The University of British Columbia | Okanagan Campus

# Integrated Rainwater Management Plan

Final Report | Part 2: Maintenance Manual

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

## Prepared for

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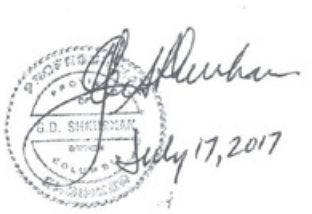


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## ACKNOWLEDGEMENT

The University respectfully acknowledges the traditions and customs of the Okanagan Nation and its people in whose territory the campus is situated. The Syilx (Okanagan) people have been here since time immemorial. In September 2005, the Okanagan Nation Alliance officially welcomed UBC to traditional Syilx (Okanagan Nation) territory in an official ceremony, Knaqs npi'lsmist, where UBC signed a Memorandum of Understanding with the Okanagan Nation.

As they have been stewards of this traditional territory since time immemorial, UBC works with the Okanagan Nation to ensure they are partners in the pursuit planning at the Okanagan Campus.

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UBC OKANAGAN CAMPUS INTEGRATED RAINWATER MANAGEMENT PLAN

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# 1 INTRODUCTION AND INTENT

The purpose of this document is to outline current best management maintenance practices for the rainwater facilities identified in the UBCO Integrated Rainwater Management Plan (UBCO IRMP) as well as for the existing campus pond and infiltration ditch adjacent to Lot H.

The maintenance manual is divided into four sections as follows:

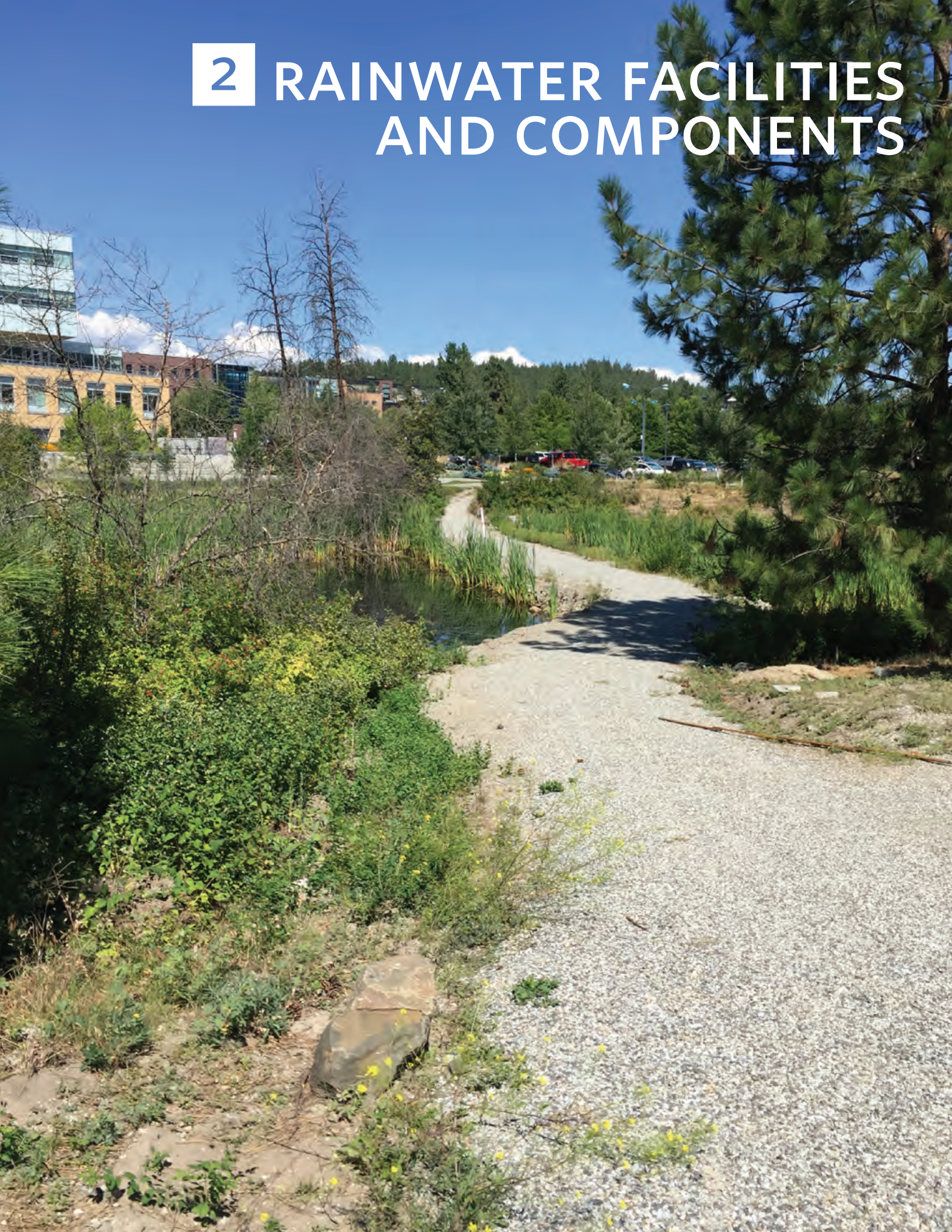
1. **Section 2.0 Facility Intent and Function** describes the proposed rainwater facility types and associated components identified as the most likely techniques to satisfy the IRMP strategy:
    - Contributing Drainage Area
    - Pre-Treatment Facility
    - Bioswale and Bioswale Components
        - Rain Gardens
        - Vegetated Swales
        - Curb Bulbs
        - Box Planters
        - Weirs
        - Building Scuppers
    - Infiltration Swale
    - Recharge Basin
    - Constructed Wetland
    - Drywell
    - Storm Sewers and Catch Basins
2. **Section 3.0 Facility Maintenance** identifies typical inspection points, triggers, activities and frequency of maintenance for the facilities and components identified within the UBCO IRMP:
    - Vegetation Maintenance and Erosion and Sediment Control
    - Bioswale Underdrain and catch basin
    - Contributing Drainage Area
    - Pre-Treatment Facility
    - Bioswales, Infiltration Swale and Recharge Basin
    - Constructed Wetland
    - Drywell
    - Storm Sewer and Catch Basin
    - Vegetation and erosion and sediment control
    - Winter maintenance and snow management

- Existing Campus Pond – Stormwater Retention Reservoir
- Existing Infiltration Ditch Adjacent to Lot H
- Contaminated Soil Warning
- Ongoing Facility Soil and Water Testing

3. **Section 4.0 Roles and Responsibilities** defines UBC staff who are responsible for each area of Operations and Maintenance.
4. **Section 5.0 Plant Selection** discusses criteria for LID specific plant material selection and recommended plant lists.

This document is not intended to provide design or construction specifications, although some general comments and recommendations based on local experience and observations are noted in section 2.0 and a list of relevant design and construction reference documents is identified in **Appendix A.**

The best management practices contained within this manual have been distilled from numerous current published documents, academic field studies and consultation with recognized experts in this field, a selection of which are identified in **Appendix B.** Maintenance recommendations for the existing pond and infiltration ditch are guided by an environmental review prepared for the UBCO IRMP.



# 2 RAINWATER FACILITIES AND COMPONENTS

## 2.1 CONTRIBUTING DRAINAGE AREA

The contributing drainage area is defined as the area generating runoff which is conveyed via overland flow, channels and/or pipes to the LID facility. The condition of the contributing drainage area and resulting conveyance of undesirable materials downstream directly affects the function of LID facilities.

> *Ensuring contributing drainage areas are clear of extraordinary debris, grit, sediments and pollutants is the most efficient and effective means of minimizing maintenance frequency for, and maximizing the proper functioning of, LID facilities.*

See **Section 3.3** for description of maintenance procedures for Contributing Drainage Areas.

*Garbage and leaves in parking lot*
*image: csufresno.edu*

## 2.2 PRE-TREATMENT FACILITIES

Pre-treatment facilities may be combined with all major rainwater facility types. They are designed to dissipate the energy of incoming runoff and detain the runoff for initial settling of coarse particulates and removal of other unwanted materials, such as trash and oil, prior to runoff discharging into the primary water quantity and quality control facility.

Pre-treatment facilities come in a variety of types, including:

- open basins, such as forebays
- manufactured structures, such as oil/grit separators
- grassed areas that promote sheet flow and reduce water velocity
- source controls, such as litter receptacles, street cleaning and choice of winter road de-icing products

Pre-treatment facilities are "primary treatment" systems only. Filtration-based water quality facilities offer greater pollutant removal capabilities than manufactured structures and should be considered in meeting sustainability objectives

> *Similar to the contributing drainage area, proper maintenance of pre-treatment facilities are efficient and effective means of minimizing ongoing maintenance requirements for downstream LID facilities.*

See **Section 3.4** for description of maintenance procedures for Pre-Treatment facilities.

