2.8*** for additional details).

ii. Setback for depressions of at least 0.6 m from adjacent structures (roads, sidewalks, etc.) and 3 m from existing buildings. If setbacks cannot be achieved, impermeable liners may be considered to protect adjacent structures.

Figure 5.6 shows cross sections of a few typical absorbent landscapes, and is for illustrative purposes only, they do not depict every detail that may be required for successful construction, operations, and maintenance. Note the figures may not show details required to meet other aspects of the City of Edmonton Design and Construction Standards such as membranes, filter fabric or clay caps, for example deeper topsoil adjacent to curbs must have a minimum 150 mm clay cap to prevent fines migration and support the sidewalk and curb.



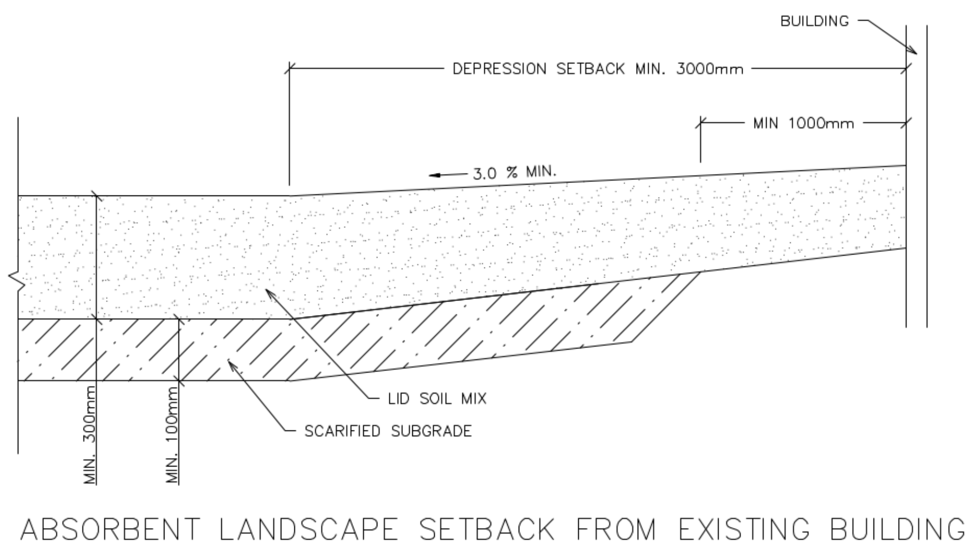


Figure 5.6: Absorbent Landscaping Cross Sections

5.8 Piping and Infrastructure Considerations

5.8.1 All piping must be smooth, rigid, PVC pipe with a minimum 150 mm diameter. This applies to distribution piping, underdrain piping, leads, and cleanouts to surface. Pre-treatment, such as a catch basin, is required for 150 mm diameter pipe. Note that pipe capacity may be affected when using smaller pipe with large catchment areas and high imperviousness.

5.8.2 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.

5.8.3 Underdrains must connect to a CB/CBMH prior to discharging into the sewer system for flushing and maintenance purposes.

5.8.4 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. The minimum radius for bends is 760 mm for 150 mm diameter pipe and 1000 mm for 200 mm diameter pipe.

5.8.5 Cleanouts may come to surface at an angle or vertically when provided with a single long radius 90 degree bend. 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 pipe must be positioned within the box to accommodate a rigid pipe extension extending past the top of the box. Underground enclosure boxes must be a minimum of 457.2 mm (18”) deep and must be firmly embedded within the LID soil media and not within the mulch to ensure sufficient stability to anchor the box. Pipe bends, pipe size, depth of pipe, and design of the enclosure box, all impact the minimum size required for the underground enclosure box and are design specific. Field cutting of the junction box must be approved by the enclosure box manufacturer (for example, some boxes come with mouse holes that can be cut out). Enclosure boxes that are modified, must maintain the specified load rating. See ***Figure 5.7*** and ***Figure 5.8*** for example configurations of cleanouts. These figures are for illustrative purposes only and do not depict every detail that may be required for successful construction, operations and maintenance. Different manufacturers have different bend dimensions/radii and it is strongly recommended that these cleanout configurations be drawn to scale for each design project. The minimum standard media layer depths might not be sufficient for the type of bend used, and greater depths may be required to properly accommodate the bend.

