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# Chapter 6
# Stormwater Management Requirements

# Design Specifications & Requirements Manual

**October 2003**

**Updated January 2025**

# City of London
# Design Specifications and Requirements Manual

The design information contained in this manual is intended to provide guidance beyond legislative and standard design practices for use in the City of London (the City). There will be site specific situations where the design will depart from these practices as it is not possible nor is it the intention of the City to anticipate every situation. The City intends to review and revise the Manual from time to time. The City also acknowledges that other references such as the 'Standard Contract Documents for Municipal Construction Projects' are to be used in conjunction with this manual. The 2012 update of this manual incorporates design information from the City's former 'Subdivision & Development Guide Manual' to provide consistent and current design information for development projects.

The City of London maintains its right to accept or refuse any design submissions and requires an acceptable design for any given circumstance.

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# 6 Stormwater Management Requirements

## Introduction

Since the late 1990s, municipalities in Ontario have constructed wet ponds to provide water quality benefits and to attenuate increased peak flows generated by new development. Wet ponds effectively reduce downstream flooding and provide water quality benefits; however, they do not reduce the additional **volume** of rainwater that is generated by increased imperviousness. This additional volume may cumulatively increase sustained peak flow that can be attributed to flooding, degradation, and disruption of water balance downstream.

In February 2015, the Ministry of Environment Conservation and Parks (MECP) issued an Interpretation Bulletin stating the provincial expectation as “going forward, the Ministry expects that stormwater management plans… will employ Low Impact Development (LID) in order to maintain the natural hydrologic cycle to the greatest extent possible”. The primary goals of Low Impact Development are to better mimic the natural hydrologic cycle by infiltrating (soak it up) or filtrating (slow it down) stormwater runoff where it falls (at the source), rather than sending all flows to one central facility.

The City of London recognizes stormwater management plays a critical role in assisting to address the challenges of a changing climate that includes increased extreme weather events and increased storm activity. LID practices as important tools in an expanding toolbox for stormwater management. In recognition of the provincial direction and the evolving practices of stormwater management, the City of London’s design standards include guidance on water balance and best management practices associated with implementing LIDs. Additional guidance regarding climate change adaptation is expected to be included in future design guideline updates.

## Intent

The SWM design standards are intended to communicate the City of London’s SWM design expectations, all in the context of current provincial and federal legislation, with regard for local conditions and municipal experiences related to operations and maintenance.

The City of London design standards are not exhaustive and there may be additional design criteria that emerge through consultation with internal and external partners, or due to emerging provincial or federal legislation. The Stormwater Engineering Division is available for consultation related to site specific design criteria and encourages open discussion, particularly as it relates to complex sites.

**Objectives**

The objectives of the proposed SWM Design Standards and Requirements are to:

1. Minimize the risk of threat to life, health of the public, and property damage as it relates to surface flooding and overland flows**;**
2. Ensure compliance with all applicable municipal requirements and provincial/federal legislation;
3. Protect watercourses against erosion, degradation, and sediment loading;
4. Design and construct stormwater management facilities that are sustainable to operate and maintain, integrate within the urban community, and support ecosystems and watershed requirements;
5. Protect the natural water balance, particularly in areas that influence the health of the Natural Heritage System; and,
6. Promote and support innovation in stormwater management practices.

# 6.1 Design References

## 6.1.1 Applicable Acts

**Provincial**

Clean Water Act (2006)

Conservation Authorities Act (1990)

Drainage Act (1990)

Environmental Bill of Rights (1993)

Municipal Act (2001)

Ontario Water Resources Act (1990)

Ontario Endangered Species Act (2007)

Ontario Environmental Protection Act (1990)

Ontario Provincial Policy Statement

Environmental Assessment Act (1990)

**Federal**

Species at Risk Act (2002)

Fisheries Act (1985)

Canadian Environmental Assessment Act (1999)

## 6.1.2 Applicable City of London By-laws and Official Plan

Wastewater & Stormwater By-law - WM-28

Drainage By-law - WM-4

Basement Flooding Grant Program - A.-7562-160

Industrial Oversizing Reserve Fund By-law - A.-5840-172

Development Charges By-law - C.P.-1551-227

Official Plan

## 6.1.3 General Stormwater Design References

Stormwater Management Practices Planning and Design Manual (MOE, 2003)
Ministry of the Environment, 2003

Ministry of Transportation, Drainage and Hydrology Section, Quality and Standards Branch, 1995

Low Impact Development Stormwater Management Planning and Design Guide
Sustainable Technologies Evaluation Program, Living Website

Low Impact Development Stormwater Planning and Design Guide
Credit Valley Conservation and Toronto Region Conservation, 2011

Hydrogeological Assessment Submissions, Conservation Authority Guidelines to Support Development Applications

Conservation Authorities Geoscience Group, June 2013

Wetland Water Balance Monitoring Protocol

Toronto and Region Conservation Authority, 2016

Water Management, Policies, Guidelines, Provincial Water Quality Objectives (PWQO's)

Ministry of Environment, Conservation and Parks, 1994

Land Development Guidelines for the Protection of Aquatic Habitats

Department of Fisheries and Oceans, Ministry of Environment, Lands and Parks, 1992

Thornthwaite, C.W.; Mather, J.R. 1957. Instructions and tables for computing potential evapotranspiration and the water balance. Publication in Climatology 10: 185-311.

Environmental Planning Policy Manual for the Upper Thames River Conservation Authority

Upper Thames River Conservation Authority, 2017

Hydrogeological Assessment Submissions, Conservation Authority Guidelines to Support Development Applications, June 2013.

Lake Simcoe Region Conservation Authority, 2013

### 6.1.4 City of London Background Information

The City of London has and continues to complete subwatershed studies, Municipal Class Environmental Assessments, and Functional Designs for SWM facilities across the City. These studies provide subwatershed-wide or area-specific design criteria or may assist to inform the stormwater management strategy for your site. All consultants must review the applicable studies to verify if there are any watershed or area specific design criteria applicable to the site.

These reports are posted on the City of London's webpage.

All engineering drawings, GIS files, and topographic/LIDAR information are available to engineering consultants via a request to the Geomatics Division using the following link: Open Data – Dataset Request Form.

### 6.1.5 City of London SWM Checklists

The City of London has developed checklists to itemize the general requirements for stormwater management designs as follows:

- Checklist 1 Subdivision Application, Stormwater Engineering Checklist
- Checklist 2 Site Plan Application, Stormwater Engineering Checklist
- Checklist 3 Low Impact Development Design Checklist
- Checklist 4 Hydrogeology Assessment Checklist
- Checklist 5 Site Alteration Application, Stormwater Engineering Checklist

  The City of London requires that Stormwater Management checklists be signed and submitted with the initial applications the checklist refers to, Please refer to Section 6.12 for copies of these checklists.

### 6.1.6 Agency Approvals

In accordance with Section 53 of the Ontario Water Resources Act, stormwater management works are considered Sewage Works that may require an Environmental Compliance Approval (ECA). The following guidance is available from the province:

- Guide to applying for an environmental compliance approval
- O. Reg 525/98: Approval Exemptions and as amended by O. Reg. 214/22: Approval Exemptions

**Note:** For municipal infrastructure, a Consolidated Linear Infrastructure ECA (CLI ECA) shall be processed in accordance with current MECP design guidelines. CLI ECA replaces the numerous ECAs that were issued for components of a municipal stormwater management system. The following guidance is available from the province:

- Municipal Consolidated Linear Infrastructure Environmental Compliance Approvals | ontario.ca (https://www.ontario.ca/page/municipal-consolidated-linear-infrastructure-environmental-compliance-approvals)

The province has granted the City of London an expanded Transfer of Review Program for stormwater Sewage Works. Please contact the Stormwater Engineering Division to determine if your project qualifies under this program.

Please note that a Section 28 permit from the applicable Conservation Authority (CA) is required as part of the ECA application and is also often required for stormwater works within or in proximity to lands regulated by the CA. See Section 28 of the Conservation Authorities Act for details. When in doubt, please contact the applicable CA to confirm.

Other approvals may apply. The onus is on the consulting engineer to confirm all necessary approvals.

## 6.2 Surface Water Considerations

The purpose of this section is to communicate the City of London's expectations related to the water quality, and quantity control targets. This section introduces a runoff control hierarchy to satisfy water quality, erosion, quantity and water balance requirements.

### 6.2.1 Water Quality Control Objectives

One of the main purposes of stormwater management is to reduce the impact of development and urbanization on our natural watercourses. Stormwater management water quality objectives and targets are intended to protect aquatic habitat in the downstream receiver.

In London, specific water quality control targets may be specified by subwatershed studies or be required to protect and enhance a sensitive feature identified through a natural heritage review of the study area (e.g., Environmental Impact Study (EIS)). Typically, all discharge to the Thames River and major tributaries will be required to meet a Normal (70% TSS removal) water quality standard. Some studies such as, but not limited to the Medway, Stanton and Mud Creeks Subwatershed Study and the Pottersburg and Crumlin Subwatershed Study specify an Enhanced (80% TSS) water quality standard in some areas.

These studies may identify the protection of wildlife habitat, Species at Risk, wetland/woodland features, a cold or cool water fishery, or other sensitive features that will need to be considered through the development of stormwater control measures

and requirements as agreed upon by appropriate City staff (i.e., Stormwater Engineer, Ecologist, Hydrogeologist, etc.), all the satisfaction of the City Engineer.

#### 6.2.1.1 Water Quality Targets

The City of London requires engineered stormwater management systems to satisfy water quality requirements for peak flows and volumes up to the 25 mm storm event.

A 25mm volume capture target represents the first flush runoff event and generally 90% of storm events in Ontario. The water quality event is also identified by the province to be a 25mm, 4-hour event in accordance with Section 4.6 of the 2003 MOE manual.

Development applications within a site plan or subdivision process, are encouraged to capture the first 25mm of any rain event on site within a stormwater management system to satisfy water quality and water balance criteria.

Implementing infiltration or filtration measures for a volume representing the 25mm event will be accepted to meet Total Suspended Solids (TSS) reduction target requirements. It should be noted that infiltration systems often require a water quality pre-treatment system to reduce sediment loading and prolong maintenance intervals.

For site developments where OGS are used, the OGS must be sized to capture and treat a minimum 90% volume of the annual runoff on a long-term average basis. The OGS water quality target is the long-term average removal of the Total Suspended Solids (TSS) reduction target on an annual loading basis from all runoff leaving the proposed development site based on the post-development level of imperviousness.

The minimum Total Suspended Solids (TSS) reduction target requirements are outlined in Table 6.1 below.

**Table 6.1 Subwatershed Minimum Water Quality**

| Subwatershed | Minimum Quality Control Requirements |
|---|---|
| Central Thames | Normal (70% TSS removal). Refer to **section 6.9**, Case 4 |
| Dingman Creek | Enhanced (80% TSS removal) * |
| Downstream Thames | Normal (70% TSS removal) ** |
| Fanshawe Reservoir | Normal (70% TSS removal) ** |
| Masonville Creek | Normal (70% TSS removal) ** |
| Medway Creek, Stanton Drain and Mud Creek | Enhanced (80% TSS removal) * |
| Oxbow Creek | Normal (70% TSS removal) ** |
| Pottersburg Creek and Crumlin Drain | Enhanced (80% TSS removal) * |

| Subwatershed | Minimum Quality Control Requirements |
|---|---|
| Sharon Creek | Normal (70% TSS removal) ** |
| South Thames | Normal (70% TSS removal) ** |
| Stoney Creek | Enhanced (80% TSS removal) * |
| The Coves | Normal (70% TSS removal) ** |
| Upper Kettle Creek and Dodd Creek | Normal (70% TSS removal) ** |
| Waubuno Creek | If tributary to the Crumlin Drain, Enhanced (80% TSS removal)*; Otherwise, Normal (70% TSS removal)** |
| Wye creek | Normal (70% TSS removal) ** |

Notes:

* Quality control requirement identified in the applicable Municipal Class EA or Subwatershed Study

** Minimum water quality control objectives as per **section 6.2.1**.

### 6.2.1.2 Stormwater Management Control Hierarchy

To meet current water balance and water quality requirements, source controls should be included as a part of the overall stormwater management strategy to complement traditional solutions or to stand alone as a complete lot level solution.

When initiating a stormwater management design, consultants are recommended to first evaluate the types of SWM infrastructure systems to be designed within the following hierarchy:

- **Priority 1 (Infiltration – Retention by native soils):** infiltration to the extent possible, evapotranspiration, re-use to recharge shallow or deep groundwater, reuse collected rainwater for internal or external uses; generally applicable in highly favorable soil conditions without high groundwater.

  General outcomes: *no discharge to the municipal storm sewer system; can partially or fully satisfy water quality and water balance requirements.*

- **Priority 2 (Filtration - Volume Capture and Release):** LID filtration technologies filter runoff and typically include a subdrain connected to the storm sewer or conveyance system; generally applicable to tighter soils.

  General Outcomes: *peak shaving/controlled discharge to the municipal conveyance system; can partially or fully satisfy water quality and water balance requirements.*

- **Priority 3 (Other Volume Detention and Release):** filtration, hydrodynamic separation (i.e. end-of-pipe facilities, oil grit separators) to detain and/or treat runoff; generally applicable to tight soils, high groundwater table or contaminated sites.

  General outcomes: *attenuated discharge to the receiving watercourse or storm sewer; these systems can satisfy water quality requirements but do not benefit the water balance.*

  **Note:**

  - Water quality requirements may be satisfied through implementing a combination of Priority 1, 2, or 3 stormwater management systems to manage the first 25mm of stormwater volume.
  - However, water balance mitigation can only be achieved through design and implementation of Priority 1 or Priority 2 stormwater management systems. Therefore, the City strongly encourages the implementation of Priority 1 or 2 systems to satisfy both water quality and water balance criteria.

#### 6.2.1.3 Clarification: Where to apply Water Quality Targets

Providing Water Quality Control applies to both new and applicable redevelopment or retrofit projects as follows:

a. For site plan applications,
   i. Water quality control shall be provided to all new and redeveloping industrial, commercial, institutional and medium/high density residential developments where the number of new or pre-existing at-grade parking spaces is 30 or greater.
   ii. If less than 30 at grade parking spaces, see **section 6.9** policy regarding water quality control requirements of Permanent Private Systems and municipal stormwater systems in Site Plan servicing.
b. For single family residential subdivisions,
   i. Water quality control shall be provided through municipal stormwater management systems.
   ii. The consultant should confirm if a Master Plan or Municipal Class Environmental Assessment has (1) been completed for the drainage area of the subdivision and (2) identifies an associated SWM facility.

iii. New SWM Facilities are constructed in accordance with the City's "Just in Time" servicing policy. See **section 6.10**.

c. Municipal Road Reconstruction Projects

i. Best efforts should be made to retrofit water quality controls for Rapid Transit Boulevard, Main Street, Urban Thoroughfare, or Civic Boulevard roads during reconstruction projects. Water quality control shall be provided for any additional impervious surface area (e.g., road widening projects).

ii. Water quality controls should be retrofitted on neighbourhood streets where feasible and practical.

As part of a complete development application, consultants should identify the type of systems being recommended as Priority 1, 2, or 3 systems and provide a brief rationale regarding the type of SWM that is being recommended. The rationale should identify any constraints that would prohibit the implementation of Priority 1 or 2 systems including but not limited to:

- High groundwater table (a separation of less than 1.0 m may be acceptable upon review of site conditions);
- Site is located in a high salt loading area (i.e., expressways, urban thoroughfares, civic boulevards, bus routes, some neighbourhood collectors or receives snow storage melt) **and** the seasonal high groundwater elevation poses a concern;
- Conflicts with existing utilities or infrastructure; or,
- Contaminated soils.

**Note:** See **section 6.5** for details. In some cases, it may be possible to mitigate these constraints through implementing a liner or subdrain within the system.

### 6.2.1.4 Additional Water Quality Considerations

a. Phosphorus

The City of London is committed to the Lake Erie Action Plan aiming to reduce phosphorus loadings to Lake Erie by 40% before 2025 and a 20% phosphorus loading reduction by 2020. Stormwater systems, including but not limited to, at source controls, are recommended to be considered and included in the planning and design of stormwater management systems for their role in trapping, storing and processing phosphorus.

b. Groundwater protection

   Stormwater activities with the potential to adversely affect groundwater may require provincial approval. Infiltration based stormwater features shall not be used to infiltrate runoff from high risk site activity area or within a contaminated site. For runoff from areas with high chloride loading, consideration for the potential salt loading to the downstream receiver should be considered to mitigate degradation of both surface water and groundwater quality.

c. Provincial Water Quality Objectives

   Provincial water Quality Objectives (PWQOs) and the interim PWQOs can be used as general background conditions of water quality parameters for surface water system in the absence of sampling or any known issues. Overall, the stormwater control objective is maintain or enhance existing surface water quality conditions.

### 6.2.2 Erosion Control Objectives

In cases where the stormwater management facility outlets to a storm sewer or ditch, a general erosion control storage of 40m$^3$/ha may be applied (MOE, 2003).

In cases where the stormwater management facility outlets to an open watercourse, specific erosion control requirements are to be used. This information may be found within a related to Subwatershed Study or Municipal Class Environmental Assessment.

Where erosion control target information is not available, the consulting engineer shall complete a site specific fluvial geomorphological study to determine the erosion threshold velocity and associated erosion control volume. Continuous simulation modelling may be required as part of this study to demonstrate that there is no net increase in erosive hours within the watercourse. The size of the contributing area of the site relative to the receiver's overall catchment area and the sensitivity of the downstream receiver may be considered to determine erosion control requirements.

In all cases, alteration or updates to the erosion control volume requirements may be considered where a consultant has done a site specific fluvial geomorphological assessment.

Erosion control storage (40m$^3$/ha) is only typically applied to regional wet ponds with long extended detention drawdown for larger developments and is not to be used on smaller site development projects unless specified as a requirement by the City Engineer.

## 6.2.3 Minor and Major Systems

The City of London design standards require that storm sewers are designed to convey, at a minimum, up to the 5-year storm event, using City of London standards per Section 5. The “Minor System” incorporates storm sewer pipes, catchbasins, roadway gutters and swales, and private storm drain connections for all land uses. The minor stormwater system is designed and constructed to convey the minor flows to prevent frequent flooding in our municipal right of ways, parks, and developed parcels.

Stormwater runoff in excess of the “Minor System” capacity is referred to as the “Major System”. During higher intensity storm events, major system flow surcharges the minor system capacity, resulting in overland flows. The major system generally includes infrastructure designed to safely convey a major storm event via road allowances, easements, spillways, ditches, swales and channels.

The major storm event may be defined as:

• Check event (100-year event for the City of London, factored by 1.3); or

• Regulatory event (250-year event for UTRCA and LTRCA, Hurricane Hazel for KCCA)

**Implementation:**

Infrastructure design to accommodate the major system event shall consider the flow rate generated by the 100-year IDF curve, factored by 1.3.

The Regulatory event flow rate will generally be used to determine flood hazard limits within natural hazards land.

### 6.2.3.1 Stormwater Management Major Storm Design

For new developments, stormwater designs are required to safely convey the 100-year event including a factor of 1.3 for climate change adaptation via overland flow routes. A “major system” area plan and supporting calculations must be submitted as part of the design package during the development approvals process to demonstrate safe conveyance of the major system, identify ponding depths below the maximum as per City of London Grading Standards, and provide erosion protection for the major storm event. For grading requirements of overland flow routes please refer to section 9.4.1.

For all municipal road or renewal projects, a “major system” catchment area plan (including external lands) shall be submitted to the City as part of the Engineering Drawing package and as part of the as-built drawing package to the Geomatics Division. A major system area plan can be incorporated with the grading plan if it includes external areas in addition to ponding limits and overland flow routes.

### 6.2.3.2 Clarification: Where to Apply Water Quantity Targets

Providing Water Quantity Control applies to both new and applicable redevelopment or retrofit projects as follows:

a. For site plan applications,
    i. Where no overland flow route is established, the owner is required to ensure that stormwater flows are self-contained on site, up to the major storm event.
    ii. See **section 6.9** policy regarding the roles of Permanent Private Systems and municipal stormwater systems in Site Plan servicing.

## 6.3 Groundwater Considerations

The purpose of this section is to communicate the City of London's expectations related to the level of detail provided in hydrogeological assessments, and promote consistency of the resulting technical studies.

