Stormwater Best Management Practices for Site Development

Many BMPs may be used in Lincoln City, but to function properly they must be matched with the characteristics of the site. The following fact sheets present applicability considerations, site constraints, and design guidance for the following BMPs:

1. Biofiltration swale
2. Dry well
3. Infiltration trench
4. Rain garden
5. Planter
6. Porous pavement
7. Stormwater wetland
8. Detention pond
9. Detention tank

The LID-type measures (the first six BMPs listed) should be used wherever site conditions permit. These BMPs most closely mimic natural processes, allowing infiltration and treatment of the runoff as it passes through the soil. In addition, the LID measures may reduce the amount of runoff enough to lessen downstream infrastructure needs, thereby reducing costs.

Simplified Procedures may be used for Biofiltration Swales, Rain Gardens, & Stormwater planters for sites less than 20,000 square feet of impervious area.

Biofiltration Swale

Biofiltration Swale at Clean Water Services Field Operations Building in Hillsboro, Oregon

Applicability

Biofiltration swales have many applications for residential development, commercial and industrial sites, and roads. Their long, linear features make them one of the few BMPs well-suited for roadway shoulders and edges of parking lots. Biofiltration swales are best at removing sediments and oil and grease.

Site Constraints

- The site must be large enough to accommodate the swale and allow maintenance access.
- Swales are not appropriate for sites with steep slopes, greater than 2 percent.
- Swales must be located at least 5 feet away from any property line.
- If proposed for areas with high groundwater tables, swales must be designed as wet biofiltration swales with appropriate design and plant types.

Design Guidance

Swales shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. The following design guidance applies:

- Use the Type 1A, 24-hour storm type.
- Design for the water quality design storm (2.1 inches).
- Swale shall be long enough to achieve a 9-minute hydraulic residence time, with a minimum of 100 feet in length.
- A Manning's *n* value of 0.2 shall be used.
- Maximum design flow depth is 3 inches.
- When selecting vegetation, consider the swale's exposure to sunlight. Many grasses require full sunlight and should not be used in swales shaded by surrounding trees, shrubs, or buildings. Other species, such as ferns, prefer shade. Consult the stormwater planting list (Appendix D) for vegetation recommendations to match the site exposure.
- Flow spreaders shall be placed in 50-foot intervals to maintain uniform flow across the swale section.

Geometry

The swale must conform to the following parameters:

- Minimum swale length: 100 feet from inlet
- Bottom width: 3 feet or greater
- Side slopes of 3 horizontal: 1 vertical (*4:1 with grass slope stabilization*) or flatter.
- Maximum longitudinal slope of 2 percent and minimum of 0.5 percent

Drywell

Guidance adapted from Portland (2008)

Commercial drywell Installation in Portland, OR

Applicability

Drywells manage stormwater from small drainage areas, including residential roofs and small parking areas. A drywell is typically a 4-foot diameter precast, perforated concrete ring installed vertically in 5-foot tall sections, below grade in permeable soils that allows for infiltration of stormwater through its perforated sides. Smaller, plastic "mini-drywells" are becoming more common for single family residential uses. Their small size, usually 2-foot diameter and 2-foot tall, allow them to be installed by hand. The drywell may be covered with grass, stone, sand, or plantings. The use of drywells is highly dependent on the soil type and depth to the groundwater table. Dry wells should be used only for flow reduction.

Note: The federal Underground Injection Control (UIC) Program considers drywells to be "Class V Injection Wells". Since the UIC Program states that these types of facilities can have a direct impact on groundwater, pollution reduction is required before discharging stormwater into them (unless they are used exclusively for residential roof runoff from three units or less).

Site Constraints

- Site soils must be adequately permeable to infiltrate runoff to groundwater. A minimum infiltration rate of 2 inches per hour is required at the facility base (see rain garden design guidelines for infiltration testing method). Installation of drywells in fill material is not permitted.
- Seasonal high groundwater elevation must be a minimum of 5 feet below the proposed base elevation of the drywell.
- Drywells are not allowed in the public right-of-way.
- Drywells must be at least 100 feet from the top of any slope 20 percent of greater, unless a geotechnical report is submitted and approved by the City.
- Drywells must be at least 5 feet from property lines and 10 feet from building foundations. The top of the drywell shall be located downgrade from foundations and at a lower elevation than local basements.
- Drywells must be at least 100 feet from any wells, and should be downgradient from septic drain fields.
- Drywells may not be constructed beneath an impervious surface, or a pervious surface subject to vehicle traffic.

Design Guidance

Drywells shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. The City has a spreadsheet that may be used for sizing purposes. The following design guidance applies:

- Use a Type 1A, 24-hour storm type.
- The drywell must be surrounded by 12 inches of gravel drain rock extending out from the outside of the drywell. The drain rock shall be washed ¾ - 2-1/2-inch round or crushed rock, and shall be separated from native soil and overlying backfill using filter fabric.

A water quality treatment facility must be constructed upstream of a drywell unless the drywell is used exclusively for residential roof runoff from three units or less. This treatment facility can be can be any of the BMPs approved for use in Lincoln City, including Biofiltration Swale, Rain garden, Planter, Stormwater Wetland, or a proprietary treatment device (Stormfilter, CDS MFS, or Filterra). See separate design guidelines for details on these BMPs, or contact Lincoln City for more information on proprietary treatment devices.

Infiltration Trench

Guidance adapted from Portland (2008)

Infiltration trench in Eugene

Applicability

Infiltration trenches can be used to provide stormwater discharge by collecting and recharging stormwater runoff into the ground. An infiltration trench is a shallow trench with perforated drainage pipe in permeable soil that is backfilled with washed drain rock and lined with filter fabric. The trench surface may be covered with grass, stone, sand, or plantings. Infiltration trenches should be used only for flow reduction, not water quality treatment.

Note: The federal Underground Injection Control (UIC) Program classifies infiltration trenches as "Class V Injection Wells". Since the UIC program states that these types of trenches can have a direct impact on groundwater, pollution reduction is required before discharging stormwater into them (unless they are used exclusively for residential roof runoff from three units or less).

Site Constraints

- Site soils must be suitably permeable to infiltrate runoff to groundwater. A minimum infiltration rate of 2 inches per hour is required at the facility base (see rain garden design guidelines for infiltration testing method).
- Seasonal high groundwater elevation must be at least 5 feet below the proposed base elevation of the infiltration trench.
- Infiltration trenches are not allowed in the right-of-way.
- Infiltration trenches must be at least 100 feet from the top of any slope 20 percent of greater, unless a geotechnical report is submitted and approved by the City.
- Infiltration trenches must be at least 5 feet from property lines and 10 feet from building foundations.
- Infiltration trenches must be at least 100 feet from any wells and downgradient from any septic drainfield.
- Infiltration trenches may not be constructed beneath an impervious surface, or a pervious surface subject to vehicle traffic.

Design Guidance

Infiltration trenches shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. The City has a spreadsheet that may be used for sizing purposes. The following design guidance applies:

