

Stormwater Planters

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Stormwater Planters structures made of a durable material such as stone, brick or concrete (treated wood is not suggested as it may leak chemicals into the stormwater) designed to capture runoff and settle and filter out sediment and pollutants. Runoff is piped, channeled, or directed by overland flow to the surface of the planter, where it is temporarily stored and then infiltrated or conveyed to another approved disposal point. In general, there are two kinds of planters. Planters that reduce runoff volumes by allowing water to seep into the surrounding soils are called infiltration planters. By contrast, filtration planters (aka flow-through planters) only cleanse stormwater runoff and don't allow infiltration because they are specifically lined to prevent infiltration in unsafe conditions. Infiltration and filtration planter differ slightly in location, soils, piping requirements and some areas of design. Some people have referred to them as a rain garden in a box and this is essentially true.

Stormwater planters can be modified to fit almost any physical setting, and are therefore optimal alternatives for sites with conditions restricting the use of other BMPs. Because of their flexible location and various designs planters can add aesthetic appeal to a landscape. They can also attract wildlife (BES 2006). Planters can also fulfill certain landscaping requirements on a site.



Figure 1 Stormwater Planter at Epler Hall on the Portland State University Campus, Portland, OR (PSMM 2008)

Filtration planters

These planters allow runoff to pass through the top mulch and the middle amended soil layers before being collected in a pipe and routed to an approved disposal point. They are used in situations in which infiltration to the underlying soil layers is unsafe or where infiltration rates of the native soils and the area available for the rain garden is so limited that the facility won't drain in a time period reasonable to ensure the survival of the plants. Typically, a 12-inch layer of $\frac{3}{4}$ -inch, washed drain rock is used in combination with a perforated, 4-inch HDPE (high density polyethylene) pipe to allow for detention and conveyance of the water (Gresham 2007) ; however recent preliminary studies indicate a detention time

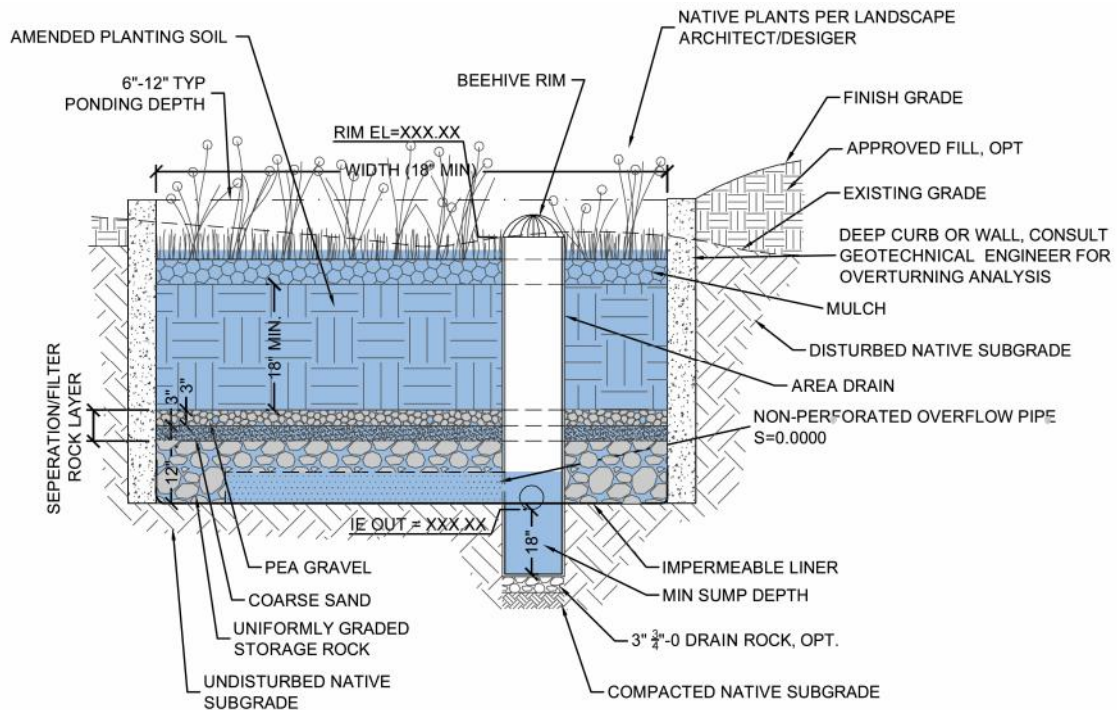


Figure 2 Filtration (aka Flow-Through) Planter

of only 13 minutes and a reduction in volume of only 15% for 0.5 inch 24-hour storms in our early storms only when soils aren't saturated¹.

