2004 Stormwater Management Manual

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STORMWATER MANAGEMENT MANUAL

SEPTEMBER 2004

REVISION #3

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
CLEAN RIVER WORKS

City of Portland

Stormwater Management Manual

Revision 3
September 1, 2004

STORMWATER MANAGEMENT MANUAL
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HOW TO USE THIS MANUAL

This section includes:

The purpose of this section is to help the user navigate the *Stormwater Management Manual* and apply it to projects of varying size, type, and complexity. The goal is a higher number of successful permit applications, resulting in fewer check-sheet revisions.

"HOW TO USE THIS MANUAL" FLOWCHART

Use the Stormwater Destination/Disposal Hierarchy from **Exhibit 1-1** to determine the ultimate disposal point for the stormwater from the site:

Category 1:
On-site infiltration:
- Surface Infiltration Facilities

Design surface infiltration facilities per **Section 2.2.2** and **Section 2.9**.

Category 2: On-site infiltration:
- Underground Injection Controls (UICs) (Soakage Trenches, Drywells, or Public Infiltration Sump Systems)

Unless used exclusively for residential rooftop runoff, UICs must be approved by and registered with DEQ. Rule authorization or permitting criteria must be met, including sufficient separation to groundwater (see **Section 1.4**). Design UICs per **Section 2.9**.

Will the UICs be used to infiltrate roof runoff only?

Y

N

Will the UICs be used to infiltrate runoff from non-residential or high-use (> 1,000 average daily trips) streets or parking lots?

N

Y

Design spill control manhole or other pollution reduction facility in accordance with **Chapter 2.0.**

Category 3:
Off-site flow to:
- Drainageway
- River
- Storm Sewer

Category 4:
Off-site flow to:
- Combined Sewer

Will the project construct or redevelop over 500 square feet of impervious surface, or discharge stormwater off-site from impervious surfaces that were previously infiltrated on-site?

Y

N

Use **Chapter 2.0** to design pollution reduction and flow control facilities for the project. Note: flow control may not be required per **Section 1.6.2**.

Use **Chapter 3.0** to compile an operations and maintenance (O&M) plan for the stormwater management facilities. Fill out **Form O&M.**

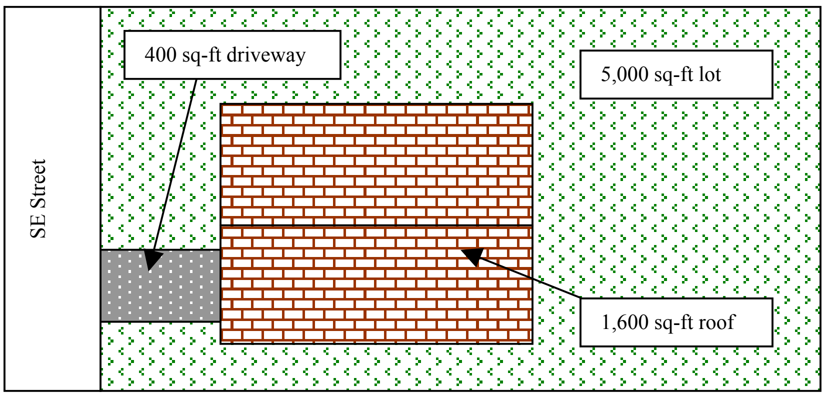
Note: If any of the following activities exist on the project site, Chapter 4.0 must be used to design source controls for each.

• Fuel Dispensing Facilities • Above-Ground Storage of Liquid Materials • Solid Waste Storage Areas, Containers, and Trash Compactors • Exterior Storage of Bulk Materials • Material Transfer Areas/ Loading Docks • Equipment and/or Vehicle Washing Facilities • Stormwater Disposal from Development on Recycled Land (brownfields) • Covered Vehicular Parking Areas

Submit plans to the City for permitting, including stormwater destination, any applicable source controls with associated submittals, and applicable pollution reduction and/or flow control facilities with sizing forms (**Form SIM**), calculations, planting plans, and O&M forms. **END.**

CASE EXAMPLE #1: Single-Family House (Southeast Portland)

A single-family house with a footprint of 1,600 square feet and a driveway with a footprint of 400 square feet will be constructed on a 5,000 square-foot lot in Southeast Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group B (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and depth to groundwater is approximately 100 feet. The lot has slopes less than 2 percent.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy** (in Chapter 1.0)

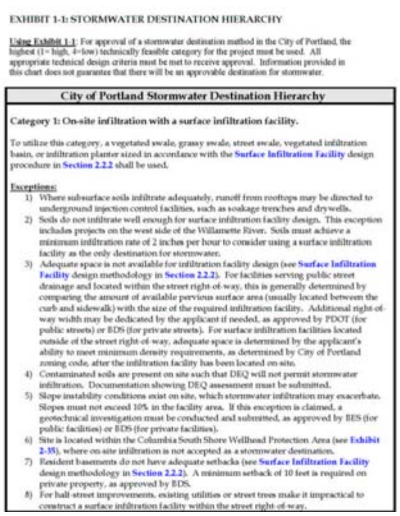


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

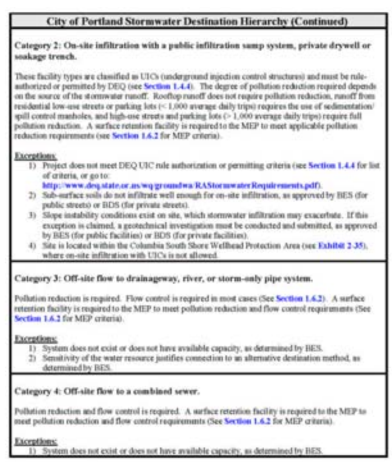
Using Exhibit 1-1: For approval of a stormwater destination method in the City of Portland, the highest (1=high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

Exceptions:
1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

Exceptions:
1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.

Under category #1, the Stormwater Destination/Disposal Hierarchy states that where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells. In this case, with B-type soils and mild slopes, on-site infiltration is most likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. In addition to drywells and soakage trenches, other options include surface infiltration facilities such as vegetated or grassy swales, infiltration planters, or vegetated infiltration basins. In addition to the options listed above, the driveway may use pervious pavement or be graded to sheet flow into adjacent lawn areas.

Step 2: Design drywells, soakage trenches, or surface infiltration facilities in accordance with **Chapter 2.0**: **Stormwater Management Facility Design**.

Soakage Trenches: If soakage trenches are used to infiltrate stormwater from the rooftop areas, **Exhibit 2-28**: **East Soakage Trench** is used. In accordance with this exhibit, 24 feet of soakage trench is required per 1,000 square feet of rooftop area. In this example, the length of soakage trench needed to dispose of stormwater from the roof area will be: 1,600 x (24/1,000) = 38.4 feet in length. If used for the roof *and* the driveway, the soakage trench will need to be: 2,000 x (24/1,000) = 48 feet. The design criteria presented in the soakage trench section of Chapter 2.0 must be used to design the trench, and to locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.

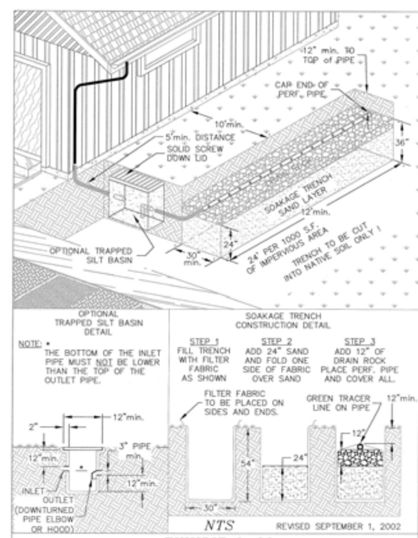
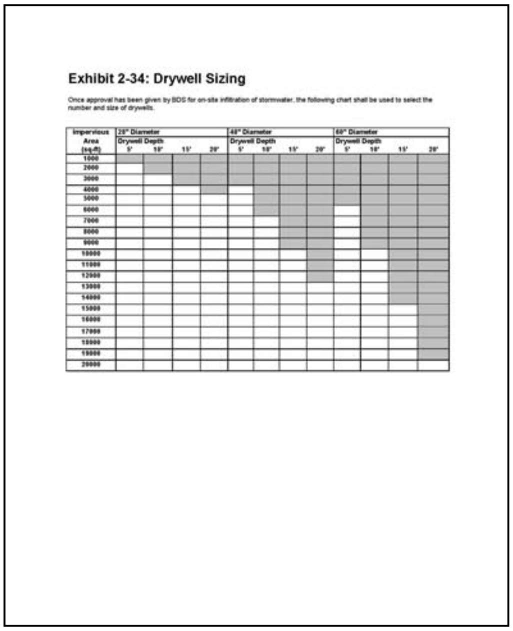
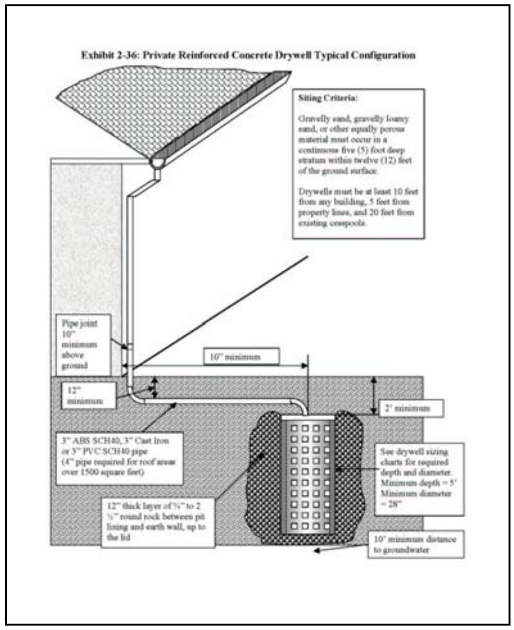


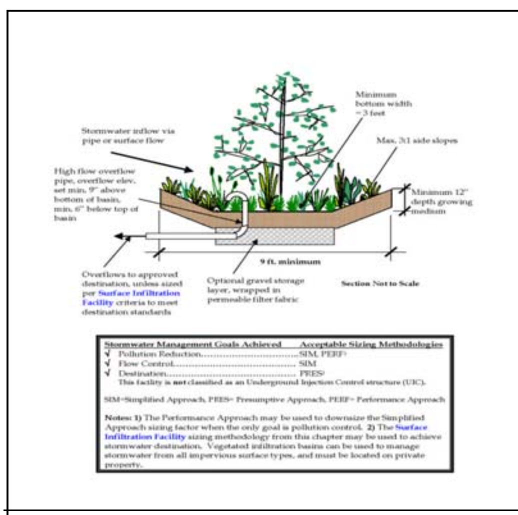
EXHIBIT 2-28
EAST SOAKAGE TRENCH

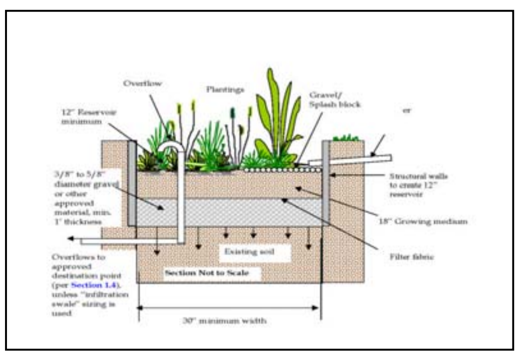
Drywells: If drywells are used to infiltrate stormwater from the rooftop areas, **Exhibit 2-34**: **Drywell Sizing** is used. In accordance with this exhibit, a 10-foot deep, 28-inch diameter drywell or a 5-foot deep, 48-inch diameter drywell is required to infiltrate stormwater from impervious areas between 1,000 and 2,000 square feet in size. The design criteria presented in the private drywell section of Chapter 2.0 must be used to design the drywell, and to locate the facility on-site. Setbacks from building structure must be considered (see **Exhibit 2-36**). The detailed design and location must be shown on the permit drawings.





Surface Infiltration Facilities: If surface infiltration facilities are used to infiltrate stormwater from the rooftop areas, **Section 2.2.2** is used. In accordance with the surface infiltration design approach from this section, enough storage volume must be provided in the facility to contain the runoff from a 10-year, 24-hour storm. For the rooftop, this volume is: 0.28 feet x 1,600 square feet = 448 cubic feet. For the rooftop and the driveway, this volume is approximated by the following equation: 0.28 feet x 2,000 square feet = 560 cubic feet. The design criteria presented in each applicable section of Chapter 2.0 must be used to design the facility, and to locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.



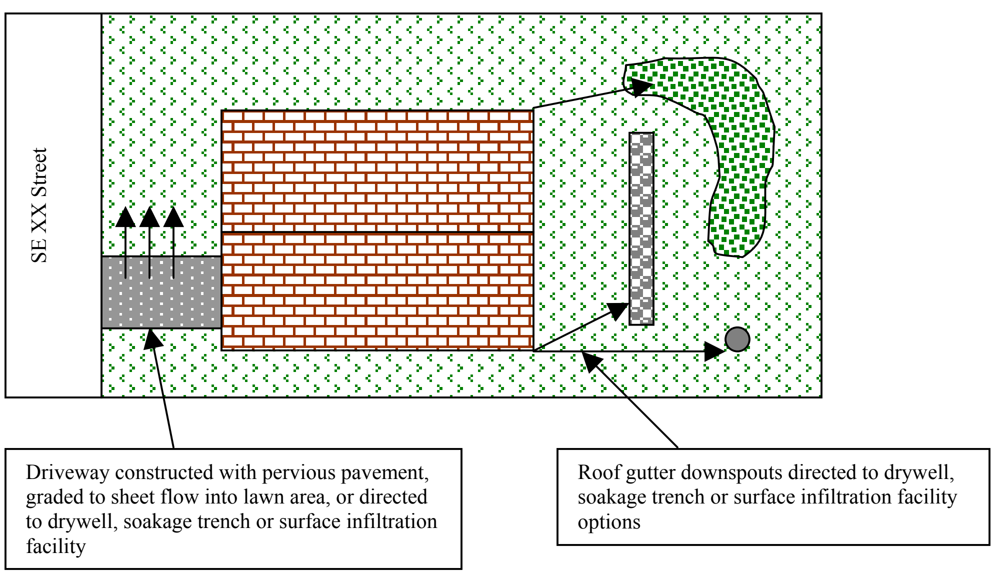


Step 3: Use Chapter 3.0: **Operations & Maintenance** to compile an operations and maintenance plan for the drywells, soakage trenches, or other stormwater management facilities used on the site. **Form O&M** must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.


FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)
REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

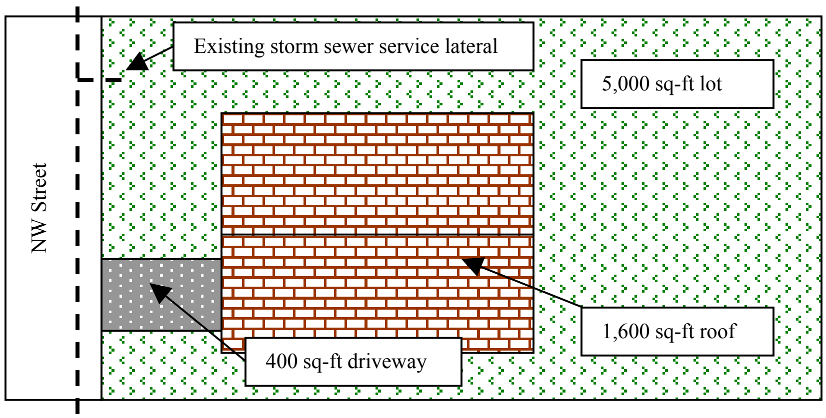

Soakage Trenches
Operations & Maintenance Plan

Step 4: Submit the house plans to the city for permitting. The drywell, soakage trench, or other stormwater management facilities must be shown on the drawings, along with applicable details, and the recorded O&M plan must be attached. **END**.



CASE EXAMPLE #2: Single-Family House (Northwest Portland)

A single-family house with a footprint of 1,600 square feet and a driveway with a footprint of 400 square feet will be constructed on a 5,000 square-foot lot in Northwest Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group C (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the lot has slopes that range from 10 to 20 percent. There is an existing public storm sewer pipe in the frontage street with an existing service lateral to the property.



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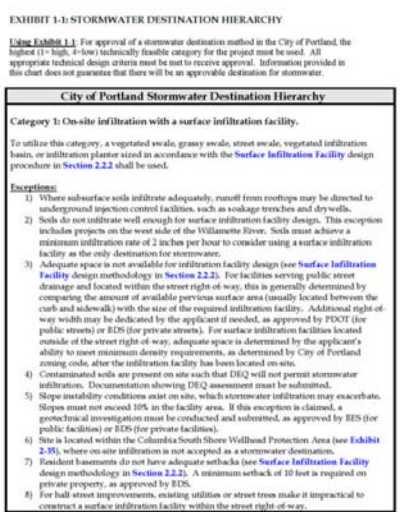

EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

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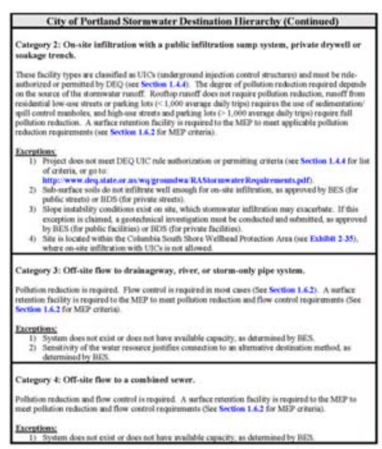
City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

Exceptions:
1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

Exceptions:
1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.

Category #1 (surface infiltration facilities) and category #2 (on-site infiltration with drywell or soakage trench) depend on project site soils that infiltrate relatively well (2 inches per hour minimum). In this example, with C-type soils and moderate slopes, on-site infiltration is not likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. Category #3 (off-site flow to drainageway, river, or storm-only pipe system) depends on the availability of such resources. Portlandmaps.com or other city maps available at the Development Services Center (1900 SW 4th Avenue) can be used to identify off-site stormwater conveyance systems. In this case, there is an existing storm sewer service lateral that the property will use. Pollution reduction and flow control are required prior to discharge into the storm sewer.

Step 2: Choose pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. There are many facility types to choose from that will achieve both pollution reduction and flow control. **Exhibit 2-1** can be used to help choose a facility type that can use the simplified approach for sizing. In this example, flow-through planters will be used to manage stormwater from the rooftop, and the overflow and underdrain pipes from the planters will be connected to the storm sewer service lateral. The driveway may use pervious pavement; may be graded to sheet flow into adjacent lawn areas if sufficiently sized in accordance with vegetated filter design criteria (at least 1 square foot of lawn area per 5 square feet of driveway area, lawn area must be at least 10 feet by 10 feet); or may be directed to the flow-through planters.

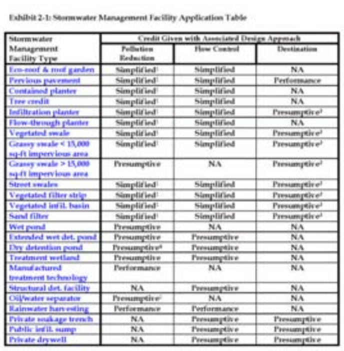
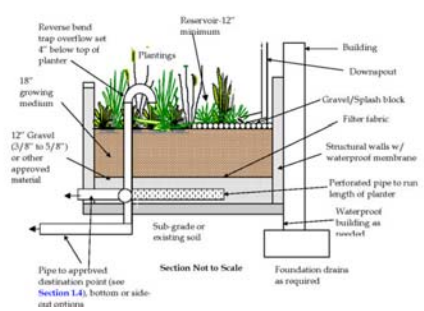
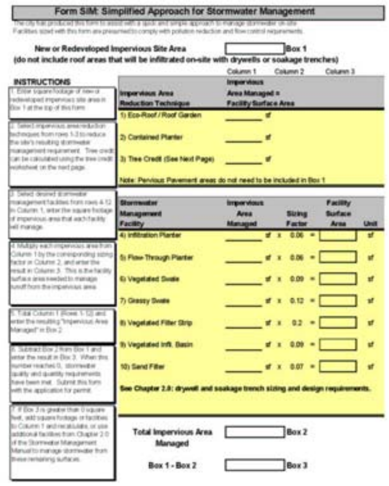


Exhibit 2-1: Stormwater Management Facility Application Table

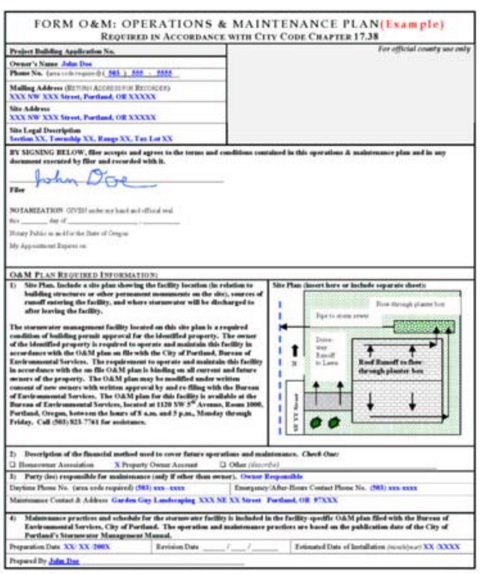
Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination
Eco-roof & roof garden	Simplified[1]	Simplified	NA
Pervious pavement	Simplified[1]	Simplified	Performance
Contained planter	Simplified[1]	Simplified	NA
Tree credit	Simplified[1]	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[2]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[2]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[2]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[2]
Street swales	Simplified[1]	Simplified	Presumptive[2]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[2]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[2]
Sand filter	Simplified[1]	Simplified	Presumptive[2]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Oil/water separator	Presumptive[5]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	NA	Presumptive	Presumptive
Public infil. sump	NA	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive

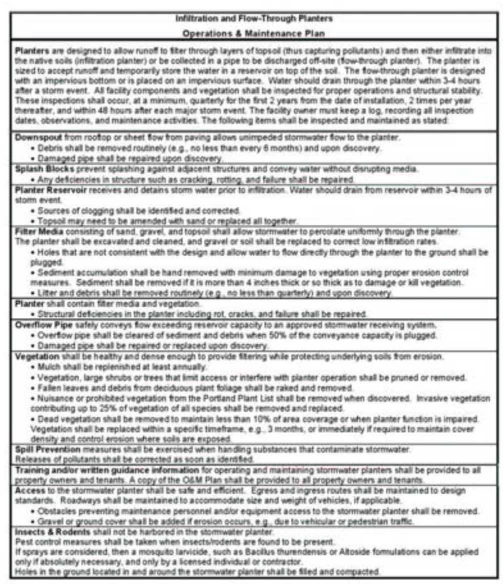


Step 3: Design pollution reduction and flow control facilities from Chapter 2.0: **Stormwater Management Facility Design**. Form SIM will be used to size the flow-through planters to meet pollution reduction and flow control requirements. From this form, the sizing factor for flow-through planters is 0.06. The required square-footage of planters is the square footage of the roof multiplied by the sizing factor: 1,600 square feet x 0.06 = 96 square feet. The planters can be split up and located at each roof downspout, or the downspouts can be plumbed to one large planter, as long as 96 square feet of flow-through planter is provided and all the planters are connected to the storm sewer service lateral.

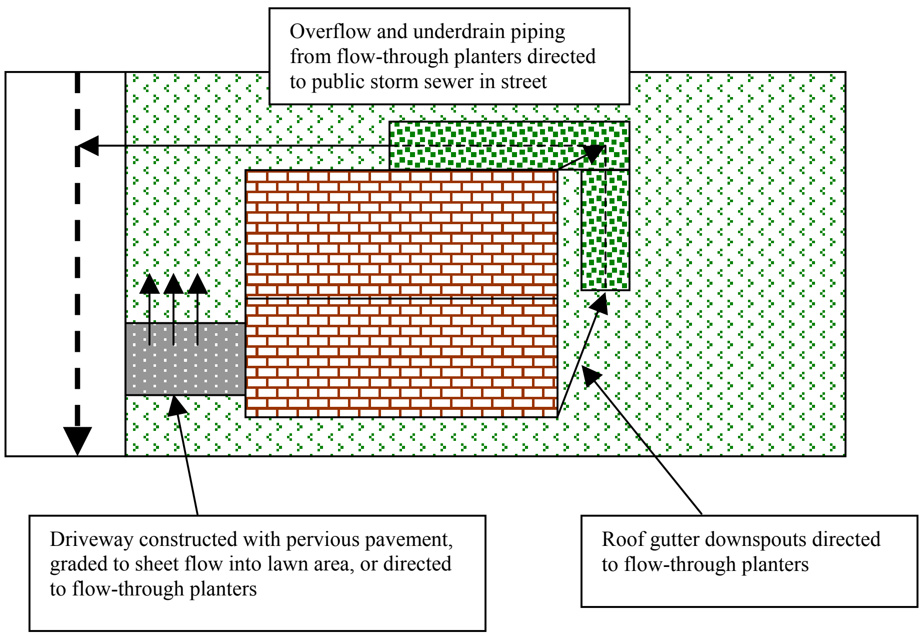

Form SIM: Simplified Approach for Stormwater Management

Step 4: Use Chapter 3.0: **Operations & Maintenance** to compile an operations and maintenance plan for the flow-through planters used on the site. Form O&M must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.


FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)
REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

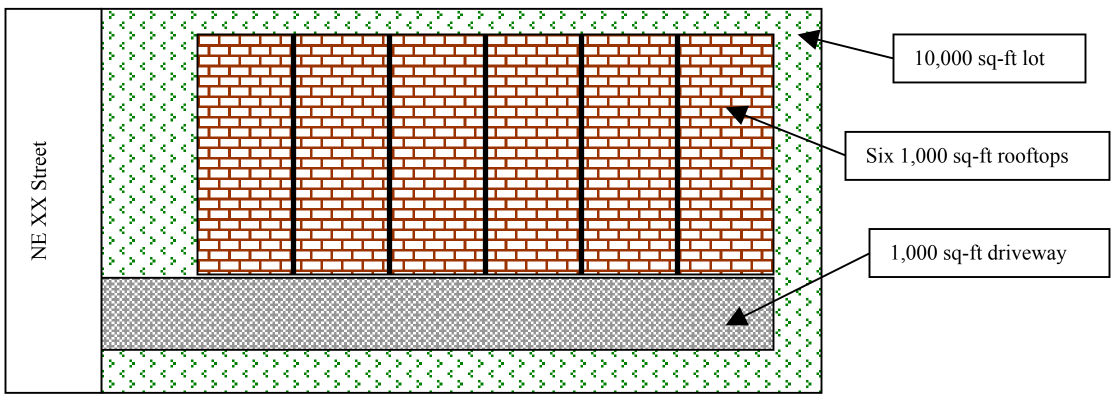

Infiltration and Flow-Through Planters
Operations & Maintenance Plan

<u>Step 5</u>: Submit the house plans to the city for permitting. The stormwater destination (pipe connection to the storm sewer service lateral) must be clearly identified on the drawings, along with flow-through planter locations and applicable details, and the completed Form SIM and recorded O&M plan must be attached. **END**.



CASE EXAMPLE #3: Rowhouse Development w/ Private Driveway (Northeast Portland)

A rowhouse development with six 1,000 square-foot rooftops and a driveway with a footprint of 1,000 square feet will be constructed on a 10,000 square-foot lot in Northeast Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group B (from the USDA/ NRCS Soil Survey of Multnomah County, Oregon), and the depth to groundwater is approximately 130 feet. The lot has slopes less than 2 percent.



<u>Step 1</u>: Determine the stormwater disposal point for the site. Use **Exhibit 1-1: Stormwater Destination/Disposal Hierarchy**.

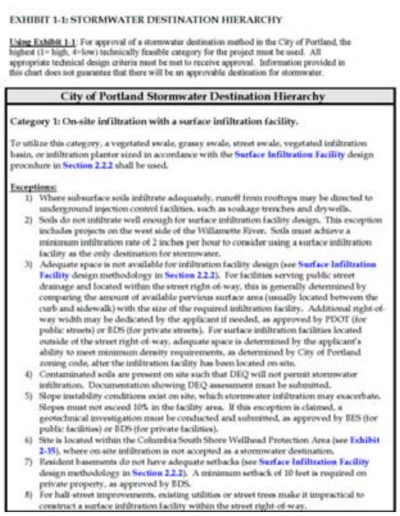


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

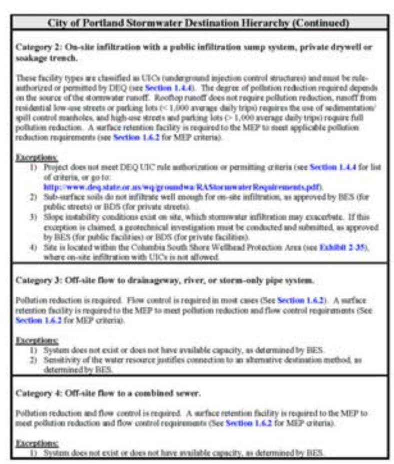
<u>Using Exhibit 1-1</u>: For approval of a stormwater destination method in the City of Portland, the highest (1= high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

<u>Exceptions:</u>
1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/ spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

<u>Exceptions:</u>
1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

<u>Exceptions:</u>
1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

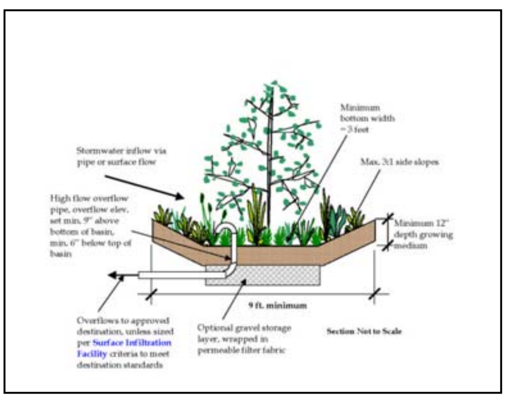
Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

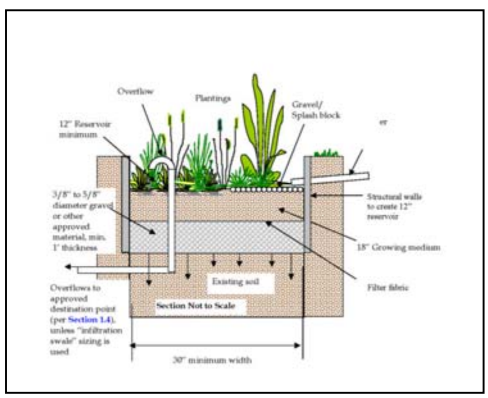
<u>Exceptions:</u>
1) System does not exist or does not have available capacity, as determined by BES.

Under category #1, the Stormwater Destination Hierarchy states that where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells. In this case, with B-type soils and mild slopes, on-site infiltration is most likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. In addition to drywells and soakage trenches, other options generally include surface infiltration facilities such as vegetated or grassy swales, infiltration planters, or vegetated infiltration basins.

In accordance with the surface infiltration design approach from **Section 2.2.2**, enough storage volume must be provided in the surface infiltration facility to contain the runoff from a 10-year, 24-hour storm. For the rooftop areas, this volume is: 0.28 feet x 6,000 square feet = 1,680 cubic feet. In this example, there is not adequate space on-site to construct surface infiltration facilities for the rooftop areas.

Under category #1, the 1,000-square-foot driveway must be evaluated for surface infiltration. In accordance with the surface infiltration design approach in **Section 2.2.2**, enough storage volume must be provided in the surface infiltration facility to contain the runoff from a 10-year, 24-hour storm. For the driveway, this volume is: 0.28 feet x 1,000 square feet = 280 cubic feet. The design criteria presented in each applicable section of Chapter 2.0 must be used to design the surface infiltration facility itself, and locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.

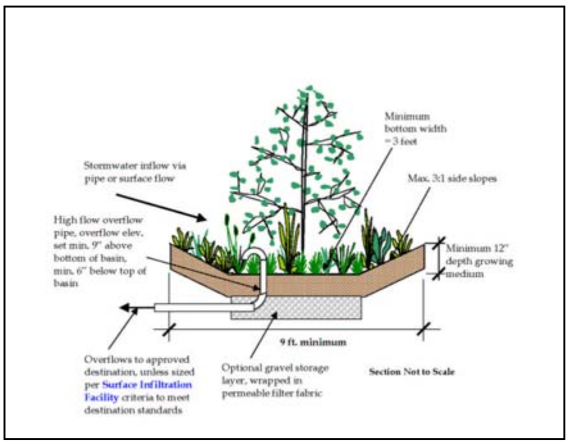


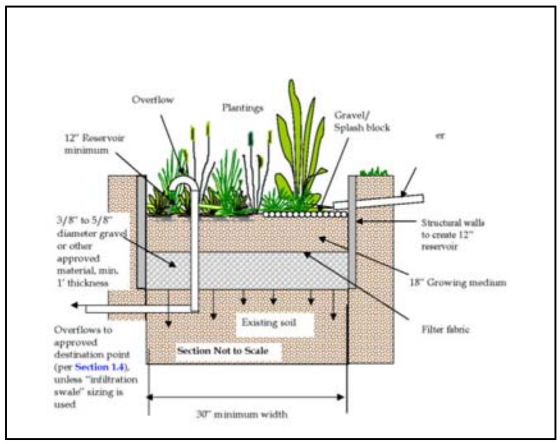


If there is not adequate space on-site to use a surface infiltration facility to infiltrate stormwater from the driveway, under category #2 the runoff from the driveway may be infiltrated on-site with a private drywell or soakage trench. In that case, a spill control manhole or other pollution reduction facility is also required. Drywells or soakage trenches must be registered with DEQ per **Section 1.4.4**.

<u>Step 2</u>: Design the drywells, soakage trenches, surface infiltration facilities, and/or pollution reduction facilities in accordance with **Chapter 2.0**: **Stormwater Management Facility Design**.

If surface infiltration facilities such as swales, infiltration planters, or vegetated infiltration basins are used to infiltrate stormwater from the driveway area, **Section 2.2.2** is used. As discussed under step 1, 280 cubic feet of storage volume must be provided. The design criteria presented in each applicable section of Chapter 2.0 must be used to design the facility, and to locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.





If there is not sufficient space to locate a surface infiltration facility on-site for the driveway runoff, a drywell or soakage trench may be used. In that case, a pollution reduction facility sized in accordance with the simplified approach from Chapter 2.0 must be used to meet pollution reduction requirements. **Exhibit 2-1** can be used to help select a facility type that can use the simplified approach for sizing. If the driveway will generate fewer than 1,000 average daily trips, a spill control manhole from Chapter 2.0 may be used instead of a pollution reduction facility to meet the pollution reduction requirements.

The following discussion assumes there is sufficient space for an on-site surface infiltration facility to manage stormwater from the driveway. A vegetated swale will be used, and the overflow from the swale will be connected to an on-site drywell or soakage trench. Drywells and soakage trenches must be registered with the Oregon Department of Environmental Quality (DEQ), in accordance with **Section 1.4.4**.

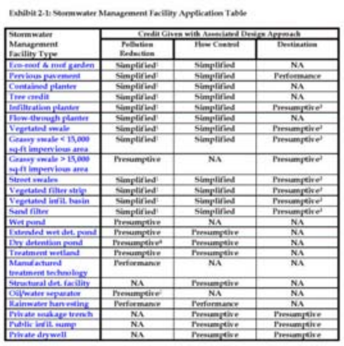
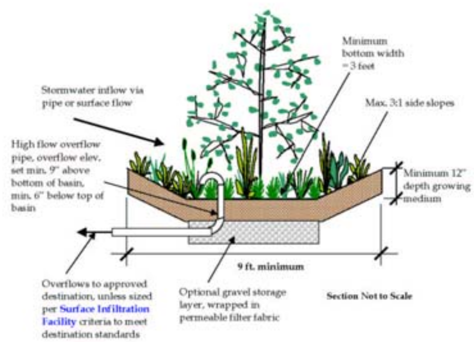
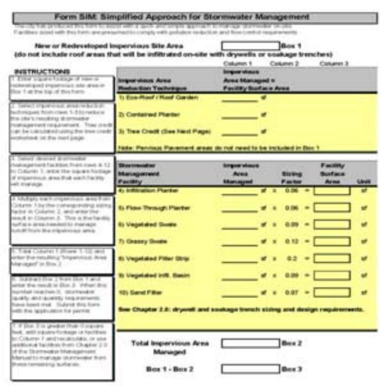


Exhibit 2-1: Stormwater Management Facility Application Table

Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination
Eco-roof & roof garden	Simplified[1]	Simplified	NA
Pervious pavement	Simplified[1]	Simplified	Performance
Contained planter	Simplified[1]	Simplified	NA
Tree credit	Simplified[1]	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[2]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[2]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[2]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[2]
Street swales	Simplified[1]	Simplified	Presumptive[2]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[2]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[2]
Sand filter	Simplified[1]	Simplified	Presumptive[2]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Oil/water separator	Presumptive[3]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	NA	Presumptive	Presumptive
Public infil. sump	NA	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive



Form SIM will be used to size the vegetated swale to meet pollution reduction requirements. From this form, the sizing factor for vegetated swales is 0.09. The required square-footage of swale is: 1,000 square feet x 0.09 = <u>90 square feet</u>. The swale will be 5 feet wide by 18 feet long, and will include an overflow catch basin plumbed to the site's drywell or soakage trench.



Form SIM: Simplified Approach for Stormwater Management

New or Redeveloped Impervious Site Area ______ **Box 1**
(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)

INSTRUCTIONS

Impervious Area Reduction Technique	Impervious Area Managed = Facility Surface Area (Column 1)
1) Eco-Roof / Roof Garden	______ sf
2) Contained Planter	______ sf
3) Tree Credit (See Next Page)	______ sf

Note: Pervious Pavement areas do not need to be included in Box 1

Stormwater Management Facility	Impervious Area Managed (Column 1)		Sizing Factor (Column 2)		Facility Surface Area (Column 3)	Unit
4) Infiltration Planter	______ sf	x	0.06	=		sf
5) Flow Through Planter	______ sf	x	0.06	=		sf
6) Vegetated Swale	______ sf	x	0.09	=		sf
7) Grassy Swale	______ sf	x	0.12	=		sf
8) Vegetated Filter Strip	______ sf	x	0.2	=		sf
9) Vegetated Infil. Basin	______ sf	x	0.09	=		sf
10) Sand Filter	______ sf	x	0.07	=		sf

See Chapter 2.0: drywell and soakage trench sizing and design requirements.

Total Impervious Area Managed ______ **Box 2**

Box 1 - Box 2 ______ **Box 3**

If a drywell is used to infiltrate stormwater from the rooftop or driveway areas, **Exhibit 2-34**: **Drywell Sizing** is used. In accordance with that exhibit, a 10-foot deep, 48-inch diameter drywell is required to infiltrate stormwater from the 6,000 square-foot impervious rooftop area. If the drywell will be used to infiltrate stormwater from both the rooftop and driveway areas (7,000 square-feet of impervious area), a 15-foot deep, 48-inch diameter drywell is required. The design criteria presented in the private drywell section of Chapter 2.0 must be used to design the drywell, and to locate the facility on-site. Setbacks from building structure must be considered (see **Exhibit 2-36**). The detailed design and location must be shown on the permit drawings.

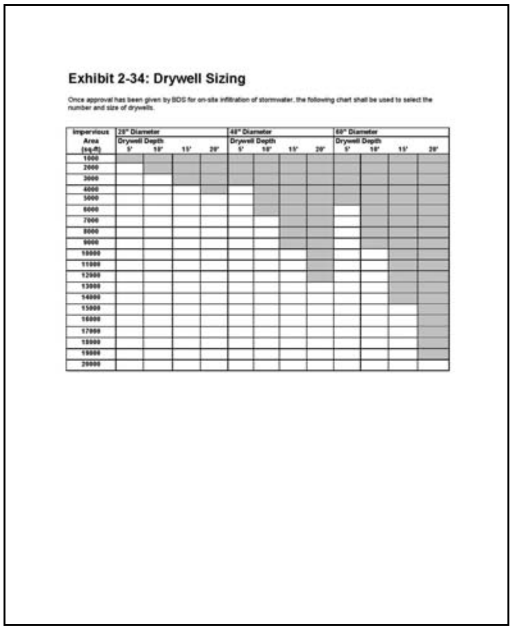


Exhibit 2-34: Drywell Sizing

Once approval has been given by BDS for on-site infiltration of stormwater, the following chart shall be used to select the number and size of drywells.

Impervious Area (sq-ft)	28" Diameter Drywell Depth 5'	10'	15'	20'	48" Diameter Drywell Depth 5'	10'	15'	20'	60" Diameter Drywell Depth 5'	10'	15'	20'
1000												
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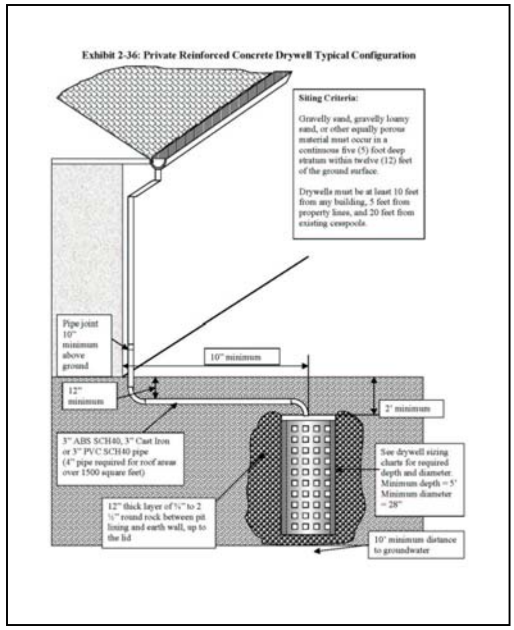
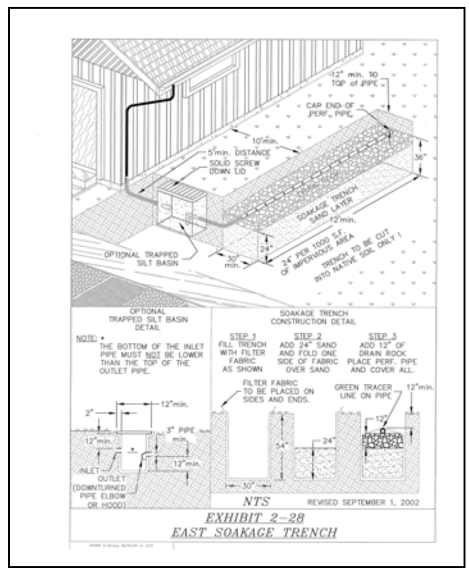
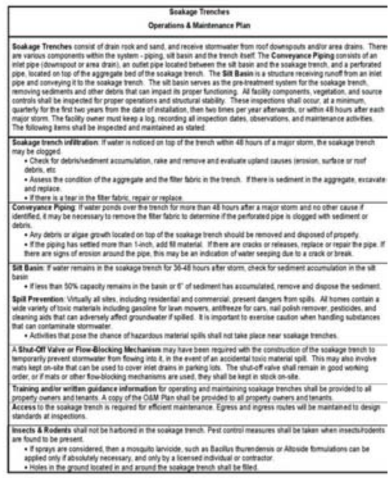


If a soakage trench is used to infiltrate stormwater from the rooftop or driveway areas, **Exhibit 2-28**: **East Soakage Trench** is used. In accordance with this exhibit, 24 feet of soakage trench is required per 1,000 square feet of rooftop area. In this example, the length of soakage trench to handle the roof runoff will be: 6,000 * (24/1,000) = <u>144 feet</u> in length. If used for the roof *and* the driveway, the soakage trench will be: 7,000 * (24/1,000) = <u>168 feet</u>. The design criteria presented in the soakage trench section of Chapter 2.0 must be used to design the trench, and to locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.



<u>Step 3</u>: Use **Chapter 3.0**: **Operations & Maintenance** to compile an operations and maintenance plan for the drywell, soakage trench, or other stormwater management facilities used on the site. **Form O&M** must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.

FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)

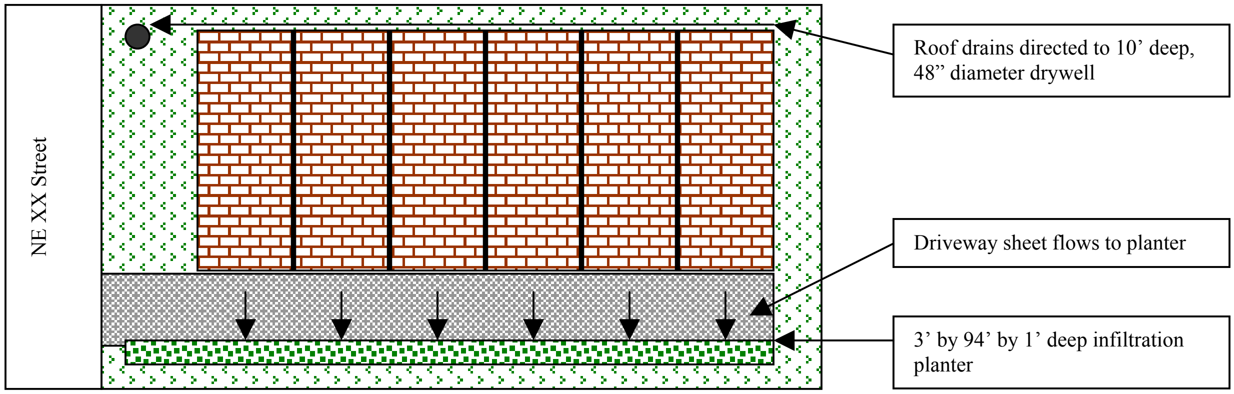


Soakage Trenches

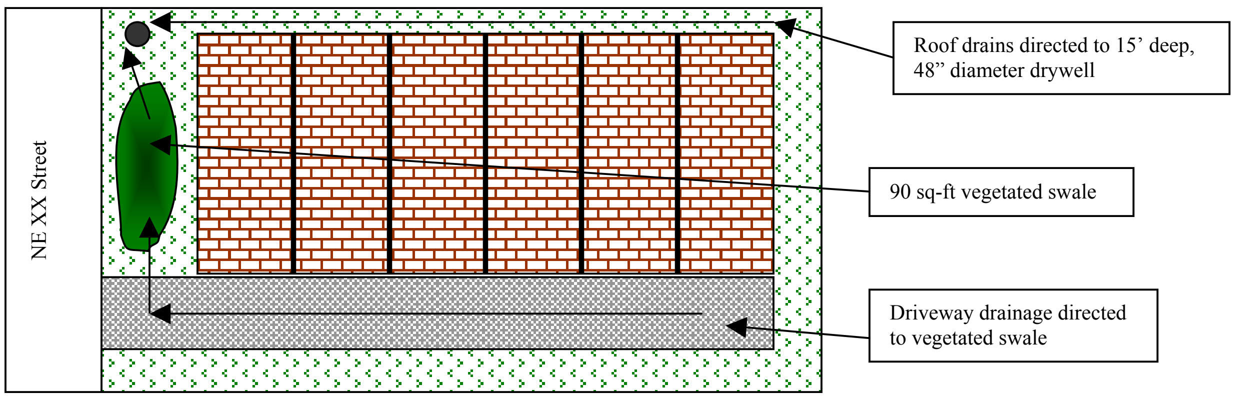
Operations & Maintenance Plan

<u>Step 4</u>: Submit the plans to the city for permitting. The drywell, soakage trenches, or other stormwater management facilities must be shown on the drawings, along with applicable details, and the recorded O&M plan must be attached. **END**.

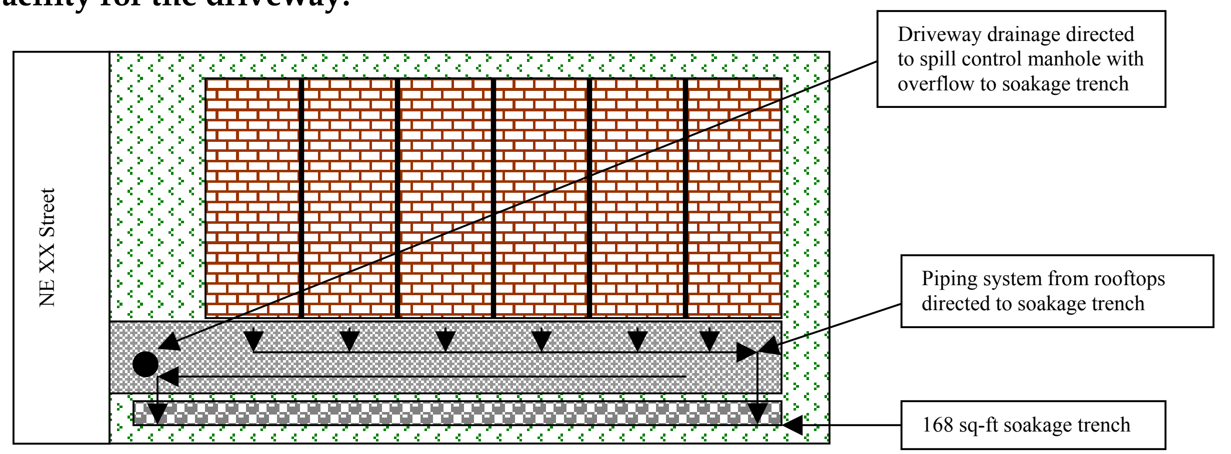
Drywell used for rooftops, surface infiltration used for driveway:



Drywell used for rooftops and driveway, with pollution reduction facility for driveway:

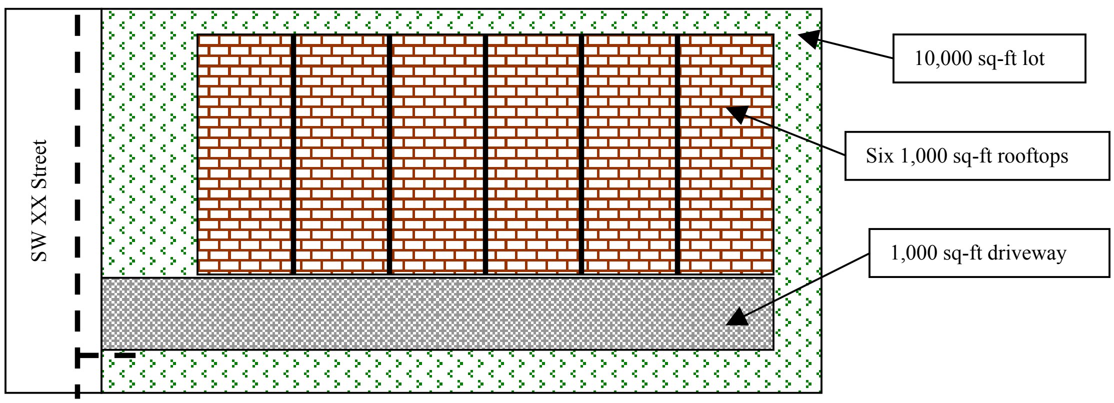


Soakage trenches used for rooftops and driveway, with a pollution reduction facility for the driveway:



CASE EXAMPLE #4: Rowhouse Development w/ Private Driveway (Southwest Portland)

A rowhouse development with six 1,000 square-foot rooftops and a driveway with a footprint of 1,000 square feet will be constructed on a 10,000 square-foot lot in Southwest Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group C (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the lot has slopes that range from 5 to 15 percent. There is an existing public storm sewer pipe in the frontage street with an existing service lateral to the property.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy**.

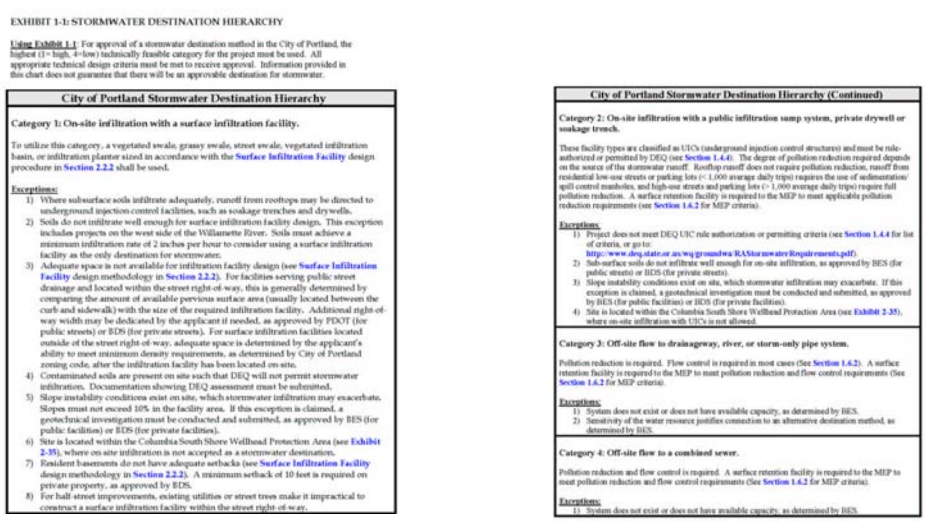


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

Using Exhibit 1-1: For approval of a stormwater destination method in the City of Portland, the highest (1=high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

Exceptions:
1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.

City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

Exceptions:
1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.

Category #1 (surface infiltration facilities) and category #2 (on-site infiltration with drywell or soakage trench) depend on project site soils that infiltrate relatively well (2 inches per hour minimum). In this example, with C-type soils and moderate slopes, on-site infiltration is not likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. Category #3 (off-site flow to drainageway, river, or storm-only pipe system) depends on the availability of such resources. **http://www.portlandmaps.com/** or other City maps available at the Development Services Center (1900 SW 4th Avenue) can be used to identify off-site stormwater conveyance systems. In this example, there is an existing storm sewer service lateral that the property will use. Pollution reduction and flow control are required prior to discharge into the storm sewer.

Step 2: Choose pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. There are many facility types to choose from that will achieve both pollution reduction and flow control. Exhibit 2-1 can be used to help choose a facility type that can use the simplified approach for sizing. In this example, a flow-through planter will be used to manage stormwater from the rooftops, and the overflow and underdrain pipes from the planters will be connected to the storm sewer service lateral. The driveway may use pervious pavement with underdrains connected to the storm sewer, or the runoff may be directed to the flow-through planter.

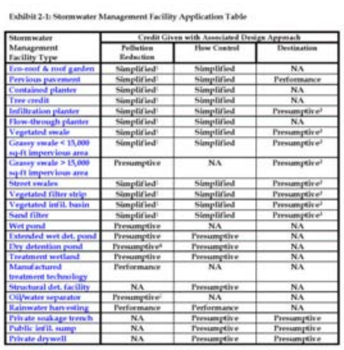
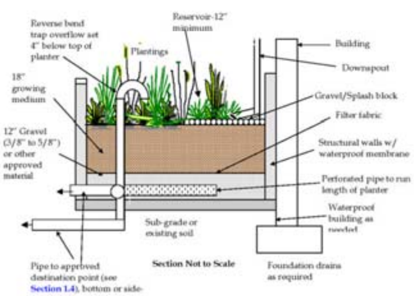
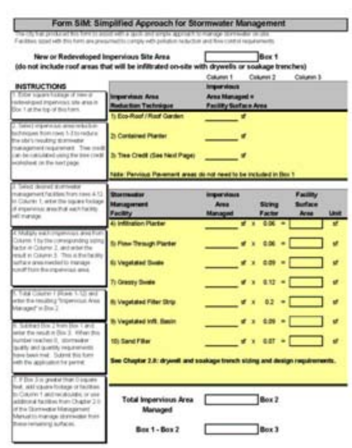


Exhibit 2-1: Stormwater Management Facility Application Table

Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination
Eco-roof & roof garden	Simplified[1]	Simplified	NA
Pervious pavement	Simplified[1]	Simplified	Performance
Contained planter	Simplified[1]	Simplified	NA
Tree credit	Simplified[1]	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[2]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[2]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[2]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[2]
Street swales	Simplified[1]	Simplified	Presumptive[2]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[2]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[2]
Sand filter	Simplified[1]	Simplified	Presumptive[2]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Oil/water separator	Presumptive[2]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	NA	Presumptive	Presumptive
Public infil. sump	NA	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive



Step 3: Design pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. Form SIM will be used to size the flow-through planters to meet pollution reduction and flow control requirements. From this form, the sizing factor for flow-through planters is 0.06. The required square-footage of planters is: 7,000 square feet (rooftops + driveway) x 0.06 = 420 square feet. The planter can be split up and


Form SIM: Simplified Approach for Stormwater Management

New or Redeveloped Impervious Site Area [ ] Box 1
(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)

INSTRUCTIONS

Impervious Area Reduction Technique	Impervious Area Managed = Facility Surface Area
1) Eco-Roof / Roof Garden	______ sf
2) Contained Planter	______ sf
3) Tree Credit (See Next Page)	______ sf

Note: Pervious Pavement areas do not need to be included in Box 1

Stormwater Management Facility	Impervious Area Managed		Sizing Factor		Facility Surface Area	Unit
4) Infiltration Planter	______ sf	x	0.06	=	[ ]	sf
5) Flow Through Planter	______ sf	x	0.06	=	[ ]	sf
6) Vegetated Swale	______ sf	x	0.09	=	[ ]	sf
7) Grassy Swale	______ sf	x	0.12	=	[ ]	sf
8) Vegetated Filter Strip	______ sf	x	0.2	=	[ ]	sf
9) Vegetated Infil. Basin	______ sf	x	0.09	=	[ ]	sf
10) Sand Filter	______ sf	x	0.07	=	[ ]	sf

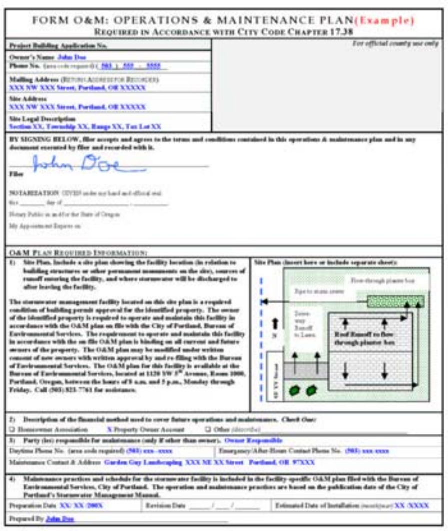
See Chapter 2.8: drywell and soakage trench sizing and design requirements.

Total Impervious Area Managed [ ] Box 2

Box 1 - Box 2 [ ] Box 3

located at each roof downspout, or the downspouts can be plumbed to one large planter, as long as 360 square feet of flow-through planter is provided and all the planters are connected to the storm sewer service lateral.

Step 4: Use **Chapter 3.0**: **Operations & Maintenance** to compile an operations and maintenance plan for the flow-through planter used on the site. Form O&M must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.


FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)
REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

Project Building Application No.	For official county use only
Owner's Name John Doe	
Mailing Address XXX NW XXX Street, Portland, OR XXXXX	
Site Address XXX NW XXX Street, Portland, OR XXXXX	
Site Legal Description Section XX, Township XX, Range XX, Tax Lot XX	

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

John Doe
Filer

NOTARIZATION

O&M PLAN REQUIRED INFORMATION:

1) Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility.

Site Plan (insert here or include separate sheet):

Roof Runoff to flow through planter box

2) Description of the financial method used to cover future operations and maintenance. Check One:
☐ Homeowner Association X Property Owner Account ☐ Other

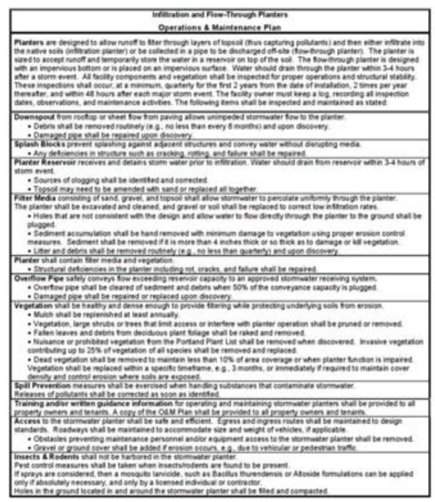
3) Party (ies) responsible for maintenance (only if other than owner). Owner Responsible

Maintenance Contact & Address Garden Guy Landscaping XXX NE XX Street Portland, OR 97XXX

4) Maintenance practices and schedule for the stormwater facility is included in the facility specific O&M plan filed with the Bureau of Environmental Services, City of Portland. The operation and maintenance practices are based on the publication date of the City of Portland's Stormwater Management Manual.

Preparation Date XX/ XX /200X | Revision Date ___/___/___ | Estimated Date of Installation XX /XXXX

Prepared By John Doe


Infiltration and Flow-Through Planters
Operations & Maintenance Plan

Planters are designed to allow runoff to filter through layers of topsoil (thus capturing pollutants) and then either infiltrate into the native soils (infiltration planter) or be collected in a pipe to be discharged off-site (flow-through planter). The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil. The flow-through planter is designed with an impervious bottom or is placed on an impervious surface. Water should drain through the planter within 3-4 hours after a storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Downspout from rooftop or sheet flow from paving allows unimpeded stormwater flow to the planter.
- Debris shall be removed routinely (e.g., no less than every 6 months) and upon discovery.
- Damaged pipe shall be repaired upon discovery.

Splash Blocks prevent splashing against adjacent structures and convey water without disrupting media.
- Any deficiencies in structure such as cracking, rotting, and failure shall be repaired.

Planter Reservoir receives and detains storm water prior to infiltration. Water should drain from reservoir within 3-4 hours of storm event.
- Sources of clogging shall be identified and corrected.
- Topsoil may need to be amended with sand or replaced all together.

Filter Media consisting of sand, gravel, and topsoil shall allow stormwater to percolate uniformly through the planter. The planter shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates.
- Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged.
- Sediment accumulation shall be hand removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Litter and debris shall be removed routinely (e.g., no less than quarterly) and upon discovery.

Planter shall contain filter media and vegetation.
- Structural deficiencies in the planter including rot, cracks, and failure shall be repaired.

Overflow Pipe safely conveys flow exceeding reservoir capacity to an approved stormwater receiving system.
- Overflow pipe shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged.
- Damaged pipe shall be repaired or replaced upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.
- Mulch shall be replenished at least annually.
- Vegetation, large shrubs or trees that limit access or interfere with planter operation shall be pruned or removed.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or prohibited vegetation from the Portland Plant List shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within a specific timeframe, e.g., 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.