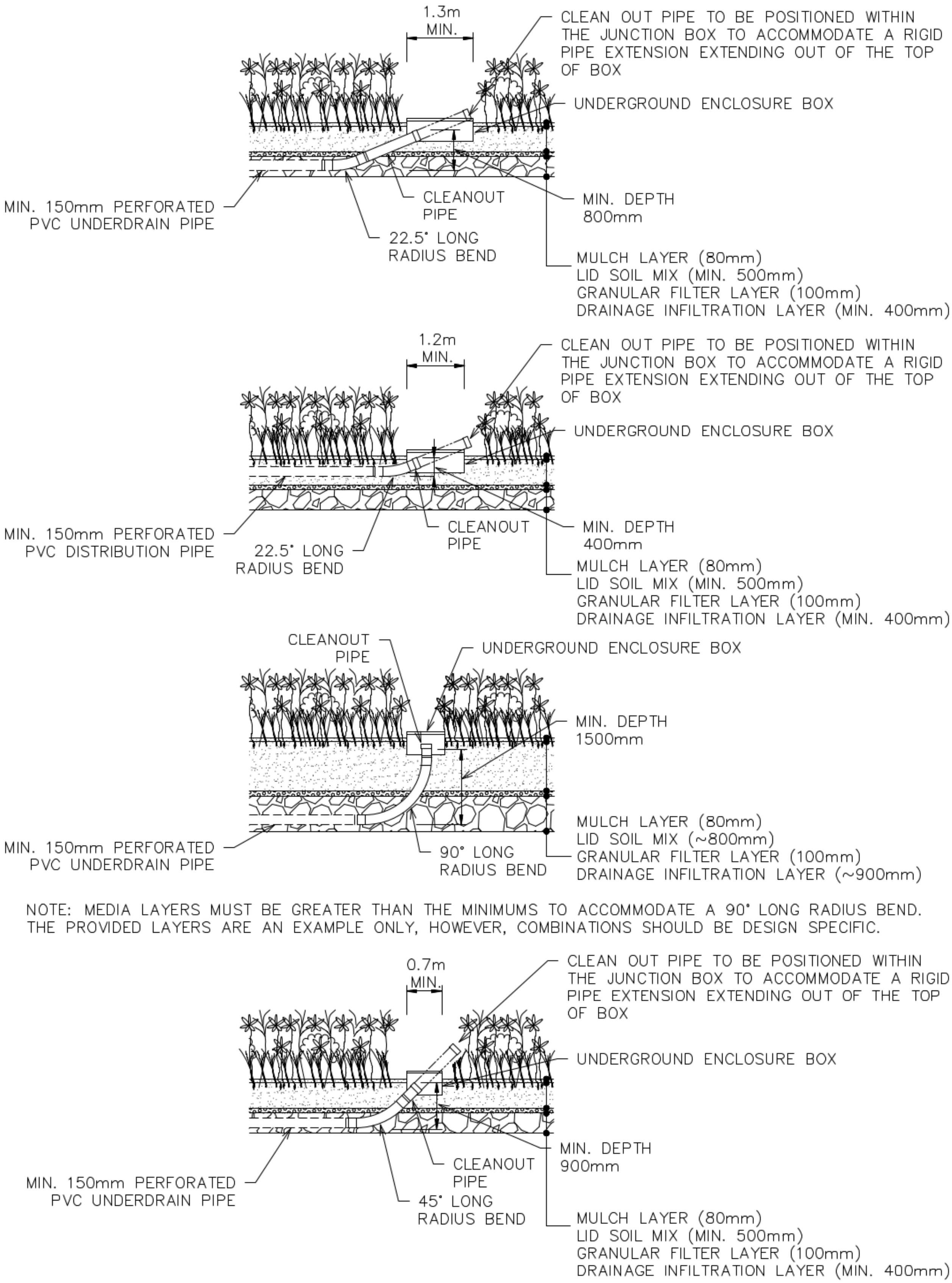


Figure 5.7: Cleanouts

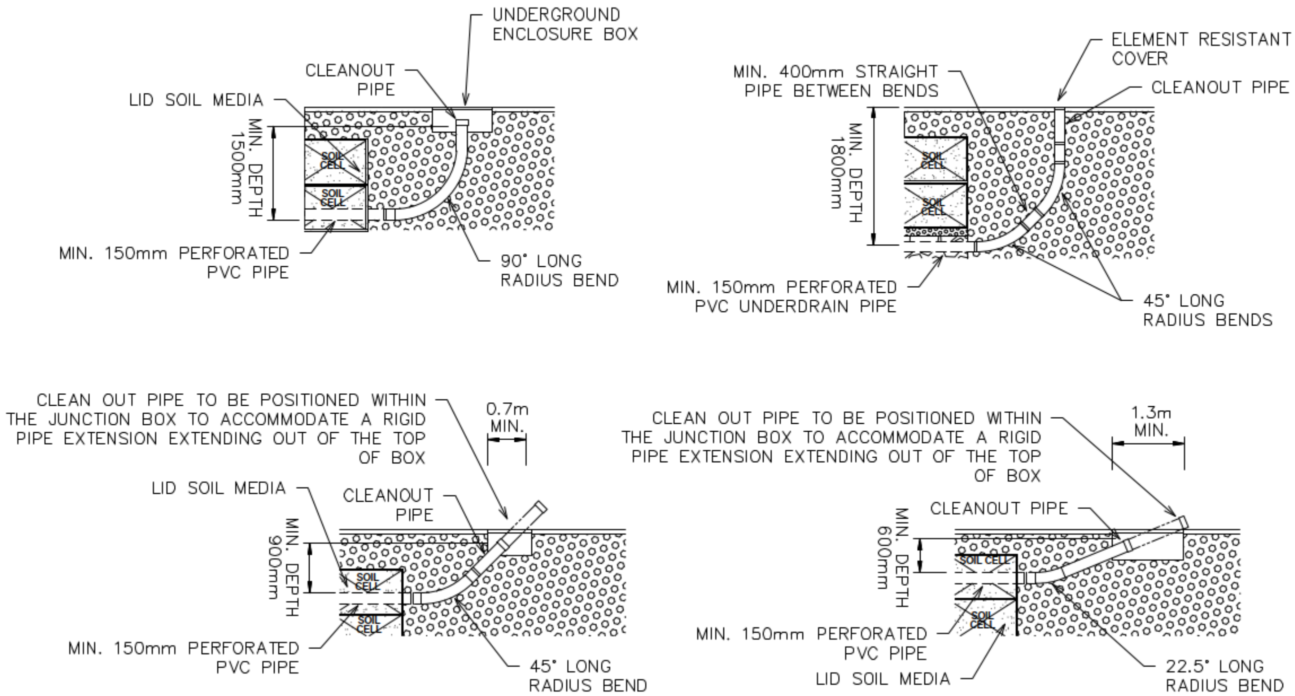


Figure 5.8: Soil Cell Cleanouts

5.8.6 If in-line cleanouts are to be used, they must be a barrel cleanout. In-line cleanouts are not preferred and should only be utilized if no other configuration is feasible. Wye fittings are not allowed. S-bends are not to be used and bends should not be used back to back to gain elevation in a short span.

5.8.7 Each separate piping line must include a CB or barrel cleanout with sump within 4 m of an accessible surface (see Section ***5.8.8*** below). The following must also be adhered to:

i. The maximum permitted spacing on a piping line between two CBs and/or barrel cleanouts is 150 m for a 200 mm diameter pipe and 75 m for a 150 mm diameter pipe.

ii. The maximum permitted spacing on a piping line between a CB/barrel cleanout and a cleanout (junction box or valve cover) is 150 m for a 200 mm diameter pipe and 75 m for a 150 mm diameter pipe if there are no bends in that section of pipe. If bends are required between the CB/barrel cleanout and cleanout, the maximum permitted spacing is 30m.

iii. The maximum amount of horizontal bends on a piping line is 90°. If more bends are required, a barrel cleanout is required before the next section of piping.

iv. If junctions are to be used, such as tee fittings, both piping lines must contain a CB/barrel cleanout/cleanout combination following the spacing outlined above.

v. See ***Figure 5.9*** for example layouts.

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

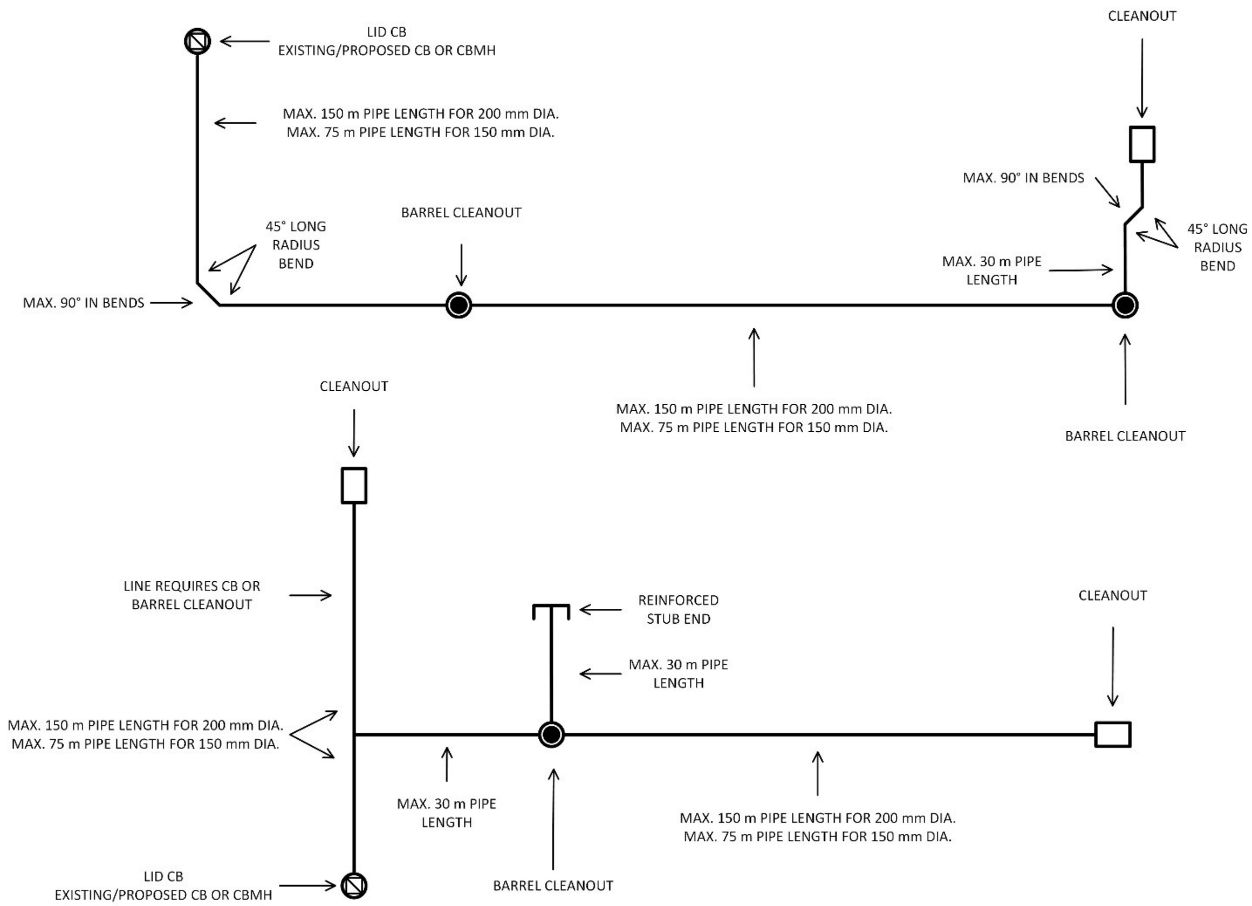


Figure 5.9: Piping Spacing

5.8.8 If a barrel cleanout with sump is utilized as the primary cleanout location, the barrel cleanout 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.

5.8.9 The minimum pipe grade shall be 0.5%. If the minimum pipe grade is not feasible the following shall apply:

i. Piping should be sloped towards a CB/barrel cleanout with sump to facilitate drainage of the pipe and allow for proper cleaning/flushing; or

ii. 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 CB/CBMH may be flat.