The City of Portland recommends a layer of 3/4-1/4-inch washed, crushed rock between the soil medium and gravel layer to prevent the soil from mixing with the drain rock (PSMM 2008). The University of New Hampshire has a rain garden installed with a pea gravel layer on top of a coarse sand layer that has been successful². Some jurisdictions will require the use of a geotextile filter fabric instead of the rocks, but if there is no requirement, we recommend using the above washed crushed rock because fines in the soil are easily transported in regularly inundated waters and often clog the geotextile, thereby precluding stormwater storage in the gravel layer below.

In situations where water should not be allowed to infiltrate the underlying soils due to nearby structures (adjacent impervious pavement, site and building walls, etc.), property lines, steep slopes (high erosion potential), high water tables, or possible groundwater contamination, use an impermeable liner along the bottom of the facility to prevent infiltration to soils beneath the garden. These liners are typically 60-mil PVC (Gresham 2007), but 30-mil polyethylene pond liners and bentonite clay mats can be just as effective.

¹ Research by Alan Yeakley and Kate Norton, "Assessment of rainwater detention structures for an urban development in Wilsonville, Oregon" presented at the Urban Ecology and Conservation Symposium, Jan 25th, 2010

² http://www.unh.edu/erg/cstev/fact_sheets/bio_ii_fact_sheet_08.pdf

Infiltration Planters

Infiltration rain gardens also allow runoff to pass through the top mulch and the middle amended soil layers of the rain garden but control runoff volumes from the site by infiltrating runoff into the native soils. This automatically detains stormwater because it's taking an entirely different route through the soil instead of in a pipe, to arrive at our waterways; therefore, the 12-inch layer of washed drain rock used in the filtration rain garden is only needed if the rain garden can't be sized in plan to accommodate the required runoff volumes. An underdrain pipe is probably not needed at all, but may be used at the designer's discretion. When using an underdrain pipe in infiltration facilities, we recommend raising the bottom invert elevation so that water can be stored in the soil and/or optional gravel for infiltration, since placing the pipe at the bottom of the facility will create the path of least resistance and not much infiltration will occur.

