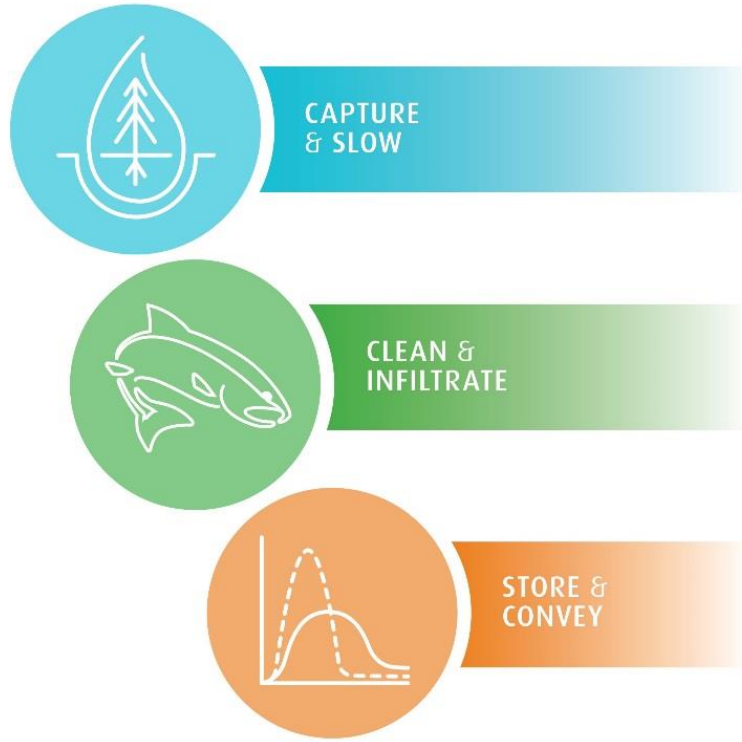

APPENDIX F - INFILTRATION & FLOW-THROUGH PLANTERS

Green Stormwater Infrastructure Design Guidelines for the Capital Region

SPRING 2019

Infiltration and Flow-Through Planters[1]

Description

These planter guidelines focus on diversion of stormwater from roofs for areas less than 1,000 m^2 and maybe designed to be raised or subgrade (sunken). If considering planters for stormwater management from impervious surfaces, such as parking lots or roadways, please refer to design guidelines for Rain Gardens, Infiltration Curb Extensions or Vegetated or Grassy Swales in this resource. When these GSI facilities are in a dense urban environments they may look like planters (vertical cement sides and flat bottom planted areas), however, require design appropriate to capture, treat and often convey stormwater.

Figure 1 Planter irrigated by roof water collected in underground detention tanks.

The **flow-through rain planter** is a contained stormwater storage and treatment unit with primary functions of reducing stormwater pollution loads and flow rates. It is essentially a contained rain garden. The flow-through planter has structural walls and a sealed bottom such that water cannot infiltrate into the ground. Stormwater runoff typically enters the unit from a downspout or scupper from a nearby roof drain. Pollutants and nutrients are removed from the runoff using 3 mechanisms including biological decomposition, plant assimilation (in the form of nutrients) and adsorption of heavy metals to soil organics. Flow control is achieved by storing runoff in the reservoir above the soil. Flow-through planter requires a high capacity overflow.

Figure 2 Flat drains such as in the infiltration planter can easily get clogged with leaves

The **infiltration rain planter** is similar to a flow-through rain planter, but with an open bottom. This GSI facility can, therefore, function to reduce stormwater pollution loads and flow rates, but also volume since water can infiltrate into the ground. Stormwater runoff typically enters the unit from a downspout or scupper from a nearby

[1] Authored by: Opus International Consultants (Canada) Limited Source: Stormwater Management Manual, City of Eugene, Oregon, 2014 https://www.eugene-or.gov/DocumentCenter/View/15783 Design guidelines drawings by: Kerr Wood Leidal Associates Ltd

roof drain. Flow control is achieved by storing runoff in the reservoir above the soil and volume control is achieved by infiltration of water into the ground. The infiltration planter requires a high capacity overflow.