Where required, a hydrogeological assessment is required to demonstrate:

- Responsible development and infrastructure improvements can proceed without adversely impacting the quantity or quality of existing groundwater and surface water resources, or the ecological community; and,
- The on-site and off-site (i.e., adjacent or downstream) groundwater quality and quantity and its users/receptors will not be adversely affected.

The level of detail to be included in the hydrogeological assessment will depend on the nature of the project, stage in the design process and general location of the site relative to downstream sensitive receivers.

It should be noted that designs that include a subsurface infiltration component, including Low Impact Development (LID) measures or sites that have the potential to impact sensitive receivers, may require long-term groundwater monitoring (i.e. pre and post construction) to adequately establish or monitor seasonal groundwater fluctuations and/or evaluate potential impacts related to developments. This should be considered in the early stages of the planning and design process to ensure the seasonal groundwater fluctuations are captured and used to influence/confirm the proposed design.

### 6.3.1 Hydrogeological Assessment Requirements

Hydrogeological studies will vary in scope, level of detail, and methodologies depending upon project scale, project location, design constraints, design function, and the study objectives. The overall purpose of the hydrogeological assessment is to evaluate if the proposed development has the potential risk to result in negative short-term or long term impacts to the on-site and off-site (adjacent or downstream) groundwater system(s).

Depending on the actual location of the site and its proximity to potential groundwater receptors, additional information may be required to fully assess the impacts of the development on the natural environment**. It is required, that prior to the commencement of a hydrogeological assessment study, the proponent and their consultant undertake pre-consultation with City of London staff to confirm the scope of the required technical study.**

Overall, hydrogeological assessments should generally conform to the requirements listed in the following document:

"*Hydrogeological Assessment Submissions, Conservation Authority Guidelines to Support Development Applications, June, 2013.*"

As listed in the Conservation Authority Guidelines (2013), a hydrogeological assessment should include, at minimum:

- Evaluation of existing conditions, prior to the proposed development;
- Evaluation of potential impact of the proposed development on the natural system and assessment; and,
- Evaluation of monitoring and/or mitigation measures to reduce the risk of negative short-term or long term impacts to the quality or quantity of the groundwater system.

The City reserves the right to request additional investigation(s) and/or data collection above that listed above, based on criteria and site location that include, but are not limited to, the following:

- Areas of significant groundwater recharge;
- Areas either in proximity to, or within, a wellhead protection area or domestic wells;
- Areas deemed vulnerable with respect to groundwater, surface water, or nearby natural features (e.g. wetlands, woodlands);
- Areas with existing groundwater contamination issues; and,
- Any other conditions deemed relevant by the City.

- Areas with shallow and/or high seasonal groundwater table.

As it relates to development applications, **Checklist 4 Hydrogeology Assessment Checklist** should be included as part of a hydrogeological assessment report.

### 6.3.2 Water Balance Requirements

A water balance analysis is required for all developments proposing changes to the site's impervious cover or drainage conditions to identify and mitigate impacts to surface runoff and groundwater infiltration conditions as part of the development application process or detailed design process.

Water balance monitoring and assessment requirements will be determined as part of the Hydrogeological Assessment pre-consultation with City of London staff.

The final detailed water balance assessment should be submitted as a standalone document, complete with all proposed mitigation measures. The final water balance assessment should also clearly demonstrate mitigation and design linkages with complimentary studies such as the hydrogeological assessment, the functional stormwater management report, and Environmental Impact Study (EIS).

A development proposing compensation for water balance in future phase blocks shall be designed at the first phase of development at the draft plan approval or focus design study stage.

The maintenance of pre-development infiltration conditions is a general requirement as groundwater frequently supports significant watershed features that are necessary components to the maintenance of a healthy watershed such as wetlands, woodlands, or watercourses. The level of detail required in the water balance may vary depending on the site, proposed works, and nearby natural heritage features and/or receivers that may be within, or adjacent to the proposed development boundaries.

A water balance assessment would be expected to consider, at minimum, estimates of water surplus and/or deficit using the Thornthwaite and Mather approach (Thornthwaite and Mather, 1957). Depending on the complexity of the site and its proximity to nearby natural heritage features, alternate approaches can be considered, including modeling to assess short-term (event scale) and long-term (annual scale) water balance objectives.

The TRCA's Stormwater Management Criteria (TRCA, 2012) provides guidance to the overall water balance assessment process and approach. For sites where a simple model would meet the water balance objectives (i.e., no sensitive downstream receiver, no groundwater recharge or baseflow maintenance requirements), analysis utilizing Hydrologic Cycle Component Values included in Table 3.1 of the Stormwater Management Planning and Design Manual (MOE, 2003) may be suitable. It should be noted that the provincial Stormwater Manual (MOE, 2003) offers example estimates only and where possible, local estimates of evapotranspiration and water surplus are to

be provided using the Thornthwaite and Mather approach and data obtained from a local climatic station.

For cases where proposed development or infrastructure has the potential to impact water balance of a wetland, a wetland water balance risk assessment should be completed following the process outlined in Toronto and Region Conservation Authority's Wetland Water Balance Risk Evaluation (TRCA, November 2017), early in the planning process.

If required, a feature-based water balance should be completed to evaluate impacts by establishing the pre-development hydroperiod of the applicable feature(s) and comparing post-development hydroperiods, with and without mitigation. To achieve this, evaluation of suitable hydrologic models (e.g., EPA-SWMM, PC-SWMM, MIKE-SHE, HEC-HMS, Qualhymo, PRMS-GS, etc.) may be required.

## 6.4 Design Requirements

SWM Facility requirements are to generally conform to the design criteria in this manual, all to the satisfaction of the City Engineer. This section discusses potential systems to meet current SWM criteria.

### 6.4.1 Catchment Delineation

A catchment area is the delineation of all surface points draining toward one specific outlet that is topographically located at the lowest elevation within the area. Catchment delineation areas shall be provided for both minor (up to 5-year storm events) and major system (up to major storm event). These drainage areas shall be shown and identified in the stormwater management functional report or servicing brief and engineering drawings for the project.

For projects incorporating LID solutions, catchment areas associated with the LID feature shall be provided in addition to the minor catchment areas for the storm sewer and/or catchment areas for major storm events.

Once a project design is accepted by the City Engineer, the final storm catchment areas are to be included in the final as-built drawing package.

### 6.4.2 Overland Flow Routes

Major flows must be safely conveyed via a defined Overland Flow Route (OLFR) to an appropriate outlet without causing damage to private property or municipal infrastructure, and with minimum risk to the public.

OLFRs must identify any potential barriers to the safe conveyance of stormwater. Any roadways with traffic calming measures such as raised intersections, speed bumps, or raised pedestrian crossings shall provide the following items to demonstrate that the

traffic calming measure(s) will not negatively impact the OLFR conveyance and surrounding municipal and private infrastructure:

a. R.O.W. flow conveyance calculations/details through the traffic calming measure(s);

b. Ponding limits and associated depths for the major storm events demonstrating conformance to the City's Grading Standards;

c. Delineation of overland flow catchment area(s);

d. Inclusion of additional inlets (e.g. curb inlet catchbasin, linear catchbasin, etc.) to allow for increased inflow capacity upstream of the traffic calming measure(s) and to reduce the ponding duration on the R.O.W.;

e. Items b) and c) shall be shown on the applicable lot grading drawings or on a separate drawing for clarity.

Only under extenuating circumstances will OLFRs be routed through private property and in these extenuating circumstances, a dedicated municipal easement will be required to the satisfaction of the City Engineer and will not be used as a precedent for other developments.

#### 6.4.2.1 Oversized Storm Sewers

Only where there are circumstances that create considerable constraints/barriers to safely convey surface flows for the major event via a defined Overland Flow Route, increasing design storm capacity of the storm sewers for conveyance of the major storm may be warranted on a case-by-case basis. The strategy shall be reviewed and approved by SWED staff, and include the following:

1. **Review sewer and PDCs connections** that may be impacted by the increased capacity storm sewer:
    a. Submit hydraulic grade line calculations to review surcharging conditions and impacts to sewer and PDC connections.
    b. Where surcharging impacts are noted, include protection measures (e.g., backflow prevention) to protect the development(s) against surcharging.
    c. Report finding in associated SWM report or design brief.
2. **Servicing drawings**: clearly identify pipe lengths with increased design storm capacity, the design event, and upstream catchment characteristics (area, runoff coefficient).
3. **Design Sheets**: include shading/hatching special characters and notes to clearly denote lengths with increased sewer capacity and capacity details.
4. **Area Plans**: include both Major & Minor drainage plans.

5. **Plan and Profile**: include a box note to refer to design sheet for oversized pipes.
6. **Grading Plans**: clearly note any inlet / outlet structures associated with the oversized pipes and refer to the report and design sheet.

#### 6.4.2.2 Hydraulic Capacity of the Municipal ROW

**Composite Manning's Roughness Coefficient**

When evaluating the hydraulic capacity of the Municipal ROW to convey major flows, a composite Manning's roughness coefficient ($n_c$) shall be used. Refer to equation 8.68 in the MTO Drainage Management Manual for more information.

### 6.4.3 Hydrologic Modeling

SWMHYMO and Visual OTTHYMO are the preferred hydrologic models to be used within the City of London. The City also has a license for PCSWMM. Most industry standard models will be considered, and the City is available for consultation if confirmation is required. For smaller sites, Rational Method or Modified Rational Method may be appropriate.

Consultants may make use of available water resources management manuals and texts as a reference to aid in the selection of hydrologic modeling parameters. Any externally referenced material employed in parameter selection should be properly referenced in the SWM Report and included in the document appendices.

A Professional Water Resources Engineer (Subdivider's Consulting Engineer) is responsible for recommending all SWM modeling parameters to ensure the application of adequate engineering knowledge is applied. At the same time, the City is required to review the proposed SWM systems and selection of the SWM modeling parameters/criteria to ensure compliance with City and Provincial standards, requirements and practices, and also ensure the adequate protection of the people and properties of the City of London.

#### 6.4.3.1 Imperviousness

Current City of London practices for determining site runoff for Conceptual and/or Preliminary SWM plans use the values for Total Impervious Percentage (TIMP) and Directly Connected Impervious Percentage (XIMP).

TIMP represents the ratio of area covered by an impervious surface (e.g. asphalt, concrete) to the entire area. XIMP represents the ratio of impervious areas directly connected to the conveyance system. An example of a directly connected impervious area would be a parking lot, a portion of roof areas, driveways, or roads that contain catchbasins draining to the storm sewer. An example of a non-directly connected impervious area is an outdoor basketball court surrounded by park land or roof area draining to a rear yard.

The table below lists current City of London preferred TIMP and XIMP values based on land use. These allowable ranges for TIMP and XIMP should be applied at the conceptual/preliminary design stage to ensure sufficient land is allocated for the proposed facility. Adjustment of Impervious Percentage values at the functional/detailed design stage will be considered subject to the consulting engineer providing engineering calculations to justify the revision of these parameters.

**Table 6.2 City of London TIMP and XIMP Values**

| Land Use | TIMP | XIMP |
|---|---|---|
| Residential | 55%<br>51% - 60% | 45%<br>43% - 48% |
| Medium and High Density Residential | 70%<br>65% - 75% | 55%<br>45% - 55% |
| Commercial/Industrial | 75% - 90% | 70% - 80% |

i. At the Master Plan level, TIMP and XIMP should be assigned the MAXIMUM (not average) imperviousness allowed by the City.

ii. At the detail design level, TIMP and XIMP can be assigned the “actual” imperviousness.

### 6.4.3.2 Methodology for Losses

Losses for the purposes of this section, refer to Initial Abstraction, infiltration, and surface depression storage. The majority of water resources submissions received by the City of London apply the SCS Method, fewer submissions apply the Horton Method and there have been no submission to date that applies the Green-Ampt Method of quantifying runoff. SCS Method, Horton, or Green-Ampt methods are all acceptable modeling techniques.

The LDI recommendation of applying the Horton Method is practiced by the City of London.

### 6.4.3.3 Initial Abstraction

Initial abstraction (Ia) represents the interception, infiltration, and surface depression storage of rainfall at the beginning of storm events. Current City of London modeling practices recommend the Ia values summarized below:

**Table 6.3 Typical Initial Abstraction Values**

| Land Cover | Typical Values (mm) |
|---|---|
| Impervious | 2 |
| Pervious – lawns | 5 |
| Pervious – meadows | 8 |
| Pervious - woods | 10 |

Deviation from the above values may be approved at the discretion of the City Engineer. The onus will be on the consultant to provide sufficient rationale to support the alternate value(s), noting that the values in **Table 6.3** are irrefutable and the City retains the right to refuse alternate values.

### 6.4.3.4 Curve Number

The curve number (CN) is a parameter used to determine the extent of rainfall that infiltrates, rather than becoming surface runoff. CN values must be consistent with provincial guidelines and standard water resources management practices and correspond with the specific geotechnical conditions of proposed developments.

If using a HYMO based model, selection of CN should be correlated with the applied Initial Abstraction (Ia). OTTHYMO model recommends the use of CN*. The CN* procedures account for recalculating CN when an initial abstraction of less than 0.2*S is used. OTTHYMO does not recommend the use of 0.2*S as initial abstraction, requiring the use of CN*.

The N parameter in the SWMHYMO model representing the number of linear reservoirs used for the derivation of the Nash unit hydrograph must be 3.

### 6.4.3.5 Design Storm Selection

In the design of site plans or subdivisions, the consulting engineer is required to evaluate the study area (i.e. total area, urban vs. rural) and recommend “critical storms” that generate the highest peak flow or the greatest volume.

The storm duration should be selected dependent on the size of catchment and attenuation within the catchment. For smaller, urbanized catchments a shorter duration event (i.e. 3, 4, or 6 hour events) may be a reasonable duration. For larger, rural catchments a 12 or 24 hour event should be considered. Subwatershed studies should be reviewed for specified preferred watershed based design storms.

The most common design storms distributions include the Chicago, Atmospheric Environmental Service (AES), and SCS Type II distributions. The 3 and 6-hour Chicago event distributions are widely accepted as a synthetic distribution to be used in the design of urban areas and the 24-hour SCS event is widely accepted as a synthetic distribution to be used in rural catchments.

Rainfall intensity duration frequency (IDF) storm parameters for the City of London are based on the Environment and Climate Change Canada February 2019 IDF update,. The table below includes a synthetic 25-mm event for application of the 4-hour water quality event (MOE, 2003).

**Rainfall Intensity**

$$I = \frac{A}{(t+B)^C}$$

Where I = rainfall intensity (mm/hr)
t = duration (minutes)
A, B, C = AES Parameters (see **Table 6.4**)

**Table 6.4 AES Parameters for Intensity Duration Frequency Curves**

| Parameter | 25mm[1] | 2yr[2] | 5yr[3] | 10yr | 25yr | 50yr | 100yr |
|---|---|---|---|---|---|---|---|
| **A** | 538.85 | 754.36 | 1183.74 | 1574.382 | 2019.372 | 2270.665 | 2619.363 |
| **B** | 6.331 | 6.011 | 7.641 | 9.025 | 9.824 | 9.984 | 10.5 |
| **C** | 0.809 | 0.810 | 0.838 | 0.860 | 0.875 | 0.876 | 0.884 |

1. IDF parameters for the 25mm event must use a four-hour storm duration.
2. 2-year IDF curve to be used in pre to post development controls and stormwater management facility design.
3. 5-year IDF curve to be used for storm sewer design (see **section 5.8**).

**Note:**
UTRCA regulatory 250-year storm AED Parameter: A=3048.22, B=10.03, C=0.888

# 6.5 Stormwater Practices

This sections aims to guide the planning and design of stormwater quality and quantity controls that include Low Impact Development (LID) or source control concepts as well as traditional stormwater control measures.

Each site or project will present unique options and challenges. The City encourages innovation as part of any stormwater project.

## 6.5.1 Best Management Practice Design

During the initial phases of design, consideration for runoff reduction and onsite infiltration should be paramount. The City will accept Best Management Practices (BMPs) that are designed by a Professional Engineer and demonstrate at-source runoff control. These systems may be eligible towards achieving water balance, quality, quantity or erosion control for the project. These stormwater best management objectives can be achieved by:

- **Decreasing Impervious Areas:** The Stormwater Engineering Division strongly supports reductions in impervious area as part of the runoff reduction strategy. This can be presented by demonstrating a decrease in the standard TIMP or XIMP values.
- **Intercepting Runoff:** Runoff from hard surfaces should be conveyed to landscape gardens or grassed area to promote onsite filtration and infiltration, and reduce the volume of water collected by the City storm sewer.
- **Increased Top Soil Depth:** Will not formally meet stormwater management criteria but, to a reasonable extent, may be considered to mitigate water balance deficits.
- **Reduced Lot Grading:** will not formally meet stormwater management criteria but are important factors to better site design, peak flow reduction and are worthwhile to include as part of any SWM strategy.

### 6.5.2 Low Impact Development (LID)

To provide a short-list of LID types to be planned and designed for land-use types (i.e. Municipal Right-of-Way (ROW), Single Family Residential, and Multifamily, Commercial, and Institutional Sites), the City reviewed LID measures using the following criteria:

- Effectiveness in meeting the 25mm volume capture;
- Ease of construction and integration into current construction practices;
- Cost; and,
- The City's ability to conduct long-term operations and maintenance.

The following outlines a short-list of LID design accepted in the City of London:

1. Infiltration Storm sewer: Consisting of a perforated stormwater exfiltration pipe laid in a granular bedding. This system may be constructed as part of the storm sewer system or as a perimeter French drain in the boulevard. Third pipe systems are designed for both conveyance and infiltration of stormwater runoff. Twin Perforated Pipe Infiltration System example is provided in Figure 6.1.

2. Third Pipe System, Foundation Drain: Storm sewer designed to collect and convey flows from foundation and/or groundwater to receiving surface water.
3. Third Pipe System, Clean Water Collector: Storm sewer designed to collect and convey 'clean' flows from foundations, groundwater, rooftops and/or rear yard catch basins to receiving surface water.
4. Bioretention Systems: i.e. Infiltration Swales, Dry Swales, Raingarden refers to grassed or vegetated stormwater practices that temporarily store runoff in depressed beds. These may include underdrain and overflow structures and pre-treatment devices (sump, rip rap). An example of an approved swale bioswale adjacent to a pathway is provided in Section 6.2.
5. Infiltration Galleries: are underground, linear, rectangular or trapezoidal excavations with level or gently sloping bottom grade, could have geotextile filter fabric on sidewalls and top and filled with clean, crushed angular stone or other void-forming structures. Typically have an underdrain connected to a catchbasin.
6. Soil Cell: are linear tree planting structures that feature supported impermeable or permeable pavements that promote healthy tree growth while also helping to manage runoff. They are often located behind the curb within the road right-of-way and consist of subsurface trenches filled with modular structures and growing medium, or structurally engineered soil medium, supporting an overlying sidewalk pavement. They improve tree health by providing access to soil, air and stormwater for irrigation, allowing them to survive longer in harsh urban conditions.
7. Infiltration chambers: include a range of proprietary manufactured, modular structures embedded in clean, crushed angular stone that are installed underground, typically under parking or landscaped areas that create large void spaces for temporary storage of stormwater, allowing it to infiltrate into the underlying native soil. They may be designed to provide sufficient load bearing capacity to allow construction of structures on top of them. They can be installed individually or in series, in trench or bed configurations. Due to the large volume of underground void space they create, and the modular nature of their design, they are well suited to sites where available space for other types of BMPs is limited, or where it is desirable for the facility to have little or no surface footprint.

The following identifies appropriate LID stormwater control measures based on land use type:

**a. Single Family Residential**

Within single family subdivisions, LID features are to be located within the municipal ROW or dedicated municipal easement, where they can be accessed and maintained.

The 2019 Development Charges (DC) One Water Background Study identifies a subsidy for LIDs constructed as part of single family residential subdivisions. Please refer to the DC by-law for details.

**b. Multifamily, Commercial, and Institutional Sites**

Bioretention, bioswales, rain gardens, green roofs, permeable pavers, or any other LID features are encouraged for Site Plans where private landscapers and maintenance personnel will be employed on regular contracts.

Multifamily, commercial and institutional sites are likely to provide a large number of parking spots in the form of a parking lot. Parking lots are large areas of impervious surface. The Site Plan Control By-law C.P.–1455-541 dictates *"One "planter" (island) should be provided for every 50 parking spaces"*. It is recommended that these planters be used as small scale LID units to capture and treat a portion of the parking lot runoff through filtration and infiltration.

