Private Water Quality Facility Management Program

Inspection Guide

April 2012

Wherever there's water, there's **Clean Water.**

Clean Water Services

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Clean Water Services and its member Cities have initiated a program to regularly inspect and support maintenance of privately-owned water quality facilities. These facilities are constructed to protect precious water resources by removing pollution from stormwater runoff. Water quality facilities are required by law and must comply with Clean Water Services' municipal stormwater (MS4) permit and Oregon Department of Environmental Quality (DEQ) regulations.

The fact sheets and operations and maintenance plans in this handbook explain proper operation and maintenance of common types of water quality facilities. They describe what to look for during required annual inspections and additional recommended inspections. If you have questions or concerns, please feel free to call our trained staff for assistance at (503) 681-3600. Your efforts to protect water resources are appreciated.

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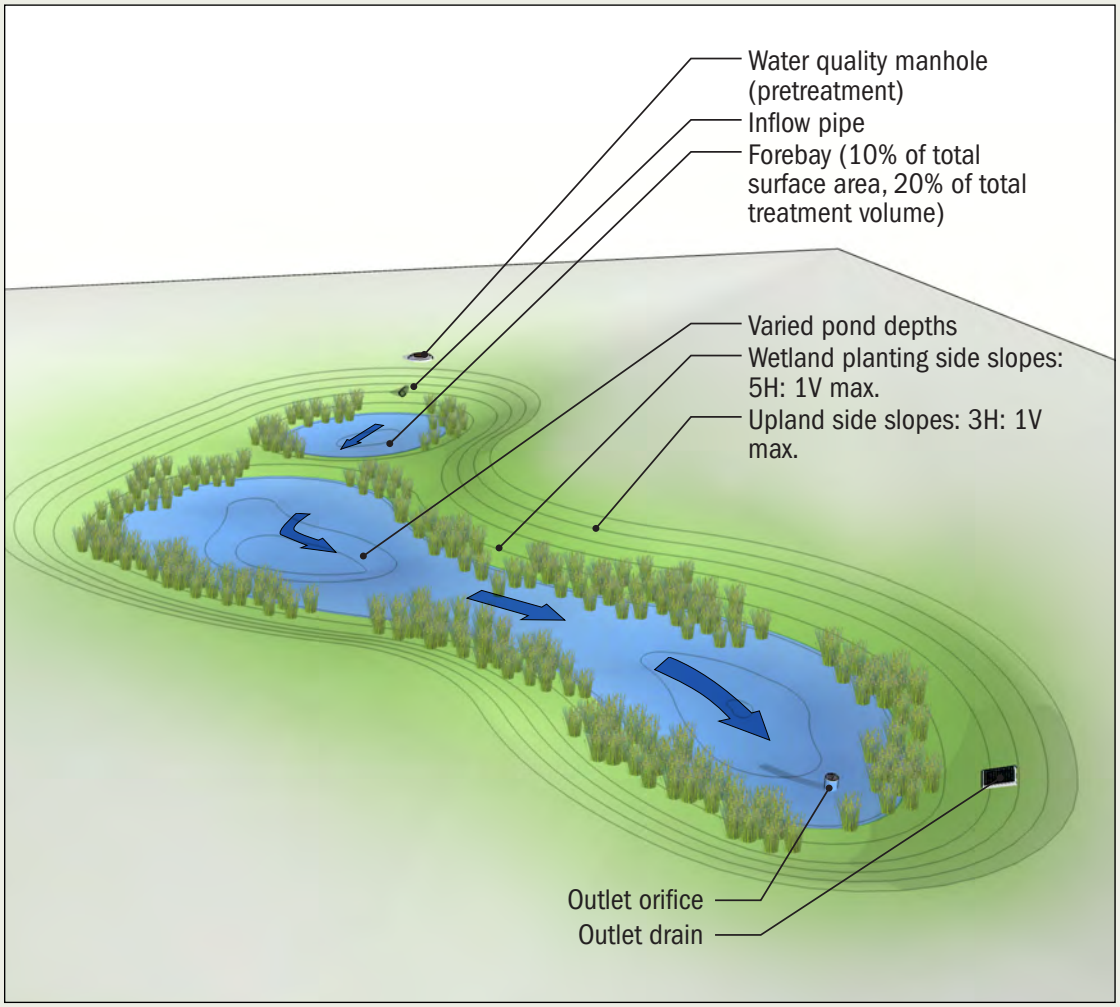
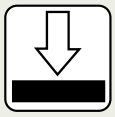
Constructed Water Quality Wetland



parking areas & impermeable landscape



impermeable soils

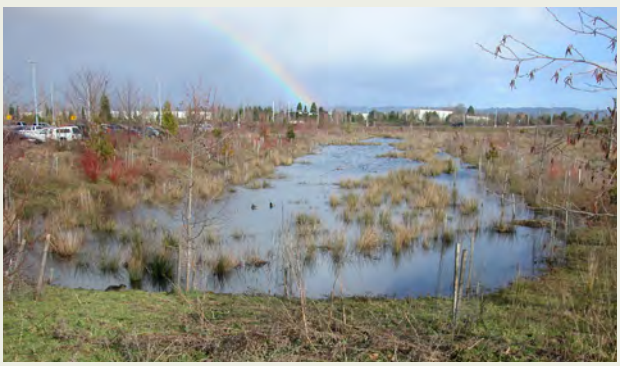
permeable soils

Description

A constructed water quality wetland is a shallow landscaped depression that collects and holds stormwater runoff and allows pollutants to settle and filter out during storm events. Constructed wetlands have a permanent pool of water and also an extended detention area above that fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to reduce pollution by settling and biological processes. The extended detention area is sized to meet flow control requirements.

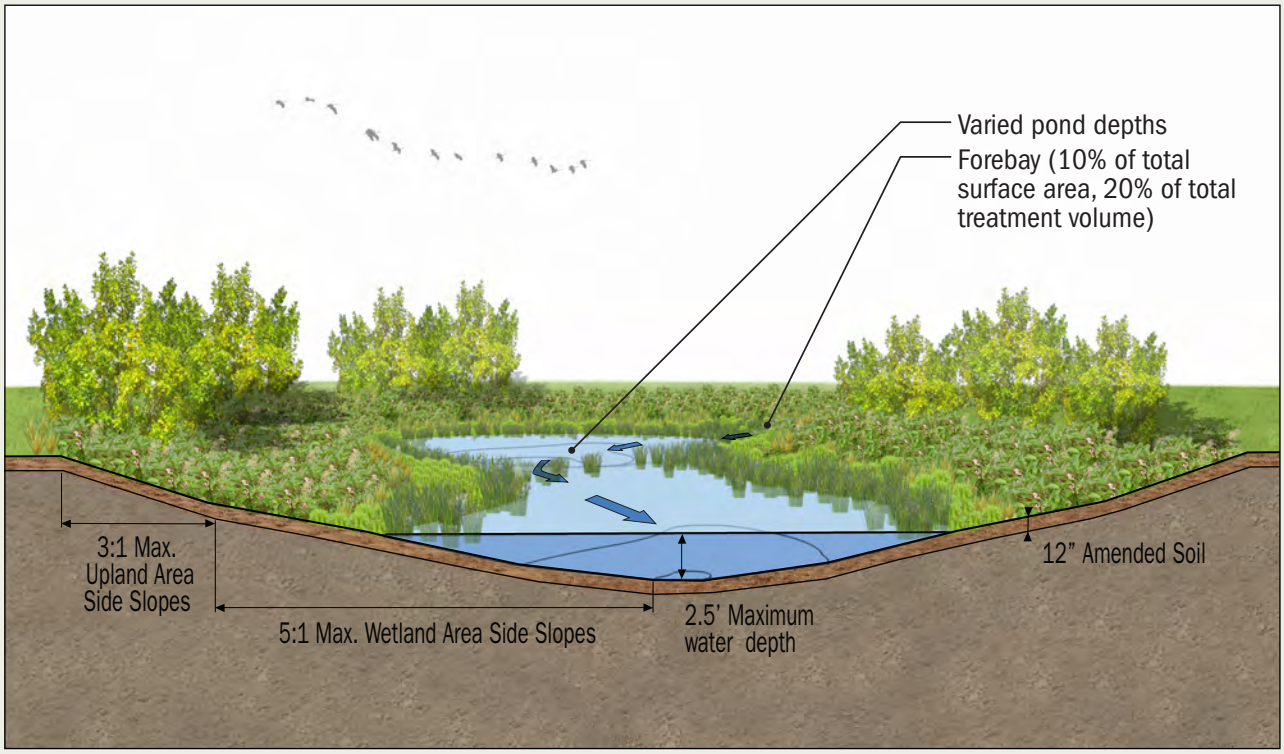
Application & Limitations

Constructed water quality wetlands may help fulfill a site's landscaping area requirement. Constructed wetlands are approved to treat stormwater from all types of impervious surfaces, including private property and the public right-of way, runoff from rooftops, parking lots, and streets.



Ronler Acres, Hillsboro

Constructed Water Quality Wetland



Design Factors

Sizing

Sizing of the constructed water quality wetland is determined by the volume of runoff and the required detention time for treatment. At a minimum, the detention basin must accommodate the water quality design storm and be sized for a 48 hour drawdown time. The minimum water quality detention volume is equal to (1)x the water quality volume (WQV). The outlet orifice size is determined by the following equation:

D = 24 * [(Q/ (C[2gH]0.5) / Pi] 0.5

Where:

D (in) = diameter of orifice
Q(cfs) = WQV(cf) /(48*60*60)
C = 0.62
H(ft) = 2/3 x temporary detention height to centerline of orifice.

Geometry/Slopes

Constructed water quality wetlands have two or more cells. The first cell, known as the forebay, is at least 10% of the entire surface area and constitutes 20% of the treatment volume. If space is limited, one cell with a forebay at the inlet will settle sediments and distribute flow across the wet pond.

Unlike the flat bottom of an extended dry basin, in a constructed wetland the pool depth varies throughout the pond. Not including the permanent pool, the maximum depth of the water quality pool is 2.5-feet unless otherwise approved by the jurisdiction.

Side slopes for wetland planting areas should not exceed 5H: 1V (20%) and side slopes for non-wetland planting areas should not exceed 3H: 1V (33.33%). The minimum freeboard height is 1 foot from the 25-year design water surface elevation. A perimeter 10 to 20 feet wide provides inundation during storm events.

Piping for Constructed Water Quality Wetlands

Incoming flows to the water quality wetland facility are pretreated by a water quality manhole or other approved pretreatment method in accordance with District Standards. Other pretreatment methods may include proprietary devices, filter strip, trapped catch basin, or other methods as approved by the District or City. An approved outlet structure is provided for all flows.

Setbacks

Check with the local building department to confirm site-specific requirements.

Oleson Woods Apartments, Tigard

Design Factors (continued)

Soil Amendment/Mulch
A minimum of 12" of topsoil should be applied to all treatment areas.

Vegetation
The entire facility area (permanent pool, side slopes and perimeter zone) are planted with vegetation appropriate for the varying planting conditions within the constructed wetland. Planting conditions within the wetland vary from saturated soil to relatively dry, and several planting zones should be considered. The zone between the bottom of the constructed wetland and the top of the permanent pool will be constantly inundated with water and have saturated soils. This wet zone should be planted with rushes, sedges, and other wetland species that are well-suited to water-saturated, oxygen-deprived (anaerobic) planting conditions. The variable depth of the bottom of the wetland will create a series of micro planting conditions. Within this wet zone, areas of open water may be too deep to support significant vegetation.

The side slopes above the permanent pool depth to the outer edges of the perimeter zone will have a moisture gradient that varies from wet near the bottom to relatively dry near the edge of the perimeter area where inundation rarely occurs. This moisture gradient will vary depending upon the maximum designed water depth, constructed wetland depth, and side slope steepness. This moist-to-wet transition zone from the top of the permanent pool to the designed high water line or top of freeboard should be planted with sedges, rushes, perennials, ferns and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. Areas above the designed high water line and immediately adjacent to the water quality wetland is a dry zone and will not be regularly inundated. The dry zone should be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate. The planting design should minimize solar exposure of open water areas to reduce heat gain in the water. Lower water temperatures help to maintain healthy oxygen levels and minimize algae blooms. Trees or other appropriate vegetation should be planted at the perimeter of the pond to maximize shading. The use of native plants is encouraged, but adapted, non-invasive ornamentals are acceptable for added aesthetic and functional value.

Constructed Water Quality Wetland

Synopsys, Hillsboro

Ronler Acres, Hillsboro

Vegetation (continued)
All vegetation should be densely and evenly planted to ensure proper hydrological function of the water quality wetland.

Plant Spacing

Constructed Water Quality Wetlands in tracts or easements are to be planted as follows to achieve the specified per acre densities:
i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
ii. Total number of trees per acre = area in square feet x 0.01
iii. Total number of shrubs per acre = area in square feet x 0.05
iv. Groundcover = plant and seed to achieve 100% areal coverage

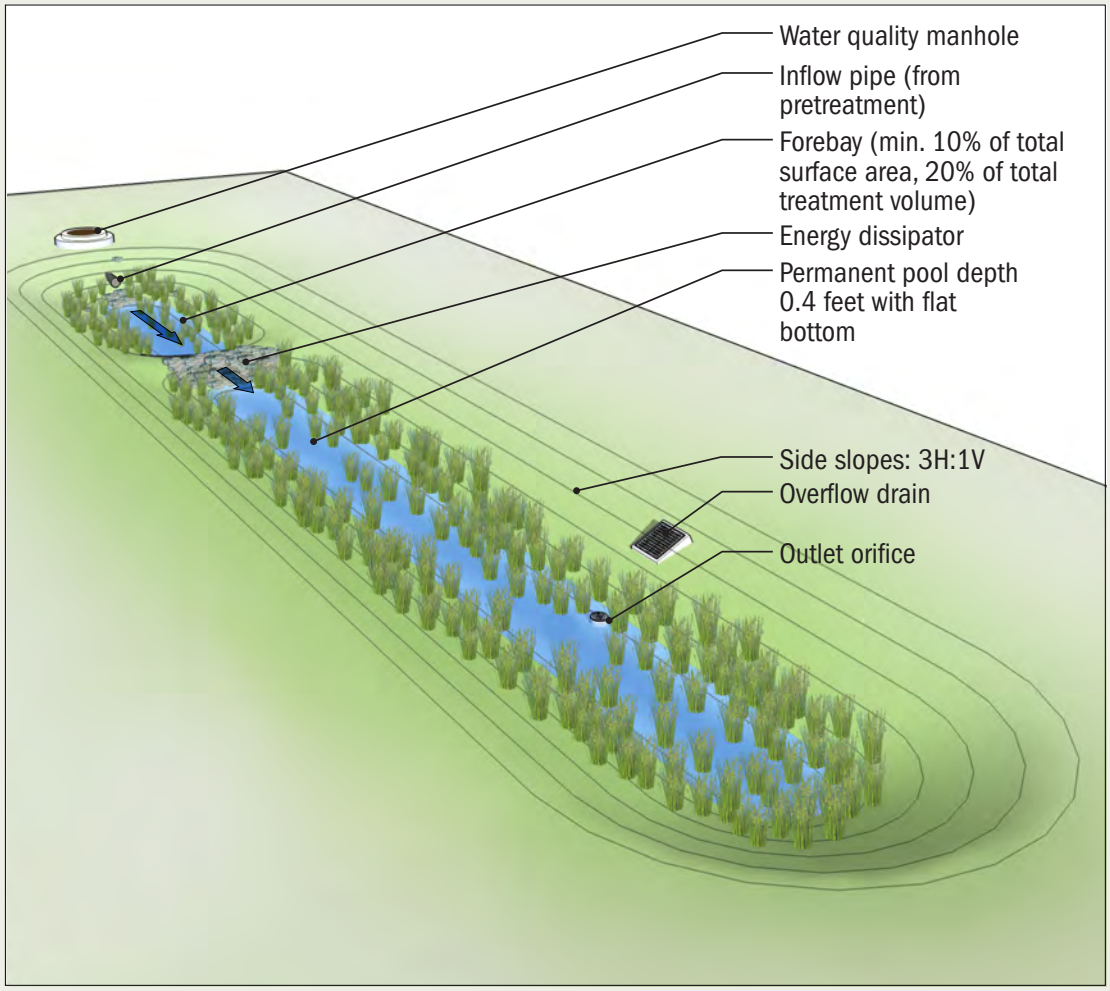
Maintenance

- Water efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation of plantings after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the constructed water quality wetland for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for an example of a maintenance agreement).
- Conduct inspections by qualified personnel at least once a year; evaluate the effectiveness of the regular maintenance schedule and determine the timing of corrective maintenance procedures.
- Remove debris and trash regularly to reduce the chance of outlet structures, trash racks and other components becoming clogged and inoperable during storm events. Dispose of debris and trash in compliance with local, state and federal waste regulations. Use only suitable disposal/recycling sites.
- Investigate any evidence of clogging or rapid release in the wetland. Correct any subsidence, erosion, cracking, unwanted vegetation growth, over-accumulation of sediment around forebays, etc.
- Place inlet structure at the appropriate level to function; not low enough to get buried or “silt in”, nor so high that it causes erosion during storm events.
- Replant any bare patches as necessary to achieve adequate coverage.
- See Appendix for detailed operations and maintenance plan.