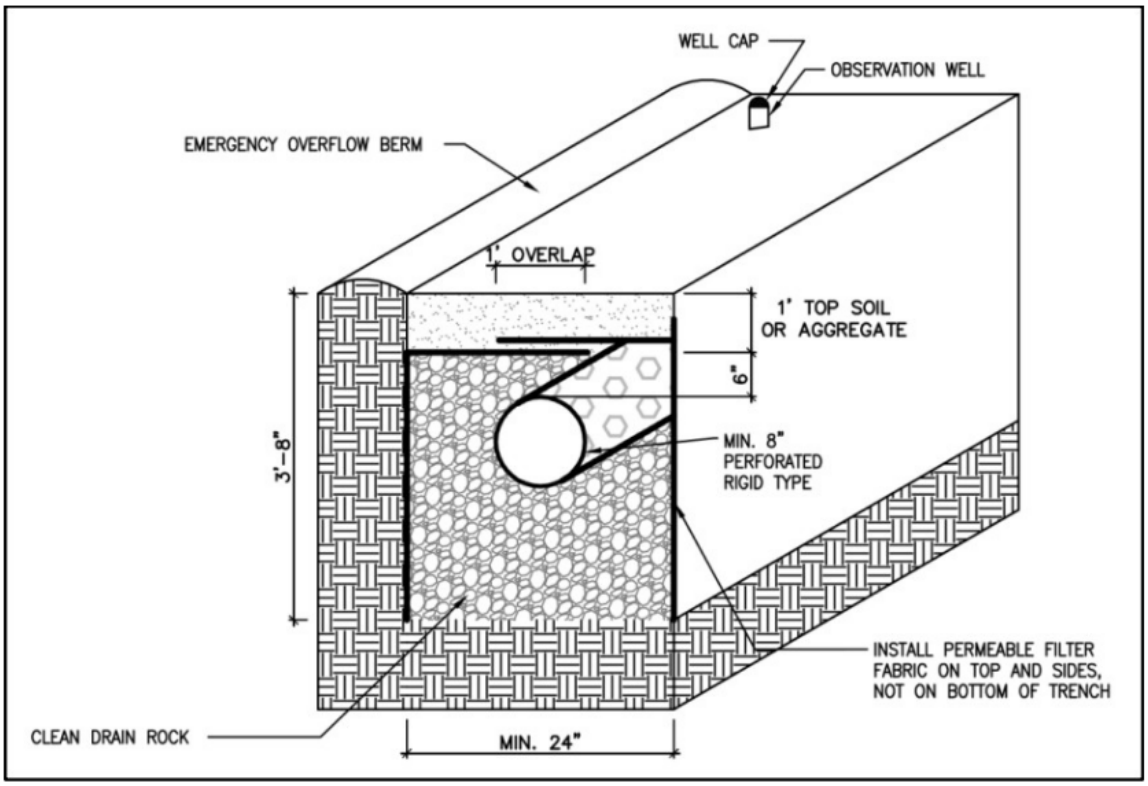
- Use a Type 1A, 24-hour storm type.
- Infiltration trench should infiltrate 90 percent of the runoff from an average annual storm event.
- Minimum drawdown time of 10 hours.
- Gravel drain rock shall be washed 3/4 - 2-1/2-inch round or crushed rock, and shall be separated from native soil and overlying backfill using filter fabric.
- A perforated pipe (PVC D2729 or HDPE leach field pipe) shall be installed on top of the gravel bed and covered with filter fabric.

A water quality treatment facility must be constructed upstream of an infiltration trench, unless it is used exclusively for residential roof runoff from three units or less. This treatment facility can be can be any of the BMPs approved for use in Lincoln City, including Biofiltration Swale, Rain garden, Planter, Stormwater Wetland, or a proprietary treatment device. See separate design guidelines for details on these BMPs, or contact Lincoln City for more information on proprietary treatment devices.

Geometry

The infiltration trench must conform to the following parameters:

- Depth of gravel bed below perforated pipe: 18 inches minimum.
- Depth of backfill over perforated pipe: 12 inches minimum.
- Trench width: 2.5 feet minimum.
- Trench length: Based on site soils/infiltration rates & drawdown time of 30hr
  Est. 3.0 CF / LF storage
-



Source and credits: Clark County, Community Development, modified from Stormwater Manual from Department of Ecology (2014 SWMMWW)

Rain Garden

Residential rain garden in Seattle, Washington

Design guidance adapted from the Oregon Rain Garden Guide.

Applicability

Rain gardens (also called bioretention) are shallow, landscaped depressions used to collect and infiltrate stormwater runoff. In areas with good infiltration, they are suitable for treating for sediment, dissolved metals, and decreasing flows.

Rain Gardens design may us a simplified sizing method, on sites less than 15,000 square feet of impervious, for water quality and flow control. A 0.06 sizing factor can be used for water quality and a 0.15 factor used for flow control/detention if using this approach.

Overflow to an approved location must be provided when using the simplified approach.

Site Constraints

- The site must be large enough to accommodate the rain garden and allow maintenance access.
- The site must have an infiltration rate of at least 1/2 inches per hour, or designed as a flow-through facility with an approved outlet point.
- Rain gardens are not appropriate where a seasonal groundwater table is within 3 feet of the bottom of the rain garden (4 to 5 feet below ground surface).
- Rain gardens must be located at least 5 feet away from property lines and at least 10 feet from building foundations.
- Rain gardens must be at least 50 feet from a septic system.
- Rain gardens must be at least 100 feet from the top of any slope exceeding 10 percent. Add an addition 5 feet of setback for each additional percent of slope, up to 30 percent.
- Rain gardens are not appropriate for sites that stay wet throughout the rainy season.

Design Guidance

- If the rain garden is to provide flow control and water quality treatment, it shall be sized to have a surface area of at least 15 percent of the impervious surface draining to it; A smaller facility may be proposed if calculations are provided demonstrating that the rain garden has adequate capacity for the 25-year, 24-hour design storm.
- Provide energy dissipation at the inflow and surface outflow in the form of rocks and gravel.
- Apply mulch or compost at a depth of 2 to 3 inches across the rain garden. Fine grade double-shredded conifer bark mulch (bark dust) is one option for mulch material, although alternative materials are acceptable.
- A safe overflow route that does not drain onto neighbors' properties shall be provided in the event of overflow.
- When selecting vegetation, consider the rain garden's exposure to sunlight. Many grasses require full sunlight and should not be used in swales shaded by surrounding trees, shrubs, or buildings. Other species, such as ferns, prefer shade. Consult the stormwater planting list in Appendix D for vegetation recommendations.
- If drain rock is installed at the base of the facility, it shall be 1½ inch to ¾ inch washed pea gravel. Gravel shall be separated from growing medium by approved filter fabric.
- Growing medium shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be approximately 1/3 compost derived from plant material. No animal waste is permitted.

- See the Oregon Rain Garden Guide for additional design, construction and maintenance guidance.

Infiltration Testing

Adapted from: The Oregon Rain Garden Guide (Stormwater Solutions 2009).

Infiltration test shall be conducted when soils are not frozen and when groundwater levels are near their highest, such as in the spring.

- Dig a test hole at the proposed facility location. Dig a hole to the expected facility depth.

- Fill the hole with water to just below the rim. This should be the same depth of water expected if the facility is filled to its design depth. Record the exact time you stop filling the hole and calculate the time required to drain completely.

- Refill the hole again and repeat Step 2 two more times. The third test will give the best measure of how quickly your soil absorbs water when it is fully saturated, as it would be during a rainy period of the year or during a series of storms.

- Divide the distance that the water dropped by the amount of time it took for it to drop. For example if the water dropped 6 inches in 12 hours, then the infiltration rate is 6/12 = 1/2 inch per hour. If the slowest infiltration rate measured of the 3 trials is less than 1/2 inch per hour, then dig another 3 to 6 inches deeper and repeat the above steps. Repeat if necessary. **If infiltration rates are less than ½ inch per hour, a rain garden is not appropriate without design modification. Consult a licensed engineer or landscape professional.**

Geometry

The rain garden must conform to the following parameters:

- Rain gardens shall have a ponding depth of between 6 and 24 inches. If the infiltration rate is less than 1 inch per hour, a minimum ponding depth of 12 inches shall be provided.

- Minimum bottom width is 2 feet.

- Maximum side slopes of 3H:1V.

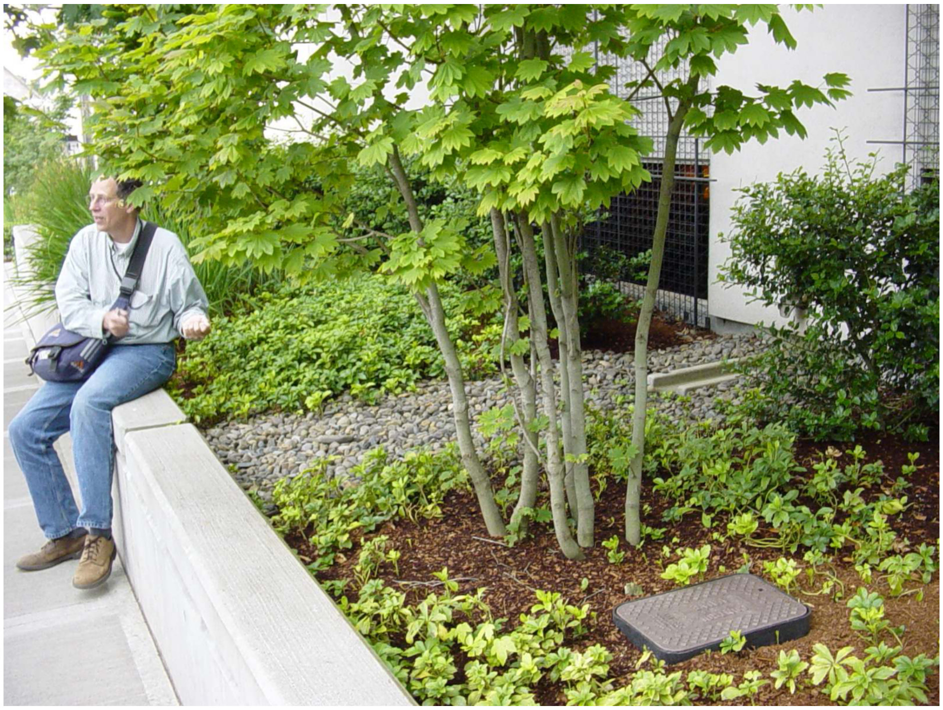
- 2-4 inches of freeboard (distance between highest water surface elevation and overtopping elevation) shall be provided above the ponding depth.