*Construction activities*
*image: City of Edmonton ISMP*

*Erosion control measures*
*image: City of Edmonton ISMP*

*Concrete basin rain garden Forebay*
*image: worldlandscapearchitecture.com*

*Concrete basin rain garden Forebay*
*image: verassets.blob.core*

*Infiltration basin riprap Forebay*
*image: uidaho.edu*

*Stormceptor oil and grit separator*
*image: dnify.io - hanson-han-stormceptor-cutawa*

## 2.3
## BIOSWALE (RAIN GARDEN, BOX PLANTER, CURB BULB, AND LINEAL VEGETATED SWALE)

Rain gardens, curb bulbs, box planters and lineal vegetated swales are all considered part of the bioswale family and are intended to have an aesthetic appeal as well as a rainwater management function. These facilities are designed to slow down, detain, infiltrate, facilitate evapotranspiration and treat runoff prior to entering another rainwater management facility. Bioswales are commonly constructed as a concave landscaped area where runoff from roofs or paving infiltrates into deep constructed soils and subsoils below. In urban environments bioswales are typically enclosed with hard landscape edges such as concrete or rectangular boulder curbs.

Design specifications such as engineered growing medium, depth of growing medium and requirements for underdrains are determined based on site specific engineering drawdown and water volume detention requirements and geotechnical investigation results pertaining to subsoil infiltration rates. Plant material is specified for its site specific aesthetic qualities, CPTED (Crime Prevention Through Environmental Design) requirements, Fire Smart requirements, ability to withstand drought and inundation conditions, and if receiving runoff from road and salted catchment areas its ability to withstand resulting soil chemistry conditions.

Within the arid Okanagan context, bioswales are characterized by densely planted drought and inundation tolerant vegetation for aesthetics and erosion control; a thick mulch layer for soil moisture retention; engineered growing medium designed for rapid drawdown to avoid ponding water and large pore spaces for water volume holding capacity; and overflow inlet and underdrains to convey excess rainwater to storm pipes, dry wells or other receiving facilities. Underdrains are particularly important for facilities implemented in close proximity to a steep slope (approximately 10 meters from top of bank) or if a series of 3 or more LID features are all in close proximity perpendicular to steep contours where seepage may accumulate downslope for one facility to the next. In these instances underdrains are important to prevent excess seepage accumulation that may result in oversaturated soil conditions, or slope instabilities.

Most bioswales in the Okanagan require an automatic drip irrigation systems to provide supplemental moisture to plants during their establishment period. Irrigation systems may be turned off after two or three seasons depending upon the type of plant material in the facility, but may be maintained for fire suppression purposes. UBCO is required to maintain a wildfire management plan which should also inform the planting selection and the need to maintain irrigation systems. UBCO aspires to reduce potable water use, particularly for uses that do not require potable work such as irrigation and maintaining water features. As such, planting schemes should first be selected to minimize irrigation demands.

The WSIP speaks to UBCO considering using reclaimed water and rainwater reuse, both of which are complex and costly systems which extend beyond the scope of the IRMP.

Bioswale structures such as weirs are frequently required to slow and detain rainwater in areas of steep slopes such as are found on the UBCO campus. Ornamental roof leaders and sidewalk paving and grills are often incorporated with box planters adjacent to buildings. A brief description of these structures are described in 3. and 4. below.

*The most common maintenance issues for bioswales within the Okanagan context are:*

- *erosion from high intensity rain storms*
- *erosion from steep design side slopes due to poor design coordination*
- *poor plant performance due to lack of adequate irrigation during establishment period and in drought conditions*
- *inundation by invasive weed species*
- *clogging of inlets with sediments and garbage from contributing drainage areas*

*Street sweeper*
*image: southwestsweepersales.com*

See **Sections 3.1, 3.2, 3.4** and **3.5** for a complete description of maintenance procedures for bioswales.

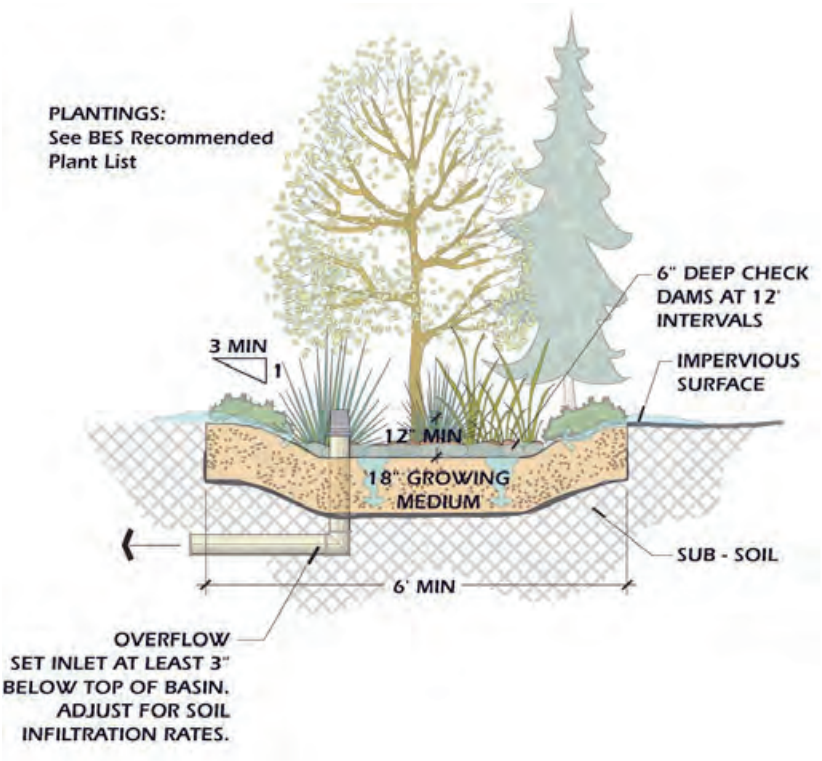



*image: City of Portland - Appendix G - Supplemental Drawings and Example Landscaping Plans, September 2004 Stormwater Management Manual*

FIGURE 1 TYPICAL SOFT LANDSCAPE BIOSWALE CROSS SECTION WITH OVERFLOW INLET

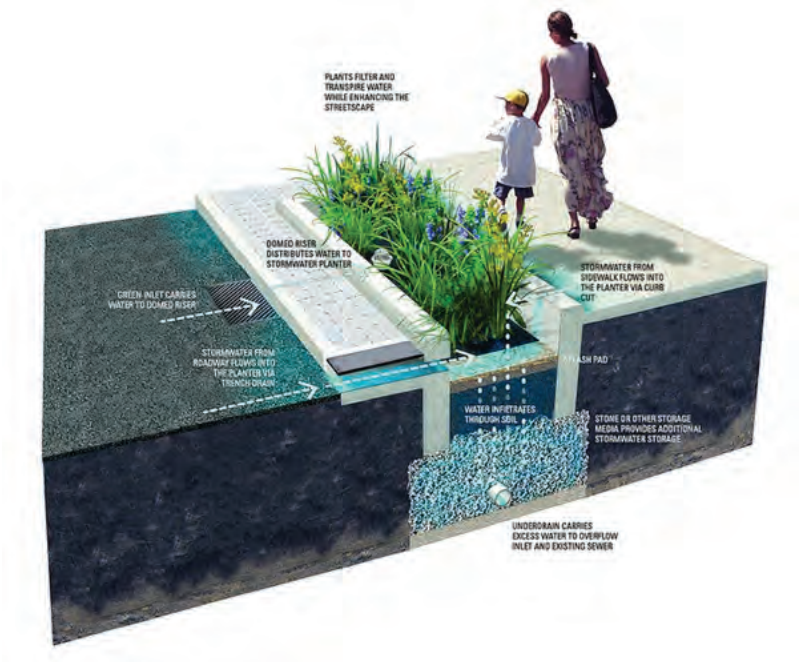



*image: phillywatersheds.org*

FIGURE 2 TYPICAL BOX PLANTER CROSS SECTION WITH UNDERDRAIN AND OVERFLOW INLET

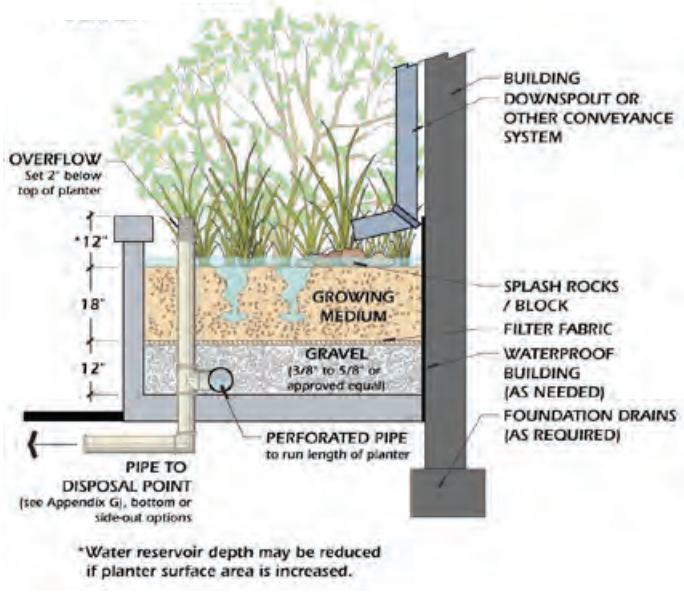



*image: City of Portland - Appendix G - Supplemental Drawings and Example Landscaping Plans, September 2004 Stormwater Management Manual*

FIGURE 3 TYPICAL BOX PLANTER ADJACENT TO BUILDING

1. *Soft landscape Rain Garden image: sissonlandscapes.com*
2. *Parking lot Rain Garden image: southsidegreen.com*
3. *Urban streetscape Box Planter image: wordpress.com-sw12thst_photo*
4. *Box Planter integrated with buildings*
5. *Curb Bulb Rain Garden image: 'The Yards' Washington DC*
6. *Lineal Vegetated Swale image: landscaperesource.com-solyndra_landscape_014*

## Bioswale Weir Structures

Weirs or check dams are components of many LID facilities and are employed on steep slopes to slow water to reduce erosion, facilitate sedimentation of suspended solids, and encourage infiltration and evapotranspiration of runoff. Weirs in bioswale facilities are commonly designed as functional artistic design features constructed of rectangular boulders or concrete and metal structures and facilitate the celebration of rainwater through the cascading water effect.