5.8.10 If permanent stub ends are to be used, they must be reinforced using one of the following options:

i. A 12-gauge stainless steel insert bonded to the inside of a threaded PVC Cleanout plug. The stainless steel insert shall fit tightly inside the cleanout plug and be bonded using marine epoxy.

ii. An approved equivalent.

5.8.11 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 piping is shown in ***Figure 5.10.*** The embedment shape can be square or circular, this is simply a depiction of one possibility.

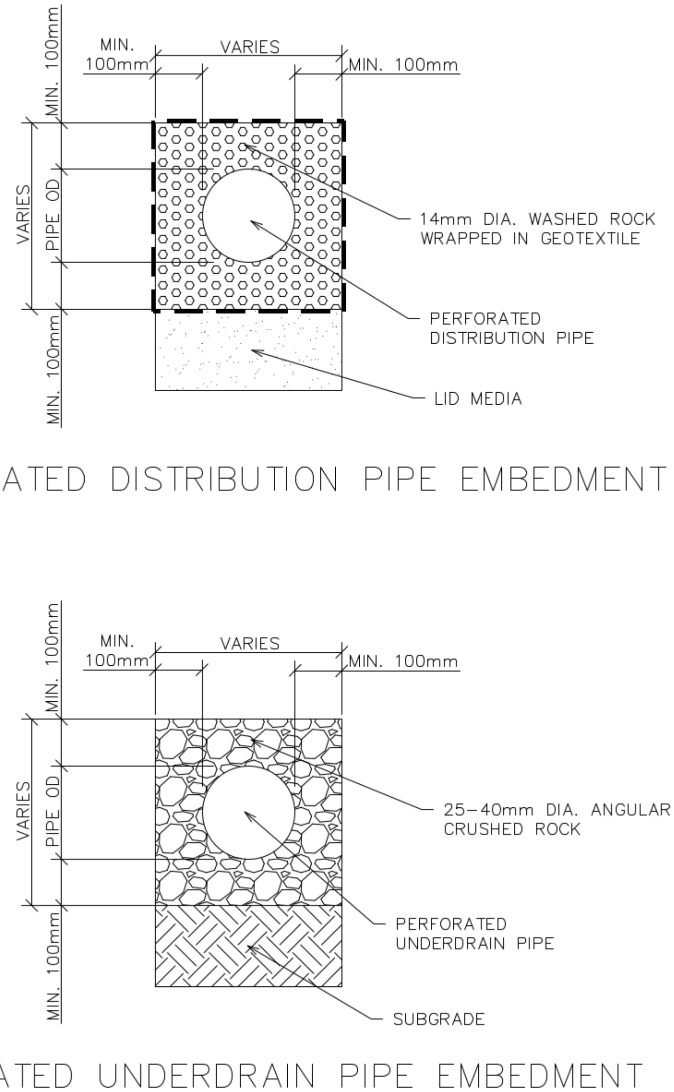


Figure 5.10: Typical Perforated Pipe Embedment

5.8.12 Pipe perforations should be spaced no more than 125 mm apart along the pipe and must be positioned at a 120° angle around the pipe's cross-section as shown in ***Figure 5.11***. 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.

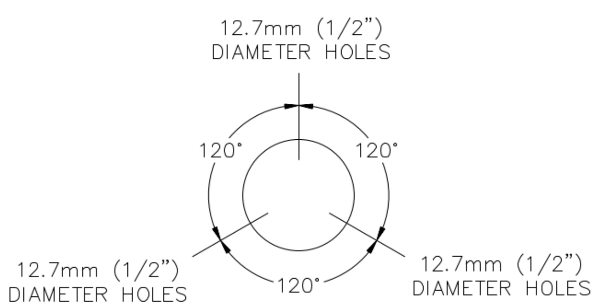


Figure 5.11: Pipe Perforations

5.8.13 LID inlets and outlets utilizing maintenance hole and CBs must meet the frame, cover and barrel size requirements in the City of Edmonton Design and Construction Standards, Volume 3-06: Construction Specifications and Standard Drawings. Barrel heights may be adjusted to better suit the LID; however, sump requirements must be followed. The specific maintenance hole 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 maintenance hole it must not protrude more than 50 mm; if there are multiple pipes protruding into the CB or maintenance hole, they must be flush with the barrel. If piping/devices must protrude into the barrel of the CB or maintenance hole a larger barrel size may be required.

5.8.14 For locations located in longitudinal sags, as well as in areas with flat grades (i.e. adjacent to curb extensions and chicanes), or with obstructions (i.e. raised crosswalks) the drainage system must have a standard (non-LID) CB installed downslope of the LID.

5.8.15 If bioretention basins and box planters contain a CB overflow, an approved beehive/dome grate compatible with existing approved frame must be installed. 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.

5.8.16 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 maintenance hole or catch basin maintenance hole 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.

5.8.17 Underground enclosure boxes (including junction boxes and valve boxes) and caps must be labelled appropriately. Underground enclosure boxes or caps should be installed to protect infrastructure coming to surface such as cleanouts. 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 m of the cleanout location (small vegetation is acceptable). If due to site constraints a 1 m radius around the cleanout is not possible, a minimum of 180° of clear space is required.

5.8.18 For LID CB inlets only, a Type 4A frame and cover can be used on a 600 mm barrel. See Figure ***5.12*** for a typical LID CB with the approved 4A grate and frame.

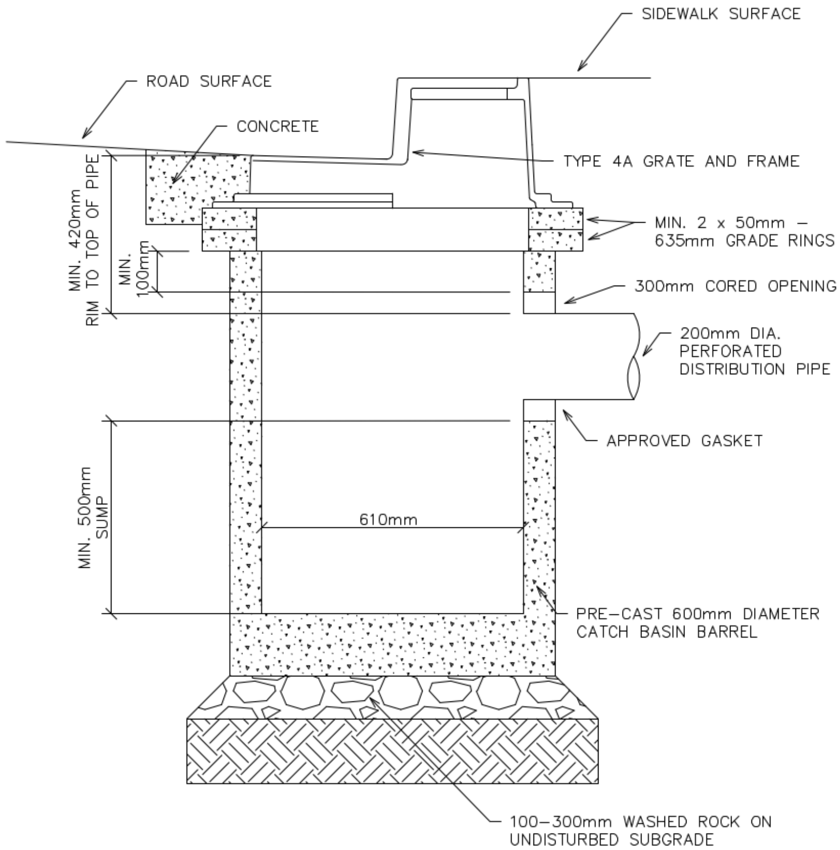


Figure 5.12: Type 4A with 600 mm Barrel

5.9 Surface Inlets

5.9.1 Size curb cut inlets to prevent blockage by ice and snow during spring runoff. See ***Figure 5.13*** below for a typical concrete curb opening approved by the City of Edmonton. Other curb openings may be accepted by the City of Edmonton.