- Flowline slope of 0.5% maximum

- Growing medium shall be 18 inches deep.

- Side slopes shall be 3 horizontal: 1 vertical maximum.

Planter



Planter box in Portland, Oregon

Applicability

Planters are similar to rain gardens in many respects, except the filtration media is confined within a planter and there is often an underdrain present. As a result, planters are generally better suited for highly urbanized properties than are rain gardens. Planters are often used to capture runoff from rooftops or sidewalks. Planters are suitable for treating for sediment, dissolved metals, and decreasing flows.

Stormwater Planter design may us a simplified sizing method, on sites less than 15,000 square feet of impervious, for water quality and flow control. A 0.03 sizing factor can be used for water quality and a 0.10 factor used for flow control/detention if using this approach.

Overflow to an approved location must be provided when using the simplified approach.

Site Constraints

- Infiltration planters must have a 10-foot setback from building foundations and a 5-foot setback from property lines. Flow-through planters do not have required setbacks. They can be located next to foundations or property lines.

- The site must have an infiltration rate of at least 1/2 inches per hour, or designed as a flow-through facility with an approved outlet point (see rain garden design guidelines for infiltration testing method).

- An infiltration planter is not appropriate where a seasonal groundwater table is within 3 feet of the bottom of the rain garden (4 to 5 feet below ground surface).

- Infiltration planters must be at least 50 feet from a septic system.

- Infiltration planters must be at least 100 feet from the top of any slope exceeding 10 percent. Add an additional 5 feet of setback for each additional percent of slope, up to 30 percent.

- The planter itself must be located on a flat area that does not slope more than 0.5 percent in any direction.

Design Guidance

- If the planter is to provide flow control and water quality treatment, it shall be sized to have a surface area of at least 10 percent of the impervious surface draining to it; A smaller facility may be proposed if calculations are provided demonstrating that the planter has adequate capacity for the 25-year, 24-hour design storm.

- Minimum infiltration planter width shall be 30 inches. The minimum flow-through planter width shall be 18 inches.

- Planter walls shall be made of concrete, stone, brick, or other durable material. Materials such as treated wood that leach out toxic chemicals shall not be used because they can contaminate stormwater.

- Flow-through planters require a waterproof liner of 30 mil PVC or equivalent.

- Planters shall have a ponding depth of between 6 and 24 inches. If the infiltration rate is less than 2 inch per hour, a minimum ponding depth of 12 inches shall be provided. (Serious consideration should be given to using a flow-through planter if infiltration rates are less than 1 inch/hour.)

- Provide energy dissipation at the inflow and surface outflow in the form of rocks and gravel, as shown in the photo.

- Washed pea gravel is recommended for covering the planting mix to a depth of 2-3 inches. Mulch has shown a tendency to wash away if flows are not completely dissipated.

- The filtration/growing media shall be at least 18 inches in depth, consisting of sandy loam mixed with 1/3 compost by volume. The compost shall be derived from plant materials and containing no animal waste.

- A safe overflow route that does not drain onto neighbors' properties shall be provided in the event of overflow for both infiltration and flow-through planters.

- When selecting vegetation, consider the planter's exposure to sunlight. Most grasses require full sunlight and should not be used in planters shaded by surrounding trees, shrubs, or buildings where most planters are located. Other species, such as ferns, prefer shade and may be more suitable. Consult the stormwater planting list in Appendix D for vegetation recommendations.

- If drain rock is installed at the base of the facility, it shall be 1½ inch to ¾ inch washed drain rock. Drain rock shall be separated from growing medium by approved filter fabric.

- Growing medium shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be approximately 1/3 compost derived from plant material. No animal waste is permitted.

Infiltration Testing

Adapted from: The Oregon Rain Garden Guide (Stormwater Solutions 2009).

Infiltration test shall be conducted when soils are not frozen and when groundwater levels are near their highest, such as in the spring.

- Dig a test hole at the proposed facility location. Dig a hole to the expected facility depth.

- Fill the hole with water to just below the rim. This should be the same depth of water expected if the facility is filled to its design depth. Record the exact time you stop filling the hole and calculate the time required to drain completely.

- Refill the hole again and repeat Step 2 two more times. The third test will give the best measure of how quickly your soil absorbs water when it is fully saturated, as it would be during a rainy period of the year or during a series of storms.

- Divide the distance that the water dropped by the amount of time it took for it to drop. For example if the water dropped 6 inches in 12 hours, then the infiltration rate is 6/12 = 1/2 inch per hour. If the slowest infiltration rate measured of the 3 trials is less than 1/2 inch per hour, then dig another 3 to 6 inches deeper and repeat the above steps. Repeat if necessary. **If infiltration rates are less than ½ inch per hour, a rain garden is not appropriate without design modification. Consult a licensed engineer or landscape professional.**

Geometry

The stormwater planter must conform to the following parameters:

- Minimum bottom width is 30 inches for infiltration planter, 18 inches for flow-through.

- 2-4 inches of freeboard (distance between highest water surface elevation and overtopping elevation) shall be provided above the ponding depth.

- Growing medium shall be 18 inches deep.

- Flow line slope shall be no greater than .5%. Planters requiring greater elevation change shall have ponding elevations divided by check dams or similar terracing.

Porous pavement

Guidance adapted from Portland (2008)

Permeable pavers in Newport, Oregon

Pervious concrete in Hillsboro, Oregon

Applicability

Pervious asphalt, pervious concrete, and permeable pavers can be used in practically all pedestrian areas, and residential driveways and commercial parking lots.

Pervious pavement

Pervious concrete and pervious asphalt are similar to conventional asphalt and concrete in structure and form and are poured in place. Pervious asphalt consists of an open-graded coarse aggregate from which the fines have been removed to create greater void space than traditional asphalt mixes. The Oregon Department of Transportation (ODOT) has approved a pervious asphalt mix for its uses on numerous public highways and freeways, referred to as its open-graded ½-inch or ¾-inch asphalt mix design. Another common asphalt mix is the 3/8-inch mix. This mix cannot be used on roadways because the long-term perviousness is not clear. Refer to the ODOT 2008 Standard Specifications 00745 for more about open-graded mixes.

Pervious concrete is a structural, open-textured concrete paving surface consisting of standard Portland cement, fly ash, locally available open-graded coarse aggregate, admixtures, fibers, and potable water. When properly handled and installed, porous concrete has a high percentage of void space (approximately 17 - 22 percent). The top lifts are thicker than traditional pavements to provide the required stability.

Permeable pavers

Permeable pavers consist of discrete blocks/pavers set in place, with annular spaces filled with sand or fine gravel rather than grout or concrete. This allows rainfall to infiltrate through the spaces between pavers to the soil below. There are many types of permeable pavers on the market today. Many manufacturers make specific pavers for pervious applications, while others make pavers that are not designed to accommodate infiltration. Brand names and specifications shall be supplied with permit applications.

Site Constraints

- Porous pavement shall not be constructed over fill soils.
- If tested infiltration rate is less than 2 inches per hour, the pavement must sheet-flow to an adequately sized filter strip.
- There are no required setbacks, but impermeable lines between base rock and adjacent foundations are highly recommended.
- Porous pavement is not allowed if slopes are 10 percent or greater. If slopes are between 5 and 10 percent, under pavement water retention must be provided.

Design Guidance

Porous pavement receives and infiltrates rainfall that falls directly on it. No flows from surrounding areas shall be allowed to drain onto porous pavement. Figure PP-1 shows typical porous pavement cross-sections. The following design guidance applies:

- The porous pavement section must be designed to directly infiltrate all stormwater from the surface into a crushed rock storage layer, which must contain enough void space to store the 10-year, 24-hour storm less the designed infiltration rate. The stormwater must infiltrate into the subgrade in less than 30 hours.
- The most common reason for porous pavement failure is improper installation. Installation should be done by crews with previous experience with the system being installed.
- The area to be paved should be leveled and lightly compacted with a plate compactor to include a slight grade away from foundations. Compaction of the subgrade soil is required for public roadways, private streets, parking lots, and fire lanes to ensure adequate structural stability and minimize rutting. Compaction should be to 95 percent for public roadways. Compaction will reduce the permeability of the soils and should therefore be done with caution and scarified prior to setting the aggregate base. The subgrade shall not be subject to truck traffic.
- For all streets, the pavement design must be prepared by a registered professional engineer.
- Geotextile is required between subgrade (native soil) and aggregate base (gravel layer).
- A 6-inch minimum of washed crushed 2-inch – ¾-inch or No. 57 rock is required for the aggregate base.
- 1 inch of clean washed coarse filter grade sand (ASTM No. 8 or 9) should be used for bedding sand. “Landscapers” or “playground” sand should not be used because it includes too many fines.