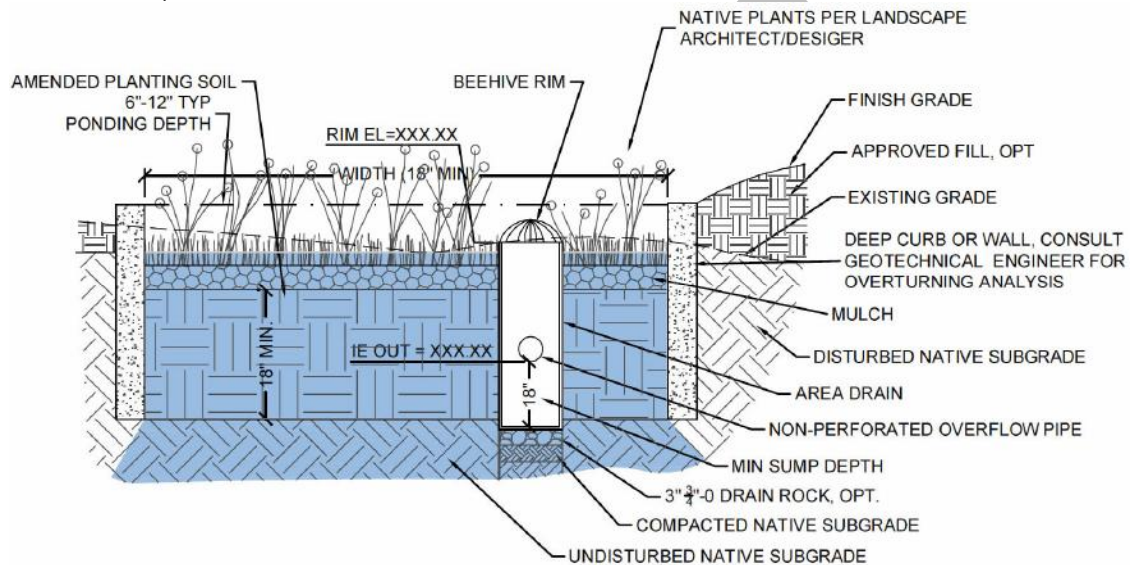


Figure 3 Infiltration Planter during a water quality storm

Design

Rain gardens are typically designed to capture and treat the stormwater runoff from surfaces draining to the garden during 80 to 90 percent of annual storm events, on average. In Oregon, this is usually a 1 inch 24-hour design storm. In some cases, cities may require rain gardens to infiltrate larger storm events, especially where local soils drain well. *Check with your local planning department for specific design requirements for your area.*

SIZING

Planters are designed to drain within 24 to 36 hours and to overflow only during larger storm events. This ensures that they won't be a haven for mosquitoes and will be available for the next round of rainfall. In situations where the surfaces are impervious and essentially all rainfall becomes runoff (for example, rooftops, driveways, and sidewalks and areas of fill even if they are landscaped), the footprint in plan of the planter typically ranges from 4 to 15 percent of the impervious surfaces draining to it. Filtration planters can be smaller since they do not need a lot of area for infiltration but are only treating runoff; however the suggested minimum width for planters, measured within the walls, is 18 inches (PSMM 2008). This rule of thumb was created by jurisdictions with dense, urban areas for places where there is

very little landscape area, but areas of fill, even when they're landscaped, can generate significant amounts of rainfall. These may also be increased for infiltration facilities if soils are poorly draining, If you have any doubts about flooding, consult a civil engineer or landscape architect.

To properly size a planter, you must account for the amount of runoff routed to the garden, the depth allowed for the water to pond before overflowing the garden (ponding depth), the side slopes of the garden, and the rate at which the water infiltrates into the native soils (infiltration rate).

The amount of runoff routed to the planter depends on local rainfall patterns, area of surfaces draining to the garden, and how much of the water runs off these surfaces. Impervious surfaces will generate the most runoff, simple landscapes like lawn will generate a moderate amount of runoff and complex garden areas with trees and shrubs and mulch will generate the least, if any, runoff. Ponding depth should be between 9-12in (Gresham 2007), with the distance between the top of the growing medium to the overflow inlet about 12 inches (PSMM 2008). The slope of the bottom of the facility should not exceed 0.5%. (BES 2006)

Because planters have vertical or near vertical walls, they should be designed in such a way that no two adjacent grades (elevations) are different by 30 inches. By law in Oregon, if you exceed this, you must include a handrail or some other barrier adequate for fall protection.

SOILS AND MEDIUM

All planters often have mulch on top and amended planting soils in the middle. Infiltration planters also use the native uncompacted soils at the bottom.

Since a planter is routinely inundated, soil can easily erode. Many planter details call for 2" of bark mulch to cover the facility, but this has been observed to float and leave soil bare even during small storms that simply redistribute the mulch around the garden, not to mention the large storms that carry it right out through the overflow structure. As with

any organic material, as mulch breaks down, it could decrease the amount of available

oxygen in the downstream water body. In non-stormwater landscape areas, bark mulch is used to control soil temperature for seed germination, to control weeds, and to feed the plants. Instead of bark mulch, we recommend using 2" coarse compost or arborist wood chips in the regularly inundated area. Above the regularly inundated area, you might continue with coarse compost or could switch to fine compost. In Western Oregon, this compost will form a mat of mycelium (mushroom roots) that will hold it together and keep it from floating. In facilities with high flows, consider using 2" of rock mulch and feeding the plants with compost tea (often supplied by the same companies that supply bark mulch) as needed. Densely vegetating the bottoms of the facilities without using any mulch is also an effective way to control erosion; however, weeding may be more difficult.