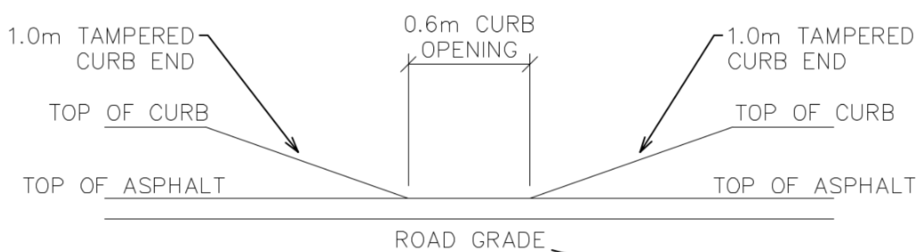


Figure 5.13: Typical Curb Cut Opening

5.9.2 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. Thoughts 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.

5.10 Signage Considerations

5.10.1 Cautionary signs are required at individual LID facilities with softscape (with the exception of absorbent landscaping) unless an alternative plan has been approved by EPCOR.

5.10.2 EPCOR has two sign types available, a caution sign as shown in ***Figure 5.14*** and an educational sign as shown in ***Figure 5.15***. Caution signs are recommended for use in road right-of-way, and near an inlet to an LID, when applicable. Educational signs are recommended in pedestrian friendly locations such as park spaces or plazas where sightlines are not a concern. Educational signage may be installed in areas of hardscape.

5.10.3 Sign Placement within each LID facility should be shown on the plan view of the drawings, and spacing should be assessed and recommended by the designer.

5.10.4 Signage must be installed two to three weeks prior to FAC inspection, signs should not be installed prior to this time.

5.10.5 Caution signs must be as per ***Figure 5.14*** below and must be:

i. 12” by 15”

ii. Holes for the signs to be 3/8” in diameter

iii. Signs must be aluminum

iv. Posts should be 12 ga x 8 Foot Steel Galvanized U Channel.

v. Holes must be placed 13” apart measured center to center, at the approximate locations of the pink circles shown in ***Figure 5.14***, these must match hole spacing on the posts.

vi. Signs must be installed at a height that meets the area’s needs and is readable for the intended purpose, as determined by the designer.

vii. Signs should not be placed on top of any utilities.

Figure 5.14: LID Caution Signage

5.10.6 Educational signs must be as per ***Figure 5.15*** below and must be:

i. 12.75” by 17.75”

ii. Holes for the signs to be 3/8” in diameter

iii. Signs must be aluminum

iv. Posts should be 12 ga x 8 Foot Steel Galvanized U Channel.

v. Holes must be placed 15” apart measured center to center, at the approximate locations of the pink circles shown in ***Figure 5.15***, these must match hole spacing on the posts.

vi. Signs must be installed at a height that meets the area’s needs and is readable for the intended purpose, as determined by the designer.

vii. Signs should not be placed on top of any utilities.

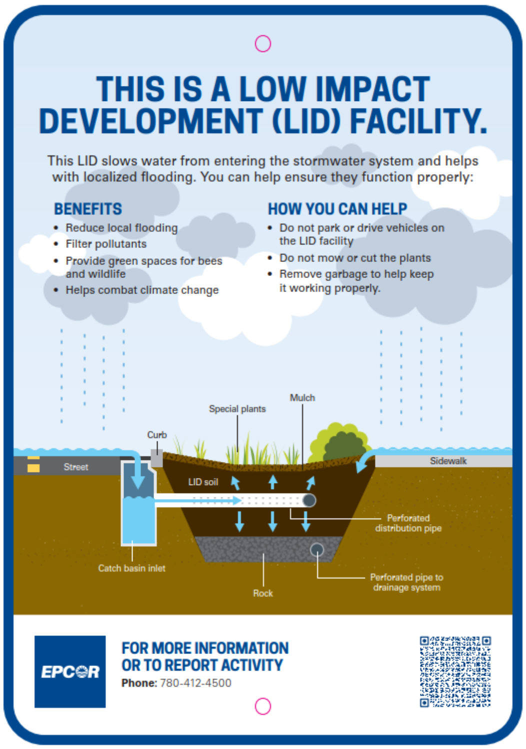


Figure 5.15: LID Educational Signage

5.11 Cold Climate Design Considerations

5.11.1 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.

5.11.2 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).

5.12 Vegetation Selection

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

i. Soil permeability and periodic inundation of the soil;

ii. LID soil media type (as per Sections ***5.15***);

iii. Tolerance of seasonal salt loadings depending on facility location;

iv. Pollutant uptake capacity;

v. Maintenance needs, including mowing and pruning;

vi. Sight lines for facilities on or near roadways;

vii. Site use, for example in high traffic pedestrian areas plants with an odour may not be appropriate;

viii. Reduction of water and fertilizer needs after establishment;

ix. Potential nuisances (i.e. pollen and aroma) in high traffic areas;

x. Resistance to pests.

5.12.2 Recommended native species for LID are listed in ***Table 5.3*** 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 5.3*** is provided for guidance and outlines some of the 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.

5.12.3 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 5.3*** however, vegetation selected for specific LID facilities is still governed by the City of Edmonton Design and Construction Standards, Volume 5: Landscape 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.

5.12.4 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 5.3*** 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: Landscape and must meet these requirements.

Table 5.3: 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 the 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 the 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

5.13 Drawing Requirements

5.13.1 Design Stage Requirements

Drawing requirements for all stages of design are outlined below. All LID facilities must be labelled as LID. Drawing sets should have a drawing index with LID Drawings clearly identified.

i. Concept/Preliminary

a. Completed LID Summary Table (see ***Table 5.4***)

b. Plan view of facility locations and catchments with cadastral

c. Proposed locations of distribution/underdrain piping and tie into drainage system, including all pipe bends and fittings. All bends must be labelled and drawn to scale.

d. Existing constraints for each LID facility

Table 5.4: LID Summary Table

Drainage Area	LID Type	Location Where Runoff Enters to LID	Catchment Area, m^2	Catchment Impervious-ness, %	Design Rainfall Depth, mm	Runoff Volume for Design Rainfall, m^3	LID Surface Area, m^2	LID Capacity, m^3	LID Capacity/ Runoff Volume, %
1	e.g. Bioretention Basin	Curb Cut	4315	90%	18	73	300	75	103
2	e.g. Soil Cell	CB	2000		35	61		65	
		Sum	**6315**			**134**		**140**	

ii. Detailed

a. All requirements outlined in ***Table 5.6***: Drawing Detail Requirements

b. Reference to an LID Soil Testing Plan in the Contract Documents, or a clearly laid out plan on the drawing set

c. A separate drawing for each LID facility should be submitted for each drawing type, i.e. Utility and landscape. Where this is not practical, it must be clear how the LID facility is split between pages.

d. If erosion and sediment control measures are required for construction this should be indicated within the drawing set.

e. Utility Drawings

I. Extent of LID facility

II. Proposed locations of distribution/underdrain piping, cleanouts (including all pipe bends and fittings, all bends must be labelled and drawn to scale), tie-ins, and CBs/CB Maintenance holes with the frame and cover type labelled

III. Flow direction through LID facility and overland drainage route

IV. Grading in the LID facility and catchment area (if applicable)

V. Existing utilities including invert elevations

VI. Landscaping is not to be shown on utility drawings unless it is the location of existing trees, shrubs, etc. to be maintained.

VII. Distances to any utilities in proximity to the LID facility or its associated piping and drainage infrastructure.

VIII. Existing infrastructure such as sidewalks, shared use paths, roads, etc.

f. Details

I. Applicable cleanout details from the standards

II. Slope and invert elevation of distribution pipe and underdrain pipe

III. Pipe perforations

IV. Pipe embedment

V. Soil cell installation layout and placement of piping within soil cells (if applicable)

VI. Profile of highest point of distribution and underdrain piping within soil cells (if applicable)

VII. Inlet and outlet (as applicable) type and location, including a detail, tie-ins, and surface flow velocities, if applicable

VIII. Inline or overflow CB, spillway or other water conveyance details (as applicable)

IX. Profile of all LID infrastructure tie-ins to existing or proposed drainage infrastructure

g. Landscape

I. Separate planting plans must be included with every LID plan

II. Vegetation maturity, species and quantity summary table

III. General layout of distribution and underdrain piping (and other potential utility conflicts) should be shown to gauge proximity to both existing and proposed 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.