Selection, Application and Limitations

- The **flow-through rain planter** option is most applicable on highly constrained sites with little available landscape area at grade.
- Flow-through planters should be used where there is seasonally high groundwater (<1 m from the bottom of the planters), where bedrock is less than 600 mm below the bottom of the planter, in areas of new fill, within 30 m of a groundwater well, or within 3 m of a building wall/footing.
- The use of a waterproof lining enables these units to be installed adjacent to building foundations, over slab construction, adjacent to property lines (if less than 750 mm in height), on bedrock controlled sites, or sites with poorly draining soils and sites with steep slopes.
- Flow-through rain planters can fit into most landscape designs and are suitable for highly urbanized areas and can replace traditional concrete planters.
- The **infiltration rain planter** option is most applicable on sites with steeper slopes or urban sites with more land available for construction on grade.
- The use of a waterproof lining between the building and main infiltration zone of the planter enables these units to be installed adjacent to building foundations.
- Due to the complexity of the design and construction techniques, infiltration and flow-through rain planters are suitable for commercial, institutional and high density multi-family buildings, however, they are not suitable for single-family applications.

Design Guidelines

1. Detailed design requirements should be evaluated for each individual application based on site-specific constraints and objectives.
2. Follow all applicable federal, provincial and municipal regulations.
3. Geo-technical investigations are recommended with soil permeability testing being the minimum requirement for design. Advice from a professional engineer for design is recommended.
4. Planter walls should be constructed of stone, brick, concrete, wood or other durable material (do not use chemically treated wood).
5. Slope to be 0.5% or less.
6. Provide 50 mm notch in wall for overflow.
7. Allow for 50 mm minimum free board.
8. Provide 100 mm from top of Bioretention Soil Mix (BSM) or growing medium to overflow.
9. Provide overflow bypass drain with beehive grate.

10. Provide 400 mm bioretention growing medium over 400 mm mixture over 50% sand/50% bioretention growing medium.
11. Provide flow dissipator, either washed pea gravel, river rock or splash pad at inlet.
12. Line box with 30-mil PVC liner (flow-through planter only).
13. Minimum width is 900 mm, measured within the walls.
14. Walls must be less than 750 mm high.
15. A facility with more plants will provide more treatment capacity.
16. There are no setbacks for lined flow-through planters.
17. Infiltration planters must be 1.5 m from property lines.
18. Infiltration planter setbacks are similar to other infiltration facilities – minimum 30 m from wells, minimum 3 m downslope of building foundations, and only in areas where foundations have footing drains.
19. The use of a waterproof lining between the building and main infiltration zone of the planter (see detail) enables infiltration planters units to be installed adjacent to building foundations.
20. Drawdown time for the maximum surface ponded volume: 24-36 hours and to bypass during larger storm events (72 hours max.).
21. A non-erodible outlet or spillway must be established to discharge overflow to the storm sewer system. This often takes the form of a grated inlet raised above the rain garden invert to create the ponding depth.
22. Avoid utility or other crossings below an infiltration planter. Where utility trenches must be constructed crossing below the planter, install low permeability trench dams to avoid infiltration water following the utility trench.
23. See Table 1 for setbacks for planters.

Table 1 Planter Setbacks

Setback From	Distance (m)	
	Infiltration	**Lined Flow Through**
Down Slope of Building Foundations	3 to 5	0
Property Line	1.5	0
Drinking Water Well	30	30
Septic Field	3	3

Sizing Planters

Sizing for both flow-through and infiltration planters is straightforward and a simplified sizing approach can be used.

1. In general, stormwater planters are sized to infiltrate or filter runoff from a limited area of upstream impervious surface, typically from a roof drain discharging through a downspout or scupper into the planter.
2. In general, the planter area is sized based on the upstream impervious area that it serves. This relationship can be defined by the ratio of impervious area to pervious area (e.g., I/P ratio). For the simplified sizing approach, this represents the ratio of upstream impervious area to the base area of the planter.
3. An infiltration planter cannot be used where the infiltration rate of the underlying soil is less than 12.5 mm/hr. Where infiltration rates are less than 12.5 mm/hr, a flow-through or partial infiltration planter must be used.
4. The simplified approach should only be used to size stormwater planters where the upstream impervious area is less than 1,000 m^2.
5. For the simplified sizing approach, the minimum size factor is 0.07 for infiltration planters and 0.03 for flow-through planters, where an impervious area of 100 m^2 would require 7 m^2 planter area for an infiltration planter and 3 m^2 planter area for a flow-through planter to manage the runoff.[2]
6. For sites with an infiltration rate of greater than 50 mm/hr, the size of the infiltration planters may be decreased, but must be sized by a professional engineer.
7. An engineered approach may be used with a measured infiltration rate to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project.
8. Sizing presented here is for filtering or infiltration of rain water for "capture" and prevention of site runoff. Sizing and design according to this guide will generally provide water quality treatment for the volume of water infiltrated. If "water quality" criteria volumes are larger than "capture volumes", additional sizing may be required and a professional engineer should be consulted.