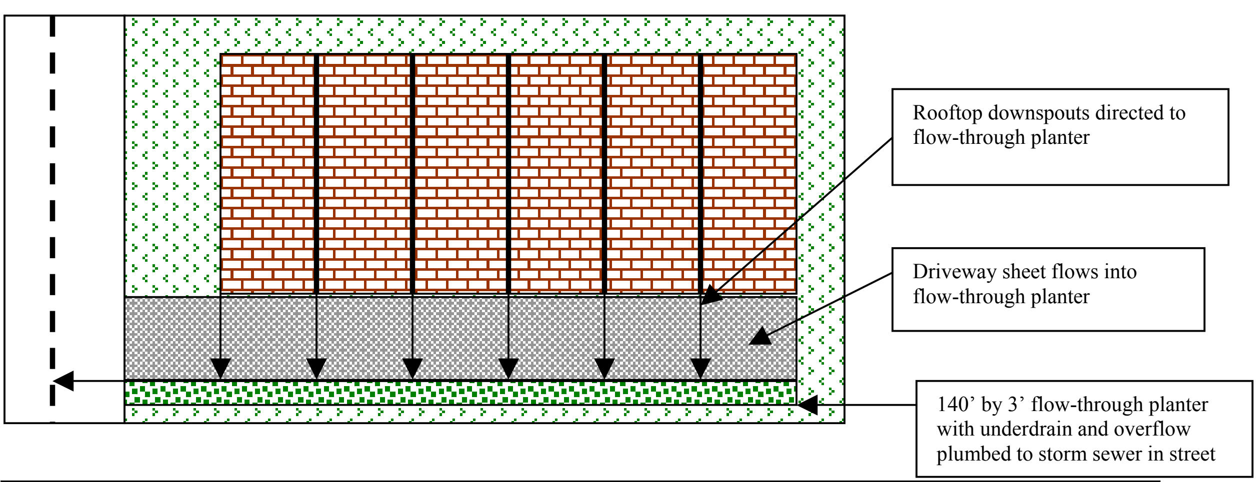
Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining stormwater planters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the stormwater planter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.
- Obstacles preventing maintenance personnel and/or equipment access to the stormwater planter shall be removed.
- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

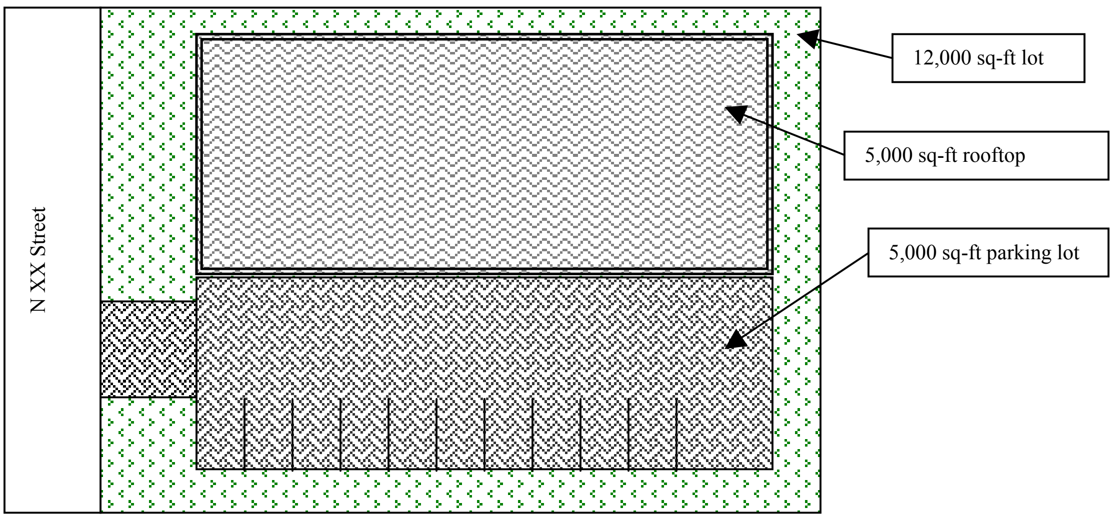
Insects & Rodents shall not be harbored in the stormwater planter.
Pest control measures shall be taken when insects/rodents are found to be present.
If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
Holes in the ground located in and around the stormwater planter shall be filled and compacted.

Step 5: Submit the plans to the city for permitting. The stormwater destination (pipe connection to the storm sewer service lateral) must be clearly identified on the drawings, along with flow-through planter locations and applicable details, and the completed Form SIM and recorded O&M plan must be attached. **END**.



CASE EXAMPLE #5: Commercial Development w/ Parking Lot (North Portland)

A commercial building development with a 5,000 square-foot building footprint and a 5,000 square-foot parking lot will be constructed on a 12,000 square-foot lot in North Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group B (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the depth to groundwater is approximately 70 feet. The lot has slopes less than 2 percent.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy**.

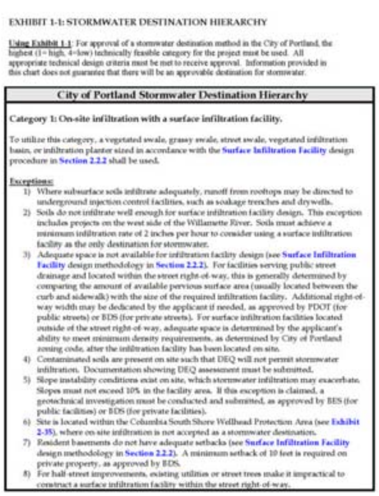


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

Using Exhibit 1-1: For approval of a stormwater destination method in the City of Portland, the highest (1= high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

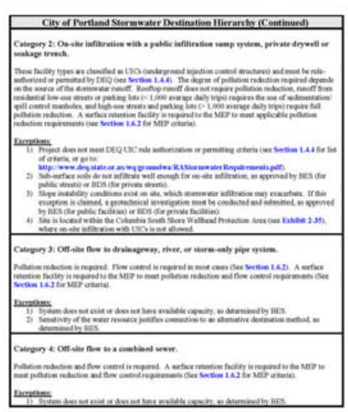
City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

Exceptions:

1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

Exceptions:

1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:

1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:

1) System does not exist or does not have available capacity, as determined by BES.

Under category #1, the Stormwater Destination/Disposal Hierarchy states that where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells. In this case, with B-type soils and mild slopes, on-site infiltration is most likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. In addition to drywells and soakage trenches, other options generally include surface infiltration facilities such as vegetated or grassy swales, infiltration planters, or vegetated infiltration basins. In accordance with the surface infiltration design approach from **Section 2.2.2**, enough storage volume must be provided in the surface infiltration facility to contain the runoff from a 10-year, 24-hour storm. For the rooftop areas, this volume can be approximated by: 0.28 feet x 5,000 square feet = <u>1,400 cubic feet</u>. In this example, there is not adequate space on-site to construct surface infiltration facilities for the rooftop areas.

Under category #1, the 5,000 square-foot parking lot must be evaluated for surface infiltration. In accordance with the surface infiltration design approach in **Section 2.2.2**, enough storage volume must be provided in the surface infiltration facility to contain the runoff from a 10-year, 24-hour storm. For the parking lot, this volume is: 0.28 feet x 5,000 square feet = 1,400 cubic feet. In this example, there is not adequate space on-site to construct surface infiltration facilities to completely dispose of stormwater from the parking lot areas.

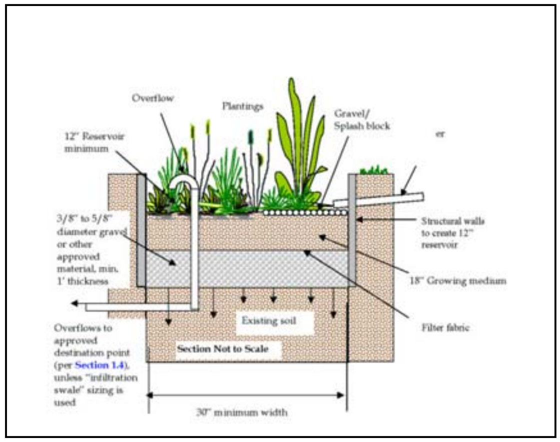
Because there is not enough space on-site for complete surface infiltration, under category #2 the runoff from the parking lot may be infiltrated on-site with a private drywell or soakage trench. A pollution reduction facility or a spill control manhole must also be used to meet pollution reduction requirements.

<u>**Step 2**</u>: Design the drywells, soakage trenches, surface infiltration facilities, and/or pollution reduction facilities in accordance with **Chapter 2.0**: **Stormwater Management Facility Design**. **Exhibit 2-1** can be used to help select a facility type that can utilize the simplified approach for sizing.

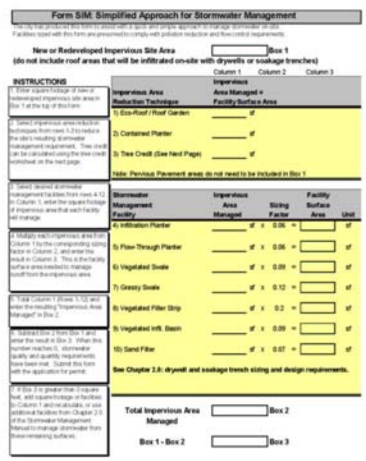
In this example, an infiltration planter will be used to manage stormwater from the parking lot, and the overflow from the planter will be connected to the site's drywell. Drywells and soakage trenches must be registered with DEQ in accordance with **Section 1.4.4**.

Exhibit 2-1: Stormwater Management Facility Application Table

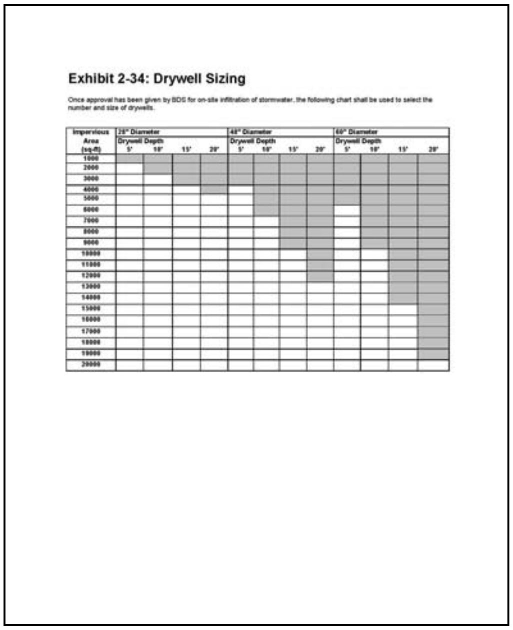
Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination
Eco-roof & roof garden	Simplified[1]	Simplified	NA
Pervious pavement	Simplified[1]	Simplified	Performance
Contained planter	Simplified[1]	Simplified	NA
Tree credit	Simplified[1]	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[2]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[2]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[2]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[2]
Street swales	Simplified[1]	Simplified	Presumptive[2]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[2]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[2]
Sand filter	Simplified[1]	Simplified	Presumptive[2]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Oil/water separator	Presumptive[3]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	NA	Presumptive	Presumptive
Public infil. sump	NA	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive

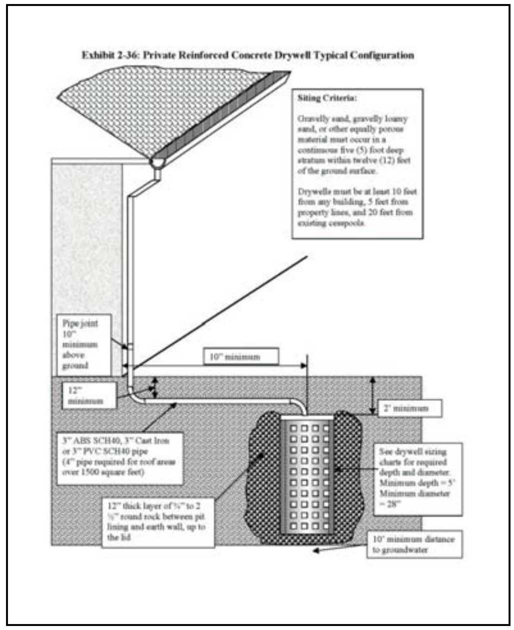


Form SIM will be used to size the infiltration planter to meet pollution reduction requirements. From this form, the sizing factor is 0.06. The required square-footage of planter is: 5,000 square feet (parking lot area) x 0.06 = 300 square feet. The planter will be 3 feet wide by 100 feet long, and will include an overflow catch basin plumbed to an on-site drywell or soakage trench.

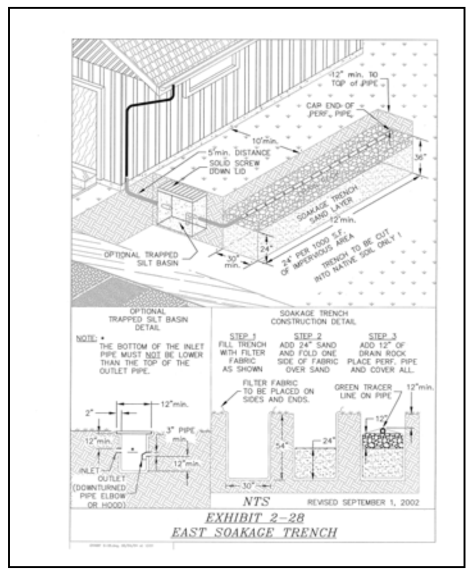


If a drywell is used to infiltrate stormwater from the rooftop, driveway, or parking lot, Exhibit 2-34: **Drywell Sizing** is used. In accordance with this exhibit, a 10-foot-deep, 48-inch-diameter drywell is required to infiltrate stormwater from the 5,000 square-foot impervious rooftop area. If the drywell will be used to infiltrate stormwater from the rooftop and parking lot (10,000 square-feet of impervious area), a 20-foot-deep, 48-inch-diameter drywell is required. The design criteria presented in the private drywell section of Chapter 2.0 must be used to design the drywell, and to locate the facility on-site. Setbacks from building structure must be considered (see Exhibit 2-36). The detailed design and location must be shown on the permit drawings.



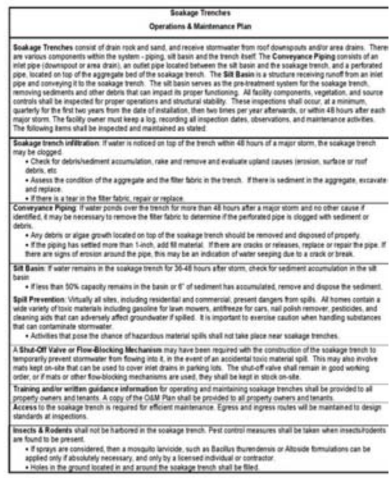


If a soakage trench is used to infiltrate stormwater from the rooftop or parking lot, **Exhibit 2-28**: **East Soakage Trench** is used. In accordance with this exhibit, 24 feet of soakage trench is required per 1,000 square feet of rooftop area. In this example, the length of soakage trench to handle the roof runoff will be: 5,000 * (24/1,000) = <u>120 feet</u> in length. If used for the roof *and* the parking lot, the soakage trench will be: 10,000 * (24/1,000) = <u>240 feet</u>. The design criteria presented in the soakage trench section of Chapter 2.0 must be used to design the trench, and to locate the facility on-site. Setbacks from building structure must be considered. The detailed design and location must be shown on the permit drawings.



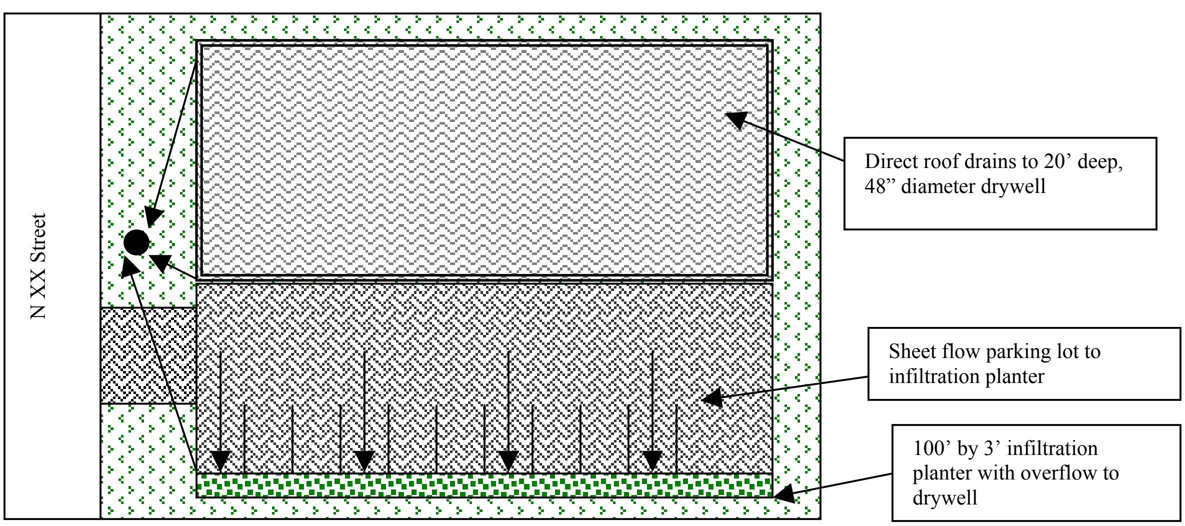
Step 3: Use Chapter 3.0: **Operations & Maintenance** to compile an operations and maintenance plan for the drywell, soakage trench, or other stormwater management facilities used on the site. **Form O&M** must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.


FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)


Soakage Trenches

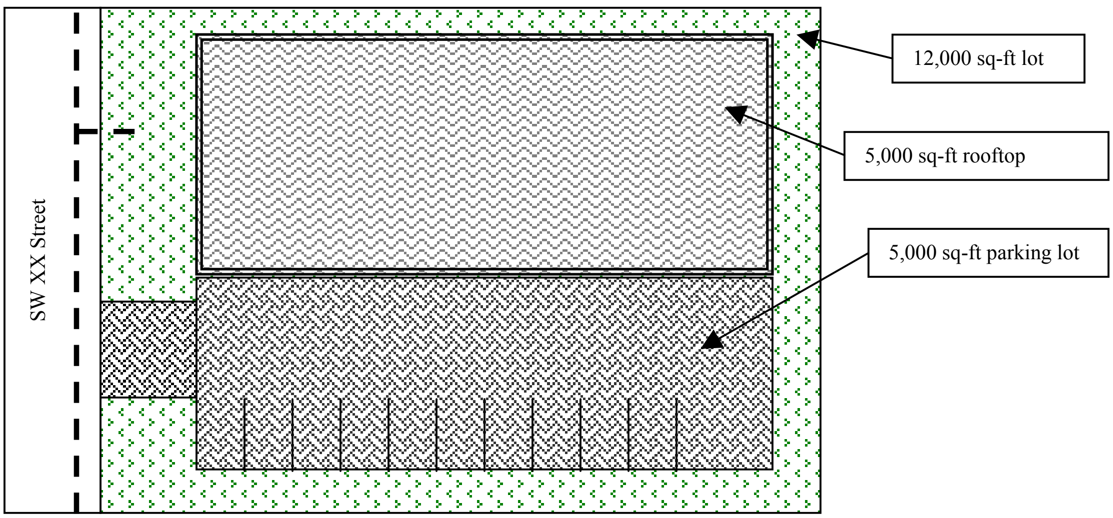
Operations & Maintenance Plan

Step 4: Submit the plans to the city for permitting. The drywell, soakage trenches, or other stormwater management facilities must be shown on the drawings, along with applicable details, Form SIM, and the recorded O&M plan must be attached. **END**.



CASE EXAMPLE #6: Commercial Development w/ Parking Lot (Southwest Portland)

A commercial building development with a 5,000 square-foot building footprint and a 5,000 square-foot parking lot will be constructed on a 12,000 square-foot lot in Southwest Portland. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group C (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the lot has slopes that range from 2 to 5 percent. There is an existing public combined sewer pipe in the frontage street with an existing service lateral to the property.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy**.

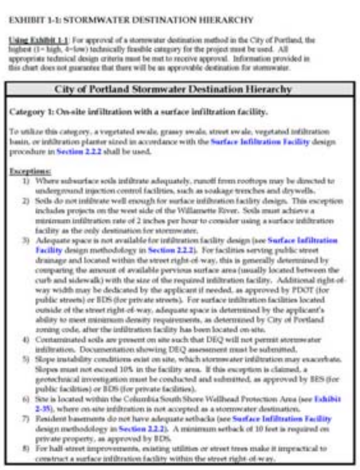


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

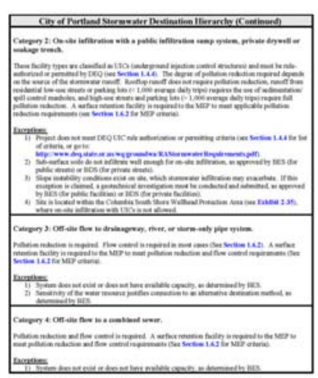
Using Exhibit 1-1: For approval of a stormwater destination method in the City of Portland, the highest (1= high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.

Exceptions:
1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour to consider using a surface infiltration facility as the only destination for stormwater.
3) Adequate space is not available for infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration is not accepted as a stormwater destination.
7) Resident basements do not have adequate setbacks (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). A minimum setback of 10 feet is required on private property, as approved by BDS.
8) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the MEP to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

Exceptions:
1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/UICStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-35**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (See **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control is required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (See **Section 1.6.2** for MEP criteria).

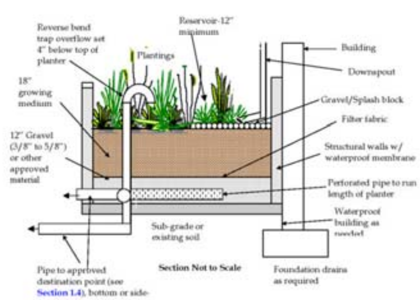
Exceptions:
1) System does not exist or does not have available capacity, as determined by BES.

Category #1 (surface infiltration facilities) and category #2 (on-site infiltration with drywell or soakage trench) depend on project site soils that infiltrate relatively well (2 inches per hour minimum). In this example, with C-type soils and moderate slopes, on-site infiltration is not likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. Category #3 (off-site flow to drainageway, river, or storm-only pipe system) depends on the availability of such resources. Portlandmaps.com or other City maps available at the Development Services Center (1900 SW 4th Avenue) can be used to identify off-site storm systems. In this example, there are no existing storm-only conveyance systems available to serve the site. Where on-site infiltration is not possible, and there is not an available storm-only system to serve the site, category #4 (off-site flow to a combined sewer) may be evaluated for use.

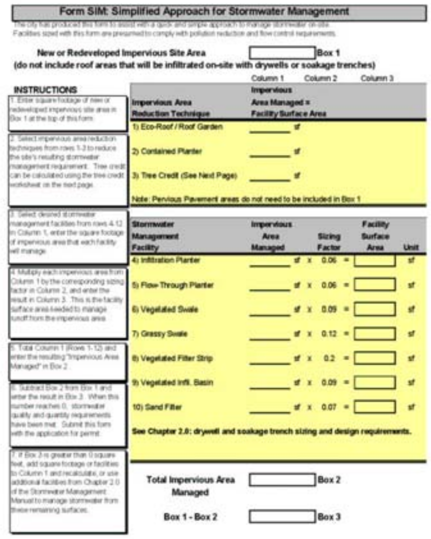
<u>**Step 2**</u>: Choose pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. There are many facility types to choose from that will achieve both pollution reduction and flow control. Options that retain water on-site are required to the maximum extent practicable. Exhibit 2-1 can be used to help choose a facility type that can use the simplified approach for sizing. In this example, flow-through planters will be used to manage stormwater from the rooftop and parking lot, and the overflow and underdrain pipes from the planters will be connected to the public combined sewer in the street. The driveway may use pervious pavement with underdrains connected to the combined sewer, or the runoff may be directed to the flow-through planter.


Exhibit 2-1: Stormwater Management Facility Application Table

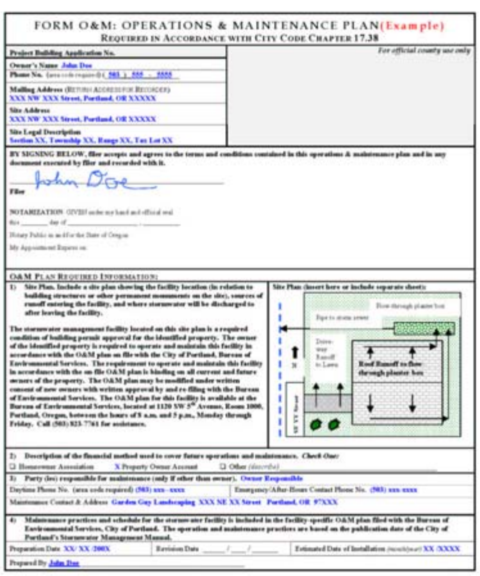
Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination
Eco-roof & roof garden	Simplified[1]	Simplified	NA
Pervious pavement	Simplified[1]	Simplified	Performance
Contained planter	Simplified[1]	Simplified	NA
Tree credit	Simplified[1]	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[2]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[2]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[2]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[2]
Street swales	Simplified[1]	Simplified	Presumptive[2]
Vegetated filter strip	Simplified[1]	Simplified	Presumptive[2]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[2]
Sand filter	Simplified[1]	Simplified	Presumptive[2]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural det. facility	NA	Presumptive	NA
Oil/water separator	Presumptive[3]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	NA	Presumptive	Presumptive
Public infil. sump	NA	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive

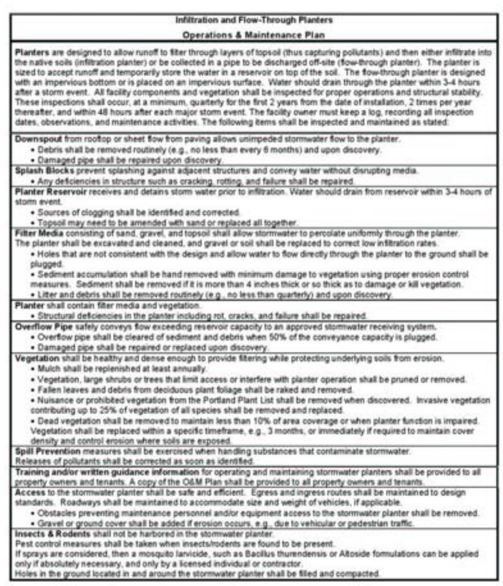


Step 3: Design pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. Form SIM will be used to size the flow-through planters to meet pollution reduction and flow control requirements. From this form, the sizing factor for flow-through planters is 0.06. The required square-footage of planters is: 10,000 square feet x 0.06 = 600 square feet for the roof drainage and the parking lot. The planter can be split up and located at each roof downspout, or the downspouts can be plumbed to one large planter, as long as 300 square feet of flow-through planter is provided for the roof, 300 square feet of planter is provided for the parking lot, and all the planters are connected to the public combined sewer in the street.

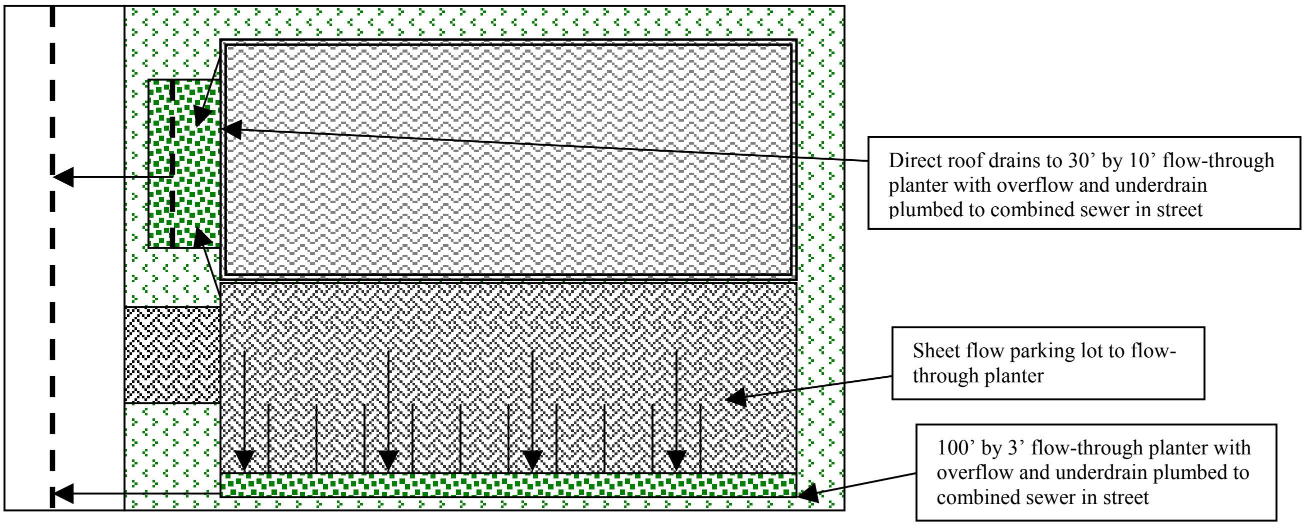


Step 4: Use **Chapter 3.0**: **Operations & Maintenance** to compile an operations and maintenance plan for the flow-through planters used on the site. Form O&M must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.



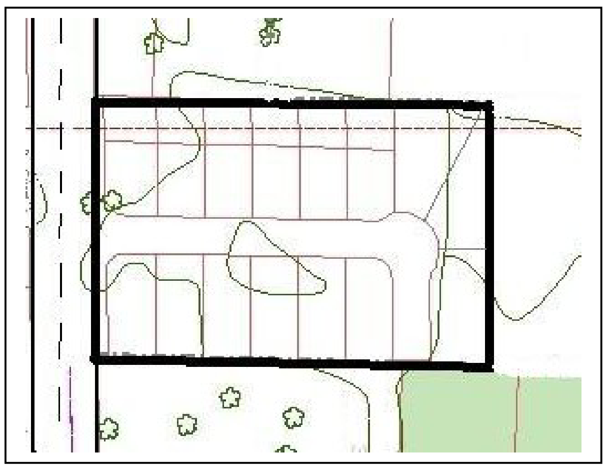


<u>Step 5</u>: Submit the plans to the city for permitting. The stormwater destination (pipe connection to the combined sewer service lateral) must be clearly identified on the drawings, along with flow-through planter locations and applicable details, and the completed Form SIM and recorded O&M plan must be attached. **END**.



CASE EXAMPLE #7: Subdivision w/ Public Street Improvement (Southeast Portland)

A residential subdivision will be developed in Southeast Portland with 14 single-family house lots and public street improvements. Each lot is approximately 5,000 square-feet in size, and the public street improvement will consist of 500 feet of 26-foot-wide street with 6-foot-wide sidewalks on each side. Total street and sidewalk impervious area is 19,000 square-feet. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group B (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the depth to groundwater is approximately 20 feet. The property has slopes less than 2 percent.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy**.

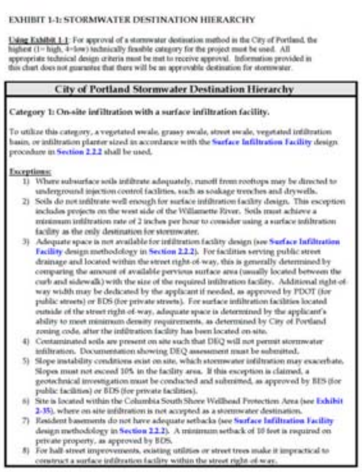
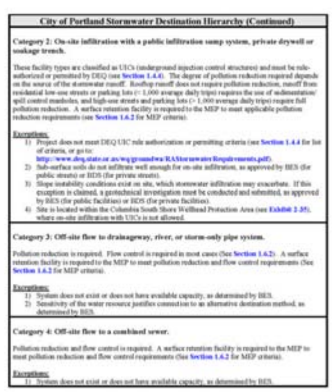


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

To utilize this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2** shall be used.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

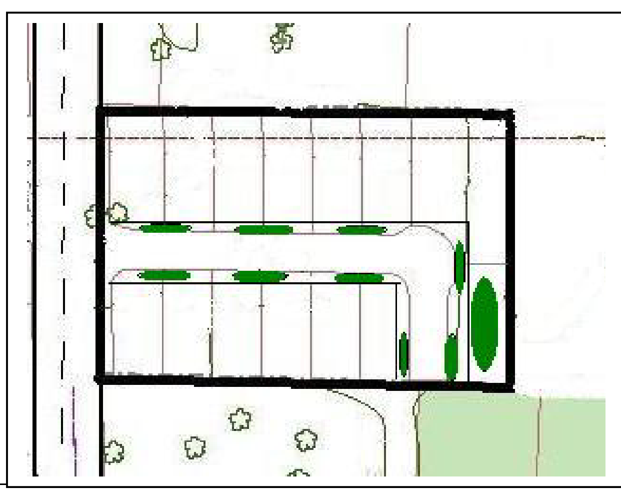
Category 4: Off-site flow to a combined sewer.

Private Home Sites: Under category #1, the Stormwater Destination/Disposal Hierarchy states that where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells. In this case, with B-type soils and mild slopes, on-site infiltration is most likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. Drywells and soakage trenches must have at least 10 feet of separation to the seasonally high groundwater table. In addition to drywells and soakage trenches, other options include surface infiltration facilities such as vegetated or grassy swales, infiltration planters, or vegetated infiltration basins. In addition to the options listed above, the driveways may use pervious pavement or be graded to sheet flow into adjacent lawn areas.

Public Streets: Under category #1, surface infiltration facilities must be evaluated for the public street and sidewalk impervious surfaces. To do this, Section 2.2.2 must be used to determine the square-footage of surface infiltration facility that would be needed, as follows:

1) Determine the preliminary facility size by using **Section 2.2.2** to calculate the runoff volume generated by the 10-year, 24-hour storm. Runoff volume (cubic feet) = 0.28 feet x impervious area (square-feet) = 0.28 feet x 19,000 square-feet = **5,320 cubic feet**. The facility will need to be capable of containing this volume of runoff through a combination of above-ground storage and below-ground storage within voids in subsurface base rock. Check the subdivision for available surface infiltration areas, which can be located within the public rights-of-way between the curb and sidewalk, or on private property in a separate stormwater tract.

Potential surface infiltration areas:



2) If there are sufficient areas on-site to use surface infiltration facilities to meet stormwater destination requirements, infiltration tests must be done to verify that the minimum rate of 2 inches per hour is met, and that the maximum drawdown time for all surface infiltration facilities will not exceed 30 hours.

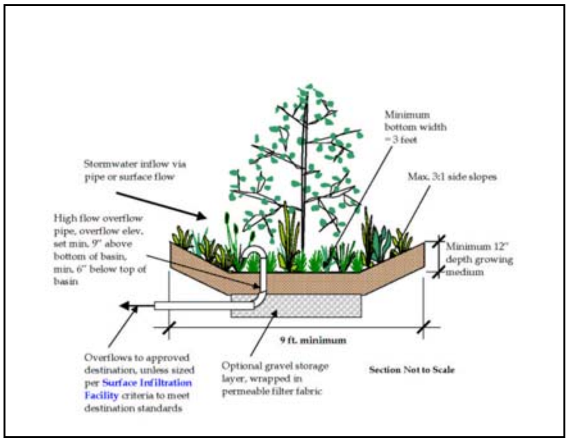
If there are not sufficient areas on-site to use surface infiltration facilities, or the minimum infiltration rate or maximum drawdown requirements are not met, go to destination hierarchy category #2: on-site infiltration with a public infiltration sump system, private drywell, or soakage trench. For the management of public street stormwater, public infiltration sump systems may be used if Oregon Department of Environmental Quality (DEQ) rule authorization criteria (presented in **Section 1.4.4**) can be met, including sufficient separation distance to groundwater and drinking water wells. In this case, adequate separation distance to groundwater (10 feet) does not exist; another option must therefore be pursued. Lots may need to be rearranged or sacrificed to provide more room for surface infiltration facilities.

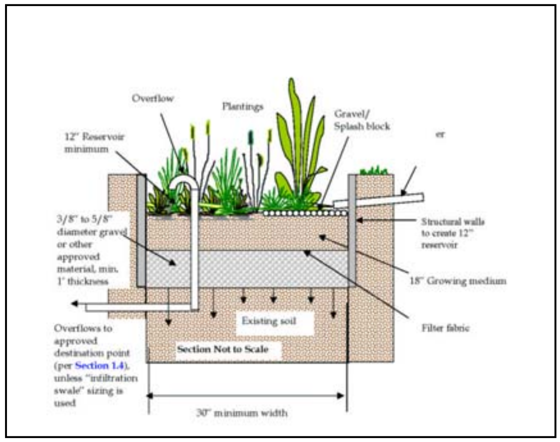
Half-Street Improvements along Existing Public Streets: Half-street improvements along existing public streets that lack curbs, sidewalks, or both are often required at the time of development, and can pose particular stormwater management challenges. Where adequate stormwater destinations exist (existing sump systems, ditches, storm or combined sewer systems), tree mitigation may be used in some cases to meet pollution reduction and flow control obligations. Where this is not possible, the design and construction of a pollution reduction and flow control facility will be required, or in cases where a facility is not practicable and special circumstances are present (see **Section 1.11**), the off-site management fee may be paid.

Step 2: Design the surface infiltration facilities and drywells or soakage trenches in accordance with **Chapter 2.0**: **Stormwater Management Facility Design**.

See **Case Example #1** for the design of drywells, soakage trenches, and surface infiltration facilities for single-family homes.

If surface infiltration facilities are used to infiltrate stormwater from the street and sidewalk areas, they must have a storage volume of 5,320 cubic feet, as discussed under Step 1. If the facilities are to be located within the public right-of-way, the design criteria presented in the street swale section of Chapter 2.0 must be used. For a 7-foot-wide swale with 3-foot by 3-foot rock trench underneath (void ratio = 30 percent), there is approximately 5.5 cubic feet of storage per linear foot. Approximately 970 linear feet of swale would be needed to provide 5,320 cubic feet of storage. Because the new public street is only 500 feet long, and 15 driveways will cross the planting strip between the curb and sidewalk (interrupting the area to be used for swales) there is not enough area within the public right-of-way. A combination of swales within the right-of-way and a surface infiltration facility located in a separate stormwater tract, or a single facility in a separate stormwater tract providing 5,320 cubic feet of storage could be used. The detailed design and location must be shown on the permit drawings.



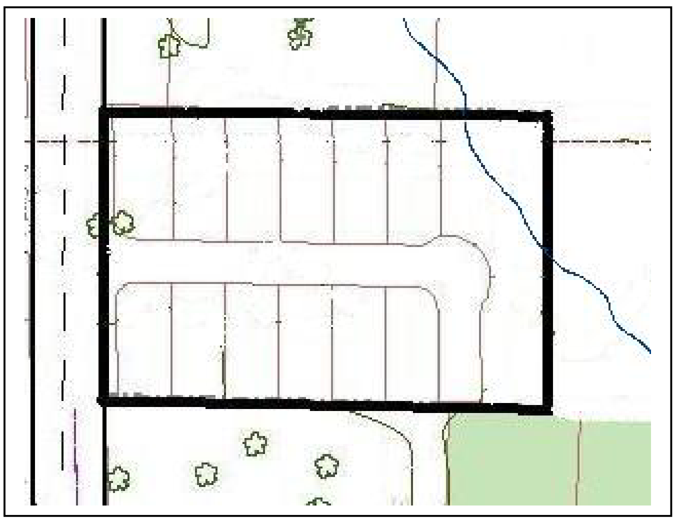


Step 3: Use **Chapter 3.0**: **Operations & Maintenance** to compile an operations and maintenance plan for the surface infiltration facilities, drywells, soakage trenches, or other stormwater management facilities used on the site. **Form O&M** must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.

Step 4: Submit the construction plans to the city for permitting. The stormwater management facilities must be shown on the drawings, along with applicable details. The recorded O&M plans for the private facilities must also be included in the submittal. **END**.

CASE EXAMPLE #8: Subdivision w/ Public Street Improvement (Northwest Portland)

A residential subdivision will be developed in Northwest Portland with 12 single-family house lots and public street improvements. Each lot is approximately 5,000 square-feet in size, and the public street improvement will consist of 500 feet of 26-foot-wide street with 6-foot-wide sidewalks on each side. Total street and sidewalk impervious surface is 19,000 square-feet. Preliminary geotechnical research indicates that the soil in the area belongs to hydrologic soil group C (from the USDA/NRCS Soil Survey of Multnomah County, Oregon), and the property has slopes that range from 2 to 10 percent. There is an existing natural drainageway through the eastern portion of the site.



Step 1: Determine the stormwater disposal point for the site. Use **Exhibit 1-1**: **Stormwater Destination/Disposal Hierarchy**.

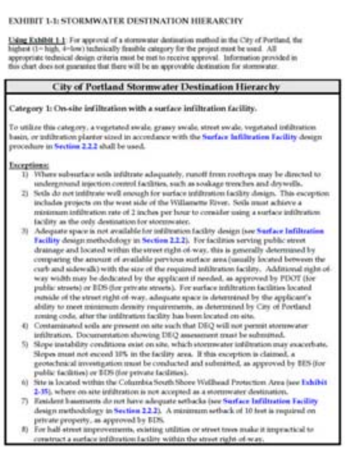
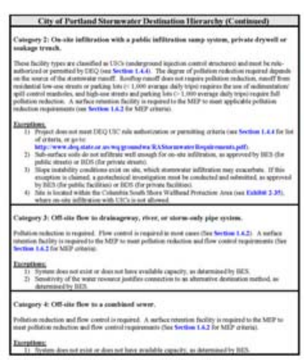


EXHIBIT 1-1: STORMWATER DESTINATION HIERARCHY

City of Portland Stormwater Destination Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.



City of Portland Stormwater Destination Hierarchy (Continued)

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Category 4: Off-site flow to a combined sewer.

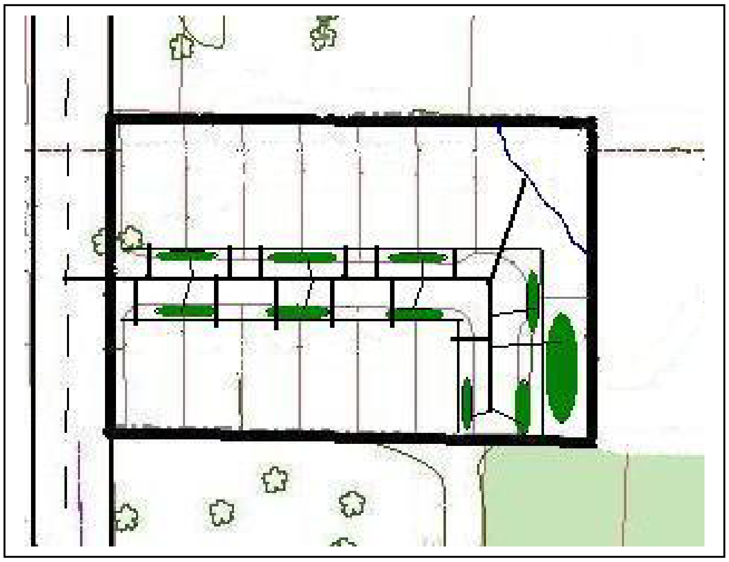
Category #1 (surface infiltration facilities) and category #2 (on-site infiltration with drywell or soakage trench) depend on project site soils that infiltrate relatively well (2 inches per hour minimum). In this example, with C-type soils and moderate slopes, on-site infiltration is not likely feasible. The Environmental Soils section of the Bureau of Development Services (BDS) may be contacted to confirm the viability of infiltration on private property at 503-823-7790. Category #3 (off-site flow to drainageway, river, or storm-only pipe system) depends on the availability of such resources. Portlandmaps.com or other City maps available at the Development Services Center (1900 SW 4th Avenue) can be used to identify off-site storm systems. In this example, there is an existing natural drainageway that will be used, in combination with a public storm sewer extension down the length of the new public street with service laterals to each lot. A Public Works Permit will be required for the construction of the new public storm sewer. When stormwater is being discharged off-site, pollution reduction and flow control are required.

Step 2: Choose pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. For the single-family home sites, there are many facility types to choose from that will achieve both pollution reduction and flow control. Exhibit 2-1 can be used to help choose a facility type that can use the simplified approach for sizing, such as flow-through planters of vegetated swales.

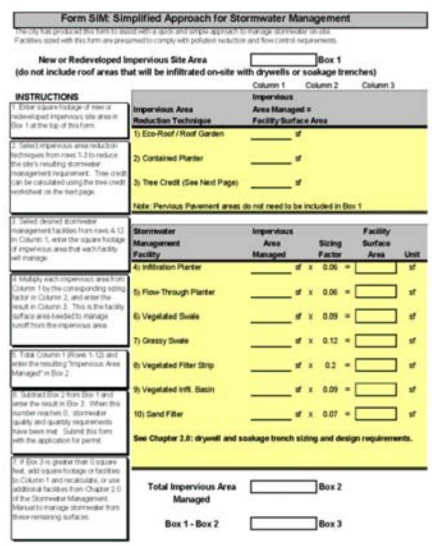
Facilities will be needed on each lot, with overflows piped to the new public storm sewer in the street. Driveways may use pervious pavement; may be graded to sheet flow into adjacent lawn areas if sufficiently sized in accordance with vegetated filter design criteria (at least 1 square foot of lawn area per 5 square feet of driveway area, lawn area must be at least 10 feet by 10 feet); or may be directed to the flow-through planters or vegetated swales.

For the public street and sidewalk areas, vegetated swales within the public right-of-way will be used to meet pollution reduction and flow control requirements.

Potential vegetated street swale locations, with new public storm sewer extension:



<u>Step 3</u>: Design pollution reduction and flow control facilities from **Chapter 2.0**: **Stormwater Management Facility Design**. Form SIM will be used to size the vegetated street swales to meet pollution reduction and flow control requirements. From this form, the sizing factor for vegetated swales is 0.09. The required square-footage of swales is: 19,000 square feet x 0.09 = <u>1,710 square feet</u>. If the width of the swales is 7 feet, the required total length of swales is <u>244 feet</u>.



Form SIM: Simplified Approach for Stormwater Management

The city has produced this form to assist with a quick and simple approach to manage stormwater on-site. Facilities sized with this form are presumed to comply with pollution reduction and flow control requirements.

New or Redeveloped Impervious Site Area ______ Box 1
(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)

INSTRUCTIONS

1. Enter square footage of new or redeveloped impervious site area in Box 1 at the top of this form.
2. Select impervious area reduction techniques from rows 1-3 to reduce the site's resulting stormwater management requirement. Tree credit can be calculated using the tree credit worksheet on the next page.
3. Select desired stormwater management facilities from rows 4-12 in Column 1, enter the square footage of impervious area that each facility will manage.
4. Multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the facility surface area needed to manage runoff from the impervious area.
5. Total Column 1 (Rows 1-12) and enter the resulting "Impervious Area Managed" in Box 2.
6. Subtract Box 2 from Box 1 and enter the result in Box 3. When this number reaches 0, stormwater quality and quantity requirements have been met. Submit this form with the application for permit.
7. If Box 2 is greater than 0 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from Chapter 2.0 of the Stormwater Management Manual to manage stormwater from these remaining surfaces.

Impervious Area Reduction Technique	Column 1: Impervious Area Managed = Facility Surface Area
1) Eco-Roof / Roof Garden	______ sf
2) Contained Planter	______ sf
3) Tree Credit (See Next Page)	______ sf

Note: Pervious Pavement areas do not need to be included in Box 1

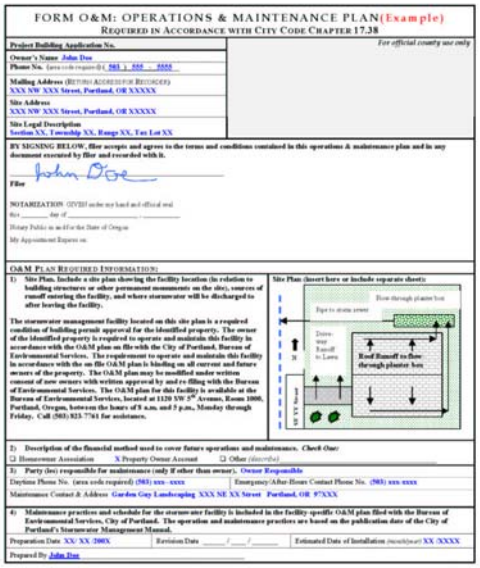
Stormwater Management Facility	Column 1: Impervious Area Managed		Column 2: Sizing Factor		Column 3: Facility Surface Area	Unit
4) Infiltration Planter	______ sf	x	0.06	=		sf
5) Flow-Through Planter	______ sf	x	0.06	=		sf
6) Vegetated Swale	______ sf	x	0.09	=		sf
7) Grassy Swale	______ sf	x	0.12	=		sf
8) Vegetated Filter Strip	______ sf	x	0.2	=		sf
9) Vegetated Infil. Basin	______ sf	x	0.09	=		sf
10) Sand Filter	______ sf	x	0.07	=		sf

See Chapter 2.0: drywell and soakage trench sizing and design requirements.

Total Impervious Area Managed ______ Box 2

Box 1 - Box 2 ______ Box 3

Step 4: Use Chapter 3.0: **Operations & Maintenance** to compile an operations and maintenance plan for the private stormwater management facilities used on the site. Form O&M must be filled out and recorded with the applicable county prior to submission to the city with the permit drawings.


FORM O&M: OPERATIONS & MAINTENANCE PLAN(Example)
REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

Project Building Application No.
For official county use only
Owner's Name John Doe
Phone No. (area code required) (503) 555 - 5555
Mailing Address (RETURN ADDRESS FOR RECORDER)
XXX NW XXX Street, Portland, OR XXXXX
Site Address
XXX NW XXX Street, Portland, OR XXXXX
Site Legal Description
Section XX, Township XX, Range XX, Tax Lot XX

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

John Doe
Filer

NOTARIZATION
Notary Public in and for the State of Oregon
My Appointment Expires on

O&M PLAN REQUIRED INFORMATION:

1) Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility.

The stormwater management facility located on this site plan is a required condition of building permit approval for the identified property. The owner of the identified property is required to operate and maintain this facility in accordance with the O&M plan on file with the City of Portland, Bureau of Environmental Services. The requirement to operate and maintain this facility in accordance with the on file O&M plan is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the Bureau of Environmental Services. The O&M plan for this facility is available at the Bureau of Environmental Services, located at 1120 SW 5th Avenue, Room 1000, Portland, Oregon, between the hours of 8 a.m. and 5 p.m., Monday through Friday. Call (503) 823-7761 for assistance.

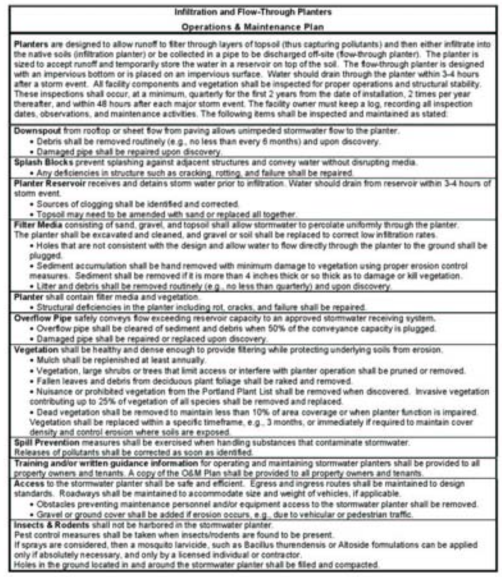
Site Plan (insert here or include separate sheets)

2) Description of the financial method used to cover future operations and maintenance. Check One:
☐ Homeowner Association X Property Owner Account ☐ Other (describe)

3) Party (ies) responsible for maintenance (only if other than owner). Owner Responsible
Daytime Phone No. (area code required) (503) xxx-xxxx
Emergency/After-Hours Contact Phone No. (503) xxx-xxxx
Maintenance Contact & Address Garden Guy Landscaping XXX NE XX Street Portland, OR 97XXX

4) Maintenance practices and schedule for the stormwater facility is included in the facility specific O&M plan filed with the Bureau of Environmental Services, City of Portland. The operation and maintenance practices are based on the publication date of the City of Portland's Stormwater Management Manual.

Preparation Date XX/ XX /200X
Revision Date ___/___/___
Estimated Date of Installation (month/year) XX /XXXX
Prepared By John Doe


Infiltration and Flow-Through Planters
Operations & Maintenance Plan

Planters are designed to allow runoff to filter through layers of topsoil (thus capturing pollutants) and then either infiltrate into the native soils (infiltration planter) or be collected in a pipe to be discharged off-site (flow-through planter). The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil. The flow-through planter is designed with an impervious bottom or is placed on an impervious surface. Water should drain through the planter within 3-4 hours after a storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Downspout from rooftop or sheet flow from paving allows unimpeded stormwater flow to the planter.
- Debris shall be removed routinely (e.g., no less than every 6 months) and upon discovery.
- Damaged pipe shall be repaired upon discovery.

Splash Blocks prevent splashing against adjacent structures and convey water without disrupting media.
- Any deficiencies in structure such as cracking, rotting, and failure shall be repaired.

Planter Reservoir receives and detains storm water prior to infiltration. Water should drain from reservoir within 3-4 hours of storm event.
- Sources of clogging shall be identified and corrected.
- Topsoil may need to be amended with sand or replaced all together.

Filter Media consisting of sand, gravel, and topsoil shall allow stormwater to percolate uniformly through the planter. The planter shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates.
- Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged.
- Sediment accumulation shall be hand removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Litter and debris shall be removed routinely (e.g., no less than quarterly) and upon discovery.

Planter shall contain filter media and vegetation.
- Structural deficiencies in the planter including rot, cracks, and failure shall be repaired.

Overflow Pipe safely conveys flow exceeding reservoir capacity to an approved stormwater receiving system.
- Overflow pipe shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged.
- Damaged pipe shall be repaired or replaced upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.
- Mulch shall be replenished at least annually.
- Vegetation, large shrubs or trees that limit access or interfere with planter operation shall be pruned or removed.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or prohibited vegetation from the Portland Plant List shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within a specific timeframe, e.g., 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining stormwater planters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the stormwater planter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.
- Obstacles preventing maintenance personnel and/or equipment access to the stormwater planter shall be removed.
- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored in the stormwater planter.
Pest control measures shall be taken when insects/rodents are found to be present.
If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
Holes in the ground located in and around the stormwater planter shall be filled and compacted.

Step 5: Submit the plans to the city for permitting. The stormwater management facilities must be clearly identified on the drawings, along with applicable details, and the completed Form SIM and recorded O&M plan must be attached. **END**.

Chapter 1.0
GENERAL REQUIREMENTS & POLICIES

Summary of Chapter 1.0

This chapter outlines the City of Portland's stormwater management requirements and identifies who is required to conform to them. It includes:

1.1 PURPOSE AND APPLICABILITY OF MANUAL

1.1.1 Purpose of Manual

Stormwater management is a key element in maintaining and enhancing the City's livability. As the City is developed, the impervious surfaces that are created increase the amount of runoff during rainfall events, disrupting the natural hydrologic cycle. Without control, these conditions erode stream channels, prevent groundwater recharge, and are the cause of combined sewer overflows (CSOs) and basement sewer backups. Parking lots, roadways, rooftops, and other impervious surfaces increase the pollution levels and temperature of stormwater runoff that is transported to streams, rivers, and groundwater resources. Protecting these waters is vital for a great number of reasons, including fish and wildlife habitat, human health, recreation, and drinking water.

The purpose of this *Stormwater Management Manual* is to provide stormwater management principles and techniques that help preserve or mimic the natural hydrologic cycle, minimize sewer system problems, and achieve water quality goals. The manual provides developers and design professionals with specific requirements for reducing the impacts of increased stormwater runoff flow quantity and pollution resulting from new development and redevelopment.

1.1.2 Applicability of Manual

This manual's requirements apply to all projects within the City of Portland, whether public or private.

- Projects of any size are required to comply with stormwater destination/ disposal requirements as identified in **Section 1.4** of this manual. Specific facility designs that meet these requirements are presented in **Chapter 2.0**.

- All projects developing or redeveloping over 500 square feet of impervious surface, or existing properties proposing new stormwater discharges off-site, are required to comply with pollution reduction and flow control requirements, presented in **Sections 1.5** and **1.6**, respectively. Specific facility designs that meet these requirements are presented in **Chapter 2.0**.

- All projects constructing destination/disposal, pollution reduction, or flow control facilities are also required to comply with operations and maintenance requirements, as outlined in **Chapter 3.0**.

- Projects that are classified as high risk because of certain site characteristics or activities (listed in **Section 4.1.1**) must comply with the source control requirements identified in **Chapter 4.0**.

1.2 SUMMARY OF MANUAL CONTENTS

How to Use This Manual, provides a flow chart for the navigation of the manual for projects of all sizes and types. It also takes a number of example projects step-by-step through the manual.

Chapter 1.0: General Requirements & Policies, outlines the purpose and applicability of this manual and defines terms. It outlines pollution reduction, flow control, and destination/disposal requirements, explains the rules for connecting to existing systems, and differentiates public and private stormwater management systems. This chapter also discusses the City's policies regarding the protection of open drainageways. Finally, it identifies special circumstances that may make it impractical to implement on-site pollution reduction or flow control to the standards specified in this manual.

Chapter 2.0: Stormwater Management Facility Design, provides methods for selecting and designing stormwater management facilities that accomplish pollution reduction, flow control, and/or destination/disposal standards. The "simplified," "presumptive," and "performance" approaches are presented.

Chapter 3.0: Operations & Maintenance, presents operations and maintenance (O&M) requirements and provides templates for stormwater management facility O&M plans.

Chapter 4.0: Source Controls, addresses site activities and characteristics with the potential to generate pollutants that may not be addressed solely through the pollution reduction facilities presented in Chapter 2.0. It identifies when and what kinds of source controls are required.

Appendix A: City Code Chapter 17.38, Policy Framework, Appeals & Update Process, contains the section of City Code that includes stormwater management policies and standards and that officially recognizes the City's *Stormwater Management Manual*. The appendix also includes the policy framework for the City's stormwater management requirements, the appeals process, and the process for updating this manual.

Appendix B: Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies, describes the City's testing protocol for acceptance of stormwater pollution reduction facilities. It includes a detailed definition of the City's basic pollution reduction requirement of 70 percent total suspended solids (TSS) removal.

Appendix C: Santa Barbara Urban Hydrograph Method, describes the Santa Barbara Urban Hydrograph method of computing stormwater runoff hydrographs. It includes the City's 24-hour rainfall depths, formulas for computing time of concentration, and runoff curve numbers.

Appendix D: Simplified Approach Sizing Calculations, provides a sample of the method used to calculate the simplified approach sizing factors.

Appendix E: Pollution Reduction Storm Report, outlines the rationale behind the development of Portland's pollution reduction storm intensity and volume, and the associated goal of treating 90 percent of the average annual runoff.

Appendix F: Facility Planting & Soil Recommendations, presents recommended plant species, soil, and design information for landscaped stormwater management facilities.

Appendix G: Supplemental Drawings, includes color cross-section and plan view drawings of many stormwater management facilities, as well as example planting plans.

Appendix H: Stormwater Facility Photos, provides a number of stormwater management facility photos, with site addresses.

References & Resources

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1.3 DEFINITIONS

Note: All definitions are used in this manual and are intended to be consistent with City Code Chapters 17.34, 17.38, and 17.39. Some references to specific chapters or sections are included to assist the user in manual navigation.

Above-Ground Storage of Liquid Materials (**Section 4.3**): Places where exterior storage (either permanent or temporary) of liquid chemicals, food products, waste oils, solvents, or petroleum products in above-ground containers, in quantities of 50 gallons or more exist.

Aboveground Storage Tank (AST)**:** A stationary container, vessel, or other permanent holding device designated for the storage and/or distribution of a liquid product.

Applicant: Any person, company, or agency that applies for a permit through the City of Portland.

Approved Receiving System (Destination): Any system approved by BES to receive stormwater runoff or other discharges. Receiving systems include, but are not limited to, groundwater; on-site, off-site, or public stormwater, sanitary, or combined sewers; and waters of the state.

Batch Discharge**:** The controlled discharge of a discrete, contained volume of water or wastewater. Batch discharges into the public sewer system must conform to the requirements of City Code sections 17.34- Industrial Wastewater Discharges; and 17.39- Stormwater Discharge.

BDS: Bureau of Development Services, City of Portland.

BES: Bureau of Environmental Services, City of Portland.

Bioretention Facility: A facility that utilizes soils and both woody and herbaceous plants to remove pollutants from stormwater runoff. Examples of bioretention facilities in this manual can include vegetated swales, flow-through and infiltration planters, vegetated filters, and vegetated infiltration basins.

Bulk Fuel Terminal**:** Any area with its primary function dedicated to the storage and distribution of fuel to distributors (such as gas stations).

Bulk Materials**:** Non-containerized materials.

***Bulk Material Transportation Route*:** Any path routinely used to transport materials regulated in **Section 4.5** onto, off of, or within a site.

Capacity: The capacity of a stormwater drainage system is the flow volume or rate that a facility (e.g., pipe, pond, vault, swale, ditch, drywell, etc.) is designed to safely contain, receive, convey, reduce pollutants from or infiltrate stormwater to meet a specific performance standard. There are different performance standards for pollution reduction, flow control, conveyance, and destination/ disposal, depending on location.

Catch Basin: A structural facility located just below the ground surface, used to collect stormwater runoff for conveyance purposes. Generally located in streets and parking lots, catch basins have grated lids, allowing stormwater from the surface to pass through for collection. Catch basins also include a sumped bottom and submerged outlet pipe (downturned 90 degree elbow, hood, or baffle board) to trap coarse sediment and oils.

Combined (or Combination) Sewers: Pipes that convey both sanitary sewage and stormwater.

Constructed Treatment Wetlands: A wetland-like facility designed and constructed for the specific purpose of providing stormwater management. Unlike natural wetlands (see definition), constructed treatment wetlands are not regulated by the Corps of Engineers or the Division of State Lands. See **Chapter 2.0** for information regarding the design of constructed treatment wetlands.