LID features installed on private property are required to meet the following conditions:

1) LIDs shall have a minimum of 4 m setback from all building foundations;
2) LIDs that discharge towards neighbouring private property shall demonstrate no adverse impact to the adjacent landowner; and,
3) Areas with demonstrated high groundwater tables shall require in-situ infiltration testing prior to the installation of the LID at the discretion of the City.

### 6.5.2.1 Stormwater Charge Reductions with LID

As an incentive for private site implementation, Section 3.4.2 of the City's Wastewater By-law identifies the opportunity for up to a 50% reduction to the monthly Stormwater Charge for sites greater than 0.4 hectares in size. This reduction is available to sites that implement at-source LIDs or demonstrate reduced impervious areas.

To be eligible to participate in the program the water customer must meet all the following criteria (full program details is listed below):

- High Density Residential, Industrial, Commercial, or Institutional property;
- Property area is greater than 0.40 hectares; and,

- Account is not exempt from Stormwater charges.

There are two avenues for a reduction in stormwater billing charges:

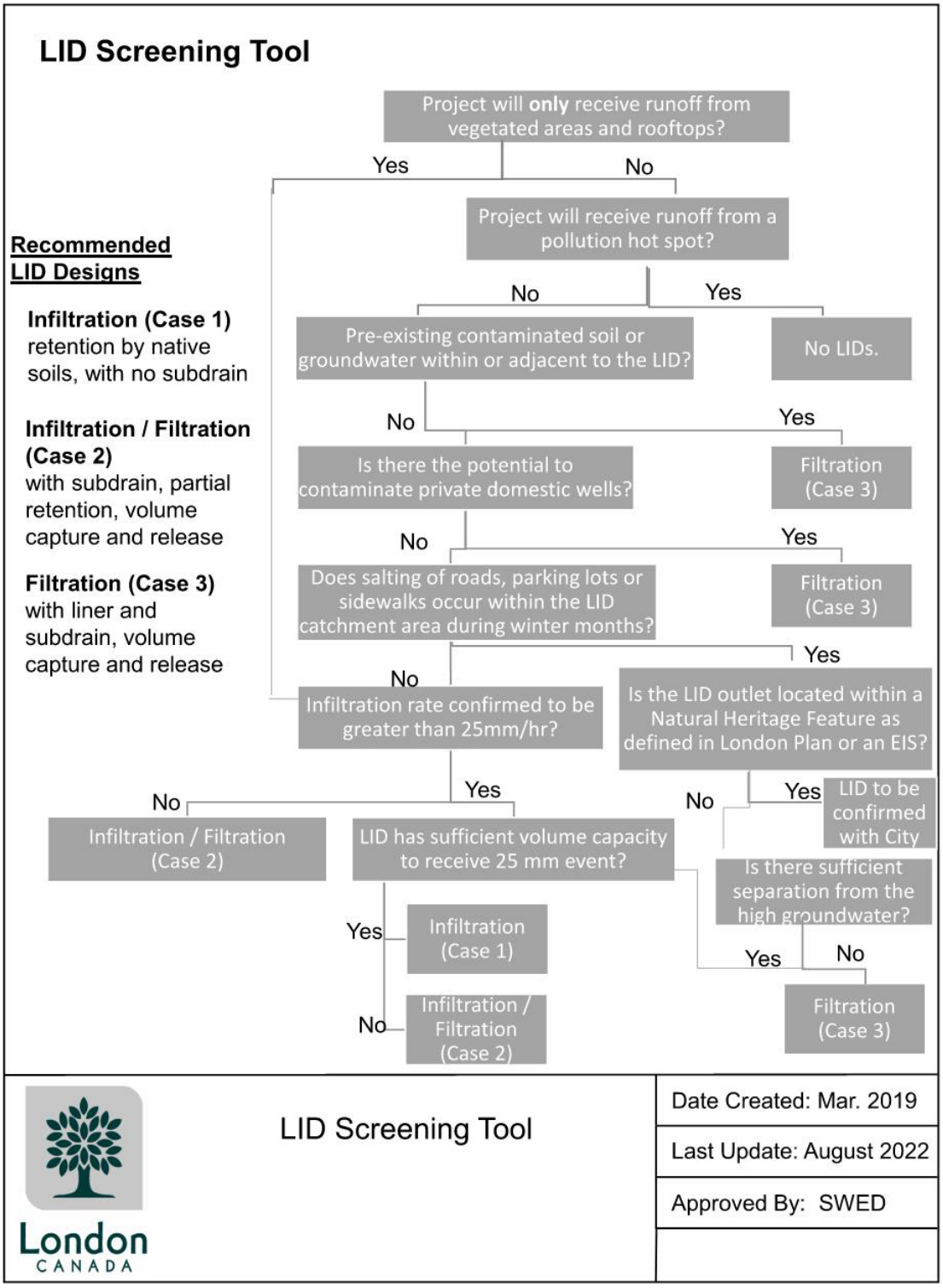
- The property classification meets the criteria listed under Section 5.3. of the Wastewater & Stormwater By-law.
- The customer submits a Professional Engineering Storm Drainage Report which demonstrates that there is a stormwater reduction in runoff which is above and beyond the current site plan requirements. The reduction in the stormwater charge will depend on the increased amount of onsite management of stormwater. This report may be submitted independently or as part of the Site Plan process.

#### 6.5.2.2 LID Screening Tool

The implementation of LIDs or source controls is highly site specific. Some systems may be more appropriate for Site Plans or parking lots rather than the municipal right-of-way. The design of each system must consider a number of factors, including but not limited to site layout, soil conditions, elevation of the seasonal high groundwater table, and grading. It is equally important to consider lifecycle costs and ongoing operations and maintenance.

Although some sites will have constraints, the provided screening tool will assist with determining which LID options may be applied at each site:

The recommended LID designs highlighted in the Screening Tool will meet **Priority 1** or **Priority 2** of the Stormwater Management Control Hierarchy.


LID Screening Tool
Project will only receive runoff from vegetated areas and rooftops?
Yes
No
Project will receive runoff from a pollution hot spot?
No
Yes
Pre-existing contaminated soil or groundwater within or adjacent to the LID?
No LIDs.
No
Yes
Is there the potential to contaminate private domestic wells?
Filtration (Case 3)
No
Yes
Does salting of roads, parking lots or sidewalks occur within the LID catchment area during winter months?
Filtration (Case 3)
Yes
No
Infiltration rate confirmed to be greater than 25mm/hr?
Is the LID outlet located within a Natural Heritage Feature as defined in London Plan or an EIS?
No
Yes
LID to be confirmed with City
No
Yes
Infiltration / Filtration (Case 2)
LID has sufficient volume capacity to receive 25 mm event?
Is there sufficient separation from the high groundwater?
Yes
Infiltration (Case 1)
No
Infiltration / Filtration (Case 2)
Yes
No
Filtration (Case 3)
Recommended LID Designs
Infiltration (Case 1) retention by native soils, with no subdrain
Infiltration / Filtration (Case 2) with subdrain, partial retention, volume capture and release
Filtration (Case 3) with liner and subdrain, volume capture and release
London CANADA
LID Screening Tool
Date Created: Mar. 2019
Last Update: August 2022
Approved By: SWED

### 6.5.2.3 Site Specific LID Design Considerations

Considerations for LID planning, design and implementation are as follows:

1. **Low Permeability "Tight" Soils:** LIDs can be implemented in all soil types. "Tight soils" with low infiltration rates do not preclude the implementation of LIDs. It is expected that any water that cannot be infiltrated can be filtrated. Adaptations such as underdrains connected to downstream LID facilities or storm sewers may be required for successful implementation. In soils with an infiltration rate of less than 15mm/hr, a subdrain will be required. Site specific infiltration testing may be required to support LID design.
2. **Risk of Groundwater Contamination:** It is important to assess if there are any potential sources of contamination (both surface and subsurface) within the LID drainage area or within surrounding soils prior to the implementation of any LID solution to evaluate the possibility for contaminating groundwater and/or mobilizing contaminant plumes. Although the majority of pollutants in stormwater runoff should be contained within filter media and underlying soils, special attention shall be made to prevent contaminants (particularly de-icing road salts) from reaching the groundwater table.
3. **Groundwater Table:** A reasonable separation distance between the bottom of the infiltration feature and the seasonal high groundwater table should be determined based on local site conditions. For smaller sites that are not in proximity to a natural heritage system, manual groundwater level information collected from monitoring wells may be adequate to assess the location of the water table. In more sensitive cases, it may be necessary to install groundwater monitoring wells equipped with continuous data loggers to capture the seasonal high groundwater elevation.
4. **Winter Operation:** It may be necessary to consider seasonal decommissioning of the LID to avoid damage from ice or winter road salt loadings, particularly if the LID outlets to a sensitive receiver.
5. **Pollution Hot Spot Runoff:** Installation of LIDs should be avoided in areas with the potential for high levels of contaminated runoff (refer to O.Reg 153/04 Table 2). However, this does not prohibit the use of those LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes. Additionally, the infiltration of rainwater from catchments that are isolated from the respective high-risk site activities such as rainwater from rooftops, employee parking facilities or directly falling on permeable surfaces is generally considered relatively 'clean' and should not be excluded from infiltration.

6. **Clogging:** Stormwater directed to LIDs may contain sediment and fines that pose a risk to clogging the system. To reduce the potential for clogging, the following should be considered:

    i. Implement Pretreatment: Pretreatment is essential to promote settling and capture of sediment prior to entering the infiltration system and must be included as part of a complete LID design. Options for pretreatment, include but are not limited to, deeper catchbasin sumps, manufactured products (e.g. goss traps, CB shields), oil and grit separator (OGS), vegetated filter strips, or pretreatment forebays.

    ii. Avoid Filter Fabric: The use of filter fabric should be minimized to reduce the opportunity for an LID system to become clogged. A choking gravel layer is recommended to be used instead of filter fabric where suitable. The use of filter fabric should be limited to aspects of the design that will not become clogged and reduce the infiltration function and capacity of the feature. The use of filter fabric may be desirable early on during construction and in final stages of site stabilization to mitigate premature clogging of filter media.

    iii. Erosion and Sediment Controls (ESCs): Do not commission LIDs until the contributing drainage area is no longer under construction. See **section 6.5.2.4**.

7. **Porosity:** A porosity of 0.40 is to be used in LID design for granular material. Other porosities may be considered where literature or field testing supports design values.

8. **Emergency Overflow**: for surface features, such as a bioretention cell, an emergency overflow to a storm sewer or ditch will be required.

9. **Vegetation:** Bioretention cells are to be planted in accordance with the neighbourhood aesthetic with paramount consideration for maintenance requirements. Naturalized plantings are encouraged and are appropriate for high volume traffic corridors. For projects within the municipal right of way or easement, the plant list must be approved by Parks Operations during the design phase.

    i. If the native soils do not possess the required nutrient levels for proper vegetation establishment, then the soil should be tilled at least 300mm and organic material should be introduced to amend the soils.

10. **Erosion:** Limiting the slopes within an LID is important to avoid excessive erosion from occurring. If applicable, rip rap, spill aprons, check dams, and vegetation can be incorporated to help minimize erosion internally.

11. **Private Property:** If the LID is to be located on private property, the consultant shall prepare an operation and maintenance manual for the LID to ensure proper functionality. The City will not accept certain LIDs on private property where no operation and maintenance plan has been presented.
12. **Standing Water and Mosquitoes:** Surface ponding of stormwater should be limited to discourage mosquitoes. Standing water should be drained in less than 24 hours. In the case of high density urban landscapes a shorter ponding time may be more visually appealing.
13. **Setbacks from Buildings:** It is recommended to construct LIDs no closer than four (4) metres from building foundations to prevent water damage in accordance with the Zoning By-law and the Ontario Building Code. In some cases, the 4m setback requirement may be reduced, subject to installation of mitigation measures.
14. **Proximity to Underground Utilities:** Location of underground utilities needs to be determined in consultation with the City's Utility Coordination Committee to ensure proper offsets from utilities and to avoid damaging existing utilities.
15. **Overhead Wires:** Ensure future tree canopies (if applicable) will not interfere with existing overhead phone and power lines.
16. **Wellhead Protection:** Any stormwater runoff received from parking lots or roads should not be located within a two (2) year time-of-travel wellhead protection area.
17. **Minimum Event**: The LID design should ensure the LID drainage area and configuration can receive and infiltrate a minimum runoff volume. LID placement should be supported by a contributing drainage area plan.
18. **Salt Impacts**: Consideration should be given to the potential impacts of receiving salt laden runoff when located adjacent to Natural Heritage features.

#### 6.5.2.4 LID Submission Requirements

**Design Brief**

A design brief shall be prepared, as part of any LID design. The design brief may be a stand-alone document or included as part of a Functional Stormwater Management report. The design brief will form part of the ECA application for the LID system. A LID design brief should include the following:

- Design objectives, considerations and constraints;
- Modeling methods and results;

- Design calculations;
- Field testing results including groundwater monitoring, soil analysis and in-situ infiltration testing results;
- Construction considerations;
- Operation and maintenance requirements; and
- Relevant design drawings.

Any supporting documentation or relevant reports are to be included as an appendix to the design brief.

**Design Drawings**

A clear and comprehensive LID design drawing is important to communicate the uniqueness of the LID systems form and function to the contractor, site inspector and operator/owner. The drawings are a critical component to the success of the project.

Where LIDs will be incorporated within the City ROW, the linear works and cross section drawings should include all relevant LID features and appurtenances within the drawing sheets. A single LID details sheet should be prepared to include:

- Limits of construction
- Detail cross sections and/or profiles showing critical LID aspects including slopes, low points;
- Construction sequencing and protection of LID components;
- Erosion and sediment control notes and inspection requirements specific to the LID design;
- Additional construction notes to address protection and mitigate compaction of the LID feature;
- Proprietary devices: provide specific locations where pretreatment devices are included or any appurtenance that require maintenance;
- Landscape or planting plans;
- Soil or fill specifications and placement notes;
- A drainage area plan (separate from the storm sewer drainage area plan) is to be provided identifying the contributing drainage areas to each LID feature.

Examples of construction best practices that should be considered when developing a Sediment and Erosion plan for LID BMPs include:

- Installing barriers in front of curb cuts to prevent sediment form washing into facilities where curbs are part of the design.

- Excavating the final grade (invert) of the infiltration bed immediately prior to backfilling with specified aggregate and media to avoid premature facility clogging.
- Redirection of runoff including overland flow routes and roof drainage away from LID facilities during construction.
- Storing all construction materials down gradient of LID features (where possible). Construction materials stored up gradient of excavated site are to be enclosed by appropriate sediment control fencing.
- Ensuring all pipes are laid in a true line and gradient on a firm bed, free from loose material.
- Installing a temporary piece of filter cloth to collect dust and debris during construction. This is to be removed before biomedia is installed.
- Installing temporary sediment basins to collect flows during construction. This is to be removed after LID works are completed.

**Monitoring Considerations**

Monitoring programs may be required to address:

- Assumption requirements (as per Chapter 19).
- Demonstration that surface and groundwater requirements and/or targets are met during construction and build out phases, as noted in an associated or supplemental report such as EIS or hydrogeological study and as per the City's Environmental Management Guidelines (EMGs).
- Confirmation that impacts to adjacent natural heritage feature(s) following completion of new development works is within a range of acceptable impacts.

### 6.5.2.5 Operation of Maintenance Requirements of LID

The development of an Operations and Maintenance plan is a critical element for creating an effective LID feature.

For LIDs within the City's ROW, the operation and maintenance program shall be consistent with the City's existing overall LID Operation and Maintenance program (available on the Stormwater Consultant Resources webpage, see **section 6.1.4**). Any deviation or specific O&M requirements in addition to the City's standard practices should be identified in a fact sheet to be included in an Appendix to the City's overall O&M maintenance guide.

For privately owned LID systems, an O&M is to be prepared as part of the design and provided to the owner to conduct ongoing maintenance. For more information on O&M plan considerations refer to section 6.8.

### 6.5.2.6 LID Component Specifications

The City generally follows the Low Impact Design guidelines put forth by the Sustainable Technologies Evaluation Program (STEP), including, but not limited to STEP's Living Website.

Below are some additional guidelines to clarify the City's preference for specific LID components.

**Infiltration Galleries**

- For third pipe (Etobicoke) systems, consideration should be given to sizing the infiltration gallery width to be the same width as the trench for the overlying storm sewer installation.

**Infiltration Pipes**

- Minimum size of a perforated pipe in an infiltration system should be 250mm to help facilitate flushing operations.

**Bioretention Systems**

- Infiltration swales and dry swales constructed in residential right of ways should be constructed to minimize impacts to the right of way. This includes minimizing the above ground exposure of the swale, maximizing 3:1 slopes, and using sod rather than planted vegetation for the swale.

**Monitoring Wells**

- Monitoring wells for LIDs should be of a durable material (e.g., metal) and have a lockable cover capable of withstanding the weight of regular maintenance equipment (e.g., riding lawnmowers).

**Pre-treatment devices**

- All upstream catch basins tributary to the third pipe exfiltration systems shall contain pre-treatment devices.
- All LIDs capturing surface runoff (e.g., bioretention systems, infiltration swales, etc.) shall have pre-treatment devices as part of the LID feature's inlet.
- Pretreatment sump shall have a minimum sump depth of 900mm
- Cast in place traps shall be required unless otherwise specified by the City of London

**Underdrains**

- Bioretention systems should be provided with underdrains and an overflow catch basin connected to the municipal storm sewer.
- Where possible the internal diameter of perforated pipe underdrains should be a minimum of 250mm to facilitate inspections and cleaning with jet nozzle equipment.

- Use of 2x 45-degree connectors or 3x 30-degree connectors should be used for subterranean underdrains in place of 90-degree connectors to facilitate inspection and cleaning.

### 6.5.2.7 LID Plantings

#### 6.5.2.7.1 Rain Gardens

**Table 6.5** below provides suggested aesthetics to be considered when determining rain garden plantings, based on the project location and local area.

**Table 6.5 Suggested Rain Garden Aesthetics**

| Rain Garden Location | Sod (mowed grass) | Meadow | Naturalized | Landscaped |
|---|---|---|---|---|
| Local Street | x | | x | x |
| Major Road | x | x | | x |
| Urban Centre | x | | | x |
| Park | x | x | x | |
| Residential Garden | x | | | x |

where:

- ‘x’ denotes the suggested aesthetic
- ‘Local Street’ means either Neighbourhood Street or Neighbourhood Connector
- ‘Major Road’ means either Rapid Transit Boulevard, Urban Thoroughfare, Civic Boulevard, Urban Thoroughfare/Civic Boulevard in Primary Transit Area, Main Street or Rural Thoroughfare

The planting list provided in **section 6.14** (**Table 6.7)** below provides guidance in selecting planting species that are suitable for achieving the desired aesthetic

#### 6.5.2.7.2 Low Maintenance Grass Seed Mix for LIDs

The following seed mix is recommended for low impact developments seeking a low maintenance grass seed solution:

- 40% Eco-Star Hard Fescue
- 20% Southport Chewing Fescue
- 20% Cascade Chewing Fescue
- 20% Fenway Creeping Fescue

#### 6.5.2.7.3 LID Planting List

Further to the suggested aesthetics above, the planting list in **section 6.14** (**Table 6.7**) includes additional information on the suggested plantings, including:

- Soil Type Preference – suitable for sand (S), loam (L) or clay (C), or a combination thereof.
- Soil Moisture – either dry (D), moist (M), wet (W), or a range thereof.
- Exposure – desired exposure for the planting, either 'Sun', 'Part Shade' or 'Shade' or a combination thereof.
- Drought Tolerance – the species tolerance denoted as either high (H), medium (M), low (L) or a range thereof.
- Salt Tolerance – the species resiliency to salt loadings denoted as either high (H), medium (M), low (L) or a range thereof.
- Height or spread in metres.
- Whether or not the species is native to the region.

## 6.5.3 Small-Scale, Traditional Water Quality Systems

Small-scale water quality systems refer to treatment areas of approximately 5 hectares. Where LIDs are not feasible to meet water quality objectives, traditional stormwater quality control systems may be implemented to comply with the provincial design requirements and include:

- Oil Grit Separators (OGS)
- Catchbasin hoods and proprietary catchbasin inserts

### 6.5.3.1 Oil Grit Separators (OGS)

Oil/grit separators are typically used for small drainage areas, for the following lands uses:

1. Industrial, commercial, institutional and medium/high density residential developments (site plans) in compliance with the stormwater Permanent Private Systems (PPS) policy
2. Municipal ROW as part of capital projects/City Renewal programs.