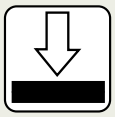
References

- Clean Water Services Design and Construction Standards
- Gardening with Native Plants poster; Clean Water Services

Extended Dry Basin



parking areas & impermeable landscape



impermeable soils

permeable soils

Description

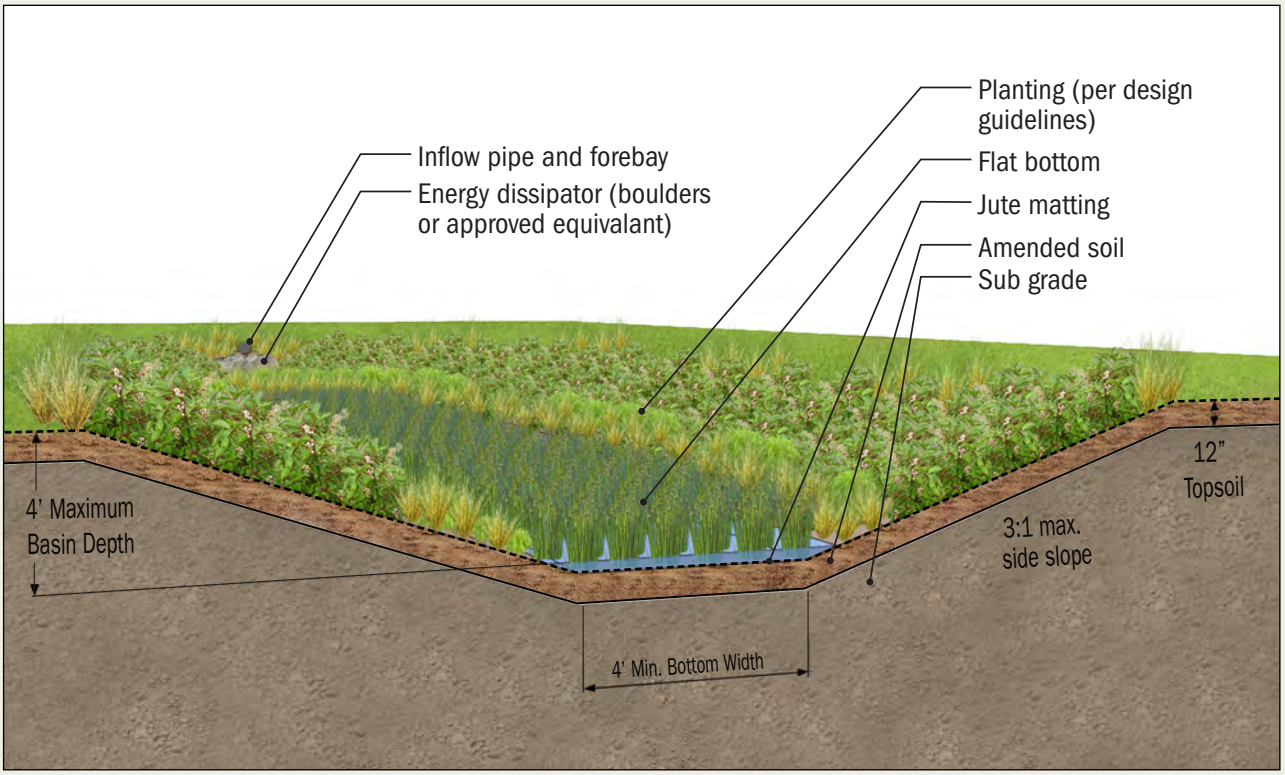
An extended dry basin is a shallow landscaped depression with a flat bottom that collects and holds stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or is discharged to an approved location. An extended dry basin has two or more cells (the first cell is the forebay). An inflow pipe conveys stormwater into the basin where it is temporarily stored. Extended dry basins may infiltrate stormwater where soils have high infiltration rates, or may overflow to an approved discharge point.

Application & Limitations

Extended dry basins may help fulfill a site's landscaping area requirement. This type of swale is approved to treat stormwater from all types of impervious surfaces, including private property and the public right-of-way, rooftops, parking lots, and streets.

Home Depot, Glenn Widing Drive, North Portland

Extended Dry Basin



Design Factors

Sizing

Sizing of the detention basin is determined by the volume of runoff and the detention period required for treatment. At a minimum, the detention basin must accommodate the water quality design storm and be sized for a 48 hour drawdown time.

The minimum water quality detention volume is equal to (1) x the water quality volume (WQV). The outlet orifice size is determined by the following equation:

D = 24 * [(Q/ (C[2gH]0.5) / pi] 0.5

Where:

D (in) = diameter of orifice

Q(cfs) = WQV(cf) /(48*60*60)

C = 0.62

H(ft) = 2/3 x temporary detention height to centerline of orifice.

Geometry/Slopes

An extended dry basin has two or more cells. The first cell, the forebay, is at least 10% of the entire surface area and constitutes 20% of the treatment volume. The minimum width of the bottom of the extended dry basin is 4 feet, and the permanent pool depth is 0.4 feet and covers the entire bottom of the basin. The maximum depth of the water quality pool, not including the permanent pool, is 4 feet unless otherwise limited by the jurisdiction.

The maximum side slopes of the basin treatment area are 3H: 1V (33.33%); the minimum freeboard is 1 foot above the 25-year design water surface elevation.

Piping for Extended Dry Basins

Incoming flows are pretreated using a water quality manhole in accordance with the District Standards. Other pretreatment may include proprietary devices, filter strip, trapped catch basin, or methods approved by the District or City. An approved outlet structure is provided for all flows.

Setbacks

Check with the local building department to confirm site-specific requirements.

Soil Amendment/Mulch

If required, place ¾" to 2-inch river run rock 2.5 to 3 inches deep where sustained flow is anticipated. River rock (if required), topsoil, and high density jute or coconut matting extend to the top of the treatment area. Topsoil and low density jute matting extend to the edge of the water quality tract or easement area.

Extended Dry Basin

Washington County

Vegetation

The entire facility area (side slopes and treatment areas) is planted with vegetation appropriate for the varying planting conditions within the extended dry basin. Planting conditions vary from saturated soil to relatively dry, and several planting zones should be considered. The flat bottom of the extended dry basin to the top of the 0.4 foot permanent pool is a saturated zone and will be constantly inundated with water. The saturated zone should be planted with rushes, sedges, and other wetland species (oxygenators) that are well-suited to water-saturated, oxygen-deprived (anaerobic) planting conditions.

The side slopes above the permanent pool depth will vary from wet at the bottom to relatively dry near the top where inundation rarely occurs. This moisture gradient will vary depending upon the designed maximum water depth, basin depth, and side slope steepness. This wet-to-moist transition zone from the top of the permanent pool to the designed high water line or top of freeboard should be planted with sedges, rushes, perennials, ferns and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the extended dry basin will not be regularly inundated. The dry zone should be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate and site.

The use of native plants is encouraged, but appropriate, adapted non-invasive ornamentals are acceptable for added aesthetic and functional value. All vegetation should be densely and evenly planted to ensure proper hydrological function of the extended dry basin.

Plant Spacing

A) Extended Dry Basins in tracts or easements *less than* 30 feet wide are planted as follows to achieve the specified per acre densities:
i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
ii. Total number of shrubs per acre = area in square feet x 0.05
iii. Groundcover = plant and seed to achieve 100% coverage

B) Extended Dry Basins in tracts or easements 30 feet wide or more are planted as followings to achieve the specified per acre densities:
i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
ii. Total number of trees per acre = area in square feet x 0.01
iii. Total number of shrubs per acre = area in square feet x 0.05
iv. Groundcover = plant and seed to achieve 100% coverage

Extended Dry Basin

Home Depot, Glenn Widing Drive, North Portland

Washington County

Maintenance

- Water efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation of plantings after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the extended dry basin for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- Remove all trash, debris and sediment regularly to keep outlet structures and trash racks operable during storm events. Proper maintenance also eliminates mosquito breeding habitats. Comply with debris and trash disposal regulations.
- Maintain adequate groundcover and shrubs in the basin, but not overgrown to the extent that storage capacity is inhibited.
- Inspect annually at a minimum by qualified personnel during wet weather to verify detention times are met. Look for and repair clogging, rapid release, subsidence, erosion, cracking, unwanted plant growth, accumulation of sediment in the forebay or around outlets, etc. Based on the inspections, determine an appropriate maintenance and repair schedule.
- See Appendix for detailed operations and maintenance plan.

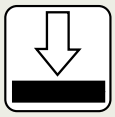
References

- Clean Water Services Design and Construction Standards
- Gardening with Native Plants poster; Clean Water Services

Flow-Through Planter

buildings

parking areas & impermeable landscape



impermeable soils

Description

Flow-through planters are structural landscaped reservoirs that collect stormwater and filter out pollutants as the water percolates through the vegetation, growing medium, and gravel. These are appropriate where soils do not drain well or there are site constraints. A liner may be required when located adjacent to buildings, over contaminated soils, and on unstable slopes. Excess stormwater collects in a perforated pipe at the bottom of the flow-through planter and drains to an approved discharge point.

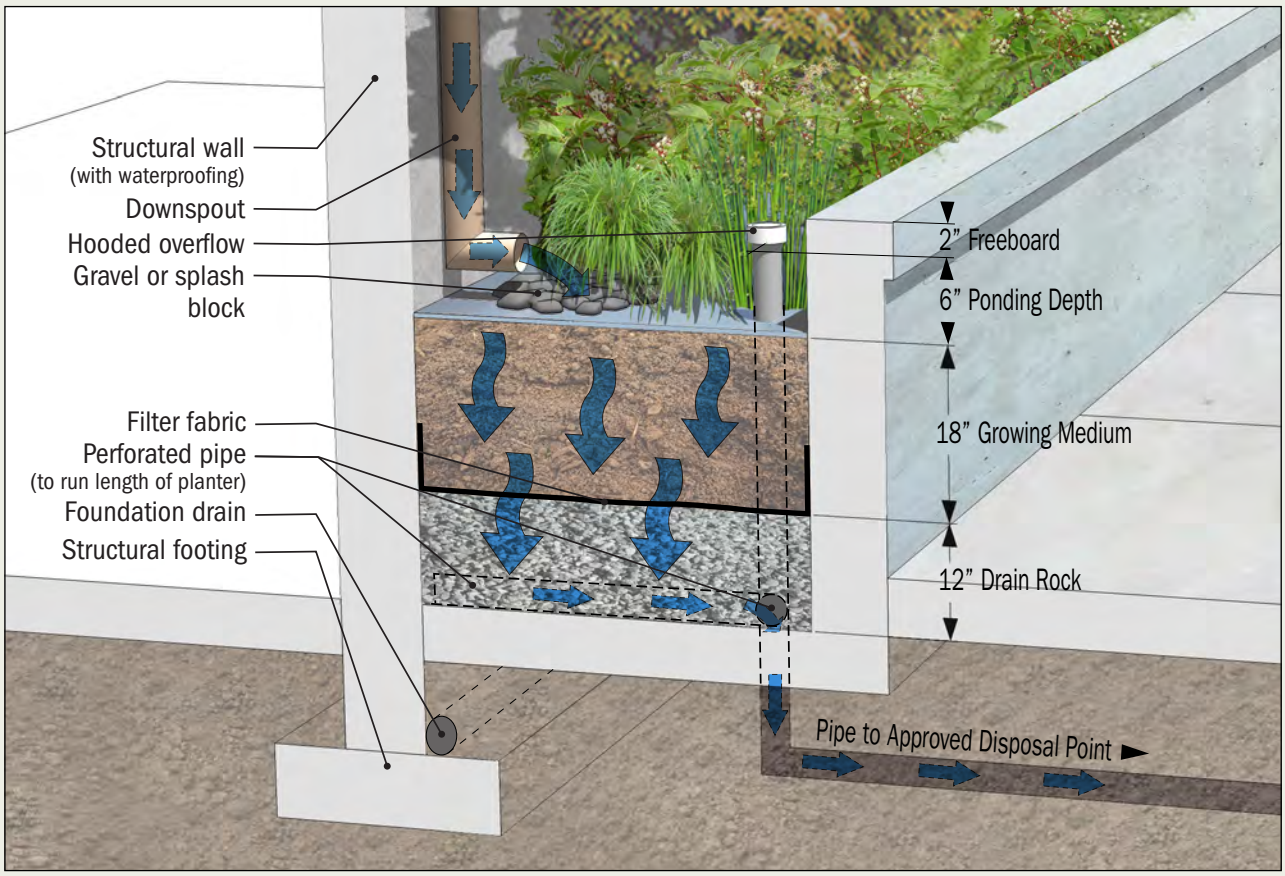
Tree box filters are flow-through planters with a concrete "box" that contains filtering growing media and a tree or large shrub. Tree box filters are used singly or in multiples, often adjacent to streets where runoff is directed to them to treat stormwater runoff before it enters a catch basin.

Application & Limitations

Flow-through planters may help fulfill a site's landscaping area requirement and can be used to manage stormwater runoff from all types of impervious surfaces on private property and within the public right-of-way. Check with the local jurisdiction if proposing to use a flow-through planter in the public right-of-way. Flow-through planters can be placed next to buildings and are ideal for sites with poorly draining soils, steep slopes or other constraints. Design variations of shape, wall treatment, and planting scheme will fit the character of any site.

Headwaters at Tryon Creek, Portland

Flow-Through Planter



Design Factors

Sizing

To calculate the planter size, multiply the impervious surface (rooftops, driveways, parking lots, etc.) area by 6%. The square footage is the peak water surface prior to overflow. For example, a 1,200 sf rooftop and 300 sf driveway (1,500 sf total impervious area) requires a 90 sf stormwater planter (1,500 x 0.06). This could be accomplished with one 9-foot by 10-foot flow-through planter.

Geometry/Slopes

- Stormwater planters may be any shape, and can be designed as square, rectangular, circular, oblong, or irregular.
- Regardless of the shape, a minimum planter width of 30 inches is needed to achieve sufficient time for treatment and to avoid short-circuiting.
- The minimum treatment depth of 18 inches is achieved in the growing medium.
- Planters are designed to evenly distribute and filter flows. Surface longitudinal slopes should be less than 0.5%.

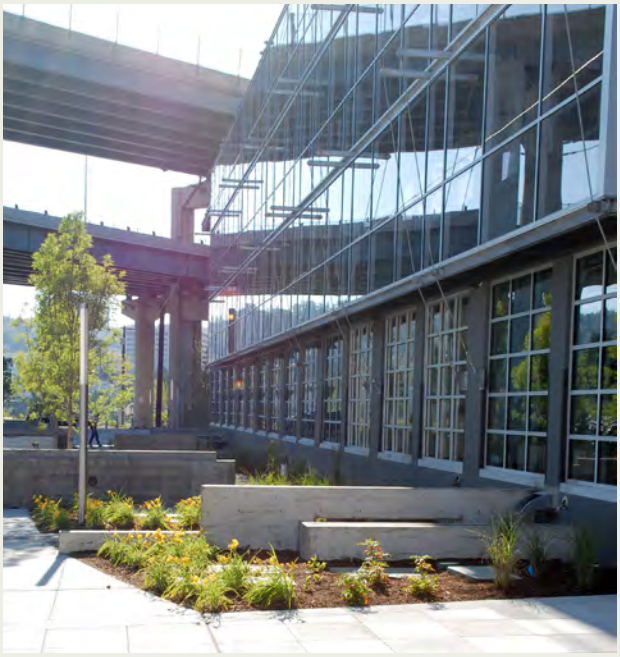
Piping for Flow Through Planters

Follow Plumbing Code requirements for piping that directs stormwater from impervious surfaces to flow-through planters. Stormwater may flow directly from the public street right-of-way or adjacent parking lot areas via curb openings. The overflow drain allows not more than 6 inches of water to pond in the planter prior to overflow. A perforated pipe system under the planter drains water that has filtered through the topsoil to prevent long-term ponding. On private property, the overflow drain and piping must meet Plumbing Code requirements and direct excess and filtered stormwater to an approved disposal point. Check with the local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

Portland Rebuilding Center

Flow-Through Planter

PSU Stephen Epler Hall, Portland



RiverEast Center, SE Portland

Design Factors (continued)

Setbacks

Check with the local building department to confirm site-specific requirements.

- For planters without an impermeable liner, generally the minimum setback from building structures is 10 feet.
- Typically, no building setback is required for planters lined with waterproofed concrete or 60 mil. PVC liner to prevent infiltration.

Soil Amendment/Mulch

Amended soils with appropriate compost serve numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and reduced erosion potential. Primary treatment will occur in the top 18 inches of the infiltration planter. Amended soil in the treatment area is composed of imported soil, mix of one part organic compost, one part gravelly sand, and one part top soil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMPs for non-structural infiltration planters.

Vegetation

Planted vegetation helps to attenuate stormwater flows and break down pollutants by interactions with bacteria, fungi, and other organisms in the planter soil. Vegetation also traps sediments, reduces erosion, and limits the spread of weeds. Appropriate and carefully considered plantings enhance the aesthetic and habitat value of a flow-through planter.

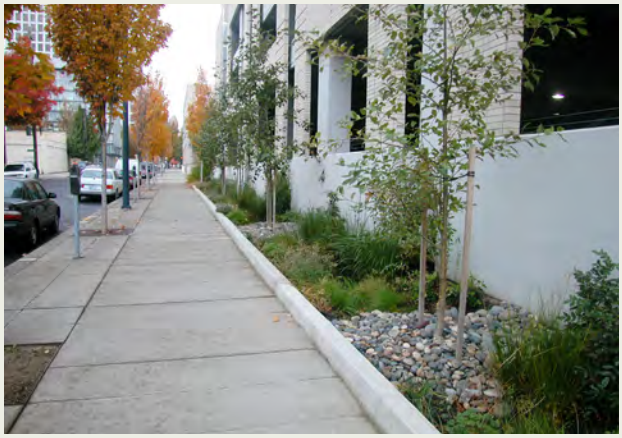
Because the entire facility will be inundated periodically, plant the water quality treatment area with herbaceous species such as rushes, sedges, perennials, ferns and shrubs appropriate for wet-to-moist soil conditions. Most moisture-tolerant plants can withstand seasonal droughts during the dry summer months and do not need irrigation after they become established.

Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional values are acceptable. Vegetation should be planted densely and evenly for proper hydrological function of the flow-through planter and to prevent erosion.

Quantities per 100 square feet:

- 115 Herbaceous plants, 1' on center spacing, ½-gal container size; or
- 100 Herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size, 2' on center

Flow-Through Planter



Rose Quarter parking structure, NE Portland

Washougal Town Square

Aloha Dog and Cat Clinic, Washington County

Buckman Terrace Apartments, Portland

Maintenance

- Water efficient irrigation should be applied the first two years after construction of the facility, particularly during dry summer months, while plantings become established. After that, irrigation is at the owner's discretion.
- If public, the permittee is responsible for the maintenance of the flow-through planter for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities, not in the public right-of-way must have a public easement. If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- Water should drain through the planter within 24 hours after a major storm event.
- All planter components should be inspected for proper operation during major storm events.
- Remove nuisance or invasive plants such as weeds or blackberry and ivy when discovered.
- Remove and replace damaged or dead plants.
- Provide insect and rodent control as necessary.
- See Appendix for detailed operations and maintenance plan.

References

- Clean Water Services Design and Construction Standards
- Green Development Practices for Stormwater Management; City of Gresham, 2007.
- Stormwater Management Manual; City of Portland Bureau of Environmental Services, 2008.

Green Roof

buildings

Clean Water Services Field Operations

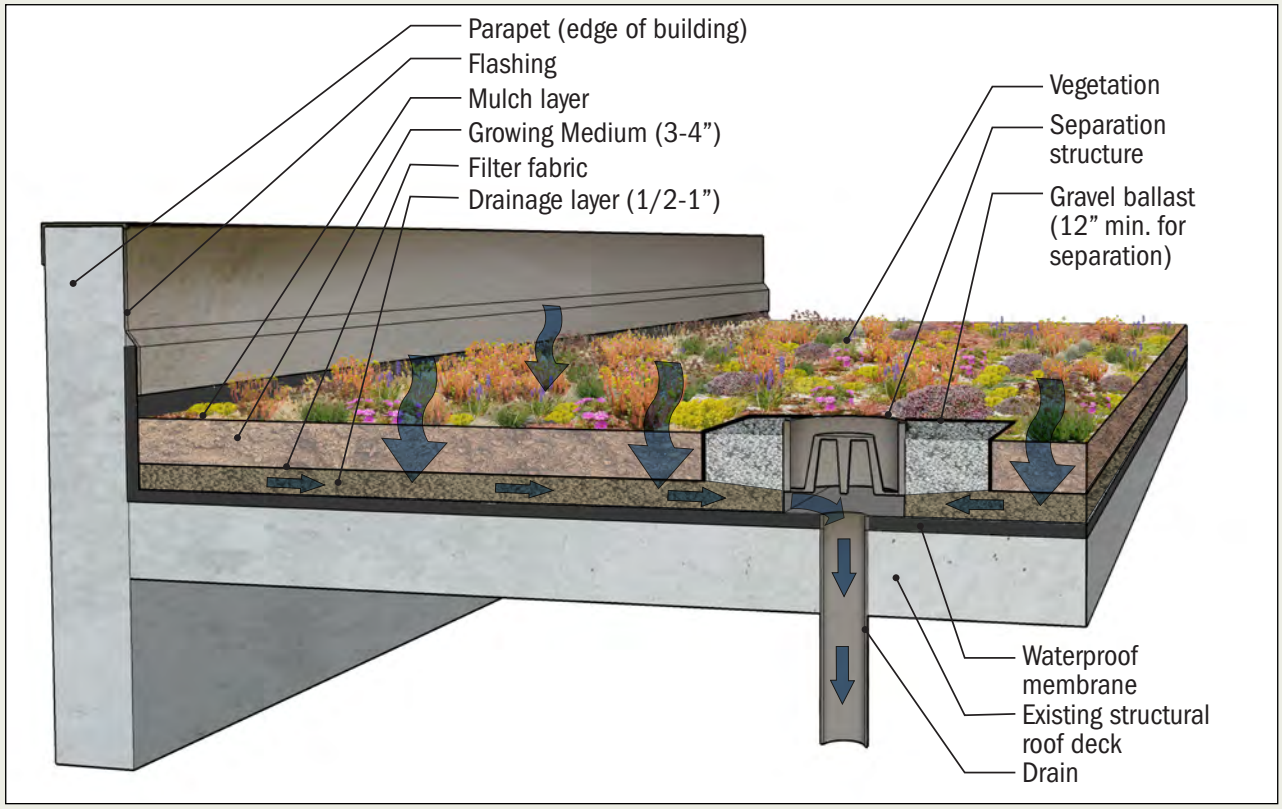
Description

A green roof (or ecoroof) is a lightweight vegetated roof system with waterproofing material, drainage, growing medium, and specially selected plants. A green roof can reduce site impervious area and manage stormwater runoff. Green roofs reduce peak runoff to near pre-development rates and reduce annual runoff volume by at least 50% (Cost Benefit Evaluation of Ecoroofs, Portland Bureau of Environmental Services, 2008). Green roofs also help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in dry seasons. Green roofs typically have thin layers of lightweight growing medium (4 to 8 inches) and low-growing succulent vegetation. Alternatively, roof gardens that are designed to be walked on have deeper soils (8+ inches) and are more heavily planted. Professional design consultation may be necessary to ensure the structural requirements of building codes are met. The design must be low maintenance and use irrigation only to sustain the health of vegetation.

Application & Limitations

Green roofs may be considered 100% pervious in water quality calculations, thus reducing the size of water quality facilities. Green roofs can be applied to a range of building types, from 'flat' rooftops (minimum of 1/4" slope per foot) to sloped rooftops with up to 4:12 pitch (3H:1V slope) or higher with adequate slope control. Depending on configuration and structure of the roof, the vegetated area may be partial or 100% coverage. The structural roof support must hold the additional weight of the green roof. Greater flexibility and options are available for new buildings, but retrofits are possible. For retrofit projects, an architect, structural engineer, or roof consultant can determine the condition of the existing building structure and what might be needed to support a green roof. Generally, the building structure must hold an additional 15 to 30 pounds per square foot for saturated weight.

Green Roof



Design Factors

Sizing
Green roofs replace impervious area at a 1:1 ratio. They may not receive water from other impervious areas such as an adjacent conventional roof.

Slope
Maximum roof pitch is 4:12 (3H:1V slope) unless the applicant provides documentation of runoff retention and erosion control on steeper slopes.

Waterproofing
On the roof surface, use a good waterproofing material such as modified asphalt, synthetic rubber, or reinforced thermal plastics. Waterproofing materials also may act as a root barrier. Waterproof membranes should be thoroughly tested to identify and remedy potential defects and leaks prior to installation of any green roof components.

Protection boards or materials (recommended)
These materials protect the waterproof membrane from damage and are usually made of soft fibrous materials. They may be required to maintain the waterproofing warranty, depending on the membrane used. Consult with roofing manufacturer for requirements.

Ballast (optional)
Gravel ballast may be placed along the roof perimeter and at air vents or other vertical elements to separate roofing elements and vegetation. The need for ballast depends on the type of roof and rooftop flashing details. Ballast or rooftop pavers may be used to provide access, especially to vertical elements that require maintenance.

Header/separation board (optional)
If needed, a header or separation board may be placed between gravel ballast and soil or drains.

Root barrier
A root barrier may be required, depending on the waterproofing material, warranty requirements, and the types of vegetation proposed. Root barriers impregnated with pesticides, metals, or other chemicals that could leach into stormwater should not be applied unless documentation that leaching does not occur is provided. If a root barrier is used it must extend under any gravel ballast and the growing medium, and up the side of any vertical elements.

Hamilton Apartments, Portland

Design Factors (continued)

Drainage
A method of drainage should allow excess water to flow into drains when soils are saturated. A manufactured drain mat, filter fabric, aggregate or gravel layers, or the growing medium itself may be used if water drains when soils are saturated. Every green roof should have an approved discharge location and drain or drains. Check with the local jurisdiction.

Growing medium
The growing medium depth is 3 to 4 inches or more, depending on the project. This material should be lightweight and provide a good base for plant growth. Mixes range from 5% organic/95% inorganic to 30% organic/70% inorganic, depending on specific vegetation needs.

Growing media should be stable over time and not break down into fine particles that might increase compaction and clog drainage layers. Components include pumice, perlite, paper pulp, digested organic fiber, and water retention components such as expanded slate, diatomaceous earth, or polymers. For growing media specification, include all constituent elements and their % composition, and a saturated weight per cubic foot (pcf) that has been tested by a third party lab.

Beranger Condominiums, Gresham

Vegetation and coverage
Green roof vegetation traits:
- Adapted to seasonal drought, excess heat, cold and high winds and other harsh conditions
- Fire resistant
- Requires little or no irrigation once established
- Predominately self-sustaining, low maintenance, with minimal fertilizer
- Perennial or self-sowing annuals that are dense and mat-forming
- Diverse palette to increase survivability and good coverage

Examples of appropriate species: Sedum, ice plant, blue fescue, sempervivum and creeping thyme. Other herbs, forbs, grasses, and low groundcovers can provide additional benefits and aesthetics, but may need more watering and maintenance to survive and may be prone to additional fire risk if allowed to dry out. Planting lists should be District approved and based on reliable sources from this region including local growers and plant suppliers.

Achieve 90% plant coverage within the 2 year maintenance period. At least 70% of the green roof should be evergreen species. No more than 10% of the green roof may be non-vegetated components such as gravel ballast or pavers for maintenance access. Mechanical units may protrude through the green roof, but are not considered elements of the green roof and may be removed from square foot totals.

Exposed areas during establishment periods should be mulched with an approved, biodegradable mesh blanket, straw, gravel, and pebbles or pumice to protect exposed soil from erosion.

Bethany Athletic Club, Beaverton

Multnomah County Office Building, Portland

Clean Water Services Field Operations Building, Beaverton

Maintenance

The owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).

Green roofs should be low maintenance but will require some scheduled maintenance to avoid or resolve problems. The level of maintenance will vary depending on soil depth, vegetation type, and location.

- During the winter rainy season, check drains monthly and remove any accumulated debris.
- Remove dead plants and replant as needed in spring and fall to maintain the required 90% plant coverage.
- During the first growing season remove weeds and undesirable plant growth monthly, and in late spring and early fall in subsequent years.
- See Appendix for detailed operations and maintenance plan.

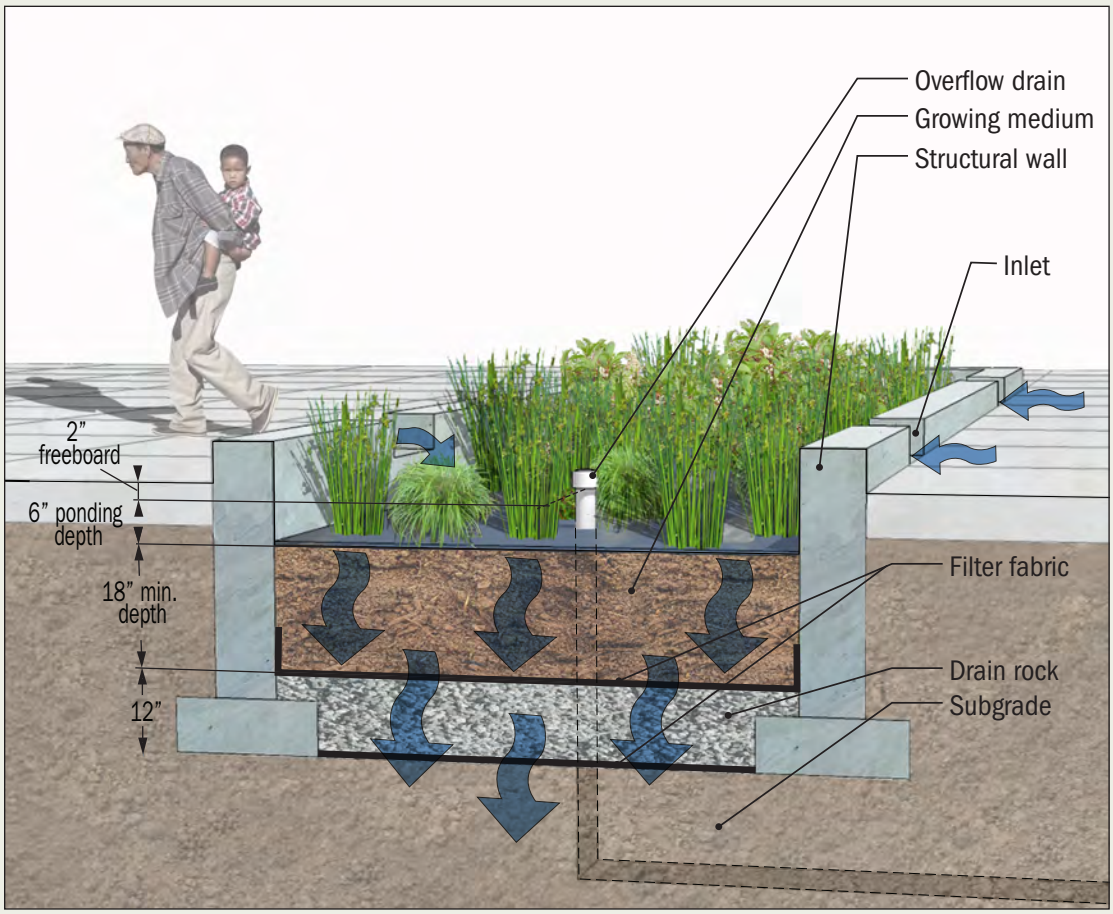
Due to the low level of organic material, fertilizers may be required for plant growth. These should be non-chemical, organic and slow release as approved by the District. Pesticides and herbicides of any kind are prohibited, unless approved by the District to contain a detrimental outbreak of weeds or other pests.

Minimal irrigation may be necessary to maintain vegetation health and ecological function of green roofs. Harvested rainwater is highly recommended for landscape irrigation. Green roofs larger than 1,000 square feet should have an automatic irrigation system for more efficient coverage and to eliminate the need for hand watering. Those larger than 5,000 square feet also should have an irrigation flow meter to monitor water usage. Irrigation during the 2-year establishment period should not exceed ½ inch of water per week (7 days) for the irrigation season (May through October). Post-establishment irrigation should not exceed ¼ inch of water every 10 days during the irrigation season.

References

- Clean Water Services Design and Construction Standards
- Stormwater Management Manual; City of Portland Bureau of Environmental Services, 2008

Infiltration Planter/Rain Garden



parking areas & impermeable landscape

permeable soils

Description

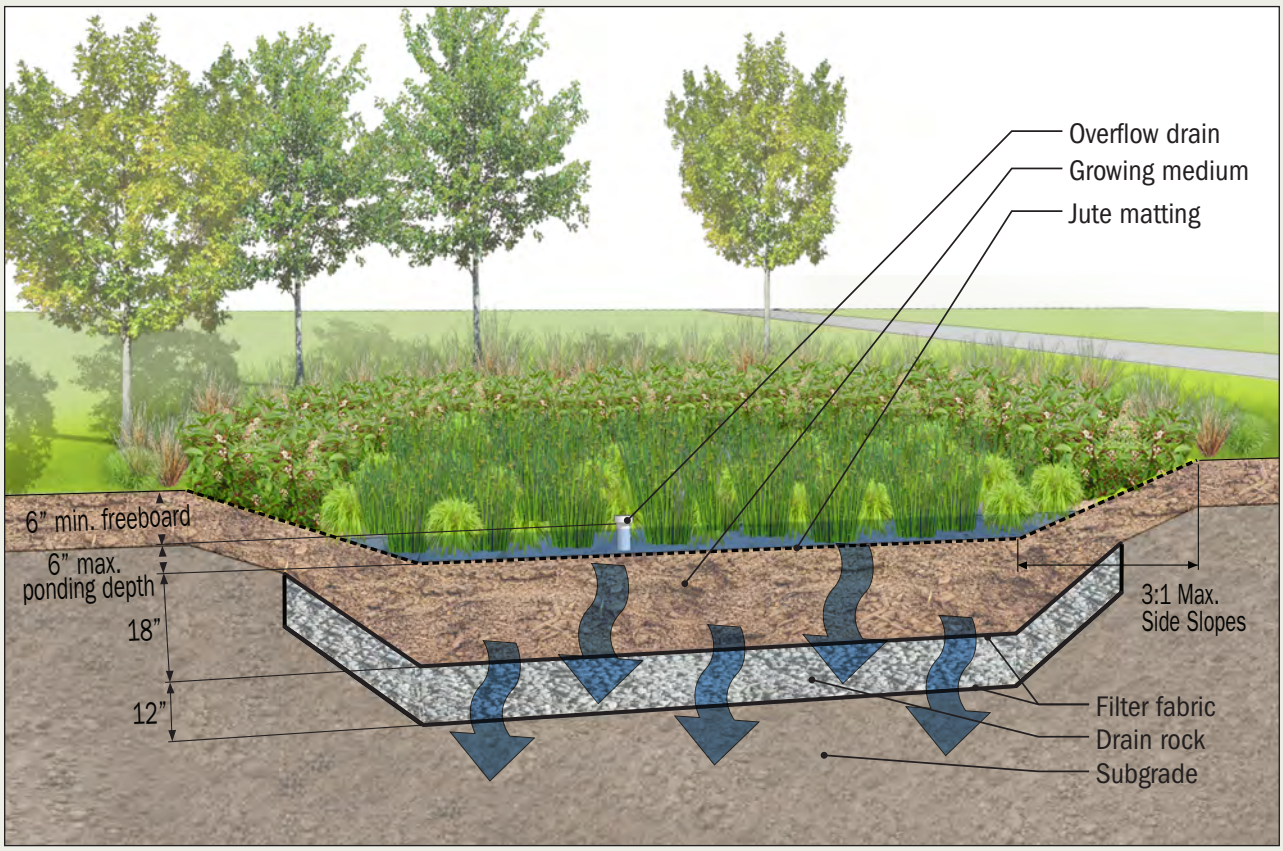
Infiltration Planters (also known as rain gardens) are landscaped reservoirs that collect, filter, and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through planter soil and infiltrates into the ground. Infiltration planters typically require less piping than flow-through planters and a smaller facility size than traditional swales where native soils allow for infiltration. Depending on the site, infiltration planters can vary in shape and construction, with or without walls to contain the facility, or formed as a shallow, basin-like depression.