[2]Stormwater Management Manual, City of Eugene, Oregon, 2014
https://www.eugene-or.gov/DocumentCenter/View/15783

Sizing for Depth Capture Criteria: R mm in 24 hrs

See Appendix A, Table 1 to determine R mm of rain in 24 hrs for area specific GSI facility rainfall capture targets – confirm with respective municipality.

1. Determine I/P ratio for the infiltration planter:

$$\text{I/P ratio} = \frac{\text{Impervious Tributary Area}}{\text{Planter Area}}$$

2. Determine the soil depth required:

$$D_S = \frac{R \times (I/P + 1) - Ks \times 24}{0.2}$$

   Where:

   D_S = Depth (thickness) of amended soil (mm)

   R = Rainfall capture depth (mm)

   Ks = Saturated hydraulic conductivity of subsurface soil (mm/hr), as measured during winter saturated soil conditions.

   I/P = Ratio of impervious tributary area to planter area (unitless)

3. Check whether the calculated soil depth is within the standard depth of 400 mm. If calculated depth exceeds 400 mm:
   - The soil depth may be acceptable upon consultation (i.e., 500 mm soil may be acceptable if landscape designers concur);
   - The I/P ratio may be reduced by routing runoff from a portion of the contributing impervious area to another GSI facility and the soil depth recalculated; or
   - The planter could be designed as a partial infiltration or lined flow-through planter, with an overflow to an approved discharge location.
4. To determine the infiltration planter area:

   Area = size factor x Impervious *Tributary Area*

Guideline Specifications

Materials shall meet Master Municipal Construction Document 2009 (MMCD) requirements, and:

1. Pipe: PVC, DR 35, 100 mm min. dia. with cleanouts certified to CSA B182.1 as per MMCD.
2. Sand: Pit Run Sand as per Section 31 05 17.
3. Growing Medium: Bioretention Soil Medium (i.e., growing media): As per Tables 2.a and 2.b Bioretention Soil Medium, but with required minimum saturated hydraulic conductivity of 70 mm/hr.

4. Seeding: conform to Section 32 92 20 Seeding or 32 92 19 Hydraulic Seeding (Note: seeding will be required for erosion control in most instances).
5. Sodding: conform to MMCD Section 31 92 23 Sodding. (Note: sodding will be required for erosion control in most instances).
6. Planting: see Supplemental 1, Planting Templates & Plant Lists.

Construction Practices shall meet Master Municipal Construction Document 2009 (MMCD) requirements, and:

1. Isolate the infiltration or flow-through planter site from sedimentation during construction, either by use of effective erosion and sediment control measures upstream, or by delaying the excavation of 300 mm of material over the final subgrade of the vegetated curb extension until after all sediment-producing construction in the drainage area has been completed.
2. Prevent natural or fill soils from intermixing with the infiltration drain rock. All contaminated stone aggregate must be removed and replaced.
3. Infiltration drain rock shall be installed in 300 mm lifts and compacted to eliminate voids between the geotextile and surrounding soils.
4. Plant and maintain planted areas to conform with municipal standards for visibility and access in the Right-of-Way and Landscape Maintenance standards shall be to the Canada Landscape Standard, 1st Edition, Maintenance Level.

Bioretention Soil Medium

Composition of Bioretention Soil Medium (BSM) is an important factor in the performance of GSI facilities. Soil mixes for bioretention and vegetated infiltration facilities need to balance 3 primary design objectives for optimum performance:

- ✓ High enough infiltration rates to meet desired surface water drawdown and system dewatering.
- ✓ A growth media to support long term plant and soil health and water quality treatment capability.
- ✓ Infiltration rates that are not too high in order to optimize pollutant removal capability.

For the latest information on bioretention soil research see the Washington Stormwater Center's webpage on Bioretention http://www.wastormwatercenter.org/lid-bioretention/.