Contained Planter: A structural facility filled with topsoil and planted with vegetation. When placed over impervious surfaces such as sidewalks or flat rooftops, contained planters intercept rainfall that would otherwise contribute to stormwater runoff. See **Chapter 2.0** for information regarding the design of contained planters.

***Containerized*:** The storage of any product, by-product, or waste that is completely held or included on all sides, within a discrete volume or area.

***Containment*:** The temporary storage of potentially contaminated stormwater or process wastewater when a City sanitary sewer is not available for appropriate discharge.

Control Structure: A device used to hold back or direct a calculated amount of stormwater to or from a stormwater management facility. Typical control structures include vaults or manholes fitted with baffles, weirs, or orifices. See **Chapter 2.0** for information regarding the design of control structures.

Conveyance: The transport of stormwater or wastewater from one point to another.

Covered Vehicle Parking Areas (**Section 4.9**): Covered vehicle parking structures used to cover parked vehicles other than single-level covers, such as canopies, overhangs, and carports.

CSO (Combined Sewer Overflow): A discharge of a mixture of sanitary sewage and stormwater at a point in the combination sewer system designed to relieve surcharging flows.

DEQ: The Oregon Department of Environmental Quality.

Destination: The ultimate discharge point for the stormwater from a particular site, also known as the stormwater disposal point. Destinations can include on-site infiltration (surface infiltration facilities, drywells, sumps, and soakage trenches) and off-site flow to ditches, drainageways, rivers and streams, off-site storm pipes, and off-site combination sewers. See **Section 1.4** for information regarding destination requirements.

Detention Facility: A facility designed to receive and hold stormwater and release it at a slower rate, usually over a number of hours. The full volume of stormwater that enters the facility is eventually released.

Detention Tank, Vault, or Oversized Pipe: A structural subsurface facility used to provide flow control for a particular drainage basin. See **Chapter 2.0** for information regarding the design of detention tanks, vaults, and oversized pipes.

Development: Any human-induced change to improved or unimproved real estate, whether public or private, for which a permit is required, including but not limited to construction, installation, or expansion of a building or other structure, land division, street construction, drilling, and site alteration such as dredging, grading, paving, parking or storage facilities, excavation, filling, or clearing. Development encompasses both new development and redevelopment.

Development Footprint: The new or redeveloped area covered by buildings or other roof structures and other impervious surface areas, such as roads, parking lots, and sidewalks.

Disposal: See definition of *Destination*.

Drainage Basin: A specific area that contributes stormwater runoff to a particular point of interest, such as a stormwater management facility, drainageway, wetland, river, or pipe.

Drainageway: An open linear depression, whether constructed or natural, which functions for the collection and drainage of surface water. It may be permanently or temporarily inundated.

Driveway**:** The area that provides vehicular access to a site. A driveway begins at the property line and extends into the site. In parking areas, the driveway does not include vehicular parking, maneuvering, or circulation areas.

Dry Detention Pond: A surface vegetated basin used to provide flow control for a particular drainage basin. Stormwater temporarily fills the dry detention pond during large storm events and is slowly released over a number of hours, reducing peak flow rates. See **Chapter 2.0** for information regarding the design of dry detention ponds.

Drywell: A structural subsurface cylinder or vault with perforated sides and/or bottom, used to infiltrate stormwater into the ground. See **Chapter 2.0** for information regarding the design and use of drywells.

Ecoroof: A lightweight low-maintenance vegetated roof system used in place of a conventional roof. Ecoroofs provide stormwater management by capturing, filtering, and evaporating rainfall. See **Chapter 2.0** for information regarding the design of ecoroofs.

Equipment and/or Vehicle Washing Facilities (**Section 4.7**): Designated equipment and/or vehicle washing or steam cleaning areas. This includes smaller activity areas such as wheel washing stations.

Extended Wet Detention Pond: A surface vegetated basin with a permanent pool of water and additional storage volume, used to provide pollution reduction and flow control for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. During large storm events, stormwater temporarily fills the additional storage volume and is slowly released over a number of hours, reducing peak flow rates. See **Chapter 2.0** for information regarding the design of extended wet detention ponds.

Exterior Materials Storage Area**:** Any outdoor materials storage location that is not completely enclosed by a roof and sidewalls.

Exterior Storage of Bulk Materials (**Section 4.5**): Outdoor areas used to stockpile erodible materials.

Flow Control: The practice of limiting the release of peak flow rates and volumes from a site. Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increased stormwater runoff peak flow rates and volumes resulting from development.

Flow Control Facility: Any structure or drainage device that is designed, constructed, and maintained to collect, retain, infiltrate, or detain surface water runoff during and after a storm event for the purpose of controlling post-development quantity leaving the site.

Flow-Through Planter: A structural facility filled with topsoil and gravel and planted with vegetation. The planter is completely sealed, and a perforated collection pipe is placed under the soil and gravel, along with an overflow provision, and directed to an acceptable destination point. The stormwater planter receives runoff from impervious surfaces, which is filtered and retained for a period of time. See **Chapter 2.0** for information regarding the design of flow-through planters.

Fuel Dispensing Facilities (**Section 4.2**): Areas where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above ground fuel tanks, fuel pumps, and the surrounding pad). This definition applies to large-sized gas stations as well as single-pump fueling operations.

Grassy Swale (or Bioswale): A long and narrow, trapezoidal or semicircular-shaped channel, planted with a dense grass mix. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle and filter out. See **Chapter 2.0** for information regarding the design of grassy swales.

***Hazardous Material*:** Any material or combination of materials that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or that may pose a present or potential hazard to human health, safety, or welfare, or to animal or aquatic life or the environment when improperly used, stored, transported or disposed of, or otherwise managed. For purposes of chemical regulation by this manual, moderate to high toxicity and confirmed human carcinogenicity are the criteria used to identify hazardous substances.
(Note: This manual does not use the Resource Conservation and Recovery Act (RCRA) definition of hazardous. For the purpose of this manual, hazardous material is intended to include hazardous, toxic, and other harmful substances.)

***Hazardous Material Containment Zone (HMC Zone)*:** An area where a specific individual activity involving use of a hazardous material takes place, and where chemical quantities at that location are expected to exceed defined thresholds. HMCs may include (but are not limited to) storage and/or process areas, transportation routes, work areas, and loading/unloading facilities.

High-Risk Site: A site with characteristics and/or activities that have the potential to generate pollutants that may not be addressed solely through the pollution reduction facilities presented in Chapter 2.0. High-risk site characteristics and activities are listed in **Section 4.1.1**.

Impervious Surface/Area: Any surface that has a runoff coefficient greater than 0.8 (as defined in BES's *Sewer Design Manual*, Chart 10: Runoff Coefficients). Types of impervious surface include rooftops, traditional asphalt and concrete parking lots, driveways, roads, sidewalks, and pedestrian plazas. *Note:* Slatted decks are considered pervious. Gravel surfaces are considered pervious unless they cover impervious surfaces or are compacted to a degree that causes their runoff coefficient to exceed 0.8.

Infiltration: The percolation of water into the ground.

Infiltration Planter: A structural facility filled with topsoil and gravel and planted with vegetation. The planter has on open bottom, allowing water to infiltrate into the ground. Stormwater runoff from impervious surfaces is directed into the planter, where it is filtered and infiltrated into the surrounding soil. See **Chapter 2.0** for information regarding the design of infiltration planters.

Inlet: A structure located just below the ground surface, used to collect stormwater runoff. Generally located in streets and parking lots, inlets have grated lids, allowing stormwater from the surface to pass through for collection. The term "inlet" is also used in reference to the point at which stormwater from impervious surfaces or conveyance piping enters a stormwater management facility.

Landscaping: See definition of *Stormwater Facility Landscaping*.

***LD-50*:** The lethal dose of a substance that is expected to kill approximately 50 percent of experimental animals through oral ingestion. (Refer to product Material Safety Data Sheet.)

***Local Dispensing Location*:** An area within 15 feet of an aboveground storage tank (AST) and used to dispense fuel directly from the AST, typically through a flexible hose.

Manufactured Stormwater Treatment Technology: A proprietary structural facility or device used to remove pollutants from stormwater. Refer to **Chapter 2.0** and **Appendix B** for approval criteria related to manufactured stormwater treatment technologies.

Material Transfer Areas/Loading Docks (**Section 4.6**): Areas designed to accommodate a truck/trailer being backed up to or into them, and used specifically to receive or distribute materials to and/or from trucks/trailers. Includes loading/unloading facilities with docks, and large bay doors without docks.

Maximum Extent Practicable (MEP): See definition of *Practicable*. A term used in the Clean Water Act.

Multi-Level Parking Structure**:** Any parking facility with greater than one continuous level of parking.

Off-site stormwater facility: Any stormwater management facility located outside the property boundaries of a specific development, but designed to provide stormwater management benefits for that development.

On-site stormwater facility: Any stormwater management facility located within the property boundaries of a specific development, and designed to provide stormwater management benefits for that development.

Open Channel: A fluid passageway which allows part of the fluid to be exposed to the atmosphere.

Operations and Maintenance (O&M): The continuing activities required to keep stormwater management facilities and their components functioning in accordance with design objectives. See **Chapter 3.0** regarding operations and maintenance requirements for stormwater management facilities.

Outfall: A location where collected and concentrated water is discharged. Outfalls can include discharge from stormwater management facilities, drainage pipe systems, and constructed open channels. See **Chapter 2.0** for information regarding the design of outfalls.

Parking Area**:** The area of a site devoted to the temporary or permanent storage, maneuvering, or circulation of motor vehicles. Parking areas do not include driveways or areas devoted exclusively to non-passenger loading.

PDOT: Portland Department of Transportation.

Permeable Pavement: See definition of *Pervious Pavement*.

Pervious Pavement: The numerous types of pavement systems that allow stormwater to percolate through them and into subsurface drainage systems or the ground. See **Chapter 2.0** for design requirements related to pervious pavement. Also referred to as porous or permeable pavement.

Pollutant: An elemental or physical material that can be mobilized or dissolved by water or air and creates a negative impact to human health and/ or the environment. Pollutants include suspended solids (sediment), heavy metals (such as lead, copper, zinc, and cadmium), nutrients (such as nitrogen and phosphorus), bacteria and viruses, organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers), floatable debris, and increased temperature.

Pollutants of Concern: Watershed-specific parameters identified by the Oregon Department of Environmental Quality (DEQ) as having a negative impact on the receiving water body. Pollutants of concern can include suspended solids, heavy metals, nutrients, bacteria and viruses, organics, floatable debris, and increased temperature.

Pollution Reduction: The practice of filtering, retaining, or detaining surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality.

Pollution Reduction Facility: A structure, landscape, or drainage device that is designed, constructed, and maintained to collect and filter, retain, or detain surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality.

Porous Pavement: See definition of *Pervious Pavement*.

Post-Developed Condition: As related to new or redevelopment: A site's ground cover and grading after development.

Practicable: Available and capable of being done as determined by the BES Director, after taking into consideration cost, existing technology, and logistics in light of overall project purpose.

Pre-Developed Condition: As related to new development: A site's ground cover and grading prior to development. Pre-developed condition, as related to redevelopment, is a site's ground cover and grading prior to any development taking place, i.e. Lewis & Clark days.

Public Facility: A street, right-of-way, sewer, drainage, stormwater management, or other facility that is either currently owned by the City or will be conveyed to the City for maintenance responsibility after construction. A new stormwater management facility that receives direct stormwater runoff from a public right-of-way shall become a public (City-maintained) facility unless the right-of-way is not part of the City's road maintenance system.

Public Works Project: Any development (excluding public buildings) conducted or financed by a local, state, or federal governmental body, including local improvements and public improvements, as defined in Portland City Code Title 17, PUBLIC IMPROVEMENTS.

Rainwater Harvesting: The practice of collecting and using stormwater for purposes such as irrigation and toilet flushing. See **Chapter 2.0** for information regarding rainwater harvesting.

Recycled Land (**Section 4.8**): Land that currently has or previously has had pollutants detected in the soil or groundwater at concentrations that exceed risk-based cleanup levels or state/federal cleanup standards for the particular pollutant(s). Requirements of Section 4.8 may also apply to development projects that are bordered by these properties.

Redevelopment: Any development that requires demolition or complete removal of existing structures or impervious surfaces at a site and replacement with new impervious surfaces. Maintenance activities such as top-layer grinding, re-paving, and re-roofing are not considered to be redevelopment. Interior remodeling projects and tenant improvements are also not considered to be redevelopment. Utility trenches in streets are not considered redevelopment unless more than 50% of the street width is removed and re-paved.

Retention Facility: A facility designed to receive and hold stormwater runoff. Rather than storing and releasing the entire runoff volume, retention facilities permanently retain a portion of the water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation. In this way, the full volume of stormwater that enters the facility is not released off-site.

Roadway**:** Any paved surface used to carry vehicular traffic (cars/trucks, forklifts, farm machinery, or any other large machinery).

Roof Garden: A heavyweight roof system of waterproofing material with a thick soil and vegetation cover. Roof gardens provide stormwater management by capturing, filtering, and evaporating rainfall. See **Chapter 2.0** for information regarding the design of roof gardens.

Runoff: Stormwater flows across the ground surface during and after a rainfall event. Also simply referred to as stormwater.

Sand Filter: A structural facility with a layer of sand, used to filter pollutants from stormwater. See **Chapter 2.0** for information regarding the design of sand filters.

Santa Barbara Urban Hydrograph (SBUH): A hydrologic method used to calculate runoff hydrographs. See **Appendix C** for information regarding the use of the Santa Barbara Urban Hydrograph method.

Soakage Trench: A linear excavation backfilled with sand and gravel, used to filter pollutants and infiltrate stormwater. See **Chapter 2.0** for information regarding the design of soakage trenches.

Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 4.4**): Outdoor areas with one or more facilities that store solid waste (both food and non-food waste). Single-family residential sites are exempt from the requirements of Section 4.4.

Stormwater: Water runoff that originates as precipitation on a particular site, basin, or watershed. Also referred to as runoff.

Stormwater Facility Landscaping: The vegetation (plantings), topsoil, rocks, and other surface elements associated with stormwater management facility design. See **Chapter 2.0** for stormwater facility landscaping requirements.

Stormwater Management: The overall culmination of techniques used to reduce pollutants from, detain and/or retain, and provide a destination for stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows or basement sewer backups, or to fit within the capacity of existing infrastructure.

Stormwater Management Facility: A technique used to reduce pollutants from, detain and/or retain, or provide a destination for stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows or basement sewer backups, or to fit within or improve the capacity of existing infrastructure.

Stormwater Re-use: See definition of *Rainwater Harvesting*.

Street Swale: A vegetated or grassy swale (or bioswale) located next to a public or private street for the purpose of managing stormwater. See **Chapter 2.0** for information regarding the design of street swales.

Sump: A large public drywell (see definition) used to infiltrate stormwater from public streets. Sumps are generally 48 inches in diameter and 30 feet deep. The term "sump" is also used to reference to any volume of a facility below the point of outlet, in which water can accumulate. See **Chapter 2.0** for information regarding the use and design of sumps.

Surface Conveyance: The transport of stormwater on the ground surface from one point to another.

Surface Infiltration Facility: A facility designed to receive and infiltrate stormwater runoff at the ground surface to meet stormwater destination/ disposal requirements. Pollution reduction and flow control requirements can also be met with surface infiltration facilities.

Surface Retention Facility: A facility designed to receive and hold stormwater runoff at the ground surface. Rather than storing and releasing the entire runoff volume, surface retention facilities permanently retain a portion of the water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation.

Tenant Improvements: Structural upgrades made to the interior or exterior of buildings. Tenant improvements may trigger **Chapter 4.0** Source Controls if they take place on sites with specified high-risk activities.

Time of Concentration (T of C): The amount of time it takes stormwater runoff to travel from the most distant point (measured by travel time) on a particular site or drainage basin to a particular point of interest. See **Appendix C** for calculations related to time of concentration.

Total Suspended Solids (TSS): Matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter.

Underground Injection Control (UIC): A federal program under the Safe Drinking Water Act, delegated to the Oregon Department of Environmental Quality (DEQ), which regulates the injection of water below ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. See **Section 1.4.4** for information regarding the UIC program.

Vegetated Facilities: Stormwater management facilities that rely on plantings to enhance their performance. Plantings can provide wildlife habitat and enhance many facility functions, including infiltration, pollutant removal, water cooling, flow calming, and prevention of erosion.

Vegetated Filter: A gently sloping, densely vegetated area used to filter, slow, and infiltrate stormwater. See **Chapter 2.0** for information regarding the design of vegetated filters.

Vegetated Infiltration Basin: A vegetated facility that temporarily holds and infiltrates stormwater into the ground. See **Chapter 2.0** for information regarding the design of vegetated infiltration basins.

Vegetated Swale: A long and narrow, trapezoidal or semicircular channel, planted with a variety of trees, shrubs, and grasses. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out. Check dams are used to create small ponded areas to facilitate infiltration. See **Chapter 2.0** for information regarding the design of vegetated swales.

Water Body: Water bodies include coastal waters, rivers, sloughs, continuous and intermittent streams and seeps, ponds, lakes, aquifers, and wetlands.

Water Quality: See definition of *Pollution Reduction*.

Watercourse: A channel in which a flow of water occurs, either continuously or intermittently, with some degree of regularity. Watercourses may be either natural or artificial.

Wet Pond: A vegetated basin with a permanent pool of water, used to provide pollution reduction for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. See **Chapter 2.0** for information regarding the design of wet ponds.

Wetland: An area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas except those constructed as pollution reduction or flow control facilities. Specific wetland designations shall be made by the Corps of Engineers and the Division of State Lands.

1.4 STORMWATER DESTINATION/DISPOSAL

1.4.1 The Purpose of Stormwater Destination/Disposal

Stormwater destination or disposal refers to the ultimate discharge point for stormwater generated by large, intense rainfall events from a particular development site. Destinations can be grouped into two general categories: on-site infiltration and off-site flow. On-site infiltration methods include surface infiltration techniques, soakage trenches, private drywells, and public infiltration sumps. Off-site flow methods include discharge to drainageways (including roadside ditches and natural drainages and streams), rivers, off-site storm sewers, and off-site combined sewers. The appropriate destination or disposal point is site-specific and depends on a number of factors, including soil type, slopes, and availability of public and private infrastructure.

While many of the stormwater management facilities in Chapter 2.0 are designed to provide pollution reduction, flow control, or both, not all of them infiltrate stormwater from large, intense rainfall events sufficiently enough to be considered the only stormwater disposal point for the site. Unless disposal credit is given, additional destination/ disposal measures are required and must be approved by BES (for off-site flow or infiltration within the public right-of-way) or BDS (for infiltration on private property). It should be noted that the disposal method might have an impact on the pollution reduction and flow control requirements for a site. Therefore, it is advantageous to determine the method of stormwater disposal first.

1.4.2 Destination/Disposal Requirements

Exhibit 1-1: Stormwater Destination/Disposal Hierarchy must be used to determine the ultimate discharge point for stormwater from a development site. The hierarchy is set up to protect watershed health and mimic predeveloped hydrologic conditions by requiring on-site infiltration wherever practicable. This also serves to protect the capacity of downstream infrastructure and minimize the occurrence of combined sewer overflows and basement sewer backups in the combined sewer system. The hierarchy is also intended to protect groundwater resources by limiting the use of infiltration in some cases. It requires infiltration at the ground surface where practicable, and pollution reduction where it isn't. Where on-site infiltration is not practicable, the hierarchy dictates the use of off-site storm-only systems for stormwater discharge if feasible, before discharge to combination sewer systems can be considered.

Section 1.4.3 identifies the standards that must be met for on-site infiltration and off-site flow conveyance.

EXHIBIT 1-1: STORMWATER DESTINATION/DISPOSAL HIERARCHY

Using Exhibit 1-1: For approval of a stormwater destination/disposal method in the City of Portland, the highest (1= high, 4=low) technically feasible category for the project must be used. All appropriate technical design criteria must be met to receive approval. Information provided in this chart does not guarantee that there will be an approvable destination for stormwater.

City of Portland Stormwater Destination/ Disposal Hierarchy

Category 1: On-site infiltration with a surface infiltration facility.

Under this category, a vegetated swale, grassy swale, street swale, vegetated infiltration basin, or infiltration planter shall be used, sized in accordance with the **Surface Infiltration Facility** design procedure in **Section 2.2.2**. This sizing procedure results in larger facilities than the simplified approach, which is used to meet pollution reduction and flow control goals only.

This category is not required if any of the following conditions exist:

1) Where subsurface soils infiltrate adequately, runoff from rooftops may be directed to underground injection control facilities, such as soakage trenches and drywells.
2) Soils do not infiltrate well enough for surface infiltration facility design. This exception includes projects on the west side of the Willamette River. Soils must achieve a minimum infiltration rate of 2 inches per hour.
3) Adequate space is not available for surface infiltration facility design (see **Surface Infiltration Facility** design methodology in **Section 2.2.2**). For facilities serving public street drainage and located within the street right-of-way, this is generally determined by comparing the amount of available pervious surface area (usually located between the curb and sidewalk) with the size of the required infiltration facility. Resident basements must have adequate setbacks. A minimum setback of 10 feet is required on private property, as approved by BDS. Additional right-of-way width may be dedicated by the applicant if needed, as approved by PDOT (for public streets) or BDS (for private streets). For surface infiltration facilities located outside of the street right-of-way, adequate space is determined by the applicant's ability to meet minimum density requirements, as determined by City of Portland zoning code, after the infiltration facility has been located on-site.
4) Contaminated soils are present on site such that DEQ will not permit stormwater infiltration. Documentation showing DEQ assessment must be submitted.
5) Slope instability conditions exist on site, as documented by a geotechnical investigation, which stormwater infiltration may exacerbate. Slopes must not exceed 10% in the facility area.
6) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-33**), where on-site infiltration is not accepted for stormwater disposal.
7) For half-street improvements, existing utilities or street trees make it impractical to construct a surface infiltration facility within the street right-of-way.

City of Portland Stormwater Destination/ Disposal Hierarchy (Cont.)

Category 2: On-site infiltration with a public infiltration sump system, private drywell or soakage trench.

These facility types are classified as UICs (underground injection control structures) and must be rule-authorized or permitted by DEQ (see **Section 1.4.4**). The degree of pollution reduction required depends on the source of the stormwater runoff. Rooftop runoff does not require pollution reduction, runoff from residential low-use streets or parking lots (< 1,000 average daily trips) requires the use of sedimentation/ spill control manholes, and high-use streets and parking lots (> 1,000 average daily trips) require full pollution reduction. A surface retention facility is required to the maximum extent practicable (MEP) to meet applicable pollution reduction requirements (see **Section 1.6.2** for MEP criteria).

This category is not required if any of the following conditions exist:

1) Project does not meet DEQ UIC rule authorization or permitting criteria (see **Section 1.4.4** for list of criteria, or go to: **http://www.deq.state.or.us/wq/groundwa/RAStormwaterRequirements.pdf**).
2) Sub-surface soils do not infiltrate well enough for on-site infiltration, as approved by BES (for public streets) or BDS (for private streets).
3) Slope instability conditions exist on site, which stormwater infiltration may exacerbate. If this exception is claimed, a geotechnical investigation must be conducted and submitted, as approved by BES (for public facilities) or BDS (for private facilities).
4) Site is located within the Columbia South Shore Wellhead Protection Area (see **Exhibit 2-33**), where on-site infiltration with UICs is not allowed.

Category 3: Off-site flow to drainageway, river, or storm-only pipe system.

Pollution reduction is required. Flow control is required in most cases (see **Section 1.6.2**). A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (see **Section 1.6.2** for MEP criteria).

This category is not required if any of the following conditions exist:

1) System does not exist or does not have available capacity, as determined by BES.
2) Sensitivity of the water resource justifies connection to an alternative destination method, as determined by BES.

Category 4: Off-site flow to a combined sewer.

Pollution reduction and flow control are required. A surface retention facility is required to the MEP to meet pollution reduction and flow control requirements (see **Section 1.6.2** for MEP criteria).

This category is not accepted if the following condition exists:

1) System does not exist or does not have available capacity, as determined by BES.

1.4.3 Destination/Disposal Standards

<u>**ON-SITE INFILTRATION**</u>

Where complete on-site infiltration is used for the destination/disposal of stormwater, the following standards shall apply:

> **Surface Infiltration Facilities (public or private):** Surface infiltration facilities must demonstrate the ability to store and infiltrate the 10-year, 24-hour storm. See **Section 2.2.2** for detailed surface infiltration facility sizing and design procedures, including safety factors.
>
> **Public Infiltration Sump Systems:** The peak flow rate from a 10-year storm must be calculated using the Rational Method (Q=C*I*A), and a safety factor of 2 applied. The intensity shall correspond to the calculated time of concentration (5-minute minimum; see the City of Portland's *Sewer Design Manual* for rainfall intensity charts; for 5-minute time of concentration, intensity = 2.86 "/hr). The infiltration sump system must demonstrate the ability to steadily infiltrate stormwater at this rate.
>
> **Private Drywells and Soakage Trenches:** Where the Bureau of Development Services (BDS) pre-approves on-site infiltration, drywell sizing charts or soakage trench sizing guidelines shall be used. See Chapter 2.0 for detailed drywell and soakage trench sizing and design procedures. Where on-site infiltration is not pre-approved, but the design professional wishes to prove the viability of on-site infiltration, the drywell testing procedure outlined in Chapter 2.0 shall be used.

<u>**OFF-SITE DISCHARGE TO SURFACE FLOW**</u>

Where stormwater is discharged to an off-site surface flow conveyance facility, such as a ditch, drainageway, stream, or river, the following standards shall apply:

> Beginning at the point of discharge from the site, the surface conveyance facility must have the capacity to convey flows from the 25-year storm from all contributing upstream drainage areas. The 25-year storm flow rate shall be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance. See the City of Portland's *Sewer Design Manual* for rainfall intensity charts and list of approved hydrologic modeling methods.

OFF-SITE DISCHARGE TO PIPED FLOW

Where stormwater is discharged to an off-site piped conveyance facility, such as a storm sewer or combined sewer, the following standards shall apply:

> For new development or redevelopment with an increase in net impervious area: Beginning at the point of discharge from the site, the piped conveyance facility must have the capacity to convey flows from the 10-year storm from all contributing upstream drainage areas without surcharge. The piped conveyance facility may surcharge during the 25-year storm, but the hydraulic grade line must remain below ground surface level. Combined sewers, or sewers in the Cascade Station/Portland International Center and Columbia South Shore Plan Districts (**Exhibit 2-33**) must have the capacity to convey flows from the 25-year storm without surcharge. The 10- and 25-year storm flow rates shall be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance. See the City of Portland's *Sewer Design Manual* for rainfall intensity charts and list of approved hydrologic modeling methods.

> For redevelopment with no net increase in impervious area: Existing downstream pipe conveyance facilities may be allowed to surcharge under certain circumstances. See the City of Portland's *Sewer Design Manual* for allowable surcharge criteria.

100-YEAR ESCAPE ROUTE

All projects must demonstrate where stormwater from the 100-year storm event will go, and that public safety concerns and property damage will be avoided. This may include storage in parking lot, street, or landscaping areas.

Also see the City of Portland's *Sewer Design Manual* for more information regarding the conveyance and destination of stormwater.

1.4.4 Requirements for Underground Injection Control Structures (UICs)

This section provides general information only. The full regulations and requirements are available on the Oregon Department of Environmental Quality (DEQ) website: **http://www.deq.state.or.us/wq/groundwa/uichome.htm**

The federal Underground Injection Control (UIC) Program (under the Safe Drinking Water Act) regulates the injection of water below the ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. DEQ administers the UIC Program in Oregon.

DEQ defines a UIC as any system, structure, or activity that discharges fluid below the ground or subsurface. UICs can pollute groundwater and surface water if not properly designed, sited, and operated. Stormwater systems such as sumps, drywells, and soakage trenches are examples of UICs subject to DEQ regulation. Surface infiltration facilities such as pervious pavements, swales, planters, and vegetated infiltration basins are not classified as UICs.

Owners or operators of new and existing UICs are required to register and provide inventory data to DEQ. UICs that serve privately owned single-family residential roof and footing drains are exempt from these requirements. This information helps DEQ determine if the UIC is eligible for "rule authorization." Rule authorization allows the owner or operator to operate the UIC without a permit from DEQ. UICs that do not qualify for rule authorization must either be closed, modified to meet requirements for rule authorization, or the owner must submit a water pollution control facility permit application to DEQ and obtain a permit.

CRITERIA FOR RULE AUTHORIZATION

UICs must be registered and approved by DEQ before construction. DEQ has set minimum criteria for rule authorization, identified below:

- No other waste is mixed with stormwater.
- Site development, design, construction, and management practices have minimized stormwater runoff.
- No other stormwater destination is appropriate. Note: Discharge to the combined sewer system is not considered appropriate if on-site infiltration is possible.
- No domestic drinking water wells are present within 500 feet.
- No public drinking water supply wells are present within 500 feet or a two-year time of travel.
- No soil or groundwater contamination is present.
- The UIC is not deeper than 100 feet and does not discharge within 10 feet of the highest seasonal groundwater level.

- A confinement barrier or filtration medium is present, or best management practices (BMPs) are used to prevent or treat stormwater contamination. Stormwater management efforts should focus on maximizing source controls, use of vegetated pollution controls, and infiltration through surface infiltration or shallow subsurface facilities.
- Design and operation prevents accidental or illicit spills and allows for temporary blocking.

Compliance with these criteria must be demonstrated during the registration process. Compliance can generally be more readily accomplished if stormwater management efforts focus on maximizing source controls, using surface vegetated pollution control options such as swales and planters, and disposing of stormwater through surface infiltration or shallow subsurface facilities.

Exhibit 1-1 identifies stormwater destination/disposal options, prioritized to guide attainment of the rule authorization criteria.

RULE AUTHORIZATION PROCESS

The City of Portland is managing the rule authorization process for public facilities (UICs that drain public right-of-ways). To allow adequate time to complete the UIC process, registration and inventory information for proposed public UICs should be submitted to the City of Portland as soon as possible after it has been determined that new or existing public right-of-way will be constructed or improved. Contact BES Development Services at 503-823-7651 to get the public UIC process started.

Registration and inventory information for UICs proposed to serve private property should be submitted directly to Mr. Rodney Weick, Oregon DEQ, (503) 229-5886.

Registration and inventory data should be submitted at least 60 days in advance of potential start of work. In some cases, DEQ and the City will need additional information from the applicant to determine the potential use of a UIC. City approval for public or private facilities will not be given until DEQ determines that the proposed UIC can be rule authorized or permitted.

The registration, rule authorization, and permit process is explained in more detail on DEQ's permit webpage: **http://www.deq.state.or.us/pubs/permithandbook/wquic.htm** For technical questions, call the DEQ UIC Program at 503-229-5945. For copies of UIC registration applications or forms, call 503-229-5189.

1.5 POLLUTION REDUCTION

1.5.1 The Purpose of Pollution Reduction

Urbanization is recognized as having a serious impact on Portland's waters. As land is developed, impervious area and surface runoff increase. This runoff collects and transports pollutants to downstream receiving waters and the City sewer system.

General pollutants of concern include:

- Suspended solids (sediment)
- Heavy metals (dissolved and particulate, such as lead, copper, zinc, and cadmium)
- Nutrients (such as nitrogen and phosphorus)
- Bacteria and viruses
- Organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers)
- Floatable debris
- Increased thermal load (temperature)

In response to the water quality impacts of urbanization, Congress passed the Clean Water Act amendments of 1987, mandating the U.S. Environmental Protection Agency (EPA) to issue regulations to control urban stormwater pollution. The regulations, published in 1990, require larger cities ("Phase I") such as Portland to obtain a National Pollutant Discharge Elimination System (NPDES) stormwater discharge permit for their municipal separate storm sewer discharges. Compliance with the NPDES permit requires the City to establish a comprehensive stormwater management program. Portland's citywide management program includes design standards for source control devices as well as best management practices designed to improve stormwater quality. This *Stormwater Management Manual* is part of Portland's NPDES stormwater management program to improve the quality of Portland's waters.

As noted in Section 1.4.4, the federal Underground Injection Control (UIC) Program (under the Safe Drinking Water Act) also requires pollution reduction in many cases prior to UIC infiltration.

1.5.2 Pollution Reduction Requirements

The City of Portland has a citywide pollution reduction requirement for all development projects with over 500 square feet of impervious development footprint area, and all existing sites that propose to create new off-site stormwater discharges. This requirement is summarized as follows:

• 70 percent removal of total suspended solids[1] is required from 90 percent of the average annual runoff.[2] • Projects in watersheds that have established total maximum daily loads (TMDLs) must also select and use a pollution reduction facility that is capable of reducing the pollutants of concern, as approved by BES.

[1] See **Appendix B** for a more detailed definition of "70% removal of TSS," which is actually a function of influent TSS concentration.

[2] In Portland, flow rate-based pollution reduction facilities (such as swales and filters) designed to treat runoff generated by a rainfall intensity of 0.19 inches per hour (depending on time of concentration; see chart below), and flow volume-based facilities (such as wet ponds) designed to treat runoff generated by 0.83 inches of rainfall over 24 hours (with NRCS Type 1A rainfall distribution) with a Vb/Vr (volume of basin/ volume of runoff) ratio of 2, will treat roughly 90 percent of the average annual runoff. Facilities that must be sized by routing a hydrograph through the facility (rate-based facilities with a storage volume component) may utilize a continuous simulation program (with a minimum of 20 years of Portland rainfall data) or single-storm hydrograph-based analysis method, such as SBUH (with 0.83 inches of rainfall over 24 hours and NRCS Type 1A rainfall distribution) to demonstrate treatment of 90 percent of the average annual runoff volume. See **Appendix E** for more detailed information regarding the formulation of Portland's pollution reduction standards.

Rainfall intensity needed to treat 90% of the average annual runoff in Portland	
Site's Time of Concentration (Minutes)	**Rainfall Intensity (Inches per Hour)**
5	0.19
10	0.16
20	0.13

One of the three design methodologies from **Chapter 2.0** must be used to design pollution reduction facilities to meet these requirements. The above rainfall intensities are to be used in the Rational Method (Q=CIA) equation to calculate pollution reduction runoff rates. These flow rates are used to size rate-based pollution reduction facilities unless the **Simplified Approach** from Chapter 2.0 is used.

TOTAL MAXIMUM DAILY LOAD (TMDL) REQUIREMENTS

In addition to the basic "70 percent TSS removal" requirement, projects discharging to water bodies that have established total maximum daily loads (TMDLs) must also select and use a pollution reduction facility that is capable of reducing the pollutants of concern, as approved by BES.

TMDL Parameters by Watershed (As of September 1, 2004)

Columbia River	Willamette River	Columbia Slough	Johnson Creek	Fanno Creek Ash Creek	Tryon Creek
· Bacteria · Temperature · Nutrients · PCB · Dioxin · Trace Metals	· Bacteria · Temperature · PCB · Dioxin · PAH · Trace Metals	· Bacteria · Temperature · Nutrients · PCB · Dioxin · Trace Metals	· Bacteria · Temperature · PAH	· Bacteria · Temperature · Nutrients	· Temperature

- Development projects in watersheds with established TMDLs may use vegetated pollution reduction facilities from **Chapter 2.0** without submitting additional data on TMDL pollutant removal.

- If a project in a watershed with established TMDLs uses non-vegetated facilities from **Chapter 2.0** for pollution reduction, the applicant shall also demonstrate through the performance approach (**see Section 2.2.3**) that the development proposal is consistent with specific TMDL requirements. Unless a specific TMDL implementation plan has been adopted for a watershed with established TMDLs, the basic requirement is to select and use a stormwater management facility that is capable of reducing the pollutants of concern, as approved by BES.

Exhibit 1-2 provides guidance on the pollution reduction or prevention capabilities of the facilities in Chapter 2.0, pertaining to TMDL parameters.

Exhibit 1-2: Pollution Reduction Facility Removal Capabilities For TMDL Parameters

■ The facility can likely remove or prevent the parameter.
▒ The facility can potentially remove or prevent the parameter, depending on design.
The facility cannot likely remove or prevent the parameter.

Pollution Reduction or Prevention Facility	**Bacteria**	**Temperature**	**Nutrients**	**Pesticides (DDT, Dieldrin, Aldrin)**	**PCB**	**2,3,7,8 TCDD (Dioxin)**	**PAH**	**Trace Metals (Pb, As, Fe, Mn)**
Ecoroof	■	■			▒	■	■	
Roof garden	▒	■			▒	■	■	
Pervious pavement	■	■	▒	▒	▒	▒	▒	▒
Tree credit		■						
Contained planter		■				■	■	
Rainwater Harvesting	■	■	■	▒	■	■	■	▒
Infiltration planter	■	■	■	▒	■	■	■	■
Flow-through planter	■	■	■	▒	■	■	■	■
Vegetated swale	▒	▒	▒	▒	▒	▒	▒	▒
Grassy swale	▒	▒	▒	▒	▒	▒	▒	▒
Street swale	▒	▒	▒	▒	▒	▒	▒	▒
Vegetated filter	▒	▒	▒	▒	▒	▒	▒	▒
Vegetated infiltration basin	■	■	■	▒	■	■	■	■
Wet pond	▒	▒	▒	▒	■	■	■	■
Extended wet detention pond	▒	▒	▒	▒	■	■	■	■
Constructed treatment wetland	▒	■	■	▒	■	■	■	■
Sand filter	■	■	■	▒	■	■	■	■
Manufactured filtration device	■	▒	■	▒	■	■	■	■

Note: This table is based on limited information and should be used for guidance only. Actual pollutant reduction and prevention capabilities are based on specific facility design and site conditions.

POLLUTION REDUCTION IN COMBINED SEWER AREAS

Because most combined sewers overflow to the Willamette River in wet conditions, it is essential to keep as much stormwater out of the combined sewer system as possible. For this reason, on-site infiltration is required to the maximum extent practicable. Pollution reduction is also required, unless all of the following conditions are met:

- The combined sewer system to which the development is connecting does not backup into basements or overflow during a 25-year storm event.
- The development has used on-site surface retention facilities within the project area to the maximum extent practicable, as approved by BES.
- The development pays the off-site stormwater management fee. See **Section 1-11** for information regarding current off-site stormwater management fee rates.

OIL CONTROL FOR VEHICLE AND EQUIPMENT TRAFFIC AREAS

Vehicle and equipment traffic areas are required to incorporate oil controls into the stormwater management design if they have the following characteristics:

- Commercial or industrial parking lots that store wrecked or impounded vehicles.
- Areas with a high likelihood of oil and grease loadings, such as fast-food restaurant drive-thru and parking, grocery and convenient store parking, vehicle repair, vehicle sales, and vehicle fueling services.

Oil controls can include spill control manholes (**Exhibit 2-26**) or the incorporation of Lynch-type catch basins within the parking lot or at the outlet to swales or other pollution reduction facilities. The discharge of stormwater with a visible sheen off-site or into on-site UICs is prohibited. Vehicle and equipment traffic areas that trigger these requirements must be paved with an impervious material. Because gasoline can react with asphalt pavement, it is preferable to pave the areas with concrete.

POLLUTION REDUCTION EXEMPTION FOR ROOFTOPS THAT INFILTRATE ON-SITE

Projects that infiltrate rooftop stormwater runoff with private soakage trenches, drywells, or surface infiltration facilities are not required to provide pollution reduction prior to infiltration. This exemption does not apply to projects that discharge stormwater off-site. Refer to **Section 1.4.4** for requirements specific to underground injection control structures (UICs).

1.6 FLOW CONTROL

1.6.1 The Purpose of Flow Control

Prior to development, runoff either appears as streamflow, evaporates into the atmosphere, or infiltrates into the ground where it recharges groundwater aquifers or surface water bodies. Urbanization results in the loss of forest, agricultural land, and open space and increases the amount of impervious area. As a result, development can have the following hydrologic impacts:

- Increased stormwater flow rates
- Increased stormwater runoff volumes
- Decreased groundwater recharge and base flows into streams
- Seasonal flow volume shifts

Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increases in stormwater runoff peak flow rates and volumes resulting from development.

The City's policy is to ensure that runoff leaving the post-development site:
- Does not exceed the capacity of the receiving conveyance facility or water body.
- Does not increase the potential for stream bank and stream channel erosion.
- Does not add significant volume to an existing closed depression, such as Holgate Lake or other similar geologic features found throughout the City.
- Does not create or increase any upstream or downstream flooding problems.
- Does not create or increase the occurrence of CSOs or basement sewer backups.

The basic design concept for flow control (detention and retention) is simple: water from developed areas is managed with a variety of flow control techniques and released to downstream conveyance systems at a slower rate (detention) and lower volume (retention). Managing flows in this way attempts to mimic the site's natural rainfall runoff response prior to development (see **Exhibit 1-3**).

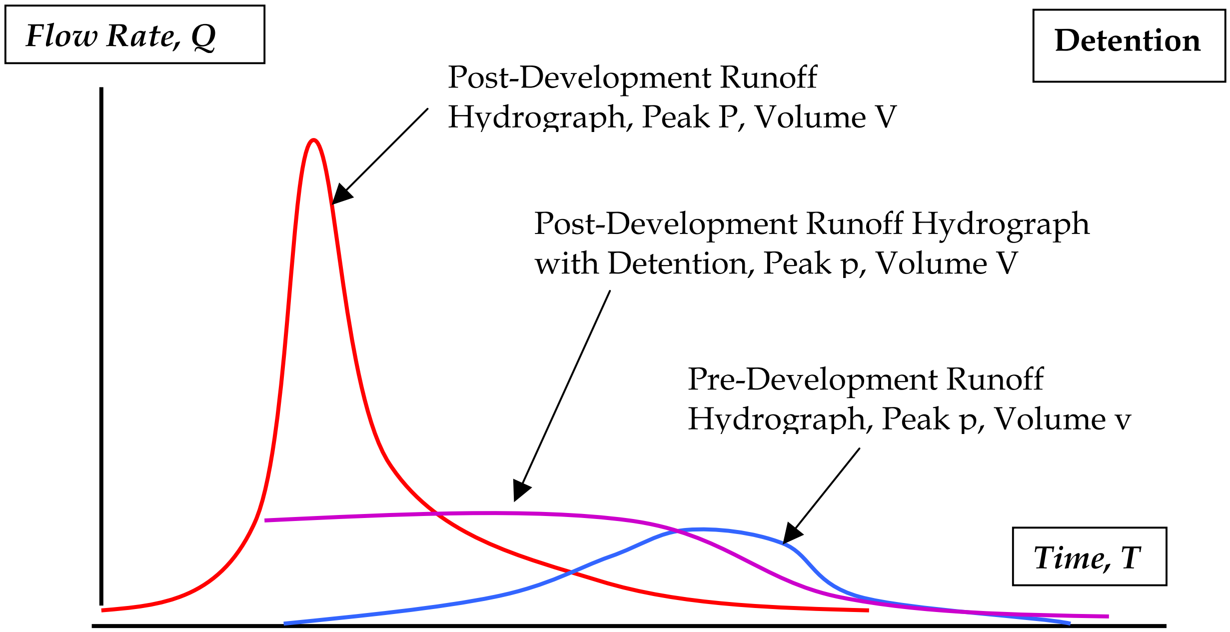
Detention facilities, such as ponds, tanks, vaults, or oversized pipes temporarily store stormwater runoff. The water is slowly released from the facility, typically over a number of hours.

Retention facilities also store stormwater runoff. Rather than storing and releasing the entire runoff volume, however, the facility permanently retains a portion of the water on-site, where it infiltrates and recharges the groundwater aquifer, and in the case of surface retention facilities, evaporates or is absorbed and used by surrounding vegetation. In this way, retention facilities reduce the total volume of water released downstream. Examples of retention facilities include surface treatments (such as eco-roofs or pervious pavements) that cover or replace traditional impervious surfaces and vegetated facilities such as swales, filters, ponds, and planter boxes.

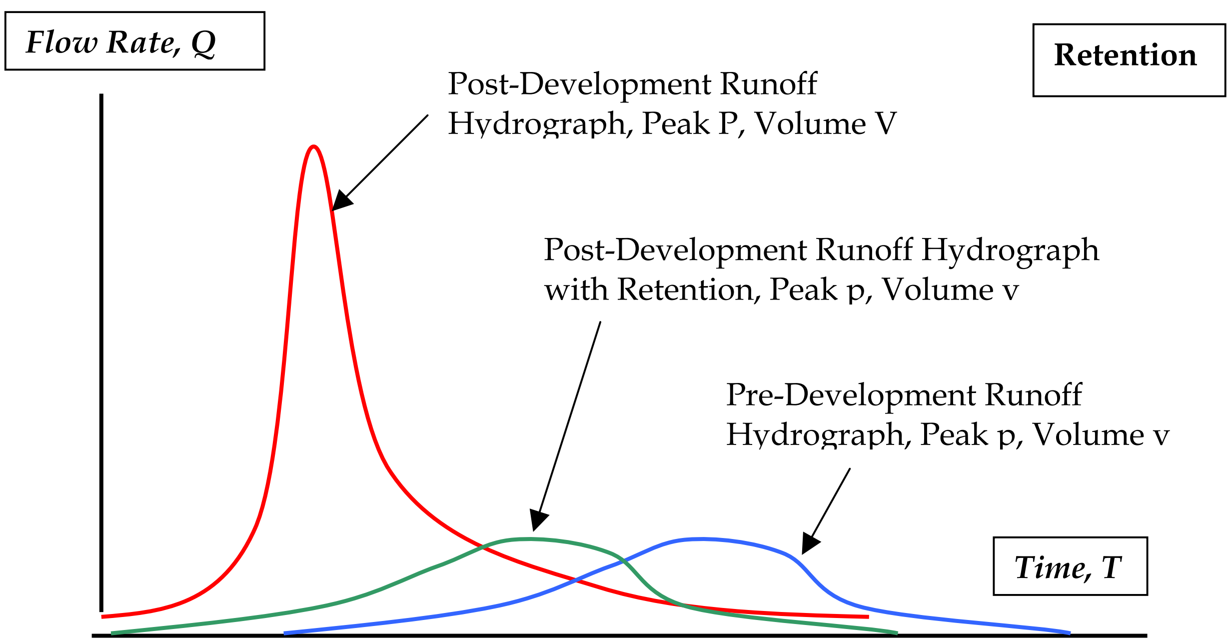
In the past, flow control plans often relied solely on detention facilities. Facilities that control only peak flow rates, however, allow the duration of high flows to increase, causing the potential for increased erosion downstream. For example, after development with detention, the magnitude of the 2-year peak flow rate may not increase, but the amount of time (duration) that the flow rate occurs will increase, and the frequency that the 2-year peak flow rate occurs will also increase. Retention systems, on the other hand, are particularly effective at lowering the overall runoff volume, reducing the amount of time (duration) that the peak flow rate occurs, as well as the frequency. In addition, by infiltrating stormwater, retention systems recharge groundwater that serves as the base flow for streams during the dry season. Therefore, stream systems that require erosion protection, including salmonid habitat streams, warrant the use of retention systems. Where retention systems cannot be used, detention systems that control the duration of the geomorphically significant flow (i.e., flow capable of moving sediment) shall be used. Such detention systems employ lower release rates and are therefore larger in volume.

Time of concentration (the time it takes rainfall to accumulate and run off a site) is another important factor in determining downstream hydrologic impacts created by development. Flow rates from individual sites may be controlled, but when they are combined quickly in fast-flowing conveyance pipes, the downstream effect will still be increased in-stream flow rates and volumes. Breaking flow patterns up into surface retention systems helps increase a site's time of concentration and lessens downstream impacts.

Exhibit 1-3: The Effect of Detention and Retention Facilities on Post-Developed Hydrographs (Large Storm Events)



General Relationship Between Pre-Development Hydrograph, Post-Development Hydrograph, and Post-Development Hydrograph with Detention Facility in Place



General Relationship Between Pre-Development Hydrograph, Post-Development Hydrograph, and Post-Development Hydrograph with Retention Facilities in Place

1.6.2 Flow Control Requirements

On-site infiltration is required to the maximum extent practicable to control stormwater volumes and flow rates. (See **Exhibit 1-1**: Stormwater Destination/Disposal Hierarchy.) Where complete on-site infiltration is not practicable, other on-site retention techniques (such as pervious pavement, ecoroofs, planters, swales, and other surface vegetated facilities) are required to the maximum extent practicable to reduce runoff volumes, with the following exceptions:

- Space constraints prohibit the construction of on-site retention facilities. Required setbacks from buildings and property lines need to be considered for each facility type.
- The use of surface retention is not practicable or safe because of soil or slope conditions. The City may require an investigation and recommendation of a qualified geotechnical engineer or engineering geologist to demonstrate that this exception applies to a site. It should be noted that some surface retention facilities, such as flow-through planter boxes, are lined and therefore do not infiltrate stormwater into surrounding soils.
- Contaminated soils limit the use of retention approaches.
- Required source controls for high-risk sites (as identified in **Chapter 4.0**) conflict with the use of on-site retention facilities.
- The development is located in an area of Portland where flow control is not required (See **Exhibit 1-4**) **and** discharges to a storm-only system with adequate capacity**.**

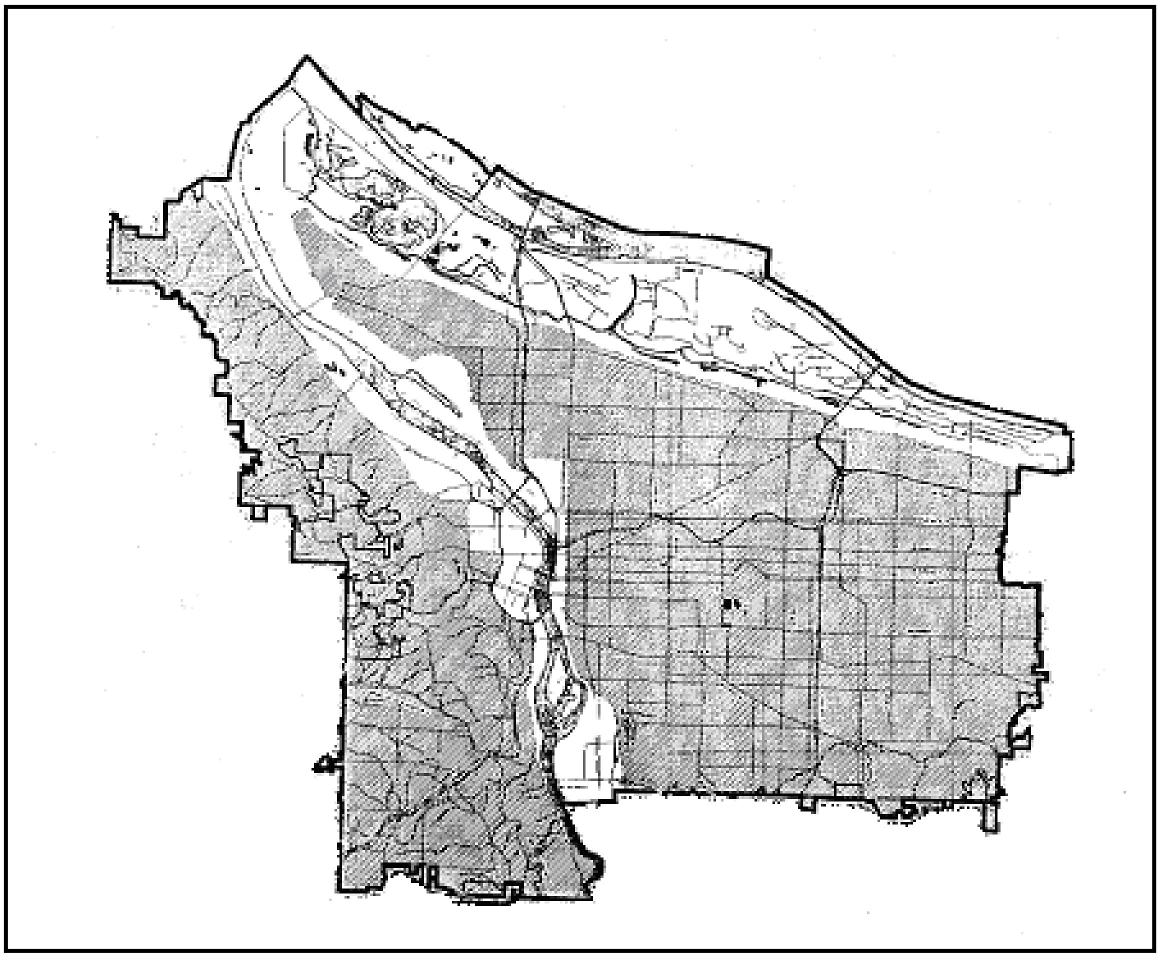
Where complete on-site infiltration or the use of retention facilities is not practicable, flow control (detention) shall be sufficient to maintain peak flow rates at their pre-development levels for the 2-year, 5-year, and 10-year, 24-hour runoff events. Note that for redevelopment projects, pre-development condition is defined as undeveloped land. (See definition of pre-developed condition in **Section 1.3**)

Because of minimum orifice size specifications (2 inches for public facilities, 1 inch for private facilities), detention facilities that rely on orifice structures to control flows for small projects (under 15,000 square feet of impervious development footprint area) may not be effective. In these cases, rather than constructing a detention facility on-site, the applicant may pay the flow control portion of the off-site stormwater management fee (see **Section 1.11**).

CIRCUMSTANCES WHEN FLOW CONTROL IS NOT REQUIRED

New development and redevelopment are exempt from flow control requirements if they discharge stormwater runoff directly into either the Willamette River, Columbia River, or Columbia Slough through a private storm sewer, separated public storm sewer, or Multnomah Country Drainage District system with available capacity. Although not always the case, these areas generally fall within the unshaded areas of Exhibit 1-4.

Exhibit 1-4: General Areas Where On-Site Flow Control May Not Be Required (Shown as unshaded areas of this map)



IMPORTANT NOTES:

- This exemption is for flow control only; pollution reduction requirements still apply.
- Development must still properly dispose of stormwater using approved methods in accordance with **Section 1.4** of this manual.

CIRCUMSTANCES WHEN MORE RESTRICTIVE FLOW CONTROL IS REQUIRED

Most tributary streams in Portland show evidence of excessive stream bank and channel erosion. Any development that discharges stormwater off-site that eventually flows to a tributary stream shall be designed to a more restrictive requirement to reduce the potential for further aggravation of instream erosion problems. This applies to all tributaries and storm sewers that drain to tributaries within the Portland area, except the Columbia Slough.

The added controls are based on the geomorphically significant flow, which is the flow that initiates sediment movement in the channels. The erosion-causing flow varies from channel to channel. Unless more specific data are available, the City assumes that the erosion-causing flow is one-half of the 2-year, 24-hour pre-developed (Lewis & Clark era) peak flow, and the requirements of this manual are based on that assumption. **Specifically, the more restrictive control requirement is to limit the 2-year, 24-hour post-development peak flow rate to the pre-development erosion-initiating rate (one-half of the 2-year, 24-hour flow rate). The facilities shall also control the post-development flows from the 5-, 10-, and 25-year, 24-hour peak flows to the pre-development 5-, 10-, and 25-year, 24 hour levels**.

Development projects proposing to discharge stormwater off-site must evaluate the capacity of the off-site receiving system (storm sewer, combination sewer, ditch, drainageway, etc.) against the standards presented in **Section 1.4.3**. Additional flow control may be required on-site if off-site receiving systems do not have sufficient capacity to accept the additional flows.

FLOW CONTROL REQUIREMENTS SPECIFIC TO DEVELOPMENTS DISCHARGING TO THE COMBINED SEWER SYSTEM

Substantial stormwater volumes in the combined sewer system result in combined sewer overflows (CSOs) and basement flooding in many areas served by combined sewers. Stormwater that enters the combined sewer system during low-flow periods is treated at the City's wastewater treatment plants, using costly energy and other resources. For these reasons, it is important to limit the quantity of stormwater entering the combined sewer system, and development projects in combined sewer areas are subject to the requirement to **infiltrate stormwater on-site to the maximum extent practicable**. For developments that are served by combined sewers but are unable to infiltrate on-site, the following requirements apply:

- Development projects that are allowed to discharge to a combined sewer system (cannot infiltrate on-site) are not required to provide detention for the 2- and 5-year storm events. Detention facilities must be designed to control post-development flows from the 25-year peak flow to the pre-developed 10-year peak flow rate.

- Redevelopment projects that result in an equal or decreased coverage of impervious surface and that discharge into a combined sewer system with available capacity (no overflows during 25-year storm event, as determined by BES) are not required to provide flow control.

SUMMARY OF THE CITY'S FLOW CONTROL REQUIREMENTS:

1) On-site infiltration is required to the maximum extent practicable.
2) Where complete on-site infiltration is not practicable, on-site retention (flow volume control) facilities must be used to the maximum extent practicable.
3) Where complete on-site infiltration or retention is not practicable, flow control requirements below shall apply, after the **Stormwater Destination/ Disposal Hierarchy** from Section 1.4 has been applied to determine the point of stormwater discharge.
4) Piping systems that provide conveyance from a site to an ultimate discharge point must have adequate capacity per BES's standard, or additional flow control on-site may be required.

Discharge Point	Retention Requirement	Detention Requirement
Direct discharge to the Willamette River, Columbia River, or Columbia Slough, or discharge to a storm-only piping system or Multnomah Country Drainage District system with capacity that directly discharges to one of the above water bodies	Use on-site retention (flow volume control) facilities and infiltrate on-site to the maximum extent practicable.	None.
Discharge to any other overland storm drainage system, including ditches, drainageways, and streams, or any storm pipe system that eventually discharges to an overland drainage system	Use on-site retention (flow volume control) facilities and infiltrate on-site to the maximum extent practicable.	Limit 2-year post-development peak runoff rate to one-half of the 2-year pre-development peak rate; 5-year post to 5-year pre; 10-year post to 10-year pre; and 25-year post to 25-year pre-peak runoff rate.
Combined sewer	Use on-site retention (flow volume control) facilities and infiltrate on-site to the maximum extent practicable.	Limit 25-year post-development peak runoff rate to 10-year pre-development peak rate, unless sewer has available capacity.

1.7 OPEN DRAINAGEWAY POLICIES

A drainageway is an open linear depression, whether constructed or natural, that functions for the collection and drainage of surface water. It may be permanently or temporarily inundated. Drainageways provide many important functions to both the stormwater conveyance system and the environment. Drainageways provide both flow management (regulation of stream flow, retention and detention of water, flood control, contribution to seasonal base flows, and groundwater recharge) and water quality protection (filtration of pollutants and reduction of stormwater temperatures).

The City of Portland protects open drainageways by requiring them to be placed in drainage reserves. Drainage reserve requirements may be imposed during land use reviews, building permit reviews, or other development processes that require Bureau of Environmental Services review. The requirement to place the drainage reserve in a dedicated tract may be imposed during partition or subdivision land use reviews only.

Storm drainage reserves shall remain in natural topographic condition, or in the case of man-made drainages such as street ditches, the topographic condition at the time of the proposed development. No private structures, culverts, excavations, or fills shall be constructed within drainage reserves unless authorized by the BES Chief Engineer.

Sizing of Drainageway Reserves: Drainage reserves shall be sized to assure that the current flow rate and pattern of the drainageway continues to be adequately conveyed through the development site. Current flow volumes and/or drainageway capacities will be determined by reviewing existing data, which may include available hydrologic records, drainage basin hydrology, historical data, high-water marks, soil inundation records, photographs of past flooding, and other similar information. Reserves shall be placed on a proposed development site in one of the following manners:

1) 15 feet from the centerline of the channel; or
2) 15 feet from the delineated edge of a designated water feature (i.e. seep, spring, wetland); or
3) Within the boundary of a designated environmental zone; or
4) Over a designated seep, spring, or stream tract.

<u>Exemptions:</u> Drainage reserves shall not be required for drainageways located within a FEMA designated and mapped area.

Disturbances or Development within Drainage Reserves: Disturbances or development within the drainage reserve shall only be allowed when all of the following conditions exist:

1) The disturbance or development will not impede or reduce flows within the drainageway.
2) The disturbance or development will not cause detrimental impacts on habitat values or downstream water bodies for the migration, rearing, feeding, or spawning of fish.
3) Where the development involves a constructed crossing of the drainageway for vehicular or pedestrian access, there are no practicable alternatives with fewer impacts.
4) The development location, design, and construction method has the least significant detrimental impact to identified functional values of the drainageway of other practicable and different alternatives, including alternatives outside of the drainageway resource.

1.8 NON-CONFORMING USE PARKING LOTS

Non-Conforming Use Parking Lot Requirements

City Code Title 33.266: *Parking and Loading*, describes dimensions, landscaping, and other requirements for parking lots within the City of Portland. Title 33.248: *Landscaping and Screening* describes planting requirements for parking lots and other site uses. (See **Appendix F** for a list of approved parking lot trees.)

Existing parking lots required to meet the non-conforming use landscaping requirements under Title 33.258.070 must use surface retention facilities from **Chapter 2.0** where practicable in the newly required landscaped areas to manage stormwater from the parking lot. The appropriate sizing requirements shown on **Form SIM (Chapter 2.0)** shall be used to calculate the area needed for the applied measures. This requirement does not apply where it is not practical for runoff to flow into landscaped areas.

The following exceptions and/or conditions to these requirements may apply. If an exception is claimed, the applicant must still fulfill all other relevant requirements of this manual.

1. Contaminated soil conditions on the site preclude the use of landscape infiltration. Each site that has contaminated soils conditions must be evaluated by DEQ to determine if areas on the property are suitable for infiltration without the risk of mobilizing contaminants in the soil or groundwater. If it is determined that there are no suitable areas for infiltration, landscape facilities may be used for stormwater management, but must be lined to prevent infiltration.

2. The parking lot has been approved without landscaping, or has landscaping conditions that conflict with the use of the landscaping for stormwater management. (For example, if landscaping were required in a location that cannot receive stormwater as gravity flow, that portion of the landscaping would not have to be used for stormwater management)

1.9 DISCHARGING TO EXISTING STORMWATER MANAGEMENT FACILITIES

The City of Portland operates and maintains many stormwater management facilities. These facilities are designed to receive stormwater runoff from certain defined areas. A development may discharge to an existing **publicly** operated stormwater facility (see definition of public facility in **Section 1.3)** if all of the following criteria are met:

- The conveyance system and facility to which the development is discharging have capacity (see definition of capacity in **Section 1.3**). Stormwater runoff from development on private property shall not be discharged into new or existing public infiltration sump systems.