*The most common cause of weir failure, and hence bioswale maintenance are:*
- *improper design for the site conditions and catchment area*
- *incorrect installation*
- *improper materials and poor workmanship*

*Boulder weir image: www.asla.org/Portland/site.aspx?id=43983-Oregon Convention Centre–C. Bruce Forster*

*Concrete and metal weir image: southwestsweepersales.com*

## Bioswale Building Scuppers and Rainwater Channels

The integration of bioswales with building rainwater systems provides additional opportunities for the creative celebration of rainwater. Artistically designed scuppers and rainwater channels, while exhibiting their own inherent aesthetic, come alive during rain events as water cascades over outlets and through channels.

The most common maintenance issues attributable to the incorporation of building rainwater into bioswales are:

- additional deposition of debris from rooftop into bioswale
- debris clogging channels leading to Bioswale facility

*Artistic scupper detail with fountain feature leading to rain garden*

*Channel leading from roof leader to rain garden*
*image: University of British Columbia*

*Tiered rainwater channel on slope*
*image: Park Killesberg –'Green Joint'-Rainer Schmidt Landschafts Architekten*

*image, right: City of Portland - Appendix G - Supplemental Drawings and Example Landscaping Plans, September 2004 Stormwater Management Manual*

*Shallow grassed Infiltration Swale in residential context*
*image: City of Edmonton ISMP*

## 2.4
## INFILTRATION SWALE/TRENCH

Infiltration swales and trenches are shallow sloped grassed or vegetated channels designed to capture, detain and treat rainwater and convey larger flows. They accept surface flows from adjacent paved surfaces, hold the water behind weirs, and allows water to infiltrate into underlying soils. The swale and weir structures provide conveyance for larger storm events to the storm drain system. Variations on designs include an underlying drain rock reservoir, with or without a perforated underdrain. Despite infiltration, significant volumes of water may still evapotranspire and water which may still be released through an underdrain system is first filtered, improving water quality.

See **Section 3.5** for description of maintenance procedures for infiltration swales.

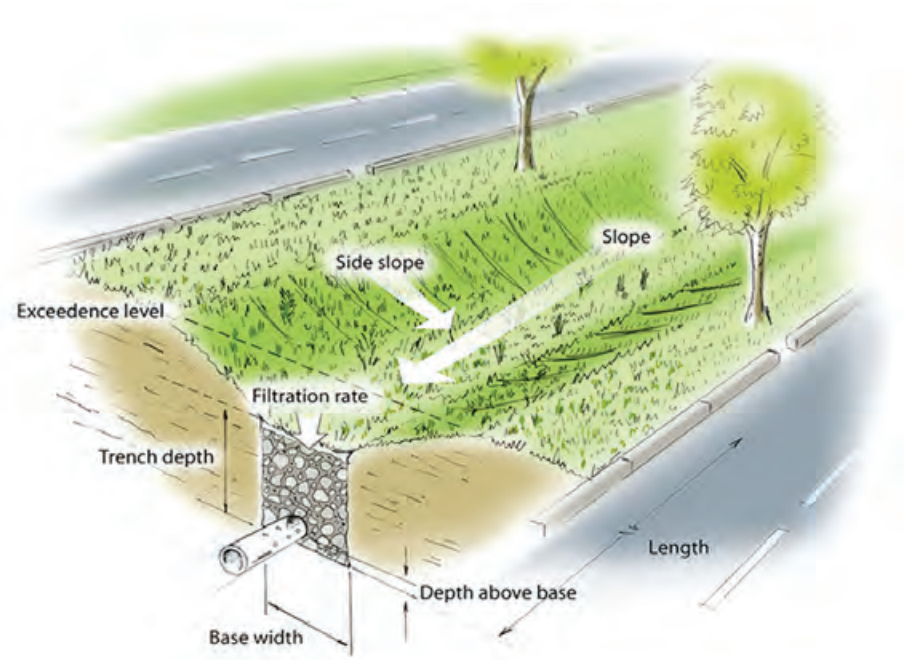



FIGURE 4 TYPICAL CROSS SECTION OF INFILTRATION SWALE

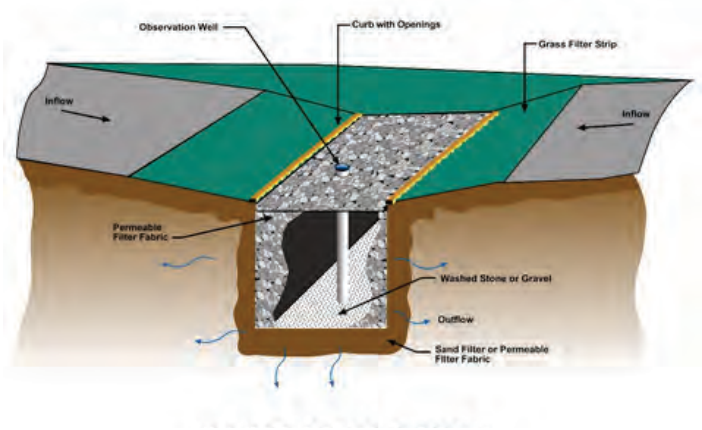



FIGURE 5 INFILTRATION TRENCH; VARIATION WITHOUT UNDER-DRAIN OR SOD INVERT. APPROPRIATE FOR AREAS OF HIGHER NATURAL INFILTRATION CAPACITY SUCH AS INNOVATION PRECINCT.

## 2.5
## RECHARGE BASIN

A Recharge Basin is either a natural or artificially constructed depression that collect water for the recharge of an aquifer. Recharge basins temporarily store runoff, but release runoff by infiltrating the water into the ground. The recharge volume is stored and allowed to infiltrate into the underlying soils over a period of time following a storm event. In the case of UBCO, there is no off-site drainage infrastructure to accept discharge, therefore the recharge basin must be sized and maintained to fully contain 100% of the runoff generated.

*Maintenance Considerations:*

- *Extreme care must be taken to ensure water quality of rainwater prior to entering facility to prevent risk of contaminating the aquifer*
- *Frequent monitoring, testing and maintenance required*
- *Excellent candidate for water quality monitoring – Learning Lab*

See **Section 3.5** for description of maintenance procedures for recharge basins.

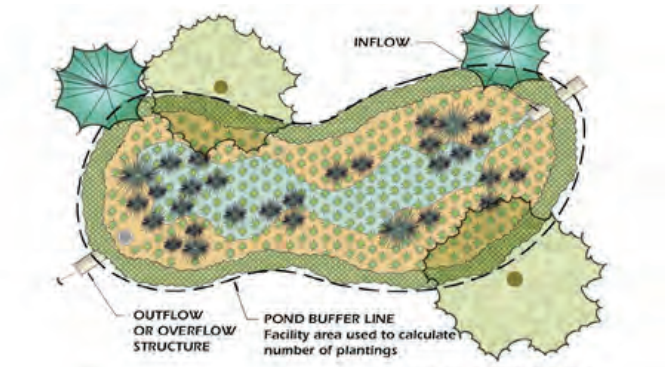



FIGURE 6 TYPICAL PLAN LAYOUT FOR A RECHARGE BASIN

**IMAGE 5**

*In the case of UBCO, an active overflow structure is not permitted. However, an emergency spillway should be included to a safe flow route downstream. Activation of this spillway would only occur in the event of a rainstorm beyond the 100 year design level, or system failure.*

*image: City of Portland - Appendix G - Supplemental Drawings and Example Landscaping Plans, September 2004 Stormwater Management Manual*

*Grass lined recharge basin*

*Required drought tolerance grass and sufficient precipitation to sustain it. The grass may serve as an additional filter, but retards flow to some degree and requires additional maintenance.*

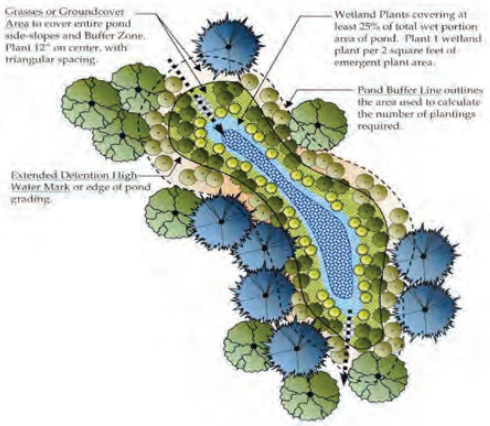
*Constructed wetland*
*image: Urban Systems Ltd.*

## 2.6
## CONSTRUCTED WETLAND

Constructed wetlands are a series of shallow ponds connected by an engineered marsh system designed to treat contaminated rainwater via sedimentation, contact with soils, and through the biological processes associated with emergent aquatic plants.