Figure 4 Filtration planter built into parking garage (NYSDM 2007)

Planters should have amended planting soil or amended native soils with infiltration rates that are not too low, so that at least small storms pass through the soil column for treatment, but not so high that stormwater doesn't have enough "retention time" in the soil. The ideal infiltration rate is between 1/2 inch/hour and 12 inches/hour³. The top 18 inches of soil is typically amended with organic compost and soil mixtures to create a sandy loam soil. In some cases, the existing topsoil is replaced with a soil mix, as specified by the local jurisdiction. In addition to infiltration rates, other key considerations for robust plant establishment and stormwater treatment by plants and soil include soil pH (between 5.5 and 7.54), cation exchange capacity (>5 millequivalents/100grams, and the resulting soil mix should be 60% sandy loam and 40% compost. Be sure that imported soil and compost is free of weed seeds.

Native soils should always be tested in the proposed planter location at the design depth or nearest that depth as possible to determine the infiltration rate of the native undisturbed soils below the amended topsoil. The minimum infiltration rate is really defined by the area available for infiltration; the larger the infiltration area, the lower the soil's infiltration rate can be while still managing the required storm. Most jurisdictions recommend at least ½ inch per hour when using an infiltration facility; some jurisdictions require higher rates. Since stormwater has already passed through the middle amended soil layer and received treatment, there is no recommended maximum infiltration rate for the native soils. If infiltration rates are so low that the plants will have wet feet for too long, you may consider building a smaller filtration rain garden because the under drain pipe will allow the water to leave the bottom of the facility.

STORAGE ROCK

Some facilities sited on soils with lower infiltration rates will require storage rock store runoff before infiltration or conveyance. This should be a granular subbase material meeting gradation requirements of AASHTO #3 or #4 aggregate (CDOT 703, #3 or #4)" (UDFCD 2008), which is a specification for uniformly graded gravel. This specification also calls for "fractured faces", but this is a specification for crushed rock, which would only be needed if the rock was needed for structural stability; therefore, rounded rock is acceptable for this application.

VEGETATION

The interaction of soil, plants, and the beneficial microbes that concentrate on plant roots is what ultimately provides the filtration benefit of rain gardens -- the more plants, the more treatment. While you may see a number of examples of rain gardens with a dry creek bed look and plants around the edges, this approach doesn't provide adequate treatment for the small, frequent storms with ponding depths that may never reach the plants on the side slopes.

A variety of trees, shrubs, grasses, and ground covers are acceptable for rain garden vegetation in both sun and shade conditions. The garden should be densely vegetated for maximum runoff treatment and to control weeds. Local jurisdictions often provide specifications for density, size, and types of vegetation to use. Vegetation should be selected based on its tolerance to flooding and its ability to

³ http://www.psparchives.com/publications/our_work/stormwater/BSMResults-Guidelines%20Final.pdf

⁴ Low Impact Development Center specifications:
http://www.lowimpactdevelopment.org/epa03/biospec_left.htm

survive in the local climate conditions with no fertilizers, and no herbicides or insecticides, and minimum to no watering after establishment. The rain garden will have zones varying from wetland to upland conditions, and the vegetation should be selected based on these conditions. Rain gardens should be designed to fit into the landscape. Vegetation such as perennial flowers, ornamental grasses, and shrubs can add significant appeal to the facility. Rain gardens can also be designed to attract beneficial insects and wildlife. Contact your local OSU Extension Service office or planning department for a list of plants appropriate for your area. Because downstream seed dispersal during flooding is well documented in natural wetlands, take special care to avoid noxious weeds (aka invasive plant species). A list of noxious weeds is available on the Oregon Department of Agriculture's Web site at <http://www.oregon.gov/ODA/PLANT/WEEDS/>.

In most cases, native plants are preferred not just because non-native seeds and rhizomes can greatly impact the habitat potential of our natural drainageways, but also because native plants will provide more food for native insects and birds. Even when native insects and birds find non-native plants appealing, non-native plants don't provide as much nutrition. Finally, native plants support native microbes and other native soil life, while non-natives have been found to negatively impact the composition of the soil life.