- The stormwater management facility is adequately designed in accordance with the most recent version of the *Stormwater Management Manual*, and was designed to include the development area in question.

- The applicant shows that private on-site infiltration facilities are being used to the maximum extent practicable, unless a previous land-use review case approved the development without such measures.

In addition to publicly owned and operated stormwater management facilities, many private facilities exist. A development may discharge to an existing **private** stormwater management facility if all of the following criteria are met:

- The conveyance system and facility to which the development is discharging has capacity (see definition of capacity in **Section 1.3**).

- The development's owner enters into a written agreement with the owner of the private stormwater management facility. BES and BDS must review and approve this agreement.

- There is no history of maintenance violations at the facility to which the development will be discharging, as determined by BES and BDS. BES may choose to conduct a site investigation to determine if the existing facility is being maintained adequately.

- The stormwater management facility is adequately designed in accordance with the most recent version of the *Stormwater Management Manual*, and was designed to include the development area in question.

1.10 PUBLIC VERSUS PRIVATE STORMWATER MANAGEMENT

Stormwater draining from private property shall be managed on private property, in privately maintained facilities. However, an applicant may construct and use a public facility for private and public stormwater management if **all** of the following conditions are met:

1) Public street improvements will require the construction of a public stormwater management facility.

2) The applicant has shown that private stormwater management facilities cannot be constructed on-site to manage the private runoff.

1.11 SPECIAL CIRCUMSTANCES

Special circumstances on a proposed site may make it impractical to implement on-site pollution reduction or flow control to the standards specified in this manual. Applicants who cite special circumstances shall submit **Form SC: Special Circumstances** (provided at the end of this section).

Properties are not eligible for special circumstances if they were divided or partitioned after this *Stormwater Management Manual* was adopted (July 1, 1999), and the division or partition resulted in the special circumstance (e.g., structural or other physical limitations at the site).

BES will determine if all or a portion of the stormwater management obligations may be fulfilled off-site. The applicant shall account for the management of all stormwater runoff from the site. If BES approves a special circumstances claim, the applicant must construct an appropriately sized off-site facility, or a fee must be paid to the City to construct off-site facilities. This fee is currently **$1.46** per square-foot of unmanaged impervious surface. The fee will be pro-rated to account for portions of the stormwater management obligation met on-site (as determined by the City's review of proposed on-site facilities). The unit cost will be further divided into pollution reduction and flow control components (**$0.73** per square-foot of impervious surface each) to account for differences in the development's ability to satisfy each component on-site.

No exceptions to meeting the stormwater management obligations are allowed. The developer shall either construct stormwater management facilities or pay the City to build off-site facilities. Except as listed above, on-site stormwater management shall be achieved to the maximum extent practicable, as approved by BES, in all cases before any off-site facilities or fees will be allowed.

In reviewing the applicant's plan submittal, the City will use the following criterion to determine if a special circumstance claim is allowed:

- Has the applicant made maximum use of on-site facilities identified in Chapter 2.0 for pollution reduction and/or flow control?

> Applicants who are citing special circumstances are encouraged to obtain early assistance from BES by calling Development Assistance at 503-823-7761. BES will publish public notice of all requests for special circumstances.

Form SC

Special Circumstances

See Section 1.11 for requirements pertaining to Special Circumstances.

Part I: Identification of Special Circumstance(s)

Check all special circumstance(s) that apply:

- ☐ The site contains sensitive ecological or cultural features, or natural features that provide significant water quality or environmental benefits that should not be disturbed. There is no opportunity to avoid impact from facilities.
- ☐ On-site management would significantly increase the risk of landslides and slope instability.
- ☐ The project is declared emergency work, where there is a hazard posing imminent danger to life or property.
- ☐ Structural or other physical limitations at the site constrain the function, placement, or necessary maintenance of on-site pollution reduction or flow control measures.
- ☐ BES has determined that the use of an off-site regional facility is a better approach to achieve pollution reduction and flow control benefits.
- ☐ The project is a "linear" facility (e.g., sidewalk, bike lane) in an existing public right-of-way, and site conditions make it impractical to construct an on-site facility, as determined by BES.

Note: *Properties are <u>not</u> eligible for special circumstances if they were divided or partitioned after this Stormwater Management Manual was adopted (July 1, 1999), and the division or partition caused the special circumstance to occur (e.g., structural or other physical limitations at the site).*

Form SC
(Continued)

Special Circumstances

Part II: Effects on Construction of On-site Stormwater Management

Describe the limiting effect(s) of the special circumstance(s) on the construction of on-site stormwater management facilities (pollution reduction, flow control, and destination):

Part III: Stormwater Management Percentages Achieved On and Off-Site

Indicate the portion of the site to be managed for pollution reduction:	
On-site:	**Off-site:**

Indicate the portion of the site to be managed for flow control:	
On-site:	**Off-site:**

Part IV: Proposed On and Off-site Stormwater Management Method(s)

Describe the destination/disposal method for the site. Also describe the on and off-site stormwater management methods to be used for pollution reduction and flow control. State "off-site management fee" if applicable.

Chapter 2.0
STORMWATER MANAGEMENT FACILITY DESIGN

Summary of Chapter 2.0

This chapter provides procedures for selecting and designing facilities that provide stormwater pollution reduction, flow control, and/or disposal benefits. It includes:

To Use This Chapter:

1) Use **Chapter 1.0** to determine the pollution reduction, flow control, and destination/disposal requirements for the project.
2) Select stormwater management facilities from **Section 2.9: Facility Design Criteria** to meet pollution reduction, flow control, and/or disposal requirements for the project.
3) Size facilities using the **simplified approach**, **presumptive approach**, or **performance approach** presented in this chapter. For simplified approach facilities, use **Form SIM** for sizing. For presumptive approach facilities, use specific sizing criteria presented with each facility type and hydrologic analysis methods listed in **Section 2.3**. Integrate the facilities into the project's overall site plan.
4) Prepare drawings and specifications for each stormwater management facility in accordance with the design criteria in **Section 2.9: Facility Design Criteria**.
5) Consult **Chapter 3.0** for the operations and maintenance requirements for each stormwater management facility.

2.1 INTRODUCTION & APPLICABILITY

Facilities presented in this chapter receive credit for pollution reduction, flow control, disposal, or in some cases a combination of the three. Three methodologies are included in this chapter for the sizing and design of stormwater management facilities: the simplified, presumptive, and performance approach. Each design approach has limitations on applicability. See **Exhibit 2-1** for a list of the facility types, their applicable design methodologies, and stormwater management credits given.

Exhibit 2-1: Stormwater Management Facility Application Table

Stormwater Management Facility Type	Credit Given with Associated Design Approach		
	Pollution Reduction	Flow Control	Destination/ Disposal
Ecoroof & roof garden	Simplified	Simplified	NA
Pervious pavement	Simplified	Simplified	Performance
Contained planter	Simplified	Simplified	NA
Tree credit	Simplified	Simplified	NA
Infiltration planter	Simplified[1]	Simplified	Presumptive[3]
Flow-through planter	Simplified[1]	Simplified	NA
Vegetated swale	Simplified[1]	Simplified	Presumptive[3]
Grassy swale < 15,000 sq-ft impervious area	Simplified[1]	Simplified	Presumptive[3]
Grassy swale > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive[3]
Street swales	Simplified[1]	Simplified	Presumptive[3]
Vegetated filter	Simplified[1]	Simplified	Presumptive[3]
Vegetated infil. basin	Simplified[1]	Simplified	Presumptive[3]
Sand filter	Simplified[1]	Simplified	Presumptive[3]
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive[4]	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Presumptive[5]	NA	NA
Structural det. facility	NA	Presumptive	NA
Spill control manhole	Presumptive[2]	NA	NA
Rainwater harvesting	Performance	Performance	NA
Private soakage trench	Presumptive	Presumptive	Presumptive
Public infiltration sump system	Presumptive[6]	Presumptive	Presumptive
Private drywell	NA	Presumptive	Presumptive

Exhibit 2-1 Notes:
[1] The performance approach may be used to downsize these simplified approach facilities when flow control is not required (**See Section 1.6.2**).
[2] Spill control manholes receive credit for oil removal only; additional pollution reduction facilities will be required to meet basic TSS removal requirements.
[3] The surface infiltration facility design criteria presented in **Section 2.2.2** must be used to receive disposal credit.
[4] Vegetated or grassy swales must be integrated into the bottom of dry detention ponds to receive pollution reduction credit.
[5] Manufactured treatment technologies must be pre-approved by BES to receive presumptive approach credit for pollution reduction.
[6] Public infiltration sump systems (sedimentation manhole and infiltration sump) will only receive credit for pollution reduction if used in residential low-use streets (< 1,000 average daily trips).

2.2 DESIGN METHODOLOGIES

2.2.1 Simplified Approach

The simplified approach is a relatively easy process for selecting and designing pollution reduction and flow control facilities, intended to save the project developer and the City time and expense. Combination facilities can be more practical to build than separate pollution reduction and flow control facilities. Facilities sized using the simplified approach retain stormwater near the ground surface, which provides a number of benefits, including pollution reduction, groundwater recharge and protection, peak flow reduction, and volume reduction. Rather than detaining stormwater and releasing it off-site at increased post-developed volumes, these facilities help infiltrate or retain water on-site. In areas with surface drainageways and streams, on-site retention lessens the "flashy" high- and low-flow impacts created by development in watershed basins. Stream erosion and temperature impacts are also decreased. In combination sewer areas, on-site retention facilities decrease the rate and volume of stormwater that flows through the system, decreasing the risk of combined sewer overflows and basement flooding. Overall, these facilities help mimic the natural hydrologic cycle by slowing and infiltrating stormwater.

Simplified Approach Sizing

Facilities designed in accordance with the simplified approach are presumed to comply with the City's pollution reduction and flow control requirements (see **Chapter 1.0**). As sized with **Form SIM** sizing factors, the simplified approach facilities do not sufficiently dispose of large storm events. Additional facilities, designed using the presumptive or performance approach, are required that meet the disposal requirements of this manual (See **Section 1.4**).

BES staff conducted a technical process to determine facility designs and sizes that would be effective on development sites. The process included a review of technical literature, review of BES monitoring data, calculations, and theoretical analysis. Sizing factors for the simplified approaches (shown on **Form SIM** below) were developed as a simple and quick tool to use for site planning and to accelerate permit review and approval. Generalized assumptions were used that may result in conservative sizing for some development sites. Manual users have the option to use the sizing factors as given on Form SIM, or follow the performance approach and submit an alternative facility size, along with supporting engineering calculations for BES review and consideration. The performance approach may be used to downsize facilities in circumstances when flow control is not required (see **Section 1.6.2**).

Appendix D: *Simplified Approach Sizing Calculations* provides information about how facility sizing factors were developed, and guidance on how the same methodology can be used to develop alternative facility sizes. An approved hydrologic analysis method (**Section 2.3**), such as a Santa Barbara Urban Hydrograph (SBUH) based approach or continuous simulation model, must be used to generate flow rates and volumes for design analysis. When facilities are downsized to meet pollution reduction requirements only, flows above the pollution reduction design flow must be routed around the facility with an approved diversion structure (**Section 2.5**) unless approved otherwise by BES.

The first three facility types on Form SIM (ecoroofs and roof gardens, contained planter boxes, and tree credits) and pervious pavements are impervious area reduction or mitigation techniques, and should be used first during the site planning and design stage to reduce the overall square-footage of impervious area that requires stormwater management. These facilities intercept rainfall, and are not generally designed to receive stormwater runoff. The second group of facilities listed on Form SIM (infiltration and flow-through planter boxes, vegetated and grassy swales, vegetated filter strips and infiltration basins, and sand filters) is designed to receive stormwater runoff from impervious surfaces.

Simplified Approach Submittal Requirements

Applicants using the simplified approach shall submit **Form SIM** as part of their permit application, along with construction drawings and details. **Page 2 of Form SIM** can be used to claim stormwater management credit for planting new trees and retaining existing tree canopy on-site. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects that utilize simplified approach facilities must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

Form SIM: Simplified Approach for Stormwater Management

The city has produced this form to assist with a quick and simple approach to manage stormwater on-site.
Facilities sized with this form are presumed to comply with pollution reduction and flow control requirements.
Stormwater disposal requirements per Section 1.4 must still be met.

New or Redeveloped Impervious Site Area ________ **Box 1**
(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)

INSTRUCTIONS

1. Enter square footage of new or redeveloped impervious site area in Box 1 at the top of this form.
2. Select impervious area reduction techniques from rows 1-3 to reduce the site's resulting stormwater management requirement. Tree credit can be calculated using the tree credit worksheet on the next page.
3. Select desired stormwater management facilities from rows 4-10. In Column 1, enter the square footage of impervious area that will flow into each facility type.
4. Multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the facility surface area needed to manage runoff from the impervious area.
5. Total Column 1 (Rows 1-10) and enter the resulting "Impervious Area Managed" in Box 2.
6. Subtract Box 2 from Box 1 and enter the result in Box 3. When this number reaches 0, stormwater pollution reduction and flow control requirements have been met. Submit this form with the application for permit.
7. If Box 3 is greater than 0 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from Chapter 2.0 of the Stormwater Management Manual to manage stormwater from these remaining impervious surfaces.

	Column 1	Column 2	Column 3
Impervious Area Reduction Technique	**Impervious Area Managed = Facility Surface Area**		
1) Eco-Roof / Roof Garden	______ sf		
2) Contained Planter	______ sf		
3) Tree Credit (See Next Page)	______ sf		

Note: Pervious Pavement areas do not need to be included in Box 1

Stormwater Management Facility	Impervious Area Managed		Sizing Factor		Facility Surface Area	Unit
4) Infiltration Planter	______ sf	x	0.06	=		sf
5) Flow-Through Planter	______ sf	x	0.06	=		sf
6) Vegetated Swale	______ sf	x	0.09	=		sf
7) Grassy Swale	______ sf	x	0.12	=		sf
8) Vegetated Filter Strip	______ sf	x	0.2	=		sf
9) Vegetated Infil. Basin	______ sf	x	0.09	=		sf
10) Sand Filter	______ sf	x	0.07	=		sf

For drywell and soakage trench sizing and design requirements, see Section 2.9.

Total Impervious Area Managed ________ **Box 2**

Box 1 - Box 2 ________ **Box 3**

Form SIM (Page 2): Tree Credit Worksheet

See **Tree Credits** in Section 2.9 for more information regarding the use of trees to meet stormwater management requirements.

New Evergreen Trees

To receive stormwater management credit, new evergreen trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree height (at the time of planting) to receive credit is 6 feet.

Enter number of new evergreen trees that meet qualification requirements in Box A		**Box A**
Multiply Box A by 200 and enter result in Box B		**Box B**

New Deciduous Trees

To receive stormwater management credit, new deciduous trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree caliper (at the time of planting) to receive credit is 2 inches.

Enter number of new deciduous trees that meet qualification requirements in Box C		**Box C**
Multiply Box C by 100 and enter result in Box D		**Box D**

Existing Tree Canopy

To receive stormwater management credit, existing tree canopy must be preserved during and after construction. Existing tree canopy must be within 25 feet of ground-level impervious surfaces. Existing trees cannot be credited against rooftop surfaces. Minimum tree caliper to receive credit is 4 inches. No credit will be given to existing tree canopy located within environmental zones. Tree canopy is measured around the tree's drip line.

Enter square-footage of existing tree canopy that meets qualification requirements in Box E		**Box E**
Multiply Box E by 0.5 and enter the result in Box F		**Box F**

Total Tree Credit

Add boxes B, D, and F and enter the result in Box G		**Box G**

For sites with less than 1,000 square-feet of new or redeveloped impervious area:
The amount in Box G is to be entered as "Tree Credit" on Form SIM. ** Stop Here **

For sites with more than 1,000 square-feet of new or redeveloped impervious area:

Multiply Box 1 of Form SIM by 0.1 and enter the result in Box H		**Box H**
Enter the lesser of Box G and H in Box I.		**Box I**

This is the amount to be entered as "Tree Credit" on Form SIM. **Stop Here**

2.2.2 Presumptive Approach

Facilities that utilize this design approach are classified as "presumptive," *presumed* to be in compliance with the City's pollution reduction, flow control, and/or disposal requirements if the presented sizing and design requirements are followed.

There are a few key differences between the presumptive and simplified approach sizing methodologies. Stormwater management goals that require the presumptive approach to be used for a particular facility type do not lend themselves well to simplified sizing. More detailed hydrologic calculations must be performed to adequately design the facility to achieve the desired goal. Another difference is that the presumptive approach presents sizing methodologies that meet the requirements of one particular goal (pollution reduction, flow control, or disposal), rather than multiple goals. See **Exhibit 2-1** for the table that specifies the design approaches that are applicable to each management goal, for each facility type.

Presumptive Approach Submittal Requirements

In addition to detailed construction drawings and specifications shown on permit drawings, all applicants using the presumptive approach for stormwater management are required to submit a detailed stormwater report. This report shall include a general description of the stormwater facility and how it is intended to function. It shall include detailed hydraulic calculations, as summarized in **Exhibit 2-2**. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be provided. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

Exhibit 2-2:
Checklist of Calculations to be Included in Stormwater Report

<u>Stormwater Facility Type</u>
A= Grassy Swale
B= Wet Pond
C= Extended Wet Detention Pond
D= Dry Detention Pond
E= Constructed Treatment Wetland
F= Detention Tank, Vault, or Pipe
G= Manufactured Treatment Technology or Spill Control Manhole

Parameter or Calculated Value to be Included in the Stormwater Report	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Site Variables:							
Site soil type (A, B, C, or D)	x	x	x	x	x	x	x
Contributing area (acres)	x	x	x	x	x	x	x
Pre-developed curve number CN			x	x	x	x	
Pre-developed time of concentration T of C (minutes)			x	x	x	x	
Post-developed curve number CN	x	x	x	x	x	x	x
Post-developed time of concentration T of C (minutes)	x	x	x	x	x	x	x
Distance from ground surface to max. height of seasonal groundwater (feet)	x	x	x	x	x	x	x
Hydrographs:							
Pre-developed hydrographs for the 2, 5, 10, 25, and 100-year storms, including peak rates and total volumes			x	x	x	x	
Post-developed hydrographs for the 2, 5, 10, 25, and 100-year storms, including peak rates and total volumes (only if routed through the facility)			x	x	x	x	
Post-developed hydrographs for the 2, 5, 10, 25, and 100-year storms after being routed through the facility, including peak rates and total volumes			x	x	x	x	
Facility Geometry:							
Table showing area and volume of the facility every 6” in elevation		x	x	x	x	x	
Side slopes (h: v or %)	x	x	x	x	x		
Longitudinal slope (h: v or %)	x				x		
Bottom width and length (feet)	x	x	x	x	x		
Overall width and length (feet)	x	x	x	x	x		
Hydraulic Controls:							
Orifice or weir descriptions, sizes, and elevations, including by-pass facilities			x	x	x	x	
Elevation, size, and type of overflow spillway or pipe	x	x	x	x	x	x	x
Calculated Values:							
Pollution reduction flow rate	x						x
Pollution reduction permanent pool volume and elevation		x	x		x		
Forebay volume and elevation		x	x	x	x		
Hydraulic residence time for the pollution control storm	x				x		
Storm routing data showing the peak water surface elevation in the facility for the 2, 5, 10, 25, and 100-year storms (only if routed through the facility)	x	x					x
Detailed storm routing data for the 2, 5, 10, 25, and 100-year storms, showing inflow rate, outflow rate, and water surface elevation in the facility every 10 minutes throughout the storm.			x	x	x	x	

SURFACE INFILTRATION DESIGN APPROACH FOR DISPOSAL

Where soil conditions allow for percolation near the ground surface, surface infiltration facilities can be used to dispose of stormwater from large storm events. The infiltration of stormwater near the ground surface helps increase the separation to groundwater, providing a greater filtration layer and decreasing the risk of groundwater contamination. It also serves to mimic the predevelopment hydrologic cycle, decreasing downstream impacts by recharging groundwater and increasing evapotranspiration.

Examples of surface infiltration facilities that can be designed under this approach include vegetated, grassy, and street swales, infiltration planters, and vegetated infiltration basins. While the design procedure in this section accounts for complete on-site infiltration of stormwater, facilities sized per the simplified approach are not sized adequately to meet destination/ disposal standards and must include an overflow to an acceptable disposal point. Surface infiltration facilities are not classified as underground injection controls (UICs) by DEQ, and therefore do not need to be registered.

<u>Surface Infiltration Design Approach to Meet Disposal Standards</u>

1) Determine the preliminary facility size by calculating the runoff volume generated by the 10-year storm (3.4 inches of rainfall over 24 hours, NRCS Type 1A rainfall distribution). The SBUH method can be used to determine this volume, or the volume can be approximated by the following formula:

   Runoff Volume (cubic feet) = 0.28 feet * Impervious Area (square-feet)

   The facility will need to be capable of containing this volume of runoff through a combination of above ground storage and below ground storage within voids in a subsurface rock trench.

2) Surface infiltration facilities require infiltration tests during the design phase of the project. For public facilities, double-ring infiltrometer tests shall be conducted, in accordance with ASTM D3385-94, with BES review and approval. For private facilities, the falling head infiltration test procedure specified in **Section 2.4.2** shall be used. The minimum acceptable infiltration rate for surface infiltration facilities to meet disposal standards is 2 inches per hour. A clogging factor of 4 is then applied to the resulting infiltration rate to be used in the design of the facility.

3) The design infiltration rate (measured infiltration rate divided by 4) is then used to check the facility drawdown time. When full, the facility drawdown time shall not exceed 30 hours.

4) The wet seasonal high water table must be determined, and a minimum 4-foot clearance to bottom of facility must be maintained.

5) The 100-year storm inundation area shall be determined and must show that structures will not be flooded and that property damage and safety risks will be avoided.

6) Minimum setbacks from surface infiltration facilities to structures are shown in **Exhibit 2-4**.

7) All areas to be used as surface infiltration facilities shall be back-filled with a suitable sandy loam planting and filtration medium. Minimum depth shall correspond to each facility type's specification. The borrow source of this medium, which may be the same or a different location from the facility area itself, must be tested as follows:

   If the borrow area is virgin, undisturbed soil, one test is required per 200 square-feet of borrow area. The test consists of "grab" samples at 1-foot depth intervals to the bottom of the borrow area. All samples at the testing location are then mixed, and the resulting sample is laboratory tested to meet the following criteria:

   USDA minimum textural analysis requirements: A textural analysis is required from the site-stockpiled topsoil. If topsoil is imported, a textural analysis shall be performed for each location where the topsoil was excavated.

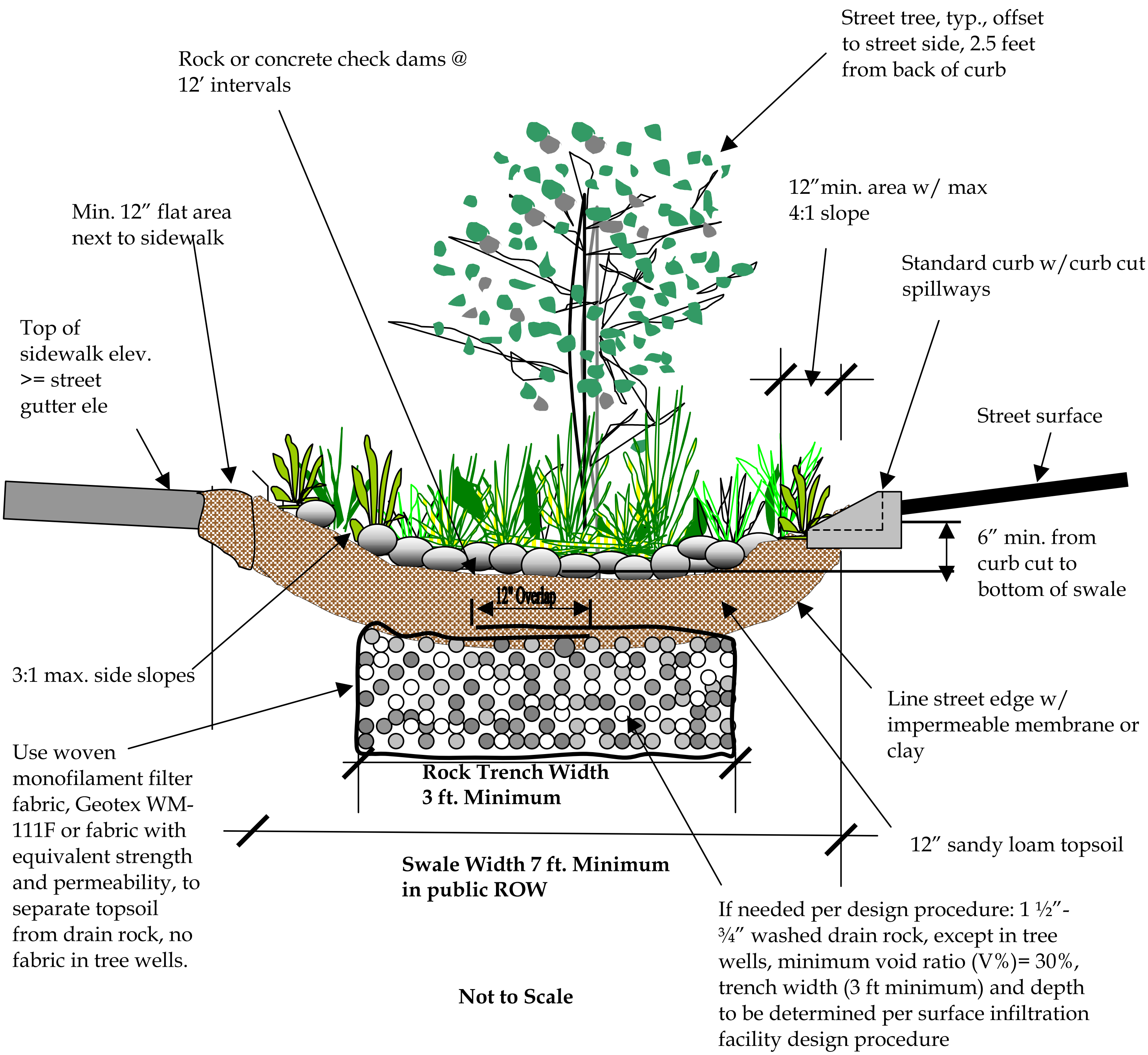
   <u>Requirements:</u>
   Sand 35 – 60%
   Silt 30 – 55% (Loam)
   Clay 10 – 25%

   The soil shall be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches.

8) Surface infiltration facility areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of surface infiltration facility areas.

9) For surface infiltration facilities, post-construction field infiltration testing will be required. Methods consistent with those used during design of the facilities shall be used. The resulting infiltration rate must show that the facility drawdown time will not exceed 30 hours.

Exhibit 2-3: Example Cross-Section of Vegetated Street Swale, Modified To Receive Credit for Disposal



Not to Scale

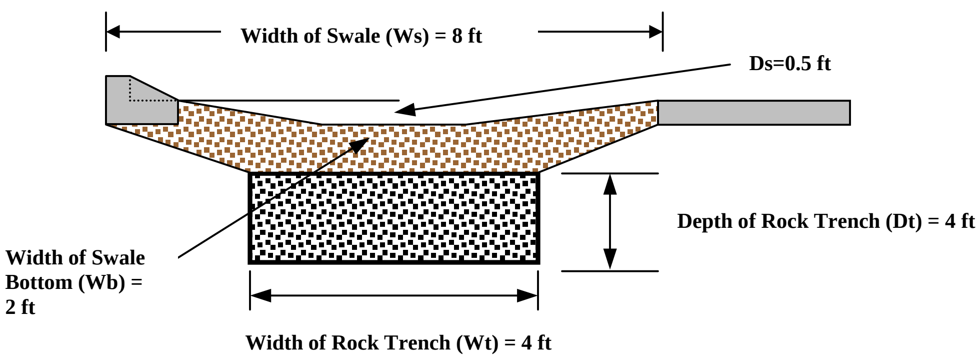
SURFACE INFILTRATION FACILITY SIZING EXAMPLE

Facility Type: Vegetated Street Swale

Objective: Find swale dimensions needed to meet stormwater disposal standards.

Givens: Design Storm (P) = 10 year, 24 hour storm = 3.4 total inches = **0.28 feet**
Maximum Drawdown Time (Td) = **30 hours**
Infiltration Rate Safety Factor = **4**

Site Characteristics:
Impervious Area (Ai) = 200′ x 28′ = **5,600 square feet**
Measured Infiltration Rate (Im), using Double-Ring Infiltrometer Test = 12″/hr = **1′/hr**
Swale width (Ws) = **8 feet**
Swale bottom width (Wb) = **2 feet**
Swale depth (Ds) = **0.5 feet**
Rock trench width (Wt) = **4 feet**
Rock trench depth (Dt) = **4 feet**
Void Ratio of Rock Trench (VR) dimensionless = **0.30**



Calculations:
Runoff Volume (Vr) cubic feet = P * Ai = 0.28 * 5,600 = **1,568 cubic feet**
Design Infiltration Rate (Id) feet per hour = Im / 4 = 1 ft/hr / 4 = **0.25 ft/hr**
Swale Storage Volume (Vs) = L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

Check #1: Runoff Volume (Vr) must be less than or equal to Swale Storage Volume (Vs)

Vr <= Vs

(0.28 * Ai) <= L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

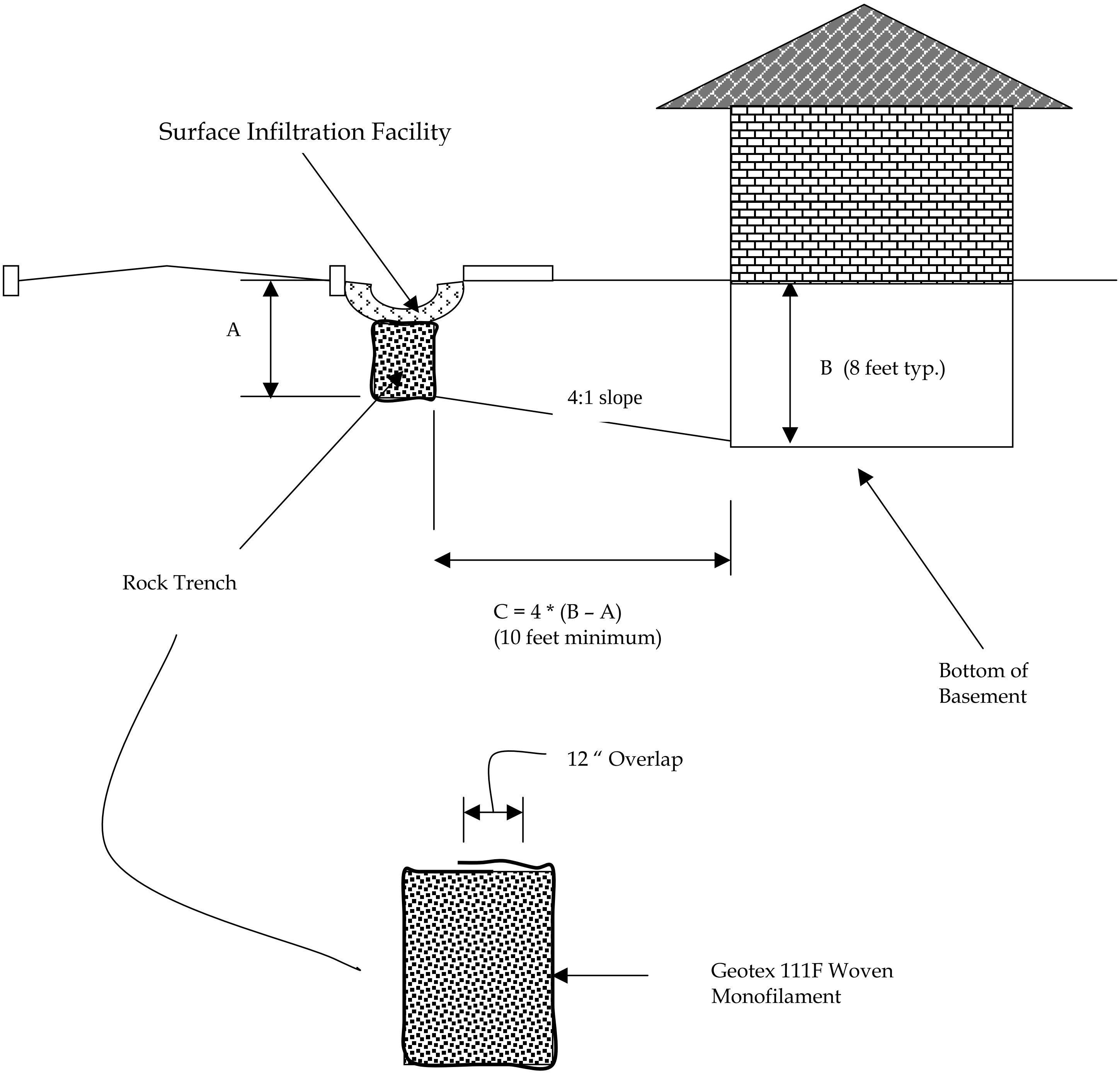
To find L: L = (0.28 * Ai) / [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]
L = (0.28 * 5,600) / [(0.5 * 0.5 * (8 + 2)) + (0.30 * 4 * 4)] = <u>215 feet</u>

Check #2: Swale drawdown time must not exceed maximum allowable (Td) = 30 hours

(0.28 * Ai) / (Id * Wt * L) <= 30 hours

(0.28 * 5,600) / (0.25 * 4 * 215) = <u>7.3 hours</u> < 30 hours, therefore OK

Exhibit 2-4: Surface Infiltration Facility Setback Detail



2.2.3 Performance Approach

The list of accepted stormwater management facilities is continually changing as new products are developed and more is learned about the performance of facilities already in use. Design professionals may propose facilities other than those included in this manual by using the performance approach. Design professionals may also use the performance approach to show that a facility is capable of reducing a TMDL pollutant of concern (See **Exhibit 1-2**), or to downsize a simplified approach sizing factor when flow control is not required.

The performance approach requires detailed engineering design and calculations, as well as documented evidence of the proposed design's performance. The City will accept the proposed design for meeting pollution reduction requirements if the design professional demonstrates that it:

- Will perform at the required efficiency: 70 percent total suspended solids (TSS) removal from 90% of the average annual runoff (See **Section 1.5**), and is capable of reducing the TMDL pollutant of concern (if applicable). See **Appendix B**: Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies, for definition of 70 percent total suspended solids removal, which is actually a function of influent concentration. Also see Appendix B for required testing protocol, related definitions, and additional requirements. Documented performance is required and shall include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.

- Can be efficiently maintained to perform at the required level, and for public facilities, will not require more costly maintenance than facilities designed using the simplified or presumptive approach.

Performance Approach Submittal Requirements

In addition to detailed construction drawings and details to be shown on permit drawings, all applicants using the performance approach for stormwater management are required to submit a detailed stormwater report. This report shall include a description of the stormwater facility, how it is intended to function, and documented evidence of the proposed design's performance. It shall include detailed hydraulic calculations as summarized in **Exhibit 2-2** and must demonstrate the performance criteria listed above. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

2.3 HYDROLOGIC ANALYSIS REQUIREMENTS

With the exception of pollution reduction and flow control facilities designed using the simplified approach, stormwater management facilities must be designed using hydrologic analysis methods described below. If one of the hydrologic analysis methods discussed below is not used, BES must pre-approve the alternative method before the plans and calculations are submitted. Regardless of how the hydrologic calculations are performed, all hydrologic submittals shall include data necessary to facilitate BES's review. This data is summarized in **Exhibit 2-2**.

2.3.1 Pollution Reduction

Flow Rate-Based Facilities: With the exception of facilities sized using the simplified approach, BES will use the Rational Method with rainfall intensities presented in **Section 1.5.2** to verify flow rates used to size rate-based pollution reduction facilities. BES has verified these intensities, through a continuous simulation model utilizing Portland rainfall data, to treat 90% of the average annual runoff volume. The design professional may also use SBUH, NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of 90% of the average annual runoff volume.

Flow Volume-Based Facilities: Volume-based pollution reduction facilities included in this manual (wet ponds and extended wet detention ponds) are required to use the pre-determined volume of 0.83 inches over 24 hours with a Vb/Vr (volume of basin/ volume of runoff) ratio of 2 to be in presumptive compliance. BES determined this volume, through a continuous simulation model utilizing Portland rainfall data, to provide adequate detention time to treat 90% of the average annual runoff volume.

Combination Rate/Volume-Based Facilities: With the exception of facilities sized using the simplified approach, BES will use a software program based on the Santa Barbara Urban Hydrograph (SBUH) method, or a continuous simulation model with Portland rainfall data, to verify the sizing of flow rate-based pollution reduction facilities that also rely on a storage volume component. An example of this includes the downsizing of simplified approach facilities (such as vegetated swales and infiltration basins) to achieve pollution reduction only. When using SBUH, a 0.83 inch, 24-hour storm with NRCS type 1A rainfall distribution shall be used. The design professional may also use NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of 90% of the average annual runoff volume.

2.3.2 Flow Control

With the exception of facilities sized using the simplified approach, BES will use a software program based on the Santa Barbara Urban Hydrograph (SBUH) to check design calculations for flow control facilities. The design professional may also use

NRCS TR-55, HEC-1, or SWMM to demonstrate compliance with flow control standards.

2.3.3 Destination/ Disposal

The Rational Method must be used to design the infiltration flow rate for public infiltration sumps. If surface infiltration facilities, such as vegetated, grassy, or street swales, vegetated infiltration basins, and infiltration planters are proposed to meet destination/ disposal requirements, the **Surface Infiltration Facility** sizing methodology in Section 2.2.2 must be used to meet presumptive compliance. The surface infiltration facility sizing methodology relies on the determination of the 10-year storm runoff volume, which can be calculated using the simple approximation formula provided, SBUH, NRCS TR-55, HEC-1, or SWMM.

2.3.4 Conveyance

Please reference the City of Portland's *Sewer Design Manual* for acceptable hydrologic analysis methods for stormwater conveyance. The Rational Method will be used to verify design calculations for pipe or surface conveyance facility sizing. HEC-1 or SWMM may be used for projects greater than 100 acres in size.

2.3.5 Hydrologic Analysis Method Resources

The **Santa Barbara Urban Hydrograph (SBUH) Method** (**See Appendix C**) may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the simplified approach.

The **SCS TR-55 Method** may be applied to small, medium, and large projects. This is also one of the recommended methods for completing hydrologic analysis necessary for designing flow control facilities when not using the simplified approach. (Refer to SCS Publication 210-VI-TR-55, Second Edition, June 1986.)

The **HEC-1 Method** may be used on medium and large projects. (Refer to the HEC User's Manual.)

The **SWMM Method** may be used on medium and large projects. (Refer to the SWMM User's Manual.)

2.4 INFILTRATION TESTING

To size stormwater management facilities, it is often necessary to know the infiltration rate of the soil at the actual facility location. The following general criteria apply to all proposed infiltration facilities:

1) For all surface infiltration facilities being designed to meet disposal standards, a minimum infiltration rate of 2 inches per hour is required. Site-specific facility design may require a much higher infiltration rate.
2) Testing can be classified into three categories, (1) initial feasibility testing, (2) design testing, and (3) post-construction testing. (see **Exhibit 2-5**)
3) Testing shall be conducted or observed by a qualified professional. This professional shall either be a registered professional engineer in the State of Oregon, or a soils scientist or geologist licensed in the State of Oregon.
4) All field-testing must be done in the proposed area of the facility.
5) Testing data shall be documented, including a description of the infiltration testing method.

2.4.1 Initial Feasibility Testing

Initial feasibility testing is conducted to determine whether full-scale testing is necessary, and is meant to screen unsuitable sites and reduce testing costs. It involves either one field test per facility (regardless of type or size) or previous testing data, such as the following:

- Pre-approval from the City of Portland Bureau of Development Services Environmental Soils section (Call 503-823-7790 for more information)
- Septic percolation testing on-site, within 200 feet of the proposed facility location and on the same contour
- Previous written geotechnical reporting on the site location as prepared by a qualified geotechnical expert
- NRCS Multnomah County Soil Mapping showing unfeasible conditions such as a hydrologic group "D" soil in a low-lying area
- In the case of public sump systems, pre-approval from BES (Call 503-823-7761 for more information)

If the results of initial feasibility testing as determined by a qualified professional show that an infiltration rate of greater than 0.5 inches per hour is probable, then the design and post-construction testing shall be in accordance with **Exhibit 2-5**. BDS and BES may waive design-testing requirements if it is determined that adequate testing data exist. In the case of infiltration testing, an encased soil boring may be substituted for a test pit, if desired.

Exhibit 2-5: Infiltration Testing Summary Table

Type of Facility	Initial Feasibility Testing (Section 2.4.1)	Design Testing (Section 2.4.2)	Post-Construction Testing (Section 2.4.3)
Private Drywell System	Required	One test pit and one falling head test per drywell, unless waived by BDS.	May be required by BDS. (see **private drywell** section for procedure)
Private Soakage Trench	Required	One test pit and one falling head test per soakage trench, unless waived by BDS.	Not applicable.
Public Infiltration Sump System	Required	Testing of an existing sump in the vicinity, or construction and testing of one sump may be required by BES.	All public infiltration sumps must be field-tested after construction. (see **public infiltration sump** section for procedure)
Surface Infiltration Facility	Required	One double-ring infiltrometer test (for public facilities) or one falling head test (for private facilities) per 200 square-feet of facility area	May be required by BDS (if private) or BES (if public). (see **surface infiltration facility** design section for procedure)

2.4.2 Design Testing

Where required, the following **test pit** procedure shall be followed:

1) Excavate a test pit or dig a standard soil boring to a minimum depth of 4 feet below the proposed facility bottom elevation. Also conduct Standard Penetration Testing (SPT) every 2 feet to a depth of 4 feet below the facility bottom.
2) Determine depth to highest seasonal groundwater table (if within 4 feet of proposed bottom) upon initial digging or drilling.
3) Determine USDA or Unified Soil Classification System textures at the proposed bottom and 4 feet below the bottom of the facility.
4) Determine depth to bedrock (if within 4 feet of proposed bottom).
5) The soil description should include all soil horizons.
6) The location of the test pit or boring shall correspond to the facility location; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such.

Where required, the following **falling head infiltration test** procedure shall be followed:

1) Install casing (solid 5-inch diameter, 36-inch length) to 24 inches below proposed facility bottom (see **Exhibit 2-6**).
2) Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing. Upon the tester's discretion, a 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill casing with clean water and allow to pre soak for 24 hours, or until the water has completely infiltrated.
3) Refill casing and monitor water level (measured drop from the top of the casing) for 1 hour. Repeat this procedure (filling the casing each time) three additional times, for a total of four observations. Upon the tester's discretion, the final field rate may either be the average of the four observations or the value of the last observation. The final rate shall be reported in inches per hour.
4) Testing may be done through a boring or open excavation.
5) The location of the test shall correspond to the facility location.
6) Upon completion of the testing, the casings shall be immediately pulled, and the test pit shall be back-filled.

Where required, the **double-ring infiltrometer test** procedure must follow ASTM D3385-94, standard test method for infiltration rate of soils in field using double-ring infiltrometer.

Note: For soils west of the Willamette River or similar soil types known as Cascade silt loams (soils with a fragipan that causes a perched water table in winter months), testing must be done between June 1 and October 1.

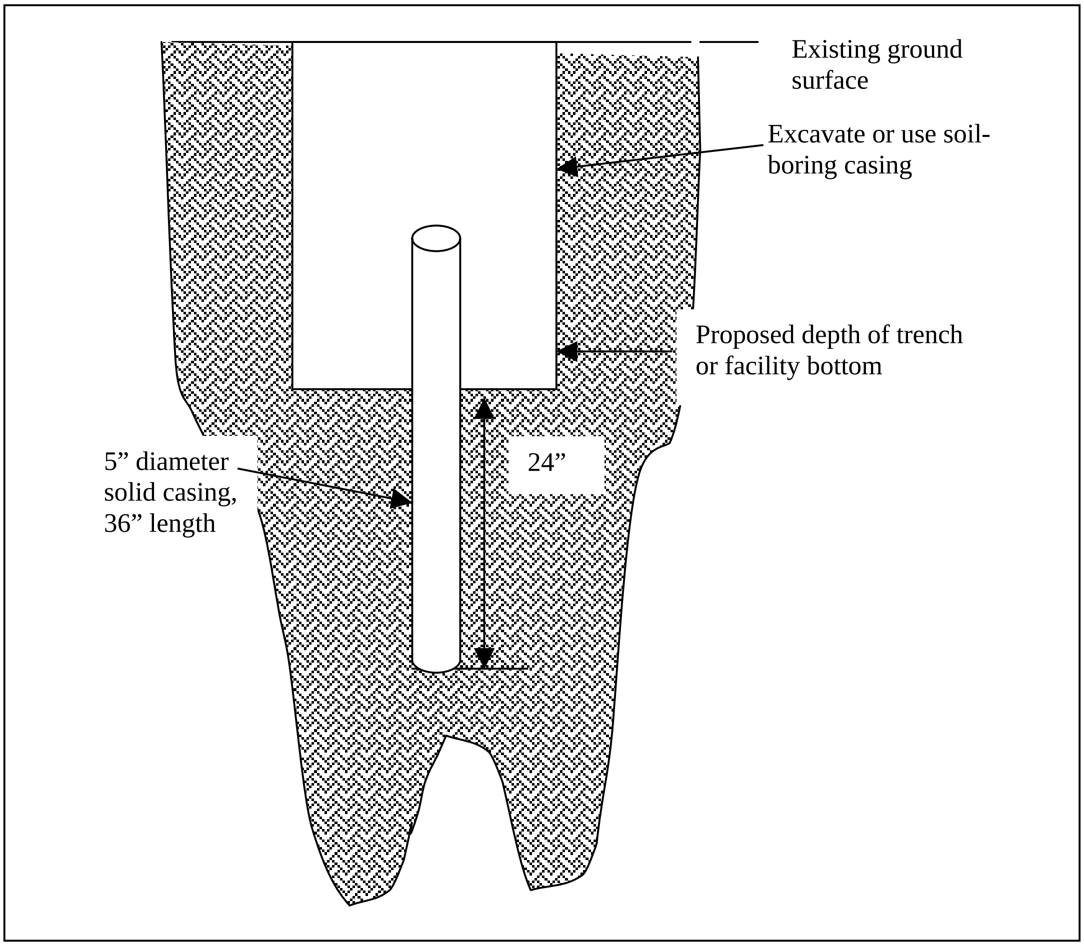
2.4.3 Post-Construction Testing

See surface infiltration facility, sump, and drywell design sections for post-construction infiltration testing requirements.

2.4.4 Laboratory Testing

Grain-size sieve analysis and hydrometer tests where appropriate may be used to determine USDA soils classification and textural analysis. Visual field inspection by a qualified professional may also be used, provided that it is documented. The use of laboratory testing to establish infiltration rates is prohibited.

Exhibit 2-6: Falling Head Test Requirements



2.5 CONTROL STRUCTURES FOR DETENTION SYSTEMS

This section presents the methods and equations for the design of flow restricting control structures, for use with extended wet detention ponds, dry detention ponds, and structural detention facilities. It includes details and equations for the design of orifices, and equations for rectangular sharp crested weirs and v-notch weirs.

Weir and orifice structures must be enclosed in a catch basin, manhole, or vault, and must be accessible for maintenance.

2.5.1 Design Requirements

The following criteria apply to control structure design.

- The control structure shall be designed to pass the 100-year storm event as overflow without causing flooding of the contributing drainage area.

Orifices

- Orifices may be constructed on a "tee" riser section (see **Exhibit 2-7**) or on a baffle (see **Exhibit 2-8**).

- The minimum allowable diameter for an orifice used to control flows in a public facility is 2 inches. Private facilities may utilize a 1-inch diameter orifice if additional clogging prevention measures are implemented. The orifice diameter shall always be greater than the thickness of the orifice plate.

- Multiple orifices may be necessary to meet the 2- through 25-year design storm performance requirements for a detention system. However, extremely low flow rates may result in the need for small orifices (< 1-inch for private facilities, < 2-inch for public) that are prone to clogging. In these cases, retention facilities that do not rely on orifice structures shall be used to the maximum extent practicable to meet flow control requirements (see **Section 1.6.2**). Where this is not practicable, the applicant must pay the off-site management fee rather than constructing a flow control facility. Large projects may also result in high flow rates that necessitate excessively large orifice sizes that are impractical to construct. In such cases, several orifices may be located at the same elevation to reduce the size of each individual orifice.

Orifice Sizing Equation:

$$Q = C A \sqrt{2gh}$$

where:

Q = Orifice discharge rate, cfs

C = Coefficient of discharge, feet (suggested value = 0.60 for plate orifices)

A = Area of orifice, square feet

h = hydraulic head, feet

g = 32.2 ft/sec^2

The diameter of plate orifices is typically calculated from the given flow. The orifice equation is often useful when expressed as an equivalent orifice diameter in inches.

$$d = \sqrt{\frac{36.88\,Q}{\sqrt{h}}}$$

where:

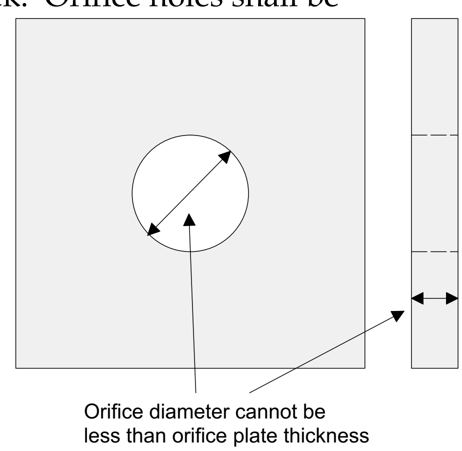
Q = flow, cfs

d = orifice diameter, inches

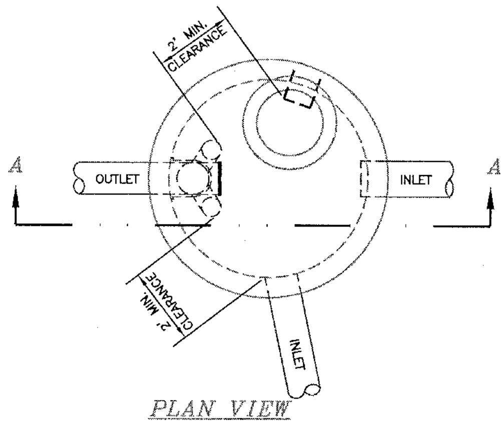
h = hydraulic head, feet

- Orifices shall be protected within a manhole structure, or by a minimum 18-inch-thick layer of 1½″ to 3″ evenly graded, washed rock. Orifice holes shall be externally protected by stainless steel or galvanized wire screen (hardware cloth) with a mesh of 3/4″ or less. Chicken wire shall not be used for this application.

- Orifice diameter shall be greater than or equal to the thickness of the orifice plate (see diagram).



- If less than 3″, the orifice shall not be made of concrete. A thin material (e.g., stainless steel, HDPE or PVC) shall be used to make the orifice plate; the plate shall be attached to the concrete or structure.



PLAN VIEW

NOTES:

1. EXCEPT AS SHOWN OR NOTED, UNITS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGER PRE CAST CONCRETE MANHOLE, PER C.O.P. STANDARD PLAN 4-08-1.

2. FOR DETAILS SHOWING GRADE RING, STEPS, MANHOLES, AND TOP SLABS, SEE C.O.P. STANDARD PLAN 4-08-1.

3. PIPE SUPPORTS SHALL ANCHORED AT 3' MAX. SPACING BY 3/8 DIA. STAINLESS STEEL EXPANSION BOLTS EMBEDDED 2" IN WALL.

4. THE RESTRICTOR/SEPARATOR SHALL BE FABRICATED FROM SOLID WALL HDPE PIPE, OR APPROVED EQUAL.

5. OUTLET SHALL BE CONNECTED TO RESTRICTOR PIPE WITH A FLEXIBLE COUPLING.

6. THE VERTICAL RISER STEM OF THE RESTRICTOR/ SEPARATOR SHALL BE THE SAME DIAMETER AS THE HORIZONTAL OUTLET PIPE, WITH A 10" MINIMUM DIAMETER.

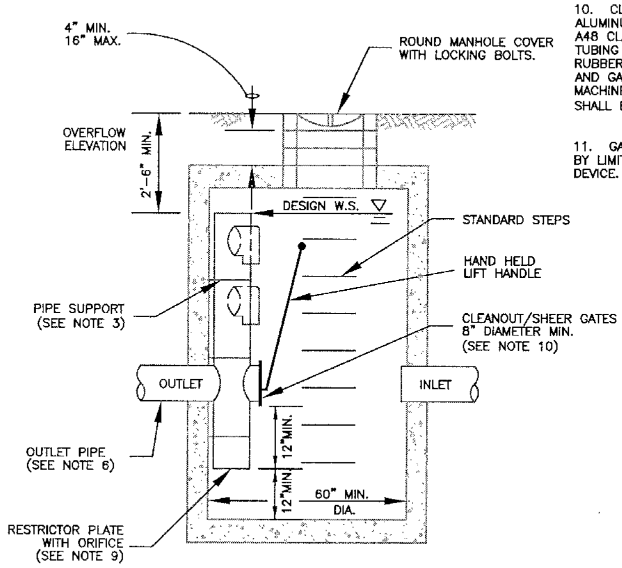
7. FRAME AND STEPS ARE TO BE OFFSET SO THAT:
   A. CLEAN OUT GATE IS VISIBLE FROM TOP
   B. CLIMB-DOWN SPACE IS CLEAR OF RISER AND GATE.
   C. FRAME IS CLEAR OF CURB (IF ANY EXISTS).

8. MULTI-ORIFICE ELBOWS MAY BE LOCATED AS SHOWN OR ALL ON ONE SIDE OF RISER TO ASSURE LADDER CLEARANCE. SIZE OF ELBOWS AND PLACEMENT TO BE CLEARLY LABELED ON THESE PLANS.

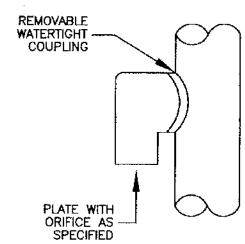
9. RESTRICTOR PLATE WITH ORIFICE AS SPECIFIED ON THESE PLANS. SPECIFIED OPENING TO BE CUT ROUND AND SMOOTH.

10. CLEANOUT/SHEAR GATE: ALUMINUM ALLOY PER B-26-26-32E OR CAST IRON ASTM A48 CLASS 308 AS REQUIRED. LIFT HANDLE EITHER SOLID OR TUBING WITH ADJUSTABLE HOOK AS REQUIRED. NEOPRENE RUBBER GASKET REQUIRED BETWEEN RISER MOUNTING FLANGE AND GATE FLANGE. MATING SURFACES OF LID AND BODY TO BE MACHINED FOR PROPER FIT. FLANGE MOUNTING BOLTS SHALL BE 3/4" DIA. STAINLESS STEEL.

11. GATE SHALL NOT OPEN BEYOND THE CLEAR OPENING BY LIMITED HINGE MOVEMENT, STOP TABS, OR SOME OTHER DEVICE.



SECTION A - A



ELBOW DETAIL

DRAWN BY
RRG

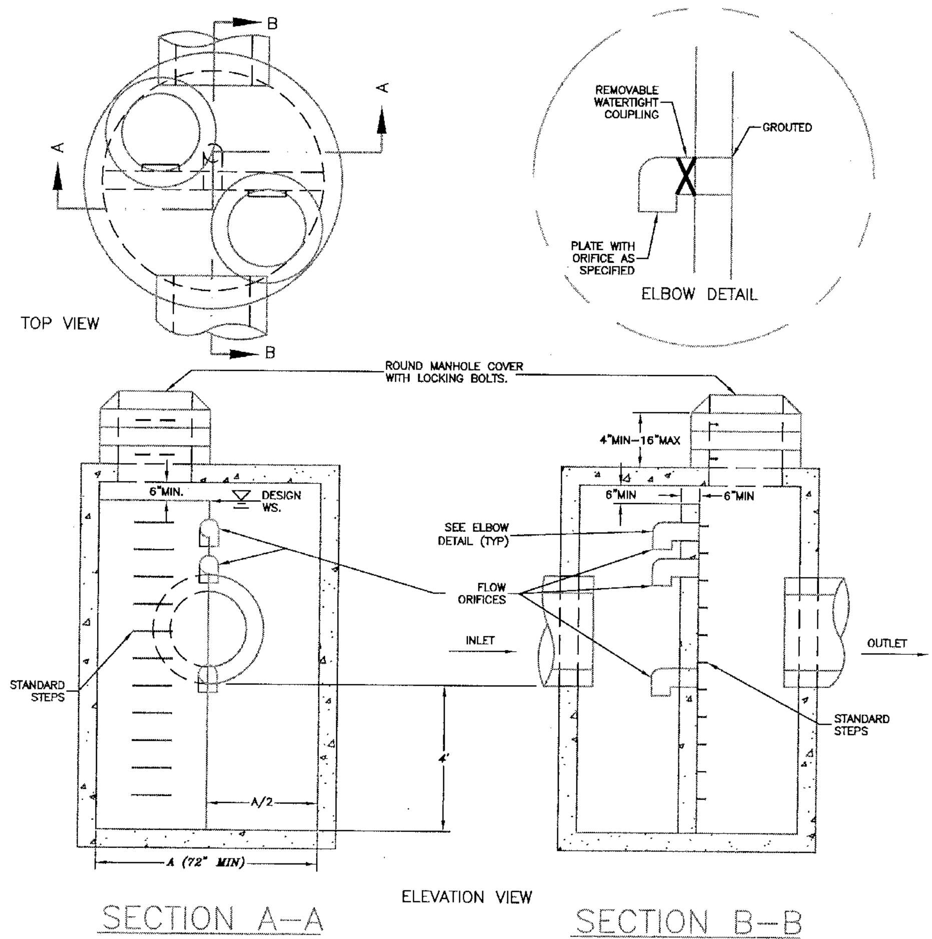
NTS

EXHIBIT 2-7
ORIFICE LOCATION
TEE RISER

EXHIBIT 2-7.DWG, 08/04/04 at 07:34

NOTES

1. EXCEPT AS SHOWN OR NOTED, UNIT SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGE PRE CAST CONCRETE MANHOLES. SEE C.O.P. STANDARD PLAN No. 4-08-1. 72", 84" & 96" DIAMETER.
2. FOR DETAILS SHOWING GRADE RINGS, STEPS, AND TOP SLABS, ALSO SEE STANDARD PLAN No. 4-08-1.
3. SEE PROJECT PLANS FOR SIZE AND LOCATION OF ORIFICES.
4. PIPE SIZES, SLOPES AND ALL ELEVATIONS AS SHOWN IN THE PLANS.
5. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
6. PRE CAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
7. ORIFICE PLATES TO BE 1/4" THICK MIN. HDPE OR APPROVED EQUAL AND ATTACHED WITH 1/2" STAINLESS STEEL BOLTS.



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PRG

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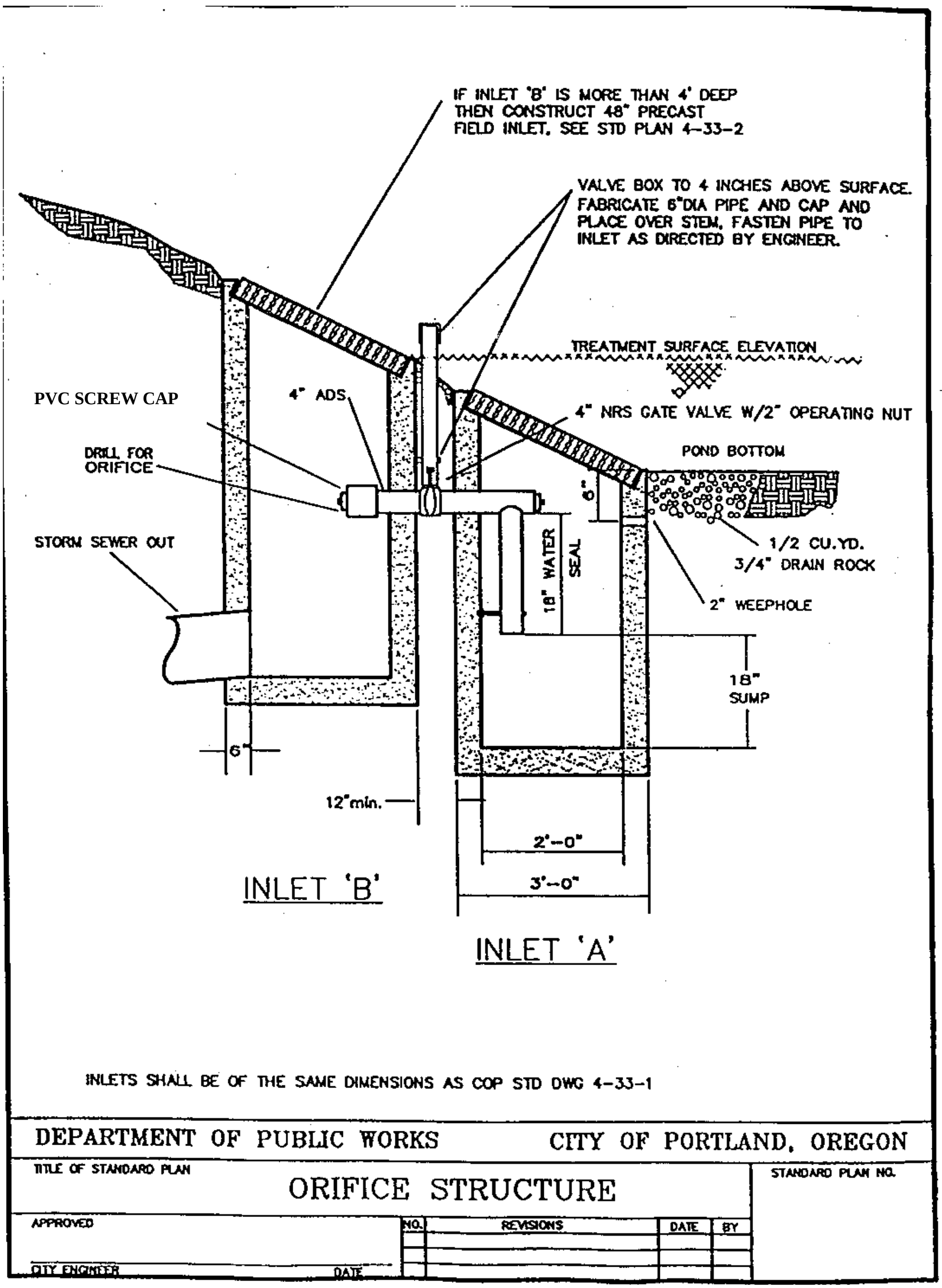
EXHIBIT 2-8

ORIFICE LOCATION

BAFFLE RISER

EXHIBIT 2-8.DWG, 08/04/04 at 07:37

Exhibit 2-9:


IF INLET 'B' IS MORE THAN 4' DEEP THEN CONSTRUCT 48" PRECAST FIELD INLET. SEE STD PLAN 4-33-2
VALVE BOX TO 4 INCHES ABOVE SURFACE. FABRICATE 6"DIA PIPE AND CAP AND PLACE OVER STEM, FASTEN PIPE TO INLET AS DIRECTED BY ENGINEER.
TREATMENT SURFACE ELEVATION
PVC SCREW CAP
4" ADS
4" NRS GATE VALVE W/2" OPERATING NUT
POND BOTTOM
DRILL FOR ORIFICE
6"
18" WATER SEAL
1/2 CU.YD. 3/4" DRAIN ROCK
STORM SEWER OUT
2" WEEPHOLE
18" SUMP
6"
12"min.
2'-0"
3'-0"
INLET 'B'
INLET 'A'
INLETS SHALL BE OF THE SAME DIMENSIONS AS COP STD DWG 4-33-1
DEPARTMENT OF PUBLIC WORKS
CITY OF PORTLAND, OREGON
TITLE OF STANDARD PLAN
ORIFICE STRUCTURE
STANDARD PLAN NO.
APPROVED
NO.
REVISIONS
DATE
BY
CITY ENGINEER
DATE

Rectangular Notched Sharp Crested Weir

$$Q = C(L - 0.2H) * H^{1.5}$$

where:

Q= Weir discharge, cubic feet per second (cfs)
C = 3.27 + 0.40*H/P, feet
P = Height of weir bottom above downstream water surface, feet
H = Height from weir bottom to crest, feet
L = Length of weir, feet*

* For weirs notched out of circular risers, length is the portion of the riser circumference not to exceed 50 percent of the circumference.