Wetlands are considered one of the most reliable forms of rainwater treatment, with excellent removal efficiencies. Wetlands require a large enough catchment area to sustain hydrology, however they can also be seasonal, which may be the case in the arid climate of the Okanagan. The existing Pond on campus is technically a wetland, as it sustains water year-round. However, a significant drop in Pond water level is reported during the hot summer, as much as a "couple feet". This same pattern can be expected for any new wetland created. Therefore, design should anticipate a significant drop in water level during drought periods. Also, any intentionally constructed wetland will require an impermeable liner, particularly if installed in the Innovation Precinct area where native soils are more permeable that the main campus.

See **Section 3.6** for description of maintenance procedures for constructed wetlands.




*image, right: City of Portland - Appendix G - Supplemental Drawings and Example Landscaping Plans, September 2004 Stormwater Management Manual*

FIGURE 7 TYPICAL PLAN LAYOUT FOR A CONSTRUCTED WETLAND

## 2.7
## DRYWELL

Dry wells are underground structures used to infiltrate rainwater runoff into the subgrade or water table. Drywells are typically perforated precast structures or rock pits lined with a geotextile. There are currently drywells in used on campus; both in the upper campus where there are low permeable soils, and in the lower campus where there are high permeable. There are no reports to suggest they perform poorly, however their true performance is not currently known. Soil permeability on campus indicates that drywells are strongly appropriate for the Innovation Precinct, but should be applied with caution in the established main campus. Particularly if applied in the established main campus, site specific permeability testing should occur first to identify sizing and spacing requirements.

See **Section 3.7** for maintenance procedures for drywells

*Typical precast concrete drywel*
*image: janewalshdesigngc.com*

## 2.8
## STORM SEWERS AND CATCH BASINS

Storm sewers and catch basins are designed to accept and convey excess rainwater runoff from impervious surfaces such as paved streets, directly connected roof tops, foundation drains, parking lots, and sidewalks. They may also receive overflow from LID features.

Catch basins act as a first-line pretreatment for other treatment practices, such as retention basins, by capturing large sediments and street litter from urban runoff before it enters the storm drainage pipes. Some of the heavier sediment and small objects may settle in a catch basin sump.

The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (for example, the size of the sump), and on routine maintenance to retain the storage available in the sump to capture sediment. Sediment is typically removed using vacuum trucks.

See **Section 3.8** for maintenance procedures for storm sewers and catch basins.

*Typical precast concrete catch basin*
*image: janewalshdesigngc.com*

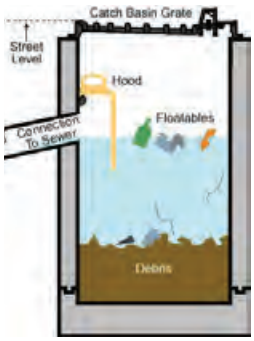



FIGURE 8 TYPICAL CATCH BASIN

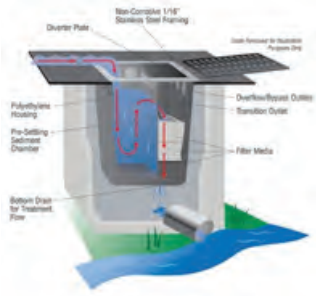
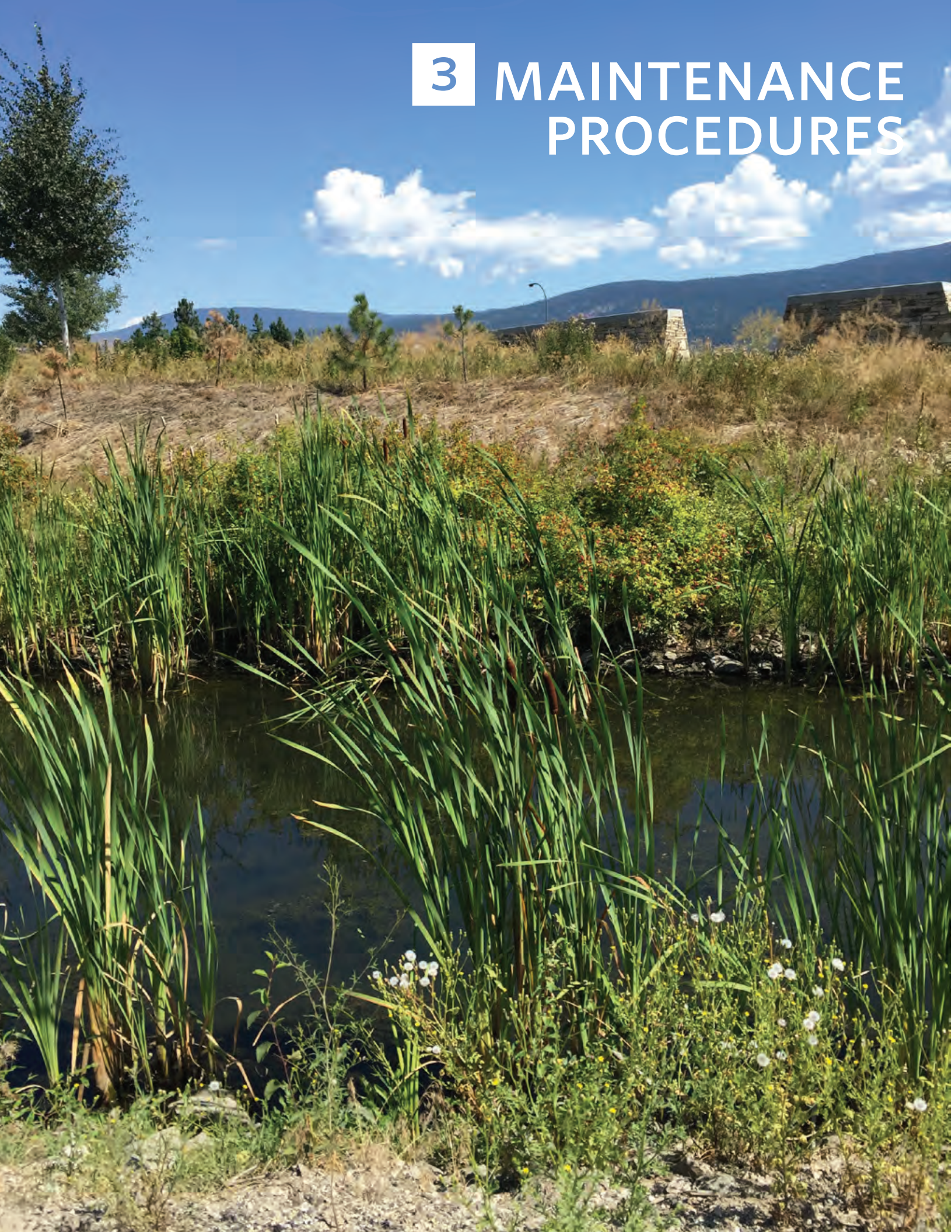


FIGURE 9 CATCH BASIN WITH FILTER

*images: (left) Edenflo.ca, (right) spillsource.net*



# 3 MAINTENANCE PROCEDURES

# 3.1. VEGETATION MAINTENANCE AND EROSION AND SEDIMENT CONTROL

Vegetative cover is vital for the successful operation of an LID facility. In addition to aesthetic and wildlife habitat values, established plant material provides erosion control, encourages deposition of sediments, may uptake pollutants and assists in water draw-down through evapotranspiration within the facility.

Procedures for maintaining vegetation within LID facilities do not vary greatly from standard practices. The primary differences are an increase in the frequency of maintenance required to ensure a continuous vegetative cover for erosion control, and restrictions on the use of fertilizers and pesticides to prevent water and soil contamination. Some projects will require more maintenance than others depending upon the type of facility and type of vegetation installed.

General vegetation maintenance activities are outlined in **Table 3.1** below.