The City accepts technologies verified to meet water quality objectives through the Environmental Technology Verification Canada program. The OGS design methodology shall include the associated catchment area in hectares, the percentage of imperviousness used to size the OGS and the particle size distribution (PSD) used to define the % of TSS removal.

**OGS Design Requirement:**

1. **Inspection Maintenance Hole:** Every OGS shall be provided with a downstream sampling/inspection maintenance hole. This sampling maintenance hole shall be located on private property as close as possible to the property line.

   To the satisfaction of the City Engineer, the City may exempt the need for an additional inspection maintenance hole in cases where:

   a. An existing municipal maintenance hole is available close to the property line, or,

   b. The City has permanent access to inspect the OGS unit on private property.

2. **Location:** The OGS location shall allow the greatest portion of the site to be treated and access for routine inspection and repairs/maintenance.

3. **Maintenance:** OGS operation and maintenance shall be in accordance with the manufacture's operation and maintenance manual. This manual should be included in the stormwater functional design report for the proposed development and a copy of this manual shall be provided to the owner for future and regular operation and maintenance activities.

4. **Drafting standard:** Engineering drawings for the proposed development shall delineate and indicate the size in hectares of the storm catchment area used to size the proposed OGS. Construction notes and details drawings shall include the type of OGS, the percentage of TSS removal, the associated storm catchment area in hectares, the location of the OGS and the downstream sampling maintenance hole, and a reference of to the associated OGS operation and maintenance manual.

5. **OGS special cases.** For developments proposing gas stations, an additional OGS shall be installed in the vicinity of the gas bars to capture oil spills. The additional OGS shall be sized using a reduced catchment area (the area of gas bars) and shall be provided with a separate downstream sampling/inspection maintenance hole. This additional OGS does not preclude the applicant to comply with applicable Technical Standards and Safety Authority's (TSSA) Fuels Safety Programs/regulations.

### 6.5.3.2 Catchbasin hoods and proprietary catchbasin inserts

Catchbasin hoods (e.g. goss traps) and proprietary catchbasin inserts are typically used as pre-treatment devices intended to work in tandem with downstream treatment such as LIDs, OGSs, or SWM facilities.

**Design requirements**

1. Catchbasin hoods and proprietary catchbasin inserts may be acceptable as a stand-alone water quality measure in redevelopment scenarios where no significant work on existing grading or sewers is proposed and the total of existing plus proposed parking spaces is less than 30. Catchbasin hoods and proprietary catchbasin inserts in existing developments, such as existing parking areas are intended to reduce concentrations of oil and grit to acceptable levels until a more permanent solution can be implemented to meet current provincial standards.
2. Catchbasin hoods are only credited for providing a Basic level of water quality treatment or up to 60% TSS removal.
3. No sampling/inspection maintenance hole is required downstream of any catchbasin hoods and proprietary catchbasin inserts unless they are working in tandem with a downstream OGS.
4. Catchbasin hoods and proprietary catchbasin inserts shall be maintained in accordance with the manufacture's operation and maintenance manual. This manual should be included in the stormwater functional design for the proposed development and a copy of this manual shall be provided to the owner for future and regular operation and maintenance activities.

## 6.5.4 Design of Municipal SWM Ponds

The following design guidance applies to the design of municipal SWM Facilities including, wet ponds, wetlands, and dry ponds. The majority of new municipal SWM ponds are regional facilities that are funded by the Development Charges and constructed as Capital Works by the City of London.

Any private stormwater management facilities must comply with the standards outlined by the province (MOE, 2003).

### 6.5.4.1 Figures

Attached, Figures 6.3. 6.4 and 6.5 which accompany these requirements, incorporate generalized design features as published in recognized manuals or guidelines, as adapted and modified to reflect accepted practice in southern Ontario municipalities.

The figures are based on the use of Attenuation/Extended Detention and/or Wet/Hybrid Wet Facilities. However, they can also apply to dry facilities if the wet pond and sediment forebay components are removed.

### 6.5.4.2 Water Quality Storage

Impervious percentage is described by two parameters, Total Impervious Percentage (TIMP) and Directly Connected Impervious Percentage (XIMP) values. The required storage is to be determined using the TIMP value in accordance with Table 3.2 of the Ministry of the Environment's Stormwater Management Planning and Design Manual (2003).

The water quality storage volumes per hectare are established in Table 3.2 of the MOE Manual and consist of two components: 40$m^3$/ha of extended detention quality control storage (live storage) and the remaining portion represents permanent pool quality storage (dead storage). The required 40 $m^3$/ha of quality extended detention storage is constant and required in all cases. The remaining permanent pool component of water quality storage is dependent upon the three following factors:

i. Total Impervious Percentage (discussed in Section 6.4.3.1);

ii. Protection Level of the Receiving Watercourses; and

iii. Proposed type of SWM facility (i.e. wet pond, dry pond, wetland, infiltration).

Additional extended detention storage may be required for erosion/stream morphology and attenuation control to comply with the Council accepted Subwatershed Study requirements and/or to address lack of conveyance capacity in the outlet system. These parameters are to be established by the Subdivider's Consulting Engineer all to the satisfaction of the City Engineer.

### 6.5.4.3 Erosion Control Storage

Erosion control storage volumes reflect the need to maintain existing fluvial geomorphology, protect watercourses from further deterioration and ensure protection of public safety and property. The City of London completed 13 Subwatershed Studies all of which were adopted by City Council in 1995 and the Dingman Creek Subwatershed Study Update which was adopted by City Council in 2005. The Subwatershed Studies identified SWM erosion control criteria on an individual basis, in some cases even establishing requirements for each tributary of subwatershed (i.e. Dingman Creek Subwatershed).

All facilities require a minimum of 40 $m^3$/ha of extended detention storage. Additional erosion control protection may be required if the facility is to be located within a subwatershed that identifies specific erosion control requirements on top of the quality control extended detention. Should the consulting engineer complete a site specific geomorphological/fluvial assessment, alteration to the erosion control requirements may be considered.

### 6.5.4.4 SWMF Inlet Pipe Design Criteria

According to the 2003 MOE Guidelines for the Design of Storm Drainage Systems, the SWM facility inlet pipe should represent a free outlet. Therefore, the inlet pipe invert is to be above the projected 5-year storm ponding elevation. Non-compliance with this standard may create surcharge conditions within the new storm sewer system requiring additional maintenance associated with the potential sediment accumulation, as well as create potential liabilities under the Ontario Highways Act should surface ponding occur on streets.

Should, in rare cases, we need to consider deviation on the above noted design criteria, the consulting engineer will be required to undertake an engineering analysis to demonstrate that the proposed deviation will have a minimum effect on the proposed sewer Hydraulic Grade Line and will not create an adverse effect on the system.

### 6.5.4.5 SWMF Outlet Pipe Design Criteria

The City supports innovative SWMF outlet design to reduce operation and maintenance burden and ensure long-term functionality of the SWMF outlet. Submerged or reverse grade outlets can reduce debris accumulation at outlet structures. Submerged outlet openings should be a minimum of 0.3 m above the pond bottom to allow for account for sediment accumulation.

Additionally, the location of any orifices within the outlet design should be considered to ensure future debris clearing can be reasonably accomplished.

### 6.5.4.6 Specific Design Features

Fifteen key SWM Facility design features have been identified to reduce the risk of injury, while maintaining facility function. These biophysical safety features are intended to restrain access to deep standing water through a series of spatial, physical, natural and aesthetic barriers or through alternatives to direct access. The intent is to replace fencing with an appropriate alternative, while maintaining SWM function and public safety. The 15 key SWM Facility design features include:

1. A sediment forebay is incorporated to induce treatment and trap sediments in an isolated basin to reduce maintenance efforts during sediment cleanout works:
    a. the City encourages innovation in forebay design to reduce suspension of settled particle during high flow events.
    b. the sediment forebay must be at least 1.0-1.5m deep to minimize a potential re-suspension and ecological conditions for West Nile Virus,
    c. the sediment forebay sizing must be done in accordance with the MOE's SWM Practices Planning and Design Manual, and

d. the sediment forebay should be constructed with a maintenance access route to permit future monitoring and maintenance as well as provide access in the event of an emergency;

2. A facility depth of 1.5-2.0m is preferred. Shallow facilities of less than 1.0m are likely to be ineffective, and should be discouraged due to the possible re-suspension of sediment and greater land requirements. The maximum SWM facility depth shall not exceed 3.0m plus a minimum 0.3m freeboard. A positive overland flow path must be provided at the 3.3m water level. The permanent pool depth in wet SWM facilities must be 1.0-1.5m deep. A minimum 0.3m freeboard must be incorporated into all SWM facility designs.

3. A naturalized low flow channel with a shallow channel depth (0.3 to 0.6m preferred) leading to the area of pond draw down; SWM facility inlet sewers must be designed to enter the facility as free outlet systems during 1:5-year storm events. This standard is in accordance with the Ministry of the Environment Guidelines for the Design of Storm Sewer Systems.

4. For extended detention, hybrid and wet facilities 5:1 side slopes maximum or flatter, for dry facilities 4:1 side slopes maximum must be applied around the perimeter of the sediment forebay and upper and lower cell; slopes may vary around a facility to create a natural appearance with the preferred slopes being maximums;

5. Steeper slopes (maximum 3:1) may be allowed to be used when these slopes are:

    - representing only 15-20 % from the total perimeter at the 0.3 m above the 100 year storm event elevation;
    - combined with a minimum buffer of 5.0m from 0.3 m above the 100 year storm event elevation to the property line; and
    - combined with unfriendly vegetation.

6. The two year storm event extended detention and storage component of wet facilities should discharge over a 24 to 48 hour period and the quality control facilities are not allowed to be located in line. Dry facilities should be used mostly as an attenuation/flood control system and ponding will be of relatively short duration and infrequent in occurrence; the permissible discharge for all facilities is based on detailed engineering analysis.

   All maintenance holes located within stormwater management facilities require hard surface access. Access roads below the 100 year flood line will require a turfstone surface or approved alternative on a granular base. The turfstone voids shall be filled with granular A. For all other requirements, refer to Section 3.15.15 for hard surface details.

7. Stormwater from the forebay shall be held in a permanent wet retention facility and should be located in the facilities lower cell (assuming the general main cell design reflects an overall safety criteria of gentle slopes and aquatic safety benches or suitable barriers);

8. Any SWM facility proposed to be located within Flood Plain lands are subject to:

   a. UTRCA guidelines and approvals;

   b. forebays being located above the 50 year storm line with any deviation from this requirement being subject to specific technical justifications approved by the City;

   c. main facilities being located above the 25 year flood line;

9. A naturalized landscape plan, approved by Parks Planning and Design in consultation with the City Engineer, is required for all stormwater retention and detention facilities.

   Seeding of exposed soil surfaces should be done as soon as possible after fine grading is complete. All landscape treatments specified in the approved plan should be installed after seed has established;

10. In lieu of fencing, unmowed vegetated buffers will be required around the perimeter. This buffer should be comprised of tall grasses and wild flowers, followed by trees and densely planted shrubs. A densely vegetated margin on the aquatic safety bench would serve as an aesthetic amenity and an additional natural barrier.

    The requirements for fencing stipulated in Section 11.5, Parks & Open Spaces, Fencing, are not applicable to SWM Facilities.

11. An aquatic safety bench must be constructed around the forebay and the main treatment cells with the lower edge to be located 0.9 m above the facility bottom with a minimum 2 m width and incorporate a minimum slope of 10:1 or flatter.

12. Pedestrian and cycle paths must always be located no lower than the 5 year storm event water elevation and used in conjunction with the preferred slopes discussed in item (4) to further maximize recreational user safety and minimize public risk and liability. Paths below this point and leading to the lower portions of a facility should be posted to warn the public of potential safety hazards during facility operation;

13. Restricted area signage will be necessary to warn the adult public to avoid areas or activities under certain conditions if a number of these features are modified extensively and/or not included.

14. The minimum buffer width (separation area between the SWMF and land features such as ESA, main watercourses, significant ecological features and open space designation, etc.), is subject to City Official Plan requirements, policies, Provincial and Federal Acts, Policies and Requirements.

15. A Sediment and Erosion Control Plan during the construction activities must be developed and included in the Functional SWM Report for the proposed SWM Facility, to be reviewed and accepted by the City. Specific requirements for the protection of adjacent natural areas may be required as outlined in the relevant Environmental Impact Statement for the development.

    These requirements must be applied to all SWM applications. It is recognized that in some instances, unique circumstances may arise where some requirements cannot be accommodated. In these cases, the onus is on the proponent to demonstrate how the proposed design deviates from the requirements, yet still meets the spirit and intent of this overall document. Deviations must be approved by City Council. Additional design guidelines for inlet structures, outlet structures, maintenance access, pathways, etc. is available in Chapter 18 – Drafting and Design Requirements for New Subdivisions. All SWM Facility design standards identified in this document, Environmental Services Design Specifications and Requirements, are based on the revised standards approved by City Council in July 2002.

## 6.5.5 Storm Culverts

The following standards apply to culverts constructed for access (i.e., roads, driveways, and multiuse pathway) crossings within a ditch, creek and/or river. All culvert crossings, where applicable, are to be reviewed and approved by SWED.

### 6.5.5.1 Calculations and Report

All proposed culverts require supporting calculations presented in a report, to be reviewed and accepted by SWED. All recommendations and details from the accepted report are to be reflected on the servicing drawings.

#### 6.5.5.1.1 Minimum Report Requirements

a. **Description**: location (watercourse and subwatershed), rationale for proposed works, discussion of alternatives considered, reference to past studies (e.g., EA).
b. **Existing conditions**: surrounding land use, historic issues (e.g., overtopping).
c. **Replacement**: if replacing an existing culvert describe its current condition (include copy of the condition assessment in the report appendix).
d. **Environmental factors**: describe the Natural Heritage features, natural hazards, watercourse geomorphology, etc.
    i. Environmental Impact Study: if the project requires an environmental impact study, then a copy of the EIS report should be included in the appendix.
    ii. Aquatic Habitat Assessment: describe the habitat and provide mitigation measures (e.g., fish passage).
    iii. Terrestrial Passage: provide details on the width of dry habitat under the 2-year flow condition, plantings and fencing to direct wildlife, and appropriate substrate within the culvert to facilitate wildlife movement.
e. **Hydraulic and Hydrologic Modelling**: including a summary table in the body of the report (see Table 6.6 below).
f. **Excessive Velocities**: Identify if the proposed design has excessive velocities and identify what stabilization methods are being used.
g. **Erosion and Sediment Controls**: to be consistent with City requirements for erosion protection, section 6.5.8 (Erosion Measures), and Chapter 10 (Erosion and Sediment Control).
h. **Figures and Drawings**: see section 6.5.5.2 below for details.

i. **Supporting Studies/Reports (as required)**:

i. Geotechnical Assessment

ii. Fluvial Geomorphic Assessment

iii. Hydrogeological Assessment

iv. Environmental Impact Study (EIS)

v. Erosion Risk Assessment

vi. Erosion and Sediment Control Plan

**Table 6.6 Example Modeling Summary Table**

| Parameters | 2yr | 5yr | 10yr | 25yr | 50yr | 100yr | UTRCA Regulatory 250yr |
|---|---|---|---|---|---|---|---|
| Discharge ($m^3/s$) | | | | | | | |
| Water Surface Elevation (m) | | | | | | | |
| Backwater Elevation (m) | | | | | | | |
| Average Velocity (m/s) | | | | | | | |
| Freeboard (m) | | | | | | | |
| Waterway Opening ($m^2$) | | | | | | | |
| Road Overflow Elevation (m) | | | | | | | |

### 6.5.5.2 Design Requirements

#### 6.5.5.2.1 Conveyance Capacity

i. New culverts or replacement culverts that are impacted by road works/ widening must be sized to meet hydraulic design requirements established by MTO.

ii. Information, coordination, and acceptance for this design element must be received from SWED and should be considered at the earliest stages of design.

### 6.5.5.2.2 Design Details

| Component | Requirement |
|---|---|
| Minimum Diameter/Size | Precast Box: 1800mm (span) x 900mm (rise).<br>Corrugated Steel: Driveways 500mm diameter, Roadway - 600mm diameter (May vary for roadway classification). Unless otherwise specified. |
| Minimum Depth of Cover | Precast Box: As per OPSD-803.010.<br>Note: If the depth of cover is less than the above, certification from a Structural Engineer is required.<br>Corrugated Steel: 300mm OR diameter divided by 6, whichever is greater. As per OPSD-805.01.<br>Note: If the depth of cover is less than the above, certification from a Structural Engineer is required. |
| Culvert Crossings Over Services | In addition to the City's review and approval, where a culvert crosses an existing/proposed sewer and/or watermain, frost protection over the above existing/proposed services is warranted, and insulation is required, as per City of London Drawing Standard W-CS-68. Refer to Section 7.4.7.2 (Crossings of Watermains and Sewers) for more information. |
| Railings | Required for concrete culverts where the drop is greater than 1.0m, as per the Ontario Building Code. As per OPSD-980.101. |
| Flood Hazard | Local Conservation Authority's review and approval is required where storm culverts are constructed within flood hazard areas. |
| Rip Rap/Rock Protection | Required at the inlet/outlet to protect against erosion. As per section 6.5.8 (Erosion Measures) and section 5.18.8 (Rip Rap/Rock Protection). |
| Erosion and Sediment Control Measures | As per Chapter 10 (Erosion and Sediment Control) and as per the Erosion and Sediment Control Guide for Urban Construction (TRCA, 2019) or most recent industry standard. |

| Component | Requirement |
|---|---|
| Bedding | Precast Box as per OPSD-803.010.<br>Corrugated Steel as per OPSD-802.010. |
| Materials | Precast Box: Concrete.<br>Corrugated Steel: Corrugated Steel Pipe.<br>• For 300mm to 600mm diameters, specified minimum wall thickness to be 1.6mm.<br>• All other diameters, minimum wall thicknesses as per OPSD-805.01. |
| Maintenance Access | A 3.0m to 4.6m wide topsoil and sodded access without trees, plantings or other obstructions is required for maintenance access and equipment used to service all culverts. Adequate curves and turn-around facilities are required for maintenance vehicles to manoeuvre.<br>Slopes (10% maximum), cross-falls (2% minimum) and drainage of access roads are also to be addressed in the design.<br>Note: a 0.3m separation is required between the maintenance access and the top/bottom of any slopes; fences; and property line(s). |
| Details | Plan and Profiles are required for all culverts together with frequent cross-sections and details (e.g., inlets/outlets). |
| Easements | See Section 5.17 (Easements) for more details. |
| Countersinking and Fish Passage Design | Where achievable, culverts are to be countersunk a minimum of 300mm (or as per applicable DFO requirements).<br>Design discharge, flow depth and velocity should not adversely impact fish passage. Designers should work with biologists to ensure that the hydraulic design meets the biological requirements for fish passage. |
| Terrestrial Passage Design | Design should provide a width of dry habitat under 2-year flow conditions and appropriate substrate within the culvert to facilitate wildlife movement and include the use of plantings and/or fencing to direct wildlife accordingly. |

| Component | Requirement |
|---|---|
| Other drawing requirements, as applicable | • Pre- and post-development hydrograph plots for all significant points of interest<br>• Construction access route(s)<br>• Phasing / staging plans complete with ESC measures<br>• Creek restoration plans, as applicable<br>• Dewatering and flow diversion plans |

### 6.5.6 Storm Channels

Specifications and design information to be in accordance with the Ontario Provincial Standard Drawings, the Municipal Works Design Manual (MEA), and as approved by SWED.

| Component | Requirement |
|---|---|
| Channel and Hydraulic Report | To be reviewed and accepted by SWED. All recommendations and details from the report are to be shown on the servicing drawings. |
| Width/Depth/Freeboard/ Type | Dependent on accepted report by SWED. |
| Side Slopes | Maximum 3:1 side slopes. |
| Linings/Material | Grass-lined slopes, and where velocities are high, gabion-lined, approved erosion protection mat, or rip/rock protection side slopes, and/or as per the accepted Stormwater Management Report and the Geotechnical Report. |
| Inlet/Outlet Structures | As per Section 5.18.1 (Types of Headwalls) and section 6.5.5 (Storm Culverts).<br>Note: All inlet/outlet structures which are different from those identified in the Ontario Provincial Standard Drawings and Municipal Works Design Manual (MEA) are to have Structural Engineer's certification. |

| Component | Requirement |
|---|---|
| Pedestrian System | Location, width, and materials to be reviewed and approved by Parks Planning & Design Division, in conjunction with Development Services.<br>Note: Grades and drainage to be reviewed by Development Services. |
| Landscaping Plan | Reviewed and approved by Parks Planning & Design Division, in conjunction with Development Services. |
| Maintenance Access | A 3.0m to 4.6m wide topsoil and sodded access without any trees, plantings or other obstructions is required for maintenance vehicles and equipment used to service all inlets/outlets within the channel. Adequate curves and turn-around facilities are required for maintenance vehicles to maneuver. Slopes (10% maximum), cross-falls (2% minimum) and drainage of access roads are also to be addressed in the design.<br>Note: A 0.3m separation is required between the maintenance access and the top/bottom of any slopes; fences; and property line(s); and sufficient room is to be provided on the top of each side of the channel, generally 6.0m. |
| Details | A plan & profile is required for all storm channel designs together with frequent cross-sections and details. Plan view, cross-sections and details of the inlet/outlet structures or other pertinent design features within the channel are also required. |

## 6.5.7 Storm Ditches

Required for existing road network surface drainage in rural road situations without existing storm drainage systems or proposed storm drainage systems have not been warranted.

| Component | Requirement |
|---|---|
| Grade | Minimum 0.3%.<br>Maximum dependent on erosion velocity of soil and erosion protection provided. |
| Depths | Dependent on right-of-way widths, safety features and other design constraints. |
| Slopes | Maximum 3:1 side slope. |
| Lining/Materials | Grass-lined, and where velocities are high, approved erosion protection mat, if warranted. |
| Inlets/Outlet Structures | As per section 5.18.1 (Types of Headwalls), section 6.5.5 (Storm Culverts) and Section 5.16.4 (Types of Catchbasins). |
| Subdrains | May be required to be constructed adjacent to and/or drain to ditches, as required by the Geotechnical Engineer and Transportation Division, as per City of London Standard Contract Documents, Section 405.07.01. |
| Erosion Measures | As per section 6.5.8 (Erosion Measures). |
| Erosion and Sediment Control | As per Chapter 10, Erosion & Sediment Control, and the Erosion and Sediment Control Guide for Urban Construction (TRCA, 2019) or most recent industry standard. |
| Details | Plan and Profile drawings required, together with frequent cross-sections and details |

## 6.5.8 Erosion Measures

The erosion measures presented in this section are permanent installations. For temporary measures during construction refer to Chapter 10 (Erosion and Sediment Control).