Application & Limitations

Infiltration planters should be integrated into the overall site design and may help fulfill the landscaping area requirement. Infiltration planters can be used to manage stormwater flowing from all types of impervious surfaces, from private property and within the public right-of-way. Check with the local jurisdiction if proposing to use infiltration planters in the public right-of-way. The size, depth, and use of infiltration planters are determined by the infiltration rates of the site's existing soils.

Beaumont Village Lofts, NE Portland

Infiltration Planter/Rain Garden



Design Factors

Soil Suitability and Facility Sizing

The size and depth of the infiltration planter will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes the site infiltration rate is less than 2 in/hr.

For example, the size of an infiltration planter managing 1,500 square feet of total impervious area would be 90 square feet (1,500 x 0.06).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased

Geometry/Slopes

The shape may be circular, square, rectangular, etc. to suit the site design requirements. Regardless of the shape, a minimum planter width of 30 inches is needed to achieve sufficient time for treatment and avoid short-circuiting. Planters in a relatively flat landscaped open area should not slope more than 0.5% in any direction.

Piping for Infiltration Planters

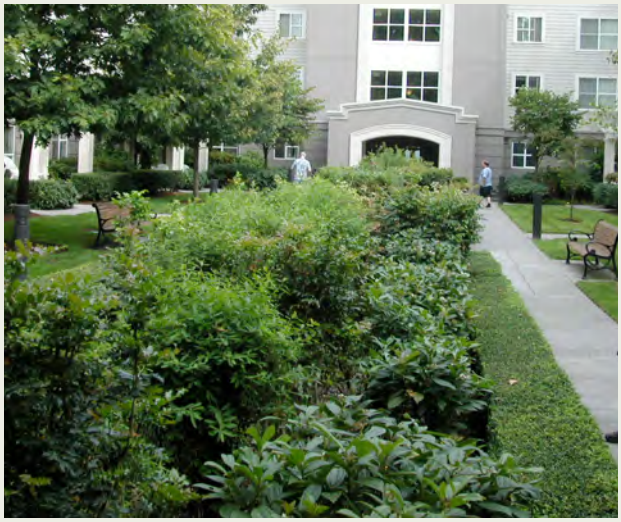
Follow Plumbing Code requirements for piping that directs stormwater from impervious surfaces to planters. Stormwater may flow directly from the public street right-of-way or adjacent parking lot areas via curb openings. For infiltration planters with walls, install an overflow drain to allow not more than 6 inches of water to pond. Infiltration planters with side slopes, such as rain gardens, need an overflow drain to ensure no more than 6 inches of water will pond. On private property, follow Plumbing Code requirements for this overflow drain and piping, and direct excess stormwater to an approved disposal point as identified on permit drawings. Check with local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

Setbacks

Check with the local building department to confirm site-specific requirements.

- Generally, a minimum setback of 10 feet from building structures is recommended.
- Planters should not be located immediately upslope of building structures.

Before site work begins, clearly mark infiltration planter areas to avoid soil disturbance during construction. No vehicular traffic should be allowed within 10 feet of



Buckman Terrace Apartments, Portland

Design Factors (continued)

infiltration planter areas, except as necessary to construct the facility. Consider construction of infiltration planter areas before construction of other impervious surfaces to avoid unnecessary traffic loads.

Soil Amendment/Mulch
Amended soils with appropriate compost and sand provide numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and, reduced erosion potential. Primary treatment will occur in the top 18 inches of the infiltration planter. Amended soil in the treatment area is composed of equal parts of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMPs for non-structural infiltration planters.

Vegetation
Planted vegetation helps to attenuate stormwater flows and break down pollutants by interactions with bacteria, fungi, and other organisms in the planter soil. Vegetation also traps sediments, reduces erosion, and limits the spread of weeds. Appropriate, carefully selected plantings enhance the aesthetic and habitat value.

The entire water quality treatment area should be planted appropriately for the soil conditions. Walled infiltration run-on planters will be inundated periodically. Therefore the entire planter should be planted with

New Seasons, 20th and SE Division St., Portland

herbaceous rushes, sedges, perennials, ferns and shrubs that are well-suited to wet-to-moist soil conditions.

If the infiltration planter has side slopes (basin without vertical walls), soil conditions will vary from wet to relatively dry; several planting zones should be considered. The flat bottom area will be moist-to-wet, and the side slopes will vary from moist at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will depend upon the designed maximum water depth, total depth of the planter, and steepness of the side slopes. This moisture gradient is a transition zone and should be planted with species that tolerate occasional standing water, and plants that prefer drier conditions toward the top of the slope. Areas above the side slopes, immediately adjacent to the basin, and above the designed high water line will not be inundated and should be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate.

All vegetation should be planted densely and evenly to ensure proper hydrological function of the infiltration planter. Quantities per 100 square feet:

- 115 herbaceous plants, 1' on center spacing, ½-gal container size; or
- 100 herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size 2' on center.

Trees are optional; if used, minimum 2 gallon by 2 feet tall.

Trees are allowed in infiltration planters and should be selected by their adaptability to wet-to-moist conditions and full size at maturity. An area twice the width of tree rootball and the depth of the rootball plus 12" (or total depth of 30", whichever is greater) should be backfilled with amended soil for optimal growth, with no sub-surface rock layer. For infiltration planters with side slopes, trees should be placed along the side slopes of the facility rather than at the bottom.

Infiltration Planter/Rain Garden

Mississippi Commons, NE Portland

Fowler Middle School, Tigard

Maintenance

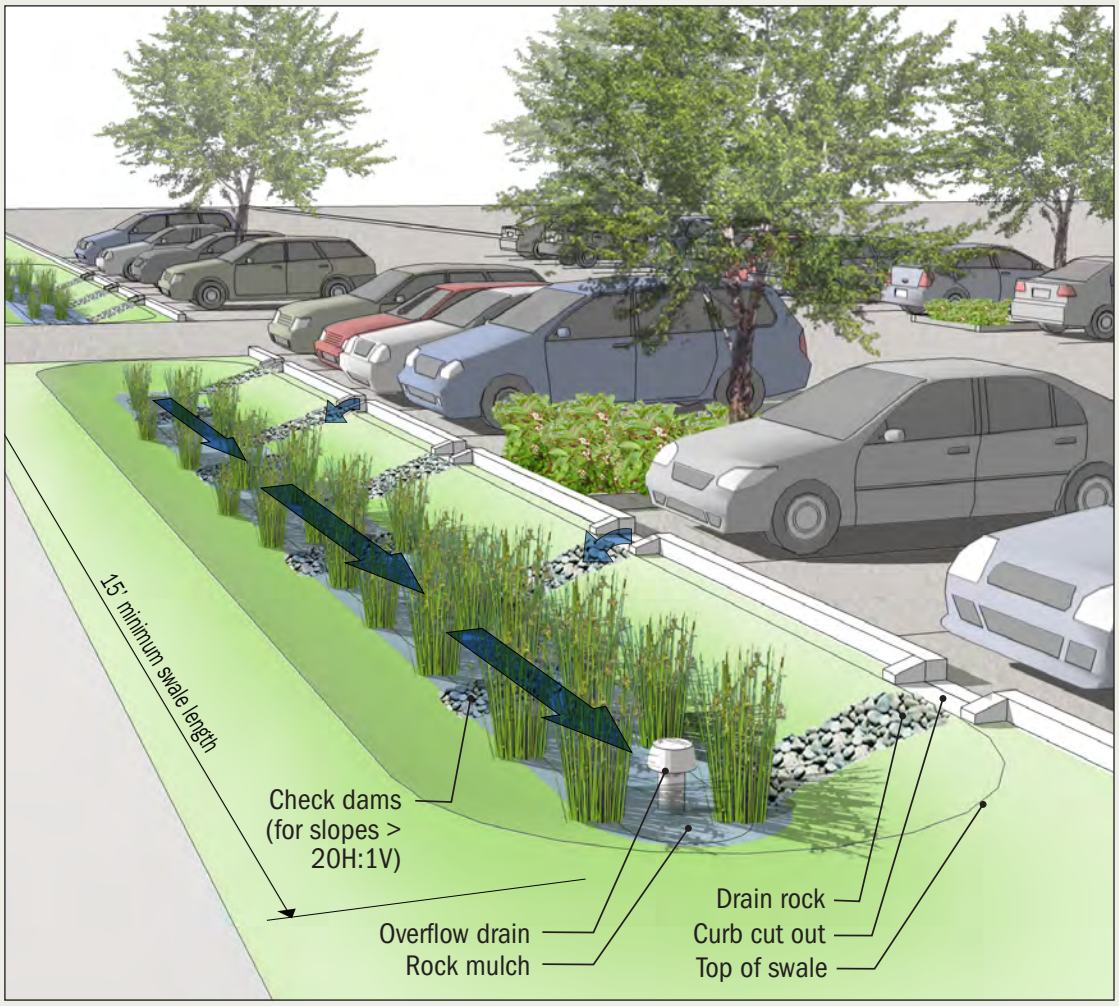
- Water efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the infiltration planter for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities not located in the public right-of-way must have a public easement. If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- Water should drain through the planter within 24 hours after a major storm event.
- All planter components should be inspected for proper operation quarterly, and within 24 hours of each major storm event
- Remove nuisance or invasive plants such as weeds or blackberry and ivy when discovered.
- Remove and replace damaged or dead plants.
- Provide insect and rodent control measures as necessary.
- See Appendix for detailed operations and maintenance plan.

12th and Montgomery St., Portland

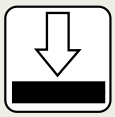
References

- Clean Water Services Design and Construction Standards
- Green Development Practices for Stormwater Management; City of Gresham, 2007.
- Stormwater Management Manual; City of Portland Bureau of Environmental Services, 2008.

LIDA Swale



parking areas & impermeable landscape



impermeable soils

permeable soils

Description

A LIDA swale is a narrow, gently sloping landscaped depression that collects and conveys stormwater runoff. The densely planted LIDA swale filters stormwater as it flows the length of the swale and allows infiltration of water into the ground. The LIDA swale discharges to a storm sewer or other approved discharge point.

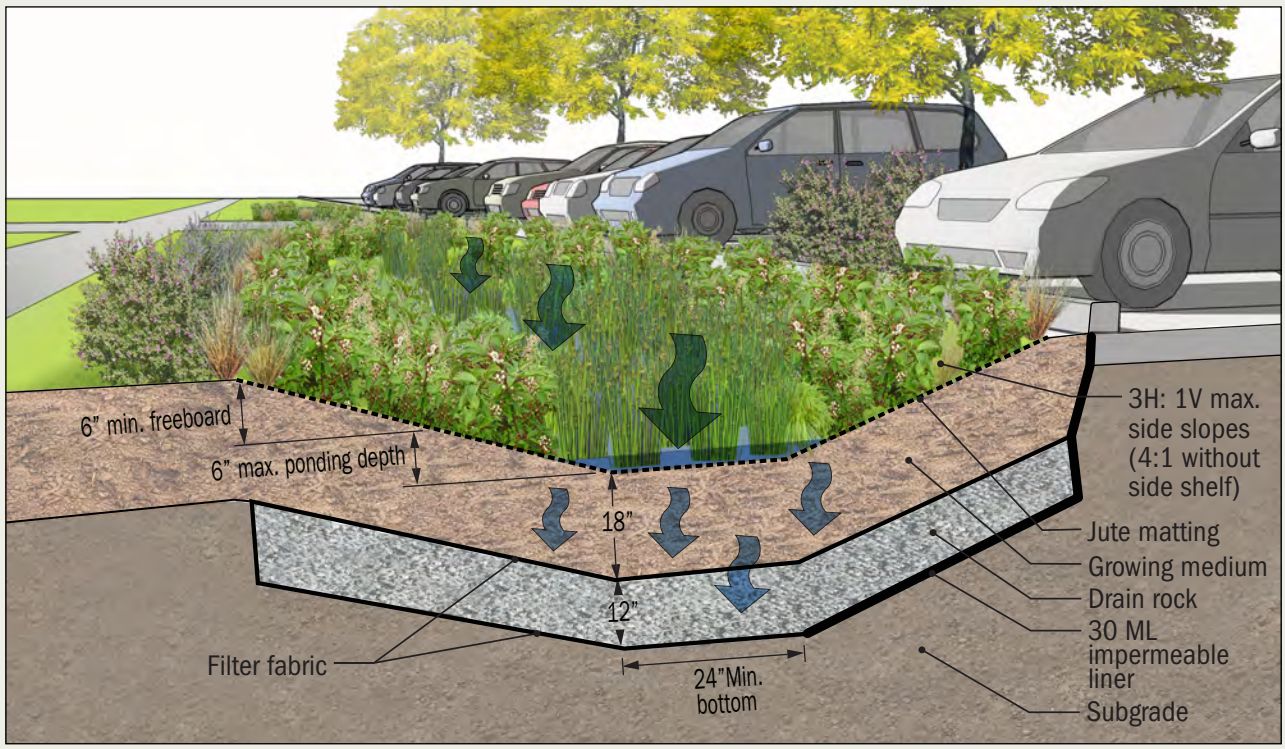
Compared to vegetated swales, LIDA swales may be shorter and narrower, but require deeper levels of amended soil and a subsurface drain rock layer to compensate for the smaller size and to function effectively.

Application & Limitations

A LIDA swale may help fulfill a site's landscaping area requirement. LIDA swales are approved to treat stormwater flowing from all types of impervious surfaces including private property and the public right-of-way, rooftops, parking lots, and streets. Check with the local jurisdiction if proposing to use a LIDA swale in the public right-of-way.

Boeckman Road, Wilsonville

LIDA Swale



Design Factors

Sizing

The size of the LIDA swale will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes the site infiltration rate is less than 2 in/hr.

For example, the size of a LIDA swale managing 1,500 square feet of total impervious area would be 90 square feet (1,500 x 0.06).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased

Geometry/Slopes

A LIDA swale's slope end to end is at least 0.5% and no more than 6%. For sites with steeper slopes, check dams may be incorporated into the design. Side slopes from the bottom to the top of the swale must be 3:1 or less. The minimum bottom width is 2 feet, and the minimum depth is 1 foot.

Piping for LIDA Swales

If needed, stormwater may be directed from impervious surfaces to LIDA swales by piping per plumbing code requirements, or may flow directly into the LIDA swale via curb openings. A LIDA swale has no underdrain. An overflow drain allows no more 6 inches of water depth to collect in the LIDA swale. On private property, the overflow drain and piping must meet plumbing code requirements and direct excess stormwater to an approved disposal point. Check with the local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

Setbacks

- Check with the local building department to confirm site-specific requirements.

Peoples Food Cooperative, SE Portland

Ecotrust building, Portland

New Seasons, SE Division St, Portland

Design Factors (continued)

Soil Amendment/Mulch

Amended soils with appropriate compost serve numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and reduced erosion potential. Primary treatment will occur in the top 18 inches of the LIDA Swale. Amended soil in the treatment area is composed of imported soil, mix of one part organic compost, one part gravelly sand, and one part top soil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Reduce water velocities and potential erosion by providing energy dissipaters such as river rock at entrances to the swale. Check with the District or local jurisdiction for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMPs.

Vegetation

The entire facility area including side slopes and treatment areas are planted with vegetation appropriate for the soil conditions. Planting conditions vary from wet to relatively dry within the LIDA swale. The flat bottom will be inundated frequently and should be planted with species such as rushes, sedges, perennials, ferns, and shrubs well-suited to wet-to-moist soil conditions. The side slope moisture gradient varies from wet at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will vary depending upon the designed water depth, the swale depth, and side slope steepness. The transition zone from the bottom of the LIDA swale to the designed high water line or top of freeboard should be planted with sedges, rushes, perennials, ferns, and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the LIDA swale will not be regularly inundated and should be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate and site.

Native plants are encouraged, but appropriate, non-invasive ornamentals are acceptable for aesthetic and functional value. All vegetation should be densely and evenly planted to ensure proper hydrological function of the LIDA swale.