### TABLE 3.1 VEGETATION MAINTENANCE AND EROSION AND SEDIMENT CONTROL

| Maintenance Activity | Frequency or Trigger |
|---|---|
| Watering | • Water plant material and turf frequently and deeply for the first 1 to 2 months following installation to aid in successful establishment<br>• After 1 to 2 months, put plant material on a reduced frequency, deep watering schedule, to encourage deep rooting<br>• Bi-weekly monitoring will be required to ensure plant material is thriving and schedule watering as required<br>• Water as required to maintain plant material in healthy condition<br>• The installation of an automatic irrigation system is recommended for establishment watering and possibly for future fire suppression. |
| Fertilization | • Fertilizers directly impact downstream water bodies by contributing to eutrophication; therefore, fertilizer application should be avoided or an environmental approach to application should be taken<br>• Fertilization can cause facility contamination and increase nutrient levels within the soils, both of which negatively impact how the facility functions<br>• If the use of a fertilizer is proposed, it must be approved prior to application. Fertilization should be done as needed through monitoring and inspection of soil conditions and plant health.<br>• Compost may be used to enhance vegetation within LID facilities but it should be selected and used with caution |

| Maintenance Activity | Frequency or Trigger |
|---|---|
| Replacement of dead or dying plant material | • Once plant material has had time to leaf out in the spring, determine percentage of dead or unhealthy material, remove this plant material from the facility, and replace with either the same species or with an approved substitution<br>• When replacing plant material, take note if one species is being replaced more than others, a species substitute (subject to approval) may be required<br>• It is beneficial to ensure that plant coverage percentage aligns with design to ensure the facility is functioning at optimal capacity (plant coverage percentage for each year that the facility is under maintenance, and when fully operational, will be specified at the design phase)<br>• For facilities with a herbaceous/meadow planting design, line trim the area in early spring to achieve the objective of full coverage by herbaceous plants<br>• Continually monitor plant material throughout the growing season (April to October) |
| Pruning | • Inspect and prune plant material semi-annually in the spring and fall to avoid unwanted disease<br>• Refer to reference documents for acceptable times to prune certain species |
| Turf repair | • Immediately apply topsoil, erosion control fabric and seed or replacement sod to bare patches and eroded areas in turf to avoid additional erosion<br>• Continually monitor turf throughout the growing season (April to October) |
| Treating pests and disease | • When disease or pests are identified, treatment shall be provided by a licensed applicator<br>• Install wire mesh or plastic guards around trees to deter animals from stripping bark; install fence or barrier around shrubs, perennials or plugs as required<br>• Monitor for pests and disease during regular maintenance activities. Treatment of pests on UBC Campuses should be in line with the Integrated Pest Management program. http://rms.ubc.ca/environment/pollution-prevention/integrated-pest-management-2/ |
| Tree stake adjustment | • Adjust and/or loosen stakes annually or as needed; stakes should not be left on the tree for more than three growing seasons |
| Weed control | • Remove weeds bi-monthly<br>• Hand pick weeds from plant beds and turf areas<br>• Weeds must be controlled as per municipal bylaws and provincial regulations<br>• Herbicides are toxic to aquatic ecosystems and should not be used unless all other options have been implemented without success and subject to approvals |

| Maintenance Activity | Frequency or Trigger |
|---|---|
| Mowing | • Mow sod areas on a monthly basis during the growing season - naturalized seed areas shall only be mowed for weed control. The optimal height depends on species, however should be left as high as practical to promote healthy root growth and water retention.<br>• Push mowing within LID facility is preferred to avoid compaction |
| Removal of debris and sediment | • Inspect facilities and remove all debris each spring<br>• Inspect the contributing drainage area on a bi-monthly basis for sources of sediment; if no debris or excess sediment is encountered within the first season (April to October), incorporate facilities into regular inspection and maintenance schedule<br>• Inspect the facility on a bi-monthly basis to ensure debris and sediment are not causing blockages and rectify issues immediately |
| Erosion control | • Regularly inspect the points of drainage inlet. Rock liner is usually required to prevent scour. If significant concentrated flows are to occur, it is likely that a more extensive rock liner will be required along the invert of the facility.<br>• During spring cleanup and after all major storm events, inspect plant beds and turf areas for rill and gullies and repair immediately<br>• Significant drilling should be investigated further to determine the cause(s) and develop mitigation efforts<br>• Repairs may include topsoil, erosion control fabric, sod, seed, mulch and plant material |
| Mulch top up | • Annually (or as needed) check mulched areas for bare patches and top up to approved depth where needed (this can be coordinated with spring cleanup activities) |

## 3.2.
## LID FACILITY UNDERDRAIN AND CATCH BASIN INSPECTION AND MAINTENANCE

Maintenance recommendations for LID facility underdrains and catch basins are included in **Table 3.2** on the following page.

TABLE 3.2 LID FACILITY UNDERDRAIN AND CATCH BASIN MAINTENANCE

| Maintenance Activity | Frequency or Trigger |
|---|---|
| Removal of debris and sediment | • Once operational, inspect all underdrains and catch basins on a monthly basis for the first year (or following a significant storm event) to ensure facility is performing as anticipated. Inspect semi-annually after the first year, or as required based on first year observations.<br>• If debris or excess sediment is noted, remove sediment and/or flush system as needed and inspect both the facility and contributing drainage area to determine source of sediment and take corrective action<br>• If no debris or excess sediment is encountered within the first season (April to October), incorporate facilities into regular inspection and maintenance schedule<br>• Check all access points to underdrain (e.g. pipe caps, catch basin and drain covers) to ensure they are secure and accessible |

## 3.3.
## CONTRIBUTING DRAINAGE AREA INSPECTION AND MAINTENANCE

Maintenance of contributing drainage areas is typically only required when downstream LID facilities are negatively impacted. The following table indicates triggers for maintenance and maintenance activities and frequency.

TABLE 3.3 CONTRIBUTING DRAINAGE AREA INSPECTION AND MAINTENANCE

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| DISTURBED LANDSCAPE (construction, erosion) | Sediment from disturbed landscape migrating into LID facility.<br><br>Construction processes are the largest risk to established LID facilities. A construction sediment control plan should be a requirement for all future projects. | • Ensure all erosion control measures are in place and functioning as intended<br>• clean out build-up of sediments at erosion control measures | • Daily<br>• During all rain and wind storm events |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| SOFT LANDSCAPE (sod, shrub beds) | Debris from landscape migrating into LID facility | • Inspect for erosion; install erosion control measures and repair immediately<br>• Remove grass clippings, leaves, prune branches | • Quarterly |
| | | • Mow/line trim and rake embankments to remove vegetation from annual/ perennial plants | • Bi-annually |
| HARD SURFACE (roads, parking lots, sidewalks) | Garbage from hard surfaces migrating into LID facility | • Remove trash and debris<br>• Empty nearby trash cans<br>• Assess need and add additional trash cans<br>• Implement public education program | • Quarterly |
| | Pollutants from motorized vehicles such as petroleum products (e.g. oils) and heavy metals (e.g. copper) migrating into LID facility | • Vacuum type street sweeping | • Frequently Between Rainfalls<br>• Prior to Storm Sewer Cleaning |
| | Winter grit from hard surfaces migrating into LID facility | • Street and sidewalk sweeping | • Immediately After Each Snow Melt |
| | Winter de-icing salts and sands damaging plant material in LID facility | • Reduce salt and sand use and promote alternatives, such as beet juice currently being applied.<br>• Do not use fertilizers as a substitute<br>• Do not use LID features for snow storage. Prepare a plowing and snow storage strategy that protects LID features. | • Annually in winter |
| | Fertilizers negatively impacting water quality in LID facility | • Reduce fertilizer use and promote alternatives | |

## 3.4.
## PRE-TREATMENT FACILITY INSPECTION AND MAINTENANCE

All pre-treatment facilities require regular maintenance to prevent damage to the main LID facility downstream. The type and frequency of maintenance is dependent upon the function of the pre-treatment facility and the character of the surrounding drainage area.

The installation of a staff gage or other measuring device to indicate depth of sediment accumulation and level at which clean-out is required is recommended.

TABLE 3.4 PRE-TREATMENT FACILITY INSPECTION AND MAINTENANCE

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| SOD FILTER STRIP |  *image: City of Edmonton ISMP* | • Removal of sediment/grit at pavement edge<br>• Rake out sediment/ grit from sod filter strip if it has accumulated<br>• Design should provide a small drop from the pavement edge onto the grass or rock lined inlet point. A common problem is that grass and sediment build up over time prevents water from entering easily, therefore causing ponding on the pavement surface. | • As-needed based on visual inspection |
| HARDSCAPE FOREBAY |  *image: City of Edmonton ISMP* | • Sweeping or removal with shovel | • Annually<br>• Inspect After Spring Melt and Major Storm Events |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| CATCHBASIN SUMP |  *image: City of Edmonton ISMP* | • Vac-truck suction | • Annually<br>• Inspect After Spring Melt and Major Storm Events |
| GRAVEL DIAPHRAGM |  *image: City of Edmonton ISMP* | • Remove grit and weeds<br>• Periodic replacement | • Annually<br>• Inspect after spring melt and major storm events |
| SPLASH PAD (note: prevents erosion but not sedimentation) |  *image: 5counties.org - handbook_04raingarden_inlet* | • Raking or sweeping | • Annually<br>• Inspect after spring melt and major storm events |
| OIL AND GRIT SEPARATOR (OGS) |  *image: City of Edmonton ISMP* | • Vac-truck flushing and suction | • Annually<br>• Inspect after spring melt and major storm events |
| PRE-TREATMENT CHAMBER |  *image: City of Edmonton ISMP* | • Vac-truck flushing and suction | • Annually<br>• Inspect after spring melt and major storm events |

## 3.5.
## BIOSWALE, INFILTRATION SWALE AND RECHARGE BASIN INSPECTION, MAINTENANCE AND TROUBLESHOOTING

Most vegetated LID facilities should require minimal maintenance once established, other than the maintenance activities outlined above in sections 3.1 Vegetation Maintenance and Erosion and Sediment Control, 3.2 LID Facility Underdrain and Catch Basin Inspection and Maintenance, and 3.4 Pre-Treatment Facility Inspection and Maintenance.