### 6.5.8.1 Rip Rap

Constructed in conjunction with an approved geotextile within inlet/outlet structures, overflow protection, channel banks, gabions and rockfill structures. Graded in sizes ranging from 100mm to 200mm, as per OPSS.MUNI 1004.05.05.02.

### 6.5.8.2 Rock Protection

Graded in sizes ranging from 100mm to 500mm, as per OPSS.MUNI 1004.05.05.03.

### 6.5.8.3 Turfstone

Constructed in conjunction with an approved geotextile, for use as overflow protection, channel lining, and/or surface access roads using City approved products.

Note: Turfstone voids are to be filled with topsoil and seeded.

### 6.5.8.4 Geotextile

Constructed within inlet/outlet structures, sub-drains, blanket drains, gabion lining, retaining walls, ditch lining, channel linings, access roads, rockfill structures, dykes and energy dissipaters. Type and sizing of geotextile is to be approved by the City.

## 6.5.9 Managing Flows During Construction

As part of any in water construction works, daily by-pass design is to be based on a 10-year design storm and estimated water elevations determined as part of the design work. The by-pass design rate and water surface elevations shall be shown on the ESC drawing and noting conditions when the by-pass can be decommissioned.

A larger storm event may be considered based on project conditions such as the upstream drainage areas, anticipated project timing, and duration. Additional consideration for adaptive bypass controls and mitigation for larger storm events shall be considered as part of the ESC plan.

The ESC design shall meet the requirements of the Contract Documents and Chapter 10 of the Design Specifications and Requirements Manual, and where a waterbody is present, shall include channel and inlet and outlet protection measures as required to protect the environment in the event of system failure or the design flow rate being exceeded.

### 6.5.10 Stormwater and Drainage Infrastructure in Park Blocks

Proposed stormwater and drainage infrastructure shall not impact usable parks blocks. Additional blocks outside of parkland dedication shall be required to accommodate infrastructure.

## 6.6 Interim Conditions

In situations where stormwater from a road widening or development will be designed prior to the ultimate storm/drainage flow path being established, the interim conditions must be designed to the same degree as the ultimate design in accordance with City Standards and Requirements.

## 6.7 Sediment & Erosion Controls

The City of London requires an Erosion Sediment Control Plan (ESCP) be designed for most Capital Works, Operational and Development Projects. The complexity of the ESCP is determined by the sensitivity of the area that is to be protected.

For further information on the requirements of the ESCP, please refer to Section 10 – Sediment & Erosion Control, within this manual.

## 6.8 Operation & Maintenance

For both public and privately owned stormwater control systems, an O&M program is required as part of the design to ensure the owner has adequate information to safeguard long-term functionality of their system. An Operation and Maintenance plan should include but not be limited to the following information:

- Site location
- Details and locations of stormwater feature(s) on site (i.e. LID, OGS, Stormwater Facility, etc.)
- Delineation of drainage area to stormwater feature
- Understanding of system design and nuisances (i.e. filter media, underdrains, inlet and outlet control functions)

- Connections to the municipal storm sewer
- Emergency overflow location and function
- Identify significant sources of sediment accumulation and how this can be managed (e.g. street sweeping)
- Provide a list of short and long-term maintenance tasks for the LID systems with a recommended maintenance schedule (i.e. monthly or seasonal inspection or frequency for each maintenance task).
    - A short-term maintenance example would be ensuring standing water within an LID infiltrates within a 24-hour time period - if not, this could be an indication of a sub-drain malfunction or clogged filter media.
    - A long-term maintenance example would be monitoring to determine pollutant saturation within the filter media and replacement/clean-outs of the filter media.  Recommended Maintenance schedule

## 6.9 Permanent Private Stormwater Systems

Effective January 1, 2012 the Design Requirements for Permanent Private Stormwater Systems are a mandatory part of a regional stormwater servicing strategy for all Medium and High Density Residential, Institutional, Commercial and Industrial (ICI) subdivisions and site plan developments.  This condition was stipulated by City Council resolution, at its session held on January 18, 2010.

The Design Requirements for Permanent Private Stormwater Systems will apply to all locations for subdivision and site plan and condominium development applications with the following land uses:

- Medium and high density residential,
- Institutional,
- Commercial, and,
- Industrial

Subject to Site Plan Control By-law (C.P.-1455-541), Section 12.3 Storm Retention Systems, the flows from a site being developed are to be restricted to those flows which were allowed for the site in the design of the receiving storm sewer.

Where no overland flow route is established, the owner is required to ensure that stormwater flows are self-contained on site, up to the major storm event (refer to section 6.2.3.1).

Regardless of applicable case (see below), water quality control shall be provided to all new and redeveloping industrial, commercial, institutional, and medium/high density residential developments where the number of new or pre-existing at-grade parking spaces is 30 or greater (refer to section 6.2.1.3).

The on-site private stormwater system must be designed to meet the minimum subwatershed criteria requirements outlined in Table 6.4.

**Case 1: A SWM Facility exists downstream, addressing subwatershed quality, erosion, and peak flow control targets:**

a. For development within the approved C-value of the downstream SWM Facility design, on-site private stormwater systems are not required.

b. For development in exceedance of the approved C-value of the downstream SWM Facility design, the site is to store volumes in excess of the allowable release rate.

**Case 2: An EA and/or SWM study have been completed and a SWM Facility will be constructed in a timely manner or a SWM Facility has been constructed but does not meet all required SWM criteria:**

- Where the downstream SWM facility does not address all required SWM criteria or environmental targets (i.e., subwatershed quality, erosion, and/or peak flow targets) the relevant on-site controls will be required for the lands to be developed, as per the applicable Subwatershed Study.
- The on-site private stormwater system must be integrated with the permanent regional storm/drainage and SWM solution within the drainage/watershed area (if the permanent regional system has been proposed for this drainage area) and attempt to maximize stormwater retention and quality control on site subject to site constraints.
- The on-site private stormwater system must be designed and constructed in accordance with the SWM criteria and the environmental targets, identified in the Subwatershed studies accepted by City Council and be consistent with the City's Design Standards and Requirements. In most cases, the water quality component should be implemented by oil-grit-separators or other applicable measures for sites less than 10 hectares. SWM facilities with a water quality component may be considered if the land development (under the site application) exceeds approximately 10 hectares.
- For development areas less than 10 hectares, the water quantity component should ensure that peak flow from the site does not exceed pre-development conditions and shall comply with riparian right (common) law. For sites larger than 10 hectares, it must be designed to meet the discharge requirements (flow targets) outlined in the applicable subwatershed study;

- Control maintenance holes must be located within the site plan prior to discharging to the municipal storm/drainage system in order to monitor private side discharges to the allowable flow rate and/or velocities.
- Monitoring may be required if the outlet from the site discharges to an open watercourse and/or Natural Heritage System in accordance with the City's Official Plan.
- A private permanent stormwater system will not be considered for site plans which are located on lands required for the construction of the conveyance and/or the regional permanent SWM system.

**Case 3: Where a municipal SWM facility does not exist, or is unlikely to be constructed in a timely manner:**

**a. If an approved sewer is established, but there is no downstream SWMF:**

i. the flows from a site being developed are to be restricted to those flows which were allowed for the site in the design of the receiving storm sewer; and,

ii. the major flows and site grading are to be controlled on site up to the major storm event and,

iii. 100% of quality and erosion controls are to be provided for the lands to be developed, as per the applicable Subwatershed Study.

**b. If an approved ditch or alternative outlet is established, but there is no downstream SWMF:**

i. ensure that peak flow from the site does not exceed pre-development conditions; and,

ii. the major flows and site grading are to be controlled on site up to the major storm event and,

iii. 100% of quality and erosion controls are to be provided for the lands to be developed, as per the applicable Subwatershed Study.

**c. If there is no approved outlet currently established for the proposed site:**

i. the on-site private stormwater system must provide 100% of the quality, erosion and quantity control for the lands to be developed as per the applicable Subwatershed Study.

ii. Where there is no overland flow route available, the major flows are to be controlled on site up to the major storm event.

- The on-site private stormwater system must be provided completely within the area to be developed and serve the entire area to be developed.

- The on-site private stormwater system must be designed and constructed in accordance with the SWM criteria and the environmental targets, identified in the Subwatershed studies accepted by City Council and be consistent with the City's Design Standards and Requirements. In most cases, the water quality component should be implemented by oil-grit-separators or other applicable measures.
- The on-site private stormwater system must be designed to meet the discharge requirements (flow targets) outlined in the applicable subwatershed study;
- A control maintenance must be located within the site plan prior to discharging to the municipal storm/drainage system in order to inspect private site discharges to the allowable flow rate and/or velocities;
- Monitoring may be required if the outlet from the site discharges to an open watercourse and/or Natural Heritage System in accordance with the City's Official Plan.
- A private permanent stormwater system will not be considered for site plans which are located on lands required for the construction of the conveyance and/or the regional permanent SWM system.

**Case 4: Where the land to be developed is located in the Central Thames Subwatershed:**

- On-site private stormwater systems located in the Central Thames Subwatershed must be designed and constructed based on the following design criteria:
- the flow from the site must be discharged at a rate equal to or less than the existing condition flow,
- the discharge flow from the site must not exceed the capacity of the stormwater conveyance system,
- the design must account the sites unique discharge conditions (velocities and fluvial geomorphological requirements),
- "normal" level water quality is required as per the MOE guidelines and/or as per the EIS field information; and
- shall comply with riparian right (common) law.

**Design Standards and Requirements Implementation:**

In conformance with these Design Standards and Requirements a variety of requirements must be incorporated into Development Agreements associated with these developments. The following conditions must be included:

- The Developer must obtain an Environmental Compliance Approval for the Private Permanent Stormwater Servicing works;
- The Developer must develop a maintenance and operational program in compliance with the flow rates, and erosion control requirements for implementation by the Owner;
- The Developer must provide the adequate site plan security allocations for the identified works (until 2 years of operation); and
- The Private Permanent Stormwater Servicing design must meet all of the standards and specifications of the City Engineer.

## 6.10 "Just in Time" Design and Construction of Storm Water Management Facilities Policy

The Design and Construction of Storm Water Management Facilities process policy was endorsed by Council July 31, 2013. Prior to the construction of the SWM facility the developer will enter into a subdivision agreement which includes the following requirements and provisions:

- The land for the SWM facility will initially be transferred to the City at no cost.
- Repayment of the SWM facilities land cost will be made when 25% of the building permits have been pulled within the storm catchment area.
- The City will tender the SWM facility following the completion of Design Studies or upon the first submission of design drawings, at the discretion of the City Engineer.

The purpose of the noted provisions is ensure that the following two key objectives are met:

1. Cash flow to the Stormwater City Services Reserve Fund is modestly improved by withholding payment for the land (approximately 25% of the value of the facility) until 25% of the building permits have been pulled within the storm catchment area, and
2. The requirement that the developer has made a substantial investment in development providing the City with the confidence that they can be reasonably expected to proceed in a timely fashion.

The overall goal of the policy is ensure that SWM facilities are constructed on a "Just in Time" basis. A figure outlining the process in included as Figure 6.6: SWM Design and Construction Process with Discussion.

## 6.11 Commissioning Considerations

### 6.11.1 Operation Prior to Assumption

Operation of the SWM facility or LID feature, prior to the City's assumption, shall be in compliance with the Operational and Maintenance Manual developed by the subdivider's Consulting Engineer and approved by the City's Environmental Services Department.

LID features are to remain offline and be protected until the upstream catchment area has stabilized. Once the contributing catchment area has developed and there is no threat of the system becoming clogged, the LID can be brought online. An interim SWM strategy will be required prior to connection of the LID system that is primary comprised of erosion and sediment control features.

### 6.11.2 Maintenance and Monitoring Prior to Assumption

Maintenance and monitoring of the SWM facility and/ or LID feature prior to City's assumption, must be:

- carried out by the Subdivider/Developer to demonstrate the effectiveness of the performance of these facilities in accordance with the approved design construction practices;
- in compliance with the City and MOE's "Monitoring and Operational Procedure for the SWM Facilities Prior to the City's Assumption", October 1996;
- able to demonstrate the Stormwater feature is functioning as designed (i.e. infiltrating as per design);
- carried out by the Subdivider, prior to the City's assumption, at no cost to the City;
- in compliance with Planning Division's Landscape Monitoring Guidelines. There may be other site specific monitoring requirements as a result of an EA or EIS for the facility or development; and
- all landscape materials are to be maintained in a healthy state in accordance with the approved landscape plan until the time of assumption. A final inspection is required by the Planning Division, prior to assumption of the facility.

## 6.11.3 Maintenance After Assumption

Maintenance of the SWM facility site, replacement of biophysical components such as dead trees and shrubs or soil erosion, after the City's assumption, will be the responsibility of the City's Planning, Environmental and Engineering Services Department.

## 6.11.4 Operation After Assumption

Operation of the SWM facility after the City's assumption, will be carried out by the City's Planning, Environmental and Engineering Department and will include periodic dredging of silt deposits from the sediment forebay of the SWM facility. Removal of potentially contaminated sediments may require compliance with regulations under the Environmental Protection Act. Lawn mowing, litter removal, trail maintenance and vegetation inspection (especially where a SWM facility is part of an open space scenario) will be subject to the Planning, Environmental and Engineering Department's maintenance and operations budget.

## 6.11.5 Proportional Cost Sharing

Proportional Cost Sharing for maintenance and monitoring of the SWM facility amongst benefiting developers will be required.

The Subdivider/Developer constructing a SWM Facility which services other subdivisions and that carry out maintenance, operations and monitoring of SWMF's prior to the City's assumption, should be allowed proportional cost sharing by others serviced by these SWMF's. The above noted proportional cost sharing shall be based on contributing storage volume of a SWM facility. Contributing Subdivider /Developer's payments to third parties shall:

- commence upon completion of the subdivider's service work connections to the existing unassumed SWM services; and
- continue until the time of assumption of the affected services by the City.

# 6.12 Stormwater Engineering Checklists

**Checklist 1 Subdivision Application, Stormwater Engineering Checklist**

| TASK (Checklist 1) | Complete? (Y, N, N/A) |
|---|---|
| **Draft Plan Submission** | |
| Confirm the submitted Final Proposal Report (FPR) is updated to respond to all comments provided by the City in the Initial Proposal Report (IPR) submission. Any additional supporting documentation and reports as identified during the IPR submission shall also be provided as part of the Draft Plan submission package along with the FDR | |
| Confirm that the proposed land use is consistent with the Area/Community Plan, Natural Heritage System (NHS) buffers and setback requirements, as well as all policies and acts of applicable agencies including the DFO, MECP, UTRCA and City. | |
| Identify/Review previously completed studies (Municipal Class EAs, subwatershed study requirements, Functional and Detailed Design Reports, Geotechnical, Hydrogeological, EIS, drawings etc.) and identify how the proposed design meets all applicable stormwater design targets. Note any deviations in the proposed approach from previous studies with a supporting rationale for the change. | |
| Provide geotechnical assessment with specific recommendations regarding soil conditions and how they inform the design of the proposed SWM system. | |
| Provide a hydrogeological assessment that demonstrates how the water balance will be maintained as part of the subdivision or SWM design and confirm compensation/mitigation measures. | |
| Provide hydrological and hydraulic modeling analysis in accordance with Checklist 4 and incorporate results into the design. Refer to file Manager Process. | |
| If outlet is to a natural watercourse, conduct fluvial geomorphic study to identify the threshold erosion velocity. Conduct continuous simulation modelling to evaluate potential impact to the watercourse from the new development and identify mitigation measures. | |
| Identify and demonstrate available capacity in the receiving storm/drainage and SWM system, all in accordance with City design standards. | |
| Identify minor/major system catchments and dedicated major overland flow routes. Drawings to show catchment area boundaries for the minor and major systems, including all external areas. | |

## Stormwater Engineering Checklist

| TASK (Checklist 1) | Complete? (Y, N, N/A) |
|---|---|
| Review and ensure compliance with the Regulatory Floodplain, hazardous slope lines, fill regulations and new storm outlet requirements associated with the UTRCA approvals. Identify any deviation and additional mitigation measures required. | |
| Note: Refer to Checklist 3 if Low Impact Development (LID) design elements are included. | |
| **Engineering (Detailed Design) Submission** | |
| Confirm the revised/updated design studies are provided as part of the 1st engineering submission. | |
| Confirm that the results and recommendations established through the water balance assessment are incorporated into the overall stormwater management plan for the development. | |
| Where applicable, provide design input and calculations to consider site specific engineering/ecological challenges, including but not limited to, energy dissipation, or assessment of how stormwater may impact environmentally sensitive areas from a terrestrial or aquatic perspective. | |
| Confirm ponding elevations, provide calculations and conveyance routes for the major storm event overland flow routes. Identify traffic calming measures and indicate any interference with overland flow route. | |
| Design the proposed storm/drainage works to service the total catchment area of the development, all to the satisfaction of the City. | |
| Identify implementation triggers such as construction phasing and interim measures. | |
| Provide georeferenced shapefiles identifying the minor and major system subcatchments and dedicated major system overland flow route. | |
| Develop and finalize the Sediment Erosion Control plan (SEC) in accordance with the City, federal and provincial requirements unless part of site alteration agreement. | |
| Confirm and finalize operational and maintenance requirements for any standard and non-standard proposed SWM systems. | |
| Confirm and finalize monitoring requirements (if applicable) for all proposed SWM systems. | |

## Stormwater Engineering Checklist

| TASK (Checklist 1) | Complete? (Y, N, N/A) |
|---|---|
| Submit a Monitoring and Operational Procedure Manual outlining the maintenance and monitoring program for each of the SWM Facilities or measures within this plan, in accordance with the City's "Monitoring and Operational Procedures for Stormwater Management Facilities" and Section and Environmental Management Guidelines (2021) | |
| **Other Site Specific Considerations as Identified by the Consultant:** | |

I confirm that I reviewed and completed the above checklist in relation to the application being submitted.