ROUTING

All facilities should have an overflow bypass for large storms. A freeboard of at least 2 inches should be used (PSMM 2008). Beehive grates or U-shaped overflows (pictured below) make good overflow devices because they are less likely to get clogged than a flat catch basin grate; however the U-shaped grates are



Figure 5 Improperly installed U-shaped overflow

commonly placed at too high an elevation (pictured below). Make sure that if you use this system, the bottom of the pipe, not the top is set to ensure adequate freeboard, at least 2" below the top of the facility.

For facilities draining areas greater than 1500 square feet, 4inch pipe is required. For facilities draining less than this, 3inch pipe is required. Public facilities in streets require 6 or 8in ASTM 3034 SDR 35 PVC pipe and perforated pipe. Private facilities require cast iron ABS SCH40, or PVC SCH40 (PSMM 2008). Outlets size should be

selected to drain the planter over 12 hours or more (UDFCD 2008). Filtration facilities

require perforated pipe beneath planter (Gresham 2007). PSMM's Sewer Design manual provides more piping detail (PSMM 2008). Check with local plumbing codes when pipes are used. Infiltration planters require an overflow drain 9-12inches high (the height of ponded water) (Gresham 2007). The overflow must also drain to an approved disposal point (BES 2006).

SETBACKS

There are typically no setbacks for lined filtration planters. Setbacks for infiltration planters vary by jurisdiction. The City of Portland (PSMM 2008) requires infiltration planters to be set back at least 10 feet from building foundations and 5 feet from property lines. Along with this is a minimum landscape requirement in their zoning codes that bans building walls within 5 feet of the property line, thereby ensuring the 10 feet of building setback. They should also be set back a minimum of 100 feet from down-gradient slopes of 10 percent. Add 5 feet of setback for each additional percent up to 30 percent, and avoid installing an infiltration rain garden where the down-gradient slope exceeds 30 percent. To ensure proper water quality treatment, the bottom of the infiltration planter should be 24" from bedrock and 36" from the seasonal high groundwater table of 3 feet.

Physical Setting

Stormwater planters are often used in green street applications in the public right-of-way (Gresham 2007), but due to the expense of the structure, these are most often seen on private sites where area for stormwater management is limited. The main advantage planters have over rain gardens is that the structure allows more water to be stored reducing the footprint.

Potential areas for planters include front and back residential yards, parking lots, and under roof spouts (Barr 2001). Planters located on slopes greater than 10% should be designed as filtration planters and with an impervious liner.

Filtration planters with liners can be used anywhere, but an improperly designed infiltration planter has the potential to contaminate groundwater, destabilize slopes, or undermine foundations.

- Use a filtration planter instead of an infiltration planters:
- Where the seasonal groundwater table is higher than 36" from the bottom of the facility
- Where bedrock is higher than 24" from the bottom of the facility
- In areas of new fill (rule of thumb: fill < 5 years old)
- In contaminated soils
- On slopes exceeding 10%
- Possible spill areas

Infiltration planters are also cautioned immediately upslope of buildings (PSMM 2008, Gresham 2007).

Pollutant Removal

Runoff from all types of impervious surfaces is acceptable for stormwater planter management (Gresham 2007). Storage of runoff within the planter allows sediments and pollutants to settle out. Vegetation also purifies waters through bioretention (removal of pollutants by a media and biological system). As with all infiltration facilities, infiltration planters are effective at reducing stormwater flow rates and volumes, which decreases the amount of runoff and subsequent pollutants leaving the system. Based on published research, the Center for Watershed Protection estimated the event mean concentration⁵ phosphorus removal rate to be 25 to 50 percent; nitrogen removal rate was estimated at 40 to 60 percent (CWP 2008). Runoff reduction was estimated at 40-80%. Further pollutant removal

⁵ The Center for Watershed Protection published event mean concentrations for "Bioretention", which is an equivalent term for stormwater planters.

information can be found in table SQ-6 in UDFCD 2007. This provides documentation of influent and effluent pollutant concentrations for specific pollutants and BMPs (UDFCD 2008).