- Edge restraints for pavers are required to be permanent (cast-in-place or pre-cast concrete curbs) and a minimum of 6 inches wide and 12 inches deep for private streets, public roadways, and commercial pavements. Residential restraints may be plastic, set with spikes. The restraints prevent the paver blocks from being displaced from traffic, opening gaps in the surface of the pavement.

- Top lift depth requirements depend on the application (See Table PP-1). Asphalt and concrete must have at least 15 percent air voids in the completed top lift. Concrete must be 2400-2500 psi in 28 days.

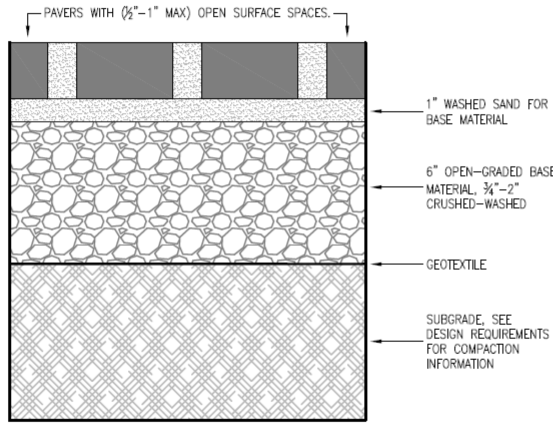
- The design should include methods to protect the subgrade from over-compaction during construction activities.

Table PP-1: Requirements for Top Lift Depth, Engineering, and Compaction

	Concrete (inches)	Asphalt (inches)	Pavers (inches)	Engineering Required?	Compaction Required?
Residential Driveway or Pedestrian Only	4	2.5	2-3/8	No	No
Private Street, Parking Lot, or Fire Lane	4	3	3-1/8	Yes	Yes
Public Street	7	6	3-1/8	Yes	95%

Maintenance

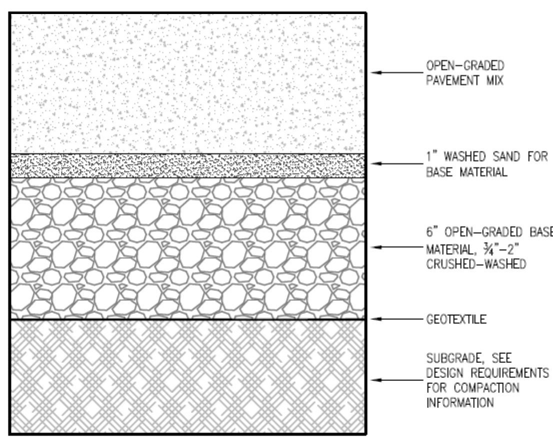
Pervious asphalt or concrete should be vacuumed at least once per year with a vac truck to remove fine particulates from the infiltration spaces. Some settling of permeable pavers may occur over time, which may require additional aggregate base, washed sand, or pavement replacement. Permeable pavers may be replaced by sections as needed.



PERMEABLE CONCRETE BLOCK OR "PAVER" SYSTEMS

	RESIDENTIAL DRIVEWAY OR PEDESTRIAN ONLY	PRIVATE STREET, PARKING LOT, OR FIRE LANE	PUBLIC STREET
CONCRETE	4"	4"	7"
ASPHALT	2 ½"	3"	6"
PAVERS	2 ⅜"	3 ⅛"	3 ⅛"
ENGINEERING REQ'D	NO	YES	YES
COMPACTION REQ'D	NO	YES	95%

EXHIBIT 2-8
PERVIOUS PAVEMENT REQUIREMENTS FOR TOP LIFT DEPTH, ENGINEERING, AND COMPACTION.



PERVIOUS (OPEN GRADED) CONCRETE AND ASPHALT SYSTEMS

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Simplified / Presumptive / Performance Design Approach -

Pervious Pavement

Bureau of Environmental Services

NUMBER

SW-110

Figure PP-1: Porous Pavement Schematic from Portland Stormwater Manual (2008)

Stormwater Wetland

Guidance adapted from Ecology (2005)

Constructed stormwater wetland in Olympia, Washington

Applicability

Stormwater wetlands are shallow, man-made ponds designed to treat stormwater by binding pollutants to their rich organic soils. Stormwater wetlands are especially well-suited for removing metals from stormwater. However, pollutants accumulated in the sediment can pose risks to aquatic life. Wetlands constructed to mitigate disturbance impacts to natural wetlands may not be used for stormwater treatment.

Site Constraints

- The site must be large enough to accommodate the stormwater wetland, adequate setbacks, and maintenance access.
- Stormwater wetlands must be at least 20 feet from all structures and property lines, unless the adjacent landowner provides adequate easement.
- Stormwater wetlands must be at least 100 feet from a septic tank distribution box or septic tank distribution field.
- Stormwater wetlands must be at least 200 feet from the top of any slope exceeding 15 percent, unless a geotechnical report is submitted and approved by the City.
- Stormwater wetlands must be at least 100 feet from any wells.
- The most critical factor for a successful stormwater wetland design is an adequate supply of water for most of the year. Careful planning is needed to ensure sufficient water will be retained to sustain good wetland plant growth. Since water depths are typically shallow, water loss by

evaporation is an important concern. Stormwater wetlands are a good option for water quality treatment in areas with high groundwater tables.

- Maximum side slopes of 3(horizontal):1(vertical), unless fenced.

- Stormwater wetlands are not recommended for infiltrative soils (Type A and B). If a stormwater wetland is proposed in a location with infiltrative soils, a liner (such as bentonite clay) is required.

Design Guidance

Stormwater wetlands shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. Lincoln City has a spreadsheet that may be used for sizing purposes. The following design guidance applies:

- Use the Type 1A, 24-hour storm type

- Total volume is volume associated with the water quality design storm. This volume is stored above the permanent wet pool.

- Planting design for stormwater wetlands is critical to ensure effective treatment and a healthy plant community. A landscape architect or designer, botanist, wetland specialist, or other professional shall be responsible for planting design for the stormwater wetland. The Lincoln City plant lists developed for other BMPs may be consulted (Appendix D), but additional plants may be necessary to provide a healthy, self-sustaining plant community and potentially provide habitat value.

- The inlet pipe shall be submerged 1 foot below water quality design surface.

- A water balance must be provided to the City to confirm that the following criteria will be met, based on average precipitation, evapotranspiration, and infiltration rates:

- The wetland cell must retain water for at least 10 months of the year.

- The presettling cell must retain at least three feet of water year-round.

- An outlet structure shall be provided. See Detention Pond, Figure D-2.

Geometry

The stormwater wetland must conform to the following parameters:

Wetland shall have 2 cells, a presettling cell and a wetland cell, with a berm separating the two cells. The presettling cell removes coarse sediments to avoid their buildup in the wetland cell. The volume and depth distribution of the cells shall conform to the following parameters:

Presettling Cell

- Shall contain approximately 1/3 of the water quality design storm volume.
- Depth shall be between 4 feet and 8 feet, excluding sediment storage.
- One-foot of sediment storage shall be provided in the presettling cell.

Wetland Cell

Shall have an average water depth of about 1.5 feet (plus or minus 3 inches).

Berm

The top of the berm shall be either at the water quality design water surface or submerged 1-foot below the water quality design water surface. If the top of berm is at the water quality design water surface, the berm side slopes shall be no steeper than 3(horizontal):1(vertical). If the top of berm is submerged 1-foot, the upstream side slope may be up to 2(horizontal):1(vertical).

Operation and Maintenance

Wetlands should be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe the following:

- Plant species presence, abundance, and condition.
- Bottom contours and water depths relative to plans.
- Sediment, outlet, and buffer conditions.
- Plants may require watering, physical support, mulching, weed removal, or replanting during the first three years.
- Nuisance plant species should be removed, and desirable species should be replanted.
- Vegetation must occasionally be harvested and sediment dredged in stormwater treatment wetlands, which may interfere with use as wildlife habitat.

Detention Pond

Combination Wet/Detention pond adjacent to Kuebler Boulevard in Salem, Oregon.

Applicability

Detention ponds are appropriate for residential developments, commercial and industrial sites, and roads. Detention ponds are basins that store water during storms to reduce peak flows. Unless designed to be a combination wet/detention pond, detention ponds drain completely between storms (except for sediment storage) and do not provide any significant water quality treatment. If treatment is required, a permanent wet pool below the detention storage depth is needed or another BMP may be used in combination with a pond. A pond with a permanent pool of water is effective at removing sediments, nutrients, and metals.