Below are 2 local BSM suggested mixes. For infiltration rates see information in "Sizing Planters".

Table 2.a Planter Bioretention Soil Mediums Mix 1[3]

Infiltration and Flow-Through Planters Bioretention Soil Medium (BSM) Mix 1 See 'Design Guidelines' and 'Sizing Planters' for recommended BSM depth and minimum required saturated hydraulic conductivity of mm/hr.	
Component (partial size classes)	**Percentage by Weight**
Gravel (greater than 2.5 mm)	0
Sand (greater than 0.05 mm and less than 2.5 mm) • Sand to be hard, granular sharp sand well washed and free of impurities, chemicals or organic matter; and • Particle size in sand to be: a) 90-100% passing a 2.50 mm sieve, b) 0-65% passing a 0.500 mm sieve, c) 0-5% passing a 0.0500 mm sieve	70-80
Silt (greater than 0.002 mm and less than 0.05 mm)	5-15
Clay (less than 0.002 mm)	2-5
Organic Content (%dry weight) • must be well aged organics, weed free, preferably manure free and biosolid free.	10-15
Other Soil Considerations	
• **pH** of mixed materials between 6-8.5 • **Phosphorus (P) and Nitrogen (N) Management Recommendations**: In some cases, bioretention facilities have the potential to export P and N at a higher rate than contained in the storm water they are receiving. See Low Impact Development Technical Guidance Manual for Puget Sound 2012 (chapter 6.1.2 Bioretention Design) for nutrient management suggestions. http://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf • **Safe Soils:** The spread and proliferation of invasive species through many regions of the province comes from the re-distribution of invasive species laden soils. In 2016, a Soils and Invasive Species Sub-Working Group was developed to explore province-wide solutions regarding the movement of soil and related materials that may contain invasive species. This Sub-Working Group involves provincial and local government representation. Learn more: Provincial Response to the Resolutions of the 2016 Union of British Columbia Municipalities Convention FEBRUARY 2017 B113 SAFE SOILS PROGRAM (page 111) http://www.ubcm.ca/assets/Resolutions~and~Policy/Resolutions/Provincial_Responses-2016_UBCM_Resolutions.pdf	

[3] Source: Rain Gardens, Stormwater Best Management Practices, District of Saanich
http://www.saanich.ca/assets/Community/Documents/Rain%20Garden.pdf

Table 2.b Planter Bioretention Soil Mediums Mix 2[4]

Infiltration and Flow-Through Planters Bioretention Soil Medium (BSM) Mix 2* See 'Design Guidelines' and 'Sizing Planters' for recommended BSM depth and minimum required saturated hydraulic conductivity of mm/hr.	
Component (partial size classes)	**Percentage by Weight**
Coarse Gravel (particles greater than 19 mm and less than 40 mm)	0 to 1
All Gravels (particles greater than 2 mm and less than 40 mm)	10 to 25
Sand, Silt, Clay & Organic components measured from remaining non gravel portion of sample (% dry weight)	
Sand (greater than 0.05 mm and less than 2.5 mm) • Sand to be hard, granular sharp sand well washed and free of impurities, chemicals or organic matter. • Note: Growing medium/BSM to be manufactured with '2 mm minus' sand to reduce gravel content in the soil. 2 mm minus sand is available from most local quarries upon request.	60-70
Combined Silt and Clays (less than 0.05 mm)	10-20
Organics (% dry weight) • must be well aged organics, weed-free, preferably manure-free and biosolid free.	15-20
Other Soil Considerations	
• **pH** of mixed materials between 6-8.5 • **Phosphorus (P) and Nitrogen (N) Management Recommendations**: In some cases, bioretention facilities have the potential to export P and N at a higher rate than contained in the storm water they are receiving. See Low Impact Development Technical Guidance Manual for Puget Sound 2012 (chapter 6.1.2 Bioretention Design) for nutrient management suggestions. http://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf • **Safe Soils:** The spread and proliferation of invasive species through many regions of the province comes from the re-distribution of invasive species laden soils. In 2016, a Soils and Invasive Species Sub-Working Group was developed to explore province-wide solutions regarding the movement of soil and related materials that may contain invasive species. This Sub-Working Group involves provincial and local government representation. Learn more: Provincial Response to the Resolutions of the 2016 Union of British Columbia Municipalities Convention FEBRUARY 2017, page 111 for B113 SAFE SOILS PROGRAM. http://www.ubcm.ca/assets/Resolutions~and~Policy/Resolutions/Provincial_Responses-2016_UBCM_Resolutions.pdf	