Quantities:

Bottom of LIDA swale (wet-to-moist zone, per 100 sf)

- 115 herbaceous plants, 1' on center spacing, ½-gal container size; or
- 100 herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size, 2' on center

Side slopes and top of LIDA swale (wet-to-moist transition zone and dry zone)

- 1 tree per 300 sq. ft, minimum 2-gal container size by 2 ft-tall and
- 10 shrubs (1-gal) and 70 groundcovers (½-gal) per 100 sf

Trees are allowed in LIDA swales, and may be required. Trees should be selected by adaptability to wet-to-moist conditions and size at maturity. An area twice the width of the tree rootball and the depth of the rootball plus 12" (or total depth of 30", whichever is greater) should be backfilled with amended soil for optimal growth, with no sub-surface rock layer. Place trees along the side slopes rather than the bottom of the LIDA swale.

LIDA Swale

Tualatin Hills Park at Portland Community College

Maintenance

- Water efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the LIDA swale for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities not located in the public right-of-way must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- Inspect the facility at least twice annually, in spring and fall.
- Evaluate landscaping and replant as necessary to ensure a minimum of 80% survival rate of the required vegetation and 90% facility coverage. Remove non-native, invasive plant species when found in the facility.
- Remove garbage, landscaping debris and other material that may impede water flow and clog the system.
- Check inlet pipes and outlet structure for damage or missing pieces. Inlet pipes and outlet structures should be free of obstructions and heavy vegetation.
- Design swales so that they do not require mowing.
- See Appendix for detailed operations and maintenance plan.

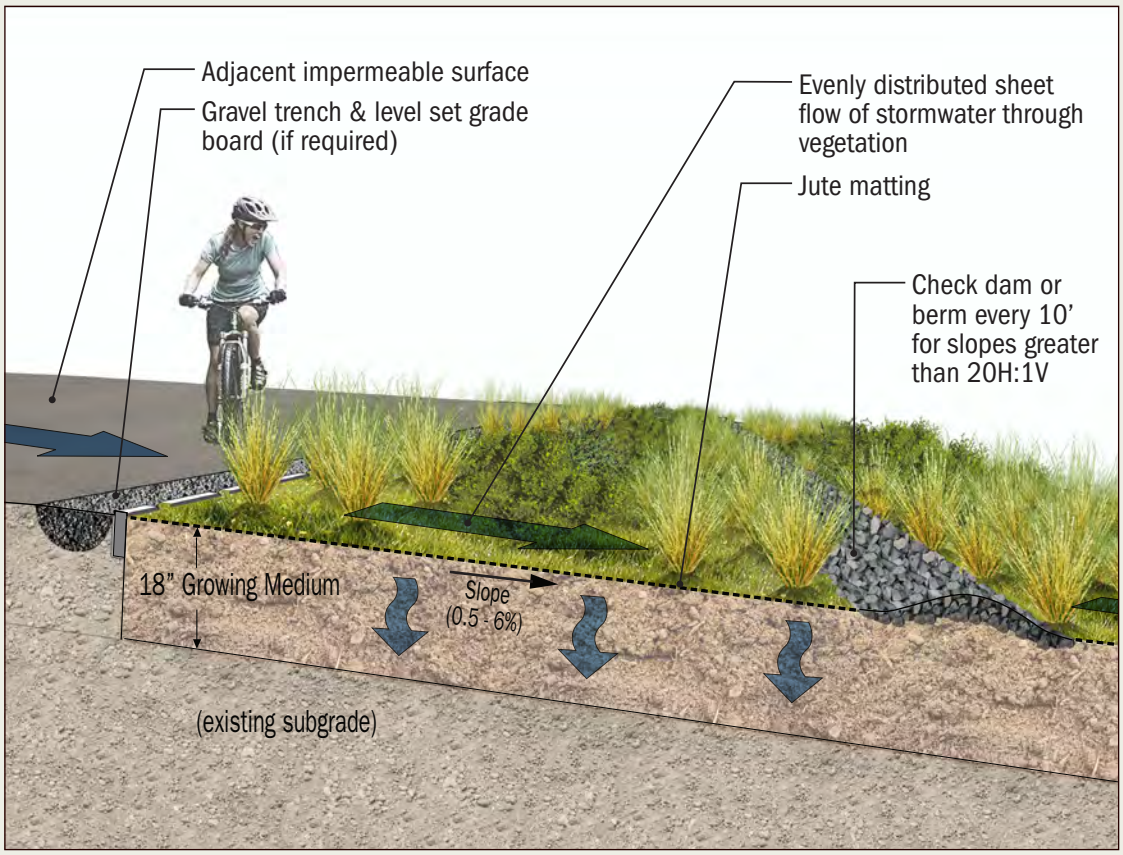
References

- Clean Water Services Design and Construction Standards

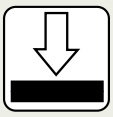
NE Siskiyou Street, Portland

155th & Hart, Beaverton

Vegetated Filter Strip



parking areas & impermeable landscape



impermeable soils

permeable soils

Description

Vegetated filter strips are gently sloped areas designed to receive sheet flows from adjacent impervious surfaces. Filter strips are vegetated with grasses and groundcovers that filter and reduce the velocity of stormwater. Peak stormwater flows are attenuated as stormwater travels across the filter strip and infiltrates or is stored temporarily in the soils below.

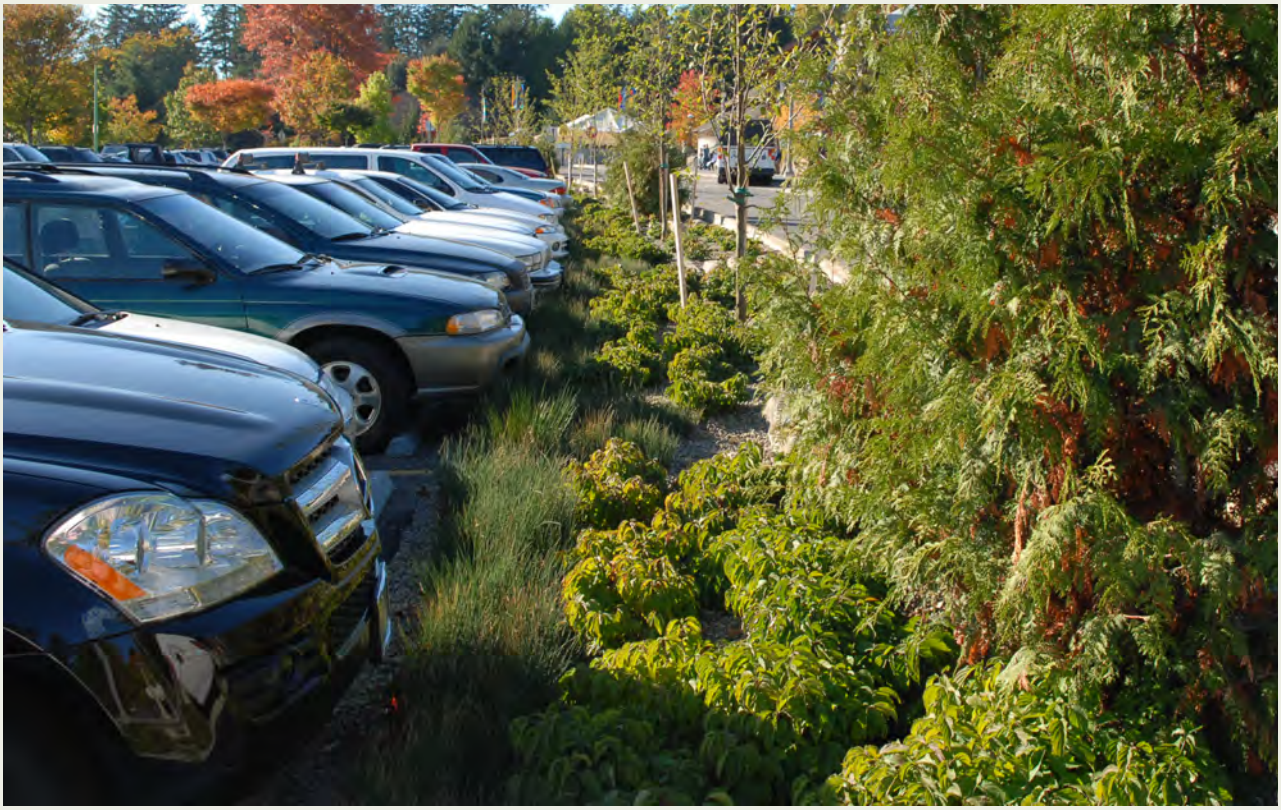
For residential driveways, center filter strips typically are 3 feet wide between two 3-foot wide paved sections. The strip treats and infiltrates stormwater only from the impervious area of the drive aisles which slope toward the center filter strip. The driveway center filter strip must be maintained to the design requirements for vegetated filter strips.

Application & Limitations

Vegetated filter strips should be integrated into the overall site design and may help fulfill a site's landscaping area requirement. Vegetated filter strips can be used to manage stormwater runoff from a variety of impervious surfaces such as walkways and driveways on private property and within the public right-of-way. Check with the local jurisdiction if proposing to use a vegetated filter strip in the public right-of-way.

Oregon Zoo parking lot, Portland

Vegetated Filter Strip



Oregon Zoo parking lot

Design Factors

Sizing

Vegetated filter strips are appropriate for all soil types and have 18" depth of growing medium. The size of the filter strip will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes that the site has an infiltration rate less than 2 in/hr.

For example, a facility managing 1,500 square-feet of total impervious area would require a 90 sq ft filter strip (1,500 x 0.06).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased

Geometry/Slopes

The minimum width of a vegetated filter strip is 5 feet measured in the direction of stormwater flow. The slope is between 0.5 and 6%, and the slope of the impervious area draining to the strip is less than 6%.

Check dams may be required to maintain shallow slopes if the existing site slopes exceed 5%. Typically, check dams are 3 to 5 inches high and are placed every 10 feet where slopes exceed 5%.

If a level spreader such as a grade board or sand/gravel trench is required to disperse runoff evenly across the filter strip, the top must be horizontal and at an appropriate height to direct sheet flow to the soil without scour. Grade boards may be any material that withstands weather and solar degradation but should not be old railroad ties, used utility poles, or other pollutant source.

Piping for Vegetated Filter Strips

Non-infiltrated flows/overflows from the vegetated filter strip are collected and conveyed to an approved system or outlet structure.

Setbacks

Check with local building department to confirm site-specific requirements.

Arata Creek School, Troutdale

Design Factors (continued)

Soil Amendment/Mulch

Amended soils with appropriate compost serve numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and reduced erosion potential. Primary treatment will occur in the top 18 inches of the vegetated filter strip. Amended soil in the treatment area is composed of equal parts of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMP.

Vegetation

Herbs, shrubs and grasses can provide the vegetation needed to remove sediment and pollutants. The vegetated filter strip is planted or seeded with a mix of grasses, wildflowers, and groundcovers well-suited to moist-to-dry soil conditions. All vegetation should be self-sustaining and drought tolerant. Native plants are encouraged but adapted, non-invasive ornamentals are acceptable for added aesthetic and functional value.

Trees are not required for vegetated filter strips, but are encouraged where applicable. Tree species should be selected by their adaptability to moist-to-dry conditions and full size at maturity.

The filter strip conveys evenly-distributed sheet flows of water through vegetation for treatment. Because unplanted areas may decrease stormwater treatment, the entire filter strip must have 100% vegetation coverage to ensure proper hydrologic function.

If check dams are required, plants suited to wet-to-moist planting conditions may be supplemented on the upslope side of the check dam where occasional inundation and pooling of water may occur.

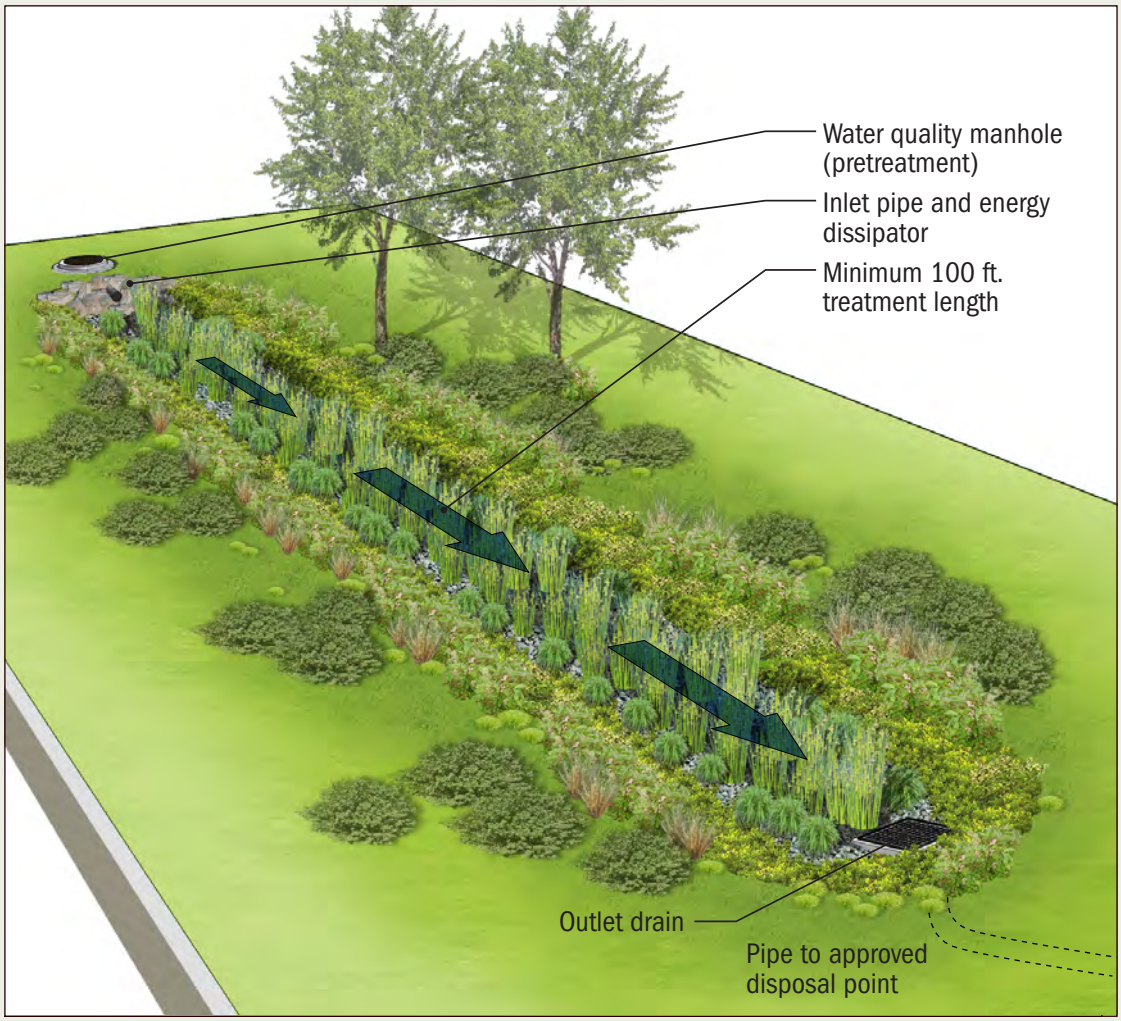
Maintenance

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the vegetated filter strip for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities not located in the public right-of-way must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- The facility should be inspected monthly during the rainy season (November - April).
- Evaluate landscaping and replant as necessary to ensure 100% facility coverage. Remove non-native, invasive plant species when found in the facility.
- Remove garbage, landscaping debris and other material that may impede uniform sheet water flow.
- See Appendix for detailed operations and maintenance plan.

References

- Clean Water Services Design and Construction Standards
- Stormwater Management Manual; City of Portland

Vegetated Swale



parking areas & impermeable landscape

impermeable soils

permeable soils

Description

A vegetated swale is a gently sloping landscaped depression that collects and conveys stormwater runoff, and is narrow and at least 100 feet in length. The densely planted swale filters stormwater as it flows the length of the swale and allows infiltration of water into the ground. The vegetated swale may discharge to a storm sewer or other approved discharge point where soils do not drain well.