Signature

**Checklist 2 Site Plan Application, Stormwater Engineering Checklist**

| TASK (Checklist 2) | Complete? (Y, N, N/A) |
|---|---|
| Identify and Review previously completed studies (Municipal Class EAs, subwatershed study requirements, Functional and Detailed Design Reports, Geotechnical, Hydrogeological, EIS, drawings etc.) and identify how the proposed design meets all applicable stormwater design targets. Note any deviations in the proposed approach from previous studies with a supporting rationale for the change. | |
| Confirm that the proposed land use is consistent with the SWM quality, quantity/flood, steam morphology control, baseflow augmentation, infiltration, groundwater recharge/discharge and NHS requirements for the SWM facility and identify any deviation and additional mitigation measures required. | |
| Finalize minor and major catchment areas boundaries including all external areas. Identify any deviations to the area or runoff coefficient in relation to the Functional Report, drawings, etc. and confirm that the proposed site plan servicing meets all stormwater targets and requirements. | |
| Review and confirm available outlet capacity in the receiving storm/drainage and SWM system. | |
| Finalize review and design of the proposed minor/major system & Best Management Practices | |
| If a hydrogeological assessment is requested at the pre-consultation stage. Refer to Checklist 4 for scoping and requirements. | |
| Develop and finalize the Sediment Erosion Control plan (SEC) in accordance with the DFO, Applicable Conservation Authorities, City and provincial requirements (this plan must be finalized and accepted by the City prior to any development activity being approved on the subject lands) | |
| Review and ensure compliance with Flood Plain Lines, storages, hazardous slope lines, fill regulations and new storm outlet requirements associated with the appropriate Conservation Authority approvals | |
| Review and ensure compliance with all applicable acts, standards, polices and requirements of the DFO, MECP, MNRF, Applicable Conservation Authority and City | |
| Other Site Specific Considerations as Identified by the Consultant: | |

I confirm that I reviewed and completed the above checklist in relation to the application being submitted.

Signature

**Checklist 3 Low Impact Development Design Checklist**

| TASK (Checklist 3) | Complete? (Y, N, N/A) |
|---|---|
| Confirm seasonal high groundwater levels of the site to an appropriate level of detail. For the hydrogeological assessment checklist, see Checklist 4. | |
| Consult Stormwater Design Standards for municipally accepted LIDs based on the Screening Tool provided in Section 6.5.2.2. | |
| Evaluate insitu percolation rates/ infiltration rates at proposed LID locations. | |
| Review recent design guidance documents for Low Impact Development systems, including Credit Valley Conservation Authority, Toronto and Region Conservation Authority, Sustainable Technologies Evaluation Program, or other reputable source. | |
| Demonstrate how the stormwater design criteria are met through LIDs (quantity, quality or erosion) or identify the level of service that is being provided. | |
| Identify an overflow outlet for the proposed system (if required). | |
| Develop an Operations and Maintenance detailed manual for the proposed system(s). | |
| For works to service new subdivisions, consult the Development Charges by-law for any applicable subsidies. | |
| For site plans, consult the latest Wastewater and Stormwater By-law for potential reductions to the City's monthly stormwater charges. | |
| Provide a finalized georeferenced shapefiles identifying the minor system subcatchments associated with each LID system. | |
| Other Site Specific Considerations as Identified by the Consultant: | |

I confirm that I reviewed and completed the above checklist in relation to the application being submitted.

Signature

**Checklist 4 Hydrogeology Assessment Checklist**

| TASK (Checklist 4) | Complete? (Y, N, N/A) |
|---|---|
| Acknowledge that prior to undertaking this assessment, the City's Hydrogeologist Engineer was contacted regarding scope and requirements of the report. | |
| Meeting notes from the scoping meeting are appended to the submitted Hydrogeology Assessment. | |
| Site location and description of development, including planned servicing for the site. | |
| Description and mapping of relevant site features, including topography and surface water drainage, physiography, regional overburden and bedrock geology, regional hydrogeology, and proximity to nearby natural heritage features (e.g., stream, ponds, wetlands, woodlots, etc.). Consideration should be given if the site falls within Highly Vulnerable Aquifers (HVAs) and/or Significant Groundwater Recharge Areas (SGRAs), as defined in the Thames - Sydenham & Region Source Water Protection Plan. | |
| Description and mapping of field activities completed as part of the assessment (e.g., advancement of boreholes, installation of monitoring wells, advancement of test pits, installation of piezometers, etc.). | |
| Description of the relevant site hydrogeological information, including aquifer properties (e.g., hydraulic conductivity), static groundwater levels, groundwater flow direction, groundwater gradients, etc. Note that if Low Impact Development (LID) measures are being considered for the site, seasonal fluctuations in water levels must be considered. | |
| Description of water quality characteristics (groundwater and surface water). | |
| Evaluation of potential domestic wells, in the area if the proposed development. In some cases, a door-to-door domestic well survey may be required. | |
| Evaluation of potential water takings required to support construction activities. This should include a summary of anticipated servicing depths, anticipated pumping rates, discharge locations, and erosion and sediment control (ESC) measures to be implemented during construction. | |

## Stormwater Engineering Checklist

| TASK (Checklist 4) | Complete? (Y, N, N/A) |
|---|---|
| Evaluation of the potential impact from the development to the natural environment including impacts on groundwater levels, water quality (groundwater and surface water), groundwater baseflow, etc. Both short-term (e.g., construction) and long-term impacts should be considered. If LID measures are being considered, an evaluation of the anticipated performance of the system(s) as it relates to the hydrogeological environment will be required. | |
| Evaluation of the potential interaction between below grade structures (e.g., basement foundations, underground parking structures, etc.) within the development and seasonal groundwater table fluctuations. Recommendations for mitigation measures (e.g., final basement elevations, foundation drain elevations, etc.) within the development should be provided to reduce basement flooding potential or frequent sump pump operation. | |
| Completion of a water balance for the site, as per Section 6.3.2 of the design standards. For sites located adjacent to sensitive natural features, the water balance should consider baseflow requirements of downstream receptors, and ensure they are maintained in the post development scenario. | |
| Evaluation of mitigation measures to be implemented at the site. Mitigation measures should be used to minimize potential impacts groundwater and surface water resources, and potential receptors. Consideration should be given to maintaining infiltration and groundwater recharge (as practical), and maintaining overall water quality. | |
| Evaluation of monitoring and contingency plans, as necessary. | |
| Other Site Specific Considerations as Identified by the Consultant: | |
| Identify any abandoned wells in this plan. | |
| Any fill required in the plan. | |
| Provide recommendations regarding soil conditions and fill needs in the location of any existing watercourses or bodies of water on the site. | |

I confirm that I reviewed and completed the above checklist in relation to the application being submitted.

Signature

**Checklist 5 Site Alteration Application, Stormwater Engineering Checklist**

| TASK (Checklist 5) | Complete? (Y, N, N/A) |
|---|---|
| Incorporate appropriate erosion and sediment control measures on all ESC plans and drawings, ensuring compliance with OPSS.MUNI 805 specifications for Temporary Erosion and Sediment Control Measures, unless otherwise specified. | |
| Ensure the ESC plan and associated notes are complete and comprehensive. ESC plan and notes to be provided per Table 10.1, and section 10.8. | |
| Site Alteration Report: outlining at minimum but not limited to erosion risk assessment, cut/fill information, sediment basin calculations, swale calculations and any other information the applicant deems required to provide for this application. Note, SWED may request additional information on site specific conditions and requirements as necessary. | |
| Engineering Drawings: At a minimum but not limited to a Grading Plan, Erosion and Sediment Control Plan and a Cut/Fill plan. Note, SWED may request additional drawings and information on site specific conditions and requirements as necessary. | |
| Acknowledge that all regulatory authorities (DFO, MNR, MECP, UTRCA and KCCA) have been contacted as applicable. | |
| Confirm that site alteration design has been reviewed with regards to natural heritage features, adjacent properties, and drainage patterns | |
| Confirm that the ESC design will prevent the pollution to the watercourses | |
| Other Site-Specific Considerations as Identified by the Consultant: | |

I confirm that I reviewed and completed the above checklist in relation to the application being submitted.