Site Constraints

- The site must be large enough to accommodate the pond, adequate setbacks, and maintenance access.
- Ponds must be at least 20 feet from all structures and property lines, unless the adjacent landowner provides adequate easement.
- Ponds must be at least 100 feet from a septic tank distribution box or septic tank distribution field.
- Ponds must be at least 200 feet from the top of any slope exceeding 15 percent, unless geotechnical report is submitted and approved by the City.
- Ponds must be at least 100 feet from any wells.

- If proposed for areas with high groundwater tables, ponds must be lined or designed as a combination wet/detention pond.

Design Guidance

Detention ponds shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. Lincoln City has a spreadsheet that may be used for calculating peak flows and volumes. A professional engineer will need to design the flow control structure to ensure that orifice sizing meets flow control design standards. The following design guidance applies:

- Use a Type 1A, 24-hour storm type.
- Pond may be designed with permanent pool to provide water quality treatment in addition to flow control.
- Pond shall be designed to provide flow control such that peak flows from the post-development 2-year, 10-year, and 25-year storms match peak flows from the corresponding pre-development storms.
- Minimum freeboard (distance from top of riser or overflow to top of pond) distance of 1 foot.
- Primary outlet works shall be a flow control structure designed in accordance with ODOT standard detail 1308 or equivalent (Figure 2).
- Pond shall have an emergency overflow spillway (auxiliary outlet).
- Overflow shall accommodate 25-year storm. Lincoln City may require that a more restrictive design storm be used depending on pond location.
- Ponds shall be vegetated according to plant guidance (See Appendix D).
- Protective fences are required for any ponds with the following conditions:
- Areas where small children are present.
- Water depth exceeds 3 feet for more than 24 hours.
- Side slopes are steeper than 1V:3H.

Geometry

The pond must conform to the following parameters:

- The pond shall have a minimum bottom grade of 1 percent, sloped towards the outlet.

- Pond embankments shall have a maximum slope of 1V:3H, a maximum height of 10 feet, and must be vegetated unless a geotechnical stability report is submitted and approved by the City.

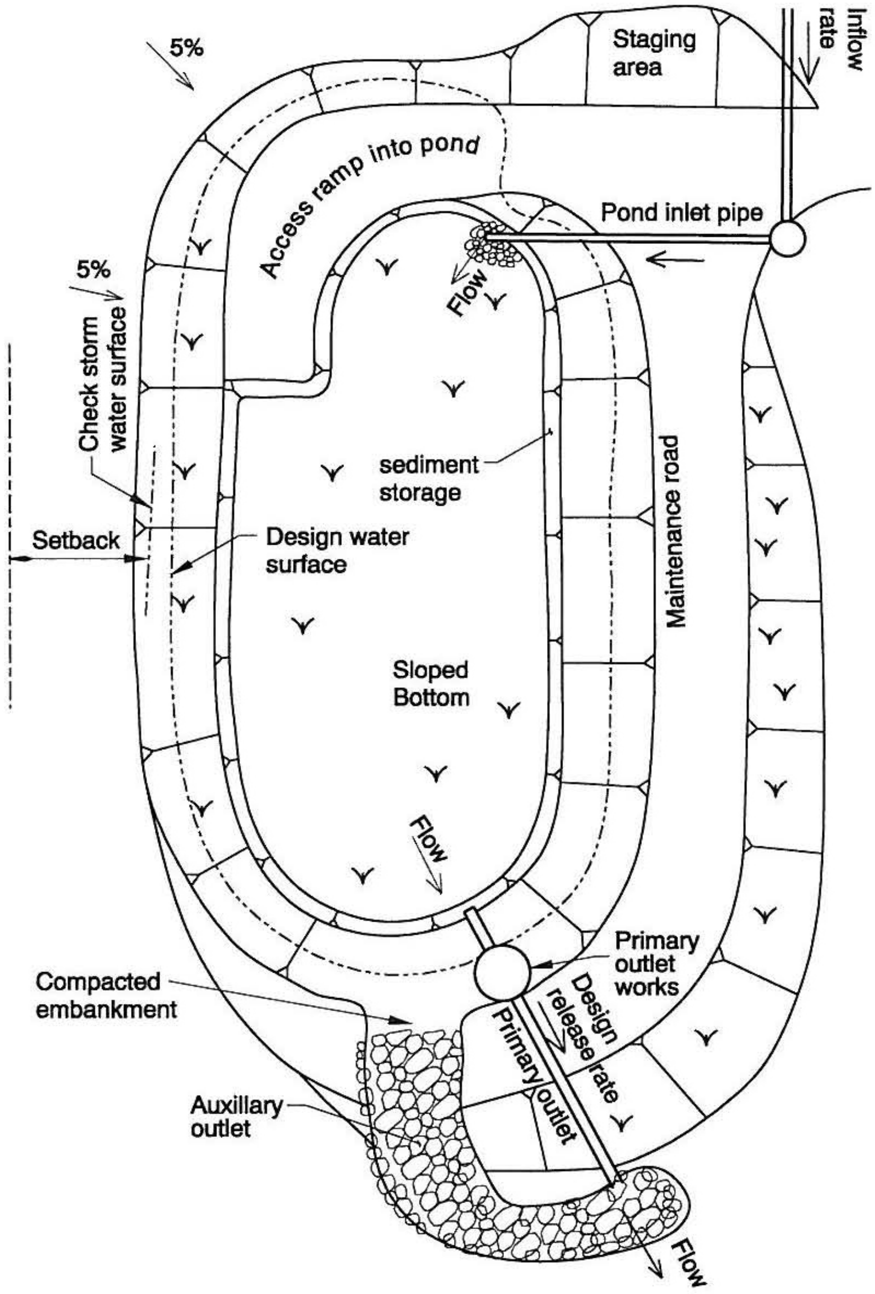
- Minimum bottom width is 10 ft.

- Minimum length to width ratio of 3:1.

Details

- See Figure D-1 for a plan view of a typical detention pond (source: ODOT Hydraulics Manual).

- See Figure D-2 for an ODOT flow control manhole (source: ODOT Detail 1308).



NOTE:
This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

Figure D-1: Detention pond (Source: ODOT Hydraulics Manual)