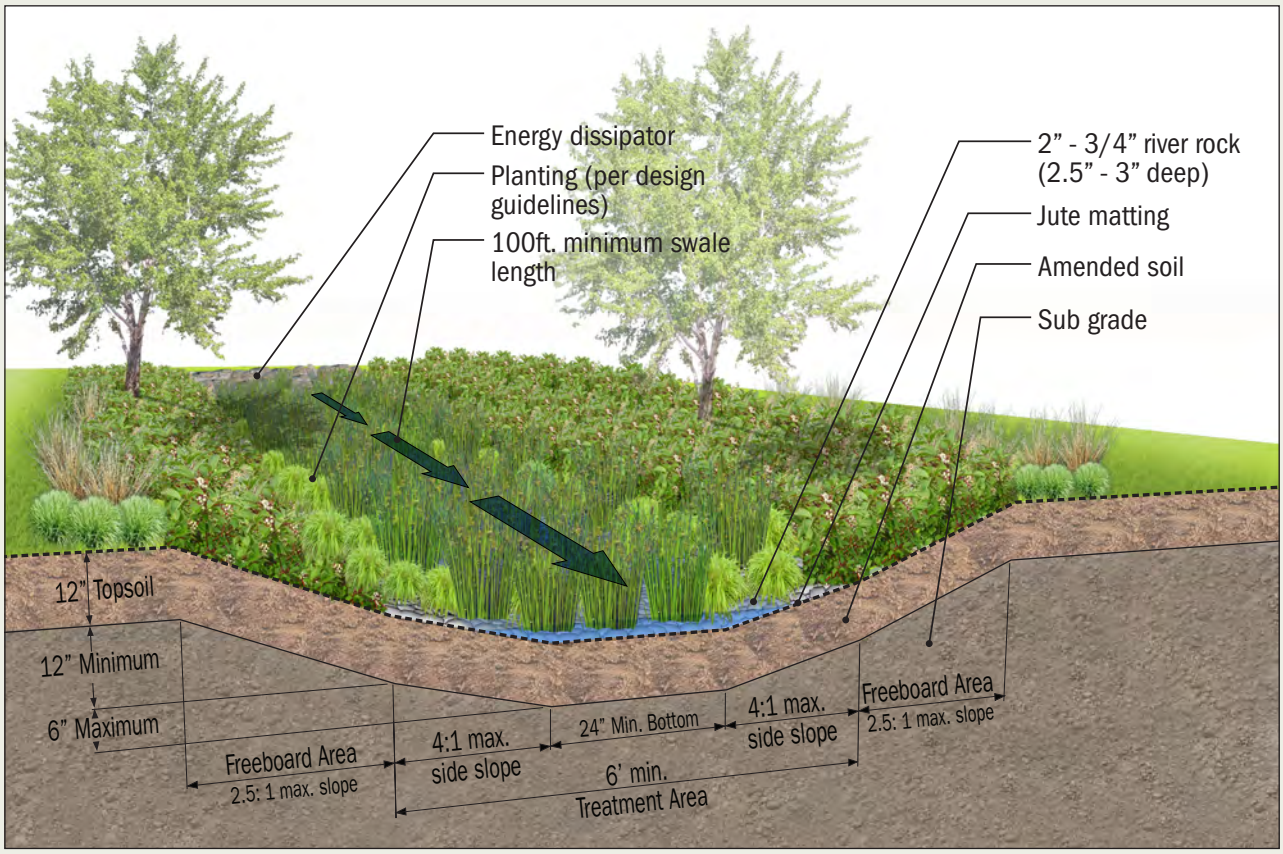
Vegetated swales have a required minimum length, width and stormwater residence time. See Clean Water Services Design and Construction Standards Details 700 and 710.

Application & Limitations

Vegetated swales may help fulfill a site's landscaping area requirement. Vegetated swales are approved to treat stormwater from all types of impervious surfaces including private property and the public right-of-way, rooftops, parking lots, and streets.

Westhaven Subdivision, Washington County, Oregon

Vegetated Swale



Design Factors

Sizing

A vegetated swale must be at least 100 feet in length and detain stormwater for at least nine minutes for treatment as specified in Clean Water Services Design and Construction Standards.

Geometry/Slopes

A vegetated swale's slope end to end is at least 0.5% and the maximum velocity for a 25 year storm flow is 2 feet per second. Side slopes within the treatment area are 25% (4 horizontal: 1 vertical) or less; side slopes of the freeboard area above the treatment zone are 40% (2.5 horizontal: 1 vertical) or less. While the bottom of the swale is at least 2 feet wide, the treatment area is at least 6 feet wide and no more than ½ foot in depth. The freeboard area has at least one foot of vertical height. All swales have an energy dissipater such as boulders at the entrance to reduce velocities and spread the flow across the treatment area. The minimum length of the energy dissipater is 4 feet. See Clean Water Services Design and Construction Standards Detail 700.

Piping for Vegetated Swales

Flows coming into the vegetated swale facility are pretreated by a water quality manhole in accordance with the Design and Construction Standards. Other pretreatment may include an approved proprietary treatment device, filter strip, trapped catch basin, or other method approved by the District or City. An approved outlet structure must be provided for all flows. If location would make access for maintenance difficult, the swale may be a flow-through facility with unsumped structures.

Arbor Oaks Subdivision, Washington County, Oregon

Tanasbourne Office Building, Washington County

Aloha Huber Park Elementary School, Washington County

Design Factors (continued)

Setbacks
Check with the local building department to confirm site-specific requirements.

Soil Amendment/Mulch
The treatment area has ¾" to 2-inch river run rock placed 2.5 to 3 inches deep on high density jute or coconut matting over 12 inches of native topsoil. The river rock, topsoil and high density jute or coconut matting extends to the top of the treatment area, topsoil and low density jute matting extends to the edge of the water quality tract or easement area.

Vegetation
The entire facility including freeboard and treatment areas is vegetated according to the Standards with vegetation appropriate for the soil conditions. Planting conditions vary from wet to relatively dry within the swale. The flat bottom will be inundated frequently and should be planted with species such as rushes, sedges, perennials, and ferns, as well as shrubs that are well-suited to wet-to-moist soil conditions. The side slope moisture gradient varies from wet at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will vary depending upon the designed water depth, swale depth, and side slope steepness. The transition zone from the bottom of the swale to the designed high water line or top of freeboard should be planted with sedges, rushes, perennials, and ferns, as well as shrubs that can tolerate occasional standing water, and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the vegetated swale will not be regularly inundated and should be planted with self-sustaining, low maintenance grasses, perennials, and shrubs suitable for the local climate and site.

Plant Spacing
A) Vegetated swales in tracts or easements less than 30 feet wide are planted as follows to achieve the specified per acre densities:
i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
ii. Total number of shrubs per acre = area in square feet x 0.05
iii. Groundcover = plant and seed to achieve 100% coverage

B) Vegetated swales in tracts or easements 30 feet wide or more are planted as follows to achieve the specified per acre densities:
i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
ii. Total number of trees per acre = area in square feet x 0.01
iii. Total number of shrubs per acre = area in square feet x 0.05
iv. Groundcover = plant and seed to achieve 100% coverage

Vegetated Swale

Broadview, Seattle

Maintenance

- Provide maintenance access as required by Clean Water Services Design and Construction Standards
- Water efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation of plantings after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the vegetated swale for a minimum of two years following construction and acceptance of the facility. All publicly maintained facilities must have a public easement. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement).
- The facility should be inspected in spring and fall, at a minimum.
- Evaluate and replant landscaping to achieve a survival rate of 80% or better with 90% facility coverage. Remove invasive, non-native plants to ensure they occupy no more than 20% of the site.
- Remove all trash and debris that might impede water flow and clog the system.
- Check inlet pipes and outlet structure for damage or missing pieces; remove obstructions and heavy vegetation.
- Make sure stormwater is traveling the length of the treatment area. If stormwater is "short circuiting" the treatment area, repair the swale to achieve full treatment.
- See Appendix for detailed operations and maintenance plan.

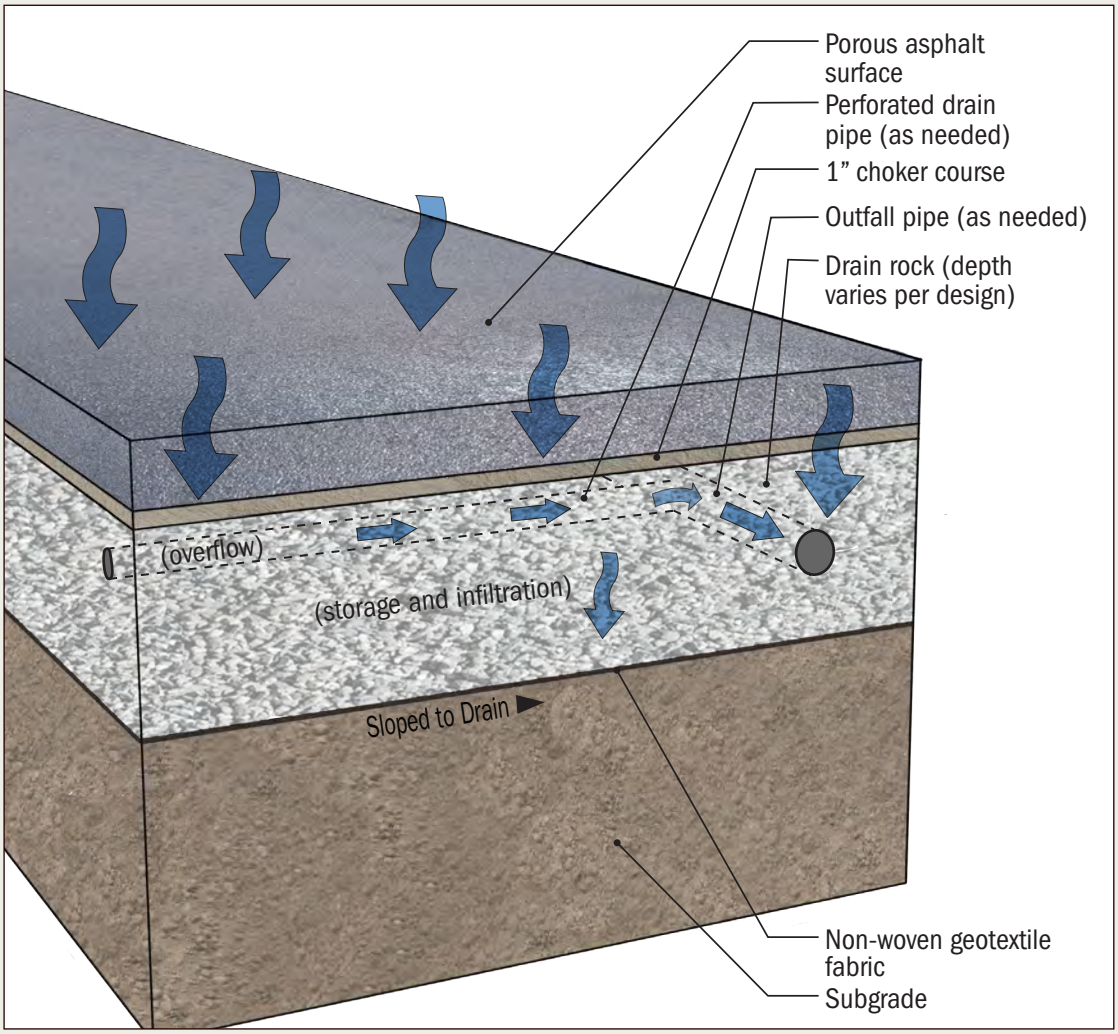
PCC Rock Creek Campus, Beaverton

Sandy Boulevard, Portland

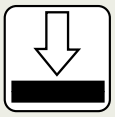
References

- Clean Water Services Design and Construction Standards
- Gardening with Native Plants poster; Clean Water Services

Porous Pavement



parking areas & impermeable landscape



impermeable soils

permeable soils

Description

Porous pavement is a water-permeable structural groundcover that infiltrates precipitation, attenuates stormwater runoff flows and volumes, and reduces temperatures. Porous pavement provides a stable load-bearing surface without increasing a project's total impervious area.

The two main categories of porous pavements are 1) pervious concrete and asphalt, and 2) permeable pavers. Pervious concrete and asphalt are poured in place and resemble their solid counterparts, except the fines (sand and finer material) are removed to create more void space for water to flow through. Permeable pavers are solid, discrete units typically made of pre-cast concrete, brick, stone, or cobbles and set to allow water to flow between them.

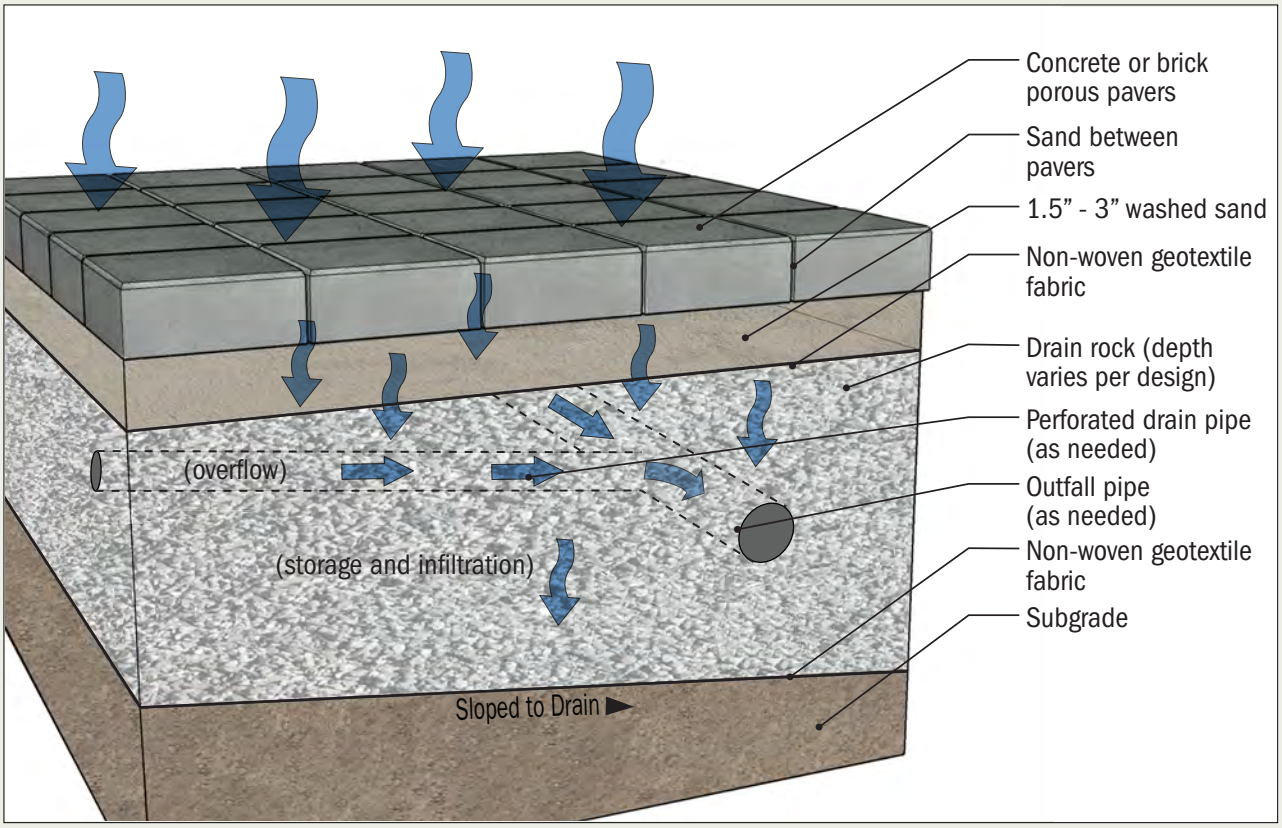
Application & Limitations

Porous pavement is not considered a water quality facility to provide treatment of runoff from other impervious surfaces. However, pollutants captured from direct rainfall on the porous pavement area are treated through filtration, absorption, and other microbial degradation actions in the subgrade. Porous pavement area may be considered 100% pervious in water quality calculations, thus reducing the size of required water quality facilities.

Pervious asphalt, pervious concrete, and permeable pavers can be used in most pedestrian areas, residential driveways, public sidewalks, and parking lots. Local jurisdictions may approve pervious asphalt and concrete for private streets and public roadways on a case-by-case basis.

Porous pavements should not be located over cisterns, utility vaults, underground parking or other impervious surfaces and should be applied only where the seasonal high water table is at least 10 feet beneath the facility's bottom or drain rock layer. Porous pavement should not be applied in locations where there is a high risk of chemical spillage.

Porous Pavement



Design Factors

Sizing
Porous pavement replaces impervious area at a 1:1 ratio. All stormwater from the porous pavement surface must infiltrate directly into a crushed rock storage layer. To deter clogging over time, porous pavement should capture only direct rainfall. If approved by the local jurisdiction, detention storage may be constructed beneath the porous pavement and sized by approved calculation. Water quality treatment must be provided for any stormwater flowing from adjacent impervious areas across the porous pavement.

Slopes
In general, porous pavement should not be used on slopes greater than 20H: 1V.

Piping
As needed, and where existing soils have low permeability and an infiltration rate of 0.5" per hour or less, provide an under-drain to an approved outlet structure.

Setbacks
Check with the local building department to confirm site-specific requirements. Impermeable liners are recommended between base rock and adjacent foundations and conventional Asphalt Cement Concrete (ACC) or Portland Cement Concrete (PCC) pavement.

Porous Pavement Design
For specific design mix, use the following references:

- Pervious asphalt
  ODOT 2008 Standard Specification, or as updated. See National Asphalt Pavement Association Information Series 131 for additional information.
- Pervious concrete
  Stormwater Management Manual, Chapter 2, Pervious Pavement section, City of Portland Bureau of Environmental Services, 2008 or as updated.
- Pavers
  Interlocking Concrete Pavement Institute specifications and Portland Department of Transportation 2007 Standard Specification Section 00760.00 or as updated.

Porous Pavers, Portland Community College, Rock Creek Campus

Porous Pavement

Porous Pavers

Porous Asphalt

Design Factors (Continued)

Bedding Course
The bedding course beneath pervious asphalt or concrete pavement consists of clean 1" or greater choker course meeting AASHTO No. 57.

Aggregate Base
The base course consists of washed, 3/4" to 2" uniformly graded aggregate. The depth of the aggregate base course will vary per design.

Geotextile Fabric
Non-woven geotextile fabric should be placed between the subgrade native soil and the aggregate base for proper separation.

Subgrade
Excavate to the bed bottom elevation. Care should be taken to avoid compaction of the subgrade surface and all construction equipment should be kept off the subgrade. If the excavation has been sealed, the surface should be lightly scarified or raked to provide infiltration values consistent with the design.

For traffic areas, compact the subgrade soil for public roadways, private streets, parking lots, and fire lanes to ensure structural stability and minimize rutting. Compaction should be to 95%. Because compaction reduces soil permeability it should be done with caution and scarified prior to setting the aggregate base. Protect the subgrade from truck traffic. It is imperative to protect the porous pavement subgrade from over-compaction. If the subgrade is to be compacted, infiltration testing should be conducted during design of porous pavement to adequately account for reduced soil permeability.