[4] Source: City of Victoria, Rainwater Management Standards – Professional Edition (June 2015) http://www.victoria.ca/assets/Departments/Engineering~Public~Works/Documents/SWVictoria_Professional_Rainwater_Mgmt_Stds_June2015.pdf

Infiltration Planter Design Example for Capture of R mm/24-hour Criteria

Scenario Description

A planter is proposed to capture a portion of the runoff from a building roof (see illustration below).

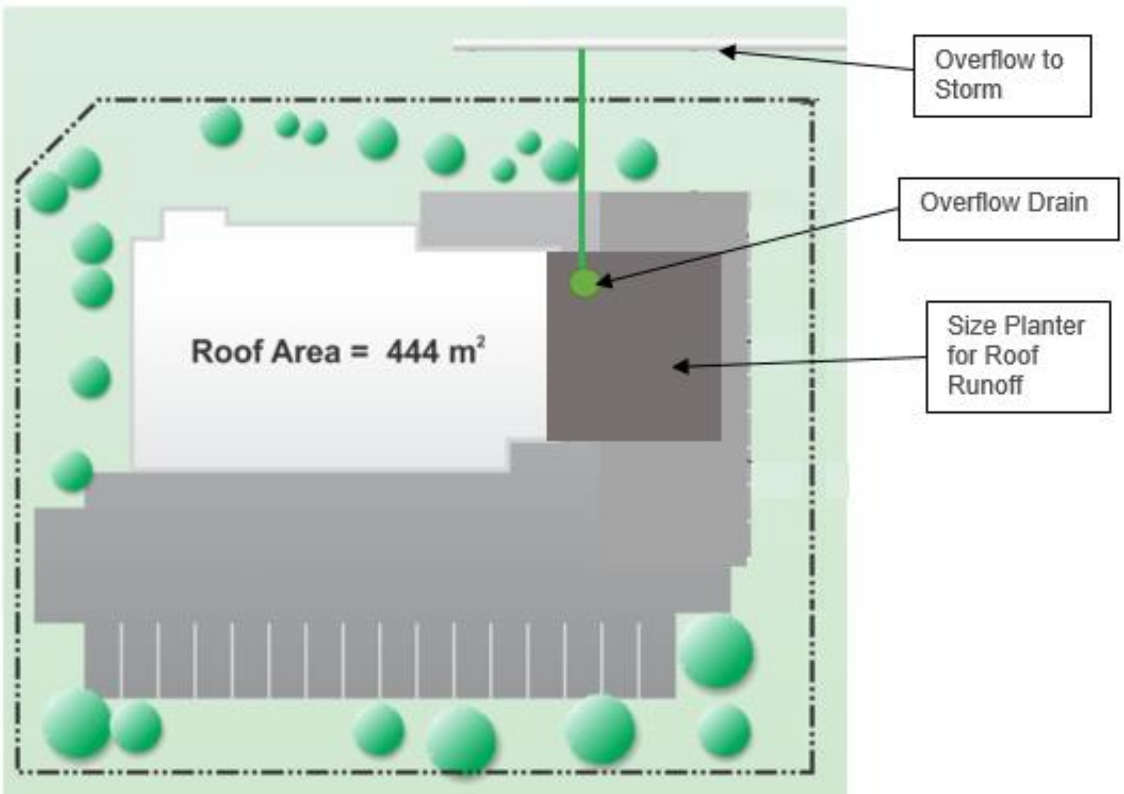

Figure 3 Example – Roof Area Draining to Planter

The following parameters are known:

- Roof area = 444 m^2
- Total Planter Area = 104 m^2
- 2-year 24-hour rain depth = 53 mm
- Native soil infiltration rate = 5 mm/hr
- Capture target is 72% of 2-year 24-hour rain amount = 38 mm

Determine whether the plater area is large enough and the growing medium depth required.