V-Notched Sharp Crested Weir

$$Q = C_d \left(\text{Tan}\ \frac{\theta}{2}\right) H^{\frac{5}{2}}$$

where:

Q = Weir discharge, cfs
C_d = Contraction coefficient, feet (suggested value = 2.5 for 90 degree weir)
θ = Internal angle of notch, degrees
H = Height from weir bottom to crest, feet

2.6 ACCESS FOR OPERATIONS AND MAINTENANCE

Adequate access for operations and maintenance must be provided to all stormwater management facilities and their components. Public facilities shall have access routes at least 8 feet wide, not to exceed 10 percent in slope, and shall be located adjacent to public rights-of-way wherever feasible. Where structural surfaces are needed to support maintenance vehicles, access routes shall be constructed of gravel or other permeable paving surface where possible. Public facility vehicular access routes shall be designed for H-20 loading.

2.7 LANDSCAPING REQUIREMENTS

Vegetation is a key element in the performance of many stormwater management facilities. Facility-specific planting requirements are given in **Section 2.9**. These requirements are based on BES experience and/or standard landscape industry methods for design and construction, and are required to be covered by a 2-year warranty period.

At the end of the first year and again at the end of the 2-year warranty period, all plants that do not survive must be replaced. Establishment procedures, such as control of invasive weeds, animal and vandal damage, mulching, re-staking, watering, and mesh or tube protection replacement, shall be implemented to the extent needed to ensure plant survival.

Designers may elect to use BES's Watershed Revegetation Program approach, which allows smaller materials to be planted in larger quantities. If this approach is chosen, the following requirements shall apply:

1) A 5-year warranty period from the time of plant installation shall be provided.
2) Plants must be installed during the dormant season, typically defined as December through March.
3) A survival rate of 75 percent (no replacements) must be achieved for all bare root plants measured in the third and fifth year after installation. If the survival rate falls below this threshold, a number of additional plants, sufficient to meet the 75% survival rate must be installed. The number of additional plants required will be based on the mortality rate of the initial planting.
4) Density of plantings shall be at least one tree and one shrub per 50 square feet of facility area. These plants are bare root (seedlings) and range in size from 10 inches to 24 inches tall.
5) Bareroot seedlings must be dormant in order to harvest from farm sites for planting.
6) All plants must be native from local seed sources and found on the Portland Plant List. A minimum of four different species of trees and shrubs must be used. At least half of the trees must be evergreen. Ground covers must be native

grasses and wildflowers from local seed sources. See **Appendix F** for a list of native plant suppliers.

7) During the period between harvest and installation, the plants must be kept in a temperature-controlled facility. Temperature must be kept between 33 and 36 degrees Fahrenheit, and plant roots must be kept moist at all times. Plants must be planted within 24 hours of removal from the temperature-controlled facility.

Applicants may obtain more information from BES's Watershed Revegetation Program.

Stormwater facilities located in the public street right-of-way are not required to use evergreen trees to meet landscaping requirements.

Where the plant material requirements of this manual and Title 33 differ, the designer shall use the larger quantity and sizes. (In calculating quantities, fractions should be rounded to the higher number.) The Watershed Revegetation Program approach uses smaller plants and may not always satisfy Title 33 requirements.

Landscaping required by Title 33 may be counted toward meeting the facility-specific landscape requirements in this chapter if the plantings are located within the facility area. Similarly, plantings that meet the requirements in this chapter may also meet Title 33 landscape requirements.

It is critical that selected plant materials are appropriate for soil, hydrologic, and other facility and site conditions. For facilities located in environmental zones, or BES maintained facilities located outside of the public right-of-way, all plants within the facility area shall be appropriate native species from the **BES recommended plant lists** in **Appendix F** or the latest edition of the Portland Plant List (no nuisance or prohibited plants). The designer may also refer to the Planning Bureau's *Environmental Handbook*.

The design for plantings shall minimize the need for herbicides, fertilizers, pesticides, or soil amendments at any time before, during, and after construction and on a long-term basis. Plantings shall be designed to minimize the need for mowing, pruning, and irrigation.

Grass or wildflower seed shall be applied at the rates specified by the suppliers. If plant establishment cannot be achieved with seeding by the time of substantial completion of the stormwater facility portion of the project, the contractor shall plant the area with wildflower sod, plugs, container plants, or other means to complete the specified plantings and protect against erosion before water is allowed to enter the facility.

Landscaping Submittal Requirements

The design must include elements that ensure landscape plant survival and overall stormwater facility functional success. Construction specifications and/or drawings need to include the following elements:

- Irrigation system to be used for the establishment period and permanent long-term. Note that public stormwater management facilities shall be designed so permanent long-term irrigation systems are not needed.

- Landscape plan showing the location of landscape elements, including size and species of all proposed plantings, and existing plants and trees to be preserved.

- Plant list/table, including scientific name, size at time of planting, quantity, type of container, evergreen or deciduous, appropriate planting season, native or non-native to region, and other information in accordance with the facility-specific planting section and landscape industry standards.

- Topsoil stockpile location, including source of topsoil, if imported. Include erosion protection per the City's *Erosion Control Manual*. Soil analysis for all topsoil to be used within the facility area. (Soil analysis is not required for single-family residential sites.)

2.8 OUTFALL DESIGN

Outfalls shall be located above the downstream mean low water level, except as approved by the City. **Exhibit 2-10** shows a typical outfall layout. Concrete endwalls will be required for all exposed outfall pipes greater than 12 inches in diameter (See **Exhibit 2-13**). Publicly accessible outfalls greater than 18 inches in diameter shall include grated protection in accordance with **Exhibit 2-14**. All outfalls shall be provided with a rock splash pad or other approved erosion control/energy dissipation measures. Rock protection at outfalls from small diameter pipes shall be as follows:

RIP-RAP PAD DIMENSIONS FOR SMALL OUTFALLS
2″ Pipe: 12″ wide x 24″ long x 2″ deep, Average Stone Size = 1″
4″ Pipe: 24″ wide x 36″ long x 4″ deep, Average Stone Size = 2″
6″ Pipe: 36″ wide x 48″ long x 6″ deep, Average Stone Size = 4″

Rock protection at outfalls from pipes greater than 6 inches shall be designed in accordance with **Exhibit 2-11**, unless otherwise approved by the City. **Exhibit 2-12** shows riprap class selection. All rock protection areas shall be inter-planted with willow stakes or other approved plantings, every two feet on-center, to increase stability, reduce erosion, provide shading, and improve aesthetics.

Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 feet per second (fps). These shall be designed by a professional engineer using published references such as *Hydraulic Design of Energy Dissipaters for Culverts and Channels* (U.S. Department of Transportation, Federal Highway Administration) and other references. The construction plan submittal shall identify the design reference.

Outfalls to drainageways and rivers are often located in environmental zones. Environmental review may be required as per City Code Title 33.

Drainageways and rivers may have steep slopes or banks and may have unstable landforms (i.e. slump). Geotechnical investigation to determine the stability of the stream or river bank, as reviewed and approved by BES or BDS, may be required for approval.

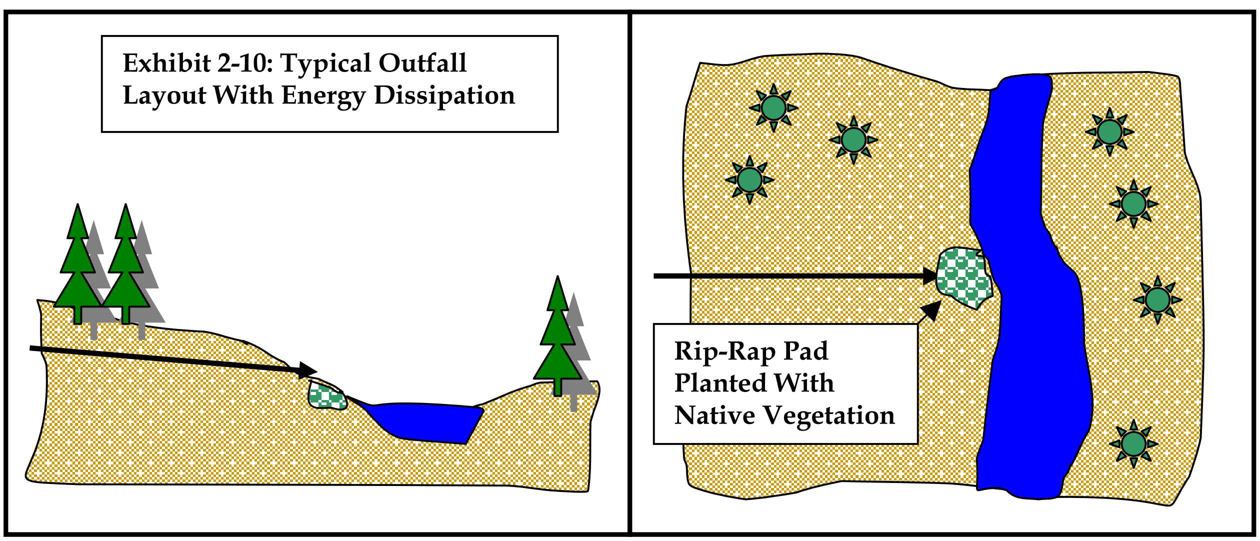


Exhibit 2-10: Typical Outfall Layout With Energy Dissipation

Exhibit 2-11
ROCK PROTECTION AT OUTFALLS FOR PIPES GREATER THAN 6 INCHES IN DIAMETER

Discharge Velocity at Design Flow (fps)			REQUIRED PROTECTION Minimum Dimensions				
			Type	Depth*	Width	Length**	Height
0	To	5	Riprap*	2 x (max stone size)	Diameter + 6 ft.	As calculated	Crown + 1 ft.
6	To	10	Riprap*	2 x (max stone size)	Diameter + 6 ft. or 3x dia. which-ever is greater	As calculated	Crown + 1 ft.
11	To	20	Gabion or Riprap*	2 x (max stone size)	Diameter + 6 ft. or 4x dia. which-ever is greater	As calculated	Crown +1 ft.
Over 20			Engineered Energy Dissipater Required				

* Riprap size shall be determined using the following formulae*** and the *City of Portland Standard Construction Specifications*, Chapter 610.2.04 Broken Stone

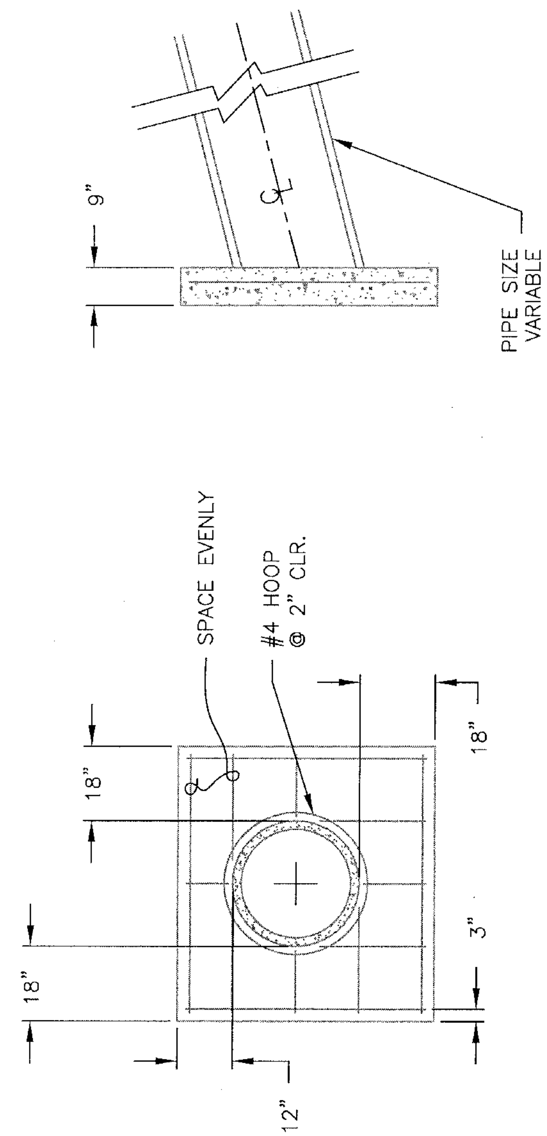
V = Average velocity (ft/s)	*Riprap size ds=0.25*Do*Fo (6″ minimum)
Do = Pipe diameter (ft)	Depth=2*ds (1 foot minimum)
ds = Riprap diameter (ft)	**Apron length Lsp= Do(8+17*Log Fo)
Lsp = Apron length (ft)	
depth = Thickness (ft)	
Fo = $V/(g*Do)^{0.5}$	$g = 32.2$ ft/s^2

***US Army Corps of Engineers design formulas from *Erosion and Riprap Requirements at Culvert and Storm Outlets*, January 1970

Exhibit 2-12: RIPRAP CLASS SELECTION

Weight (lbs)	Spherical Size (inches)	% by Weight	Average Stone Size (inches)
Class 50			6.3
30 – 50	8.5 – 10	20	
15 – 30	6.7 – 8.5	30	
2 – 15	3.5 – 6.7	40	
0 – 2	0 – 3.5	10	
Class 100			7.6
60 – 100	10.6 – 12.8	20	
25 – 60	8.0 – 10.6	30	
2 – 25	3.5 – 8.0	40	
0 – 2	0 – 3.5	10	
Class 250			11.3
200 – 250	15.0 – 18.0	20	
100 – 200	12.0 – 15.0	30	
10 – 100	6.0 – 12.0	40	
0 – 10	0 – 6.0	10	
Class 700			15.2
500 – 700	21.5 – 24.0	20	
200 – 500	15.9 – 21.5	30	
20 – 200	7.4 – 15.9	40	
0 – 20	0 – 7.4	10	
Class 2000			21.7
1400 – 2000	30.4 – 34.0	20	
700 – 1400	24.0 – 30.4	30	
40 – 700	9.3 – 24.0	40	
0 – 40	0 – 9.3	10	

Reference: Erosion and Riprap Requirements at Culverts and Storm-Drain Outlets
U.S. Army Engineers, Jan 1970



NOTES:

1. CONCRETE TO BE 3000psi (28 DAYS ULTIMATE STRENGTH, SLUMP OF 2" TO 5" AND 1 1/2" MINUS AGGREGATE).
2. ALL REINFORCING STEEL fy = 60,000psi.
3. FILL AROUND ENDWALLS TO 6" BELOW TOP OF WALL.
4. BASE OF OUTFALL SHALL BE POURED AGAINST UNDISTURBED SOIL.

DRAWN BY
RRG

NTS

EXHIBIT 2-13

END WALL DETAIL

EXHIBIT 2-13.dwg, 08/04/04 at 07:47

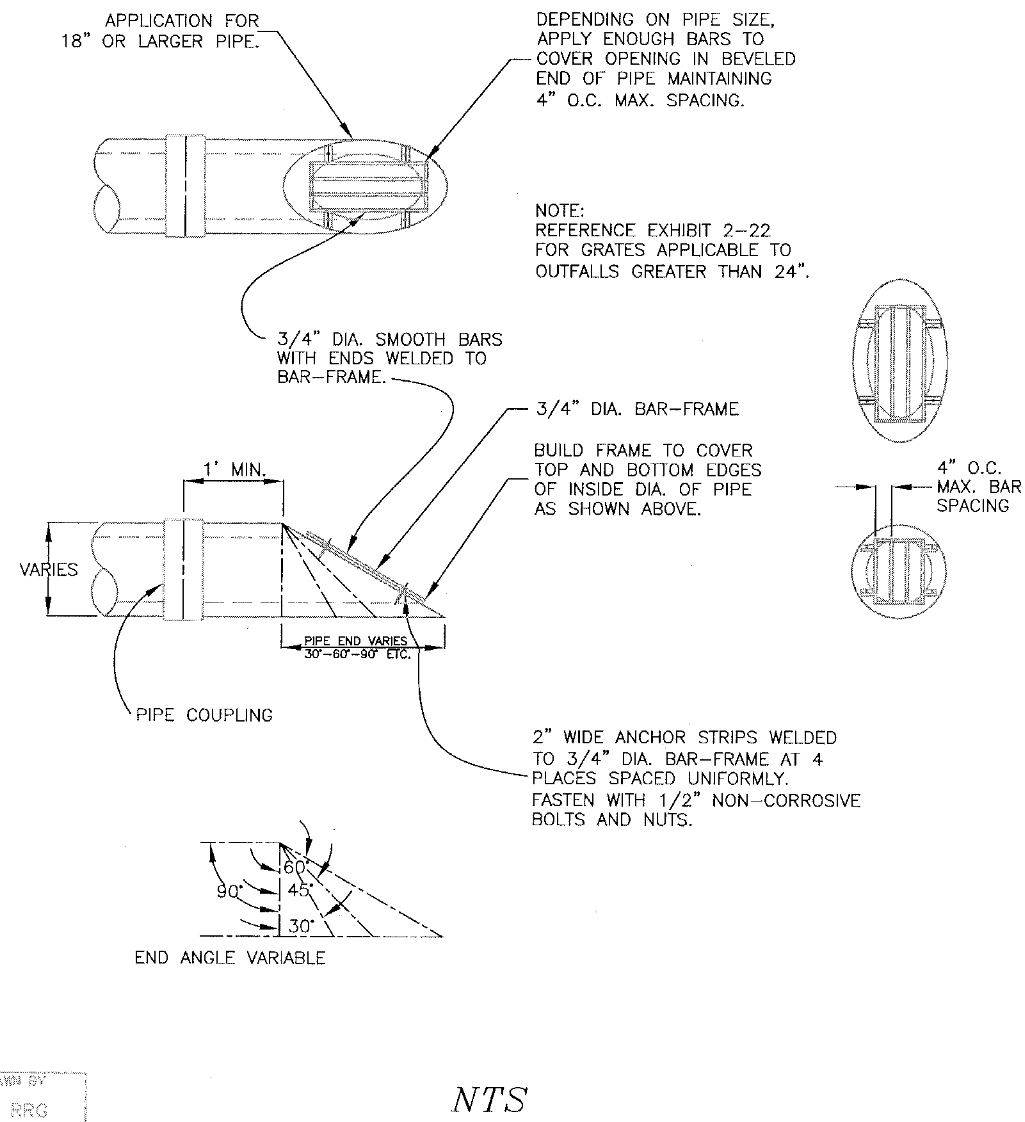
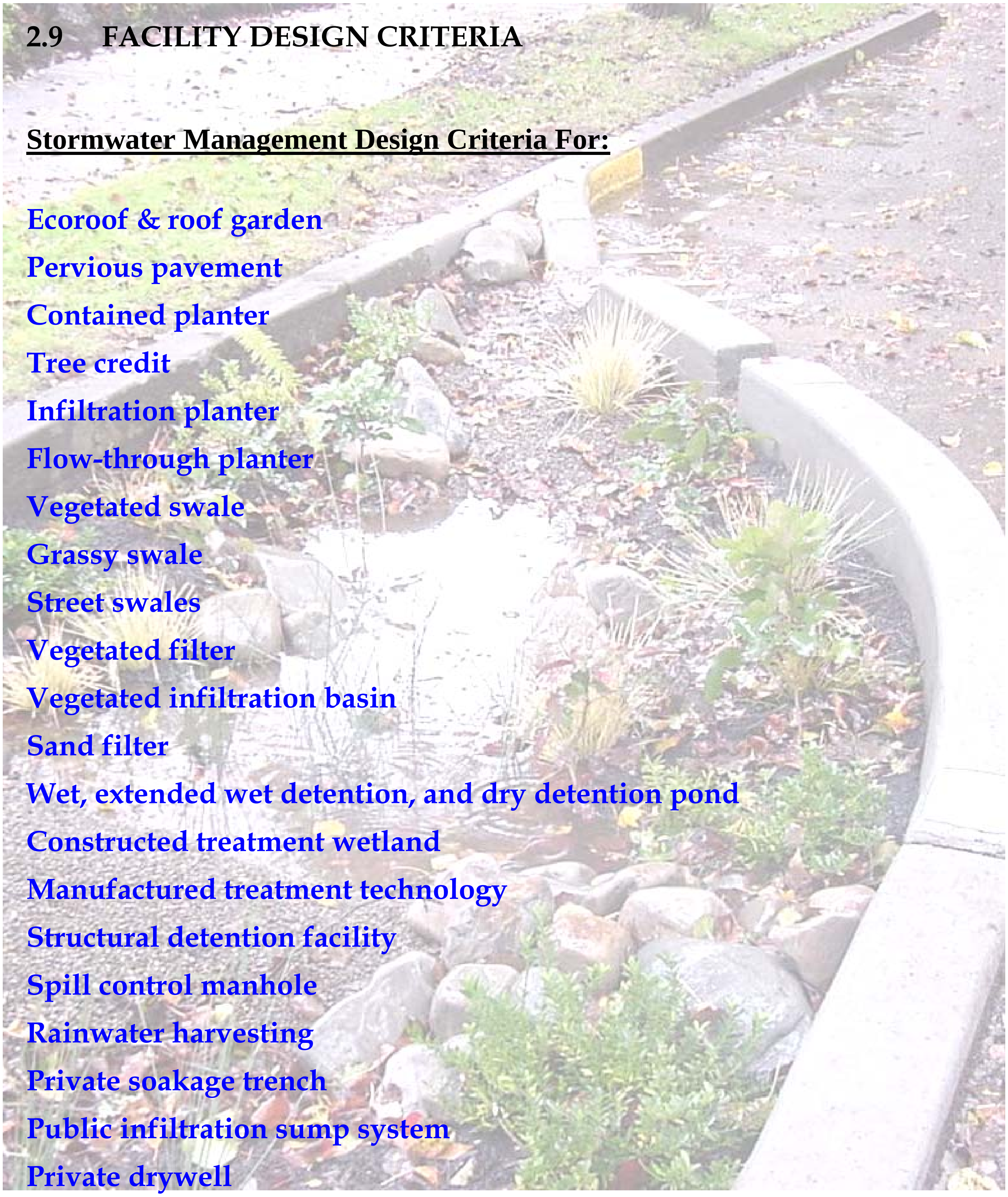


EXHIBIT 2-14

OUTFALL PIPE

GRATED PROTECTION DETAIL

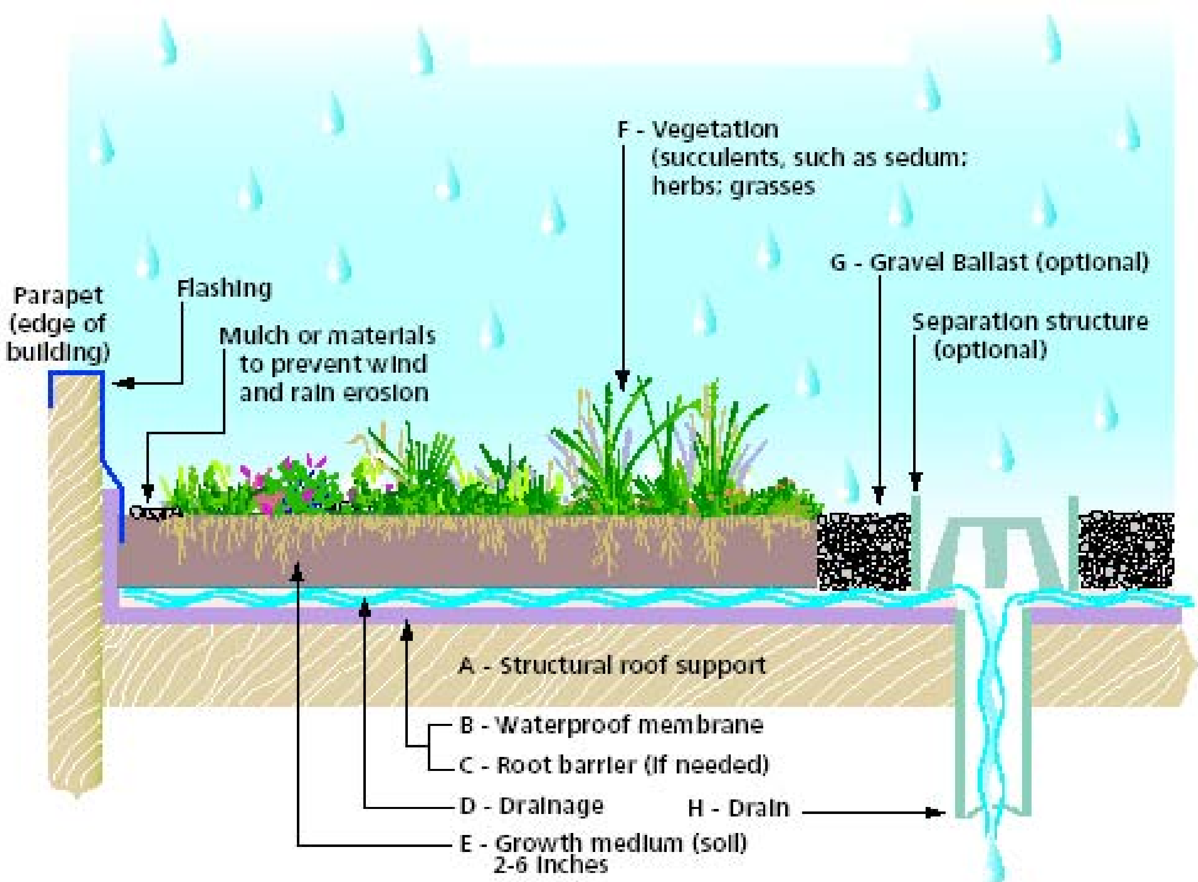


2.9 FACILITY DESIGN CRITERIA

Stormwater Management Design Criteria For:

Ecoroof & roof garden
Pervious pavement
Contained planter
Tree credit
Infiltration planter
Flow-through planter
Vegetated swale
Grassy swale
Street swales
Vegetated filter
Vegetated infiltration basin
Sand filter
Wet, extended wet detention, and dry detention pond
Constructed treatment wetland
Manufactured treatment technology
Structural detention facility
Spill control manhole
Rainwater harvesting
Private soakage trench
Public infiltration sump system
Private drywell

Ecoroof & Roof Garden



Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Impervious Area Reduction…………………	SIM
√ Pollution Reduction…………………………..	SIM
√ Flow Control…………….……………………	SIM
Destination/ Disposal……………………	NA

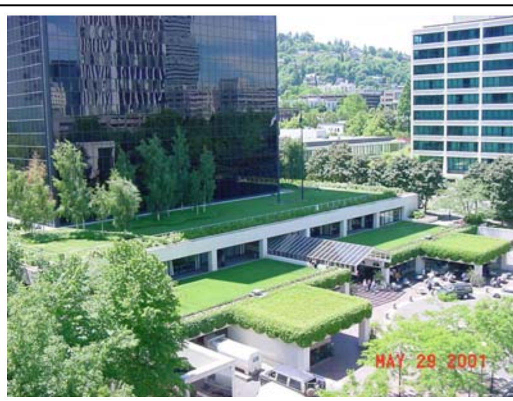
This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility is an impervious surface reduction technique. Its applicability is limited to rooftops or decks above building structures.

Ecoroof & Roof Garden

Ecoroof Description: An ecoroof is a lightweight roof system of waterproofing material with a thin soil/vegetation protective cover. The ecoroof can be used in place of a traditional roof as a way to limit impervious site area. The ecoroof captures and depending on the season, evapotranspirates 10 to 100 percent of the precipitation. Ecoroofs attempt to mimic pre-developed ground cover hydrology, reducing post-developed peak runoff rates to near pre-developed rates. Ecoroofs help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in warm seasons. An underdrain system and overflow to an approved conveyance and destination/disposal method per **Section 1.4** will be required.



Ecoroof & Roof Garden

Roof Garden Description: A roof garden is a heavy weight roof system of waterproofing material with a thick soil/vegetation protective cover. The roof garden can be used in place of a traditional roof to limit impervious site area. The roof garden captures and then evapotranspirates 50 to 100% of precipitation, depending on the season. Roof gardens attempt to mimic pre-developed hydrology, therefore reducing post-developed peak runoff rates to near pre-developed rates. They help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in warm seasons. Roof gardens should not be used on slopes greater than 10%. A drain system and overflow to an approved conveyance and destination/disposal method per **Section 1.4** will be required.

Design Requirements:

General Specifications: Good quality waterproofing material must be used on the roof surface. Soil of adequate fertility and drainage capacity at depths of 2-6 inches, and weight of 10 to 30 pounds per square foot, shall be applied. The building structure must be shown to be adequate to hold the additional weight. Vegetation shall be self-sustaining plants, without the need for fertilizers or pesticides. Soil coverage to prevent erosion shall be established immediately upon installation by using mulch, vegetation mats, or other approved protection method. Ninety-percent plant coverage shall be achieved within 2 years. Temporary irrigation to establish plants is recommended. A permanent irrigation system using potable water may be used, but an alternative means of irrigation, such as air conditioning condensate or other non-potable sources is recommended. Alternative sources should be analyzed to determine if the source has chemicals that might harm or kill the vegetation. Maximum roof slope shall be 25%, unless the applicant can provide documentation for runoff control on steeper slopes.

A. Structural Roof Support: The structural roof support must be sufficient to hold the additional weight of the ecoroof. For retrofit projects, check with an architect, structural engineer, or roof consultant to determine the condition of the existing building structure and what might be needed to support an ecoroof. This might include additional decking, roof trusses, joists, columns, and/or foundations. Generally, the building structure must be adequate to hold an additional 10 to 25 pounds per square-foot (psf) saturated weight, depending on the vegetation and growth medium that will be used. (This is in addition to snow load requirements.) An existing rock ballast roof may be structurally sufficient to hold a 10-12 psf ecoroof. (Ballast typically weighs 10-12 psf.)

For New Construction the project architects and structural engineers shall address the structural requirements of the ecoroof during the design process.

Greater flexibility and options are available for new buildings than for re-roofing. The procedures for the remaining components (B through H) are the same for both re-roofing and new construction.

B. **Waterproof Membrane (Impermeable Material):** Waterproof membranes are made of various materials, such as modified asphalts (bitumens), synthetic rubber (EPDM), hypolan (CPSE), and reinforced PVC. Some of the materials come in sheets or rolls and some are in liquid form. They have different strengths and functional characteristics. Some of these products require root inhibitors (refer to C) and other materials to protect the membrane. Numerous companies manufacture waterproofing materials appropriate for ecoroofs.

Protection Boards or Materials: These materials protect the waterproof membrane from damage during construction and over the life of the system, usually made of soft fibrous materials.

C. **Root Barrier (If needed):** Root barriers are made of dense materials that inhibit root penetration. The need for a root barrier depends on the waterproof membrane selected. Modified asphalts usually require a root barrier, while synthetic rubber (EPDM) and reinforced PVC generally do not. Check with the manufacturer to determine if a root barrier is required for a particular product. Note: membranes impregnated with pesticides are not allowed. Manufacturers must provide BES with evidence that membranes impregnated with copper will not leach out at concentrations of concern.

D. **Drainage Layer (If needed):** There are numerous ways to provide drainage. Products range from manufactured perforated plastic sheets to a thin layer of gravel. Some ecoroof designs do not require any drainage layer other than the growth medium itself, depending on roof slope and size (for example, pitched roofs and small flat roofs).

E. **Growth Medium (Soil):** The growth medium is generally 2 to 6-inches thick and well drained. It weighs from 10 to 25 pounds per square-foot when saturated. A simple mix of one-fourth topsoil, one-fourth compost, and one-half pumice perlite may be sufficient for many applications. Some companies have their own growth medium specifications. Other components could include digested fiber, expanded clay or shale, or coir.

F. **Vegetation:** Ecoroof and roof garden vegetation should have the following attributes:
- Drought-tolerant, requiring little or no irrigation after establishment

• A growth pattern that allows the plant to thoroughly cover the soil. At least 90% of the overall surface shall be covered.
• Self-sustaining, without the need for fertilizers, pesticides, or herbicides
• Able to withstand heat, cold, and high winds
• Very low-maintenance, needing little or no mowing or trimming
• Perennial or self-sowing
• Fire resistant

A mix of sedum/ succulent plant communities is recommended because they possess many of these attributes. Herbs, forbs, grasses, and other low groundcovers can also be used to provide additional benefits and aesthetics; however, these plants may need more watering and maintenance to survive and keep their appearance.

***Link to Ecoroof Landscaping Plan Example**
***Link to Ecoroof and Roof Garden Recommended Plants**

Installation: Four methods (or combinations of them) are generally used to install the vegetation: vegetation mats, plugs/ potted plants, sprigs, and seeds.

1. **Vegetation mats** are sod-like, pre-germinated mats that achieve immediate full plant coverage. They provide immediate erosion control, do not need mulch, and minimize weed intrusion. They also need minimal maintenance during the establishment period and little ongoing watering and weeding.
2. **Plugs or potted plants** may provide more design flexibility than mats. However, they take longer to achieve full coverage, are more prone to erosion, need more watering during establishment, require mulching and more weeding.
3. **Sprigs** are hand-broadcast. They require more weeding, erosion control, and watering than mats.
4. **Seeds** can be either hand-broadcast or hydraseeded. Like sprigs, they require more weeding, erosion control, and watering than mats.

G. Gravel Ballast (If needed): Gravel ballast is sometimes placed along the perimeter of the roof and at air vents or other vertical elements. The need for ballast depends on operational and structural design issues. It is sometimes used to provide maintenance access, especially to vertical elements requiring periodic maintenance. In many cases, very little, if any, ballast is needed. In some situations a header or separation board may be placed between the gravel ballast and adjacent elements (such as soil or drains). If a root barrier is used, it must extend under the gravel ballast and growth medium, and up the side of the vertical elements.

H. Drain: As with a conventional roof, an ecoroof must safely drain runoff from the roof to an approved stormwater destination. See **Section 1.4** for stormwater destinations.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from roof lines
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification, including weight
4) Filter fabric specification
5) Drainage layer specification
6) Waterproof membrane specification, including root barriers
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Planting and irrigation plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Roof Structure	Call for inspection
Waterproof membrane	Call for inspection
Drainage layer/ plumbing & pipes	Call for inspection
Growing medium, plantings & irrigation	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to ecoroof and roof garden O&M form**

Additional photos and drawings:

*** Link to ecoroof and roof garden photos**
*** Link to ecoroof and roof garden drawings**

Ecoroof & Roof Garden

FAR Bonus for Ecoroofs and Roof Gardens in the Central City:

Under City Code Chapter 33.510.210: Floor Area and Height Bonus Options, Option #10 provides an ecoroof bonus option in the Central City. The option is provided below:

10. Ecoroof bonus option. Ecoroofs are encouraged in the Central City because they reduce stormwater run-off, counter the increased heat of urban areas, and provide habitat for birds. An ecoroof is a rooftop stormwater facility that has been certified by the Bureau of Environmental Services (BES). Proposals that include ecoroofs receive bonus floor area. A proposal may not earn bonus floor area for both the ecoroof option and the rooftop gardens option; only one of these options may be used.

    a. Bonus. Proposals that include ecoroofs receive bonus floor area as follows:

        (1) Where the total area of ecoroof is at least 10 percent but less than 30 percent of the building's footprint, each square foot of ecoroof earns one square foot of additional floor area.
        (2) Where the total area of ecoroof is at least 30 percent but less than 60 percent of the building's footprint, each square foot of ecoroof earns two square feet of additional floor area.
        (3) Where the total area of ecoroof is at least 60 percent of the building's footprint, each square foot of ecoroof earns three square feet of additional floor area.

    b. The applicant must submit a letter from BES with the application for land use review. The letter must certify that the ecoroof is approved and must specify the area of the ecoroof.

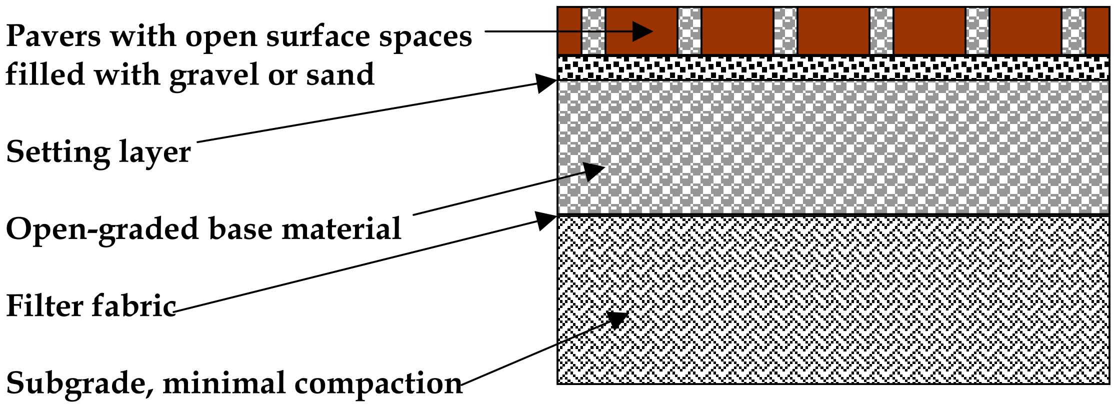
c. The property owner must execute a covenant with the City ensuring installation, preservation, maintenance, and replacement, if necessary, of the ecoroof. The covenant must comply with the requirements of 33.700.060.

The City is currently exploring options to expand the FAR bonus to other districts.

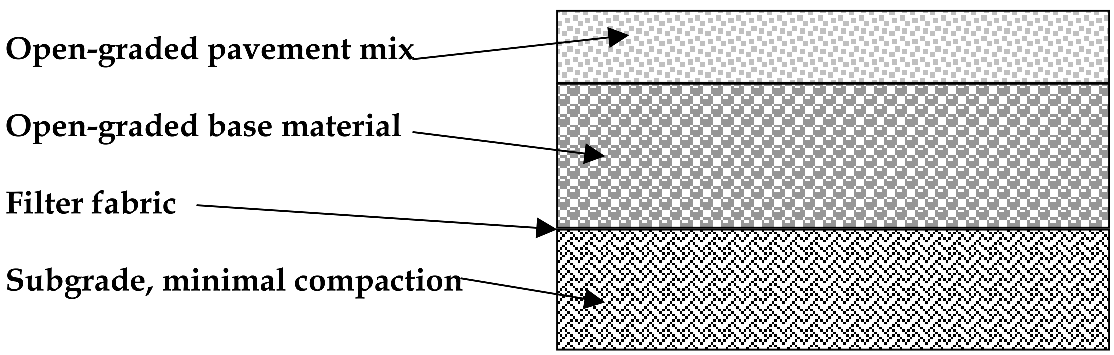
Ecoroof & Roof Garden

Pervious Pavement

Pervious Concrete Block or “Paver” Systems



Pervious (Open Graded) Concrete and Asphalt Mixes



Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Impervious Area Reduction	
√ Pollution Reduction………………………...	SIMP
√ Flow Control……………………………….	SIMP
√ Destination/ Disposal……………………..	PERF

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility is an impervious surface reduction technique. It is applicable for use in parking lots, driveways, and in some cases streets.

Pervious Pavement

Description: There are many types of pervious pavement on the market today. Numerous products and design approaches are available, including special asphalt paving; manufactured products of concrete, plastic, and gravel; paving stones; and brick. It may be used for walkways, patios, plazas, driveways, parking lots, and some portions of streets, subject to compliance with building codes and PDOT and BES Administrative Rules. To receive credit, the material must be installed and maintained to manufacturer's specifications. These materials may not be allowed in certain areas (see **Chapter 4.0** for restrictions). A professional engineer, registered in the state of Oregon must design pervious pavement systems that will be supporting vehicular traffic. For EPA's "Porous Pavement Phase I Design and Operational Criteria" (EPA-600/2-80-135), go to: **http://www.epa.gov/ednnrmrl/repository/abstrac2/abstra2.htm.** For BES's report on pervious pavement demonstration projects, vendors, and other resources, go to: **http://www.portlandonline.com/bes/index.cfm?&a=41626** .

Design Considerations: When designing pervious pavement systems, the infiltration rate of the native soil is a key element in determining the depth of base rock for the storage of stormwater, or for determining whether an underdrain system is appropriate. Traffic loading and design speed are important considerations in determining which type of pervious pavement is applicable. Pedestrian ADA accessibility, aesthetics, and maintainability are also important considerations, depending on pavement use.

Construction Considerations: Installation procedures are vital to the success of pervious pavement projects, particularly pervious asphalt and concrete pavement mixes. The subgrade cannot be overly compacted with the inclusion of fine particulates or the void ratio critical to providing storage for large storm events will be lost. Weather conditions at the time of installation can affect the final product. Extremely high or low temperatures should be avoided during construction of pervious asphalt and concrete pavements.

Pervious Pavement

Design Requirements:

Soil Suitability: Pervious pavement systems are appropriate for all soil types, but will require underdrain systems to an approved stormwater disposal point (per **Section 1.4**) for soils that do not infiltrate well (less than 2 inches per hour, generally NRCS soil types C and D). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the base rock and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.), unless an underdrain system is used.

Dimensions and Slopes: Minimum/ maximum dimensions and other specifications are product-specific and shall comply with manufacturer's recommendations. Slopes shall be less than 10% in all cases.

Setbacks: Not applicable.

Sizing: Pervious pavement systems are not considered to be impervious surfaces, and therefore do not trigger pollution reduction and flow control requirements. A high-flow overflow or underdrain system must be provided to an approved destination point per **Section 1.4**, unless the performance approach is used by a professional engineer to design the system for complete stormwater disposal.

Limitations: Pervious pavements shall not be used on sites with a likelihood of high oil and grease concentrations. These site uses include vehicle wrecking or impound yards, fast food establishments, automotive repair and sales, and parking lots that receive a high number of average daily trips (> 1,000).

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Pervious pavement materials and installation procedure specifications
4) Subgrade and base course specifications
5) Filter fabric specification (if applicable)
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Pervious Pavement

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Subgrade	Call for inspection
Filter fabric (if applicable)	
Underdrain piping (if applicable)	Call for inspection
Base rock	
Pervious pavement installation	Call for inspection

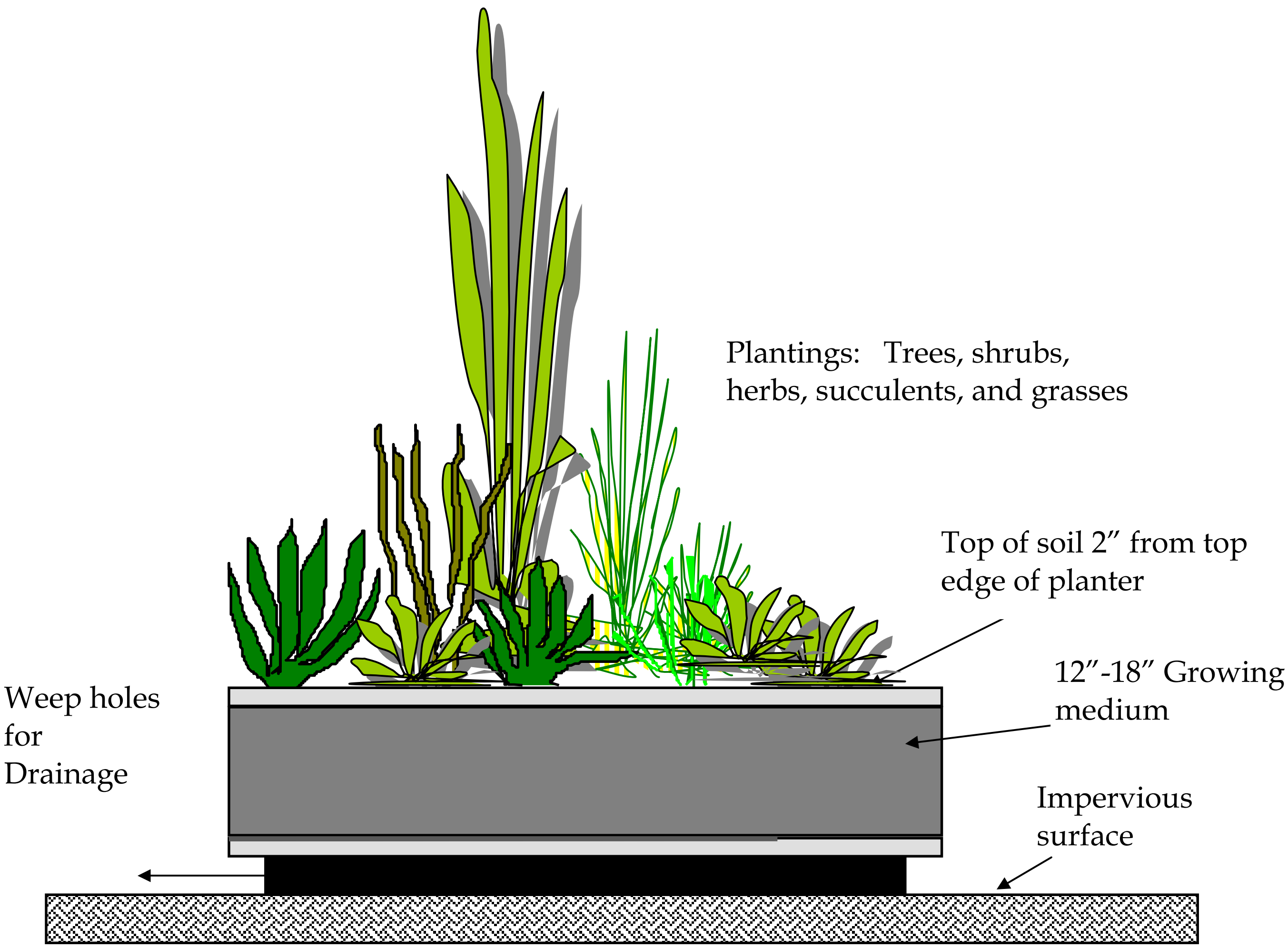
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to pervious pavement O&M form**

Additional photos and drawings:

- **Link to pervious pavement photos**
- **Link to pervious pavement drawings**
    - **Link to pervious Asphalt drawing**
    - **Link to pervious concrete drawing**
    - **Link to brick drawing**
    - **Link to cobble drawing**
    - **Link to crushed aggregate drawing**
    - **Link to natural stone drawing**
    - **Link to turf block drawing**
    - **Link to unit pavers on sand drawing**

Contained Planter



Section Not to Scale

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Impervious Area Reduction	SIM
√ Pollution Reduction	SIM
√ Flow Control	SIM
Destination/ Disposal	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility is an impervious surface reduction technique. It may be placed over sidewalk, parking lot, flat roof, and plaza areas to reduce the effective impervious area.

Contained Planter


1100 block of bus mall, downtown Portland


Federal Building (1200 block of SW 3rd Ave.)

Description: Contained planters are used for planting trees, shrubs, and ground cover to be placed over impervious surface. The planter may be a prefabricated pot of various dimensions or may be constructed in place and have an infinite variety of shapes and sizes. Contained planters accept precipitation only, not stormwater runoff. Planters are placed on impervious surfaces, such as sidewalks, plazas and rooftops. Drainage is allowed through the bottom of the planter.

Design Considerations: Plants shall be relatively self-sustaining, with little need for fertilizers or pesticides. Irrigation is optional, although plant viability must be maintained. Trees are encouraged and may receive added stormwater management credit on the tree credit section of Form SIM.

Design Requirements:

Soil Suitability: Contained planters are appropriate for all soil types, as they are placed over impervious surface. Topsoil shall be used within the top 12 to 18 inches of the facility.

Setbacks: Not applicable.

Planter Walls: Planter walls shall be made of stone, concrete, brick, clay, plastic, wood, or other stable material. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Contained planters are given stormwater management credit for the square-footage of impervious surface that they cover, at a 1 to 1 ratio.

Landscaping: Contained planters shall be planted to cover at least 50% of the planter surface.

Contained Planter

***Link to Planter Recommended Plants**

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material specification
4) Growing medium specification
5) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Structural planter components	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to contained planter O&M form**

Additional photos and drawings:

*** Link to contained planter photos**
*** Link to contained planter drawings**

Contained Planter

Tree Credits

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Impervious Area Reduction………………..	SIM
√ Pollution Reduction……..…………………..	SIM
√ Flow Control……………..……………………	SIM
Destination/ Disposal………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) This facility intercepts rainfall and provides shade for impervious surfaces. Trees may only receive credit against the construction of ground-level impervious surfaces.

Tree Credits

Description: Trees intercept precipitation and provide several stormwater management benefits:

- Flow control: Trees hold water on the leaves and branches and allow it to evaporate, retaining flow and dissipating the energy of runoff. These functions are most measurable for storms of less than 0.5 inches over 24 hours, typical of Portland storm events. While deciduous trees are not as effective during winter months, evergreen trees are effective year round for these smaller storms and portions of larger storms. Generally, large trees with small leaves are the most efficient rainfall interceptors. Trees also facilitate stormwater infiltration and groundwater recharge.

- Pollution reduction/ stormwater cooling: Trees can provide shade over large areas of impervious surface. This provides two direct benefits. First, the hard surface is protected from direct solar exposure, which reduces heat gain. The less heat gain there is in pavement, the less heat is absorbed by stormwater as it flows over the surface. Second, by shading pavement, the trees help reduce or minimize air temperature increases caused by the hot pavement. Cooler air may help prevent stream temperature increases associated with air temperatures.

New trees planted within 25 feet of ground-level impervious surfaces are eligible for stormwater management credit. 100 square feet of credit is given for new deciduous trees, and 200 square feet of credit is given for new evergreen trees (See minimum sizes below). Stormwater management credits also apply to existing trees kept on a site if the trees' canopies are within 25 feet of ground-level impervious surfaces. The credit is the square-footage equal to one-half of the existing tree canopy. No credit will be given for existing trees within an environmental zone. For sites with over 1,000 square-feet of impervious surface to manage, no more than 10% can be mitigated through the use of trees.

Tree Credits

Trees used for stormwater management credit shall be clearly labeled on permit drawings. A note shall be included on the permit drawings that calls for City inspection after the tree has been planted, or in the case of existing tree canopy, after the site grading has been completed.

NEW EVERGREEN AND DECIDUOUS TREES:

Trees shall be maintained and protected on the site after construction and for the life of the development (50-100 years or until any approved redevelopment occurs in the future). During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City. Trees that are removed or die shall be replaced within 6 months with like species. Trees may be pruned for safety purposes only; however, if a tree is planted near a building, pruning to protect the structure is recommended.

The trees selected shall be suitable species for the site conditions and the design intent. Trees should be relatively self-sustaining and long-lived. Native conifers are highly encouraged, as many of these trees naturally grow in harsh/rocky conditions. Long-term irrigation is not required. New deciduous trees must be at least 2 caliper inches and new evergreen trees must be at least 6 feet tall to receive simplified approach credit. Trees planted to meet stormwater facility planting requirements cannot also receive simplified approach credit.

By City ordinance, the City Forester is authorized to set standards for tree sizes planted on publicly owned lands and public rights-of-way. A permit is required from Urban Forestry to plant, prune, or remove right-of-way trees. Right-of-way trees shall be at least 2 caliper inches for residential and 3.5 caliper inches for other zones, including commercial areas. For parks and other public areas, the tree standard is 3.5 caliper inches.

Approved Trees

The following tree and arborescent shrub* species are approved outright for use as simplified approach tree credits. Other species may be given credit, as approved by BES.

Acer macrophyllum	Juniperus occidentalis*	Quercus garryana
Alnus rubra	Libocendrus decurrens	Rhamnus purshiana
Arbutus menziesii	Pinus contorta	Sequoia sempervirens
Castanopsis chrysophylla*	Pinus monticola	Thuja plicata
Chamacyparis lawsoniana	Pinus ponderosa	Tsuga heterophylla

Tree Credits

Cornus nuttallii
Fraxinus latifolia
Pseudotsuga menziesii
Quercus chrysolepis*
Umbellularia californica

EXISTING TREES:

Mature evergreen and deciduous trees can have significant benefits in addition to stormwater management. They already provide habitat for urban wildlife, energy and cost conservation, aesthetics, visual screens, heritage value, windbreaks, and recreation.

The stormwater credit applies to existing trees of 4-inch caliper or larger. Credit is based on one-half of the square footage of the tree canopy, measured within the drip-line. An existing tree for which protection is required by City Title 33 code is not eligible for credits.

Protection during construction shall be in the form of minimizing disruption of the root system. Construction shall not encroach within a space measured 10 feet outside of the drip line to the tree trunk, unless the City Forester approves exemptions to this requirement. The applicant will have to provide documentation required by the Forester to ensure the tree will remain healthy after construction and during the life of the project. During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City. Stormwater management functions of any removed trees shall be replaced on the site with other trees or stormwater management approaches. Trees that die shall be replaced within 6 months. Trees may be pruned for safety purposes only; however, if a tree is near a building, pruning to protect the structure is recommended.

Checklist of minimal information to be shown on the permit drawings:

1) Trees to be given stormwater management credit shall be clearly labeled as such, with the size and species included.
2) Approximate setbacks from property lines and structures shall be shown.
3) Temporary irrigation measures shall be shown, if applicable.
4) Form SIM must be submitted, clearly showing that less than 10% of the impervious area is being mitigated for with tree credits if the project impervious area exceeds 1,000 square feet.

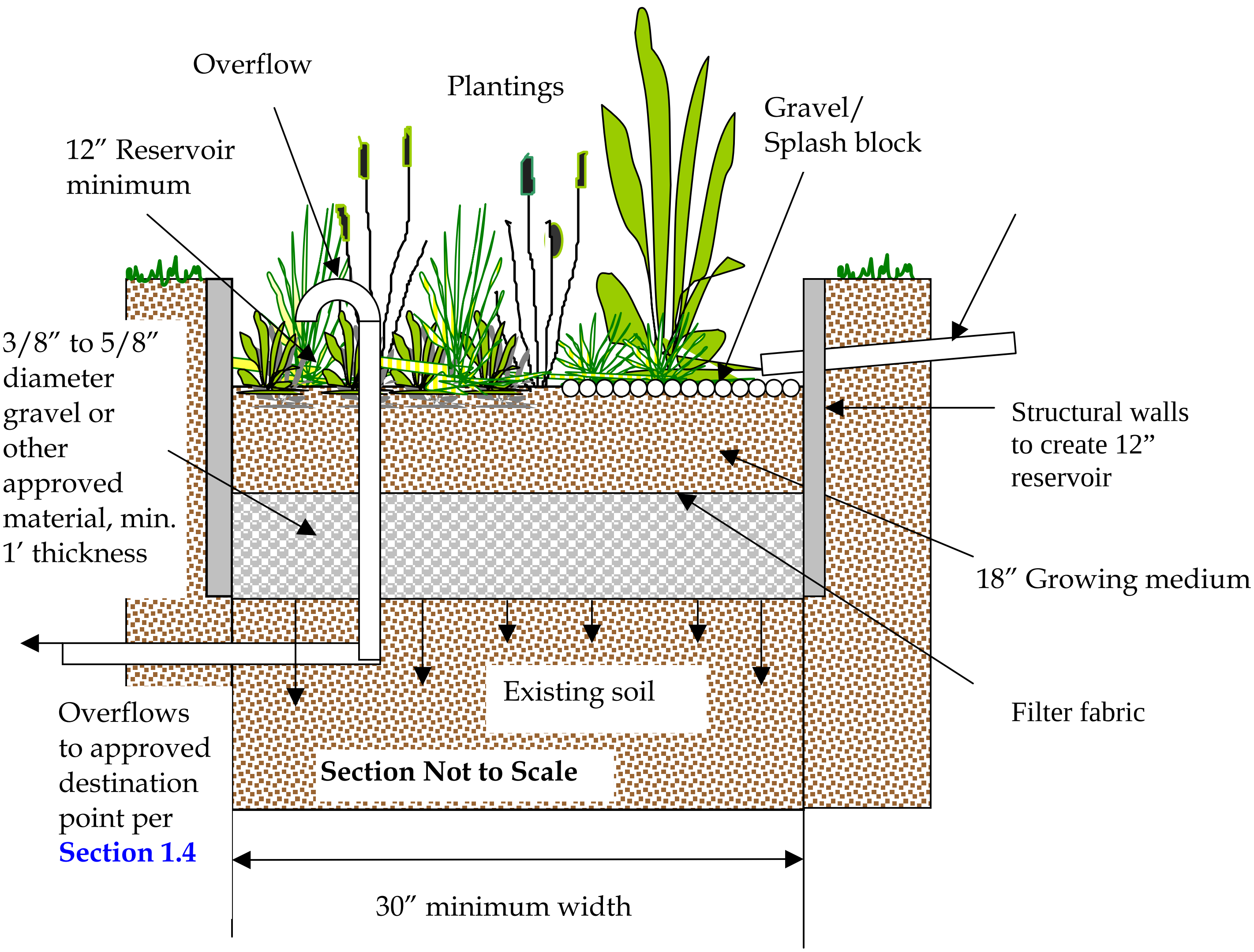
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to new tree O&M form**

Additional photos:

*** Link to tree photos**

Infiltration Planter



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction………………………..	SIM, PERF[1]
√ Flow Control…………………………………	SIM
√ Destination/ Disposal………………………	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution control. **2)** The surface infiltration facility design procedure from **Section 2.2.2** may be used to receive credit for stormwater disposal.
Infiltration planters may be designed to manage runoff from rooftops, and if submerged into the ground, parking lots and streets in many cases.

Infiltration Planter

Description: Infiltration planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil and infiltrates into the ground. In addition to providing pollution reduction, flow rates and volumes can also be managed with infiltration planters. Planters can be used to help fulfill a site's required landscaping area requirement and should be integrated into the overall site design. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. An overflow to an approved conveyance and disposal method per **Section 1.4** will be required, unless the facility is sized per surface infiltration facility guidelines presented in **Section 2.2.2**.

Design Considerations: When designing infiltration planters, the infiltration rate of the native soil is a key element in determining size and viability.

Construction Considerations: Infiltration planter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of planter areas.

Design Requirements:

Soil Suitability: Infiltration planters are appropriate for soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.) Topsoil shall be used within the top 18 inches of the facility.

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 30 inches. Planters shall be constructed without slope.

Infiltration Planter

Setbacks: Required setback from property lines is 5 feet, and 10 feet from building foundations. Proposed variances to this standard must request an exception to the building code through BDS.

Planter Walls: Planter walls shall be made of stone, concrete, brick, wood, or other durable material. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Individual infiltration planters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution and flow control. A high-flow overflow must be provided, or to receive credit for stormwater destination, the surface infiltration facility design criteria from **Section 2.2.2** must be used. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor. Planters shall be designed to pond water for less than 12 hours after each storm event.

Landscaping: Plantings shall be designed at the following quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

4 - Large shrubs/small trees	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Note: Tree planting is not required in planters, but is encouraged where practical. Tree planting is also encouraged near planters.