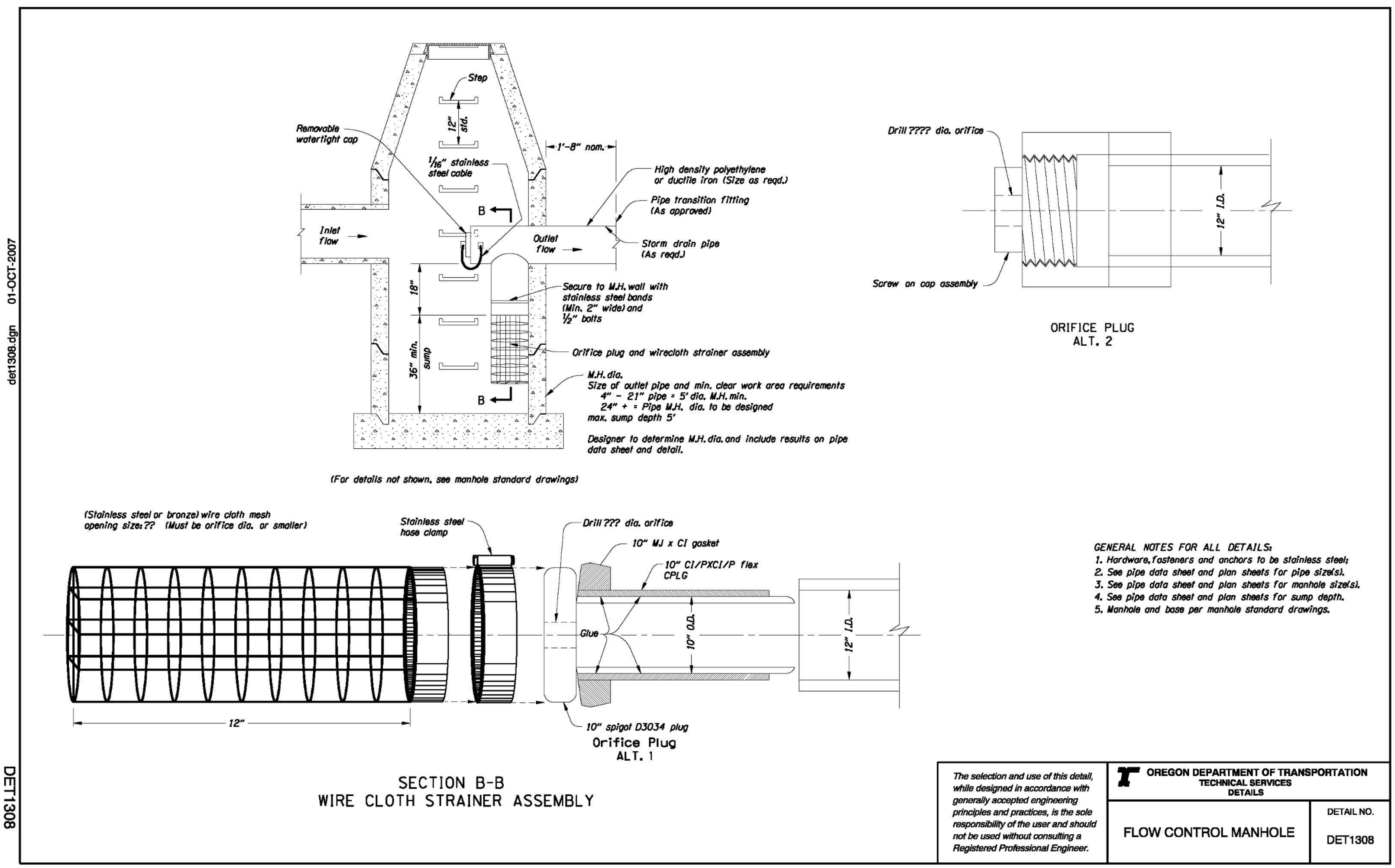


Figure D-2: Flow control manhole (Source: ODOT standard details)

Detention Tank

Applicability

Detention tanks are appropriate for residential developments, commercial and industrial sites, and roads, where there is insufficient space for a detention pond and soils or site constraints prohibit infiltration for flow control. Detention tanks are large underground storage facilities that are typically constructed of large-diameter corrugated metal pipe (CMP) or an alternate material. Except for a small amount of sediment storage, detention tanks drain completely between storms and do not provide any significant water quality treatment.

Site Constraints

- The site must allow for maintenance access.
- If proposed for areas with high groundwater tables, detention tanks must be designed to balance buoyancy forces by ballasting with backfill or concrete backfill. A professional engineer must provide calculations demonstrating that the detention tank will not be buoyant when empty.
- If a detention tank is proposed for a site where soils consist of fill materials, a geotechnical report confirming stability and constructability of the proposed tank is required.

Design Guidance

Detention tanks shall be designed using the Santa Barbara Urban Hydrograph (SBUH) method, and calculations must be submitted to the City for review. Lincoln City has a spreadsheet that may be used for calculating peak flows and volumes. A professional engineer will need to design the flow control structure to ensure that orifice sizing meets flow control design standards. The following design guidance applies:

- Use a Type 1A, 24-hour storm type.
- See ODOT Hydraulics Manual, Section 12.5.3, for complete design guidance.
- Detention tank may be designed as "flow-through" or "backup" systems – see Figure 1.
- Minimum freeboard (vertical distance between design headwater elevation and auxiliary outlet rim – see Figure 1) of 6 inches. Minimum "check storm" freeboard from 100-year design storm elevation to top of tank is 6 inches – see Figure 1.
- Tank shall be designed to provide flow control such that peak flows from the post-development 2-year, 10-year, and 25-year storms match peak flows from the corresponding pre-development storms.
- Primary outlet works shall be a flow control structure designed in accordance with ODOT standard detail 1308 or equivalent (see Figure 2 of detention pond design guidance).

- Tank shall have a vented access cover or other design measures shall provide venting to avoid pressure or vacuum as the surface water in the tanks fluctuates.

- Pre-treatment for sediment is required. At a minimum, a sump manhole shall be provided upstream of inlet.

- 6 inches of sediment storage is required.

Geometry

The pond must conform to the following parameters:

- The tank bottom shall be flat or gently sloped.

- The detention volume shall be calculated as the storage volume available above the outlet invert elevation and below the design water surface. If a sloped tank is used, the lost volume due to the difference in elevation between the higher invert elevation at the upstream end of the tank shall be considered in calculating the volume.

- Minimum tank diameter is 36 inches. If tank consists of pipe larger than 36-inch diameter, sections of tank may be connected by short (24-inch maximum lengths) of 36-inch diameter pipe.

Details

- See Figure D-3 for a plan view of a typical detention tank (source: ODOT Hydraulics Manual).

- See Figure D-2 of detention pond design guidance for an ODOT flow control manhole (source: ODOT Detail 1308).

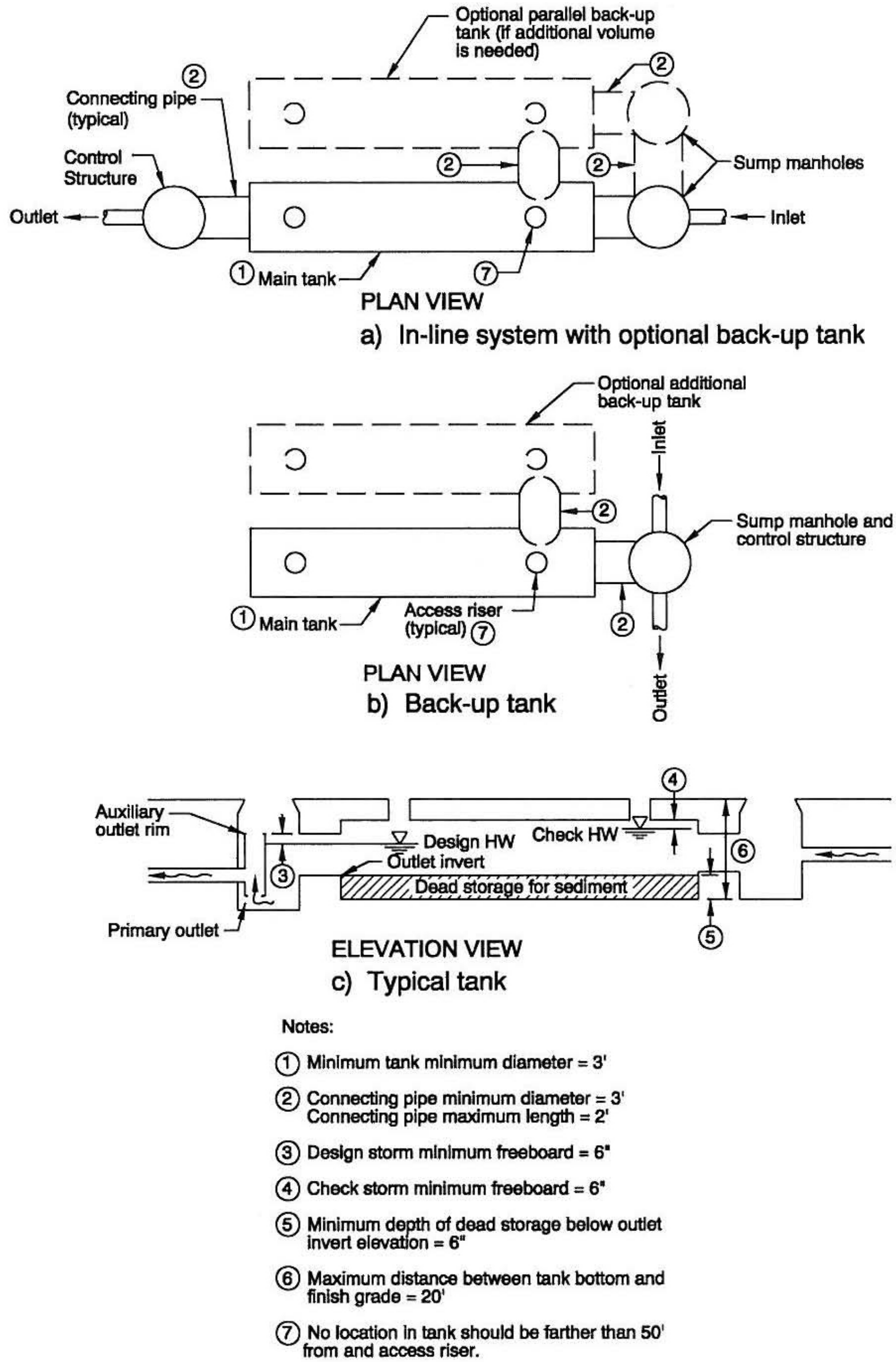


Figure D-3: Detention tank (Source: ODOT Hydraulics Manual)

Plant List

Successful planting is one of the keys to ensuring that stormwater BMPs work when they are first constructed and into the future. Plants are highly adapted to specific ecological conditions, such as temperature, the amount of sunlight, and the amount of soil moisture. Many species that thrive in Washington may wither in Oregon. Plants native to the Willamette Valley may not be suitable for the Oregon Coast. A list of plants adapted for stormwater facilities in the Lincoln City area was developed as part of this stormwater master plan and is included in this appendix.