IV. Operations & Maintenance Template to be provided by EPCOR

iii. IFT/IFC

a. Changes required to detailed drawings as noted during detailed drawing review.

b. Specifications and Special Provisions for LID packages are to be standalone documents. If Specifications or Special Provisions for LID will not be developed, information typically found in these documents must be included within the notes on the Drawings. This includes but is not limited to:

I. LID soil mix requirements

II. Testing protocols and requirements

III. Construction methodologies for components not currently in this Standard (i.e. clay check dams)

IV. Erosion and sediment control requirements

c. Shop Drawings

I. Must be approved by a Professional Engineer at the supplier or manufacturer if design varies from LID Standards

II. Must be provided to EPCOR Drainage and/or all applicable stakeholders for review prior to installation

iv. As-Built

a. All requirements outlined under Utility Drawings and Details and Landscape in Section ***5.13.1.ii***, as well as all requirements in Section ***5.13.1.iii***.

b. Completed LID Summary Table, including hydraulic conductivity (see ***Table 5.5***)

Table 5.5: As-Built LID Summary Table

Drainage Area	LID Type	Location Where Runoff Enters to LID	Catchment Area, m^2	Catchment Imperviousness, %	Design Rainfall Depth, mm	Runoff Volume for Design Rainfall, m^3	LID Surface Area, m^2	LID Capacity, m^3	LID Capacity/ Runoff Volume, %	Average Hydraulic Conductivity (from Guelph Permeameter), mm/hr
1	e.g. Bioretention Basin	Curb Cut	4315	90%	18	73	300	75	103	
2	e.g. Soil Cell	CB	2000		35	61		65		
		Sum	**6315**			**134**		**140**		

c. LID Calculator spreadsheet attached to the as-built drawings as a PDF (to be provided by EPCOR)

d. Coordinates of all single point facilities including MHs, CBs, junction boxes, cleanouts, including the depth at which they were installed, pipe inverts, etc.

e. Clear distinction between perforated and non-perforated pipes

f. Clear distinction between old and new infrastructure

g. Number of each type of vegetation planted in each LID, broken down into shrubs, trees, grasses, and forbs

5.13.2 Drawing Details

Required plan view, detail, and profile view drawing details are listed in ***Table 5.6*** below. All drawing packages are required to have a drawing index.

Table 5.6: 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 ***Table 5.4***.
Location	x			Aerial 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 five definitions outlined in ***Sections 5.3, 0, 5.5, 5.6, 5.7***) or definitions as per EPCOR's *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.

Parameter	Plan	Detail	Profile	Description
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.

5.13.3 Drawing Considerations

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

a. 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.

b. For LID infrastructure/utility drawings, ensure piping layouts, inlets and outlets are unobstructed. If existing utilities are displayed, they should be dimmed but still remain visible.

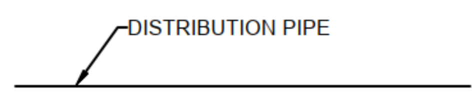
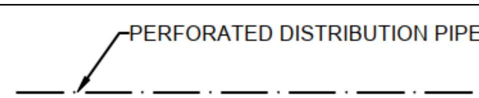
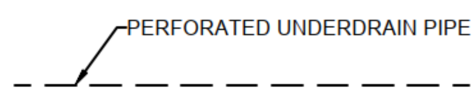
c. Increasing piping lineweight or using colour when pipes in plan view are close to other lines to ensure piping layout is clear.

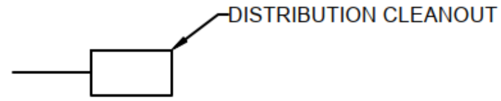
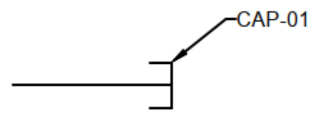
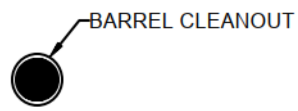
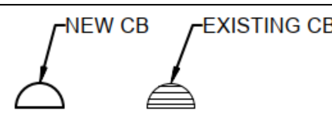
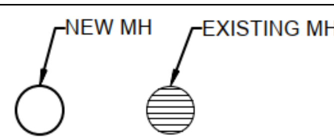
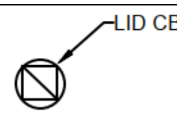
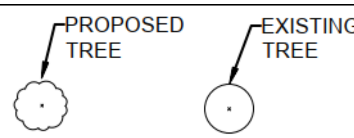
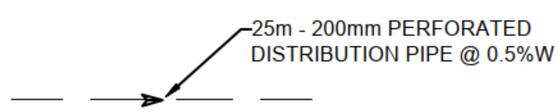
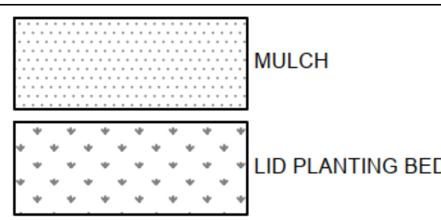
d. Utility offsets should be shown on the drawings (see Section ***5.2.7*** for further details).

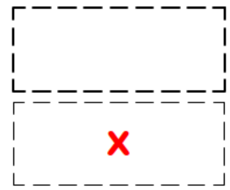
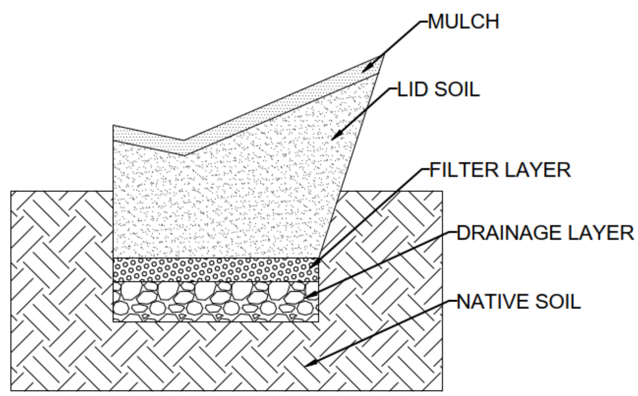
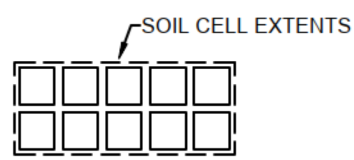
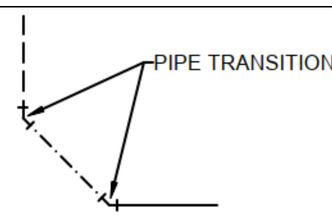
e. Aggregate around distribution pipes should be drawn to scale in section views to ensure that there is sufficient soil depth between the distribution pipe embedment and the filter rock layer.

ii. The following drawing standards should be utilized for LID drafting whenever possible:

Table 5.7: LID Drafting Standards

Item	Note	Example
Solid Pipe (can be used for both distribution and underdrain pipes)	Continuous solid lines	
Perforated Distribution Pipe	ISO dash dot (ACAD_ISO10W100) lines.	
Perforated Underdrain Pipe	ISO dash (ACAD_ISO02W100) lines	

Item	Note	Example
Junction Box Cleanouts (can be used for both distribution and underdrain pipes)	Square boxes with empty fill	
Stub End	Underground reinforced steel cap with unique number identifier	
Barrel Cleanout	Full circle with black fill	
Catch Basins (CB)	Semi-Circles, striped for existing, bold for proposed	
Maintenance Holes (MH)	Full circle, striped for existing, bold for proposed	
LID CB Inlet	Circle with a square and diagonal line inside it - empty fill	
Trees	Existing trees indicated with simple circles.	
Leaders	Linewidth for leaders and pipe to be made clearly visible. Labels for pipe should indicate pipe length	
Flow Arrows	Flow direction to be denoted using arrows. Slope direction to be identified through labelling i.e. 0.5% West.	
LID Areas	LID Planting beds will have GRASS hatching and be clearly differentiated from non-LID planting beds.	

Item	Note	Example
LID Boundaries	Boundary lines to be clearly identified and distinct by line weight or color.	
Catchment Areas	Distinct color outlines, coloured transparent hatching or line weights to differentiate between catchment areas.	
LID Facility Hatching	LID Soil Mix hatched as AR-SAND Native Soil hatched as EARTH Filtration Layer hatched as HEX Drainage Layer hatched as GRAVEL Mulch hatched as DOT	
Soil Cell Extents	Soil Cells to be drawn to scale in a grid with trench outline/LID boundaries identified clearly with linewidth or color.	
Pipe Transitions	Pipe transitions including bends and perforation changes will be indicated by tick marks at the locations of pipe joints.	