***Link to Flow-Through Planter Landscaping Plan Example**
***Link to Planter Recommended Plants**

Checklist of minimal information to be shown on the permit drawings:

Infiltration Planter

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification
5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Planter grading/ excavation	
Structural components/ liner	Call for inspection
Piping	Call for inspection
Drain rock	
Filter fabric	
Growing medium	
Plantings	Call for inspection

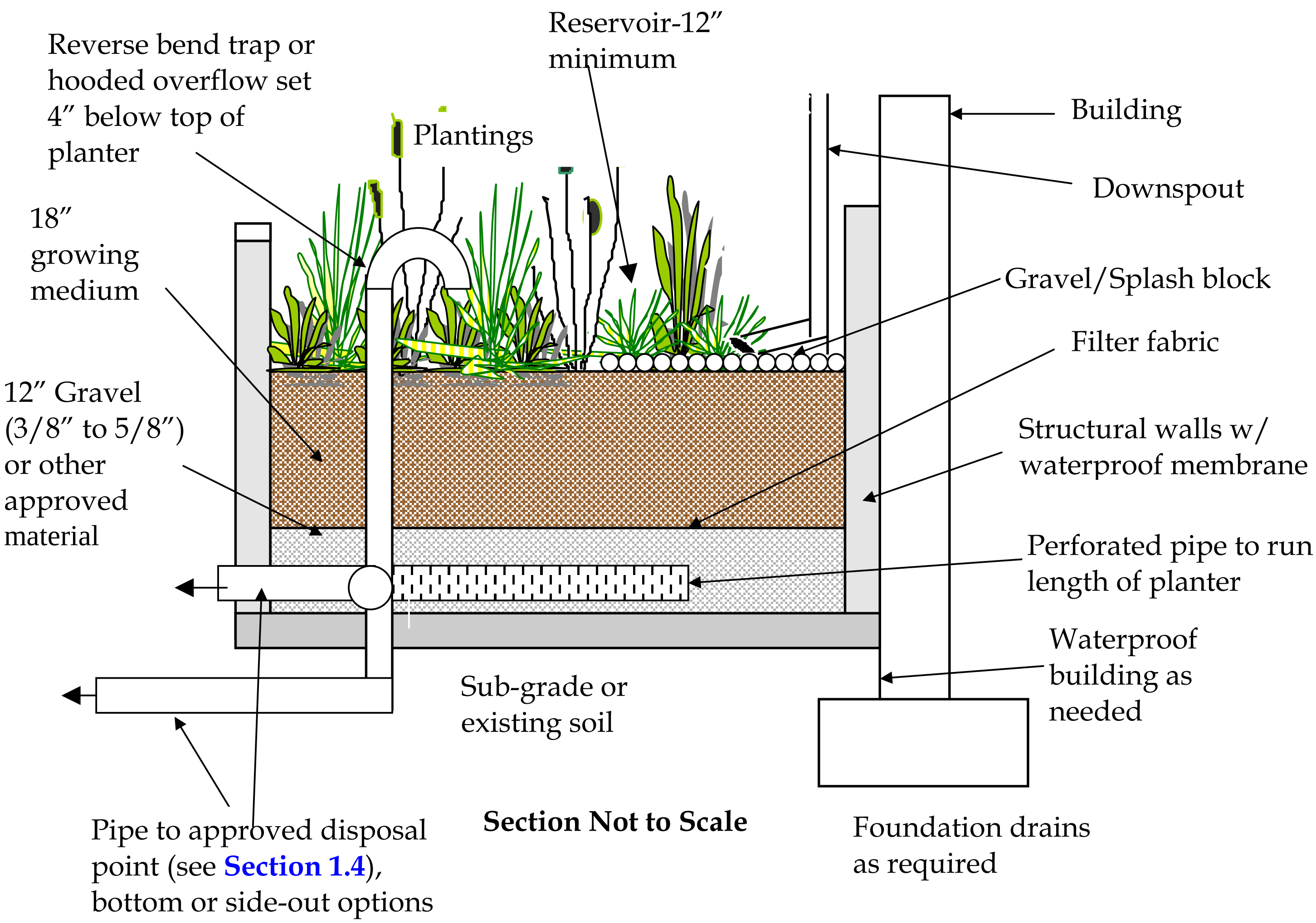
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to infiltration planter O&M form**

Additional photos and drawings:

*** Link to infiltration planter photos**
*** Link to infiltration planter drawings**

Flow-Through Planter



Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Pollution Reduction…………………………..	SIM, PERF[1]
√ Flow Control…………………….……………	SIM
Destination/ Disposal………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Flow-through planters may be designed to manage runoff from rooftops, and if submerged into the ground, parking lots and streets in some cases.

Flow-Through Planter

Description: Flow-through planters are structural landscaped reservoirs used to collect and filter stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil. In addition to providing pollution reduction, flow rates and volumes can also be managed with flow-through planters. Planters should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. Because they include a waterproof lining, flow-through planters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance and destination/ disposal method per **Section 1.4** will be required.

Design Considerations: When designing flow-through planters, the structural walls can often times be incorporated with building foundation plans.

Construction Considerations: Special attention needs to be paid to the planter waterproofing if constructed adjacent to building structures.

Design Requirements:

Soil Suitability: Flow-through planters are appropriate for all soil types. Topsoil shall be used within the top 18 inches of the facility.

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 18 inches. Planter slopes shall be less than 0.5%.

Setbacks: Required setback from property lines is 5 feet, unless the planter height is less than 30 inches.

Flow-Through Planter

Planter Walls: Planter walls shall be made of stone, concrete, brick, or wood. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Individual flow-through planters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution reduction and flow control. A high-flow overflow must be provided to an approved disposal point per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used to downsize the simplified approach sizing factor. Planters shall be designed to pond water for less than 12 hours after each storm event.

Landscaping: Plantings shall be designed at the following minimum quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

4 - Large shrubs/small trees	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Note: Tree planting is not required in planters, but is encouraged where practical. Tree planting is also encouraged near planters.

***Link to Flow-Through Planter Landscaping Plan Example**
***Link to Planter Recommended Plants**

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification

5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Planter grading/ excavation	
Structural components/ liner	Call for inspection
Piping	Call for inspection
Drain rock	
Filter fabric	
Growing medium	
Plantings	Call for inspection

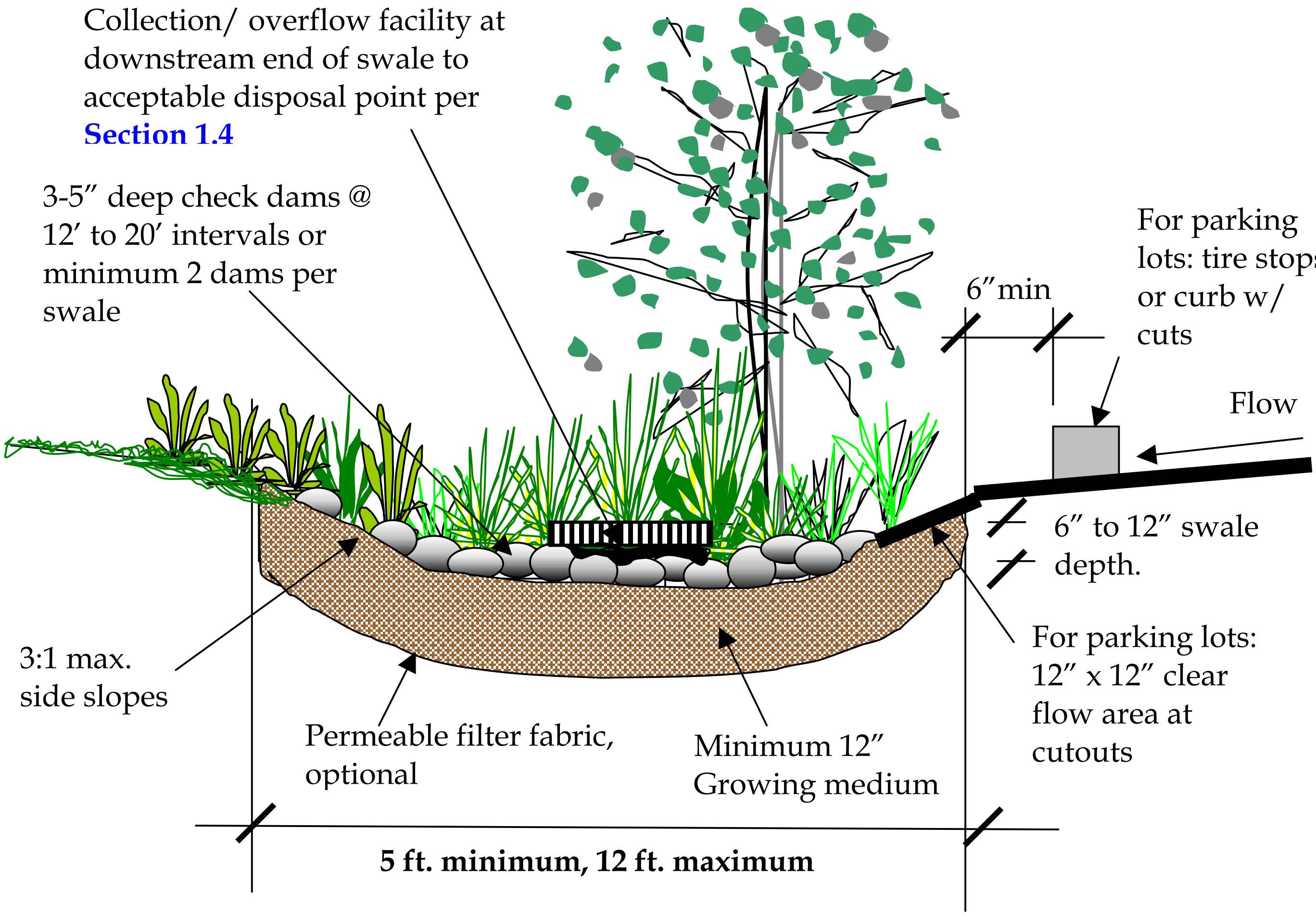
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to flow-through planter O&M form**

Additional photos and drawings:

*** Link to flow-through planter photos**
*** Link to flow-through planter drawings**

Vegetated Swale



Section Not to Scale

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Pollution Reduction	SIM, PERF[1]
√ Flow Control	SIM
√ Destination/ Disposal	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Vegetated swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **2)** The surface infiltration facility design procedure from **Section 2.2.2** may be used to receive credit for stormwater disposal.

Vegetated Swale

Description: Vegetated swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and destination/ disposal method per **Section 1.4** will be required at the end of the swale.

Design Considerations: When designing vegetated swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility.

Construction Considerations: Vegetated swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Vegetated swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Maximum longitudinal slope is 6%.

Vegetated Swale

Setbacks: Required setback from centerline of swale to property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric or approved by BES and BDS.

Sizing: Vegetated swales sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrating them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 6 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Minimum plant material quantities per 100 square feet of facility area are as follows:

1 - Evergreen or deciduous tree (planted around the perimeter of the swale):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs/small trees:	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants:	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

Vegetated Swale

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	Call for inspection
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

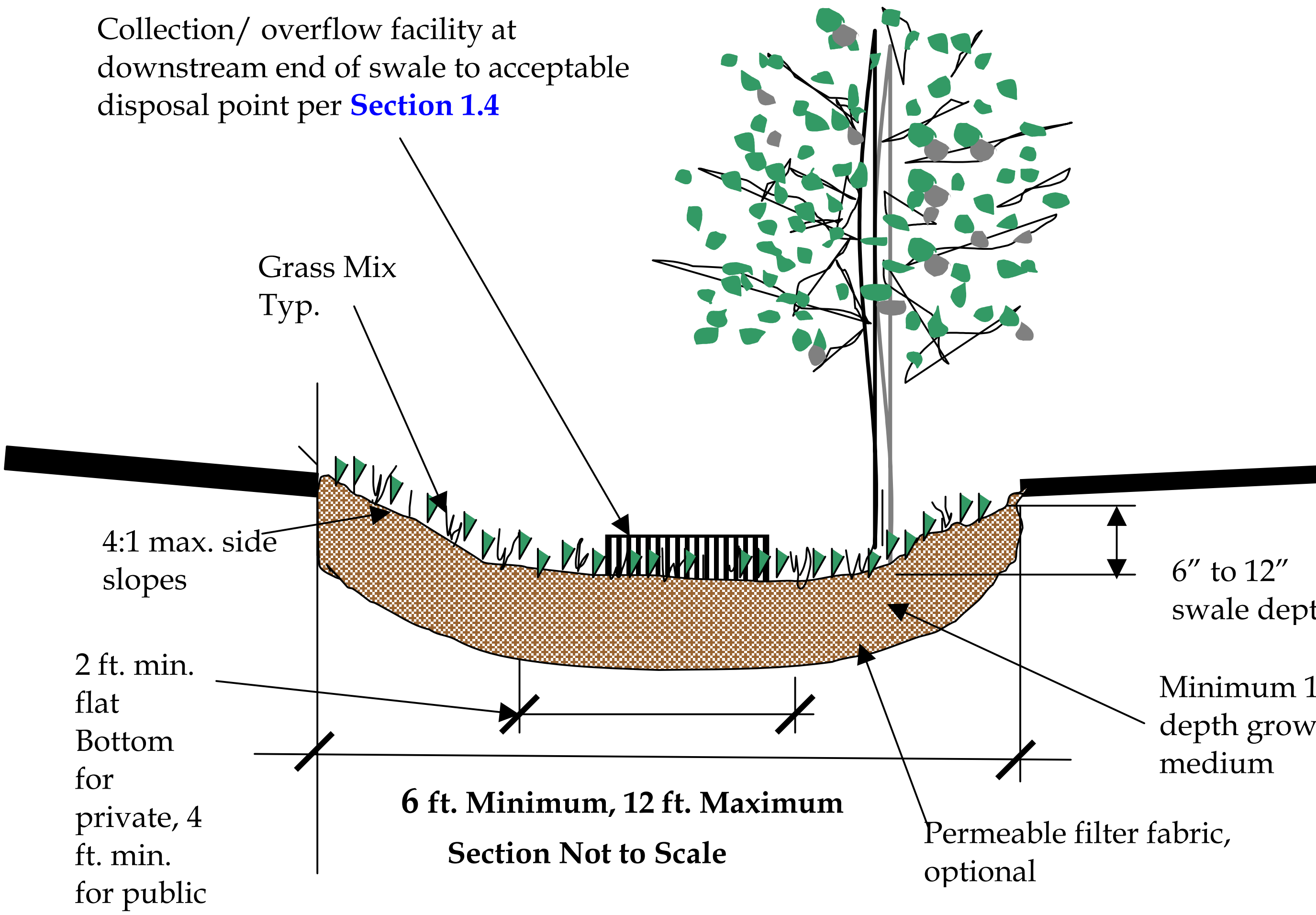
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to vegetated swale O&M form**

Additional photos and drawings:

*** Link to vegetated swale photos**
*** Link to vegetated swale drawings**

Grassy Swale



Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Pollution Reduction……………………………	SIM[1], PRES[2]
√ Flow Control…………………………………	SIM[1]
√ Destination/ Disposal………………………	PRES[3]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Flow and volume control credit will only be given for projects with less than 15,000 square-feet of impervious area to manage. **2)** For projects with more than 15,000 square-feet of impervious area to manage, the presumptive approach must be used to size the swale for pollution reduction, and additional facilities may be required to meet flow control requirements. Grassy swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **3)** The surface infiltration facility design procedure from Section 2.2.2 may be used to receive credit for stormwater disposal.

Grassy Swale

Description: Grassy swales are long narrow grassy depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed for small projects (<15,000 square feet of impervious surface) with grassy swales. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and disposal method per **Section 1.4** will be required at the end of the swale.

Design Considerations: When designing grassy swales, slopes and depth should be kept as mild as possible to avoid safety risks and prevent erosion within the facility.

Construction Considerations: Grassy swale areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Grassy swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 4 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Maximum longitudinal slope is 5%, while minimum slope is 0.5%. Maximum surrounding ground slopes shall be 10%.

Grassy Swale

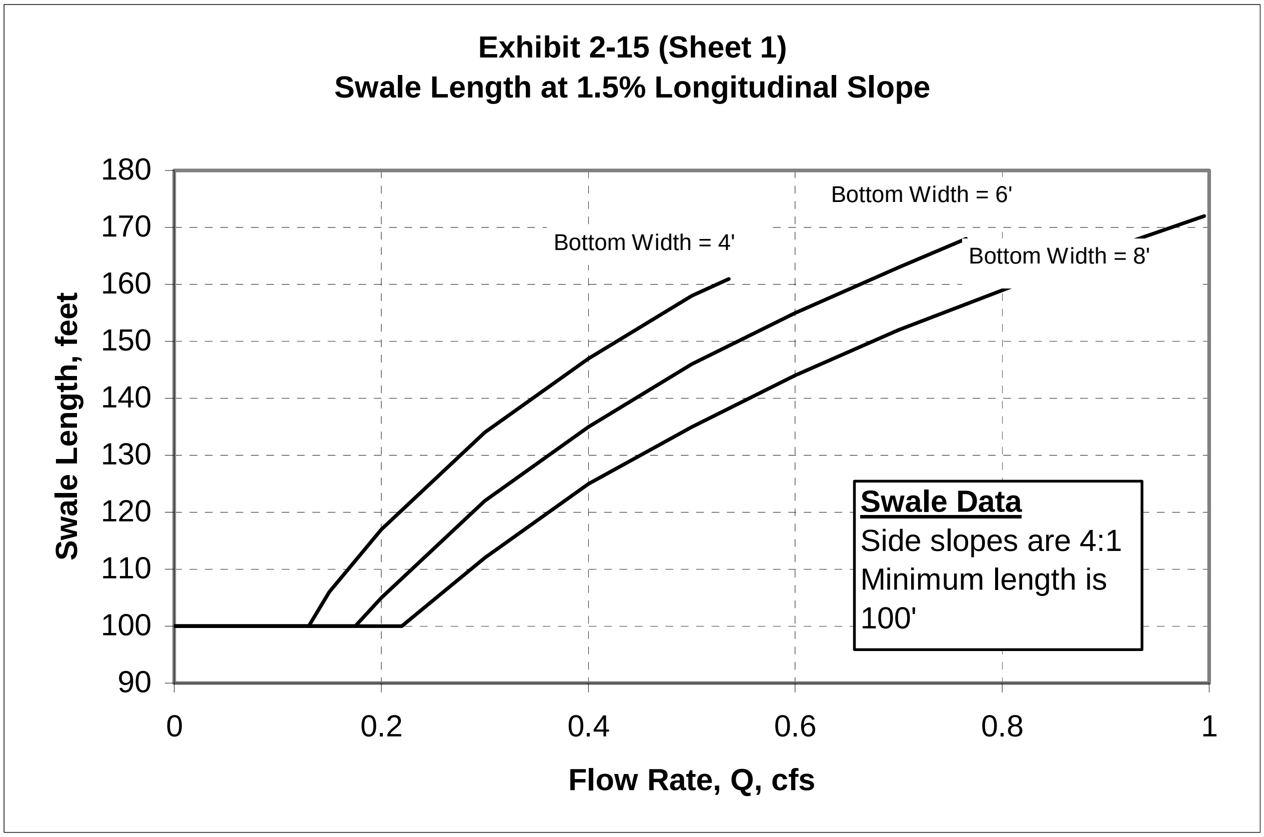
Setbacks: Required setback from centerline of swale to property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric.

Sizing: Grassy swales sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.1 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, or there is more than 15,000 square feet of impervious area to manage, the presumptive approach must be used size the swale for pollution reduction, and additional facilities will be required to meet flow control requirements, where applicable.

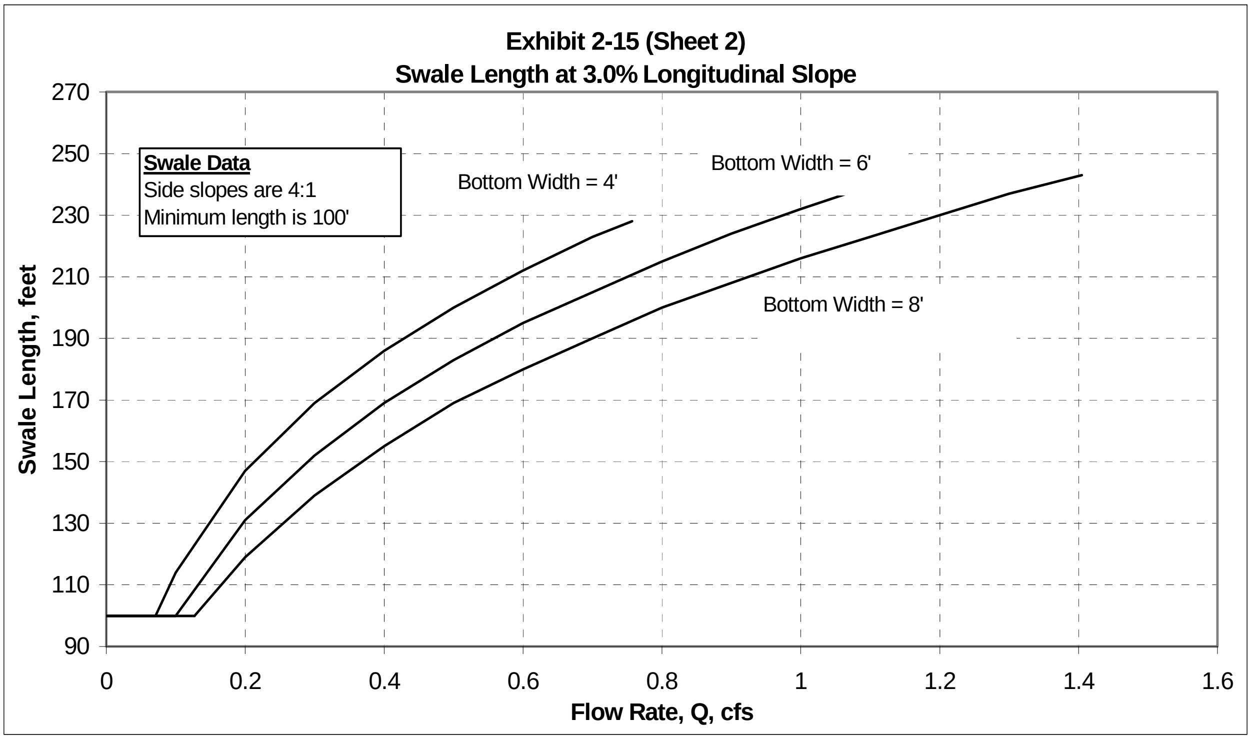
Presumptive Approach Sizing Criteria:

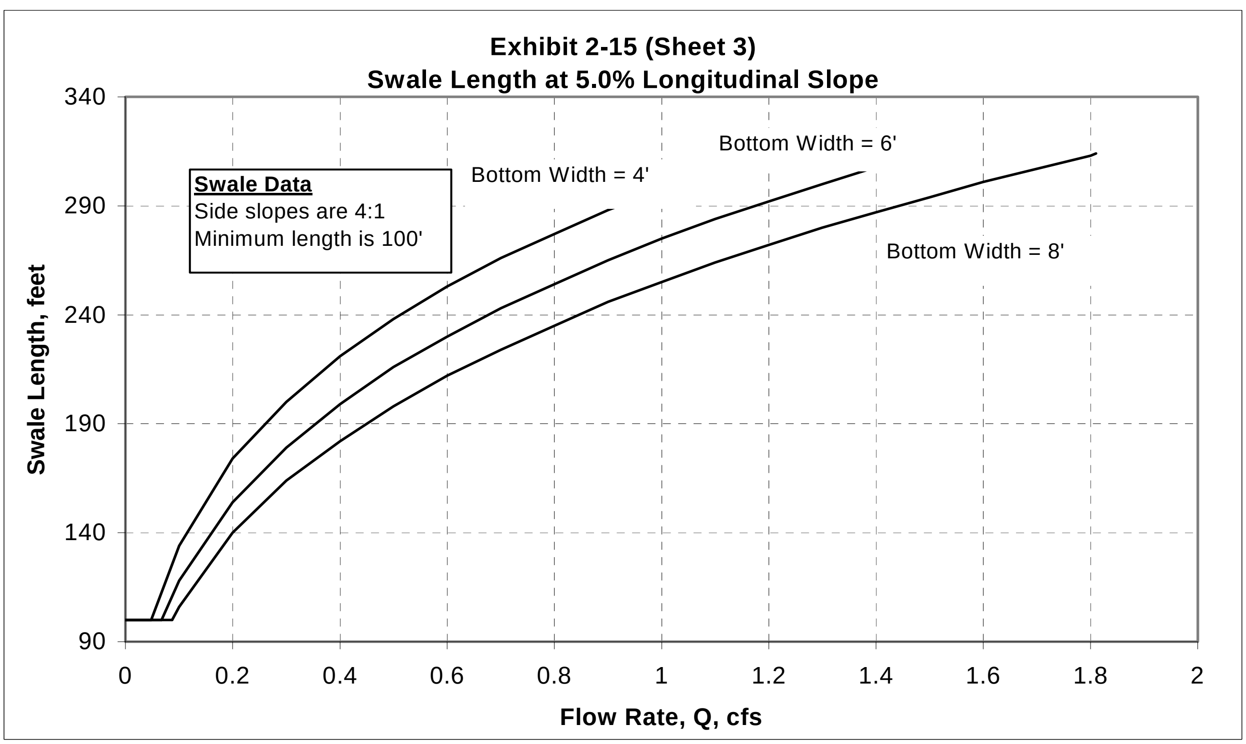
Exhibit 2-15 shows swale side slopes of 4:1 and lengthwise slopes of 1½ percent, 3 percent, and 5 percent. These charts are based on the City standards shown below and may be used to easily determine swale length, given the peak flow rate and the desired swale bottom width.

Grassy Swale



Grassy Swale





Grassy Swale

1) The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity (see **Section 1.5.2**) at:

   - Maximum design depth of 0.33 feet.
   - Maximum design velocity of 0.9 feet per second.
   - Minimum hydraulic residence time (time for Q_{design} to pass through the swale) of 9 minutes.
   - Minimum longitudinal slope of 0.5 percent, maximum slope of 5 percent. For slopes greater than 5 percent, check dams shall be used (one 6-inch high dam every 10 feet).
   - Designed using a Manning "n" value of 0.25.
   - 4:1 (or flatter) side slopes in the treatment area.
   - Minimum length of 100 feet.

   A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute intensity = 3.32 inches per hour).

   Velocity through the facility shall not exceed 3 feet per second (fps) during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

2) The swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than 6 feet, a flow spreader shall be installed at least every 50 feet.

3) To minimize flow channelization, the swale bottom shall be smooth, with uniform longitudinal slope, and with a minimum bottom width of 2 feet for private facilities and 4 feet for public facilities. Maximum bottom width shall be 8 feet.

4) Grasses or sod shall be established as soon as possible after the swale is completed, and before water is allowed to enter the facility.

5) Unless vegetation is established, biodegradable erosion control matting appropriate for low-velocity flows (approximately 1 foot per second) shall be installed in the flow area of the swale before allowing water to flow through the swale.

6) Access routes to the swale for maintenance purposes must be shown on the plans. Public swales will need to provide a minimum 8-foot wide access route, not to exceed 10 percent in slope.

Stormwater Report Requirements For Presumptive Approach: See **Exhibit 2-2**.

Landscaping: Plantings shall be designed at the following quantities per **200** square feet of facility area. Facility area is equivalent to the area of the swale calculated from Form SIM. (Note: Facilities smaller than 200 square feet shall have a minimum of one tree per facility.):

1 Evergreen or Deciduous tree:

Evergreen trees:	Minimum height: 6 feet.
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.

Grass: Seed or sod is required to completely cover the grassy swale bottom and side slopes. (Shrubs are optional)

For the swale flow path, approved native grass mixes are preferable and may be substituted for standard swale seed mix. Seed shall be applied at the rates specified by the supplier. The applicant shall have plants established at the time of facility completion (at least 3 months after seeding). No runoff shall be allowed to flow in the swale until grass is established. Trees and shrubs may be allowed in the flow path within swales if the swale exceeds the minimum length and widths specified.

Native wildflowers, grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

Environmental zones shall meet requirements established by Title 33 for grass in E-zones.

***Link to Grassy Swale Recommended Seed Mixes**

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

Grassy Swale

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	Call for inspection
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings/ seeding/ sod	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

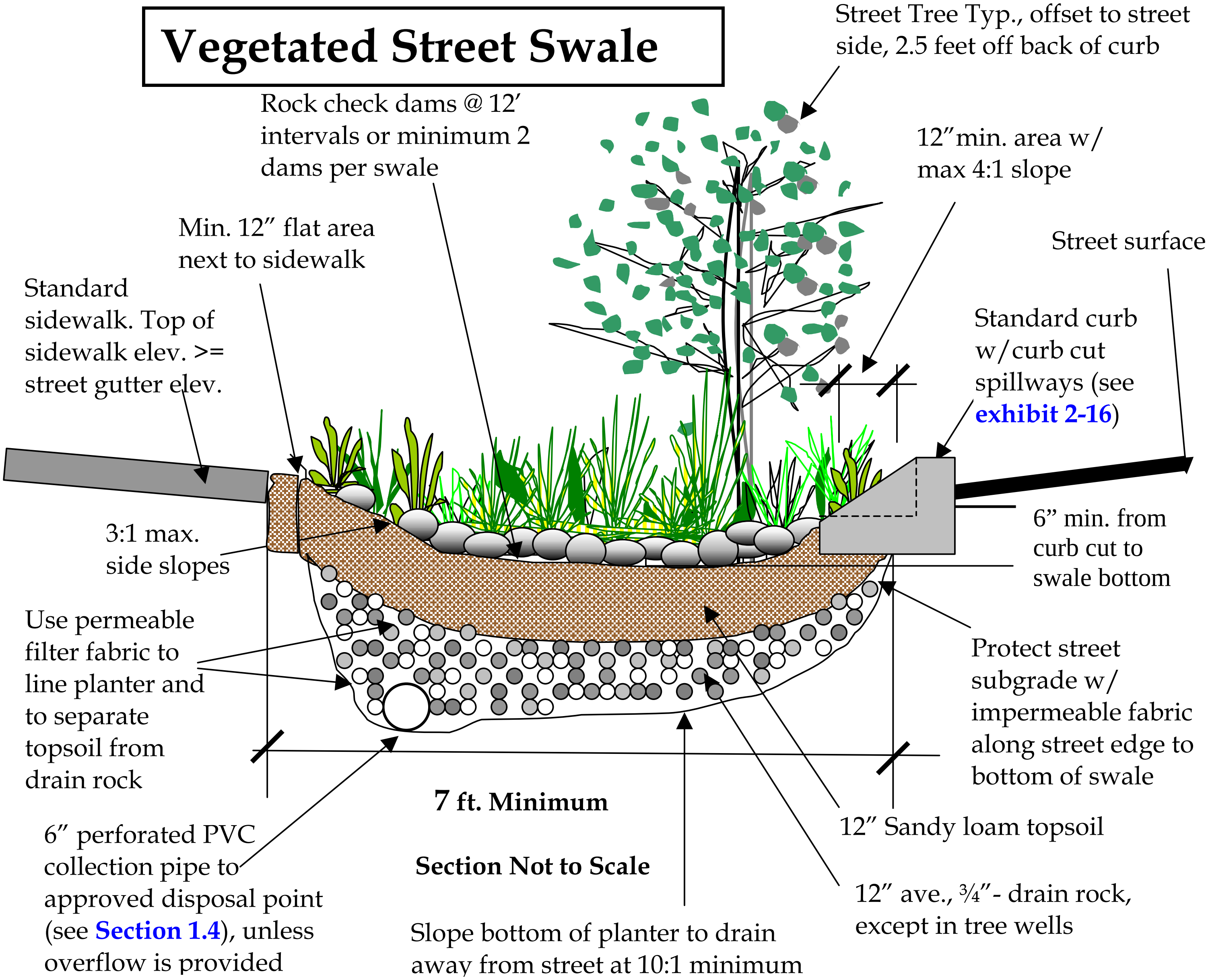
*** Link to grassy swale O&M form**

Additional photos and drawings:

*** Link to grassy swale photos**
*** Link to grassy swale drawings**

Street Swales

Vegetated Street Swale



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction…………………………….	SIM
√ Flow Control……………..……………………	SIM
√ Destination/ Disposal………………………	PRES[1]

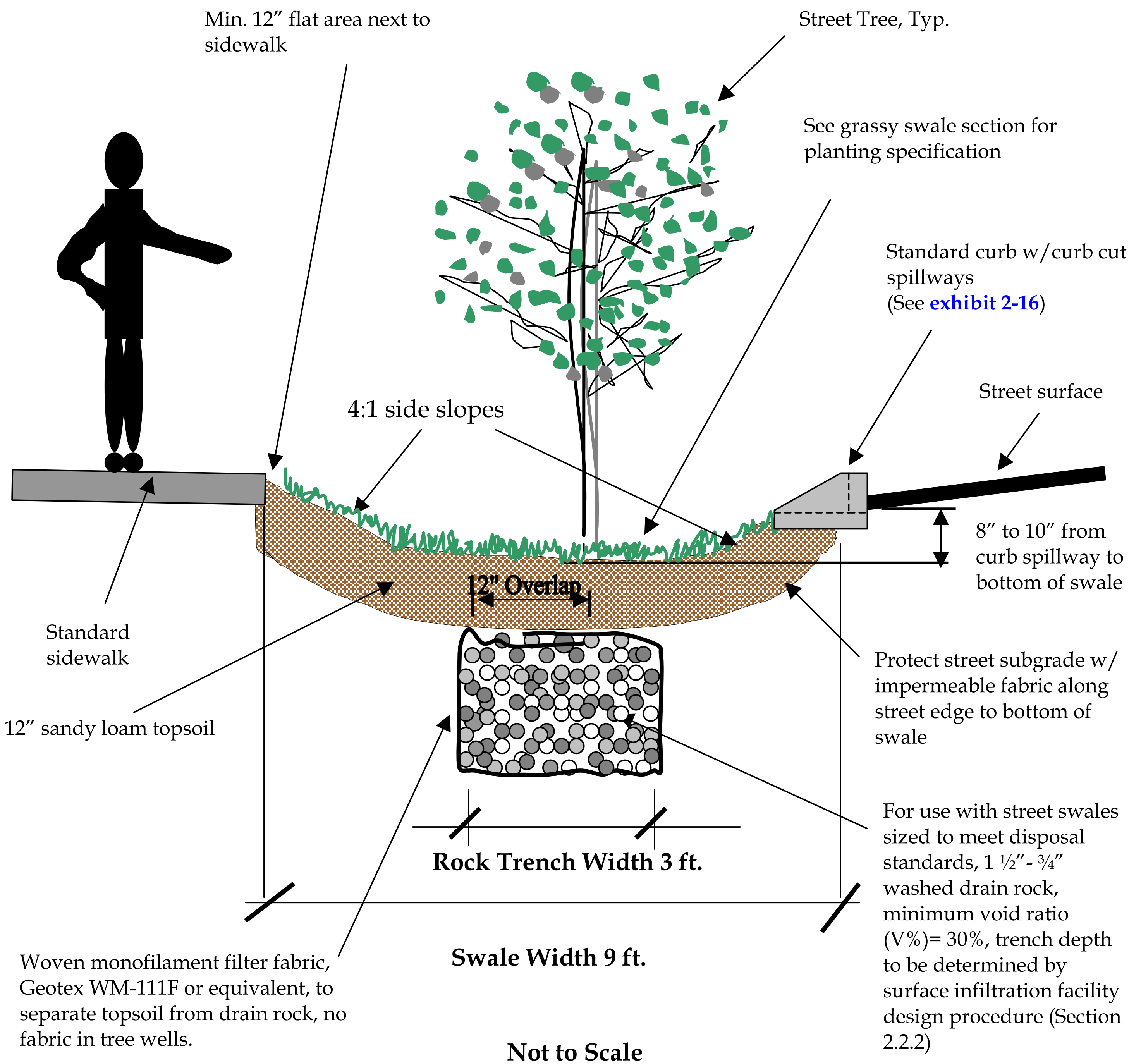
This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The surface infiltration facility sizing criteria from Section 2.2.2 may be used to size the street swale for complete stormwater infiltration. This facility may be used on private property or in the public right-of-way.

Street Swales

Grassy Street Swale



Note: Overflow to an approved disposal point is required, unless swale is sized in accordance with surface infiltration facility design procedure presented in **Section 2.2.2**.

Street Swales

Description: Street construction poses particular challenges related to stormwater management design. Lack of available space is often the most difficult hurdle in locating stormwater pollution reduction and flow control facilities in or near allocated rights-of-way. BES and the Portland Office of Transportation have developed specific street swale designs that incorporate pollution reduction and flow control into the cross-section of the street. For more information and ideas about stormwater friendly street designs, Metro has developed three handbooks: "Creating Livable Streets," "Green Streets," and "Trees for Green Streets." These handbooks can be purchased from Metro at: **www.metro-region.org**.

Street swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with street swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and disposal method per **Section 1.4** will be required at the end of the swale, unless the swale is designed per the surface infiltration facility criteria presented in **Section 2.2.2**.

Design Considerations: When designing street swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility. All applicable PDOT, BDS, and Urban Forestry requirements for other street elements (curbs, sidewalks, trees, etc.) must be met.

Construction Considerations: Street swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction.

Street Swales

No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

Design Requirements:

Soil Suitability: Street swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Dimensions and Slopes: Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical for vegetated swales, and 4 horizontal to 1 vertical for grassy swales (to accommodate for mowing). Minimum flat bottom width is 2 feet. Maximum longitudinal slope is 6%.

Setbacks: Required setback from building foundations is 10 feet unless lined with impermeable fabric.

Sizing: To meet pollution reduction and flow control requirements, the square-footage of street swales is to be determined using vegetated or grassy swale sizing criteria (shown on **Form SIM**), depending on which surface treatment is being used. The minimum width for street swales is 7 feet for vegetated, and 9 feet for grassy. Street swales sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrated them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 5 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The “facility area” is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Turf grass may be used to cover the entire swale surface area. If plantings are chosen to landscape the swale, the minimum plant material quantities per 100 square feet of facility area shall be as follows:

4 - Large shrubs/small trees:	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants:	1-gallon containers or equivalent

Street Swales

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually.

Recommended street trees in or near street swales:

With overhead power lines	**Without overhead power lines**
Carpinus caroliniana	Acer campestre 'Evelyn'
Cercis Canadensis	Betula jacquemontii
Fraxinus pennsylvanica 'Johnson'	Celtis occidentalis
Gleditsia triacanthos 'Impcole'	Gleditsia triacanthos 'Skycole'
Koelreuteria paniculata	Nyssa sylvatica
Prunus virginiana 'Canada Red'	Quercus shumardii

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All curb cut details and stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Street Swales

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Swale grading	Call for inspection
Curbs / curb cuts	Call for inspection
Piping (if applicable)	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

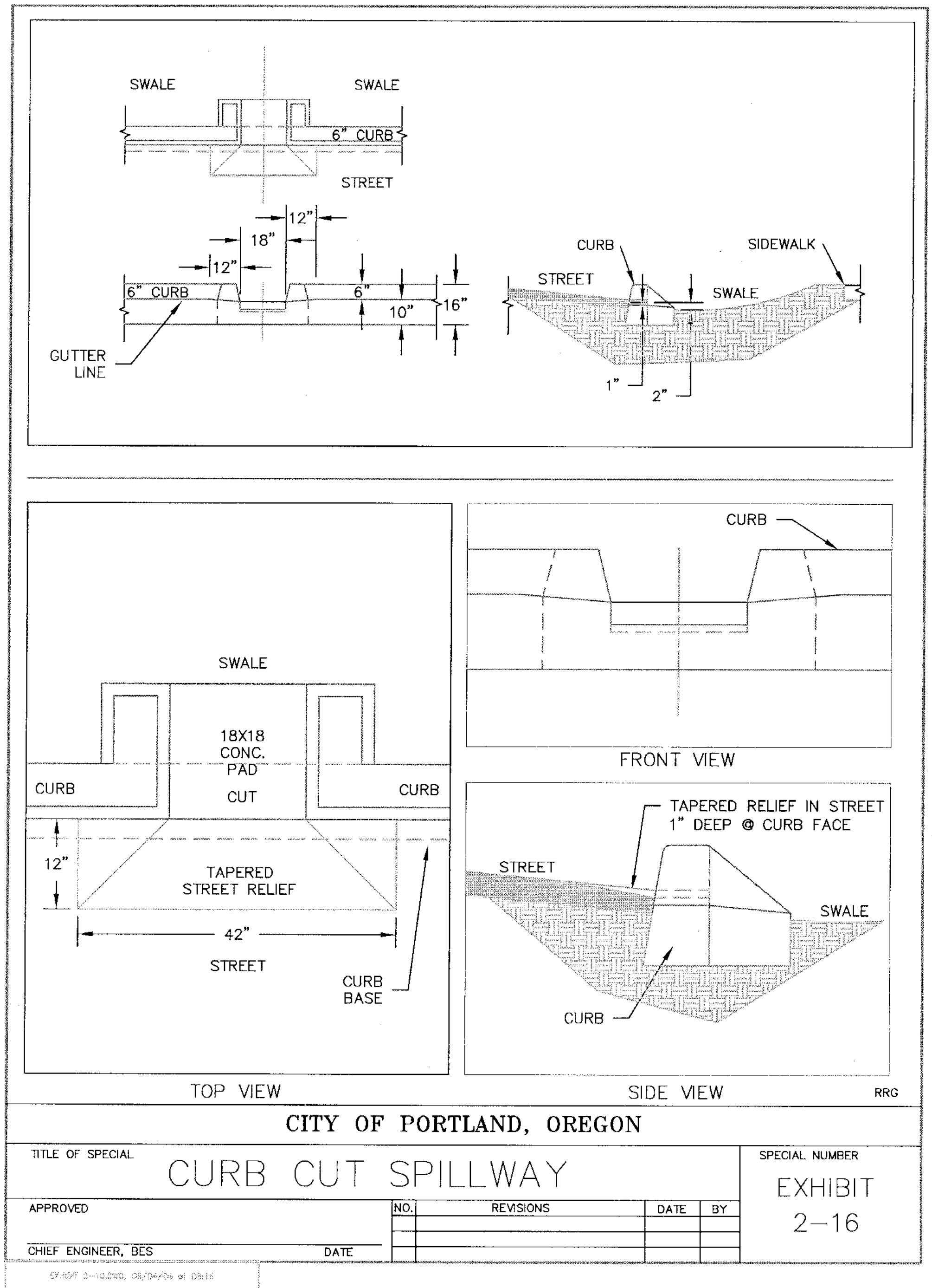
*** Link to vegetated and grassy swale O&M form**

Additional photos and drawings:

*** Link to street swale photos**

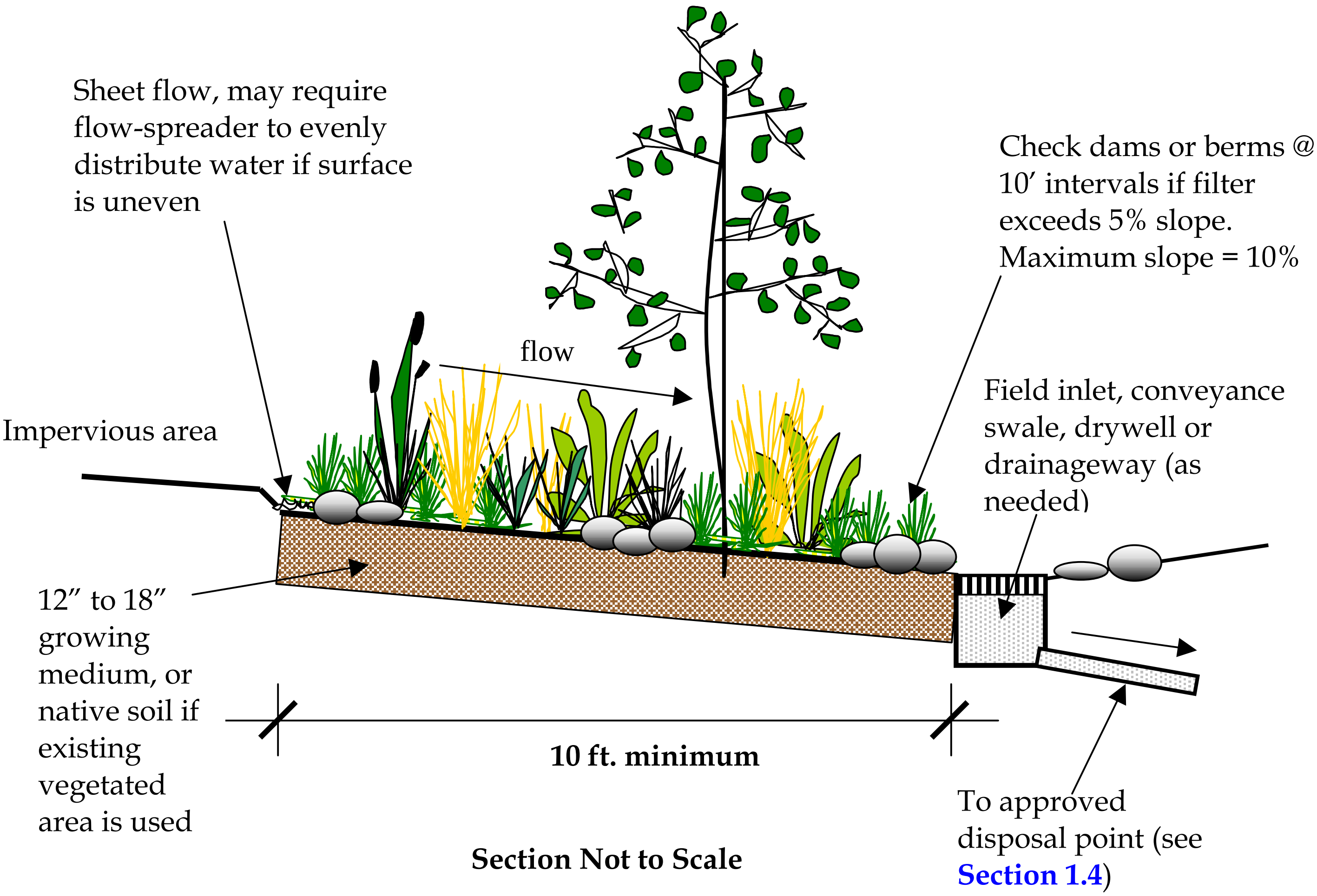
*** Link to street swale drawings**

Street Swales



Street Swales

Vegetated Filter



Section Not to Scale

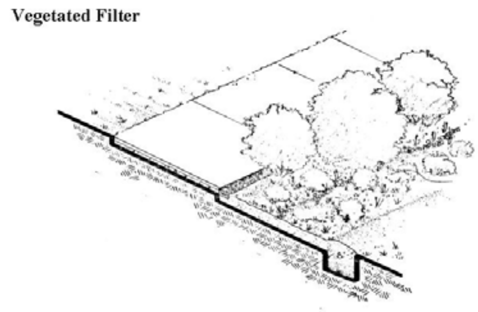
Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction…………………………..	SIM, PERF[1]
√ Flow Control…………………………………	SIM
√ Destination/ Disposal[2]………………………	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The Performance Approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Vegetated filters can be used to manage stormwater from rooftops, pathways, parking lots, and potentially streets (with flow spreaders or if the runoff is left as unconcentrated sheet flow). **2)** Where soils infiltrate sufficiently per BDS, stormwater disposal credit may be given for projects with less than 500 square feet of impervious surfaces to manage.

Vegetated Filter



Description: Vegetated filter strips, or vegetated filters, are gently sloping areas used to filter, slow, and infiltrate stormwater flows. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Flow control is achieved using the relatively large surface area and for slopes greater than 5%, a generous proportion of check dams or berms. Pollutants are removed through filtration and sedimentation. Filters can be planted with a variety of trees, shrubs, and ground covers, including grasses. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. There can be many ways to fit this concept into site designs and designers are encouraged to use the site landscape areas for this purpose. Unless designed for stormwater disposal, an approved conveyance and disposal method per **Section 1.4** will be required at the end of the filter.

Design Considerations: When designing vegetated filters, slopes should be kept as flat as possible to prevent erosion. Spreading the flow evenly across the filter is also important in ensuring that the facility functions correctly and avoids flow channeling.

Construction Considerations: Vegetated filter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of filter areas. Flow spreaders must be constructed perfectly level to distribute flows evenly across the filter, and for public facilities must be surveyed after construction.

Design Requirements:

Soil Suitability: Vegetated filters are appropriate for all soil types. Unless existing vegetated areas are used for the filter, topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Dimensions and Slopes: Maximum allowable vegetated filter slopes are 10%. Terraces may be used to decrease ground slopes. Minimum slopes are 0.5%.

Setbacks: Required setback from property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric.

Sizing: Unless used for very long, narrow projects such as pathways and trails, vegetated filters cannot be used to manage flow from more than 2,000 square-feet of impervious area. Filters shall be a minimum of 10 feet wide x 10 feet long. A simplified approach sizing factor of 0.2 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the filter to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor.

Check Dams: Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or graded into the native soils. Check dams shall be 12 inches in length, by the width of the filter, by 3 to 5 inches in height.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. For other projects, minimum plant material quantities per **100** square feet of facility area are as follows. The "facility area" is equivalent to the area of the filter, as calculated from Form SIM.

1 - Evergreen or deciduous tree (planted around the perimeter of the swale):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs/small trees:	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants:	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Vegetated Filter

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification (if applicable)
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
5) Landscaping plan
6) Flow spreader details and specifications
7) Check dam or terrace details and specifications

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Filter grading (if applicable)	Call for inspection
Flow spreaders/Terraces (if applicable)	Call for inspection
Piping (if applicable)	Call for inspection
Growing medium (if applicable)	
Plantings	Call for inspection

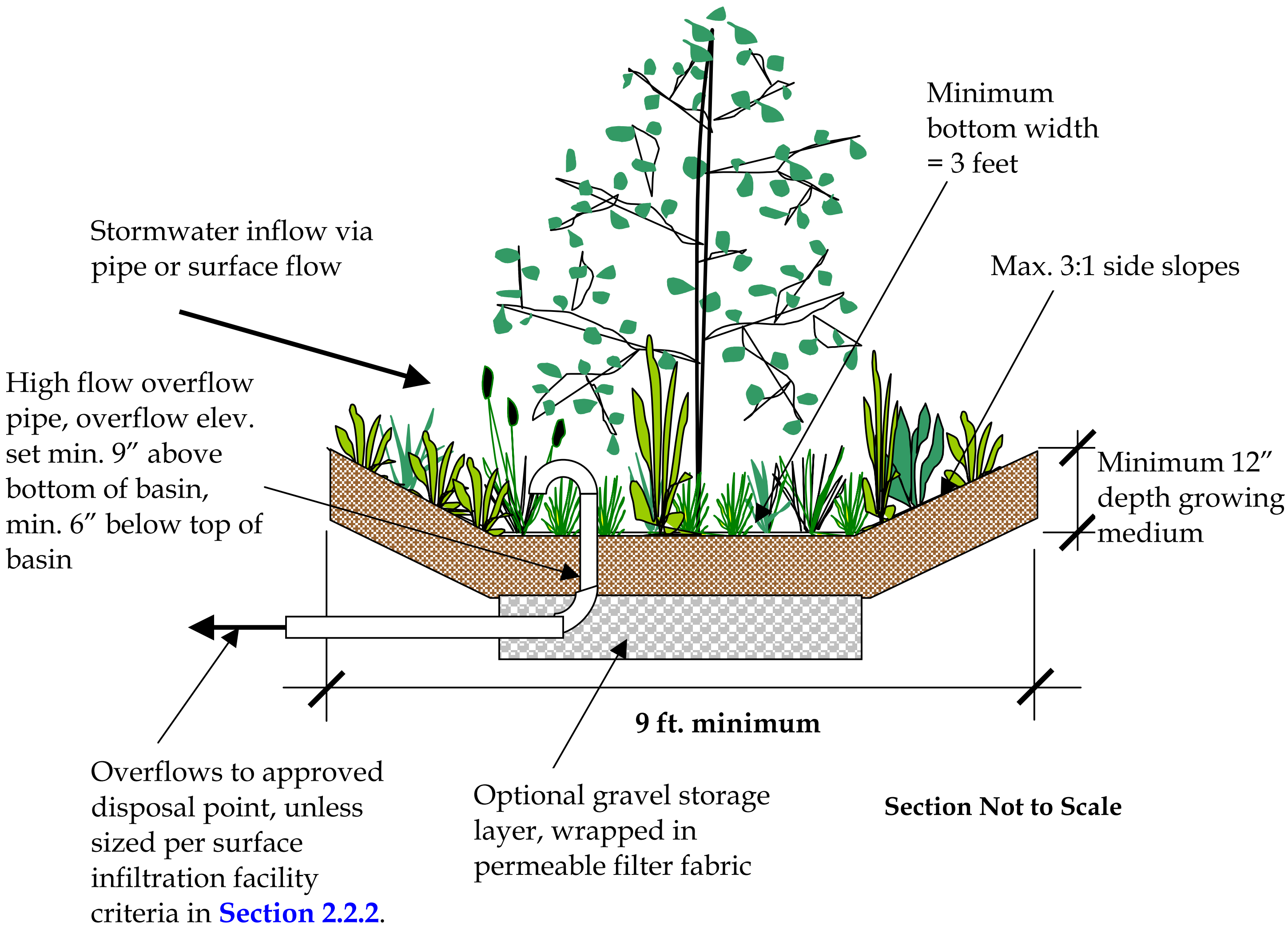
Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to vegetated filter O&M form**

Additional photos and drawings:

*** Link to vegetated filter photos**
*** Link to vegetated filter drawings**

Vegetated Infiltration Basin



Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Pollution Reduction	SIM, PERF[1]
√ Flow Control	SIM
√ Destination/ Disposal	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution control. **2)** The surface infiltration facility sizing methodology from Section 2.2.2 may be used to achieve stormwater disposal. Vegetated infiltration basins can be used to manage stormwater from all impervious surface types, and must be located on private property.

Vegetated Infiltration Basin

Description: Vegetated infiltration basins are shallow landscaped depressions used to collect and hold stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated infiltration basins. They should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. As shown in the example photos, the design can be formal or informal in character and planting scheme. An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required, unless the basin is designed per surface infiltration facility guidelines presented in **Section 2.2.2**.

Design Considerations: When designing vegetated infiltration basins, the infiltration rate of the native soil is a key element in determining size and viability. Slopes and depth should be minimized to avoid safety risks.

Construction Considerations: Infiltration basin areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration basin areas.

Design Requirements:

Soil Suitability: Vegetated infiltration basins are appropriate for soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Vegetated Infiltration Basin

Dimensions: Facility storage depth may vary from 9 to 18 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum bottom width is 2 feet.

Setbacks: Required setback from property lines is 5 feet, and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; infiltration trenches shall not be used where slopes exceed 30%.

Sizing: Vegetated infiltration basins sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow overflow must be provided, or to receive credit for complete stormwater infiltration, the surface infiltration facility design criteria from **Section 2.2.2** must be used. In this case, pre and post-construction infiltration tests are required to demonstrate infiltration performance. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor. Drawdown time (time for the basin to empty when full) shall not exceed 30 hours.

Landscaping: Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the basin, including bottom and side slopes, plus a 10-foot buffer around the basin. Minimum plant material quantities per 300 square feet of facility area are as follows:

1 - Evergreen or deciduous tree (planted around the perimeter of the basin):

Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs/small trees:	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants:	1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

For public vegetated infiltration basins, the following additional design criteria shall apply:

1) Two staff gauges shall be installed at opposite ends of the bottom of the basin, to enable maintenance staff to measure the depth of accumulated silts.
2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for infiltration.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Basin grading	Call for inspection
Piping	Call for inspection
Filter fabric	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

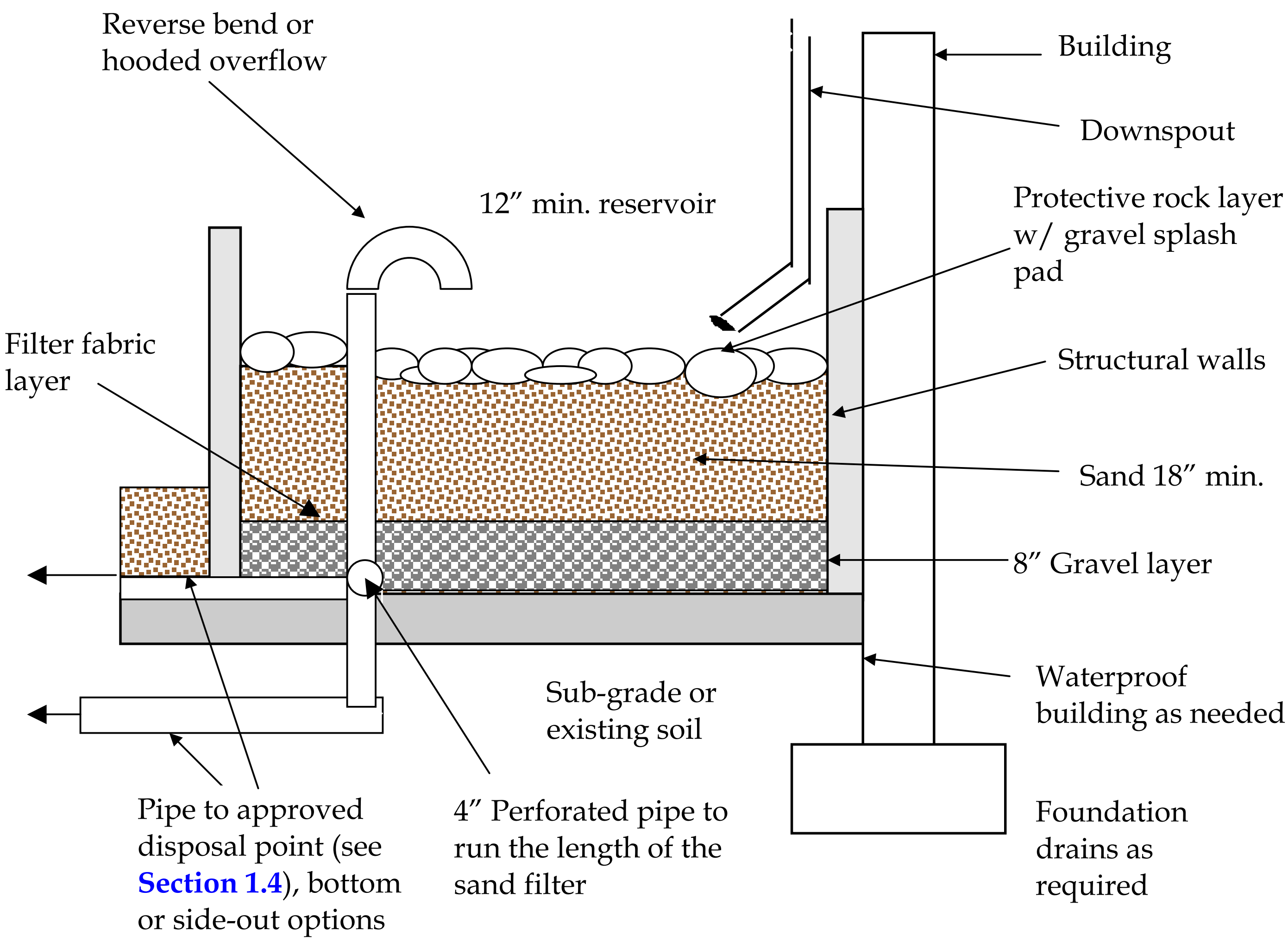
*** Link to vegetated infiltration basin O&M form**

Additional photos and drawings:

*** Link to vegetated infiltration basin photos**

*** Link to vegetated infiltration basin drawings**

Sand Filter



Section not to scale

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction..............................	SIM, PERF[1]
√ Flow Control..	SIM
√ Destination/ Disposal..........................	PRES[2]

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Sand filters can be used to manage stormwater from any impervious surface, and must be located on private property. **2)** The surface infiltration facility design procedure from **Section 2.2.2** may be used to receive credit for stormwater disposal.

Sand Filter


Description: There are two sand filter options. One is designed with an impervious bottom or is placed on an impervious surface. It can be used for all soil types. The other option, for native soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B), allows filtered water to infiltrate into the ground. For both options, pollutant reduction is achieved as the water filters through the sand; flow control is obtained by slowing the discharge rate as the water filters through the sand. Filters may be constructed in-ground or above grade. Because they can include a waterproof lining, sand filters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance and disposal method per **Section 1.4** will be required.

Design Considerations: When designing sand filters, the structural walls can often times be incorporated with building foundation plans.

Construction Considerations: Special attention needs to be paid to the filter waterproofing if constructed adjacent to building structures.

Design Requirements:

Soil Suitability: Lined sand filters are appropriate for all soil types. Filters designed to infiltrate into native soils are appropriate in soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B).

Dimensions and Slopes: Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum sand filter width is 18 inches. Filter slopes shall be less than 0.5%.

Setbacks: Required setback from property lines is 5 feet, unless the sand filter height is less than 30 inches. Required setback from building structures is 10 feet, unless the sand filter is properly lined.

Sand Filter

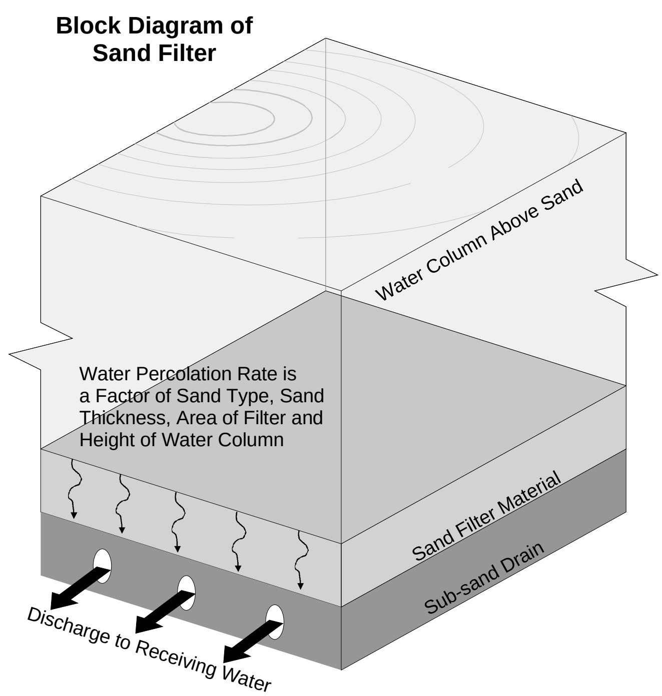
Structural Walls: Sand filter walls shall be made of stone, concrete, brick, or wood. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

Sizing: Sand filters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution reduction and flow control. For projects with more than 15,000 square-feet of impervious surface, additional facilities may be required to meet flow control requirements. A high-flow overflow must be provided to an approved disposal point per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used to downsize the simplified approach sizing factor. Sand filters shall be designed to pond water for less than 4 hours after each storm event.