Figure D-4 shows a cross-section of a rain garden or biofiltration swale, indicating the ecological planting zones, which are explained below. Figure D-5 shows a similar cross-section for a stormwater pond. These figures and explanations should be used in conjunction with the Lincoln City-specific planting lists at the end of this appendix to select appropriate species for stormwater facilities within the city.

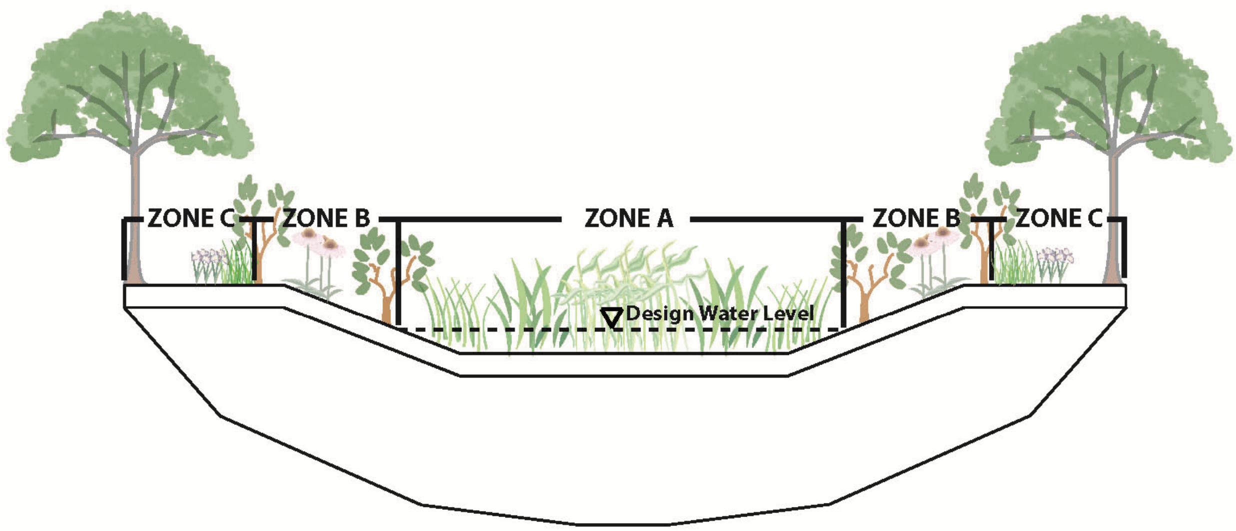


Figure D-4: Rain Garden or Biofiltration Swale Cross-Section

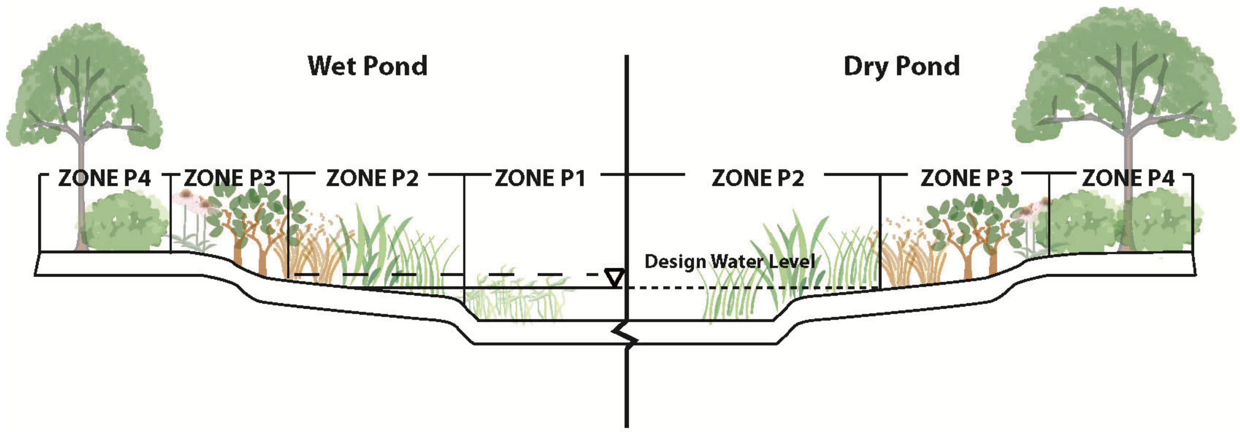


Figure D-5: Wet and Dry Pond Cross-Sections

Stormwater BMP Zones

Zone A

This is the basin of a stormwater facility, where soil remains wet or moist longest. These areas may be wet anywhere between 1 and 3 days after a storm event, but soils will dry out between storms. Plants in this area must be able to tolerate water levels to the designed water level.

Zone B

This is the area of the facility defined as the side slopes from the defined high water mark up to the top edge of the facility. The soils are typically drier, with more moist soils located further down the side slopes. Plants located in this area need to stabilize facility slopes and tolerate moist to dry conditions.

Zone C

This is the dry/upland area of the facility. Plants in this area need to tolerate dry conditions.

Pond Zones

Zone P1: This is the area of a pond where submerged vegetation grows in 2 to 6 feet of standing water. Submerged species may float free in the water column or may root in the pool bottom and have stems and leaves that generally stay under water.

Zone P2: This is the emergent to wet area of the pond, where plants grow in 0 to 18 inches of water. Emergent zones are often designed as benches within ponds to optimize the area plants can inhabit.

Zone P3: This area experiences water level fluctuations so that soil can be moist at times and seasonally dry at others. Plants that survive in this area must be tolerant of varying soil moisture conditions.

Zone P4: This zone is considered the dry/upland zone, where plants are seldom or never inundated.

Other Notes

O.C. Spacing: On Center Spacing describes the distance the center of one plant should be spaced from the center of the next plant.

Plant Name		Proposed Facility Type								Characteristics		
Latin Name/ Common Name	**Zone**	**Biofiltration Swale**	**Planter**	**Rain Garden**	**Filter Strip**	**Wet Pond**		**Dry Pond**		**Potential Height**	**Sun and Shade Preference**	**O.C. Spacing**
						Saturated Soils	**Emergent to Wet Soils**	**Moist to Dry Soils**	**Dry/ Upland Soils**			
Herbaceous Plants												
Alisma plantago-aquatica / Great water plantain	P3							X			Full sun	
Athyrium felix-femina/ Lady Fern	B/C	X		X	X					3'	Full to part sun	24"
Azolla mexicana/ Water fern	P1/P2					X	X				Part sun	
Blechnum spicant/ Deer fern	B/C	X		X						24"	Part sun to full shade	24"
Brasenia schreberi/ Watershield	P1/P2					X	X				Full to part sun	
Bromus carinatus/ California Brome	A			X						18"	Full sun	12"
Bromus sitchensis/ Alaska Grass	A			X						18"	Full sun	12"
Bromus vulgaris/ Columbia brome	A			X						18"	Full sun to full shade	12"
Camassia quamash/ Common camas	A/B/C P4	X	X	X					X	24"	Full to part sun	12"
Carex deweyana/ Dewey sedge	A	X	X	X						3'	Full to part sun	12"
Carex densa/ Dense sedge	A	X	X	X						24"	Full sun	12"
Carex obnupta/ Slough sedge	A	X	X	X						4'	Full to part sun	12"
Carex vesicaria/ Inflated sedge	A/ P2/ P3	X	X	X			X	X		3'	Full to part sun	12"
Ceratophyllum demersum/ Coontail	P1					X					Full to part sun	
Deschampsia cespitosa/ Tufted hair grass	A/B/C	X	X	X	X					3'	Full sun	12"
Dodecatheon jeffreyi/ Jeffrey's shootingstar	P2/P3						X	X		12"	Full to part sun	6"
Eleocharis ovata/ Needle spike rush	A	X	X	X						30"	Full sun	12"

Plant list (continued)