However, when maintenance issues do arise, bioswales, infiltration swales and recharge basins share common maintenance problems. The following table provides guidance on inspection activities, potential maintenance actions, and inspection frequency for each inspection point within these LID facilities. Where facility specific maintenance requirements exist they are noted in the table.

TABLE 3.5 BIOSWALE, INFILTRATION SWALE AND RECHARGE BASIN INSPECTION, MAINTENANCE AND TROUBLESHOOTING

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| INLET | Flow bypassing inlet (evidenced by sediment and debris deposits and dehydrated plant material) | • Correct inlet flow capture by re-grading, lowering inlet, re-shaping inlet or replacing inlet | • Semi-Annually<br>After Major Storm Event |
| | Trash and debris blocking inlet to facility | • Remove debris Evaluate contributing drainage area for sources of debris that can be reduced Evaluate if additional pre-treatment is required | • Semi-Annually<br>• After Spring Melt<br>• After Major Storm Event |
| | Erosion at inlet | • Assess inlet design; flows may need to be redistributed or slowed and inlet protection may need to be increased Potentially, regrade inlet, install flow spreaders and/or addition inlet protection Stabilize with fabric, matting, stone or other material Re-distribute and top up mulch or soil media | • Semi-Annually<br>• After Major Storm Event |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| | Structural damage to inlet | • Determine source of damage (e.g. Age, snow clearing, vandalism) Assess function of site during rain event conditions Repair structural damage | • Annually |
| SIDE SLOPE | Confirm if facility size has changed | • Estimate percentage of deviation in surface area Note if facility is smaller or larger Identify cause of change (e.g. Plant growth or death, sod migration, erosion, sedimentation)<br>• Re-design facility perimeter, if function and/or facility health is greatly impacted | • Annually |
| SIDE SLOPE | Side slope erosion | • Evaluate if erosion caused by water flowing from top of slope, or seepage out of the slope.<br>• Assess gradient of side slopes<br>• Consider re-design options to lower side slope gradient and/ or increase erosion protection to slow flows<br>• Stabilize with fabric, matting, stone or other material as instructed by inspector<br>• Re-grade side slopes; install flow spreaders and/or addition erosion protection<br>• Re-distribute and top up mulch or soil media | • Annually |
| | Damage to facility enclosure | • Determine cause of damage to enclosure<br>• Repair enclosure | • Annually |
| BED AND VEGETATED ZONE | Growing medium texture is high in clay and slow to drain when wet | • Send soil sample for composition test<br>• Perform infiltration test<br>• Remove and replace soil | • Annually |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| BED AND VEGETATED ZONE | Trash and debris have negatively impacted facility function and decreased aesthetic | • Remove debris<br>• Evaluate contributing drainage area for sources of debris that can be reduced<br>• Evaluate if additional pre-treatment is required | • Quarterly |
| BED AND VEGETATED ZONE | Severe erosion in bed zone; concentrated flows evident by deep gully formation and/or sinking occurring | • Assess bed for preferential flow path<br>• Consider if facility and/or inlet are adequately sized for storm events<br>• Provide ornamental rock liner along preferential flow path Install check dams<br>• Consider underdrain malfunction or animal activity as source of sinking<br>• Re-distribute and top up mulch or soil media | • Semi-annually |
| | Sediment accumulation and caking is reducing facility infiltration | • Evaluate contributing drainage area for sources of debris that can be reduced<br>• Assess pre-treatment functionality and capacity<br>• Clean out pre-treatment device<br>• Remove and replace top 150 mm of growing medium | • Semi-annually |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| BED AND VEGETATED ZONE | Structural damage to weirs evidenced by flows deviating from design, non-distributed storage and or facility flooding, dehydrated vegetation or severe downstream erosion due to higher than expected flows | • Evaluate cause of structural damage<br>• Evaluate cause of flow deviation (weir size or shape)<br>• Repair structural damage or replace structure if deteriorated beyond repair; re-establish proper weir size and shape<br>• Repair any erosion caused by faulty structure<br>• Monitor in future inspections | • Annually<br>• After Major Storm Event |
| | Riprap dislodged or unstable | • Evaluate riprap design for effectiveness (riprap coverage, rock size, rock placement, slope)<br>• Evaluate contributing drainage area to ensure facility is receiving design flow – re-grade area if required<br>• Evaluate effectiveness of riprap and the need for a new BMP type for erosion protection<br>• Repair erosion, remove soil accumulation, replace dislodged rocks, or stabilize unstable sections | • Annually<br>• After Major Storm Event |
| | Mulch too thick or too thin | • Investigate reason for mulch discrepancy (e.g., Staff not familiar with standard practice, facility undersized for storm events) and rectify<br>• Top up or remove mulch to specified depth and 100% coverage | • Semi-annually |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| BED AND VEGETATED ZONE | Plant material showing signs of dehydration or disease | • Assess planting to ensure species are appropriate for facility<br>• Assess facility and ensure plant species are receiving the intended amount of water and sunlight; test amended soil media<br>• Create a new planting plan according to assessment; remove existing species and re-plant | • Semi-annually |
| | Plant material density and coverage low | • Assess planting to ensure species are appropriate for facility and disease free<br>• Assess for signs of dehydration<br>• Assess facility and ensure plant species are receiving the intended amount of water and sunlight; test amended soil media<br>• Treat diseased plants, if necessary<br>• Water where needed Fill in bare areas with recommended plant material<br>• Reseed bare patches of turf Create a new planting plan according to assessment; remove existing species and re-plant | • Annually |
| | Plant material has taken over facility OR facility is bare | • Plant bare areas OR replace aggressive species with something more suitable for the location | • Semi-annually |
| | Invasive weed species present | • Evaluate surrounding area for source of weed aggression and remove<br>• Increase weeding frequency | • Quarterly |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| OUTLET AND UNDERDRAIN | Underdrains and pipe outlet blocked, has sagged or is damaged and requiring repair | • Flush pipe and/or remove debris<br>• Investigate cause of obstruction or damage<br>• Replace pipe if required | • Annually |
| | Outlet is blocked and flow cannot enter | • Investigate cause of accumulation, such as maintenance frequency or frequent mulch application<br>• Clear debris | • Semi-annually<br>• After Major Storm Event |
| | Outlet is not visible | • Consult original design drawings<br>• Hand excavate to locate and expose outlet.<br>• Modify or replace outlet to prevent future occurrences. | • Annually |
| FACILITY PERFORMANCE | Confirm size and shape of facility matches the design | • Investigate cause of any discrepancy<br>• Consult design team to ensure facility function is not compromise<br>• Adjust as required in the field | • Annually |
| | Flow bypasses inlet | • Determine cause of bypass<br>• Re-grade drainage path and/or install new inlet structure | • Annually |
| | Flow distribution within facility not even | • Determine cause for preferential path<br>• Remove mulch, re-grade drainage path and replace mulch<br>• Install baffles or weirs to redirect water | • Semi-annually<br>• After Major Storm Event |

| Type | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| FACILITY PERFORMANCE | Ponding depth greater than design grades | • Determine cause of discrepancy (such as mulch depth, amended soil settlement, poor grading)<br>• Check position of overflow and adjust accordingly<br>• Correct facility depth based on cause of discrepancy | • Semi-annually<br>• After Major Storm Event |
| | Facility-wide ponding exceeding design drawdown time | • Increase inspection frequency<br>• Evaluate actual facility ponding depth versus original design<br>• Take soil sample and test for soil structure<br>• Perform infiltration test<br>• Adjust mulch or growing medium as required<br>• Cctv underdrain<br>• Pump out facility underdrain<br>• Add an underdrain if one does not exist | • Semi-annually<br>• After Major Storm Event |

## 3.6. CONSTRUCTED WETLAND INSPECTION AND MAINTENANCE

This section applies to UBCO's existing pond and any future wetland.