Vegetation: Plantings are optional in sand filters. For aesthetic purposes, potted plants may be submerged in the sand filter.

For public sand filters, the following additional criteria shall apply:

The sand filter consists of an inlet structure, sand bed, underdrain piping, and basin liner. Criteria for these components are provided below.



Inlet Structure

1) The inlet structure shall spread the flow of incoming water uniformly across the surface of the filter medium during all anticipated flow conditions. This flow shall be spread in a manner that prevents roiling or otherwise disturbing the filter medium.

Sand Bed/ Filter Medium

1) The length-to-width ratio shall be 2:1 or greater.

2) The sand bed configuration may be either of the two configurations shown in **Exhibit 2-17**. All depths shown are final depths. The effects of consolidation and/or compaction must be taken into account when placing medium materials. The surface of the filter medium shall be level.

3) Sand used as filter medium shall be certified by a testing laboratory as meeting or exceeding the specifications presented below:

The filter bed medium shall consist of clean medium to fine sand with no organic material, or other deleterious materials and meeting the following gradation:

Sieve Size	Percent Passing
3/8″	100
#4	95-100
#8	80-100
#16	45-85
#30	15-60
#50	3-15
#100	< 4

Sand Bed with Gravel Filter (**Exhibit 2-17:A**)

1) The top layer shall be a minimum of 18 inches of approved sand.

2) The sand shall be placed over an acceptable geofabric material covering a layer of ½- to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) No gravel is required below the underdrain piping system.

Sand Bed Using Trench Design (**Exhibit 2-17:B**)

1) The top layer shall be a minimum of 12 inches of approved sand.

2) The sand shall be placed over an acceptable geotextile fabric material covering a layer of ½ to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) The piping and gravel shall be underlain with geotextile fabric.

Sand Filter

Underdrain Piping

1) The underdrain piping system shall consist of appropriately sized (minimum 4-inch diameter) collector manifold with perforated lateral branch lines. The pipe used in this conveyance system shall be schedule 40 polyvinyl chloride (PVC) material or an approved equal. Lateral spacing shall not exceed 10 feet.

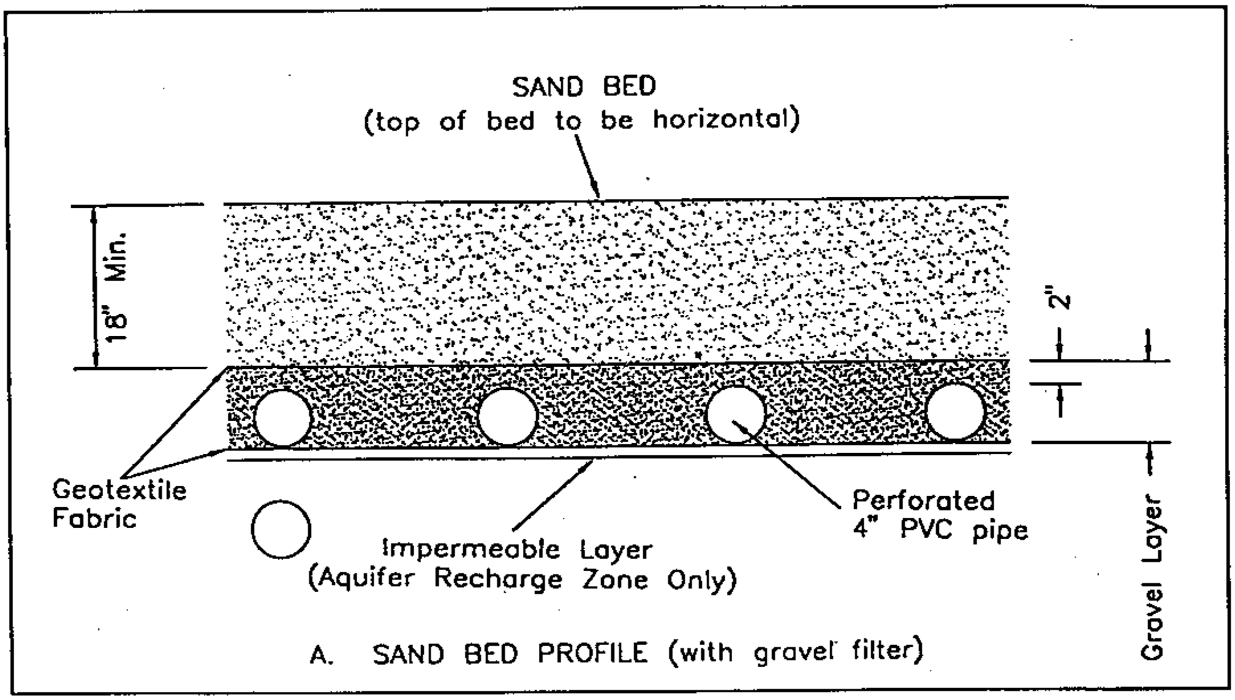
2) The underdrain laterals shall be placed with positive gravity drainage to the collector manifold.

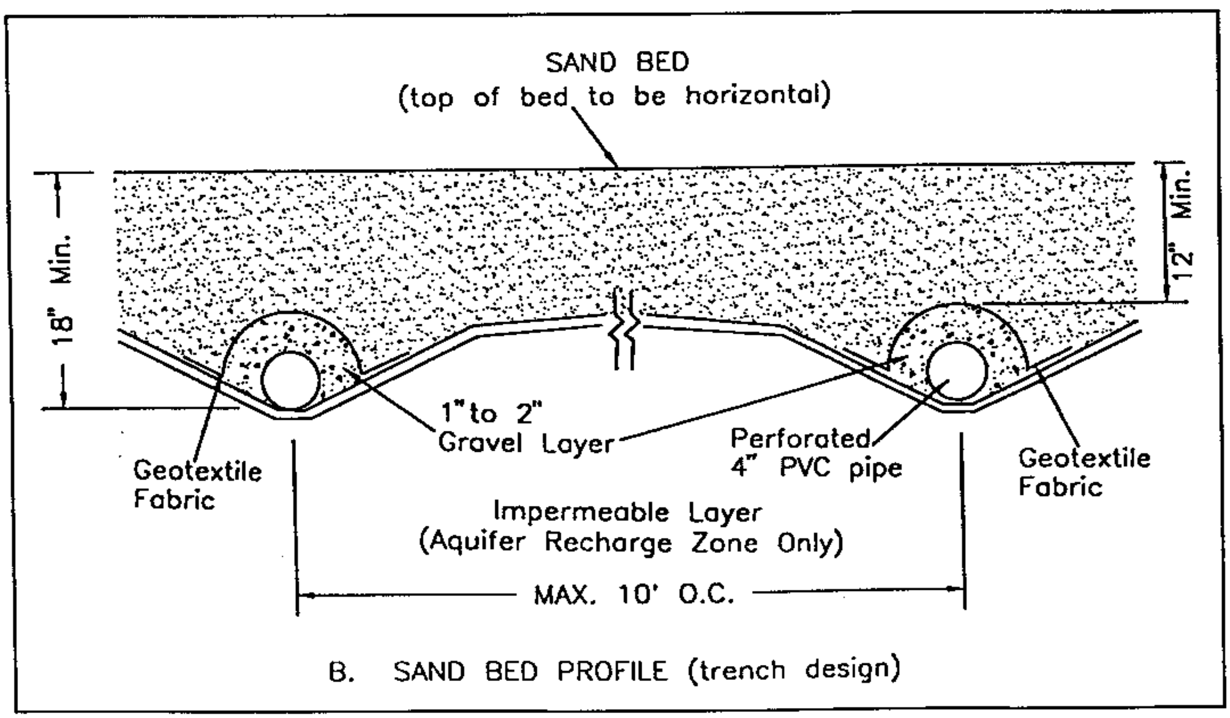
3) The collector manifold shall have a minimum 1 percent grade toward the discharge point.

4) All laterals and collector manifolds shall have cleanouts installed, accessible from the surface without removing or disturbing filter media.

Sand Filter

Exhibit 2-17





Sand Filter

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Structural wall material specification
4) Sand specification
5) Filter fabric specification
6) Rock surface layer specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Sand filter grading	Call for inspection
Structural walls	Call for inspection
Piping	Call for inspection
Sand	
Filter fabric	
Rock layer	Call for inspection
Plantings (if applicable)	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to sand filter O&M form**

Additional photos and drawings:

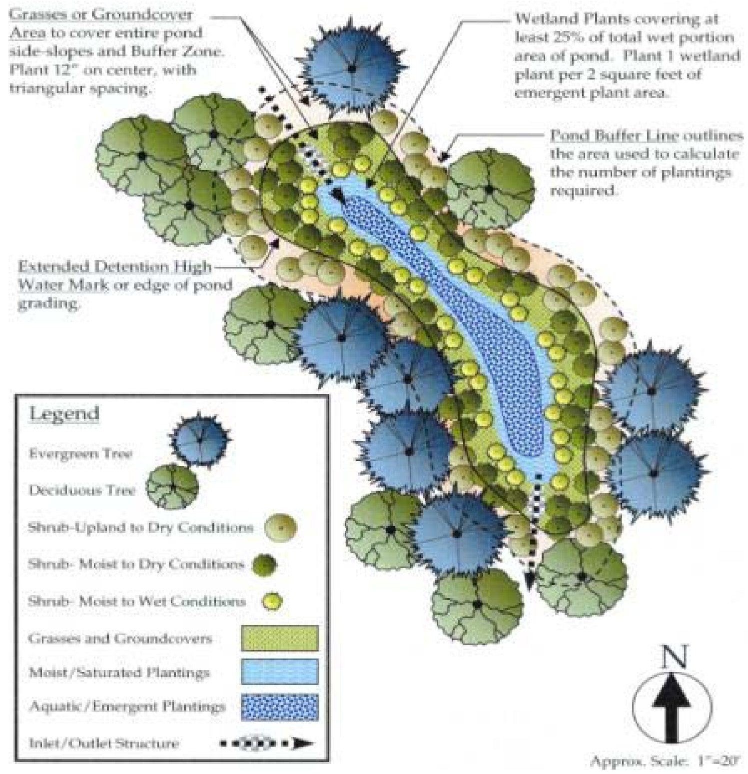
*** Link to sand filter photos**

Sand Filter

Wet, Extended Wet, & Dry Detention Pond

Wet and Extended Wet Ponds

The plan below illustrates a typical planting plan for an approximately 3,500 square foot wet or extended wet pond. This plan is diagrammatic use only. The actual project site condition may require designers to consider numerous other pond configurations and planting layouts.



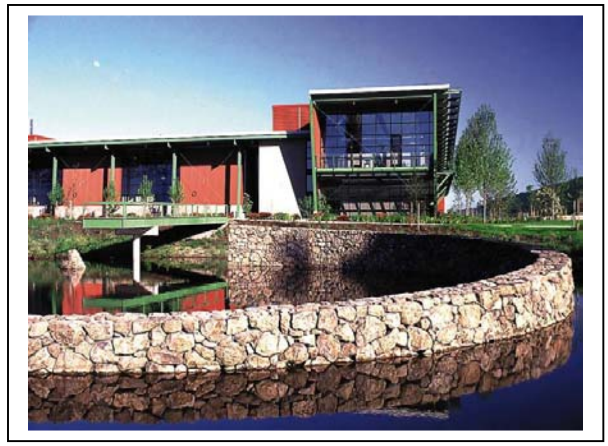
Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction……………………………	PRES[1]
√ Flow Control……………….…………………	PRES[2]
Destination/ Disposal………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Wet and extended wet detention ponds receive credit for pollution reduction. For dry detention ponds to receive credit for pollution reduction, the bottom flow path of the pond must be designed as a vegetated or grassy swale, with sizing and design in accordance with criteria presented in this chapter. **2)** Only extended wet detention and dry detention ponds receive credit for flow control. All ponds must overflow to an acceptable stormwater disposal point per **Section 1.4**. Wet and extended wet detention ponds can be used to provide pollution reduction for any impervious surfaces, and must be located outside of public rights-of-way.

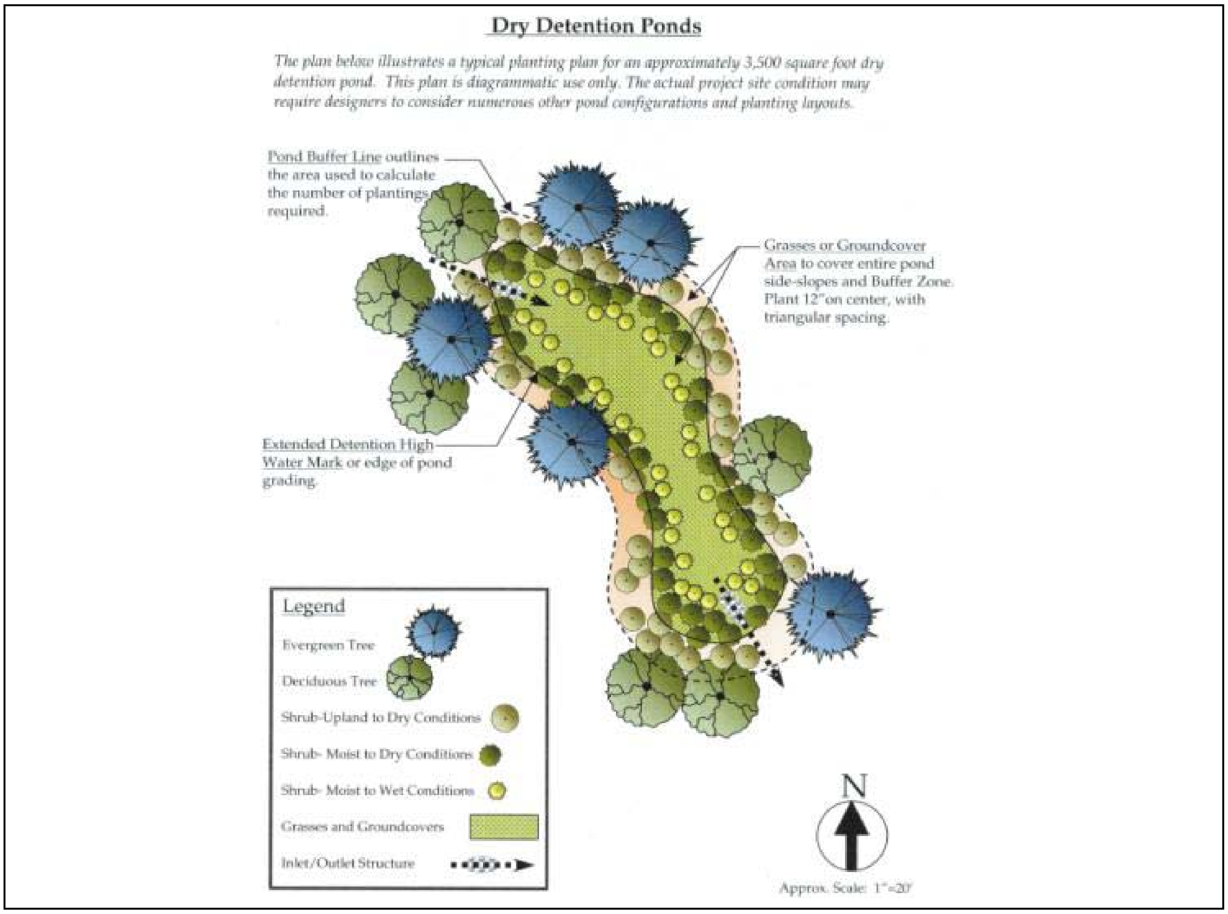
Wet, Extended Wet, & Dry Detention Pond



Wet Pond Description: Wet ponds are constructed with a permanent pool of water (called pool storage or dead storage). Stormwater runoff enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. Additional facilities will be required to meet flow control requirements, as applicable. An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.

Extended Wet Detention Pond Description: Extended wet detention ponds are constructed with a permanent pool of water (called pool storage or dead storage) and additional storage above, which fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to provide pollution reduction, and the additional storage above (extended detention area) is sized to meet flow control requirements. Pollutants are removed from stormwater through gravitational settling and biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. The extended detention portion of this facility must be designed using acceptable hydrologic modeling techniques (see **Section 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**). An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.

Dry Detention Pond Description: Dry detention ponds are vegetated basins designed to fill during storm events and slowly release the water over a number of hours. Dry detention ponds must be designed using acceptable hydrologic modeling techniques (see **Section 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**). Additional facilities are required to meet pollution reduction requirements, unless the bottom flow path of the pond is designed as a vegetated or grassy swale, per swale sizing and design criteria. An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.



Wet, Extended Wet, & Dry Detention Pond

Design Considerations: Slopes and depth should be kept as mild as possible to avoid safety risks. Wet and extended wet detention ponds should be designed for large drainage areas (5 to 150 acres) to help avoid problems associated with long periods of stagnant water. The City encourages applicants to design ponds to function as multi-purpose facilities (e.g., parks, open space, recreation facilities, or parking lots), provided that any alternative uses are compatible with the primary stormwater functions and maintenance standards. Instream ponds are not encouraged. If used, they require special approvals from the National Marine Fisheries Service, Oregon Department of Fish and Wildlife, Oregon Division of State Lands, and City of Portland, in addition to water rights from the Oregon Division of Water Rights.

Construction Considerations: As pond grading generally requires the topsoil to be removed to form the basin shape of the pond, the resulting top layers of soil must to be amended, or topsoil must be brought back in to ready the soil for planting.

Location and Ownership:

- All open ponds to be maintained by the City of Portland shall be located in a separate open space tract with public sewer easements dedicated to the City.
- Open ponds serving more than one tax lot, or designed to function as multi-use/recreational facilities, shall be located in a separate tract (e.g., Tract A), defined easement, or designated open space.

Setbacks: Ponds shall be constructed to maintain the following setback distances from structures and other facilities. (All distances are measured from the edge of the maximum water surface elevation. The setback limit applies to ponds near the top of slope, not the bottom.)

- Minimum distance from the edge of the pond water surface to property lines and structures: 20 feet, unless an easement with adjacent property owner is provided.
- Distance from the toe of the pond berm embankment to the nearest property line: one-half of the berm height (minimum distance of 5 feet).
- Minimum distance from the edge of the pond water surface to septic tank, distribution box, or septic tank drain field: 50 feet.
- Surrounding slopes shall not exceed 10%. Minimum distance from the edge of the pond water surface to the top of a slope greater than 15 percent: 200 feet, unless a geotechnical report is submitted and approved by BES (**Exhibit 2-18**).
- Minimum distance from the edge of the pond water surface to a well: 100 feet (**Exhibit 2-18**).

Wet, Extended Wet, & Dry Detention Pond

Geometry/ Design Requirements:

- Slopes within the pond shall not exceed 3 horizontal to 1 vertical.
- The distance between all inlets and the outlet shall be maximized to facilitate sedimentation. The minimum length-to-width ratio is 3:1, at the maximum water surface elevation. This ratio is critical to prevent "short-circuiting," where water passes directly through the facility without being detained for any length of time. If area constraints make this ratio unworkable, baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short-circuiting.
- The maximum depth of the pond shall not exceed 4 feet. The 0 to 2-foot depth shall be distributed evenly around the perimeter of the pond.
- Minimum freeboard shall be 1 foot above the highest potential water surface elevation (one foot above the emergency overflow structure or spillway elevation).
- Wet and extended wet detention ponds are applicable in NRCS Type C and D soils (A and B soils with impermeable liner). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.
- Dry detention ponds are applicable in NRCS type B, C, and D soils (the pond should most likely be designed as an infiltration basin in type A soils). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.
- Unless designed with a pollution reduction swale in the bottom flow path, dry detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area, and shall provide at least 0.5 feet of dead storage for sediment accumulation.
- Wet and extended wet detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area, and shall provide at least 0.5 feet of dead storage for sediment accumulation.
- Public ponds shall be designed with an upstream sedimentation manhole with downturned elbow or tee riser outflow pipe (See **Exhibit 2-32**) to trap oils and reduce the likelihood of a visible sheen on the pond surface.
- Access routes to the pond for maintenance purposes must be shown on the plans. Public ponds will need to provide a minimum 8-foot wide access route, not to exceed 10 percent in slope.
- Where possible, a dewatering outlet with shut-off valve shall be provided to aid in the maintenance of the permanent pool.
- For wet and extended wet detention ponds, a water budget shall be submitted for review. The water budget must demonstrate that the baseflow to the pond is sufficient such that water stagnation/alga matting will not become a problem.

Outlet/ Overflow:

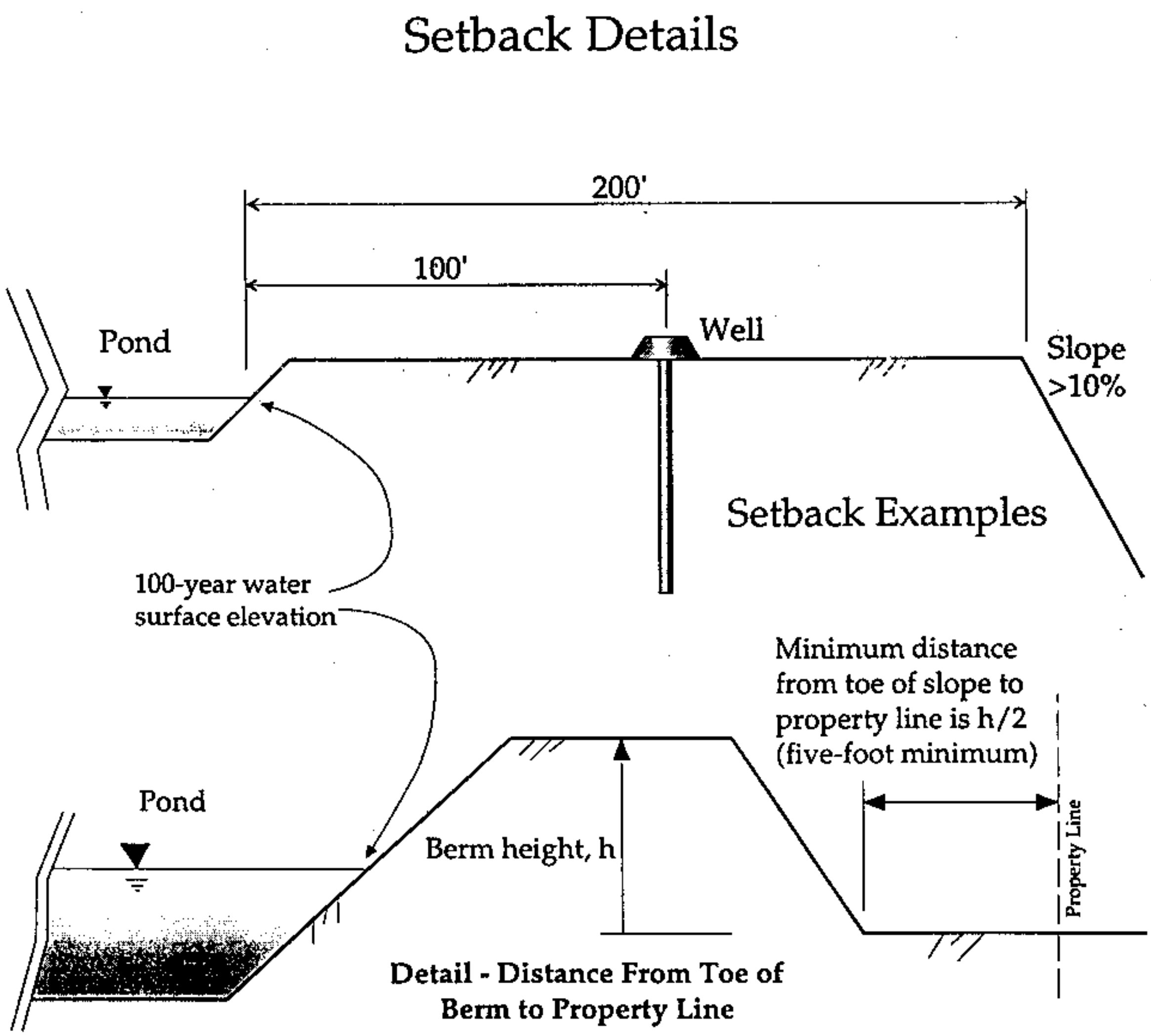
- If a riser pipe outlet is used, it shall be protected by a trash rack and anti-vortex plate. If an orifice plate is used, it shall be protected with a trash rack with at least 10 square feet of open surface area. In both cases, the rack must be hinged or easily removable to allow for cleaning. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.
- All ponds shall have an emergency overflow spillway or structure designed to convey the 100- year, 24-hour design storm for post-development site conditions, assuming the pond is full to the overflow spillway or structure crest. The overflow shall be designed to convey these extreme event peak flows around the berm structure for discharge into the downstream conveyance system. The overflow shall be designed and sited to protect the structural integrity of the berm. This will assure that catastrophic failure of the berm is avoided, property damage is avoided, and water quality of downstream receiving water bodies is protected (see **Exhibit 2-20**).
- The subgrade of the spillway shall be set at or above the 100-year overflow elevation of the control structure. The spillway shall be located to direct overflows safely towards the downstream conveyance system and shall be located in existing soil wherever feasible. The emergency overflow spillway shall be armored with riprap or other flow-resistant material that will protect the embankment and minimize erosion. Riprap shall be designed in conformance with **Section 2.8** and shall extend to the toe of each face of the berm embankment. The emergency overflow spillway weir section shall be designed for the maximum design storm event for post-development conditions, using the following formula:

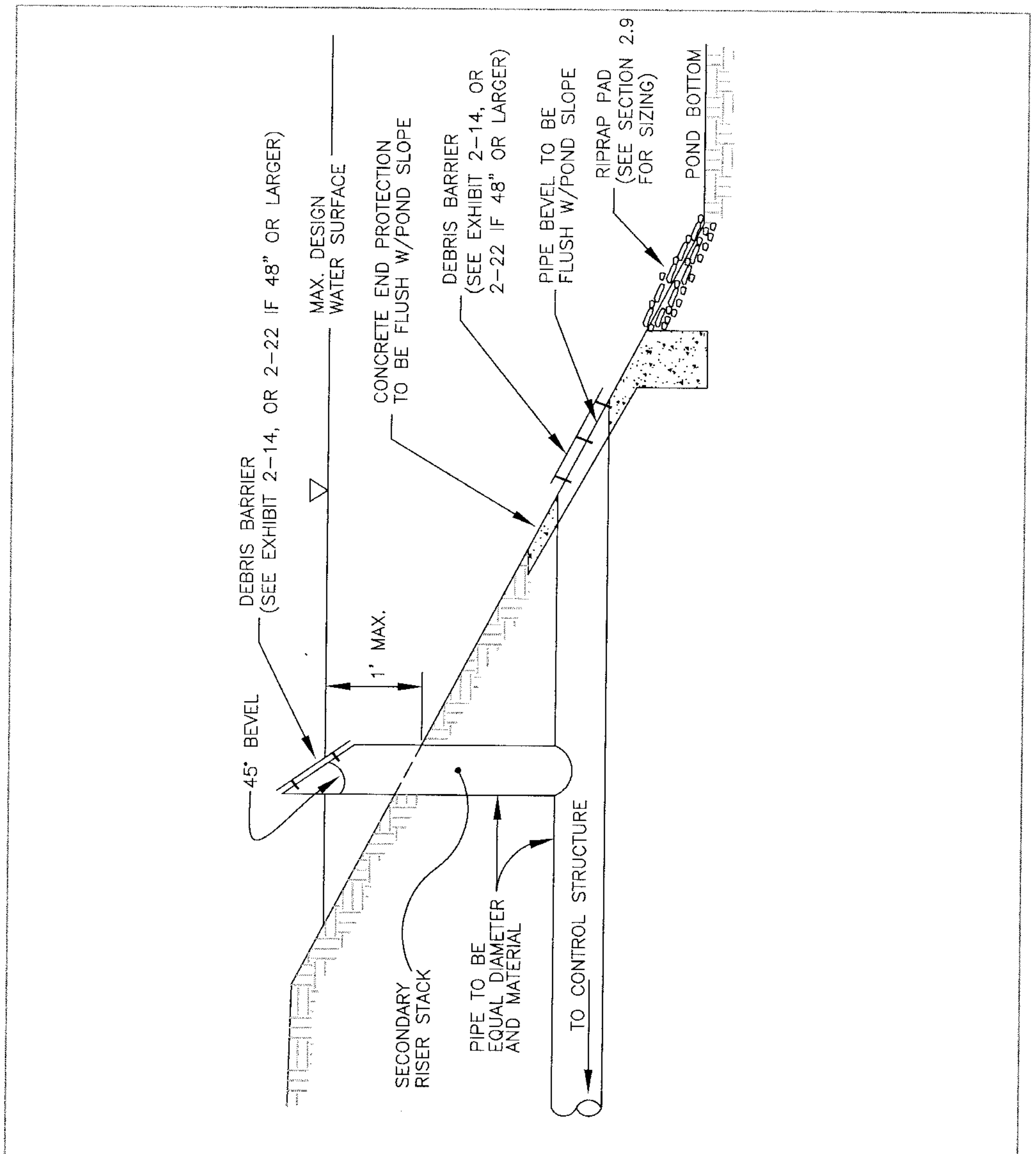
$$L = \frac{Q_{100}}{3.21H^{1.5}} - 2.4\,H$$

where:	L	= Length of bottom of weir, feet
	Q_{100}	= 100-year post-development flow rate, cfs
	H	= Height of emergency overflow water surface, feet

Wet, Extended Wet, & Dry Detention Pond

EXHIBIT 2-18





DRAWN BY
RRG

NTS

EXHIBIT 2–19

SECONDARY RISER STACK

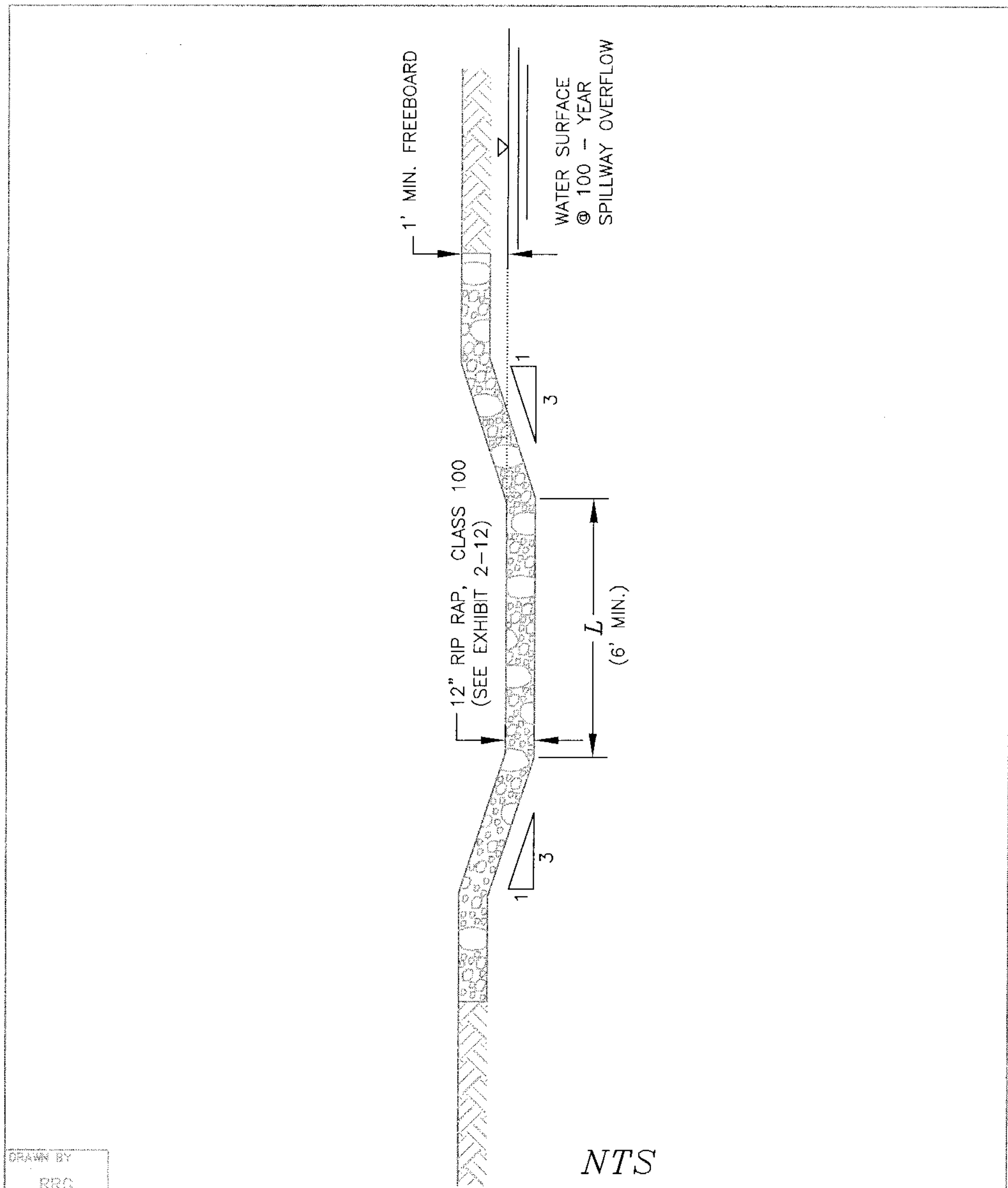


EXHIBIT 2-20
EMERGENCY OVERFLOW
SPILLWAY WEIR SECTION

Berm Embankment/Soil Stabilization:

- Pond berm embankments shall be designed by a civil engineer licensed in the State of Oregon.
- Pond berm embankments shall be constructed on native consolidated soil (or compacted and stable fill soil) that is free of loose surface soil materials, roots, and other organic debris. Topsoil will be required over the consolidated soil to support required plantings.
- Pond berm embankments shall be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width measured through the center of the berm. (Note: A key in a berm is an excavated trench below the berm filled with soil material used to make the berm. It acts to "key" the berm into the native soil to prevent it from sliding.)
- The berm embankment shall be constructed of compacted soil (95 percent maximum dry density, Modified Proctor Method per ASTM D1557) placed in 6- to 8-inch lifts with hand-held equipment, or 10- to 12-inch lifts with heavy equipment.
- Anti-seepage collars shall be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth **(**see **Exhibit 2-21).**
- During construction, exposed earth on the pond side slopes shall be sodden or seeded with appropriate seed mixture. Establishment of protective vegetative cover shall be ensured with appropriate surface-protection best management practices (BMPs) and reseeded as necessary. See the City of Portland's *Erosion Control Manual*.
- Pond embankments shall be constructed with a maximum (i.e. steepest) slope of 3H: 1V on the upstream and downstream face. Side slopes **within** the pond shall be sloped no steeper than 3H: 1V. The use of retaining walls in ponds requires pre-approval from BES. Retaining walls shall not exceed one-third of the circumference of the pond. Detailed structural design calculations must be submitted with every retaining wall proposal.
- Pond berm embankments 6 feet or less in height including freeboard, measured through the center of the berm, shall have a minimum top width of 6 feet, or as recommended by a geotechnical engineer.
- Where maintenance access is provided along the top of berm, the minimum width of the top of berm shall be at least 15 feet.

For public ponds, the following additional design criteria shall apply:

- Two staff gauges shall be installed at opposite ends of the bottom of the pond, to enable maintenance staff to measure the depth of accumulated silts.

Wet, Extended Wet, & Dry Detention Pond

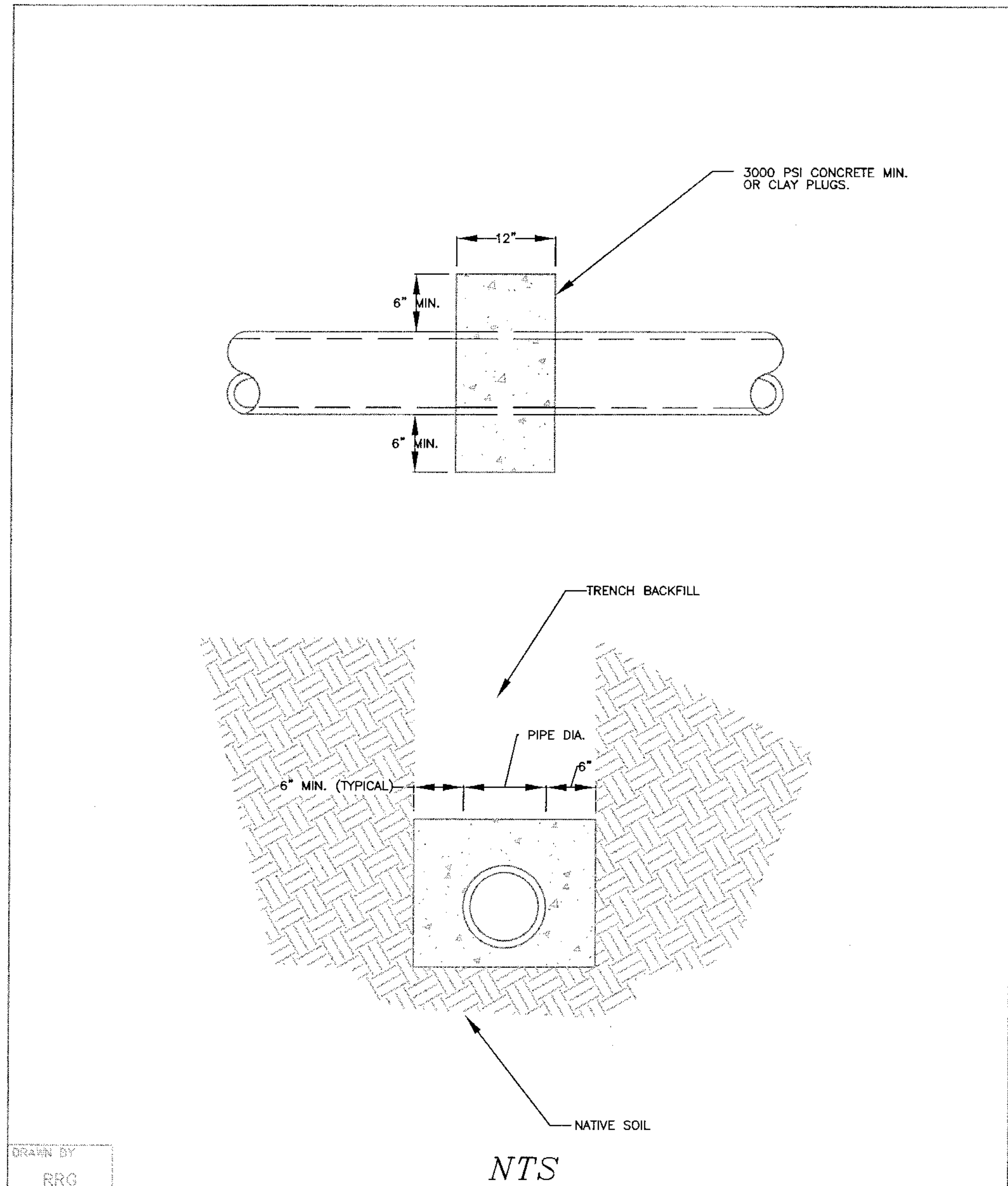


EXHIBIT 2-21
POND INLET / OUTLET
ANTI-SEEPAGE COLLAR

Fencing and Signage: Fences are required for all City-maintained ponds with a permanent or temporary pool greater than 18 inches deep, interior side slopes steeper than 3H: 1V, or any walls/bulkheads greater than 24 inches high. Generally, a pond with gently sloping sides (less than 3:1) and including a 10-foot-wide safety bench around the facility at the point of slope transition does not require a fence. Applicants can request BES approval to use fencing if there are safety concerns.

For City-maintained facilities where fencing is not required, the applicant must have BES approval to use fencing. Approval will be granted only if there is no practical alternative. If fencing is required or approved, the design shall address screening requirements.

Fencing for privately owned facilities is at the discretion of the owner. The owner may, however, want to use the criteria for City-maintained facilities.

For both private and City-maintained facilities, Title 33 may prohibit fencing or require screening in some locations. The designer is responsible for determining which sections of Title 33 apply to the project. If fencing is prohibited by Title 33, the designer may have to modify the facility or site design to provide an alternate means of securing the site (for example, reducing the depth of water or side slopes of the facility to minimize safety concerns).

For both private and City-maintained facilities where fencing is used, fences shall be at least 6 feet high. The 6-foot height may not be required in situations where fences are not needed to prevent climbing (e.g., on steep slopes to prevent slipping). For City-maintained facilities, a minimum of one vehicular locking access gate shall be provided. It shall be 10 feet wide, consisting of two swinging sections each 5 feet wide. At least one pedestrian gate shall be provided, with a minimum 4-foot width.

Fencing materials shall be complementary to the site design. If chain link fencing is proposed for a City-maintained facility, it shall be designed to City of Portland *Standard Construction Specifications.*

Wet, Extended Wet, & Dry Detention Pond

Wet and Extended Wet Detention Permanent Pool Sizing: The permanent pool (or "dead") storage volume, V_{pond}, is equivalent to twice the runoff volume generated by a storm of 0.83 inches over 24 hours (NRCS Type 1A rainfall distribution). This volume can be approximated using the following formula:

Volume = 2 * (2,276 * Impervious Acreage)

Volume = permanent pool volume, cubic feet
Impervious Acreage = area of impervious surfaces to manage, acres

EXAMPLE

A 20-acre site is to be developed. After development, the site will be 60 percent impervious. What is the required volume for a wet pond to meet pollution reduction requirements?

For the post-development condition, the total area is 20 acres and the impervious area has increased to 60 percent, or 12 acres:

Permanent Pool Volume = 2 * (2,276 * 12) = 54,624 cubic feet

Flow Control for Extended Wet Detention and Dry Detention Ponds: To restrict flow rates exiting the pond to those required by **Section 1.6.2**, a control structure designed in accordance with **Section 2.5** must be used. For extended wet detention ponds, this control structure must be located above the permanent pool elevation. The outlet orifice shall be designed to minimize clogging (see **Section 2.5: Control Structures**).

Wet, Extended Wet, & Dry Detention Pond

Landscaping: Shrubs and wetland plantings shall be designed to minimize solar exposure of open water areas. Trees or other appropriate vegetation shall be located around the east, south, and west sides of a facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, and it helps maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop.

Facility area is equivalent to the area of the pond, including bottom and side slopes, plus a 10-foot buffer around the pond. Minimum plant material quantities per **250** square feet of the facility area are as follows:

1 - Evergreen or deciduous tree:	
Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs/small trees	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.
Wetland plants:	1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

Wet, Extended Wet, & Dry Detention Pond

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Pond grading	Call for inspection
Piping	Call for inspection
Control (orifice) structure for extended wet detention and dry detention ponds	Call for inspection
Filter fabric or lining (if applicable)	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to wet, extended wet detention, & dry detention pond O&M form**

Additional photos and drawings:

*** Link to wet and extended wet detention pond photos**
*** Link to wet and extended wet detention pond drawings**
*** Link to dry detention pond photos**
*** Link to dry detention pond drawings**

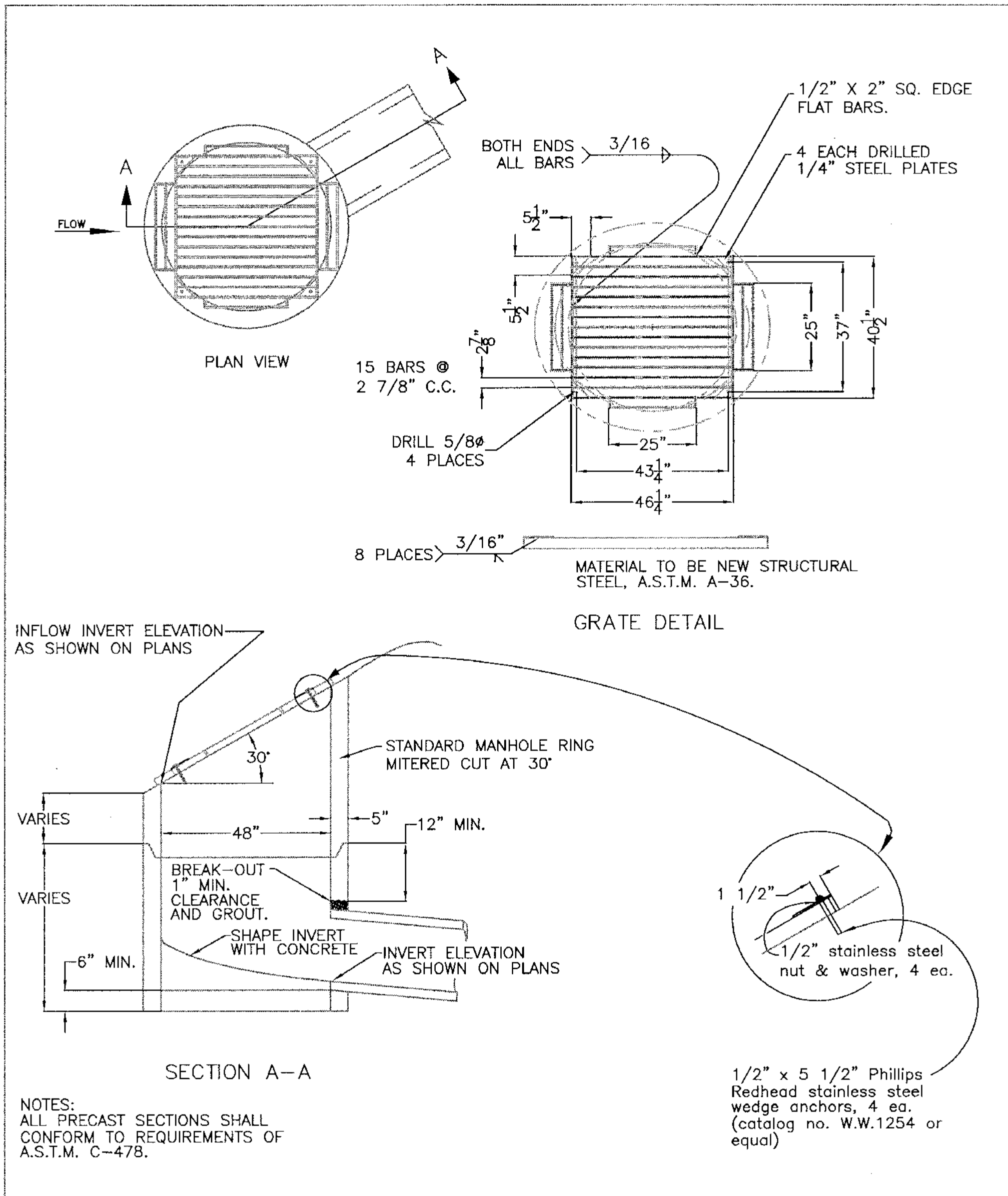


EXHIBIT 2-22
INFLOW RISER MANHOLE
WITH / GRATE COVER

Constructed Treatment Wetland

Stormwater Management Goals Achieved | **Acceptable Sizing Methodologies**

√ Pollution Reduction…………………………..PRES
√ Flow Control………………..…………………PRES
Destination/ Disposal……………………… NA
This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Wetlands can be used to manage stormwater from any type of impervious surface.

Constructed Treatment Wetland

Description: A wetland is an area inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Jurisdictional wetlands include swamps, marshes, bogs, and similar areas except those constructed as pollution reduction or flow control facilities. The Corps of Engineers and Division of State Lands make specific wetland designations. Constructed treatment wetlands are wetlands designed and constructed for the specific purpose of providing stormwater management. Unlike natural wetlands, constructed treatment wetlands are not regulated by the Corps of Engineers and the Division of State Lands.

Wetlands remove pollutants through several treatment processes, including sedimentation, filtration, and biological uptake. When enough volume is provided, constructed treatment wetlands can also provide a significant level of flow control.

Design Criteria: To receive pollution reduction credit, the wet portion or permanent pool of the wetland shall be equal to that required for wet ponds, or the residence time of the stormwater volume (calculated as the pollution reduction design storm volume divided by the average facility outflow rate) shall be no less than 36 hours. A design team with experience in hydrology, wetland plants, and engineering will be needed to develop a successful wetland pollution reduction facility. A water budget analysis shall be performed with the design of the facility.

Sizing: Drainage area to be served shall be no less than 10 acres. To meet pollution reduction requirements, dead storage within the wetland must equal or exceed wet pond dead storage criteria. To meet flow control requirements, a detailed hydraulic analysis must be performed by a Professional Engineer, showing compliance with flow control standards presented in **Section 1.6.2**. For stormwater report requirements, see **Exhibit 2-2**.

Geometry: The configuration of a constructed wetland shall be tailored to each site, rather than limited to one design. Major elements of a wetland can include channels or trenches, shallow marshes, and deeper ponded areas. These elements shall be combined to take advantage of the site topography. Maximum slopes within the wetland area shall be 20%, and maximum slopes of surrounding land shall not exceed 10%. All wetland design shall address habitat, planting, and aesthetic issues.

1) The volume of water to be treated shall be allocated over the treatment area of the facility as follows:

Component	**Percent of Design Volume** (approx.)	**Percent of Facility Surface Area** (approx.)
Forebay	10	5
Micropool	10	5
Deep water (> 18")	50	40
Deep wetland (6"-18")	20	25
Shallow wetland (<6")	10	25

Definitions:

Forebay: A relatively deep zone placed where influent water discharges to a stormwater wetland. It traps coarse sediments, reduces incoming velocity, and helps distribute runoff evenly over the wetland.

Micropool: A deep (4 to 6 feet) pool placed at the outlet of a stormwater wetland forebay.

Deep-water: The area within a stormwater wetland that has a water depth greater than 18 inches.

Deep wetland: The area within a stormwater wetland that has a water depth between 6 and 18 inches.

Shallow wetland: The area within a stormwater wetland that has a water depth less than 6 inches.

2) The minimum length-to-width ratio shall be 3:1, unless otherwise approved by the City. If area constraints make this ratio unworkable, baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short-circuiting.

3) Where wetland vegetation is to be planted, side slopes shall be no steeper than 5:1. Wetland plant selection shall be consistent with anticipated hydrology.

4) Access routes to the wetland for maintenance purposes must be shown on the plans. Public wetlands will need to provide a minimum 8-foot wide access route, not to exceed 10 percent in slope.

Flow:

1) Flow velocity through the wetland shall average less than 0.01 feet per second for the water quality design storm event (see **Section 1.5.2**). If natural slope does not allow for this velocity, berms shall be used to create ponded benches.

2) Flow through the wetland shall be distributed as uniformly as possible across the marsh and ponded section.

Forebay:

1) The forebay area shall be established along the wetland inflow points to capture sediment. The forebay shall have a water depth of about 3 feet and have at least 10 percent and up to 25 percent of the total treatment wetland volume.

An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

Soil Suitability: Constructed treatment wetlands are appropriate for NRCS type C and D soils. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

Setbacks: Required setback from property lines is 5 feet, and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; 200-foot setback for slopes of 30%; infiltration trenches shall not be used where slopes exceed 30%.

Landscaping: Shrubs and wetland plantings shall be designed to minimize solar exposure of open water areas. Trees or other appropriate vegetation shall be located around the east, south, and west sides of a facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, and it helps maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop.

Facility area is equivalent to the area of the wetland, including bottom and side slopes, plus a 10-foot buffer around the wetland. Minimum plant material quantities per **200** square feet of the facility area are as follows:

1 - Evergreen or deciduous tree:	
Evergreen trees:	Minimum height: 6 feet
Deciduous trees:	Minimum caliper: 1 ½ inches at 6 inches above base.
4 - Large shrubs/small trees	3-gallon containers or equivalent.
6 - Shrubs/large grass-like plants	1-gallon containers or equivalent

Ground cover plants:	1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.
Wetland plants:	1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

***Link to Recommended Plants**

Constructed Treatment Wetland

For public constructed treatment wetlands, the following additional design criteria shall apply:

1) Two staff gauges shall be installed at opposite ends of the bottom of the wetland, to enable maintenance staff to measure the depth of accumulated silts.

2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for planting.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Wetland grading	Call for inspection
Piping	Call for inspection
Filter fabric (if applicable)	
Growing medium	
Plantings	Call for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to constructed treatment wetland O&M form**

Additional photos:

*** Link to constructed treatment wetland photos**

Manufactured Treatment Technology

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
√ Pollution Reduction……………………………	PERF
Flow Control……………………………………	NA
Destination/ Disposal………………………	NA

These facilities may or may not be classified as Underground Injection Control structures (UICs), depending on specific manufacturer design.

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) For a list of currently accepted manufactured stormwater treatment technologies, call BES at 503-823-7761. Manufactured stormwater treatment technologies can be used to provide pollution reduction for any impervious surface. They can be located on private property, and some are approved for use in public right-of-ways.

BES has developed "Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies," located in **Appendix B**. For a manufactured stormwater treatment technology to be approved for general use within the City of Portland, the manufacturer must submit detailed performance testing data that meets the testing protocols included in the "Vendor Submission Guidance".

To be approved for use as a public facility (see **Section 1.10**: Public vs. Private Stormwater Management), the manufacturer must also submit detailed information about the facility's design criteria, construction techniques, operation and maintenance procedures, reliability, and cost. This information will be reviewed by BES's Standards and Practices Committee, which will decide whether or not the facility can be used for public projects.

Manufactured stormwater treatment technologies on BES's approved list must be designed and constructed in accordance with the manufacturer's recommendations. BES may have also placed special design conditions on the acceptance of the technology, such as sizing requirements that go beyond the manufacturer's recommendations, which must also be followed to obtain plan approval.

In addition to design calculations shown in **Exhibit 2-2**, the following must be submitted with each manufactured stormwater treatment technology project:

1) Pollution reduction capacity of the facility
2) Flow-through conveyance capacity (i.e., how much flow can be passed through the facility without stirring up and releasing trapped pollutants)

Manufactured Treatment Technology

An operations and maintenance manual must also be submitted for BES review. See **Chapter 3.0** for O&M plan guidance.

Manufactured stormwater treatment technologies on BES's approved list for general use may not be capable of meeting specific TMDL requirements for certain watersheds. In that case, the treatment technology will not be accepted as a stand-alone pollution reduction facility. Rather, a pollution reduction facility that is presumed by BES to meet the TMDL requirement must be used.

For a list of currently approved manufactured stormwater treatment technologies, contact BES at (503) 823-7761.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Vault excavation	
Piping	Call for inspection
Vault installation	Cal for inspection

Operations and Maintenance requirements: An operations and maintenance plan will be required, including information from the manufacturer, as per **Chapter 3.0**.

Structural Detention Facility

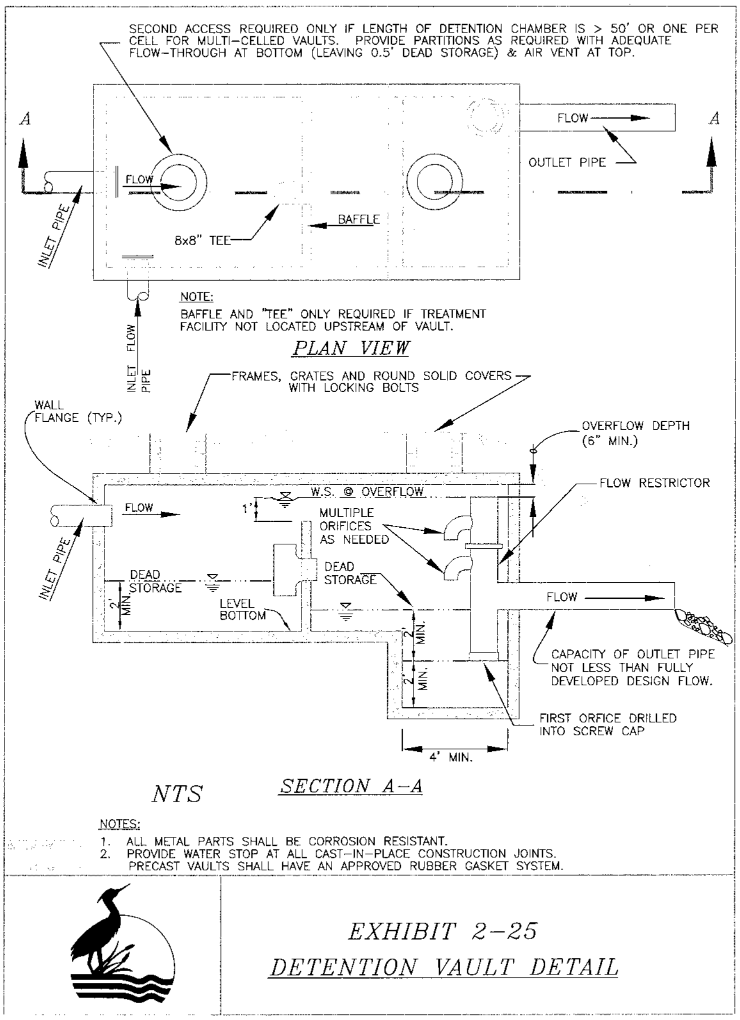


EXHIBIT 2–25
DETENTION VAULT DETAIL

Stormwater Management Goals Achieved	Acceptable Sizing Methodologies
Pollution Reduction…………………………..	NA
√ Flow Control………………….……………..	PRES
Destination/ Disposal………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) See **Exhibit 2-2** for hydrologic and hydraulic calculations that must be submitted with structural detention design. Structural detention facilities may be used to provide flow control for any impervious surface type, and may be located on private property or within the public right-of-way.

Structural Detention Facility

Description: Structural detention facilities such as tanks, vaults, and oversized pipes provide underground storage of stormwater as part of a runoff flow control system. As with any underground structure, they must be designed not only for their function as runoff flow control facilities, but also to withstand an environment of periodic inundation, potentially corrosive chemical or electrochemical soil conditions, and heavy ground and surface loadings. They must also be accessible for maintenance. Facilities in this section must be designed using acceptable hydrologic modeling techniques (See **Section 2.3**) to meet applicable flow control requirements. Additional facilities will be required to meet applicable pollution reduction requirements.

Tanks and vaults typically do not have a built-in design feature for containing sediment, as do multi-cell ponds. When tanks or vaults are used for detention storage, therefore, either a surface sediment containment pond shall be placed upstream of the tank or vault, or the tank/vault shall be oversized to allow for the temporary accumulation of sediment. Where the tank or vault is designed to provide sediment containment, a minimum of ½ foot of dead storage shall be provided, and the tank or vault shall be laid flat.

Tanks and vaults can be used in conjunction with other detention storage facilities, such as ponds or parking lot ponds, to provide initial or supplemental storage.

Because of minimum orifice size specifications, structural flow control facilities (such as detention tanks, vaults, and oversized pipes) for projects with less than 15,000 square feet of impervious surface are not effective and will not be required. Projects with less than 15,000 square feet of impervious surface are required to use surface retention facilities to control flows. Where this is not possible, the applicant must pay the off-site management fee (See **Section 1.11**).

Design Requirements:
The following criteria apply to detention tank, vault, and oversized pipe design.

- All areas of a tank or vault shall be within 50 feet of a minimum 36-inch diameter access entry cover. All access openings shall have round, solid locking lids.
- Publicly owned detention tanks, vaults, and pipes are permitted within public rights-of-way. If developments are served with publicly operated and maintained tanks and vaults that are not located within the right-of-way, the tanks/vaults shall be located in separate open space tracts with public sewer easements that are dedicated to the City of Portland. All privately owned and maintained facilities shall be located to allow easy maintenance and access. (**See Chapter 3.0**: Operation and Maintenance)

Structural Detention Facility

- All tanks and vaults shall be designed as flow-through systems, unless separate sediment containment is provided.
- Minimum size for a public detention pipe shall be 36 inches. If the collection system piping is designed also to provide storage, the resulting maximum water surface elevation shall maintain a minimum 1-foot of freeboard in any catch basin below the catch basin grate. Pipe capacity shall be verified using an accepted methodology approved by the City (see BES's Sewer Design Manual). The minimum internal height of a vault or tank shall be 3 feet, and the minimum width shall be 3 feet. The maximum depth of the vault or tank invert shall be 20 feet. Pipe material and surface treatment shall conform to the standards for detention tanks and vaults (see **Exhibits 2-23 and 2-25).**
- Detention tanks and vaults shall have a minimum of ½ foot of dead storage, unless upstream sedimentation is provided (see **Exhibits 2-23 and 2-25**).

Flow Control:
- To restrict flow rates exiting the pond to those required by **Section 1.6.2**, a control structure per **Section 2.5** must be used.

Materials and Structural Stability:
- For public facilities, pipe materials and joints shall conform to the City of Portland *Sewer Design Manual*. For private facilities, the pipe material shall conform to the Unified Plumbing Code.
- All tanks, vaults, and pipes shall meet structural requirements for overburden support and traffic loadings, if appropriate. H-20 live loads shall be accommodated for tanks and vaults under roadways and parking areas. End caps shall be designed for structural stability at maximum hydrostatic loading conditions.
- Detention vaults shall be constructed of structural reinforced concrete (3000 psi, ASTM 405). All construction joints shall be provided with water stops.
- In soils where groundwater may induce flotation and buoyancy, measures shall be taken to counteract these forces. Ballasting with concrete or earth backfill, providing concrete anchors or other counteractive measures shall be required. Calculations shall be required to demonstrate stability.
- Tanks and vaults shall be placed on stable, consolidated native soil with suitable bedding. Tanks and vaults shall not be allowed in fill slopes, unless a geotechnical analysis is performed for stability and construction practices.