Plant Name		Proposed Facility Type								Characteristics		
Latin Name/ Common Name	**Zone**	**Biofiltration Swale**	**Planter**	**Rain Garden**	**Filter Strip**	**Wet Pond**		**Dry Pond**		**Potential Height**	**Sun and Shade Preference**	**O.C. Spacing**
						Saturated Soils	**Emergent to Wet Soils**	**Moist to Dry Soils**	**Dry/ Upland Soils**			
Eleocharis palustis/ Creeping spike rush	A			X						30”	Full sun	12”
Elodea canadensis/ Elodea						X					Full sun	
Elymus glaucus/ Blue wild rye	B/C	X		X	X					24”	Full sun	12”
Festuca occidentalis/ Western fescue grass	A	X		X	X					24”	Full sun to full shade	12”
Festuca rubra/ Red fescue	B/C	X		X	X					24”	Full sun to full shade	12”
Fragaria chiloensis/ Coastal strawberry	B/C	X		X			X		X	6”	Full sun to full shade	12”
Iris douglasiana/ Douglas iris	B/C	X		X						18”	Part sun to full shade	12”
Iris texax/ Oregon iris	B/C	X		X						18”	Full to part sun	12”
Juncus effuses var. pacificus/ Soft rush	A	X	X	X						3’	Full sun	12”
Juncus ensifolius/ Dagger-leaf rush	A P2/P3	X	X	X						10”	Full sun	12”
Juncus tenuis/ Slender rush	A	X	X	X			X	X		3’	Full sun	12”
Lemna minor/ Duckweed	P1/P2										Full sun	
Lupinus micranthus/ Small flowered lupine	B/C	X		X	X					18”	Full sun	12”
Polystitchum munitum/ Sword fern	A/B/C	X		X	X			X		24”	Part to full shade	24”

Plant list (continued)

Plant Name		Proposed Facility Type								Characteristics		
Latin Name/ Common Name	**Zone**	**Biofiltration Swale**	**Planter**	**Rain Garden**	**Filter Strip**	**Wet Pond**		**Dry Pond**		**Potential Height**	**Sun and Shade Preference**	**O.C. Spacing**
						Saturated Soils	**Emergent to Wet Soils**	**Moist to Dry Soils**	**Dry/ Upland Soils**			
Sagittaria latifolia/ Wapato	P1/P2					X	X			24”	Full sun	12”
Scirpus americanus/ American bulrush	A/P2/ P3	X	X	X			X	X		30”	Full to part sun	12”
Scirpus microcarpus/ Small fruited bullrush	A			X			X			24”	Full to part sun	12”
Scirpus validus/ Soft-stem bullrush	P2/P3						X	X		24”	Full sun	24”
Sisyrinchium idahoense/ Blue-eyed grass							X			6”	Full to part sun	12”
Sparganium emersum/ Narrowleaf Bur-reed							X			24”	Full sun	12”
Typha latifolia/ Cattail	P2						X				Full to part sun	
Viola palustris/ Marsh violet							X	X		6”	Full to part sun	6”

Plant list (continued)

Plant Name	Proposed Facility Type									Characteristics		
Latin Name/ Common Name	Zone	Biofiltration Swale	Planter	Rain Garden	Filter Strip	Wet Pond		Dry Pond		Potential Height	Sun and Shade Preference	O.C. Spacing
						Saturated Soils	Emergent to Wet Soils	Moist to Dry Soils	Dry/ Upland Soils			
Large Shrubs and Small Trees												
Acer circinatum/ Vine maple	A/B/ C/P3	X	X	X	X			X		15’	Full sun to full shade	10’
Amelanchier alnifolia/ Western serviceberry	B/C/P4	X		X					X	20’	Full to part sun	10’
Ceanothus sanguineus/ Oregon redstem ceanothus	B/C	X		X	X					7’	Full to part sun	4’
Holodiscus discolor/ Oceanspray	B/C/P4	X		X	X				X	6’	Full sun to full shade	4’
Lonicera involucrata/ Black Twinberry	B/C/P4	X		X					X	5’	Full to part sun	4’
Oemleria cerasiformis/ Indian plum	B/C/P3/ P4	X		X	X			X	X	6’	Full sun to full shade	4’
Philadelphus lewisii/ Mock orange	B/C/P4	X		X	X				X	6’	Full sun to full shade	4’
Ribes sanguineum/ Red-flowering current	B/C	X		X						8’	Full to part sun	4’
Rubus parviflorus/ Thimbleberry	B/C	X		X						8’	Full sun to full shade	4’
Rubus spectabilis/ Salmonberry	A	X	X	X						10’	Part sun to full shade	4’
Salix lucida var. ‘Lasiandra’/ Pacific Willow	A	X	X	X						13’	Full sun	6’
Salix sitchensis/ Sitka Willow	A/P2/ P3	X	X	X			X	X		20’	Full to part sun	6’
Sambucus cerulea/ Blue elderberry	B/C	X		X						10’	Full to part sun	10’
Sambucus racemosa Red elderberry	B/C/P3	X		X				X		10’	Full sun to full shade	12”
Spiraea doublasii/ Douglas spiraea	A/B/ C/P3	X	X	X	X			X		4’	Full to part sun	12”
Viburnum edule/ Highbush cranberry	A/B/ C/P3	X	X	X	X			X		6’	Full sun to full shade	4’

Plant list (continued)

Plant Name		Proposed Facility Type								Characteristics		
Latin Name/ Common Name	**Zone**	**Biofiltration Swale**	**Planter**	**Rain Garden**	**Filter Strip**	**Wet Pond**		**Dry Pond**		**Potential Height**	**Sun and Shade Preference**	**O.C. Spacing**
						Saturated Soils	**Emergent to Wet Soils**	**Moist to Dry Soils**	**Dry/ Upland Soils**			
Shrubs												
Ceanothus velutinus/ Snowbrush	B/C/P4	X		X					X	4’	Full sun	3’
Cornus sericea/ Red-twig dogwood	A/P2/P3	X	X	X			X	X		6’	Full to part sun	4’
Gaultheria shallon/ Salal	B/C/P4	X		X					X	24”	Part sun to full shade	24”
Mahonia aquifolium/ Oregon grape	B/C/P4	X		X				X	X	5’	Full to part sun	3’
Mahonia nervosa/ Dull Oregon grape	B/C/P3/ P4	X		X				X		24”	Full sun to full shade	24”
Physocarpus capitatus/ Pacific ninebark	A/B/C/P3/ P4	X	X	X				X	X	6’	Full sun to full shade	3’
Rosa gymnocarpa/ Baldhip rose	B/C/P3	X		X				X		3’	Part sun to full shade	3’
Rosa nutkana/ Nootka rose	B/C/P3	X		X				X		8’	Full to part	3’
Rosa pisocarpa/ Swamp rose	A/B/ P2	X	X	X			X			8’	Full to part sun	3’
Symphoricarpos alba/ Common snowberry	B/C/P3	X		X				X		6’	Full sun to full shade	3’

Plant Name	Proposed Facility Type									Characteristics		
Latin Name/ Common Name	**Zone**	**Biofiltration Swale**	**Planter**	**Rain Garden**	**Filter Strip**	**Wet Pond**		**Dry Pond**		**Potential Height**	**Sun and Shade Preference**	**O.C. Spacing**
						Saturated Soils	**Emergent to Wet Soils**	**Moist to Dry Soils**	**Dry/ Upland Soils**			
Trees												
Acer macrophyllum/ Big leaf maple	B/C/P3	X		X	X			X		30'	Full to part sun	
Alnus rubra/ Red alder	A/P2/P3	X		X			X	X		80'	Full to part sun	
Arbutus menziesii/ Madrone	B/C/P4			X					X	35'	Full sun	
Cornus nuttalii/ Western flowering dogwood	A/B/C/ P3/ P4				X			X	X	20'	Part to full shade	
Fraxinus latifolia/ Oregon ash	A/B/P2/ P3	X		X			X	X		30'	Full to part sun	
Malus fusca/ Pacific crabapple	A/P2/P3	X	X	X			X	X		30'	Full to part sun	10'
Populus tremuloides/ Quaking aspen	A/B/C/P2/P3			X	X		X	X		40'	Full sun	
Prunus emarginata/ Bitter cherry	A/B/C/ P2/ P3	X	X	X			X	X		50'	Full sun to part sun	
Prunus emarginata/ Bitter cherry	A/B/C/ P2/ P3	X	X	X			X	X		50'	Full sun to part sun	
Pseudotsuga menziesii/ Douglas fir	B/C/P3/ P4	X		X	X			X	X	100'	Full to part sun	
Rhamnus purshiana/ Cascara	A/B/ C/ P2/ P3	X	X	X			X	X		30'	Part sun to full shade	
Salix hookeriana/ Hooker's willow	A/B/ P2/ P3	X	X	X	X		X	X		15'	Full to part sun	
Salix scouleriana/ Scouler's willow	A/B/C/ P2/P3	X	X	X	X		X	X		15'	Full to part sun	
Thuja plicata/ Western red cedar	A/P2/P3			X			X	X		150'	Full to part sun	
Tsuga heterophylla/ Western hemlock	A/P2	X		X				X		125'	Full sun to full shade	

Plant list (continued)