Signature

## 6.13 Stormwater Figures

**Figure 6.1 Twin Perforated Pipe Infiltration System**

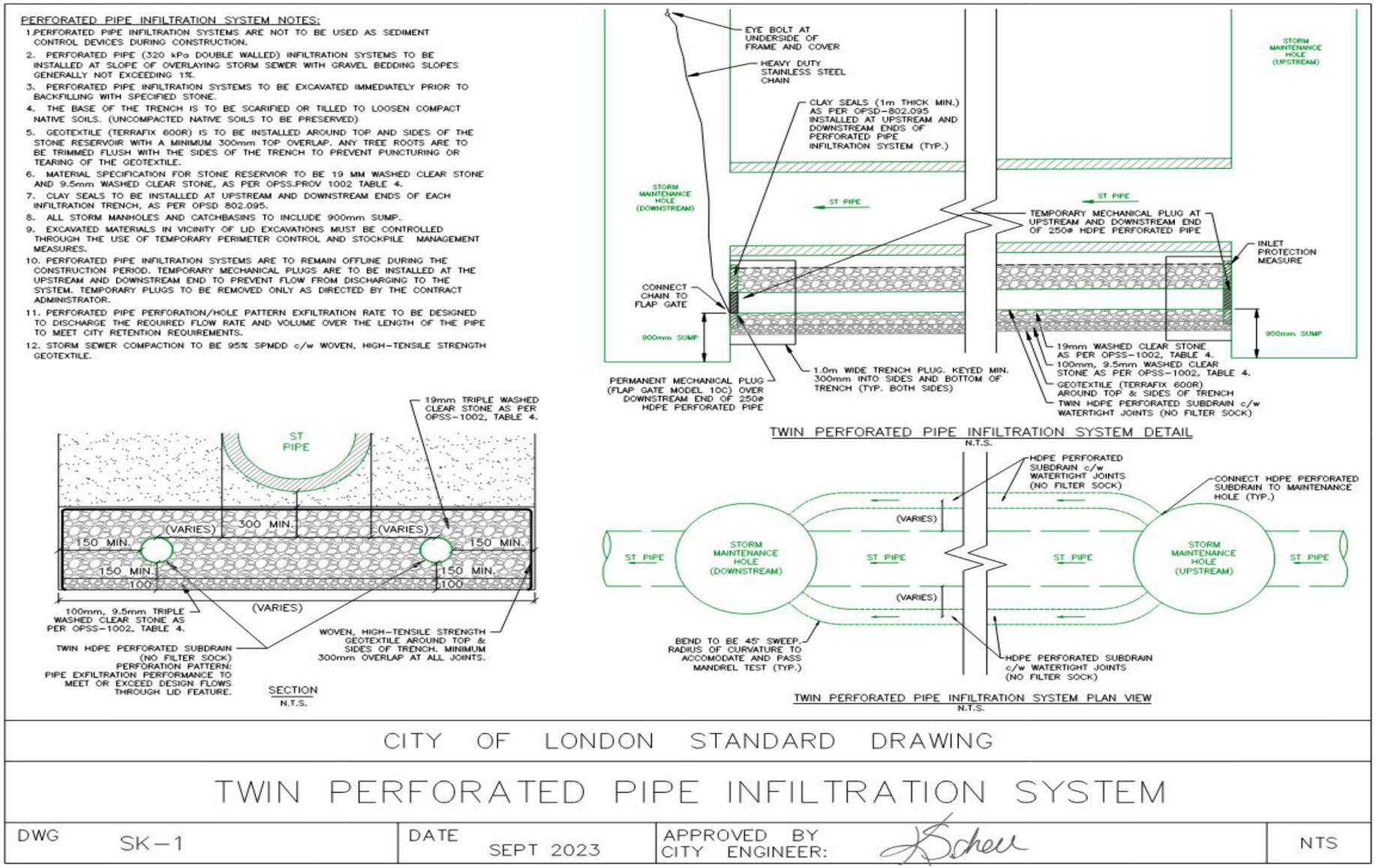


**Figure 6.2 Bioswale Adjacent to Pedestrian Path**

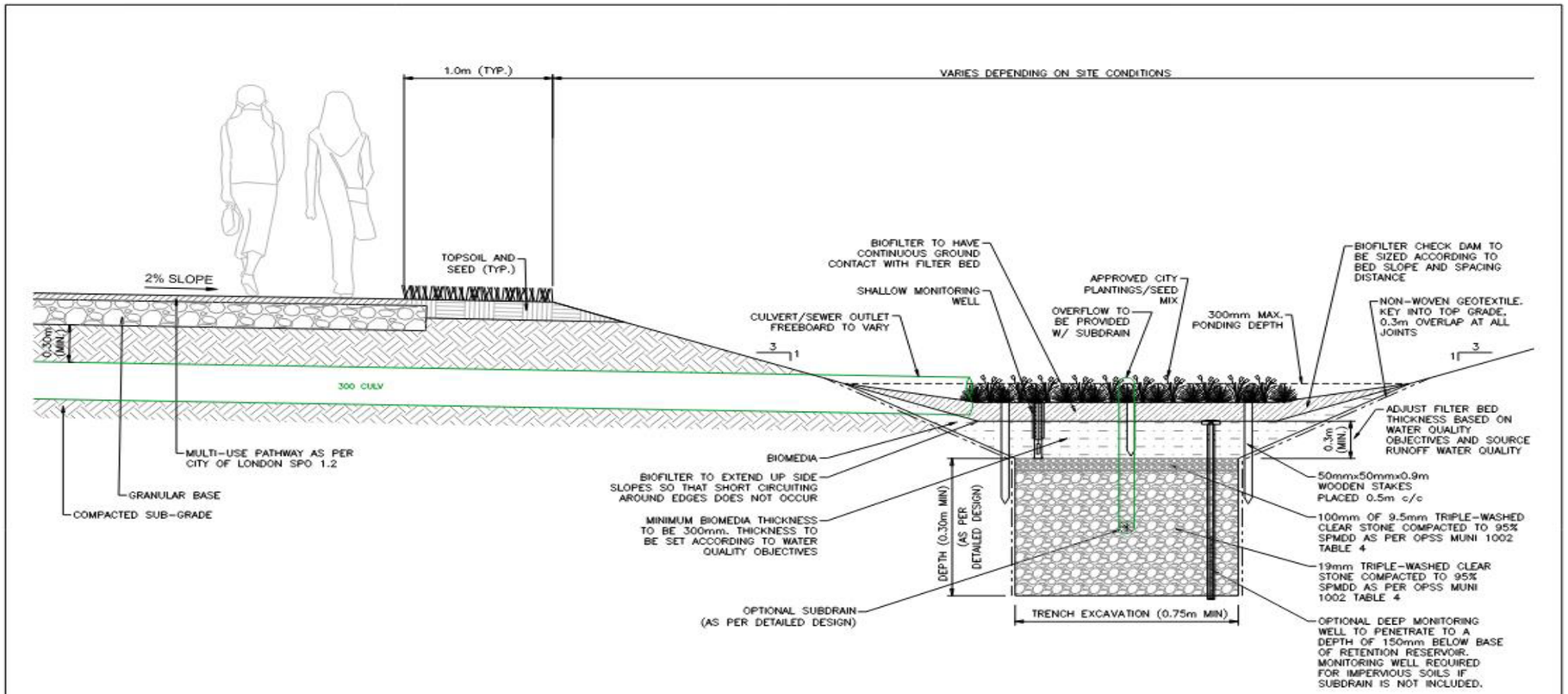


**Figure 6.3 Plan View Typical Conceptual Facility Design Wet/Dry/Hybrid**

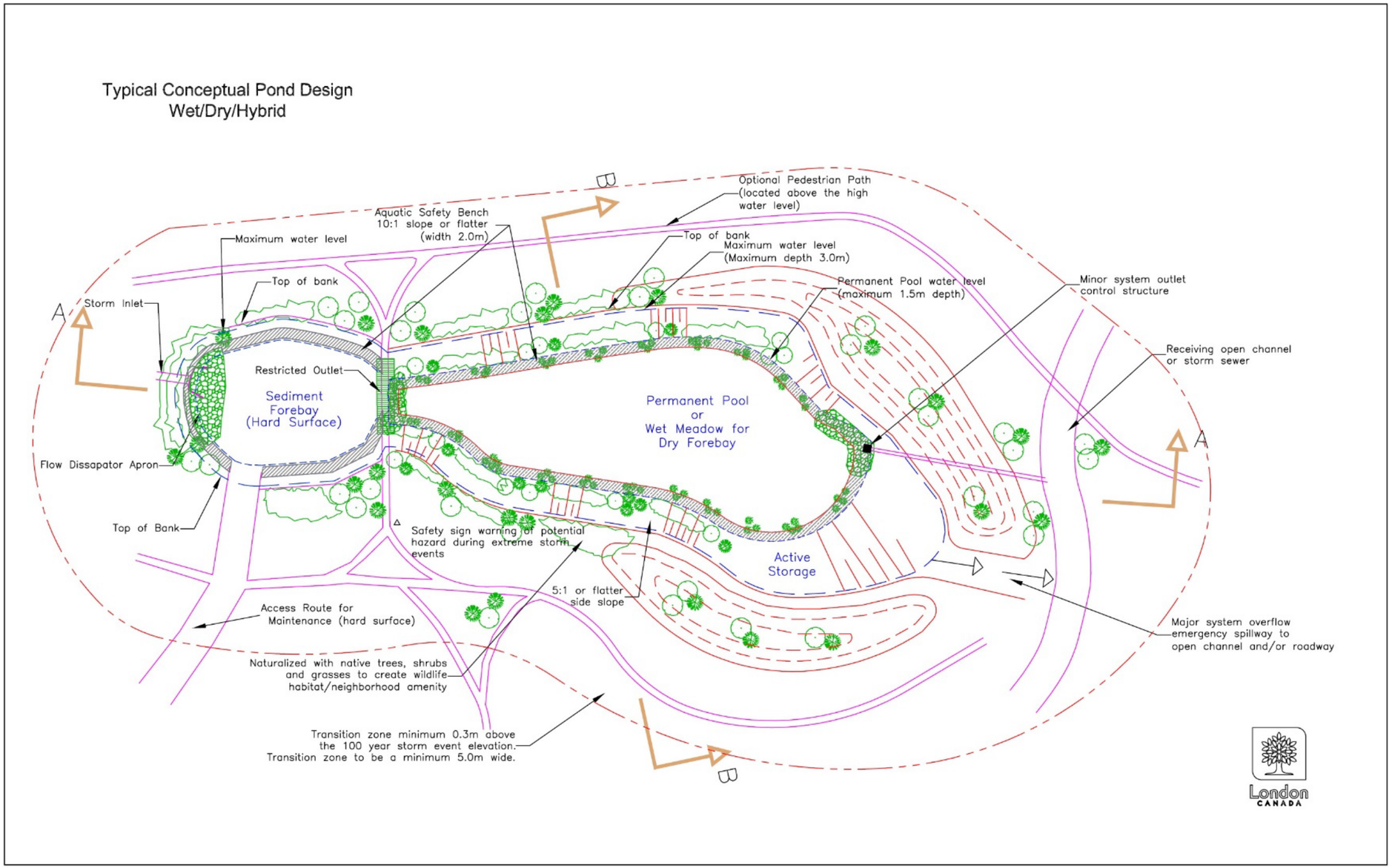


**Figure 6.4 Sectional Views of Typical Conceptual Facility Design Wet/Dry/Hybrid**

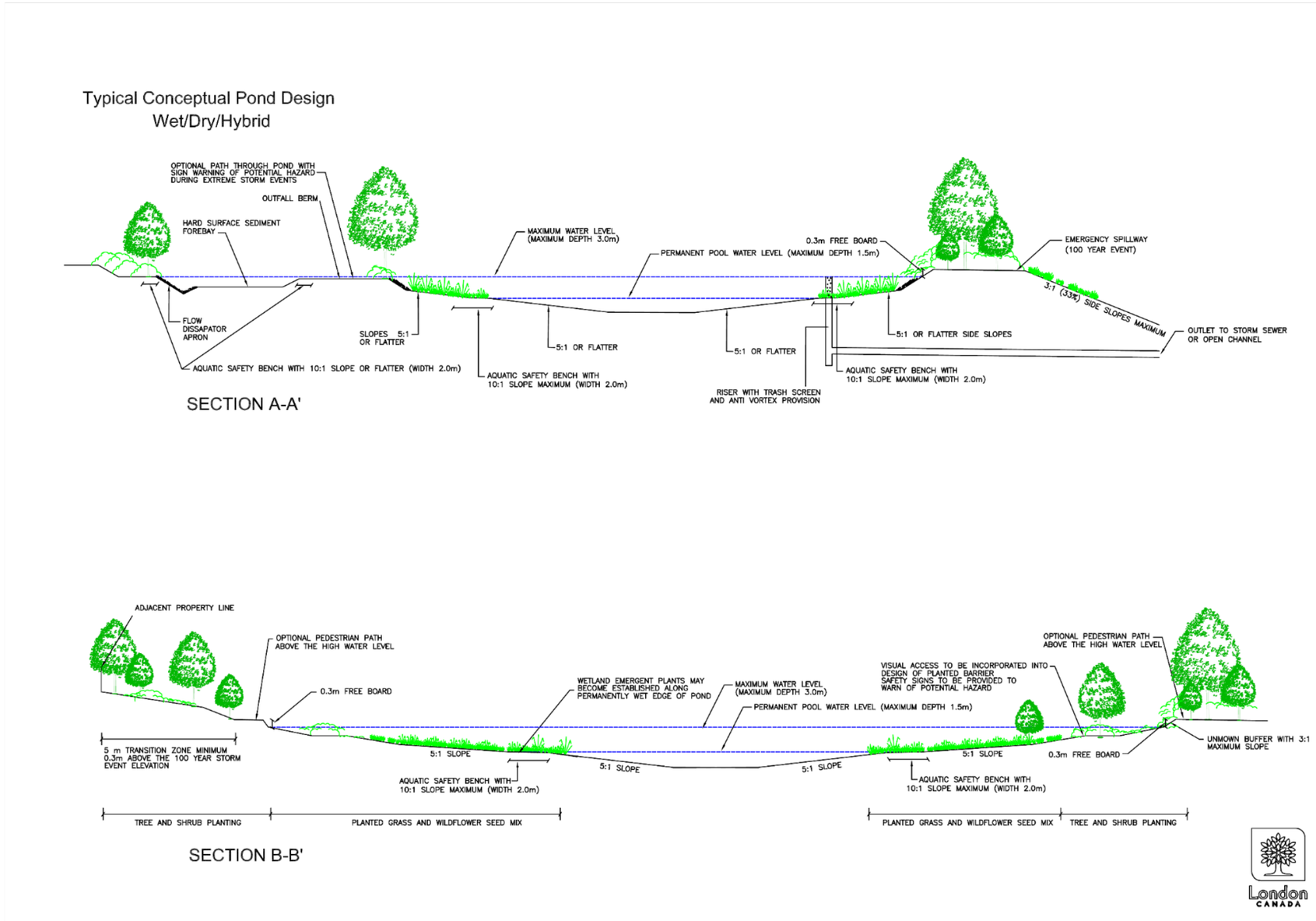
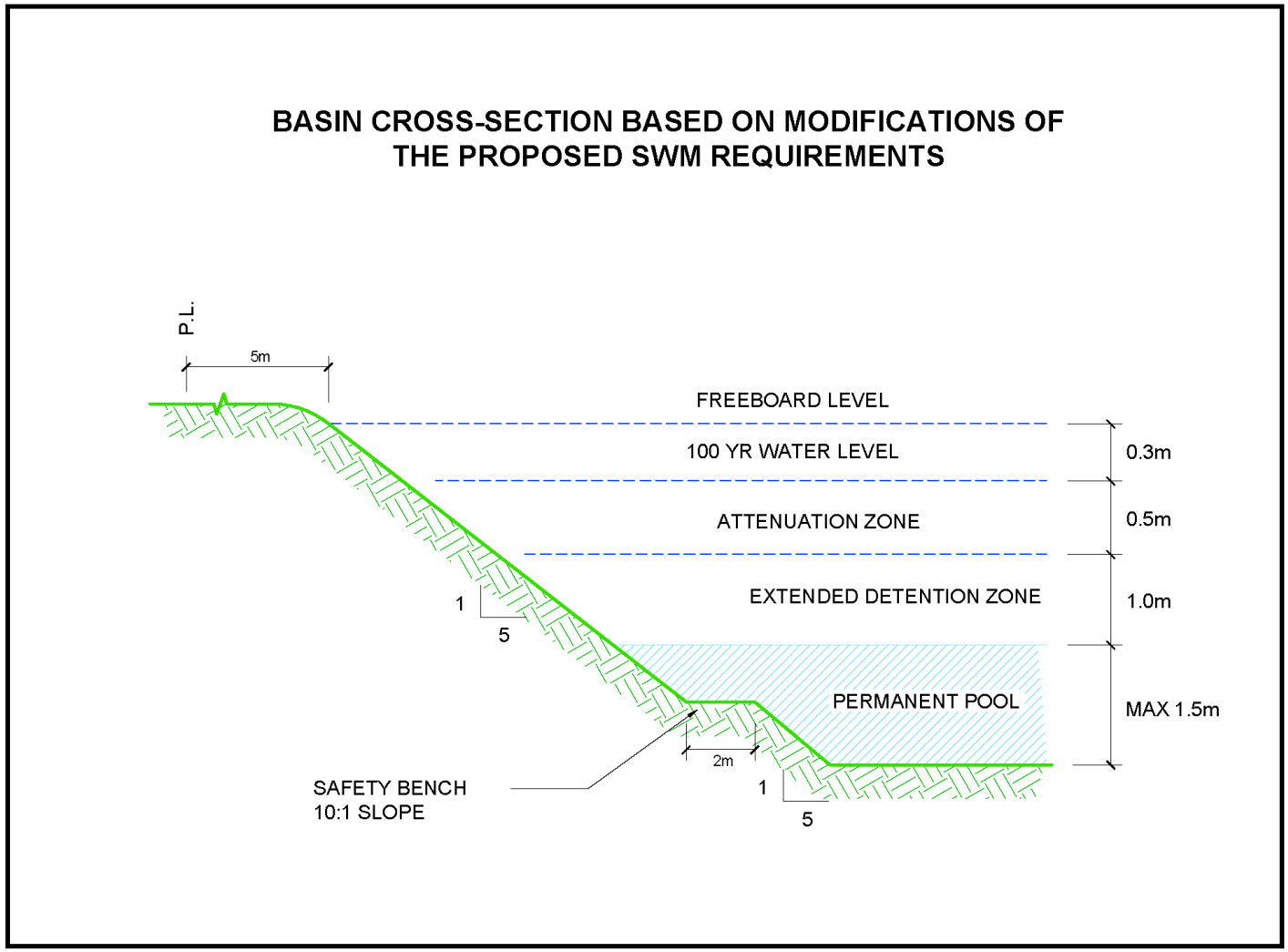
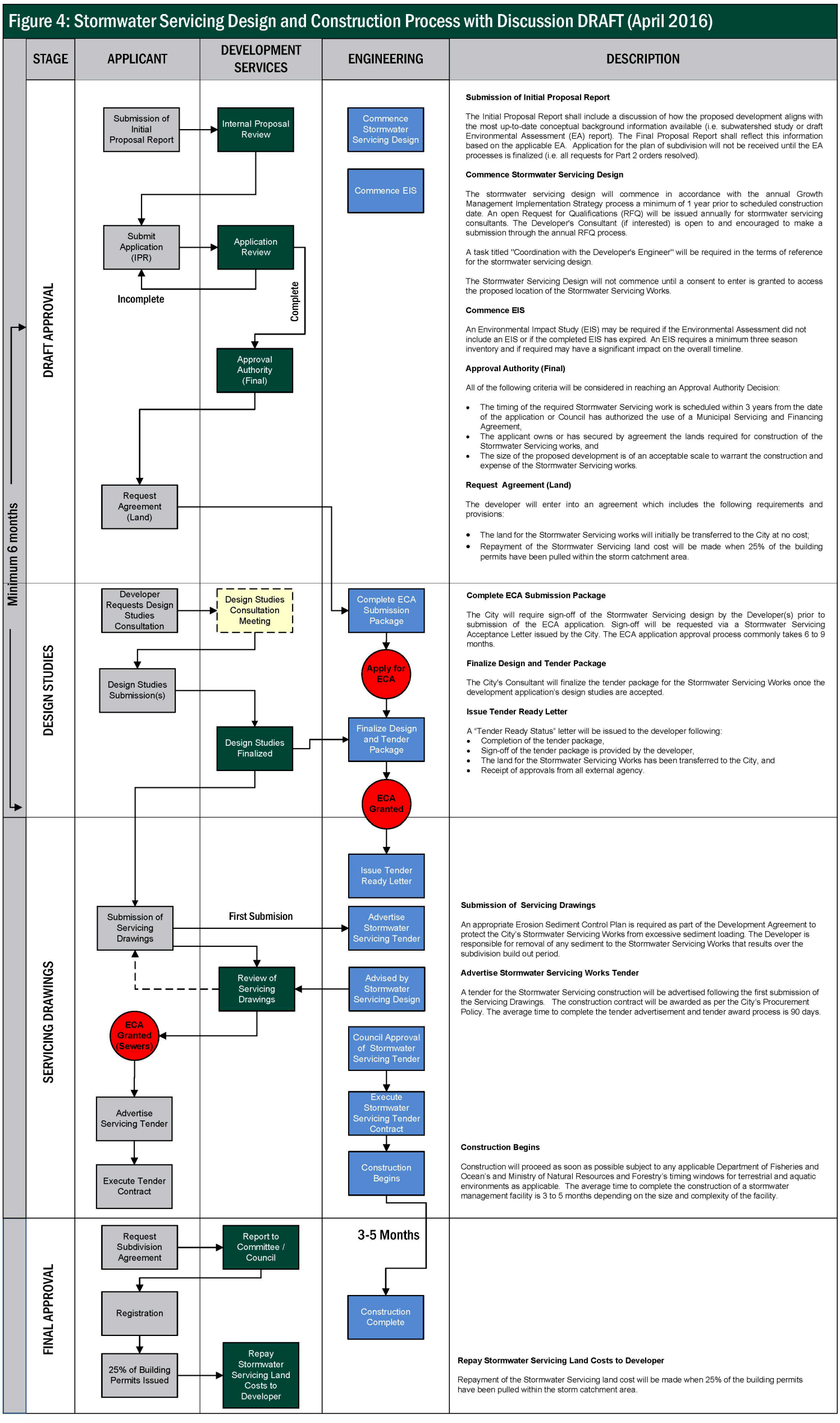


**Figure 6.5 Basin Cross-Section Based on Modification of the Proposed SWM Requirements**



## Figure 6.6 SWM Design and Construction Process with Discussion



## 6.14 LID Planting List

**Table 6.7 Low Impact Development Suggested Planting List to Achieve Desired Aesthetic**

| **Species**<br>**Scientific Name**<br>(Common Name) | **Soil Type Preference**<br>S = Sand<br>L = Loam<br>C = Clay | **Soil Moisture**<br>D = Dry<br>M = Moist<br>W = Wet | **Exposure**<br>Sun /<br>Part Shade /<br>Shade | **Drought Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Salt Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Height or Spread**<br>(metres) | **Native**<br>Yes / No | **Additional Information, Aesthetic Attributes and Other Notes** | **Local Street Landscaped** | **Local Street Naturalized** | **Major Road Landscaped** | **Major Road Meadow** | **Urban Centre Landscaped** | **Park Landscaped** | **Park Naturalized** | **Park Meadow** | **Residential Landscaped** | **Top Pick** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nurse Crops** | | | | | | | | | | | | | | | | | | |
| **Avena sativa**<br>(Cultivated Oat) | SLC | M | Sun | H | H | 0.4 - 0.6 | No | Nurse crop for soil stabilization. | | | | | | | | | | |
| **Lolium multiflorum**<br>(Annual Ryegrass) | Variable | Variable | Sun / Part Shade | H | H | 0.4 - 0.5 | No | Low-growing cool season meadow grass. Nurse Crop for soil stabilization; considered minimally invasive - to be controlled if necessary and limit spread to other areas. | | | | | | | | | X | |
| **Graminoids** | | | | | | | | | | | | | | | | | | |
| **Andropogon gerardii**<br>(Big Bluestem) | SLC | WM-MD | Sun | H | M | 0.45 - 0.7 | Yes | Turkey-foot shaped head, very tall. Grows in clumps, sod-forming. Suitable for planters. | X | X | X | X | X | X | X | X | | |
| **Carex atherodes**<br>(Awned Sedge) | LC | W | Sun | M | M | 0.5 - 0.6 | Yes | Dark green, robust forming solid stands. Grows in wet areas and along base of slopes. | | X | | X | | | X | X | X | X |
| **Carex bebbii**<br>(Bebb's Sedge) | SLC | W-M | Sun | L-M | M | 0.3 | Yes | Small spiky plant with small but attractive seed heads. | | X | | X | | | X | X | X | X |
| **Carex morrowii**<br>(Japanese Sedge) | SL | W-M | Sun / Part Shade | L-M | M | 0.3 - 0.6 | No | Effective accent for smaller gardens. Grows well in the shade of a tree. | X | | X | | X | X | | | X | |
| **Carex pensylvanica**<br>(Pennsylvania Sedge) | SL | D | Part Shade | M-H | M | 0.15 - 0.3 | Yes | Delicate foliage forms low mound. Spreads rapidly; sod-forming in full sun. | X | X | X | X | X | X | | X | X | X |
| **Carex vulpinoidea**<br>(Fox Sedge) | SLC | W-M | Sun | L-M | M | 0.4 - 0.5 | Yes | Brown-yellow upright seed heads in mid-summer. Grows in clumps; highly suitable. | | X | X | X | | X | X | X | X | X |
| **Deschampsia cespitosa**<br>(Tufted Hairgrass) | SLC | D | Part Shade | M-H | M-H | 0.2 - 0.3 | Yes | Very fine texture, evergreen. Grows in clumps. | X | | X | | X | X | | | X | |
| **Elymus canadensis**<br>(Canada Wild-rye) | SLC | M-MD | Sun | M-H | H | 0.6 - 0.9 | Yes | Attractive drooping seed heads. Individual plants do not persist but does self-seed. | | X | | X | | | X | X | | |

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| **Elymus riparius**<br>(River Wild-rye) | SL | M | Sun / Part Shade | M | M | 0.6 - 0.75 | Yes | Attractive drooping seed heads. Highly suitable; individual plants do not persist but does self-seed. | | X | | X | | | X | X | | |
| **Elymus virginicus var. virginicus**<br>(Virginia Wild-rye) | SLC | W-M | Sun / Part Shade | M | M | 0.6 - 0.75 | Yes | Attractive upright seed heads. Highly suitable; will grow more robust in full sun; clumping. | | X | | X | | | X | X | | |
| **Festuca spp.**<br>(Fescue species.) | SL | M-D | Sun / Part Shade | H | M-H | 0.2 - 0.25 | No | Low-growing, fine-textured, dense mix that does not need to be mowed as a replacement to traditional turf grass. Proprietary fescue mixes are created for seeding, with very few inputs required; commercially available blends for the region include 'Eco-Lawn' by Wildflower Farm. Not to be mowed more than once a month. Some fescues can be mildly invasive. Seek more information prior to use. | X | | X | X | X | X | | X | X | |
| **Juncus tenuis**<br>(Path Rush) | SLC | M | Sun / Part Shade | M | H | 0.15 - 0.6 | Yes | Somewhat small and inconspicuous. Highly suitable; more drought tolerant than other rushes. | X | | X | X | | | | | | |
| **Schizachyrium scoparium**<br>(Little Bluestem) | S | D | Sun | H | M-H | 0.6 - 0.9 | Yes | Blue summer colour, reddish fall colour stems remain upright during winter. Clump forming; best on poor, dry soil to avoid being outcompeted. Sometimes difficult to establish. | X | X | X | X | X | X | X | X | X | |
| **Sporobolus neglectus**<br>(Small Dropseed) | SL | MD-D | Sun | H | H | 0.15 - 0.25 | Yes | Distinctive when mass-planted on dry soils. Develops late in growing season; self-seeds. | | X | | X | | | X | X | X | X |
| **Sporobolus heterolepsis**<br>(Prairie Dropseed) | SL | MD | Sun | H | M-H | 1 | Yes | Fine, green leaves take on orange hues in the fall. Warm season, clumping grass | X | X | X | X | X | X | X | X | | |

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| **Broadleaf Herbaceous & Ferns** | | | | | | | | | | | | | | | | | | |
| **Achillea millefolium ssp. Lanulosa**<br>(Common Yarrow) | SL | MD | Sun | M-H | M | 0.6 x 0.6 (Spread) | Yes | Flat-topped white flowers, feathery foliage. Highly suitable; naturalizes readily in disturbed areas. | X | X | X | X | | X | X | X | | |
| **Aquilegia canadensis**<br>(Wild Columbine) | SLC | M | Sun / Part Shade | M | M | 0.6 - 0.9 | Yes | Red pendulous flowers. Suitable for nutrient-poor, low competition situations; habitat value for butterflies & hummingbirds; self sows; easy to maintain once established. | X | X | X | X | X | X | X | X | | |
| **Armeria maritima 'Dusseldorf Pride'**<br>(Dusseldorf Pride Sea Thrift) | SLC | M-D | Sun | H | H | 0.1 - 0.15 | Yes | Blooms mid-Spring to early-Summer; deep pink. Ornamental plantings only. | X | | | | X | | | | X | |
| **Asclepias incarnata ssp. Incarnata**<br>(Swamp Milkweed) | SLC | W | Sun | M | M | 0.9 - 1.2 | Yes | Deep pink flower in summer. Highly suitable; spreads rapidly. | | X | | X | | | X | X | | |
| **Asclepias tuberosa**<br>(Butterfly Milkweed) | SLC | M-D | Sun | M-H | M-H | 0.6 - 0.9 | Yes | Orange summer flower. Young plants transplant easily, mature plants difficult to move; does not tolerate wet soil. | X | X | X | X | X | X | X | X | X | X |
| **Athyrium filix-femina**<br>(Lady Fern) | SLC | MW | Part Shade | M | M | 0.6 - 1.2 | Yes | Shelter from wind to protect fonds from breaking. | X | X | | | X | X | X | | | |
| **Dryopteris marginalis**<br>(Marginal Shield Fern) | LC | DMW | Part Shade | MH | L | 0.6 | Yes | Evergreen | X | X | | | X | X | X | X | | |
| **Euthamia graminifolia**<br>(Flat-top Goldentop) | SLC | WM-M | Sun / Part Shade | M-H | M | 0.7 - 0.8 | Yes | Clusters of showy yellow flowers in fall. Highly suitable; spreading by root system, can be aggressive in moist sunny locations. | | X | | X | | | X | X | | |
| **Fragaria virginiana ssp. Virginiana**<br>(Common Strawberry) | SLC | M-D | Sun / Part Shade | M | M | 0.15 - 0.6 | Yes | Small white flowers, small red strawberries in summer. Highly suitable; spreads rapidly in spring and fall by runners; important food source for insects, birds, & animals. | X | X | X | X | | X | X | X | X | |

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| **Geum triflorum**<br>(Prairie Smoke) | SL | M-MD | Sun | H | M | 0.25 - 0.3 | Yes | Pink flowers in spring, followed by development of hairy 'tails' giving smoky appearance. Poor soils and gravels; seasonally moist; dislikes strong competition. | X | X | X | X | X | X | X | X | X | X |
| **Hemerocallis 'Stephanie Returns'**<br>(Daylily) | SLC | M-W | Sun / Part Shade | H | H | 0.45 - 0.6 | No | A short but plentiful purple, pink, yellowish blossom is produced. Can survive harsh conditions such as pollution, slopes and salted areas. | X | | X | | X | X | | | X | X |
| **Hosta spp.**<br>(Hosta (many varieties)) | Variable | Variable | Dependent upon variety | M | M | Dependent upon variety | No | One of the most distinctive perennials due to form and leaf size. Many varieties are available; ranging in size, colour, and preferences for soil and moisture. | X | | X | | X | X | | | X | |
| **Hydrophyllum virginianum**<br>(John's Cabbage / Virginia Waterleaf) | L | M | Sun / Part Shade | M | M | 0.25 - 0.4 | No | Cut-leaved, densely growing with white flowers. Highly suitable; outcompetes invasives such as Garlic Mustard. | | | | X | | | X | X | | |
| **Iris sibirica**<br>(Ruffled Velvet Siberian Iris) | SL | W-M | Sun | M | M | 0.6 - 1 | No | Beardless Dutch Iris-like, with rich purple blooms. Used to simulate water in dry streambeds or around landscape boulders. | X | | X | | X | X | | | X | |
| **Iris versicolor**<br>(Blue Flag Iris) | LC | M-W | Sun | M | L | 0.9 - 1.25 | Yes | | X | X | | | X | X | X | X | X | |
| **Lespedeza capitata**<br>(Round-head Bush-clover) | SL | M-D | Sun / Part Shade | M-H | H | 0.6 | No | Tall spike of yellowish flowers. Grows easily from seed; adds nitrogen to soil. | | X | | X | | | X | X | | |
| **Leucanthemum x superbum**<br>(Shasta Daisy) | SLC | M-D | Sun | H | M | 0.75 - 0.9 | No | White double daisy-like flowers. | X | | | | X | X | | | X | |
| **Liatris cylindracea Michx.**<br>(Barrelhead Blazing Star) | SL | D | Sun | H | M | 0.6 | Yes | Magenta-purple flowerheads. Attracts butterflies and birds. Special value to bumble bees. | X | X | X | | X | X | X | X | X | |
| **Liatris aspera**<br>(Rough Blazing Star) | | | Sun | H | M | 0.45 | Yes | | X | X | X | | X | X | X | X | X | X |