Construction
Porous pavement is to be protected from fines infiltration during site construction by covering with visqueen or similar impervious material.

Porous Concrete

Porous Recycled Concrete

Porous Pavement

Porous Concrete, SW Broadway and Lombard, Beaverton

Porous Pavers, Tigard Library

Maintenance

- Check with the local jurisdiction about use of porous pavement for public facilities.
- If approved for use in the public right-of-way, the permittee must comply with local jurisdiction requirements for a maintenance assurance period. If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see Appendix for example maintenance agreement). Porous pavement on private roads must be in a separate tract.
- Porous pavement requires regenerative air style vacuuming at least once a year, but twice a year is recommended to remove fine particulates from the infiltration spaces. Without this ongoing maintenance, the facility may become impervious. Over time, settling may occur and aggregate base, washed sand, and/or pavers may need to be replaced or repaired.
- Sealing is a common maintenance practice with conventional asphalt. Pervious asphalt must not be sealed or it will lose its pervious function. Owners should take extra care not to seal pervious asphalt pavement. If porous pavement is sealed, additional stormwater treatment may be required.
- See Appendix for detailed operations and maintenance plan.

Porous Concrete, Clean Water Services Field Operations Center

References

- Clean Water Services Design and Construction Standards
- Stormwater Management Manual; City of Portland Bureau of Environmental Services, 2008.

Porous Pavers, West Linn Willamette Park

Filter Structure

Exterior of filter structure

Interior of structure showing installed filter cartridges

Opened filter structure

Description

Filter structures are a proprietary treatment option that may be appropriate for specific uses. This Best Management Practice (BMPs) can target a full range of pollutants in urban runoff, including Total Suspended Solids (TSS), soluble heavy metals, oil and grease, and total nutrients. During a storm, runoff passes through the filtration media and starts to fill the cartridge center tube. As the water rises, air below the hood is purged through a one-way check valve. When water reaches the top, the float releases and filtered water drains out.

After the storm, the water level in the structure starts to fall. A water column hangs under the cartridge hood until the water level reaches the scrubbing regulators. Then air rushes through the regulators, releasing water and creating air bubbles that agitate the surface of the filter media and cause accumulated sediment to drop to the vault floor. This patented surface-cleaning mechanism helps restore the filter's permeability between storm events.

Application & Limitations

Filter structures can be used to manage stormwater flowing from all types of impervious surfaces, including private property and the public right-of-way, treating runoff from rooftops, parking lots, and streets. Generally, these facilities are allowed in ultra high density development with high pollutant load potentials, such as commercial parking lots. Consult the Design and Construction Standards for allowed uses.

Filter Structure

Stormfilter cartridges and interior filter media

Design Factors

Designers should contact the manufacturer's representative for correct design and sizing. Only 18-inch height Filter Structure cartridges are allowed. Filter Structures should be designed to treat the water quality storm, which is a dry weather storm event totaling 0.36 inches of precipitation falling in 4 hours with an average storm return of 96 hours. The water quality volume (WQV) is the volume of water that is produced by the water quality storm. The WQV equals 0.36 inches over the impervious area that is required to be treated, as shown in the formula below.

$$\text{WQV (cu.ft)} = \frac{0.36(\text{in.}) \times \text{Area(sq.ft.)}}{12(\text{in./ft.})}$$

Inspection & Maintenance Guidelines

As with any effective filtration system, pollutants must be removed periodically to restore the Filter Structure to full efficiency and effectiveness. Maintenance requirements and frequency are determined by the pollutant load characteristics of each site. Maintenance activities may be required in the event of a chemical spill or due to excessive sediment loading from site erosion or extreme storms. It is a good practice to inspect the system after major storm events.

Maintenance

Contact the manufacturer for specific maintenance procedures. At a minimum, the following procedures that use common equipment and existing maintenance protocols are required:

1. Inspection: At least once a year, before the winter season. After major storm events, filters should be inspected for damage. Inspect the vault interior to determine the need for maintenance.

2. Maintenance: Frequency may be adjusted in response to monitoring information from regular inspections.

Cartridge replacement: Replace cartridges as needed per the maintenance checklist, or every 3 years if no checklist problems exist. All cartridges should be replaced after a chemical or fuel spill, regardless of their age.
Sediment removal: Accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols.

3. See Appendix for detailed operations and maintenance plan.

References

Clean Water Services Design and Construction Standards
Contech-cpi.com/stormwater/products/filtration/stormfilter/15

Water Quality Manhole (Hydrodynamic Separator)

Interior and exterior images of standard water quality manholes

Description

A water quality manhole (hydrodynamic separator) provides pretreatment to a series of Best Management Practices (BMPs). The water quality (WQ) manhole removes coarse solids and floatable pollutants that may rapidly clog other BMPs, reducing maintenance.

The WQ manhole may provide required pretreatment for a vegetated swale, an extended dry basin, and constructed water quality wetland. Two types of WQ manholes are approved:

1) Standard WQ manhole with snout or mechanical tee assembly, and
2) Proprietary hydrodynamic separators

Contech's CDS® is an approved proprietary hydrodynamic separator. It is a flow-through structure with a settling or separation unit to remove sediment and other pollutants.

Application & Limitations

Water quality manholes manage stormwater flow from all types of impervious surfaces including private property and the public right-of-way, treating runoff from rooftops, parking lots, and streets. Generally, these facilities are allowed in ultra high density development with high pollutant load potentials, such as commercial parking lots. Consult the Design and Construction Standards for allowed uses.

Water Quality Manhole (Hydrodynamic Separator)

Diagrams and construction photographs of hydrodynamic separators

Design Factors

Designers should use Standard Detail Number 240 or 250 in the Clean Water Services Design and Construction Standards to size a standard WQ manhole.

WQ manholes are sized by treatment objectives, including desired level of pollutant removal, flow to be treated and target particle size. Designers should contact the manufacturer's representative for design and sizing guidance. The pollutant removal rates differ by product and should be evaluated before a system is selected for a site. Because performance is affected by hydraulic loading rate, excess flow should not be routed through the device.

Inspection & Maintenance Guidelines

Contact the manufacturer for specific maintenance procedures. At a minimum, the following procedures that use common equipment and existing maintenance protocols are required:

1. Inspection: Monthly monitoring is recommended during the first year of a new installation after the site has been stabilized.

2. Maintenance: Clean the structure when the sump is half full (e.g., 2 feet of material collects in a 4-foot sump), or if there is a spill or other incident. Use a vacuum truck for best results.

Snout: Annual inspection of the anti-siphon vent and access hatch is recommended. Open and close the access hatch. Flush the vent or clean with a flexible wire.

HDS: Vacuum trucks which are typically used for maintenance must have unobstructed access for pollutant removal.

References: Clean Water Services Design & Construction Standards
Contech-cpi.com/stormwater/13

3. See Appendix for detailed operations and maintenance plan.

Constructed Water Quality Wetland Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Unobstructed inlet/outlet; material and blockages removed
	Annually Required	General	Erosion	Erosion of pond side slopes; scouring of the pond bottom more than 6 inches, or continued erosion is prevalent	Slopes and pond bottom repaired and stabilized using proper erosion control measures
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C standards	No invasive vegetation is planted or permitted to remain, including but not limited to: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly from November through April Annually Required	Inlet/Outlet Pipe	Inlet/Outlet Pipe Blocked	Inlet/outlet pipe clogged with sediment or debris	Inlet and outlet piping cleared

Constructed Water Quality Wetland Operations and Maintenance Plan (continued) _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Annually Required	Emergency Overflow/ Spillway	Exposed Soil or Erosion	Native soil is exposed at the spillway, or only one layer of rock in areas 5 sf or larger; rip-rap on inside slopes need not be replaced	Rocks and pad depth are restored to design standards
	Monthly from November through April Annually Required	Pond	Oil Sheen on Water	Prevalent and visible oil sheen	Oil removed using oil-absorbent pads or vactor truck; source of oil located and corrected. If low levels of oil persist, plant wetland plants that can uptake small concentrations of oil such as Juncus effusus (soft rush)
	Monthly from November through April Annually Required	Pond Bottom Dike/Berm Internal Berm	Sediment Accumulation in Pond Bottom	Sediment depth in wetland bottom exceeds 6 inches or affects inlet/outlet functions or plant growth in treatment area	Sediment removed to designed wetland shape and depth; reseed if necessary to control erosion, or replant to achieve treatment
	Annually Required		Settlement of Pond Dike/Berm	Any part has settled 4 inches or lower than the design elevation; inspector determines dike/berm is unsound	Dike/berm is repaired to specifications
	Annually Required		Erosion	Berm dividing cells should be level so water flows evenly over entire length of berm	Berm surface is leveled
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

Extended Dry Basin Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C Standards	No invasive vegetation is planted or permitted to remain, including but not limited to: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible; Refer to Clean Water Services integrated pest management guidance documents.
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	General	Contaminants and Pollution	Evidence of oil, gasoline, contaminants or pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local jurisdiction
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Annually Required		Tree Growth and Hazard Trees	Tree growth interferes with access for maintenance (slope mowing, silt removal, vactoring, or equipment movements). Do not remove trees that are not interfering with access or maintenance.	Trees do not hinder maintenance activities; recycle harvested trees into mulch or beneficial uses (e.g., alders for firewood)
	Annually Required	General	Hazard Trees	Dead, dying or diseased trees	Hazard trees removed; certified Arborist to determine health of tree or removal requirements

Extended Dry Basin Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Unobstructed inlet/outlet; material and blockages removed
	Annually Required	Pond Berms (Dikes)	Erosion	Discernable water flow through pond berm or ongoing and potential erosion; recommend inspection by licensed civil engineer to evaluate condition and recommend repair	Piping eliminated; erosion potential resolved
	Annually Required	Pond Berms (Dikes)	Settlements	Any part of berm has settled 4 inches lower than the design elevation; measure settlement to determine amount. Settling may indicate more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is reconstructed to the design elevation
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	Compacted Berm Embankment	Erosion	Erosion observed on a compacted berm embankment; a licensed civil engineer should be consulted to resolve the source of erosion.	Erosion resolved
	Annually Required	Emergency Overflow/ Spillway	Blockage of Overflow/ Spillway	Tree growth on emergency spillways creates blockages and may cause the berm to fail due to uncontrolled overtopping. A licensed civil engineer should be consulted for proper berm/spillway restoration.	Trees removed Small root system (base less than 4 inches) may be left in place; otherwise, roots are removed and the berm is restored
	Annually Required	Emergency Overflow/ Spillway	Exposed Soil or Erosion	Native soil is exposed at the spillway, or there is only one layer of rock in areas 5 sf or larger; rip-rap on inside slopes need not be replaced	Rocks and pad depth are restored to design standards
	After any major storm (use 1-inch in 24 hours as a guideline) Annually Required	Overflow Structure and Orifice Plate	Excessive Standing Water or Water Is Not Detained For Required Time	If water is not detained check to see if the orifice plate is installed; if water does not drain in required time, check to see if overflow structure is plugged	Orifice plate is cleared for proper drainage or re-installed to ensure required detention; overflow structure is unobstructed

Extended Dry Basin Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	Pond Bottom	Sediment Accumulation in Pond Bottom	Sediment accumulation in pond bottom exceeds 6 inches or affects facility inlet/ outlet or plant growth in treatment area	Sediment removed to designed pond shape and depth; reseeded as necessary to control erosion; replanted to achieve treatment; stormwater is evenly distributed within treatment area
	Monthly from November through April Annually Required	Liner (If Applicable)	Exposed or Damaged	Liner is visible; more than three 1/4-inch holes in liner	Liner repaired or replaced and fully covered
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	Side Slopes of Pond	Erosion	Eroded damage more than 2 inches deep if cause of damage is still present or there is potential for continued erosion	Slopes stabilized using appropriate erosion control measures (rock reinforcement, planting of grass, compaction)
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

Flow-Through Planter Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	General	Sediment Accumulation in Treatment Area	Sediment depth exceeds 3 inches	Sediment removed from vegetated treatment area; planter is level from side to side and drains freely toward outlet; no standing water within 24 hours after any major storm (1-inch in 24 hours)
	Monthly from November through April Annually Required	General	Erosion Scouring	Eroded or scoured planter bottom due to flow channelization, or higher flows	Repair ruts or bare areas by filling with topsoil during dry season; regrade and replant large bare areas
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	General	Standing Water	Standing water in the planter between storms that does not drain freely	Remove sediment or trash blockages; improve end to end grade so there is no standing water 24 hours after any major storm (1-inch in 24 hours)
	Monthly from November through April Annually Required	General	Flow Not Distributed Evenly	Flows unevenly distributed through planter width due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire planter width
	Annually Required	General	Settlement / Misalignment	Failure of planter has created a safety, function, or design problem	Planter replaced or repaired to design standards
	Monthly from November through April Annually Required	General	Constant Baseflow	Small, continual flow of water through the planter even after weeks without rain; planter bottom has an eroded, muddy channel	Add a low-flow pea gravel drain the length of the planter or bypass the baseflow around the planter
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening

Flow-Through Planter Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly Annually Required	General	Poor Vegetation Coverage	Grass or other vegetation is sparse, or bare in more than 10% of the planter bottom	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants as needed to meet current density standards during next appropriate planting season.
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C Standards	No invasive vegetation is planted or permitted to remain, including but not limited to the following: Himalayan Blackberry; Reed Canary Grass; Teasel English Ivy; Nightshade; Clematis; Cattail Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April Annually Required	General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local water quality response agency
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Remove material to clear inlet and outlet area
	Monthly during growing season Annually Required	General	Excessive Shading	Vegetation growth is poor because sunlight does not reach planter	Trim over-hanging limbs, if possible; remove brushy vegetation as needed
	Monthly during growing season Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

Green Roof Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Summer Annually Required	Green Roof structural components	Standing water, super saturated soil	Clogged drain or compacted soil	Clear drains; remove organics and other debris from drain; loosen compacted soil and amend
	Summer Annually Required	Structural components	Leaks in roof	Tears or perforation of membrane	Contact manufacturer for repair or replacement
	Fall and Spring Annually Required	Vegetation	Dead or stressed vegetation	Vegetation should cover 90% of facility	Replant per original planting plan; irrigate as needed
	Fall and Summer Annually Required	Vegetation	Dry grass or plants	Viable plant life	Prune grass and plantings; remove clippings
	All seasons weed as necessary Annually Required	Vegetation	Weeds	Weeds on more than 20% of the site	Remove weeds by hand; do not use pesticides
	Annually Required	Growing medium	Exposed soil	Vegetation should cover 90% of facility	Cover with plants and mulch as needed
	Annually Required	Growing medium	Erosion	Rill or gully formation	Fill eroded areas with approved soil and lightly compact and replant
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)
If replanting in the Summer, irrigation will be necessary.					

Infiltration Planter—Rain Garden Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C Standards	No invasive vegetation is planted or permitted to remain, including but not limited to: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	No invasive vegetation; Remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April and after any major storm (use 1-inch in 24 hours as a guideline) Annually Required	General	Contaminants and Pollution	Evidence of oil, gasoline, contaminants or other pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local jurisdiction
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	General	Erosion	Eroded damage more than 2 inches deep if cause of damage is still present or there is potential for continued erosion	Area stabilized using appropriate erosion control measures
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Unobstructed inlet/outlet; material and blockages removed

Infiltration Planter–Rain Garden Operations and Maintenance Plan (continued) _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly from November through April Annually Required	Storage Area	Sediment or standing water	Water ponding after rainfall ceases and infiltration time has passed, or testing indicates facility is working at 90% or less of design capability; sediment depth exceeds 2 inches	No standing water 24 hours after major storm (1-inch in 24 hours); sediment is removed and facility works according to design
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms	Gravel in rock filter is replaced
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

LIDA Swale Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	General	Sediment Accumulation in Treatment Area	Sediment depth exceeds 3 inches	Remove sediment deposits on grass treatment area of the bioswale; swale is level from side to side and drains freely toward outlet; no standing water after inflow has ceased
	Monthly from November through April and after any major storm 1-inch in 24 hours) Annually Required	General	Standing Water	Standing water in the planter between storms that does not drain freely	Remove sediment or trash blockages; improve grade from end to end of planter; no standing water 24 hours after any major storm (1 inch in 24 hours)
	Monthly from November through April Annually Required	General	Flow Not Distributed Evenly	Flows unevenly distributed through swale due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire swale width
	Monthly from November through April Annually Required	General	Constant Baseflow	Small, continual flow of water through the swale even after weeks without rain; swale bottom has an eroded, muddy channel	Add a low-flow pea gravel drain the length of the swale or bypass the baseflow around the swale
	Monthly Annually Required	General	Poor Vegetation Coverage	Grass or other vegetation is sparse, bare or eroded in more than 10% of the swale bottom	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants as needed to meet current density standards
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C standards	No invasive vegetation is planted or permitted to remain, including but not limited to the following: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.