5.14 Construction

5.14.1 CCC/FAC Requirements

The following are required at CCC and FAC, unless otherwise noted. Inspections will not be conducted during cold weather, and vegetation must be fully established prior to cold weather to qualify for inspection. The functionality and inspection of the LID cannot be evaluated in frozen ground conditions or if snow cover is present.

i. Inspection of drainage infrastructure and landscaping, including grading and slope of the facility.

ii. One inspection for both drainage infrastructure and landscaping will be conducted and one CCC and one FAC will be issued. If either portion (drainage or landscape) fails, the CCC and/or FAC will not be issued.

iii. Public trees will be inspected by the applicable group at the City of Edmonton and the inspection report shall be provided to EPCOR, prior to CCC issuance and as requested at FAC.

iv. Soil and hydraulic conductivity testing results, prior to CCC issuance, and additional results as applicable at FAC. Testing results should clearly indicate that they were reviewed/verified by the design consultant or facility owner.

v. CCTV of all pipes, prior to CCC issuance, and as requested at FAC.

vi. Red-lines or as-builts including updated planting plans, prior to CCC issuance.

vii. As-builts including updated planting plans, prior to FAC issuance.

5.14.2 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, the 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 Design and Construction Standards, Volume 5: Landscape - 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.

5.14.3 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/hr, hydraulic simulations and calculations should be completed using a hydraulic conductivity of 20 mm/hr.

5.15 LID Growing Soil Media Specifications

The LID soil media must meet the requirements in Section ***5.15.1*** or the performance-based standards outlined in Section ***5.15.2***. If performance-based standards are chosen, the designer must prove the standards can be met with their design.

5.15.1 Texture and Property

The LID soil media specification in ***Table 5.8*** 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 ***5.15.2***.

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 5.8: 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 - 60 ppm
In-situ Saturated Hydraulic conductivity, at soils specified compaction and moisture	Minimum 40 mm/hr Maximum 300 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.

5.15.2 Performance-Based Standards

i. If a soil mix other than that specified in ***Table 5.8*** 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. Refer to Section ***5.2.3***. 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.

ii. 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 ***5.8*** Piping and Infrastructure Considerations and must provide adequate support for the specified piping.

iii. 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.

iv. 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.

5.15.3 Tree Root Package

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 ***5.15***). ***Figure 5.16*** 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: Landscape.

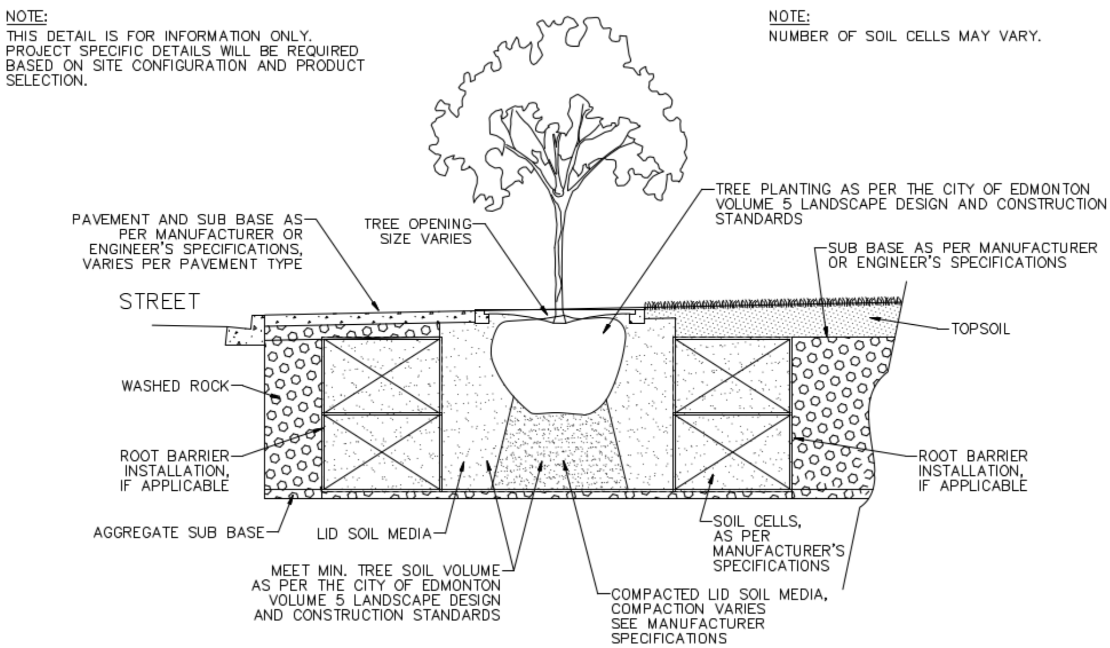


Figure 5.16: Typical Tree Root Package

5.16 Testing Requirements

5.16.1 Soil Sampling and Analysis

i. Soil media analysis shall be conducted and the results shall be approved by the City/EPCOR prior to:
   a. Soil arriving on site; and
   b. Soil being placed in the LID facility
ii. Analyses conducted shall include the following:
   a. Texture classification by a qualified professional;
   b. Grain size classification (sieve and/or hydrometer) (%);
   c. Organic matter (Loss on ignition);
   d. pH
   e. Available Phosphorus
iii. 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 Design and Construction Standards, Volume 5: Landscape - 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.

iv. 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 ***5.15***, 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 ***5.15***, 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.

5.16.2 LID Soil Compaction and Infiltration

i. 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 300 mm lifts; unless otherwise specified by the designer. Where substrate infiltration is slow (<15 mm/hr) an underdrain must be installed.

ii. Following LID soil placement the following test shall be completed:

Guelph Permeameter testing

a. Prior to the placement of concrete or planting, saturated hydraulic conductivity testing must be completed. Guelph Permeameter testing must be conducted at a minimum of two locations per LID facility for facilities less than 1000 m^2. For facilities greater than 1000 m^2, an additional test will be required for every additional 500 m^2.

b. A QA/QC test must be completed at a location adjacent to one of the aforementioned tests (within 3 m).

c. For facilities with soil deeper than 650 mm, the tests shall be conducted at approximately ¼ to ½ depth and ½ to ¾ of the soil depth. The QA/QC test must be conducted at the same depth as the adjacent test. It is preferred that facilities less than 650 mm be tested at the halfway depth of the soil.

d. 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.

e. If Guelph testing fails specifications the Contractor can request alternate testing at their cost.

f. For facilities with a soil depth of 300 mm or less, Guelph Permeameter testing is not required.

iii. At FAC, Guelph Permeameter testing may be required at the request of EPCOR.

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

v. When limiting compaction, care must be taken to follow the Construction Considerations located in Section ***5.14.2.***

vi. Additional Subgrade Compaction for Soil Cells

Subgrade and granular base compaction shall be completed prior to soil cell placement to a minimum of 95% Standard Proctor density or as per manufacturer specifications.

vii. Additional LID Inspections

All pipes within LID facilities must be CCTV'ed as per the City of Edmonton Design and Construction Standards, Volume 3-06: Construction Specifications and Standard Drawings. CCTV requirements are located in 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: the 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 the 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 the City of Edmonton, Development Services, Lot Grading web page ***www.edmonton.ca/lotgrading***.

v. General considerations in the establishment of Lot Grading Plans

   a. 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.

   b. 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.

   c. 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***.