Construction

Like all stormwater management facilities, special care must be taken to properly construct an infiltration planter. Since we rely on the native subgrade soils to infiltrate stormwater, planter areas should be off-limits to construction traffic and stockpiling activities using orange protection or chain link fence. Avoid vehicle traffic within 10ft of facility, except for that needed to construct the facility (PSMM 2008). Construction techniques such as using track equipment and/or excavating from the sides of the infiltration area should be used to protect the soils during excavation. If the soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils. Rake the surface to loosen soil before proceeding.

Once the native subgrade has been exposed, geotextile will be installed to preserve the voids in the overlying gravel storage rock (LIDMM 2008). If soils infiltrate fast, then neither the base rock nor the geotextile would be needed. Where geotextile fabrics are required, they should be high quality and resistant to punctures from sharp edges and rocks (UDFCD 2008). Sheets should overlap at least 12 inches and should be laid across the intended area with an additional 4ft beyond the planter to ensure sediment and runoff do not enter the bed during construction (LIDMM 2008). This can and, for aesthetic reasons, should be cut a few inches below the planting medium level at the very end of construction.

Next, the storage rock, if needed, will be installed. Dust or fine particles not washed away could clog the geotextile (Hicks and Lundy 1998), so not only should the rock be delivered clean from the quarry, but should also be washed carefully on-site. One successful method for this is to hose the rock off in the delivery truck when it arrives. Another method might be to dump the rock and wash off the pile. In both instances, scooping of the rock should be done from the surface and the rock should be closely monitored for fines. As you work your way down the pile, fines from above might only have been washed off halfway through. If careful attention isn't paid to this step, the geotextile fabric could become clogged, creating an unintentional impervious pavement at the bottom of the pavement section.

Place the planting medium in 6" lifts and compacting lightly with boot tamping or water compaction to avoid settlement after the first storm. Vibratory compaction should never be used as this will over compact the soil and impact the many benefits that the soil provides.

Next, place the mulch.

Allow the plants to establish for at least 3 months before allowing stormwater to route to the facility. In this time, the plants roots will have a better hold on the soil and erosion from the facility can be decreased.

Maintenance

Maintenance requirements are typical of vegetated areas. If properly maintained, a facility can last indefinitely (Barr 2001). If the facility receives large volumes of silt and clay, clogging is possible. Watering and weeding may be needed frequently within the first 1 to 3 years during Oregon's very dry summers, but this will taper off dramatically if you choose plants that require little to no watering after establishment. It's important to inspect the facility after major storm events and tend to them as needed:

- Remove sediment and debris.
- Clean and repair inlets and outlets, embankments, and berm dams.
- Control erosion.
- Ensure proper drainage.
- Replace plants as necessary.

Permits

Consult your local planning and building department and plumbing codes for permits and piping requirements. Ask about the applicable permits, plumbing codes, and piping requirements. Find out if there are any maps, as-built drawings, or site specific constraints. In many cases, if building a planter on a non-residential site, a commercial building permit is required and a clearing, grading, and erosion control permit may be required if ground disturbance is large enough (BES 2006).

UIC PERMITTING

An Underground Injection Control (UIC) is a system designed "for the subsurface placement of fluids" and is regulated through the Oregon Department of Environmental Quality's UIC program. This program protects groundwater resources from injection of pollutants directly underground and depending on the potential of various pollutants to be on-site, may be rule authorized or require a more formal permitting process.

An infiltration planter designed and installed per the details shown is not considered a UIC; however, changes to the design detail that might allow runoff to shortcut infiltration through the top of the facility could turn the facility into a UIC. For instance, if the area drain were perforated or had an open bottom, or if the system incorporated a perforated pipe below grade instead of daylighting runoff at the surface. A UIC permit may also be triggered because the facility is deeper than it is wide.

A filtration planter is also not considered a UIC, because by design, it doesn't infiltrate.

Cost

Planters will vary with size, site conditions and vegetation and are generally only used where sites are too constrained to build a rain garden. Due to piping requirements and waterproofing concerns against the buildings that they're often located next to, filtration planters are more costly than infiltration planters.

If the planter has no pretreatment, maintenance costs can vary with the choice of long-term erosion control, either compost mulch, rock mulch, or dense vegetation since the mulch option will probably be removed with the sediment and have to be replaced. Rock mulch has a more expensive up-front cost than compost mulch.

References and Resources

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