LIDA Swale Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	General	Excessive Shading	Vegetation growth is poor because sunlight does not reach swale	Trim over-hanging limbs, if possible; remove brushy vegetation as needed
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Remove material to clear inlet and outlet area
	Monthly from November through April Annually Required	General	Erosion Scouring	Eroded or scoured planter bottom due to flow channelization, or higher flows	Repair ruts or bare areas by filling with topsoil during dry season; regrade and replant large bare areas
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly from November through April Annually Required	General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local water quality response agency
	Monthly from November through April Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

Vegetated Filter Strip Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	General	Flow not distributed evenly	Flows unevenly distributed through filter strip due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire filter strip width
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C standards	No invasive vegetation is planted or permitted to remain, including but not limited to the following: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly from November through April Annually Required	General	Vegetation	Grass more than 10 inches tall; weeds and other vegetation taking take over	Mow grass to a height of 3 to 4 inches; control nuisance vegetation such that flow is not impeded
	Monthly from November through April Annually Required	General	Erosion	Eroded or scoured filter bottom due to flow channelization, or higher flows	Repair ruts or bare areas by filling with topsoil during dry season; regrade and replant large bare areas
	Monthly from November through April Annually Required	General	Scouring Sediment Accumulation	Sediment depth exceeds 2 inches	Remove sediment deposits; re-level so slope is even and flows pass evenly through strip
	Monthly and after any major storm (use 1-inch in 24 hours as a guideline) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs

Vegetated Swale Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Unobstructed inlet/outlet; material and blockages removed
	Monthly from November through April Annually Required	General	Flow not distributed evenly	Flows unevenly distributed through swale due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire swale width
	Annually Required	General	Structure Damage to Frame or Top Slab	Frame not sitting flush on top slab (more than 3/4 inch between frame and top slab); frame not securely attached	Frame is firmly attached and sits flush on the riser rings or top slab
	Annually Required	General	Fractures or Cracks in Basin Walls or Bottom	Maintenance person determines the structure is unsound	Basin replaced or repaired to design standards
	Annually Required	General	Fractures or Cracks in Basin Walls or Bottom	Grout fillet is separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe, or evidence of soil entering through cracks	Pipe is regrouted and secure at basin wall
	Annually Required	General	Settlement / Misalignment	Failure of basin has created a safety, function, or design problem	Basin replaced or repaired to design standards
	Monthly from November through April Annually Required	General	Constant Baseflow	Small, continual flow of water through the swale even after weeks without rain; swale bottom has an eroded, muddy channel	Add a low-flow pea gravel drain the length of the swale or bypass the baseflow around the swale
	Monthly from November through April Annually Required	General	Sediment Accumu-lation in Treatment Area	Sediment depth exceeds 3 inches	Remove sediment deposits on grass treatment area of the bio-swale; swale is level from side to side and drains freely toward outlet; no standing water once inflow has ceased

Vegetated Swale Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	General	Erosion Scouring	Eroded or scoured planter bottom due to flow channelization, or higher flows	Repair ruts or bare areas by filling with topsoil during dry season; regrade and replant large bare areas
	Monthly Annually Required	General	Poor Vegetation Coverage	Grass or other vegetation is sparse or bare in more than 10% of the swale bottom	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants as needed to meet current density standards
	Monthly Annually Required	General	Vegetation	Nuisance weeds or other invasive vegetation is taking over	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly Annually Required	General	Vegetation	Vegetation blocking more than 10% of the basin opening	No vegetation blocking opening to basin
	Monthly from November through April Annually Required	General	Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart	No vegetation or root growth present
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly from November through April Annually Required	General	Excessive Shading	Vegetation growth is poor because sunlight does not reach swale	Trim over-hanging limbs, if possible; remove brushy vegetation as needed

Vegetated Swale Operations and Maintenance Plan (continued) _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April Annually Required	General	Standing Water	Standing water in the swale between storms that does not drain freely	Remove sediment or trash blockages; improve grade from end to end of swale; no standing water 24 hours after any major storm (1-inch in 24 hours)
	Monthly from November through April Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed
	Monthly from November through April Annually Required	General	Contamination and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local water quality response agency
	Monthly from November through April and after any major storm (1-inch in 24 hours) Annually Required	Grates	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from grate
	Annually Required	Grates	Damaged or Missing	Grate missing or broken grate members	Grate is in place and meets design standards
	Annually Required	Outlet Structure	Grate Not in Place	Grate is missing or only partially in place	Any open structure needs maintenance; replace grate if missing
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs

Wetpond Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April Annually Required	General	Oil Sheen on Water	Prevalent and visible oil sheen	Oil removed from water using oil- absorbent pads or vactor truck; source of oil located and corrected. If low levels of oil persist, plant wetland plants that can uptake small concentrations of oil such as Juncus effusus (soft rush)
	Monthly and after any major storm (use 1-inch in 24 hours as a guideline) Annually Required	General	Obstructed Inlet/ Outlet	Inlet/outlet areas clogged with sediment, vegetation or debris	Unobstructed inlet/outlet; material and blockages removed
	Annually Required	General	Erosion	Erosion of pond side slopes; scouring of the pond bottom more than 6 inches, or continued erosion is prevalent	Slopes repaired and stabilized using proper erosion control measures
	Monthly Annually Required	General	Invasive Vegetation as outlined in Ch.4 D&C standards	No invasive vegetation is planted or permitted to remain, including but not limited to: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	No invasive vegetation; remove excessive weeds. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services integrated pest management guidance documents.
	Monthly from November through April Annually Required	General	Vegetation	Vegetation blocking more than 10% of the inlet pipe opening	No vegetation blocking inlet pipe opening
	Monthly Annually Required	General	Rodents	Evidence of rodents or water piping through facility via rodent holes	No rodents; facility repaired. Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	General	Insects	Insects such as wasps and hornets interfere with maintenance activities	Harmful insects removed

Wetpond Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Annually Required	Dike/Berm	Settlement of Pond Dike/Berm	Any part of dike or berm settled 4-inches or lower than the design elevation; inspector determines dike/berm is unsound	Dike/berm is repaired to specifications
	Annually Required	Internal Berm	Erosion	Berm dividing cells should be level so that water flows evenly over entire length of berm	Berm surface is leveled
	Monthly from November through April Annually Required	Pond Bottom	Sediment Accumulation in Pond Bottom	Sediment more than 6 inches deep in pond bottom, usually in the first cell, that affects inlet or outlet condition of the facility or plant growth in treatment area	Sediment removed to designed pond shape and depth; reseed if necessary to control erosion, or replant to achieve treatment
	Annually Required	Overflow Spillway	Erosion of Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope	Rocks replaced to specifications
	Monthly Annually Required	General	Vegetation	Specified or approved grass grows so tall that it competes with shrubs or becomes a fire danger.	String trim grass to 4" to 6" and remove clippings; take care not to girdle the bark of trees and shrubs. (Note: except emergent wetland grasses in the treatment area of low maintenance facilities)

Catch Basin Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from catch basin
	Monthly Annually Required	General	Vermin and Odors	Dead animals or vegetation that could generate odors or dangerous gases (e.g., methane) and could cause complaints	No dead animals or vegetation in the catch basin
	Monthly from November through April Annually Required	General	Contamination and Pollution	Evidence of oil, gasoline, contaminants, or other pollutants	No contaminants or pollutants present; coordinate removal/ cleanup with local water quality response agency
	Annually Required	General	Settlement or Misalignment	Failure of basin has created a safety, function, or design problem	Basin replaced or repaired to design standards
	Monthly Annually Required	General	Vegetation	Vegetation blocking more than 10% of the basin opening	No vegetation blocking basin opening
	Monthly Annually Required	General	Vegetation	Vegetation in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart	No vegetation or root growth present
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	Grates	Trash and Debris	Trash and debris blocking more than 20% of grate surface inletting capacity	Grate free of trash and debris
	Annually Required	Grates	Damaged or Missing	Missing grate; missing or broken grate members	Grate is in place and meets design standards
	Annually Required	Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place	Closed catch basin cover; any open catch basin requires maintenance
	Annually Required	Catch Basin Cover	Cover Difficult to Remove	One maintenance person cannot remove lid using normal lifting pressure; difficult to access for maintenance	Cover can be removed by one maintenance person

Catch Basin Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Annually Required	Frame and Top Slab	Structure Damage to Frame or Top Slab	Holes in top slab larger than 2 square inches or cracks wider than 1/4 inch; intent is to ensure no material is running into basin	Top slab is free of holes and cracks
	Annually Required	Frame and Top Slab	Structure Damage to Frame or Top Slab	Frame not sitting flush on top slab (more than 3/4 inch between frame and top slab); frame not securely attached	Frame is firmly attached and sits flush on the riser rings or top slab
	Annually Required	Ladder	Ladder Rungs Unsafe	Ladder is unsafe (missing rungs, not securely attached, misalignment, rust, cracks, sharp edges, etc.)	Ladder meets design standards and allows safe access for maintenance person
	Annually Required	Basin Walls and Bottom	Fractures or Cracks	Maintenance person determines the structure is unsound	Basin replaced or repaired to design standards
	Annually Required	Basin Walls and Bottom	Fractures or Cracks	Grout fillet is separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe; evidence of soil entering through cracks	Pipe is re-grouted and secure at basin wall
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	Sump	Trash & Debris	Trash or debris in the basin exceeds 50% of the sump depth from the bottom of basin to invert of the lowest pipe into or out of the basin; less than 6 inches clearance from the debris surface to the invert of the lowest pipe	No trash or debris in the catch basin; in no case less than 6 inches clearance from the debris surface to the invert of the lowest pipe
	Monthly Annually Required	Sump	Sediment	Sediment in the basin exceeds 50% of the sump depth from the bottom of basin to invert of the lowest pipe into or out of the basin; in no case less than 6 inches clearance from the sediment surface to the invert of the lowest pipe	No sediment in the catch basin
	Monthly from November through April Annually Required	Inlet/Outlet	Blockage of Inlet/ Outlet	Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its capacity	Inlet and outlet pipes free of trash or debris

Closed Detention System (Tank/Vault) Operations and Maintenance Plan _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly and after any major storm (1-inch in 24 hours) Annually Required	General	Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility
	Monthly from November through April Annually Required	Storage Area	Debris and Sediment	Depth of accumulated sediment depth exceeds 10% of the storage area diameter for ½ length of storage vault, or exceeds by 15% of diameter at any point (Example: 72-inch storage tank to be cleaned if sediment is 7 inches deep for more than ½ length of tank)	Sediment and debris removed from storage area
	Monthly from November through April	Storage Area	Plugged Air Vents	Vent is damaged or ½ of vent cross section is blocked	Vents open and functioning
	Annually Required	Storage Area	Open Joints Between Tank/Pipe	Openings or voids that allow material into facility; requires engineering analysis to determine structural stability	All joint between tank/pipe sections are sealed
	Annually Required	Storage Area	Section Tank/Pipe Bent Out of Shape	Any part of tank/pipe is bent more than 10% of its design shape; requires engineering analysis to determine structural stability	Tank/pipe repaired or replaced to design
	Annually Required	Storage Area	Vault Structure Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil entering the structure; maintenance or inspection determines the vault is not structurally sound	Vault replaced or repaired to design specifications and is structurally sound
	Annually Required	Storage Area	Cracks at joints of inlet/outlet pipes or walls	Cracks wider than 1/2-inch at the joint of inlet/outlet pipe or any evidence of soil entering the vault through the walls	No cracks wider than 1/4-inch at inlet/outlet pipe joints
	Annually Required	Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools; bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids)	Mechanism opens with proper tools

Closed Detention System (Tank/Vault) Operations and Maintenance Plan (continued) _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Annually Required	Manhole	Cover Not in Place	Cover is missing or only partially in place; any open manhole needs maintenance.	Manhole is closed
	Annually Required	Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid using normal lifting pressure; cover maces access for maintenance difficult	Cover can be removed and reinstalled by one maintenance person
	Annually Required	Manhole	Ladder Rungs Unsafe	Maintenance person determines ladder is unsafe (missing rungs, misalignment, rust, cracks); ladder must be repaired or secured immediately	Ladder meets design standards and allows safe access for maintenance

Porous Pavement Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Annually Required	Structural components	Water infiltrates unevenly across surface or ponds in low areas	Clogged surface	Water infiltrates evenly across surface; recommend vacuum sweep at least twice per year and power wash annually or as needed; do not use surfactants
	Annually Required	Structural components	Cracked or moving edge constraints; cracked or settled pavement	Cracked or moving edge constraints, or cracked or settled pavement that affects overall performance	Repair all cracks, settlement or other defects that affect performance per manufacturers' specifications
	Annually during the Fall Required	Vegetation	Leaf litter deposition on surface	Leaf litter that could affect stormwater infiltration through pavement	Sweep leaf litter and sediment to prevent surface clogging and ponding
	Annually during the growing season Required	Vegetation	Weeds	Weeds that cover 10% of the surface area	Remove weeds by hand, or use an herbicide approved for use around sensitive areas; Refer to Clean Water Services integrated pest management guidance documents.
	Annually Required	Filter medium between pavers	Aggregate loss in pavers from settling and power washing	Settling of pavers or lack of aggregate around pavers	Reset pavers and replace pore space with aggregate from original design

Filter Structure and Catch Basin Unit Operations and Maintenance Plan

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	Forebay	Sediment accumulation	Sediment accumulation exceeds 6 inches or 1/3 of available sump	Sediment accumulation less than 6 inches
	Monthly from November through April Annually Required	Forebay	Trash and floatable debris accumulation	Trash and floatable debris accumulation; significant oil accumulation may indicate the need for additional treatment or source control	Trash and floatable debris removed during monthly inspections
	Monthly from November through April Annually Required	Media filter vault	Sediment accumulation on top of filter cartridges	Sediment accumulation exceeds 0.25 inches on top of cartridges	No sediment deposits on top of cartridges; sediment on cartridges likely indicates that cartridges are plugged and require replacement
	Monthly from November through April Annually Required	Media filter vault	Sediment accumulation in vault	Sediment accumulation in vault exceeds 4 inches; look for other indicators of clogged cartridges or overflow	Sediment in vault removed; cartridges checked and replaced as needed
	Monthly from November through April Annually Required	Media filter vault	Trash and floatable debris accumulation	Trash and floatable debris accumulation in vault	No trash or other floatable debris in filter vault
	Annually and after any major storm (1-inch in 24 hours) Annually Required	Media filter vault	Filter cartridges submerged	Filter vault does not drain within 24 hours following storm; look for evidence of submergence due to backwater or excessive hydrocarbon loading	Replace filter cartridges If cartridges are plugged with oil additional treatment or source control BMP may be needed; NOTE: If filters have not been changed in 3 years, replace immediately
	Monthly from November through April Annually Required	Media filter vault	Vault is in bypass	Filter vault remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges) during an average rain fall event	Replace filter cartridges

Filter Structure and Catch Basin Unit Operations and Maintenance Plan (continued)

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April	Media filter vault	Scum line	Obvious scum line above top cap more than ¼ inch	Remove sediment and replace filter cartridges
	Annually Required Annually Required	Below ground vault	Access cover damaged or not working	One maintenance person cannot remove lid using 80 pounds of lift; cover is corroded or deformed	Cover replaced or repaired to working specifications
	Annually Required	Below ground vault	Damaged Pipes	Any part of the pipes are crushed or damaged due to settlement or corrosion	Pipe repaired or replaced
	Annually Required	Below ground vault	Baffles	Baffles corroded, cracked, warped, or showing signs of failure determined by maintenance or inspection person; failed baffle wall seals	Baffles repaired or replaced to design specifications; baffle wall seal repaired using grout or mastic
	Annually Required	Below ground vault	Vault structure has cracks in wall, bottom, damage to frame or top slab	Cracks wider than ½ inch or evidence of soil entering through the cracks; maintenance or inspection determines the vault is not structurally sound	Vault repaired or replaced; vault meets design specifications and is structurally sound
	Annually Required	Below ground vault	Vault structure has cracks in wall, bottom, damage to frame or top slab	Cracks wider than ¼ inch at the joint of any inlet/outlet pipe or evidence of soil entering through the cracks	Vault repaired; no cracks wider than ¼ inch at the joint of inlet/outlet pipe
	Annually Required	Below ground vault	Ladder rungs unsafe	Maintenance person determines ladder is unsafe (missing rungs, misalignment, rust, cracks); ladder must be repaired or secured immediately	Ladder meets design standards and allows safe access for maintenance

Water Quality Manhole (Hydrodynamic Separator) Operations and Maintenance Plan _____

Annual inspections are required. This checklist describes inspection activities, and notes additional recommended inspections. Contact the design engineer, Clean Water Services or City representative for more information.

CHECK ✓	Recommended, in addition to required annual inspection	System Feature	Problem	Conditions to Check for	Preferred Conditions and Maintenance Practices
	Monthly from November through April Annually Required	General	Trash, Debris and Sediment	Material exceeds 50% of sump depth or one foot below the Tee or Snout	Tee or Snout is not blocked; trash, debris and sediment removed
	Annually Required	General	Structural Damage	Tee or Snout is not securely attached to manhole wall	Tee or Snout securely attached to wall and outlet pipe
	Annually Required	General	Structural Damage	Structure is not upright (allow up to 10% from plumb)	Structure in correct position
	Annually Required	General	Structural Damage	Connections to outlet pipe are not watertight	Connections to outlet pipe are watertight; structure repaired or replaced and works as designed
	Annually Required	General	Structural Damage	Any holes in the structure (other than designed)	No holes except as designed
	Annually Required	Manhole	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools; bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids)	Mechanism opens with proper tools
	Annually Required	Manhole	Cover Not in Place	Cover is missing or only partially in place; any open manhole needs maintenance	Manhole is closed
	Annually Required	Manhole	Cover Difficult to Remove	One maintenance person cannot remove lid using normal lifting pressure; cover makes access for maintenance difficult	Cover can be removed by one maintenance person
	Annually Required	Manhole	Ladder Rungs Unsafe	Maintenance person determines ladder is unsafe (missing rungs, misalignment, rust, cracks); ladder must be repaired or secured immediately	Ladder meets design standards and allows safe access for maintenance