Sizing

Determine the site I/P ratio:

$$I/P = \frac{444\,sq.m}{104\,sq.m} = 4.3$$

$$D_S = \frac{R \times (I/P + 1) - Ks \times 24}{0.2}$$

Where:

D_S = Depth (thickness) of amended soil (mm)

R = Rainfall capture depth (mm)

Ks = Saturated hydraulic conductivity of subsurface soil (mm/hr), as measured during winter saturated soil conditions

I/P = Ratio of impervious tributary area to absorbent landscape area (unitless)

$$D_S = \frac{38mm \times 5.3 - (5mm/hr \times 24)}{0.2}$$ = 407 mm

Hydraulic Components

- Inlet: Roof runoff is piped onto a flow dissipator or splash pad in the planter.
- Overflow: Surface overflow notch in top of planter wall or overflow stand pipe connects to the municipal major system.

GSI Driver Effectiveness – Runoff Reduction and Contaminant Removal

International Stormwater BMP Database http://www.bmpdatabase.org/ is a recommended resource for performance summaries of GSI facilities and latest research.

Bioretention areas function as soil and plant-based devices that can achieve both runoff reduction and pollutant removal. Runoff reduction is achieved through canopy interception, soil infiltration, and evapotranspiration. Pollutant removal is achieved through a variety of physical, biological, and chemical treatment processes. A number of pollutants including trace metals, suspended solids, nutrients, and oil and grease are removed from stormwater by filtering, adsorption, biological uptake, and denitrification within the bioretention cell's mulch and soil media. The pollutant removal efficiency can be increased or decreased based on the design components, underlying soil infiltration capabilities and what pollutants are being targeted for reduction. The following table shows the effectiveness of bioretention facilities for GSI drivers, including pollutant removal and stormwater runoff reduction.

Table 3 Runoff Reduction and Contaminant Removal

Bioretention and Vegetated Infiltration GSI Facilities (rain gardens, swales, planters, curb extensions)	
GSI Driver	***Estimated Effectiveness or typical % Reduction or Removal**
Capture & Slow – Volume Runoff Reduction	85% without underdrain 45% with underdrain low with liner and underdrain
Store & Convey – Rate Control Delay Peak	Medium to high without under drain Medium with underdrain Low with liner and underdrain
Clean & Infiltrate – Water Quality Treatment	Highly variable with design, BSM, native soil and depth, plant type. Below are typical results. Research has observed good retention and at times production and export. Export is more likely with an underdrain.
Heavy Metals (Copper, Lead, Zinc)	35-90
Oil and Grease	>70% (higher with mulch)
Phosphorus	(+70) – 85
*Nitrogen	20 – 30+
Total Suspended Solids (TSS)	60 – 95+
Bacteria (Fecal coliform bacteria or E. coli)	>70%

Note: *Performance of individual GSI facilities will vary depending on site specific contexts and facility design.

Sources:

http://extension.oregonstate.edu/stormwater/sites/default/files/Planters_0.pdf
http://www.creditvalleyca.ca/wp-content/uploads/2012/02/lid-swm-guide-chapter4-4.5-bioretention.pdf
*http://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf
http://www.lid-stormwater.net/bio_benefits.htm
https://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
http://your.kingcounty.gov/dnrp/library/water-and-land/stormwater/juanita-retrofit/appendix-d-removal-rates.pdf
http://www.bmpdatabase.org/
https://stormwater.pca.state.mn.us/index.php?title=Information_on_pollutant_removal_by_BMPs

Maintenance

Bioretention and infiltration areas require annual plant, soil, and mulch layer maintenance to ensure optimal infiltration, storage, and pollutant removal capabilities. The successful establishment of a bioretention and infiltration area requires a first year inspection and maintenance operation that includes the following tasks:

- Initial inspections after storm events of over 13 mm of rainfall
- Spot reseeding of bare or eroding areas
- Spot fertilization requirements of initial plantings
- Watering once a week during first 2 months and as needed during first growing season
- Remove and replace dead plants to ensure that vegetation is properly established (up to 10% of plant stock may die off in the first year)

After the first year, it is highly recommended that an annual spring maintenance inspection and cleanup be conducted at all bioretention and infiltration facilities which would include the following:

- Check % vegetative cover
- Check for sediment buildup at entrance points
- Check for winter killed vegetation and replace
- Note presence of accumulated sediment
- Check for any erosion
- Check for signs of excessive ponding
- Check for clogged soil media and crust formation
- Remove leaves each fall

Routine Maintenance

Most of the routine maintenance procedures are typical landscape care activities.