TABLE 3.6 CONSTRUCTED WETLAND INSPECTION AND MAINTENANCE

| Component | Maintenance Activity | Frequency |
|---|---|---|
| INLET | • Inspect and remove debris and garbage from inlet<br>• Check around inlet for erosion and repair | • Monthly<br>• Inspect after storm events |

| Component | Maintenance Activity | Frequency |
|---|---|---|
| FOREBAY (If applicable) | • Check the Forebay for accumulated sediment<br>• Dredge or vacuum forebay if sediment fills over 50% of design volume<br>• Test sediments for contaminants (e.g. Heavy metals) prior to removal<br>• Inspect for wildlife and conduct salvage in accordance with Provincial and Federal regulations prior to cleaning.<br>• Dispose of sediment to landfill or similar suitable for contaminant levels | • Every 2-5 years<br>• Inspect annually and after storm events |
| CONTROL STRUCTURES | • Inspect outflow pipes for leaking joints or erosion and repair<br>• Inspect anti-seep collars for repair or replacement<br>• Inspect outfall and water discharge areas for erosion and repair<br>• Inspect and confirm energy dissipaters are adequate | • Bi-Annually<br>• Inspect after storm events |
| | • Inspect control structures, weirs, orifices, outfall pipes for leaks and blockages – repair leaks and remove sediments and debris to avoid local flooding and maintain flows | • Monthly<br>• Inspect after storm events |
| VALVES AND PUMPS (If applicable) | • Inspect valves and pumps and confirm are operating properly; repair if required Perform required maintenance | • Annually |
| EMERGENCY OVERFLOW OR SPILLWAY | • Inspect overflow path and remove any blockages<br>• Inspect flow path for erosion and repair<br>• Inspect structural components and repair immediately to avoid catastrophic failure | • Monthly<br>• Inspect after storm events |
| SIDE SLOPE | • Inspect banks for erosion, sloughing and seepage; stabilize bank as required | • Monthly<br>• Inspect after storm events |
| MAIN WATER BODY | • Remove floating debris from pond<br>• Inspect for algal blooms as indicators of low oxygen or high nutrient loads; test water quality and take measures to correct<br>• Remove vegetation only as absolutely required if choking out habitat of Western Painted Turtle. Removal will require environmental permits and prior salvage of Western Painted Turtle. | • Monthly Inspect after storm events |

| Component | Maintenance Activity | Frequency |
|---|---|---|
| WILDLIFE | • Monitor for mosquito larvae and take approved measures to control<br>• Control pest species<br>• Remove dead animals to prevent spread of disease | • Monthly |
| BED AND VEGETATED ZONE | • Inspect for exotic or invasive plants and remove manually | • Monthly during growing season |
| | • Mow grass | • Bi-Annually in spring and fall |

## 3.7.
## DRYWELL INSPECTION AND MAINTENANCE

Drywells should be visually inspected twice a year and vacuumed out if noticeable accumulation of debris and sediment. At least one inspection should occur during a significant rainfall to observe water level performance. If performance is poor then cleaning may be warranted. Primarily it will be vacuumed, but it may also require some assistance with very gentle power washing in combination with vacuuming. Great care is required to ensure that only materials within the sump and its openings are removed, and not the subgrade material outside of the drywell.

## 3.8.
## STORM SEWER AND CATCH BASIN INSPECTION AND MAINTENANCE

Storm sewers should require very little maintenance. Maintenance requirements are highly determined by the slope of the pipe and whether or not cleansing velocity is achieved. Pipes under about 0.2% grade may be susceptible to sediment build up or blockage.

It is recommended that a comprehensive CCTV inspect of the campus system be undertaken to establish a benchmark understanding of condition and issues. If deficiencies are noted, they should be addressed. If sedimentation is observed then these pipes will require an inspection and cleaning program. Generally, however, unless significant issues are observed, CCTV and cleaning should not be required with frequency less than 5 years.

Catch basins should be inspected twice a year and their sumps vacuumed as required on an annual basins.

Given that many of the manholes are not benched, a baseline assessment of manhole conditions should be done as part of the CCTV inspection program noted above. If any signs of scour are noted, concrete benching should be applied. Otherwise, the inspection and maintenance program is the same as for storm sewers described above.

## 3.9. WINTER MAINTENANCE

Snow storage and de-icing are key considerations in maintaining facility integrity. Snow should never be stored in or on LID facilities due to the potential presence of salt or fines from gravel. Fines may clog the pores within the growing medium and subgrade and impede infiltration. Residual chlorides from salt are detrimental to most plantings. If areas adjacent to a facility require the use of a de-icer, remove snow promptly and use a de-icer application with low chloride concentration.

TABLE 3.9 WINTER INSPECTION AND MAINTENANCE

| Issue | Maintenance Activity | Inspection Frequency |
|---|---|---|
| Snow is being stored on facility | • Evaluate alternate snow storage locations with snow removal crew<br>• Remove snow from facility if alternate location is available and removal will not damage facility | • After first snow plough<br>• Monthly in winter months |
| Flow route to facility is blocked by snow and ice | • Create flow path to facility inlet | • Prior to and during spring melt |

## 3.10. SUPPLEMENTAL GUIDANCE FOR EXISTING CAMPUS POND

The UBCO IRMP recommends that no, or limited, maintenance activities should be undertaken within the main cell of the existing campus pond due to the presence of the Western Painted Turtle and the impact maintenance has on it and its habitat. It is, however, recommended and necessary that the pre-treatment forebay be maintained regularly. This recommendation is to create a balance between the need to maintain the systems utility function, while at the same time minimizing impact and costs associated with protecting the habitat and resident Western Painted Turtle. If the forebay is properly maintained and efforts are taken to reduce the use of fertilizers in the upstream catchment, maintenance of the main pond cell should diminish. Although bull rushes have taken hold in the main

pond cell, they may be difficult to prevent and they do not substantially reduce the live storage volume of the pond, as they will generally remain below the normal water level. However, literature[1] indicates that mowing cattails after the heads are well formed, but not mature, and then following up with another mowing about a month later, when new growth is two or three feet high, will kill at least 75% of the plants. It the case of UBCO, the challenge will be in obtaining sufficient reach. It is presumed that a long reach boom of some kind will be required; either a boom lift to provide elevated human access, or a mechanical boom with a cutting implement of same kind, like would be used in the forest industry. This is based on the assumption that the pond is too deep to permit wading.

The earth berm separating the forebay from the main pond cell currently exhibits erosion do to its steep slopes. This issue is exacerbated during maintenance activities. It is recommended that UBCO consider flattening the bank slopes and apply bio-engineering solutions (live plantings) and / or coarse rock at these slopes to help stabilize these banks. Also, if it is observed during a heavy rainfall event that this berm is overtopped by flood waters, refinishing of the entire berm surface should be considered to reduce erosion, or the berm raised to not overtop.

### TABLE 3.10 EXISTING CAMPUS POND INSPECTION AND MAINTENANCE

| Inspection Point | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| FOREBAY | Sedimentation of Pond | • Check the Forebay for accumulated sediment<br>• Dredge Forebay if sediment fills 50% of design volume or shows signs of blocking culverts leading into main pond cell<br>• Ensure culverts connecting forebay to main pond are clear of debris and sediment<br>• Test sediments for contaminants (e.g. heavy metals) prior to dredging<br>• Dispose of sediment to landfill or similar suitable for contaminant levels | • Likely every 2-5 years<br>• Inspect after spring melt and major storm events |

[1] US Department of Agriculture / National Resources Conservation Service – Broad Leafed Cattail, Plant Guide, 2006

| Inspection Point | Issue | Maintenance Activity | Frequency |
|---|---|---|---|
| SIDE SLOPES AND TOP OF BANK | Vegetation, roots and stones discouraging turtles from reaching upland nesting sites(as recommended in the IRMP, a dedicated turtle inventory and assessment is recommended to map out habitat) | • Remove vegetation along routes to potential nesting sites. (based on a comprehensive habitat review by a qualified biologist specializing in Western Painted Turtles) | • Bi-annually |
| | | • Remove roots and stones from nesting sites | • Annually |
| BED AND VEGETATED ZONE | Non-native invasive plant species impacting native species | • Weed out invasive species on accessible banks and surrounding area by hand | • Inspect and remove weekly |
| | | • Attempt mowing of cattails as discussed above this table | • Frequency unknown, but likely every 2 to 5 years. |
| | | • Re-plant native species on banks and surrounding area as required | • Bi-annually in spring and fall |

*Please note that any work in and around the pond will require environmental applications and permits and must be overseen by a qualified environmental monitor.*

## 3.11. EXISTING INFILTRATION DITCH ADJACENT TO LOT H INSPECTION AND MAINTENANCE

The UBCO IRMP recommends near term measures be taken to stabilize current bank erosion, however that ongoing maintenance be minimized so as to not impact to the Great Basin Spadefoot Toad habitat. The proposed overflow to a centralized wetland and recharge basin will also reduce the risk associated with this facility.

It is recommended that the snow management program be adjusted to not use this ditch for snow storage. In addition, it would be preferential for UBC to street sweep / vacuum the parking lot semi-annually to reduce the loading of sediment into the ditch.

## 3.12.
## CONTAMINATED SOIL WARNING

LID facilities are designed to treat rainwater runoff and contaminants will collect in facility soils and pre-treatment sediment basins. All material removed from these sites should be tested for contaminants and disposed of appropriately.

## 3.13.
## ONGOING FACILITY SOIL AND WATER TESTING

Water exiting the LID facilities should ideally be tested annually for contaminant levels of heavy metals, petroleum hydrocarbons, pH and nutrients such as nitrogen. Testing will not only provide useful baseline data on the efficacy of the facility itself, but will also help to refine maintenance requirements and lifecycle costing estimates. Testing will also assist in determining when growing medium within the facility requires removal and replacement. It will also validate performance objectives and allow for adaptive management and design decisions.

Monitoring programs for the existing pond and future wetland / recharge basin in Innovation Precinct are described in the IRMP.