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| **Liatris ligulistylis** (Rocky Mountain Blazing Star) | | | Sun | H | M | 0.7 | Yes | | X | X | X | X | X | X | X | X | | |
| **Monarda fistulosa** (Wild Bergamot Bee-balm) | SLC | WM-D | Sun | M-H | M-H | 0.6 - 1.2 | Yes | Lavender flowers, many cultivars available. Easy to grow from seed; spreading. Soil depth should be >15cm. | | X | X | X | | X | X | X | X | X |
| **Penstemon digitalis** (Foxglove Beardtongue) | SLC | M-D | Sun | M-H | M-H | 0.75 - 0.9 | Yes | White flowers May-June. Easily grown from seed; readily self-sows. | X | X | X | X | X | X | X | X | | |
| **Penstemon hirsutus** (Hairy beardtongue) | SLC | M-D | Sun / Part Shade | H | | 0.5 | Yes | Pink flowers May. Easily grown from seed; readily self-sows. | X | X | X | X | X | X | X | X | | |
| **Rudbeckia fulgida** (Orange Coneflower) | SLC | M-MD | Sun | H | | 0.3 - 0.9 | No | Golden daisy flower June-October, typical cultivar: 'Goldstrum'. Very drought-tolerant; attractive to bees, butterflies and/or birds; self-sows freely; deadhead if you do not want volunteer seedlings. | X | X | X | X | X | X | X | X | X | |
| **Sisyrinchium montanum** (Strict Blue-eyed-grass) | SLC | W-M | Sun | M | M | 0.1 - 0.15 | Yes | Bright blue flowers in spring. Self-seeds once established; tolerates inundation. | X | X | | | X | X | | | | |
| **Solidago flexicaulis** (Zig-zag Goldenrod) | L | M | Sun / Part Shade | M | M-H | 0.3 - 0.5 | Yes | Showy golden flowers, finely fringed dark green leaves. Highly suitable; endures conditions of difficult urban sites. | X | X | X | X | X | X | X | X | | |
| **Solidago nemoralis ssp. Nemoralis** (Grey Goldenrod) | S | D | Sun / Part Shade | M | H | 0.3 - 0.4 | Yes | Large upright yellow flower cluster in late summer/fall. Highly suitable on less fertile soils; forms colonies. | | X | | X | | | X | X | | |
| **Solidago ptarmicoides (Oligoneuron album)** (Prairie Goldenrod) | S | MD-D | Sun | H | M | 0.15 - 0.3 | Yes | White flowers in late summer, compact rosettes. Grow from seed or install as plugs; tolerates short term inundation if drainage is good. | | X | | X | | X | X | X | | |
| **Solidago rugosa 'Fireworks'** (Fireworks Goldenrod) | SL | MD-D | Sun / Part Shade | M | M | 1 | Yes | Wands of yellow bloom. Well behaved Strong, upright stems | X | | X | X | X | X | | X | | |

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| **Solidago sphacelatum 'Golden Fleece'**<br>(Golden Fleece Goldenrod) | SL | MD-D | Sun / Part Shade | M | M | 0.45 | Yes | Compact and well behaved For mass planting | X | | X | X | X | X | | X | X | |
| **Solidago x LITTLE LEMON 'Dansolitlem'**<br>(Dwarf Goldenrod) | SL | MD-D | Sun / Part Shade | M | M | 0.35 | No | Compact and well behaved Finely textured green leaves | X | | X | | X | X | | | | |
| **Symphyotrichum cordifolium**<br>(Heart-leaved Aster) | SLC | D | Part Shade | M-H | M-H | 0.25 - 0.45 | Yes | White flowers in August, large heartshaped leaves. Highly suitable; forms colonies; excellent ground cover in partial shade. | X | X | X | X | X | X | X | X | | |
| **Symphyotrichum ericoides var. ericoides**<br>(White Heath Aster) | SLC | M-D | Sun | M | M-H | 0.6 | Yes | Blooms in August; profuse tiny white flowers. Highly suitable. | X | X | X | X | X | X | X | X | | |
| **Symphotrichum laeve 'BLUE AUTUMN 'Oudshoom1'**<br>(Blue Autumn Smooth Aster) | SLC | M-D | Sun | H | M-H | 0.6 | Yes | Compact selection, mounding habit Daisy-like flowers | X | | X | X | X | X | | X | X | |
| **Symphyotrichum lanceolatum ssp. Lanceolatum**<br>(Panicled Aster) | SLC | M | Sun / Part Shade | M | M-H | 0.75 | Yes | Profuse small white flowers, narrow leaves. Highly suitable; prefers soil which pools water then later dries out. | | X | X | X | | X | X | X | | |
| **Symphyotrichum oblongifolium 'October Skies'**<br>(Aromatic aster) | SL | MD | Sun / Part Shade | MH | M | 0.6 | No | Compact, long blooming, well behaved. Highly tolerant of drought and poor soils. Can be used as groundcover. | X | | X | | X | X | | X | | |
| **Symphyotrichum oolentangiense**<br>(Sky-blue Aster) | SL | D | Sun / Part Shade | M-H | M | 0.5 | Yes | Arrow-shaped leaves, deep blue flowers in late summer. Self-seeds; diversifies on poor soils; attracts butterflies. | X | X | X | X | | X | X | X | | |
| **Thalictrum pubescens**<br>(Tall Meadow-Rue) | SLC | W-M | Part Shade | M | M | 0.6 - 0.7 | Yes | Delicate rounded white flower clusters, very tall. Highly suitable. | | X | | X | | | X | X | | |
| **Verbena urticifolia**<br>(White Vervain) | SLC | M | Part Shade | H | M | 0.5 - 0.75 | Yes | Spikes of very small white or lavender flowers. Highly suitable, spreading, can be weedy, self-seeds. | X | X | X | X | X | X | X | X | | |

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| **Waldsteinia fragarioides**<br>(Barren Strawberry) | SLC | M-MD | Part Shade | M | M-H | 0.1 - 0.15 | Yes | Profuse yellow flowers on low, spreading strawberry-like plants. Tolerates drought once established. | X | X | X | X | X | X | X | X | | |
| **Zizia aurea**<br>(Common Alexanders) | SLC | WM-MD | Part Shade | M | M | 0.45 - 0.9 | Yes | Yellow flowers. Easy to grow & maintain. | | X | | | | | X | | X | |
| **Shrubs** | | | | | | | | | | | | | | | | | | |
| **Amelanchier canadensis 'Multi-stem'**<br>(Multi-Stem Shadblow Serviceberry) | SLC | W | Sun | M-H | H | 6 - 9 | Yes | Orange to red in the fall; White flower in the spring. | X | X | X | X | X | X | X | X | X | X |
| **Arctostaphylos uva-ursi**<br>(Bearberry) | SL | M-D | Sun / Part Shade | M-H | M-H | 0.15 - 0.3 | Yes | Evergreen small, dark-green, shiny leaves; small, white to pink flowers in spring, followed by red berries in late summer; red fall color. Highly suitable on green roofs; spreads slowly. Does well on gravelly substrates. | | | | | X | X | X | | | |
| **Aronia melanocarpa (Photinia melanocarpa)**<br>(Black Chokeberry) | SL | W-D | Sun / Part Shade | L-M | M-H | 0.9 - 2 | Yes | White flowers May-June, black berries in fall. Forms colonies. | | X | | X | | | X | X | | |
| **Cephalanthus occidentalis**<br>(Common Buttonbush) | SLC | W-M | Sun / Part Shade | M | M | 3 | Yes | White orb-like flowers in summer. Can form colonies. | | X | | X | | | X | X | X | |
| **Cornus foemina spp. Racemosa**<br>(Stiff Dogwood / Gray Dogwood) | SLC | M-D | Sun / Part Shade | M | M-H | 1.9 - 3 | Yes | White fruit, red fall colour. Highly suitable; tolerant of periodic short-term inundation; colony forming. | | X | | X | | X | X | X | X | X |
| **Hamamelis virginiana**<br>(Witch Hazel) | SLC | M-D | Sun / Part Shade | M | M-H | 3 - 6.5 | Yes | Fragrant, yellow flowers with strap-like, crumpled petals appear in the fall after leaf drop. | | X | | X | | X | X | X | | |
| **Hypericum kalmianum**<br>(Shrubby/Kalm St. Johns-wort) | S | W-M | Sun / Part Shade | M-H | H | 0.5 - 0.9 | Yes | Compact bush, yellow flowers in June-July. A shoreline species, good in gravel with periodic inundation. Ensure local seed sourcing. | X | X | X | X | X | X | X | X | X | X |

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| **Kerria japonica** (Japanese Rose) | L | M-MD | Sun / Part Shade | H | H | 1.2 | No | Yellow flowers late-spring to late summer. Suitable for mass plantings and borders in areas not adjacent to natural features. Plant only in root-restricted sites since it can spread through root suckers. | X | | X | | X | X | | | X | |
| **Lindera benzoin** (Spicebush) | SLC | M-W | Sun / Part Shade | M | M | 1.9 - 3 | Yes | Showy yellow flowers & fruit, fragrant leaves. Difficult to transplant. | | X | | X | | X | X | X | X | |
| **Mahonia repens** (Creeping Oregon Grape-Holly) | SLC | W-D | Sun / Part Shade | H | M-H | 0.45 - 0.6 | No | Deep yellow flowers appear in the spring, with small clusters of grape-like berries. Excellent evergreen ground cover for sunny areas. | | | | | | | | | | |
| **Physocarpus opulifolius** (Eastern Ninebark) | SLC | W-D | Sun / Part Shade | M-H | H | 1.5 - 2.4 | Yes | Lobed leaves, peculiar shredded bark, whitish flowers, drooping clusters of inflated fruits, arching habit. Easy to cultivate; very adaptable; use local genotypes as cultivars are commonly grown. | | X | | X | | | X | X | | |
| **Potentilla fruticosa (Dasifora floribunda)** (Shrubby Cinquefoil) | SLC | W-D | Sun / Part Shade | M-H | M | 0.5 - 1 | Yes | Abundant yellow flowers. Attracts pollinators. CAUTION: only use the native species for natural areas (there are a few nurseries that supply it); European varieties appropriate for ornamental settings. | X | | X | | X | X | | | X | X |
| **Prunus pensylvanica** (Pin Cherry) | SLC | M-D | Sun | M-H | M | 1.9 - 5 | Yes | White flowers, red berries, reddish bark. | | X | | | | | | X | | |
| **Rhus aromatica** (Fragrant Sumac) | SL | M-D | Sun / Part Shade | M-H | M | 0.9 - 2 | Yes | Red fruit, aromatic leaves. Colony forming; smaller and less aggressive than Rhus typhina; may be suitable on some green roofs (semi-intensive); will not persist on richer sites due to competition. | | X | | X | | | X | X | | |

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| **Rhus hirta (Rhus typhina)** (Staghorn Sumac) | SLC | M-D | Sun | H | H | 2.7 - 4.5 | Yes | Red fruit, red fall color, fuzzy new growth. Highly suitable; transplants easily; colony forming; needs lots of space. | | X | | X | | | X | X | | |
| **Rubus idaeus ssp. Strigosus** (Common Red Raspberry) | SLC | M-MD | Sun / Part Shade | M | M | 0.5 - 1 | Yes | Prickly stems, red berries. Highly suitable; colony forming. | | X | | X | | | X | X | | |
| **Rubus odoratus** (Purple Flowering Raspberry) | SLC | M-D | Sun / Part Shade | M | M | 0.75 - 1.25 | Yes | Large pink/purple flowers, large leaves. Highly suitable; colony forming. | | X | | X | | | X | X | | |
| **Salix repens** (Creeping Willow) | LC | M | Sun / Part Shade | M | M | 0.3 - 0.6 | No | Silvery catkins maturing to yellow in spring. Good on slopes and in rock gardens. | | X | | X | | | X | X | | |
| **Sambucus racemosa ssp. Pubens** (Red Elderberry) | SL | M | Sun / Part Shade | M-H | M | 1.5 - 2 | Yes | White flower clusters June-July, red fruits Aug-Sept. Highly suitable; fruit very attractive to birds; prefers drier soils than Sambucus canadensis. | | X | | | | | X | X | | |
| **Spirea japonica** (Little Princess Spirea) | SLC | M | Sun | H | M-H | 1.4 - 2.0 | No | White to pink flowers occur in clusters. Aggressive self-seeders. | X | | X | | X | X | | | X | |
| **Viburnum dentatum** (Arrowwood) | SLC | M-D | Sun / Part Shade | M | M | 1.9 - 3 | Yes | White flowers in summer, blue fruits in fall. Transplants well. | | X | | | | | X | X | | |
| **Viburnum rafinesquianum** (Downy Arrowwood) | SL | D | Sun / Part Shade | H | M | 0.9 - 2 | Yes | White flowers in summer, blue fruits in fall. Colony-forming, excellent screening and wildlife cover. | | X | | | | | X | X | | |
| **Trees** | | | | | | | | **Final tree selection for City Boulevards / Parks shall be consistent with Chapter 12.** | | | | | | | | | | |
| **Acer x freemanii** (Hybrid Maple / Freeman Maple) | SLC | W-M | Sun / Part Shade | M | L-M | 15 - 20 | Yes | Medium-large shade tree. Naturally-occurring hybrid between A. rubrum & A. saccharinum. Better maple choice than A. saccharinum for water tolerance. | | | | | | X | X | X | X | X |

| **Species**<br>**Scientific Name**<br>(Common Name) | **Soil Type Preference**<br>S = Sand<br>L = Loam<br>C = Clay | **Soil Moisture**<br>D = Dry<br>M = Moist<br>W = Wet | **Exposure**<br>Sun /<br>Part Shade /<br>Shade | **Drought Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Salt Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Height or Spread**<br>(metres) | **Native**<br>Yes / No | **Additional Information, Aesthetic Attributes and Other Notes** | **Local Street Landscaped** | **Local Street Naturalized** | **Major Road Landscaped** | **Major Road Meadow** | **Urban Centre Landscaped** | **Park Landscaped** | **Park Naturalized** | **Park Meadow** | **Residential Landscaped** | **Top Pick** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Acer rubrum**<br>(Red Maple) | SLC | W-M | Sun / Part Shade | M | M | 15 | Yes | Medium-large shade tree. Red flowers appear before the green foilage on this fast-growing tree. Good fall colour Thrive in a wide range of soil types, tolerating more moisture and pH than other trees. Limit use if possible. | X | | X | | X | X | | | X | X |
| **Celtis occidentalis**<br>(Common Hackberry) | L | M | Sun | M | M | 12 - 18 | Yes | Large shade tree, smooth gray bark with "warts". Easily transplanted in spring, plant with care in fall, generally tolerant. Very adaptable tree | X | | X | | X | | | | | |
| **Ginkgo biloba**<br>(Ginkgo) | SL | M | Sun / Part Shade | M | M-H | 15 | No | Yellow fall color, unique leaves. Specify male trees to avoid fruit litter and fruit foul smell. Easy fall clean up if necessary since all leaves drop within days of each other. Very adaptable tree | X | | X | | X | X | | | | |
| **Nyssa sylvatica**<br>(Sourgum) | LC | MW | Sun / Part Shade | L-M | L-M | 15 | Yes | Orange-scarlet fall colour, blue-black fruit ripens in fall. Specimen tree suitable for poorly drained sites. | | | | | | X | X | X | X | X |
| **Prunus serotina**<br>(Wild Black Cherry) | SL | M | Sun | M | M-H | 18 - 25 | Yes | Med-large tree when mature, white flowers in a spike, reddish-black berries, mature trees have distinctive black flaky bark. Highly suitable; sensitive to compaction; somewhat difficult to transplant. Not a City of London approved street tree. | | | | | | X | X | X | | |

| **Species**<br>**Scientific Name**<br>(Common Name) | **Soil Type Preference**<br>S = Sand<br>L = Loam<br>C = Clay | **Soil Moisture**<br>D = Dry<br>M = Moist<br>W = Wet | **Exposure**<br>Sun /<br>Part Shade /<br>Shade | **Drought Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Salt Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Height or Spread**<br>(metres) | **Native**<br>Yes / No | **Additional Information, Aesthetic Attributes and Other Notes** | **Local Street Landscaped** | **Local Street Naturalized** | **Major Road Landscaped** | **Major Road Meadow** | **Urban Centre Landscaped** | **Park Landscaped** | **Park Naturalized** | **Park Meadow** | **Residential Landscaped** | **Top Pick** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quercus alba**<br>(White Oak) | SL | M-D | Sun / Part Shade | H | H | 20 - 30 | Yes | Large canopy tree. Extremely sensitive to compaction; difficult to transplant but very much worth the effort to do so; suitable in non-compacted soil where there is room; use plugs/small containers or seed; maintain carefully for 1-2 yrs after planting. **Consider issues with Oak Wilt.** | X | | X | | X | X | X | X | X | |
| **Quercus bicolor**<br>(Swamp White Oak) | LC | W-M | Sun | H | M-H | 18 - 25 | Yes | Large canopy tree, coarse branching, bark peeling when young. Withstands spring season inundation; wildlife food/shelter; Planted with increasing frequency outside its natural habitat and range. **Consider issues with Oak Wilt.** Not a City of London approved street tree. | | | | | X | X | X | X | X | |
| **Quercus macrocarpa**<br>(Bur Oak) | SLC | W-D | Sun | H | M-H | 18 - 25 | Yes | Large canopy tree. Coarse branching structure, corky bark, unique acorn. Highly suitable; wildlife food/shelter. **Consider issues with Oak Wilt** | X | | X | | X | X | X | X | | |
| **Quercus muehlenbergii**<br>(Chinquapin oak / Yellow oak) | SL | D | Sun | M-H | M | 10 - 15 | Yes | Large canopy tree. Carolinian zone plant. Ensure appropriate seed sourcing. **Consider issues with Oak Wilt.** Not a City of London approved street tree. | | | | | | X | X | X | | |
| **Tilia americana**<br>(American Basswood) | SL | M | Sun / Part Shade | M | L-M | 12 - 20 | Yes | Dense, wide crown with large leaves, nut-like fruit; single or multi-stem form. Highly suitable; tolerates relatively high moisture conditions; attracts pollinators. Highly adaptable tree. Also, benefits pollinators. | X | | X | | X | X | X | X | | X |

| **Species**<br>**Scientific Name**<br>(Common Name) | **Soil Type Preference**<br>S = Sand<br>L = Loam<br>C = Clay | **Soil Moisture**<br>D = Dry<br>M = Moist<br>W = Wet | **Exposure**<br>Sun /<br>Part Shade /<br>Shade | **Drought Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Salt Tolerance**<br>H = High<br>M = Medium<br>L = Low | **Height or Spread**<br>(metres) | **Native**<br>Yes / No | **Additional Information, Aesthetic Attributes and Other Notes** | **Local Street Landscaped** | **Local Street Naturalized** | **Major Road Landscaped** | **Major Road Meadow** | **Urban Centre Landscaped** | **Park Landscaped** | **Park Naturalized** | **Park Meadow** | **Residential Landscaped** | **Top Pick** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Vines** | | | | | | | | | | | | | | | | | | |
| **Lonicera hirsute**<br>(Hairy Honeysuckle) | L | W-M | Sun | M | M | 0.6 - 0.75 | Yes | Small yellow flowers, red berries. Forms thickets, flowers are attractive to insects and hummingbirds. | | X | | | X | | X | X | | X |
| **Vitis riparia**<br>(Riverbank Grape) | SLC | M | Sun / Part Shade | M | H | 0.5 | Yes | Large leaves, grapes in fall. Extremely aggressive and competitive; use mostly in situations where invasive exotics are a major threat, can smother small trees and shrubs, wildlife food & habitat. | | X | | | X | | X | X | | |