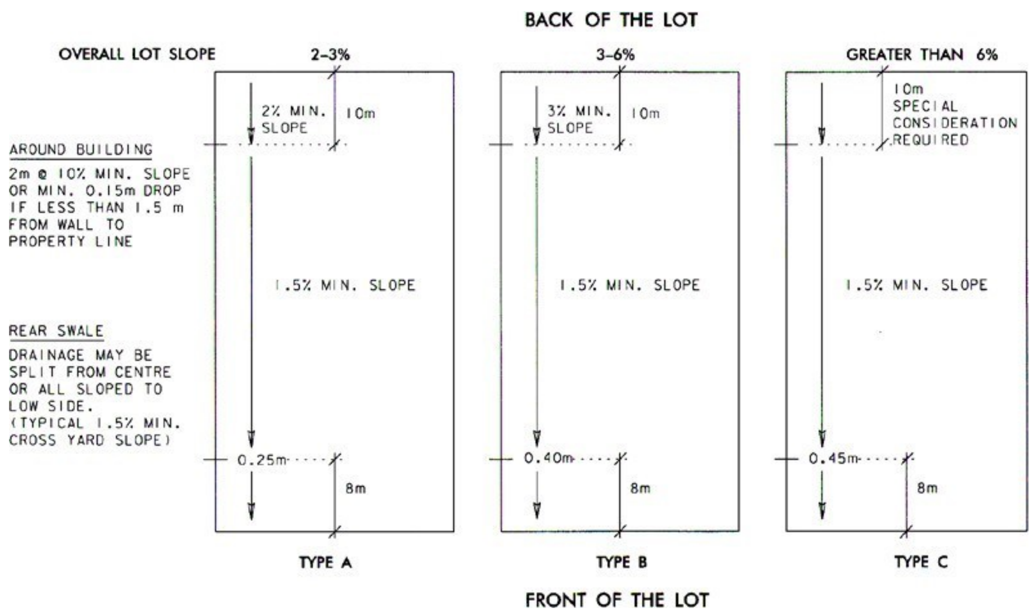


Figure 6.1: Typical Lot Grading Details – Rear to Front Drainage

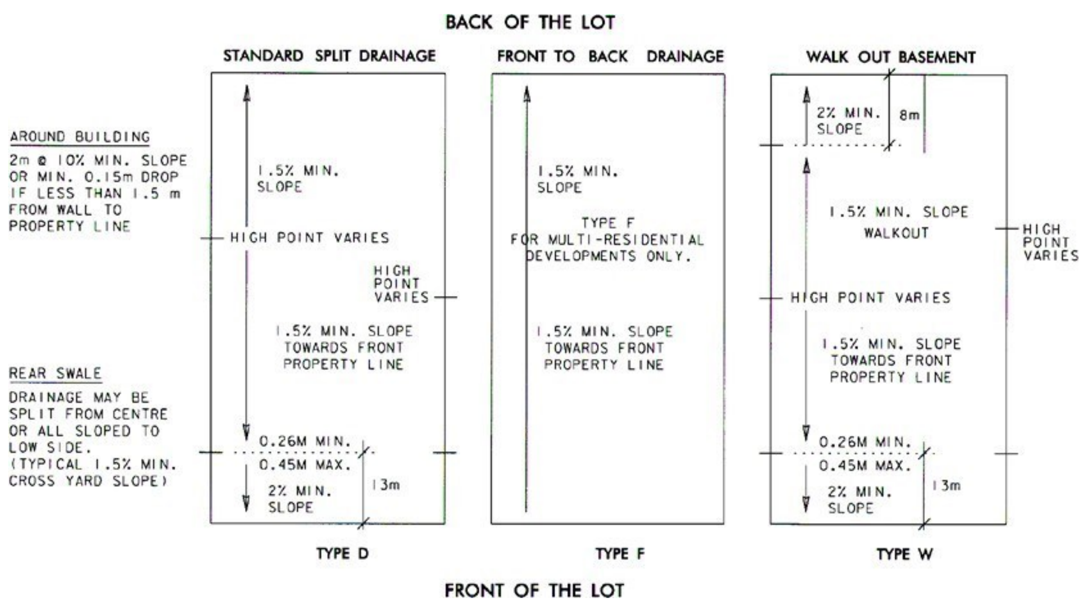


Figure 6.2: Typical Lot Grading Details – Split/Front to Back Drainage

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:

   a. 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***).

   b. 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.

   c. 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

   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.

ii. Alleyless subdivisions (properties with no alley)

   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:

   a. It is not feasible to achieve rear-to-front drainage due to extreme natural topography;

   b. The receiving downstream lot has an overall grade of 3.0% or more;

   c. There is no concentration of flow from upstream lots to downstream lots;

   d. Only one lot drains to another lot; if more than one lot drains to another lot downstream (see

Figure 6.4 and ***Figure 6.5*** for more details), all of the following conditions must be met:

I. The receiving downstream lot must meet the design grading requirements of a typical type B Lot; zero type B Lot may be permitted;

II. A 2.0 m private to private cross-lot drainage easement and restrictive covenant are required for the receiving downstream lot, with the City of Edmonton as a party for the purposes of enforcement only (refer to Section ***0*** for detail requirements for swales);

III. Internal lot grades are set along side lot lines 2.0 m from the rear property line; and

IV. No roof leader discharge shall be directed from upstream type D Lots to the maintenance easement.

e. All the upstream lots shall have roof runoff directed to a storm service and the grading of each lot is designed with the ridge as close as possible to the rear property line.

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.

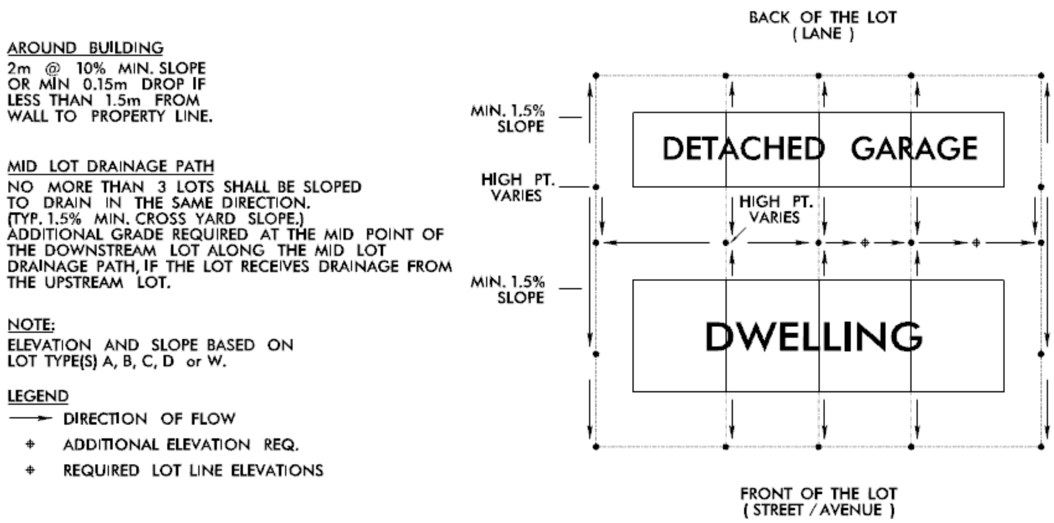


Figure 6.3: Typical Multiplex Lot Grading Details

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 public swale, that is to be owned and maintained by EPCOR, which will 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 If the Engineer approves a private swale under Section ***6.2.5.ii***, that is to be owned and maintained by private landowners, which will drain numerous properties, it shall be covered by an easement and restrictive covenant in favour of the land being drained, but the City of Edmonton will be a party for the purpose of enforcement only, to the satisfaction of the Engineer.

6.3.4 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.

6.3.5 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

   a. Location: Rear of upstream lot in a 2.0 m easement

   b. Cross Section: V-shape, 150 mm minimum depth and 4H:1V maximum side slope

   c. Longitudinal slope: 1.5% minimum

ii. Grass swales serving lots on both sides

   a. Location: Common rear property line as centre of a 4.0 m easement.

   b. Cross-section: Trapezoidal with 1.0 m bottom, 150 mm minimum depth and 4H:1V maximum slope.

   c. Longitudinal slope: 1.5% minimum

iii. Grass swales with concrete gutter (swale), serving lots on one or both sides

   a. Location: Upstream lot with the gutter preferably centred on the 2.0 m easement.

   b. 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.

   c. 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. Grass swales on downstream Type B Lot servicing upstream more than one split Type D Lots

   a. Location: Rear of downstream lot in a 2.0 m private to private easement. The City of Edmonton will be a party for the purposes of enforcement only.

   b. Cross Section: V-shape, 150 mm minimum depth and 4H:1V maximum side slope.

   c. Longitudinal slope: 1.5% minimum.

   d. Set internal lot grades at 2.0 m from rear property line for the downstream Type B Lot at extension of all upstream Type D Lots and side yards (see ***Figure 6.4*** and ***Figure 6.5*** for more details).

v. Other Parameters and Requirements

   a. Capacity: Contain the 1:5 year storm flow within the concrete gutter and the 1:100 year storm major flow within the easement.

   b. 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.

   c. 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.

   d. Bends: Bends greater than 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.

   e. Conveyance: The grading of the boulevard and sidewalk shall be such that the major flow is not allowed to flow down the sidewalk.

   f. 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.

g. 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.

h. Future swale extensions shall be identified and evaluated to ensure that anticipated constraints and capacities are addressed.

i. Details: Show on the Lot Grading Plan, the cross-section, inverts, slopes and lot grades along the swale.

j. Calculations for the swale's minor and major flow capacities shall be submitted with the engineering drawings.