*Please note that any work in and around this ditch will require environmental applications and permits and must be overseen by a qualified environmental monitor.*

## 3.14
## PROPRIETARY TREATMENT SYSTEMS

If engineered proprietary treatment systems are selected (Oil and Grit separators, or filtration type systems), operation and maintenance manuals should be provided by the supplier, therefore are not contained herein.

# 4 PLANT MATERIAL SELECTION

Table 4.1 lists plant material commonly used in LID facilities within the Okanagan. The table is not intended to be an exclusive list; new varieties are continually being created and tested for suitability. Plants that have proved to be problematic are noted at the bottom of the table.

TABLE 4.1 RECOMMENDED PLANT MATERIAL

| Scientific Name | Common Name | Soil Moisture W = Wet M = Moist D = Dry | Salt Tolerance High/ Medium/ Low | Notes |
|---|---|---|---|---|
| **Nurse Crop** | | | | |
| Lolium multiflorum | Annual Ryegrass | Variable | H | Nurse crop for slope stabilization |
| **Ornamental Grasses** | | | | |
| Andropogon gerardii | Big Bluestem | W-M | M | Sod forming – for use in contained box planters or naturalized areas |
| Calamagrostis acutiflora | Karl Foerster Feather Reed Grass | M-D | M | Clump forming – will not become invasive |
| Carex ssp. | Sedge (many varieties) | W-M | M-L | Many varieties available; both sod and clump forming |
| Deschampsia cespitosa | Tufted Hairgrass | D | M-H | Clump forming |
| Helictotrichon sempervirens | Blue Oat Grass | M | M | Clump forming |
| Pennisetum hameln | Fountain Grass | M-D | H | Clump forming |
| Schizachyrium scoparium | Little Bluestem | D | M-H | Clump forming; does not perform well in rich soils or with irrigation |
| Scirpus ssp. | Bulrush species | W | M | Low drought tolerance; aggressive spreader |
| Typha latifolia | Broadleaf Cattail | W | M-H | Low drought tolerance; aggressive spreader; efficient at pollutant uptake |

| Scientific Name | Common Name | Soil Moisture W = Wet M = Moist D = Dry | Salt Tolerance High/ Medium/ Low | Notes |
|---|---|---|---|---|
| **Broadleaf Perennials** | | | | |
| Achillea millefolium | Common Yarrow | M | M | Okanagan native |
| Artemisia frigida | Pasture Sage | D | L | Okanagan native |
| Artemisia schmidtiana 'Silver Mound' | Silver Mound Artemesia | M-D | H | Ornamental planting |
| Coreopsis lanceolata | Lance-leaf Coreopsis | M-D | H | Ornamental planting |
| Coreopsis rosea | Pink Flowered Tickseed | M | M | Ornamental planting |
| Echinacea purpura | Purple Coneflower | M-MD | M | Attracts bees and butterflies |
| Gaillardia aristata | Brow Eyed Susan | D | M | Okanagan native; self- seeds |
| Heterotheca villosa | Golden Aster | D | X | Okanagan native; self- seeds |
| Hosta ssp. | Hosta (many varieties) | Variable | M | Many varieties available; range in moisture requirements |
| Iris versicolor | Blue Flag Iris | W | M | Low drought tolerance, slow spreader |
| Lavandula x intermedia Grosso | Grosso Lavender | D | M | Ornamental; attracts bees due to presence of lavender researchers on campus, lavender species is a "living lab" opportunity. |
| Lavandula angustifolia 'Hidcote' | Hidcote Lavender | D | M | Ornamental; attracts bees |
| Leucanthemum | Shasta Daisy | M-D | M | Drought tolerant |

| Scientific Name | Common Name | Soil Moisture W = Wet M = Moist D = Dry | Salt Tolerance High/ Medium/ Low | Notes |
|---|---|---|---|---|
| Perovskia atriplicifolia 'Little Spire' | Dwarf Russian sage 'Little Spire' | D | M | Drought tolerant; does not do well with excessive moisture; attracts bees |
| Rudbeckia ssp. | Coneflower (many varieties) | W-M | M-H | Many varieties available; attractive to bees, some self-sow, some very drought tolerant |
| Sedum ssp. | Sedum (many varieties) | D | M | Literature recommends only for use on green roofs due to potential to become invasive elsewhere |
| Stachys byzantina | Lamb's Ear | D | M | Literature recommends only for use on green roofs due to potential to become invasive elsewhere |
| Symphyotrichum ssp. | Aster (many varieties) | M-D | M-H | Many varieties available; tolerant of wide range of soil and moisture conditions. |
| **Shrubs** | | | | |
| Amelanchier alnifolia | Saskatoon | M-D | M | Okanagan native; edible |
| Arctostaphylos uva-ursi | Bearberry | M-D | M-H | Native to the Okanagan |
| Cornus sericea ssp. sericea | Red-Osier Dogwood | W-M | L | Native to the Okanagan |
| Ericameria nauseosa | Rabbitbrush | D | M | Native to the Okanagan |
| Juniperus communus | Common Juniper | D | H | Suitable for rocky sites |

| Scientific Name | Common Name | Soil Moisture W = Wet M = Moist D = Dry | Salt Tolerance High/ Medium/ Low | Notes |
|---|---|---|---|---|
| Juniperus horizontalis | Creeping Juniper | D | H | Suitable for rocky sites |
| Mahonia aquifolium | Oregon Grape Holly | D | L | Okanagan native; wildlife food |
| Potentilla fruticosa | Shrubby Cinquefoil | M | M | Okanagan native; attracts bees |
| Ribes cereum | Squaw Currant | D | L | Okanagan native; attracts bees |
| Rosa 'Nearly Wild' | Nearly Wild Rose | M | L | Hardy; attracts bees |
| Rosa woodsii 'Kimberley' | Kimberley Wild Rose | M | L | Okanagan native; wildlife food |
| Sambucus caerulea | Blue Elderberry | M | L | Okanagan native; very large shrub/ small tree |
| **Trees** | | | | |
| Acer saccharinum | Silver Maple | W-M | L-M | Tolerant of periodic short term inundation |
| Larix laricina | Tamarack / American Larch | W-D | H | Tolerant of periodic short term inundation |
| Populus tremuloides | Trembling Aspen | M | M-H | Tolerant of periodic or short term inundation |
| **Turf Grass** | | | | |
| Festuca ssp. | Festuca species | M-D | M-H | Low growing fine textured sod requiring mowing not more than once per month. |
| **Problematic Species in the Okanagan** | | | | |
| Festuca glauca 'Elijah Blue' | Elijah Blue Fescue | Short lived; requires replacement every 2-3 years | | |
| Festuca idahoensis | Idaho Festuca | Short lived; requires replacement every 2-3 years | | |

| Scientific Name | Common Name | Soil Moisture<br>W = Wet<br>M = Moist<br>D = Dry | Salt Tolerance<br>High/<br>Medium/<br>Low | Notes |
|---|---|---|---|---|
| Leymus arenaris | Blue Lyme Grass | Extremely invasive and out-competes most other plant material; use only in completely sealed containers | | |
| Yucca | Yucca | Difficult to remove due to rhizomes | | |
| Typha latifolia | Broadleaf Cattail | Aggressive spreader; excavate deep zones (1.0m / 3.5') in ponds to deter growth | | |
| Ericameria nauseosa | Rabbitbrush | Great plant but does not tolerate over watering – roots rot and plants die – do not use in irrigated areas | | |

# APPENDIX A

## Appendix A – Landscape Design Reference Documents

- UBC Landscape Design Guidelines (pending)
- UBCO Landscape Maintenance Program (January 2014)
- UBCO Okanagan Design Guidelines
  http://planning.ubc.ca/sites/planning.ubc.ca/files/documents/planning-services/policies-plans/UBCODesignGuidelinesRev08.pdf
- UBCO Wildland Fire Management Plan
  http://planning.ubc.ca/sites/planning.ubc.ca/files/documents/planning-services/policies-plans/UBCO%20Wildland%20Fire%20Mngt%20Plan%20Final%20July%2028.pdf
- UBCO Landscape Maintenance Recommendations (Okanagan Xeriscape Association)

  http://okanaganxeriscape.org/
- City of Kelowna Bylaw 7900 Schedule 5 – Supplemental Specifications
  http://apps.kelowna.ca/CityPage/Docs/PDFs/Bylaws/Subdivision,%20Development%20and%20Servicing%20Bylaw%20No.%207900/Schedule%205%20-%20Construction%20Standards.pdf
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  http://apps.kelowna.ca/CityPage/Docs/PDFs/%5CBylaws%5CSubdivision%2C%20Development%20and%20Servicing%20Bylaw%20No.%207900/Schedule%205%20-%20Drawings%20-%20Part%206B%20-%20Landscaping.pdf?t=054721642
- Master Municipal Construction Documents (MMCD) (current edition)
  https://www.mmcd.net/
- British Columbia Landscape Standard (current edition)
  http://bcsla.org/initiatives/bcsla-publications-2
- APPA Standards (current edition)
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# APPENDIX B

## APPENDIX B – LID MAINTENANCE BEST MANAGEMENT PRACTICES RESEARCH

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# CREDITS

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