ACTIVITY	OBJECTIVE	SCHEDULE
Watering (by hand or irrigation system)	Maintain a minimum 80% survival rate of plants	Once established, water thoroughly every 2 weeks or as indicated by plant health.
Cleaning entrance points	Maintain proper flow from impervious areas	Twice annually (October & January)
Pruning vegetation	Maintain plant coverage and health, soil health, and infiltration capability	Once or twice annually
Weeding (by hand)	Reduce plant competition and maintain aesthetics	Twice annually preceding weed seed disbursement
Trash removal	Maintain aesthetics and prevent clogging	Twice annually
Minor sediment removal (with shovel or rake)	Reduce clogging, maintain plant survival, maintain ponding depths	Annually

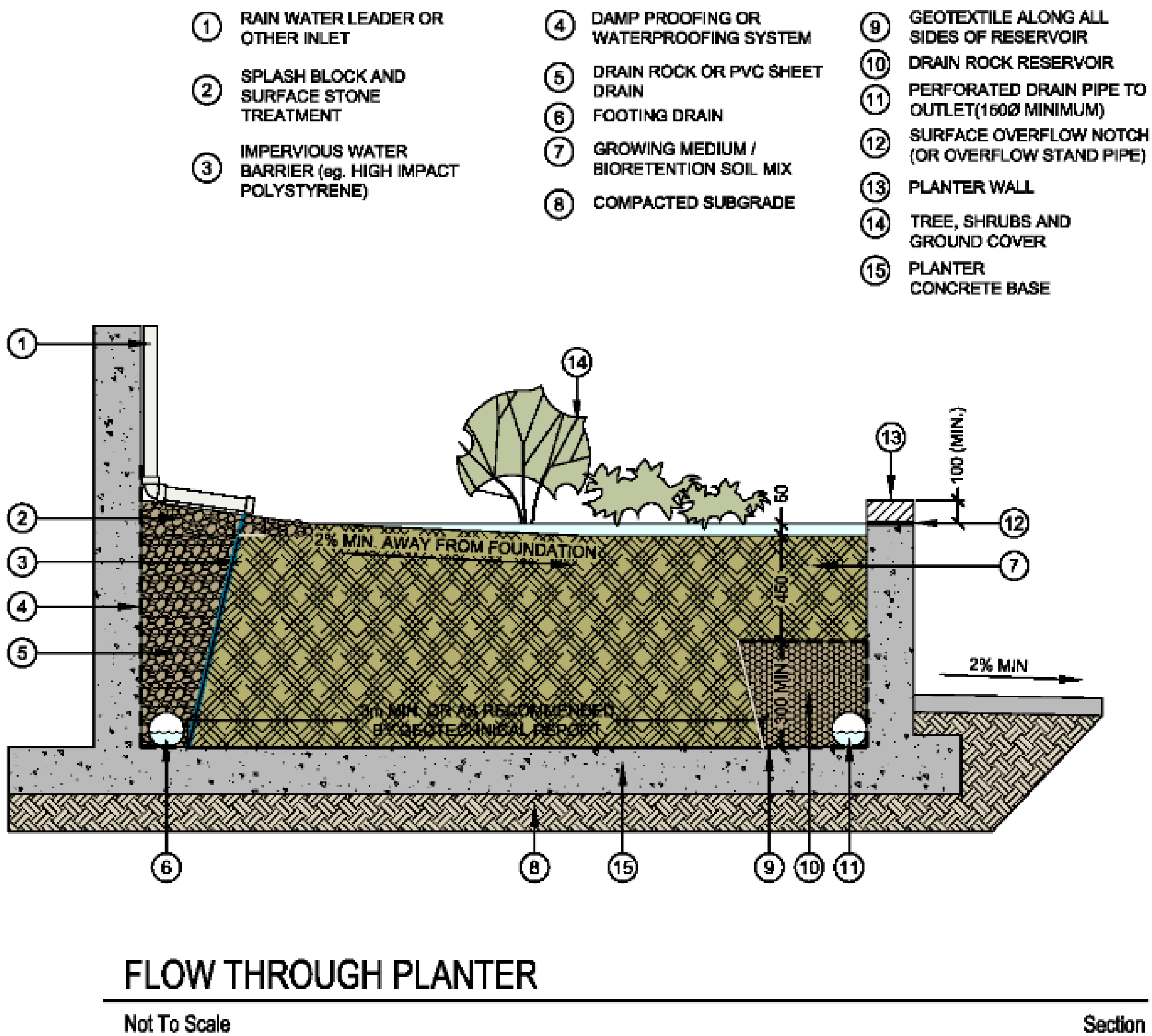

Figure 4 Flow-Through Planter

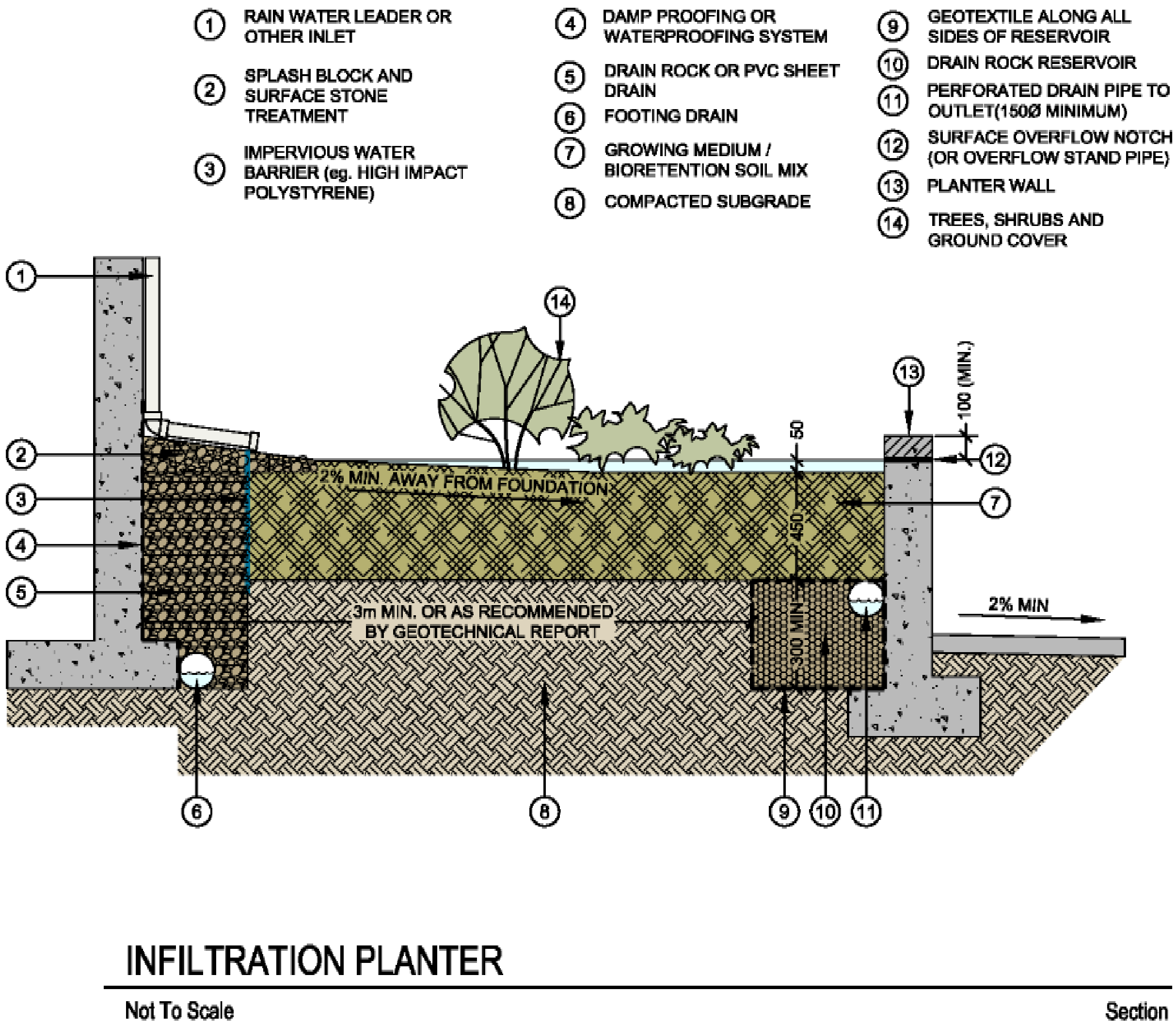

Figure 5 Infiltration Planter