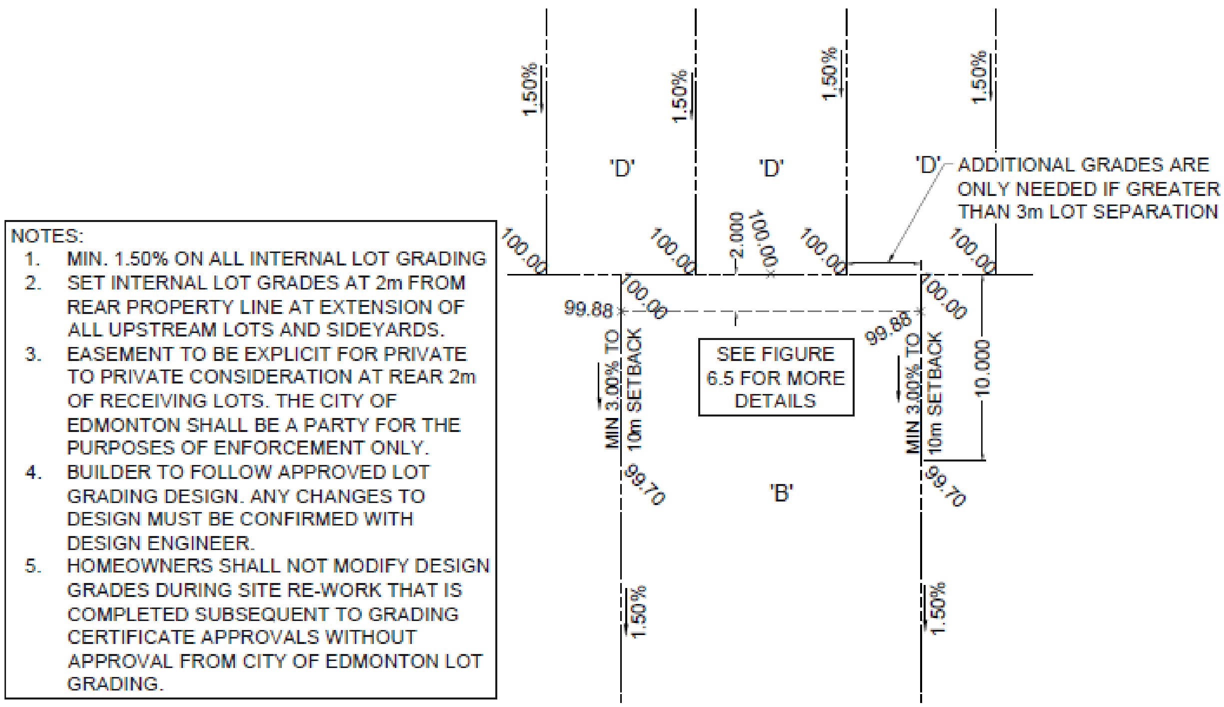
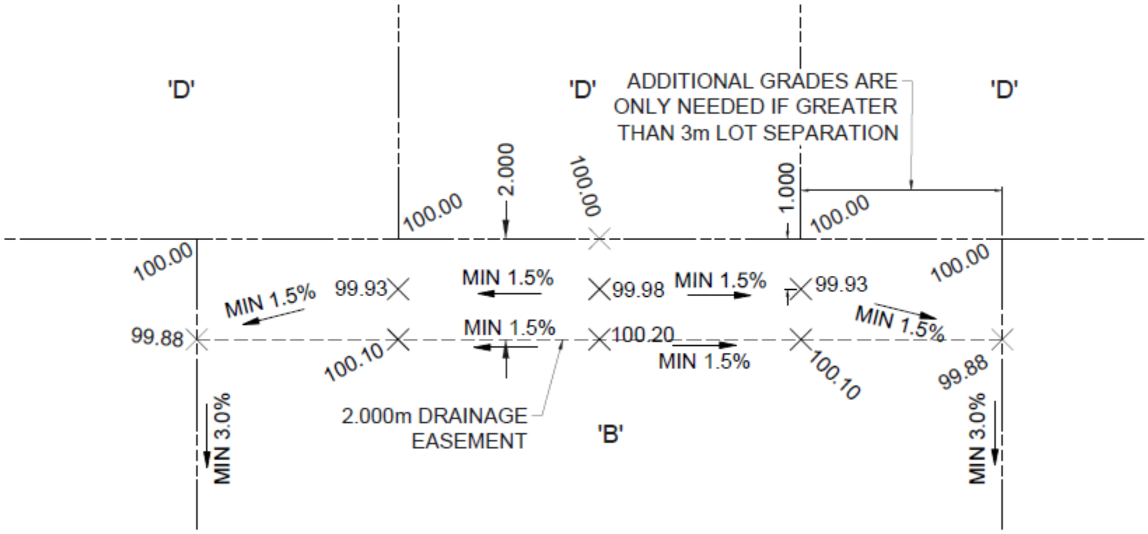


Figure 6.4: Lot Grading - More Than One Typical D Lots Drain to Downstream Type B Lot



NOTES:
1. GRADES ARE REFERENCED TO 100.00m ELEVATION DATUM
2. HIGH POINT LOCATION WITHIN EASEMENT IS VARIABLE, BUT MUST MAINTAIN 1.50% GRADE WITHIN PRIVATE PROPERTY

Figure 6.5: Lot Grading Detail - More Than One Typical D Lots Drain to Downstream Type B Lot

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.

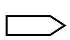
ii. Surface discharge of roof drains is proposed:

   a. Only when supported by the conclusions of the geotechnical investigations applicable to the development site.

   b. 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;

iii. 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

i. DHI Models (Mike+), CHI Models (PC-SWMM) (current version)

ii. Operating environment- e.g. Windows 11

1.1.2 Model Facts Sheet

i. # of nodes/links, e.g. combined, sanitary, storm sewers (regular and dummy connections)

ii. # of stormwater management facilities and RTCs

iii. # of open and natural channels

iv. # of special hydraulic elements: weirs, orifices, pump stations

v. Total study area (in ha) and # of sewersheds/catchments

1.1.3 Overall Maps

i. Location map and catchments or sewershed delineation maps

GIS shape file of catchment areas. Shape file to have 3 attributes: Catchment Name, Inlet Node and Drainage Area

ii. Schematic maps of Combined and Storm collection Systems

iii. Special structure details

1.1.4 Basic Model Setup

List of assumptions and boundary conditions

1.1.5 Hydrological Data

i. Major inflow source, e.g. rainfall, design storms, inflow hydrograph, etc.

ii. Population for domestic flow components

iii. Landuse and surface runoff parameters for what year?

iv. Digital Elevation Map/LiDAR

v. Impervious classification

vi. I/I components, etc.

vii. Rainfall and storm event analysis

1.1.6 Hydraulic Parameters

i. Closed conduit cross-sections, connectivity, diversions, etc.

ii. Open channels and natural creeks cross-section and profile data

iii. Rating curves: Pump stations, storage nodes, equivalent channel for storm detention ponds

iv. Control set points, etc.

1.1.7 Simulations and Results

i. Model calibrations, verifications: Flow monitoring data analysis

ii. Include all result files, runoff and hydraulic and include the Summary HTM for each

1.1.8 Files

i. Final report, presentation and all supporting files such as tables, charts and maps. Format: Searchable PDF format, GIS shape file, Microsoft Office, etc.

ii. Model input and output files (organized index list with descriptions)

iii. 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

iv. Include all result files

v. Detailed scenario descriptions. What is included in each and why?

vi. Other relevant information

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

1.2.1 The Model

i. DHI Models (Mike+), CHI Models (PC-SWMM) (current version)

ii. Operating environment- e.g. Windows 11

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

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, land use 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

1.2.8 Files

i. Final report, presentation and all supporting files such as tables, charts and maps. Format: Searchable PDF format, GIS shape files, Microsoft Office, etc.

ii. 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

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v. Detailed scenario descriptions. What is included in each and why?

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