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures

Structural Detention Facility

2) Profile view of facility, including typical cross-sections with dimensions
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

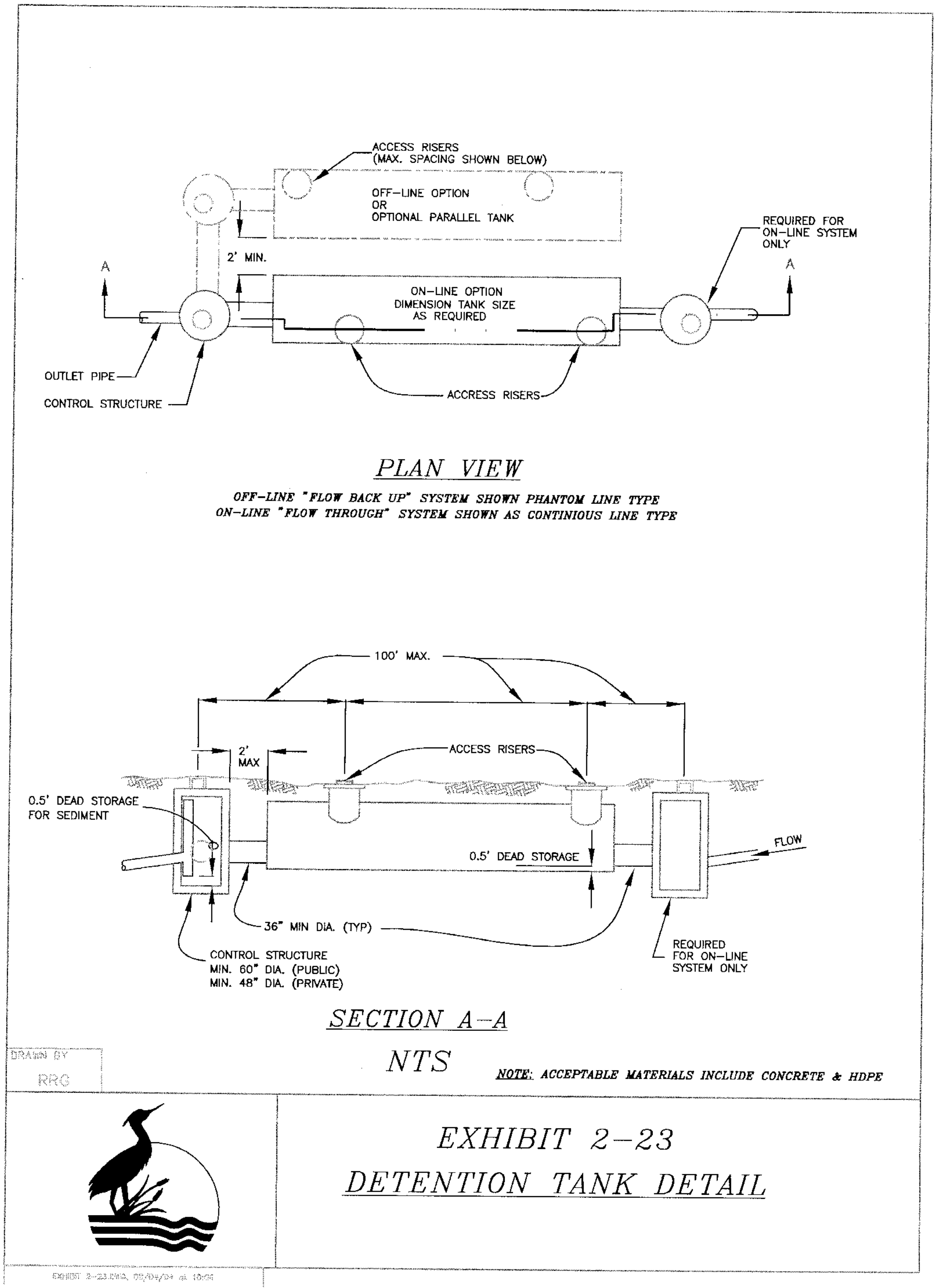
Facility Component	Inspection Requirement
Vault excavation	
Piping	Call for inspection
Vault installation	Call for inspection
Control structure (orifice structure)	Call for inspection

OPERATIONS AND MAINTENANCE REQUIREMENTS: **See Chapter 3.0.**

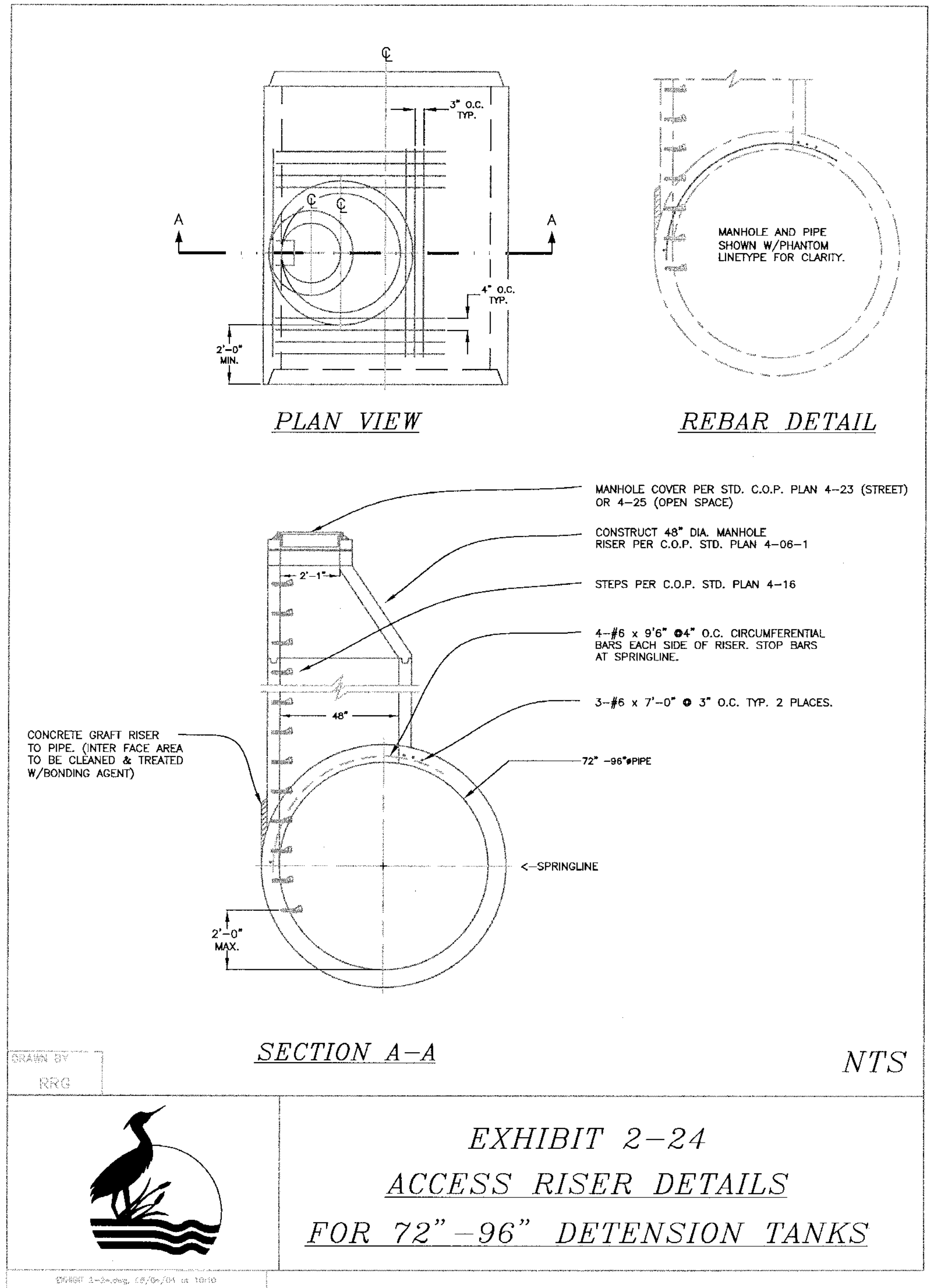
*** Link to tank, vault, and oversized pipe O&M form**

STORMWATER REPORT REQUIREMENTS: See **Exhibit 2-2**.

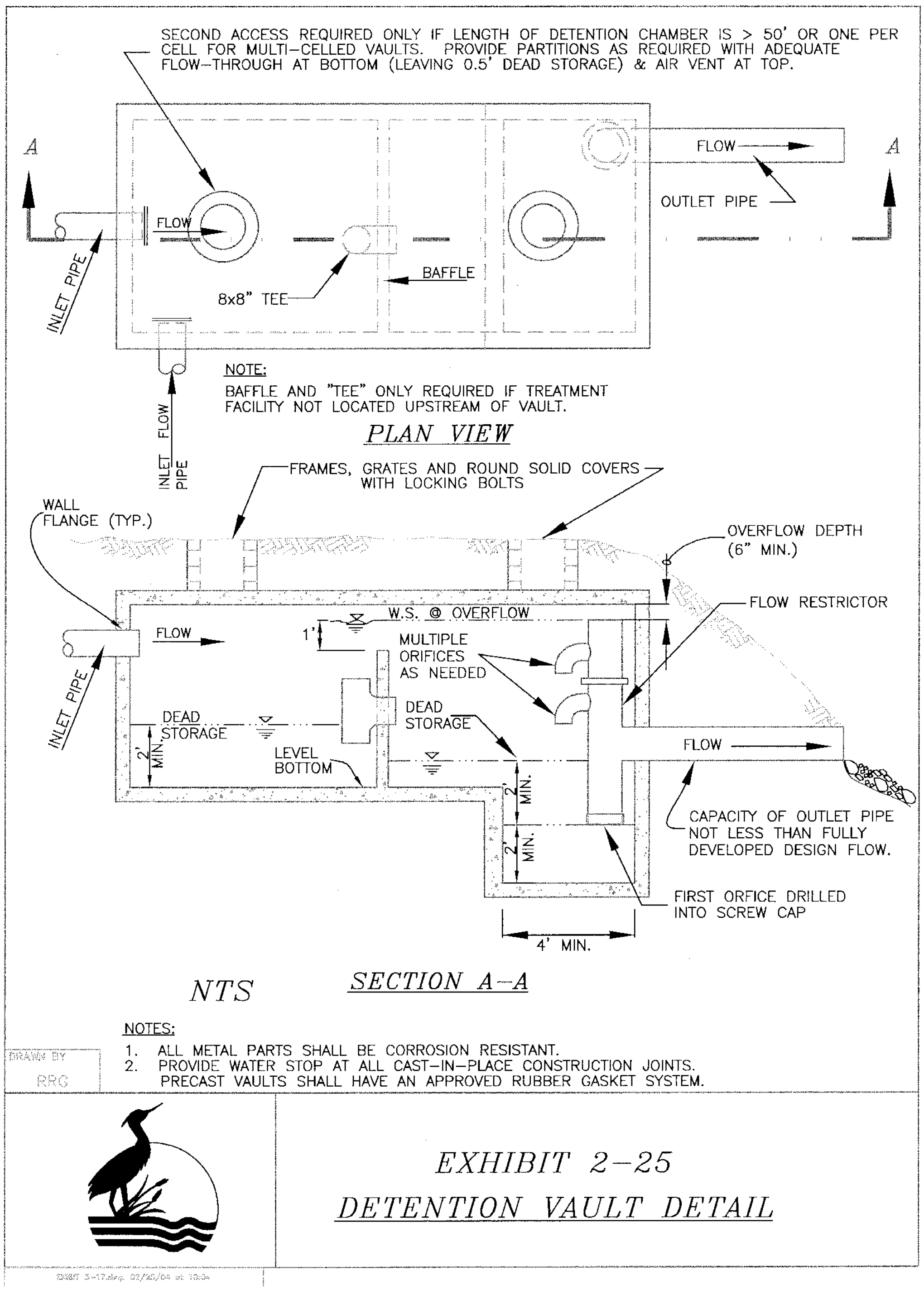
Structural Detention Facility



Structural Detention Facility

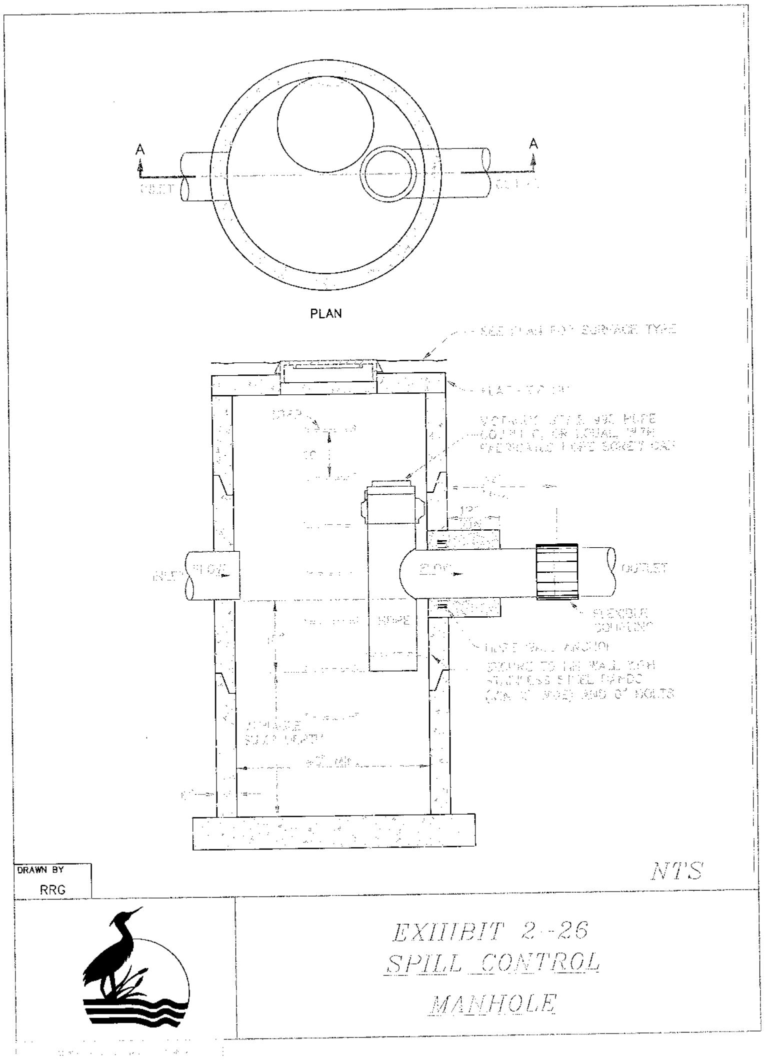


Structural Detention Facility



Structural Detention Facility

Spill Control Manhole



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction[1] (Oil Only)……………..	PRES[1]
Flow Control…………………………………	NA
Destination/ Disposal………………………	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Spill control manholes receive credit for oil removal only. They may be used to remove oil from parking lots and other vehicular access areas.

Spill Control Manhole

Description: Spill control manholes rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. They consist of a simple underground manhole with a "T" outlet designed to trap small spills. Spill control manholes will not be given credit for basic pollution reduction requirements. They must be used in conjunction with other pollution reduction systems from this chapter to meet oil control and pollution reduction requirements.

Other Options: There may be other acceptable oil controls not listed above. Applicants may propose an alternative oil control option under the performance approach. However, proposal of a new oil control will require an additional review process for approval, which may delay issuance of related building permits.

Design and Sizing Criteria:

- Spill control manholes shall be used in conjunction with an appropriately sized vegetated pollution reduction facility from this chapter to achieve 10 ppm oil effluent from the peak flow generated by the pollution reduction design storm intensity of 0.19 inches per hour. The spill control sump volume shall be 60 cubic feet *or* 20 cubic feet of sump capacity for each cubic feet per second (cfs) of peak pollution reduction design flow, whichever is greater. This treatment train configuration, when sized per the above requirements, will be presumed to meet the 10 ppm effluent design standard.

- To maintain efficiencies and reduce size, all roof drainage shall enter the stormwater system downstream of the spill control manhole, unless sized accordingly.

- Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification in stormwater.

- Engineered calculations are required, using the Rational Method (Q=C*I*A).

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures.

Spill Control Manhole

2) Profile view of facility, including typical cross-section details with dimensions. These details shall match manufacturer specifications and details.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

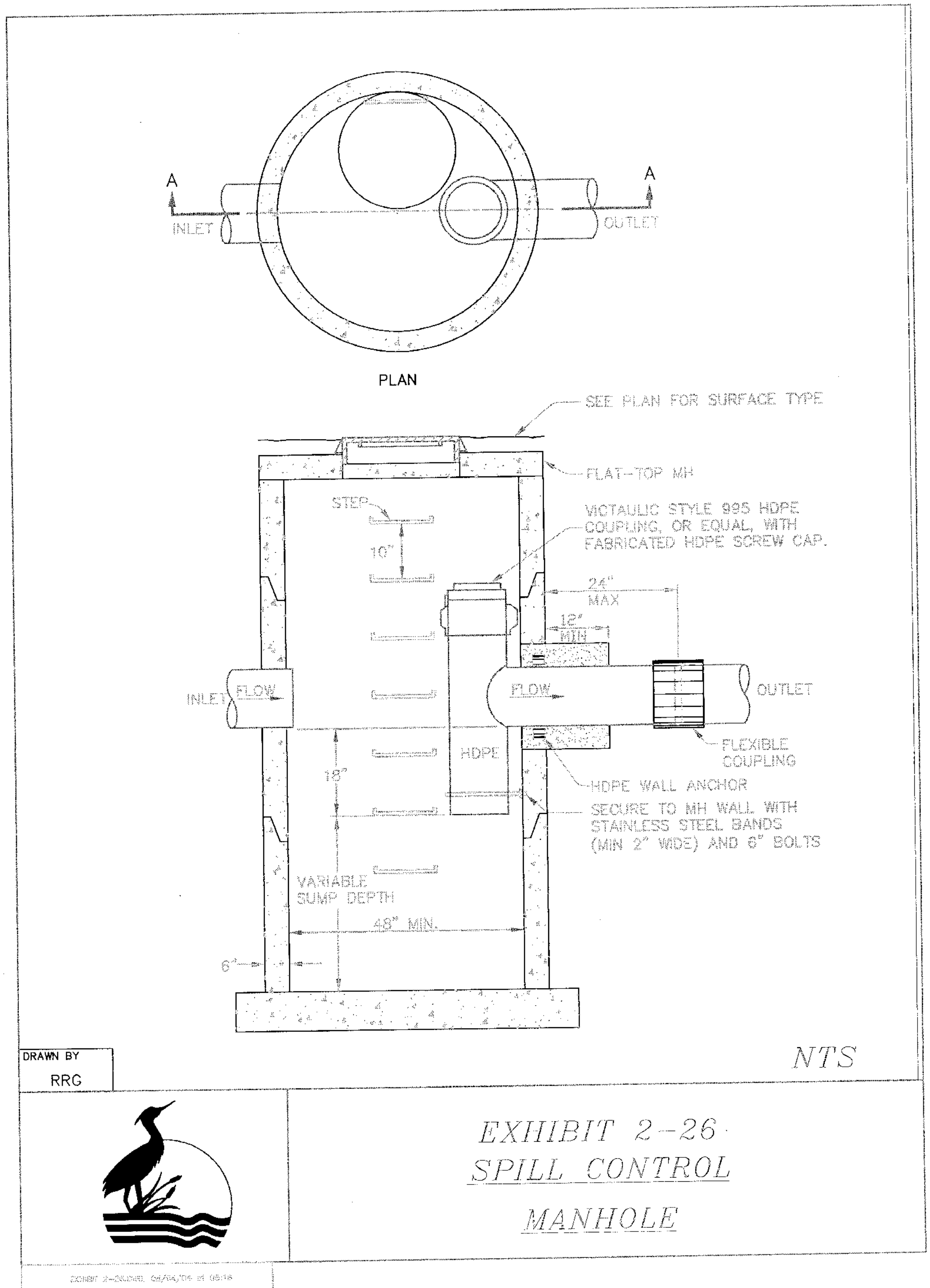
Facility Component	Inspection Requirement
Manhole excavation	
Piping	Call for inspection
Manhole installation	Cal for inspection

OPERATIONS AND MAINTENANCE REQUIREMENTS: See Chapter 3.0.

*** Link to Spill Control Manhole O&M form**

STORMWATER REPORT REQUIREMENTS: See **Exhibit 2-2**.

Spill Control Manhole



Rainwater Harvesting

Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
√ Pollution Reduction................................	PERF[1]
√ Flow Control...	PERF[1]
Destination/ Disposal...........................	NA

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) The required water storage volume is a function of drainage area, rate of water usage, and stormwater management goal. Rainwater harvesting systems may be used to manage stormwater from rooftops and depending on the water use, other impervious surfaces, and must be located on private property.

Rainwater Harvesting

Description: Stormwater may be collected and reused for non-potable water uses within a house or building, or for landscape irrigation purposes. Uses can include reusing water in toilets and at hose bibs. Reducing the water used from the City water system can reduce a site's water bill. BDS plumbing approval must be obtained with any such system. Reference the BDS website for more information on re-use guidelines:

http://www.bds.ci.portland.or.us/pubs/CodeGuides/Upc/RES34 1.pdf

Rainwater harvesting can provide several stormwater management benefits:

- Flow control: In many areas of the city where on-site infiltration is not feasible and the only means of stormwater destination is off-site flow to a combination sewer system (including much of the downtown district and inner east side), rainwater harvesting can provide significant flow-reduction benefits. Depending on the size of the water storage facility and the rate of use, a significant percentage of the annual runoff volume can be reused. Where it isn't feasible to meet a development site's full flow control obligation, rainwater harvesting can be used to manage a portion of the flow and lessen the overall flow control requirement.

- Pollution reduction: As a result of the significant reduction in off-site flow volume that can be achieved, a significant reduction in the discharge of pollutants associated with stormwater can also be accomplished. Where it isn't feasible to meet a development site's full pollution reduction obligation, rainwater harvesting can be used to manage a portion of the flow and lessen the overall pollution reduction requirement.

Checklist of minimal information to be shown on the permit drawings, or included with the permit submittal package:

1) Water storage facility details and specifications
2) Pump and associated electrical details and specifications
3) Piping size, material, and placement details and specifications
4) Average daily water use documentation
5) Hydraulic calculations demonstrating compliance with stormwater management requirements (pollution and flow control)
6) Approximate setbacks from property lines and structures shall be shown
7) Overflow connection to approved stormwater destination per **Section 1.4**

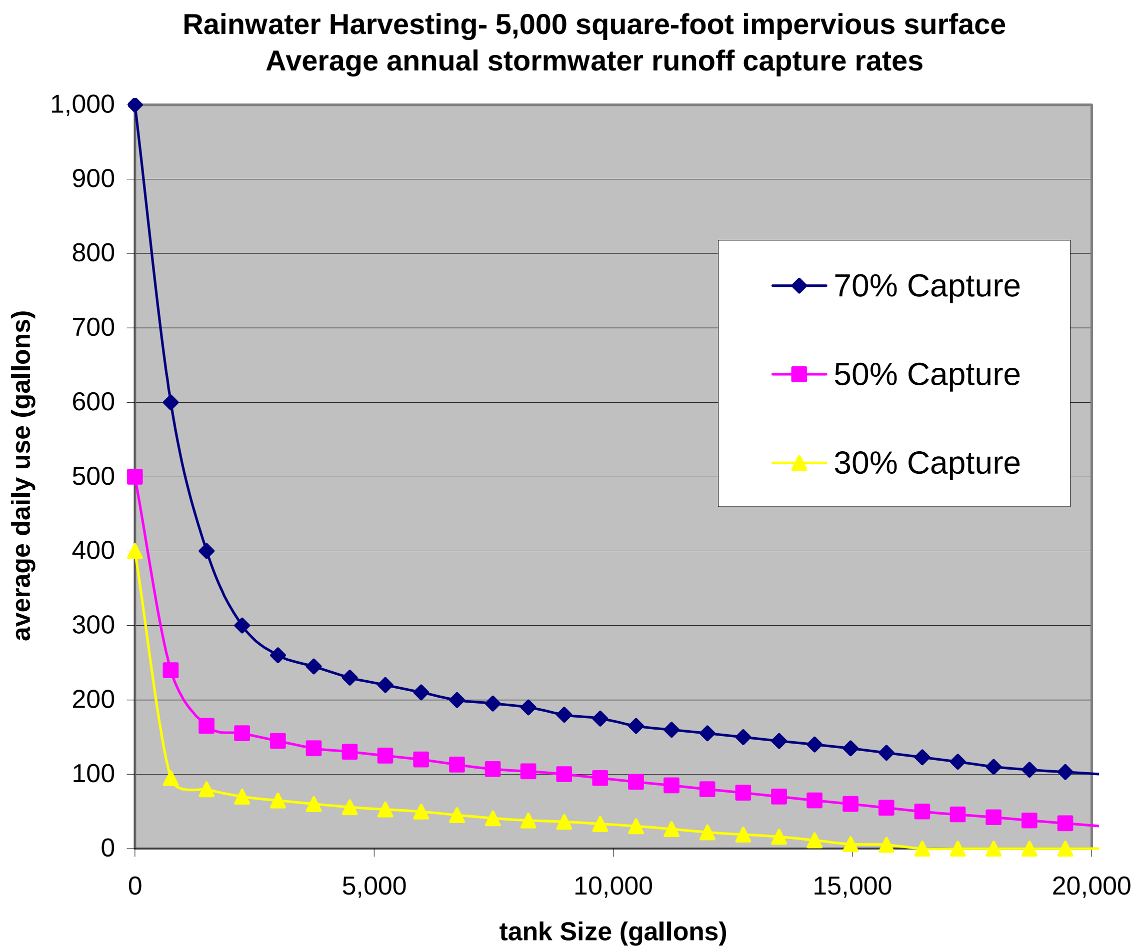
Operations and Maintenance requirements: See **Chapter 3.0**.

Rainwater Harvesting

The following chart represents an analysis done on a 5,000 square-foot project site with 100% impervious surface. 8.5 months of 5-minute rainfall intensity data from the Fernwood rain gage in Portland was used in the analysis, which shows the relationship between water storage volume and average daily water use rate for average annual runoff capture goals of 30%, 50%, and 70%.

For example, if the stormwater management goal is 50% reduction of the annual release volume, the pink line is used to show that if a 2,000-gallon tank were used, the average daily use would need to be approximately 160 gallons per day. A larger tank would necessitate a smaller average daily use rate to achieve the same stormwater management goal of 50% annual volume reduction.

Exhibit 2-27:



Rainwater Harvesting

Private Soakage Trench

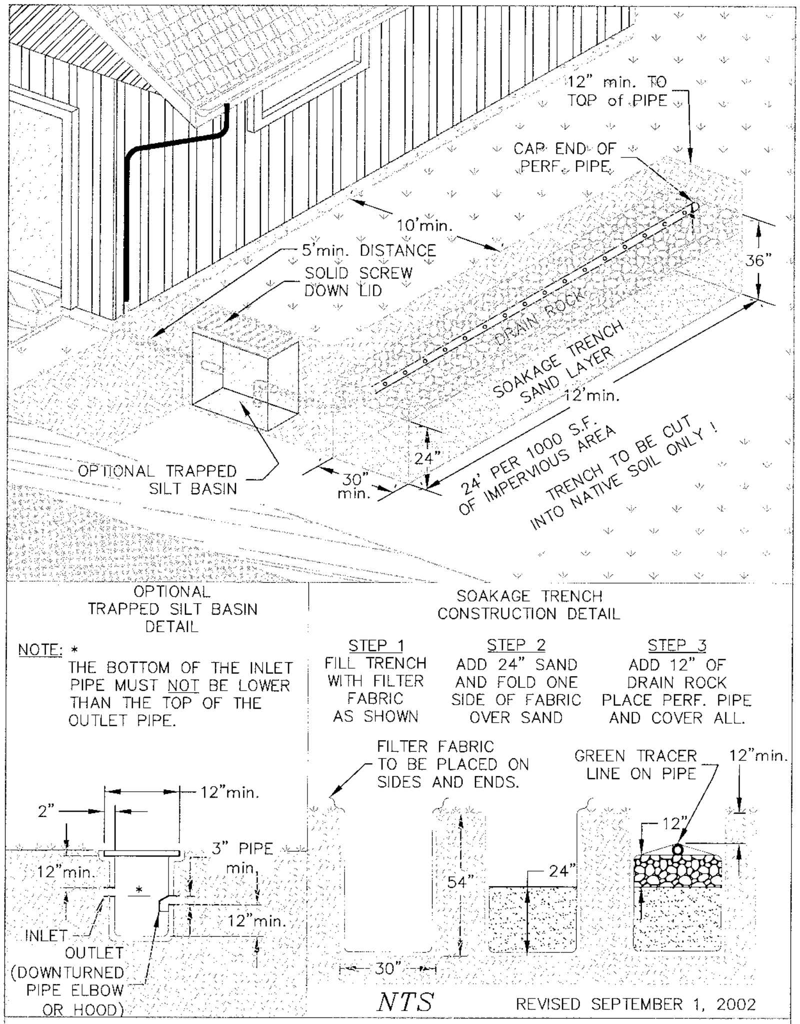


EXHIBIT 2-28
EAST SOAKAGE TRENCH

Stormwater Management Goals Achieved | **Acceptable Sizing Methodologies**

√ Pollution Reduction……….………………….. PRES
√ Flow Control………………………………… PRES
√ Destination/ Disposal……………………… PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Soakage trenches can be used to manage stormwater runoff from private property.

Private Soakage Trench

A soakage or "infiltration" trench is a shallow trench in permeable soil that is backfilled with sand and coarse stone and lined with filter fabric. The trench surface may be covered with grating, stone, sand, grass, or plantings.

Private soakage trenches can be used to provide stormwater disposal by collecting and recharging stormwater runoff into the ground. The use of soakage trenches is highly dependent on soil type and height of the groundwater table.

Note: DEQ has identified soakage trenches as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of soakage trenches that serve rooftops only. All soakage trenches, with the exception of those that drain residential rooftops only, must be registered with DEQ.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call DEQ- UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189.

Soakage trenches are recognized as a stormwater disposal point, and with a sufficient layer of sand or soil for filtration, may be used to meet pollution reduction requirements. **Exhibits 2-28 and 2-29** provide detailed drawings of standard soakage trenches.

Soakage trenches are excluded from use within the Columbia South Shore and Cascade Station/ Portland International Center Plan Districts (see **Exhibit 2-33**).

Private Soakage Trench Design and Sizing Method

Soil conditions are critical to the success of soakage trenches. Because of this, the use of soakage trenches must be pre-approved by the Environmental Soils section of BDS. Supporting geotechnical evidence and a documented infiltration test may be required to demonstrate that soakage trenches will work in the project area. Soakage trenches shall be sized in accordance with **Exhibits 2-28 and 2-29**, once BDS approval has been given for on-site infiltration.

Private Soakage Trench

General Requirements:

Maximum area to be served:	15,000 square-feet per trench
Soils requirements: (NRCS classification)	A or B; C soils may be used if drawdown times are met
Maximum ground slopes	20 percent
Soil test requirement	ASTM D 3385-88 or BDS approval

1) If designed as the only stormwater destination, the soakage trench shall infiltrate the entire design storm without overflow.

2) Soakage trenches shall not be accepted in soils with a tested infiltration rate of less than 2 inches per hour.

3) There shall be no less than 4 feet of undisturbed depth of infiltration medium between the bottom of the facility and any impervious layer (hardpan, solid rock, etc.) or seasonal high groundwater levels.

4) Drawdown time when full shall not exceed 10 hours.

5) Soakage trenches shall meet the following setback requirements for downstream slopes: minimum of 100 feet from slopes of 20%; add 5 feet of setback for each additional percent of slope up to 30%; infiltration trenches shall not be used within 200 feet of where slopes exceed 30%.

6) The bottom of the soakage trench shall be flat, or clay check-dams may be used to prevent water from collecting near the downstream end.

7) Drain medium shall have filter fabric between the medium and native soils or backfill.

8) Soakage trench areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of soakage trench areas.

9) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional engineer, shall inspect the soil after the system is excavated, before trenches are filled with drain medium, to

confirm that soils remain in suitable condition to perform at anticipated infiltration rates.

10) Soakage trenches should be located down slope of structures, and are required to be setback at least 10 feet from buildings, 5 feet from property lines, and 5 feet from public utility lines.

Checklist of Minimal Information To Be Shown on the Permit Drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Drain rock specification
4) Sand specification
5) Filter fabric specification
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

Inspection Requirements and Schedule:

The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Trench grading	Call BDS for inspection
Piping	Call BDS for inspection
Filter fabric	
Sand layer	Call BDS for inspection
Drain rock	Call BDS for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to private soakage trench O&M form**

Private Soakage Trench

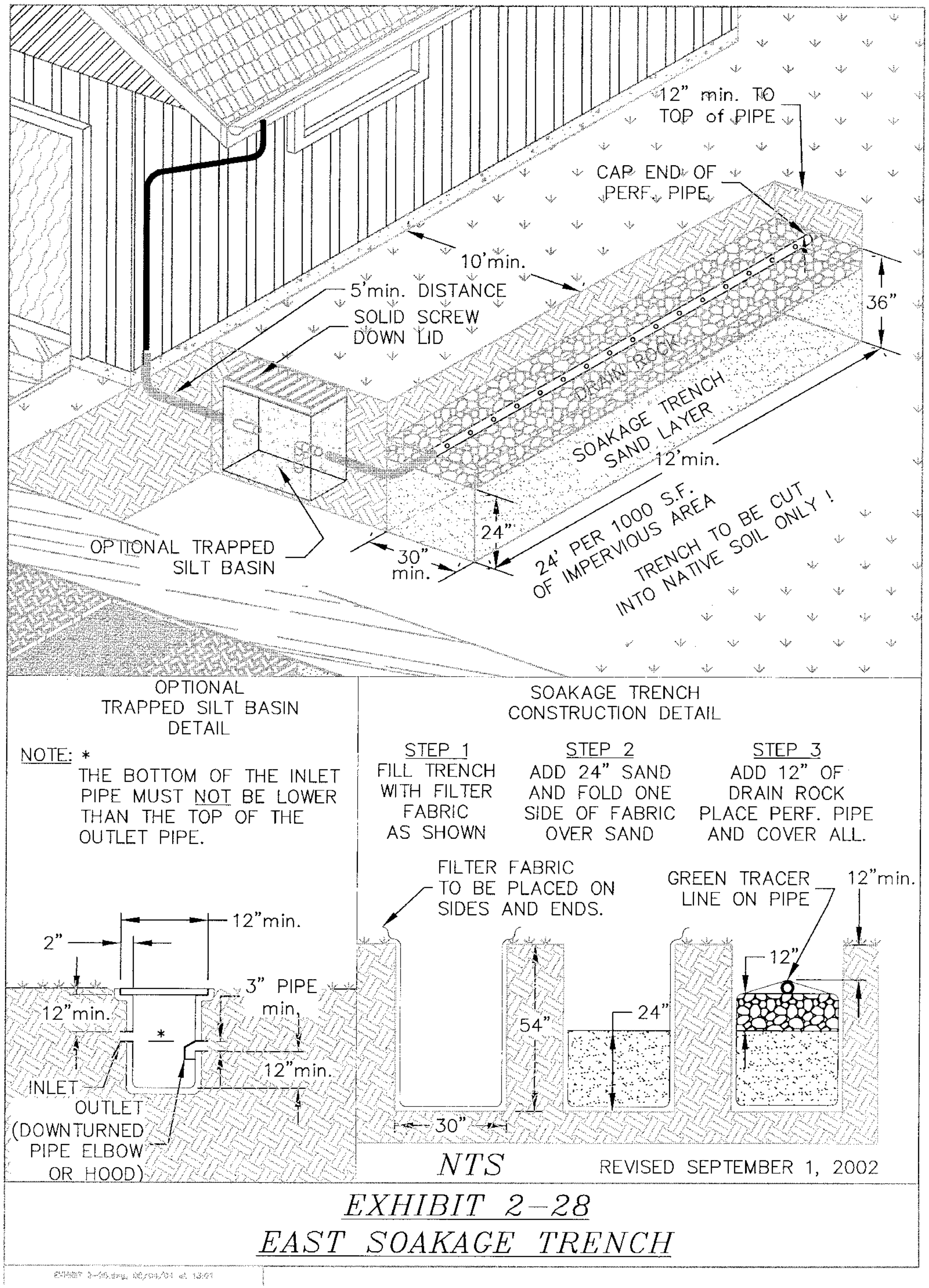


EXHIBIT 2–28

EAST SOAKAGE TRENCH

Private Soakage Trench

East Side Soakage Trench

Applicable to Areas **East** of the Willamette River

Soakage Trench Sizing

For every 1,000 sf of impervious surface, 24 linear feet of 30″ wide soakage trench is required, with a minimum 12-foot long trench. Soakage trenches 12 feet long serve a maximum of 500 sf of horizontally projected roof area or other impervious surface.

Trench

- Soakage trench and perforated pipe must be installed level and parallel to contour of finish grade.
- Soakage trench shall be located no closer than 10 feet to any building structure and not closer than 5 feet from property line.
- Unless a separate pollution reduction facility is used upstream of the trench, the sand filter portion of soakage trench must be filled with a minimum of 24″ medium sand meeting OAR 340-71-295 (3)(e).
- Minimum 12″ of ¾″ – 2 ½″ round or crushed rock to cover sand separated by one layer of filter fabric.
- The pipe shall be laid on top of this gravel and covered with filter fabric.
- At least 12″ minimum of backfill shall be placed over the trench.
- All trenches shall be constructed on native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.
- Slope shall not exceed 20% without a stamped and signed geotechnical report addressing slope stability.
- Trench shall not be constructed under current or future impervious surface.

Sand

Medium sand meeting OAR 340-71-295 (3)(e) will be required. Sieve analysis of the medium sand is required to be made by a qualified party and a report provided to City of Portland plumbing inspector at the time of inspection. Analysis to comply with ASTM C136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregate and in conjunction and accordance with ASTM C-117, Standard Test Method for Materials Finer than No.200 Sieve in Mineral Aggregates by Washing.

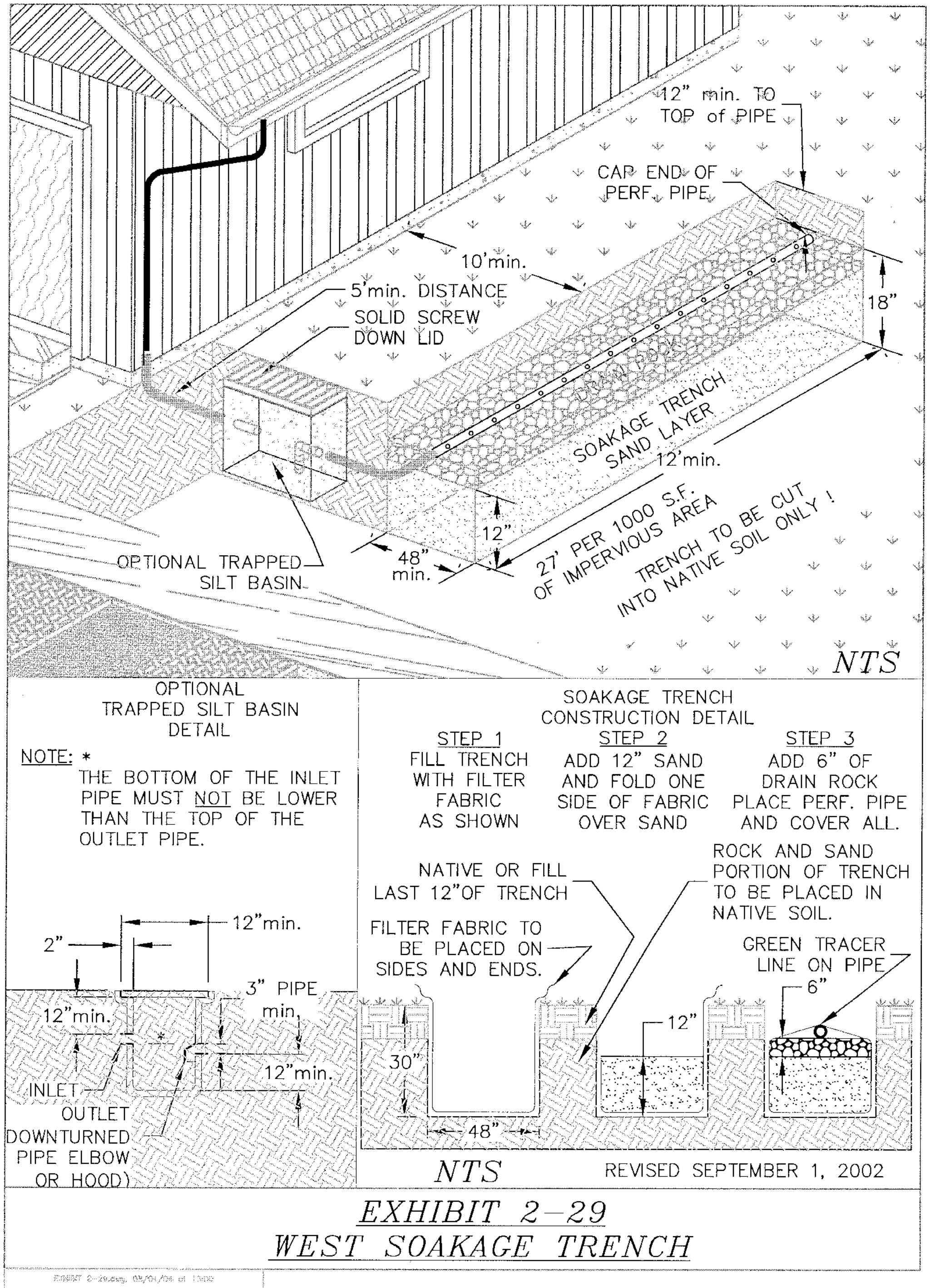
Sieve #	% Passing
3/8	100%
#4	95-100%
#8	80-100%
#16	45-85%
#30	15-60%
#50	3-15%
#100	4% or less

Pipe

- The solid pipe from building or other source to connection with perforated pipe must be installed at a ¼″ per foot slope.
- All piping within 10 feet of building must be sch. 40 ABS, sch. 40 PVC, cast iron, sch. 40 ABS, 3″ sch. 40 PVC or 3″ cast iron pipe may be used for rain drain piping serving not more than 1500 sf of roof or surface area. Use 4″ pipe if area is greater than 1500 sf.
- Pipe must have a minimum cover of 12″ measured from top of pipe to finished grade.
- The pipe within the trench shall either be PVC D2729 or HDPE Leach field pipe.
- The silt trap shall be installed between the dwelling and the sand filter, a minimum of 5′ from the dwelling.

Filter Fabric must be one of the following types/brands: LINQ 125EX; LINQ TYPAR3201; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL.

Private Soakage Trench



Private Soakage Trench

West Side Soakage Trench
Applicable to Areas **West** of the Willamette River

Soakage Trench Sizing
For every 1,000 sf of impervious surface, 27 linear feet of 48″ wide soakage trench is required, with a minimum 13.5-foot long trench. Soakage trenches 13.5 feet long serve a maximum of 500 sf of horizontally projected roof area or other impervious surface.

Trench

- Soakage trench and perforated pipe must be installed level and parallel to contour of finish grade.
- Soakage trench shall be located no closer than 10 feet to any building structure and not closer than 5 feet from property line.
- Unless a separate pollution reduction facility is used upstream of the trench, the sand filter portion of soakage trench must be filled with a minimum of 12″ medium sand meeting OAR 340-71-295 (3)(e).
- Minimum 6″ of ¾″ – 2 ½″ round or crushed rock to cover sand separated by one layer of filter fabric.
- The pipe shall be laid on top of this gravel and covered with filter fabric.
- At least 12″ minimum of backfill shall be placed over the trench.
- All trenches shall be constructed on native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.
- Slope shall not exceed 20% without a stamped and signed geotechnical report addressing slope stability.
- Trench shall not be constructed under current or future impervious surface.

Sand
Medium sand meeting OAR 340-71-295 (3)(e) will be required. Sieve analysis of the medium sand is required to be made by a qualified party and a report provided to City of Portland plumbing inspector at the time of inspection. Analysis to comply with ASTM C136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregate and in conjunction and accordance with ASTM C-117, Standard Test Method for Materials Finer than No.200 Sieve in Mineral Aggregates by Washing.

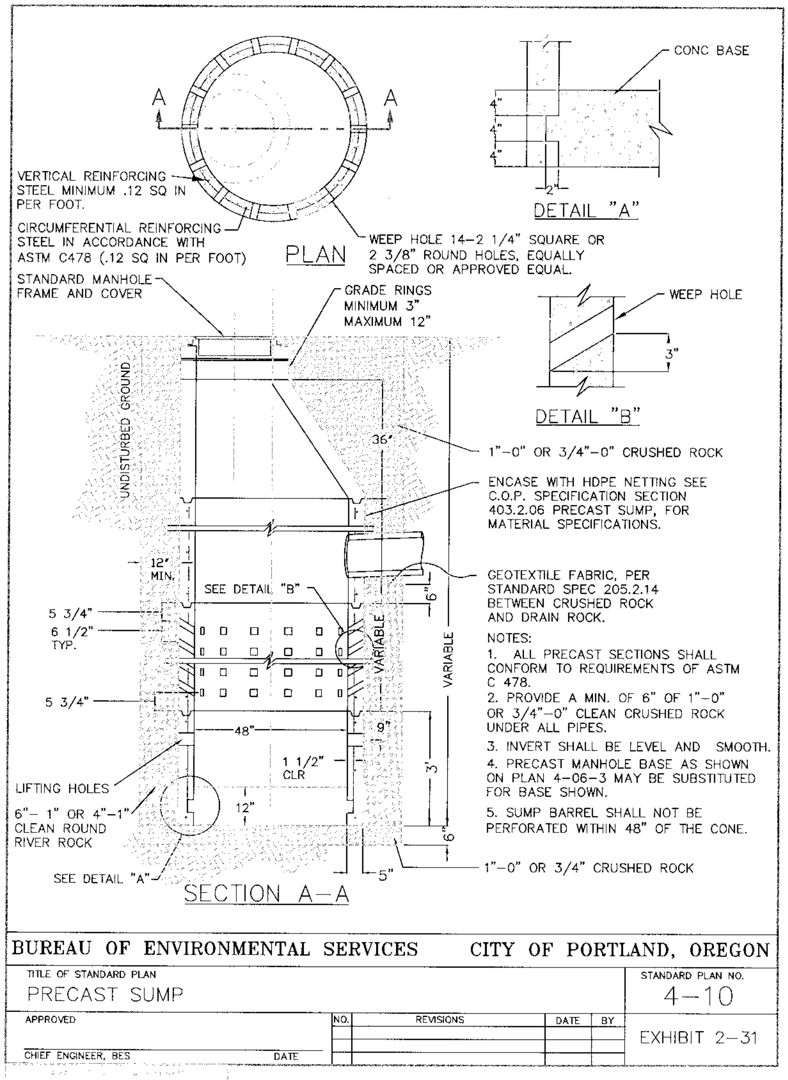
Sieve #	% Passing
3/8	100%
#4	95-100%
#8	80-100%
#16	45-85%
#30	15-60%
#50	3-15%
#100	4% or less

Pipe

- The solid pipe from building or other source to connection with perforated pipe must be installed at a ¼″ per foot slope.
- All piping within 10 feet of building must be sch. 40 ABS, sch. 40 PVC, cast iron, sch. 40 ABS, 3″ sch. 40 PVC or 3″ cast iron pipe may be used for rain drain piping serving not more than 1500 sf of roof or surface area. Use 4″ pipe if area is greater than 1500 sf.
- Pipe must have a minimum cover of 12″ measured from top of pipe to finished grade.
- The pipe within the trench shall either be PVC D2729 or HDPE Leach field pipe.
- The silt trap shall be installed between the dwelling and the sand filter, a minimum of 5′ from the dwelling.

Filter Fabric must be one of the following types/brands: LINQ 125EX; LINQ TYPAR3201; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL.

Public Infiltration Sump System



<u>Stormwater Management Goals Achieved</u> **<u>Acceptable Sizing Methodologies</u>**

√ Pollution Reduction[2]………..……………….. PRES[2]

√ Flow Control……………………..………………… PRES

√ Destination/ Disposal……………………… PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Public infiltration sump systems are used to manage stormwater from public street surfaces. **2)** Pollution reduction credit is only given in low-use (< 1,000 average daily trips) residential scenarios.

Public Infiltration Sump System

PUBLIC INFILTRATION SUMP SYSTEMS

Public infiltration sump systems can be used to provide public street drainage by collecting and recharging stormwater runoff into the ground. The use of sumps is highly dependent on soil type and elevation of the groundwater table.

> **Note:** The Oregon Department of Environmental Quality (DEQ) has identified sumps as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be either authorized by rule or authorized by permit by DEQ. In the case of public infiltration sumps, BES administers the rule authorization process with DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, site controls and pollution reduction facilities are required prior to disposing stormwater into them.
>
> More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**
>
> For technical questions call DEQ- UIC Program at 503-229-5886, and for copies of applications or forms call 503-229-5189.

Sumps are recognized as a disposal method for managing stormwater runoff. Sump systems are excluded from use within the following specific areas and land-use types within the City:

- Columbia South Shore and Cascade Station/ Portland International Center Plan Districts (see **Exhibit 2-33**)
- Major City traffic streets (including district collectors) in combined sewer areas, or neighborhood collectors in commercially zoned areas (Refer to *Transportation Element, Comprehensive Plan,* Office of Transportation, 2000)
- Within 500 feet of municipal or domestic drinking water wells, or a two-year time of travel zone, whichever is greater
- In areas with permanent or seasonally-shallow groundwater (< 40 feet below the ground surface)

A "sump system" (see **Exhibit 2-30**) is the total of all sump components at a single location (e.g., an intersection) and consists of inlets, piping, a sedimentation manhole, and one or more sumps. If one sump lacks adequate capacity to handle the design flow, a second sump may be placed in series with the first to provide additional capacity.

Public Infiltration Sump System

Sedimentation manholes with oil traps receive runoff from inlets before stormwater enters the sumps. The sedimentation manholes settle out most of the large particulate material that can clog sumps' drainage holes, decreasing maintenance needs and increasing long-term effectiveness.

Detailed drawings of a standard sump and standard sedimentation manhole can be found as **Exhibits 2-31** and **2-32** of this manual.

When constructed according to the standard design procedures, the sump system achieves both flow control and some pollution reduction benefits. The sedimentation manhole reduces pollution through removal of sediment, oils, and grease. Additional pollution reduction facilities, such as street swales, planters or filters, must be used in non-residential streets, or streets with over 1,000 average daily trips.

Public Sump System Method of Analysis

- Hydraulic calculations for public sumps shall be performed using the Rational Method. Information on the use and application of the Rational Method is found in BES's *Sewer Design Manual.*

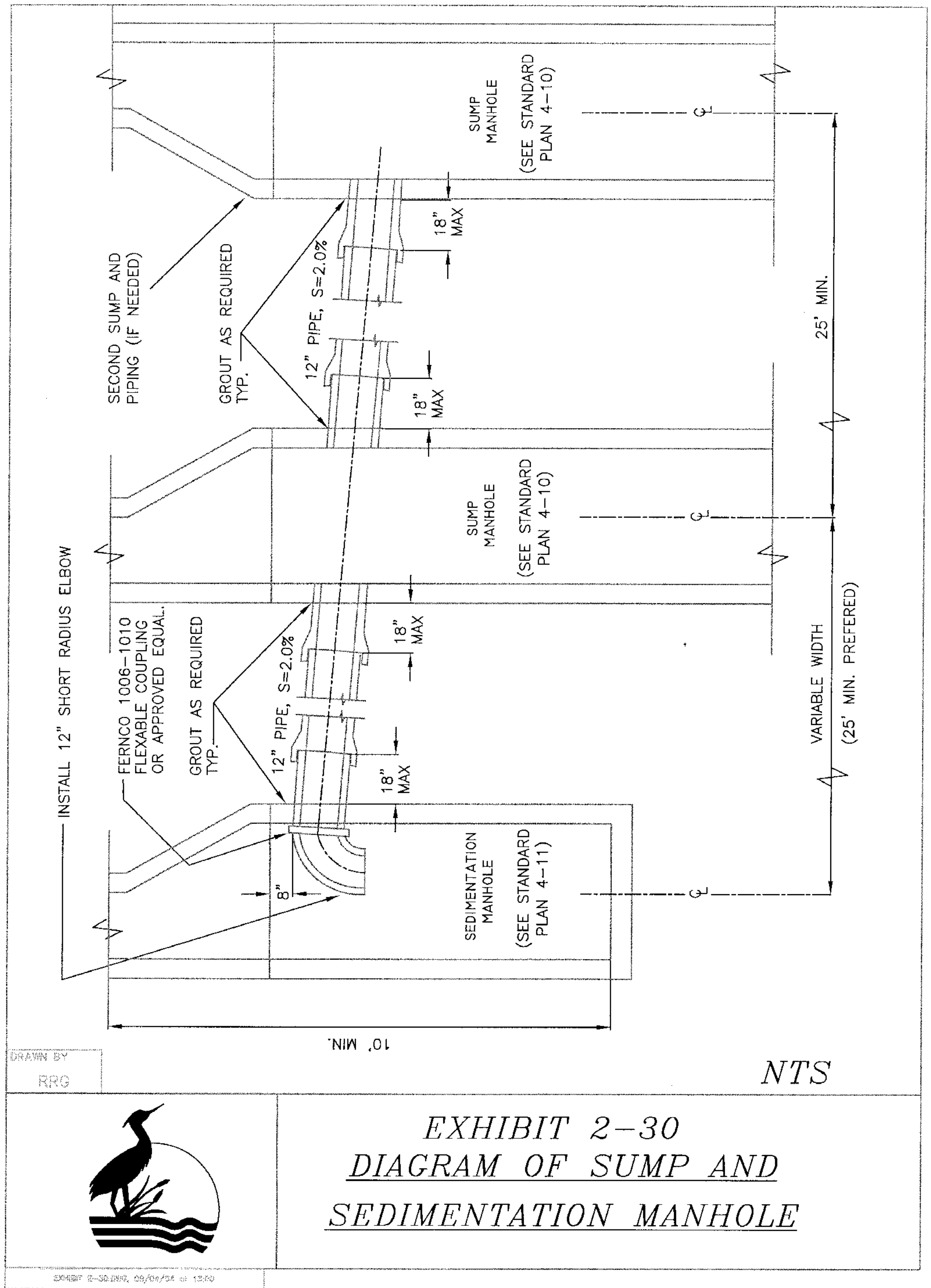
- Sumps shall be designed for a 10-year design storm, with a safety factor of 2.

- The time of concentration for sump design shall be 5 minutes.

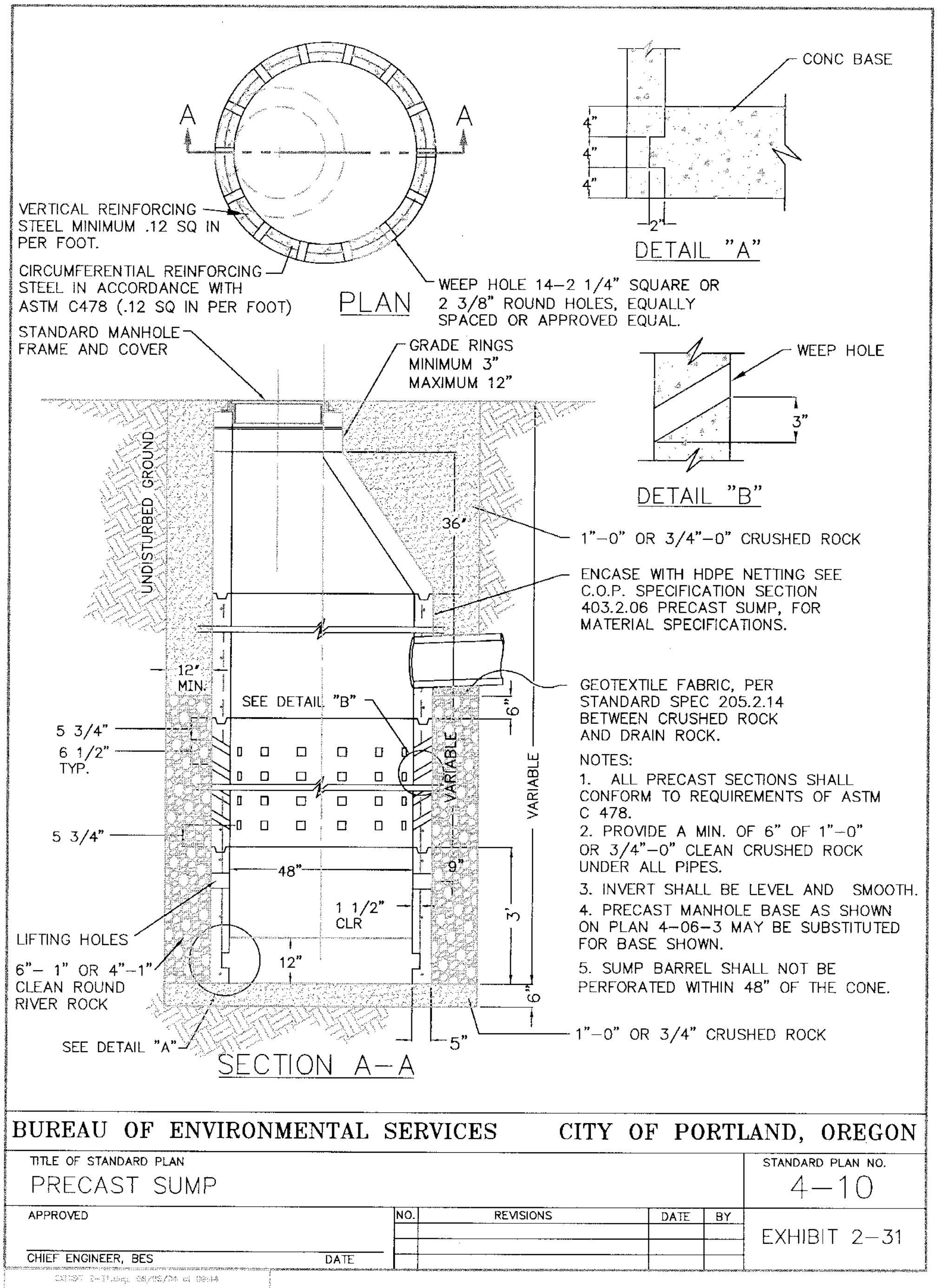
Example: What is the design percolation rate that a sump system must achieve to adequately dispose of runoff from 10,000 square-feet of paved street area?

Rational Formula:	Q=C*I*A
Assume:	Time of concentration = 5 minutes for the street area
Where:	Q= Flow in cubic feet per second C= Runoff Coefficient (0.9 for paved surfaces) I= Intensity (2.86 inches per hour for a 10-year storm event and a time of concentration of 5 minutes) A= Area in acres (10,000 square-feet = 0.23 acres)
	Q= (0.9) * (2.86) * (0.23) = 0.59 cfs
Apply safety factor of 2:	Q= 2 * 0.59 cfs = **1.18 cfs or 530 gallons per minute**

Public Infiltration Sump System



Public Infiltration Sump System



Public Infiltration Sump System

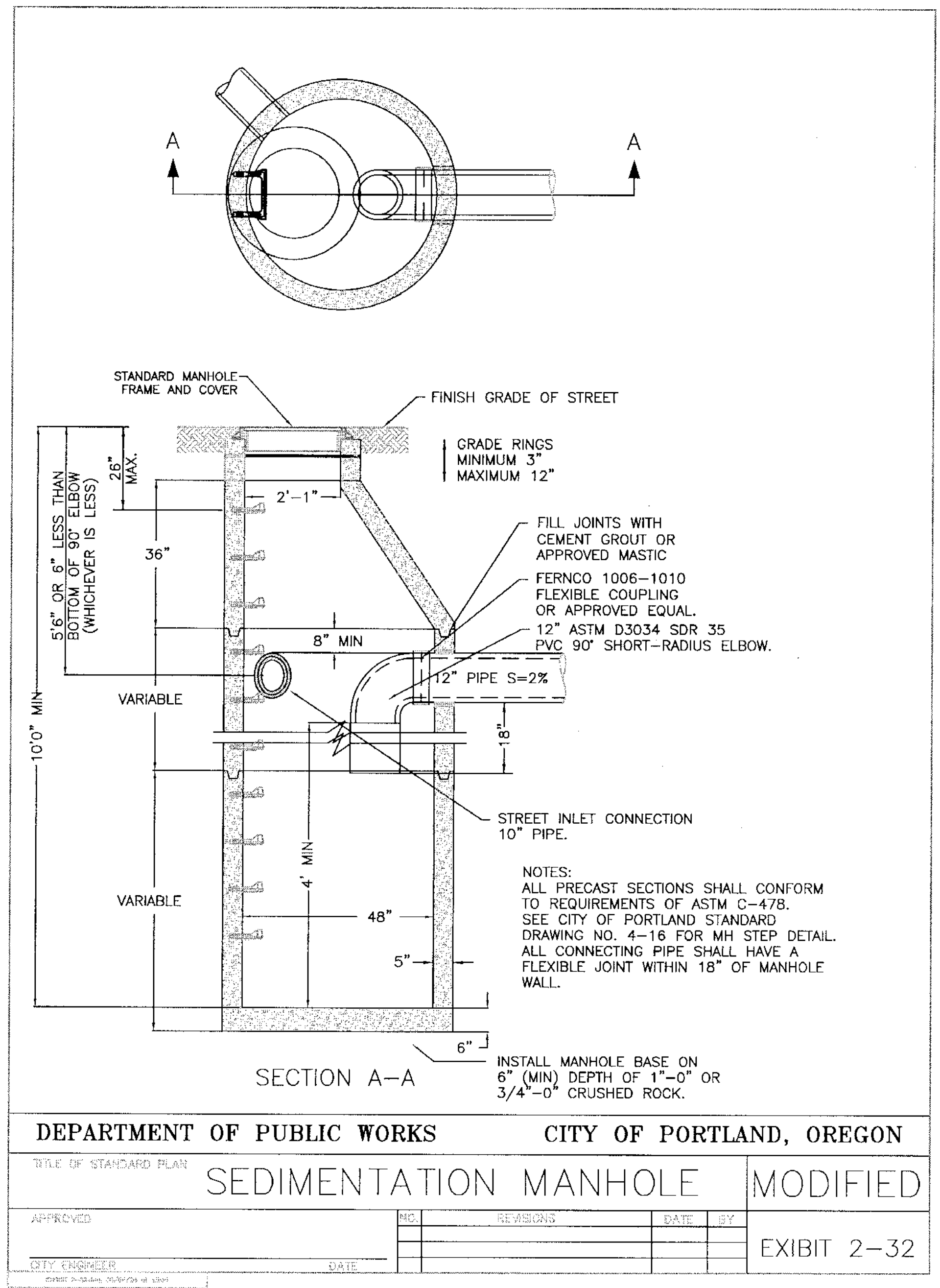
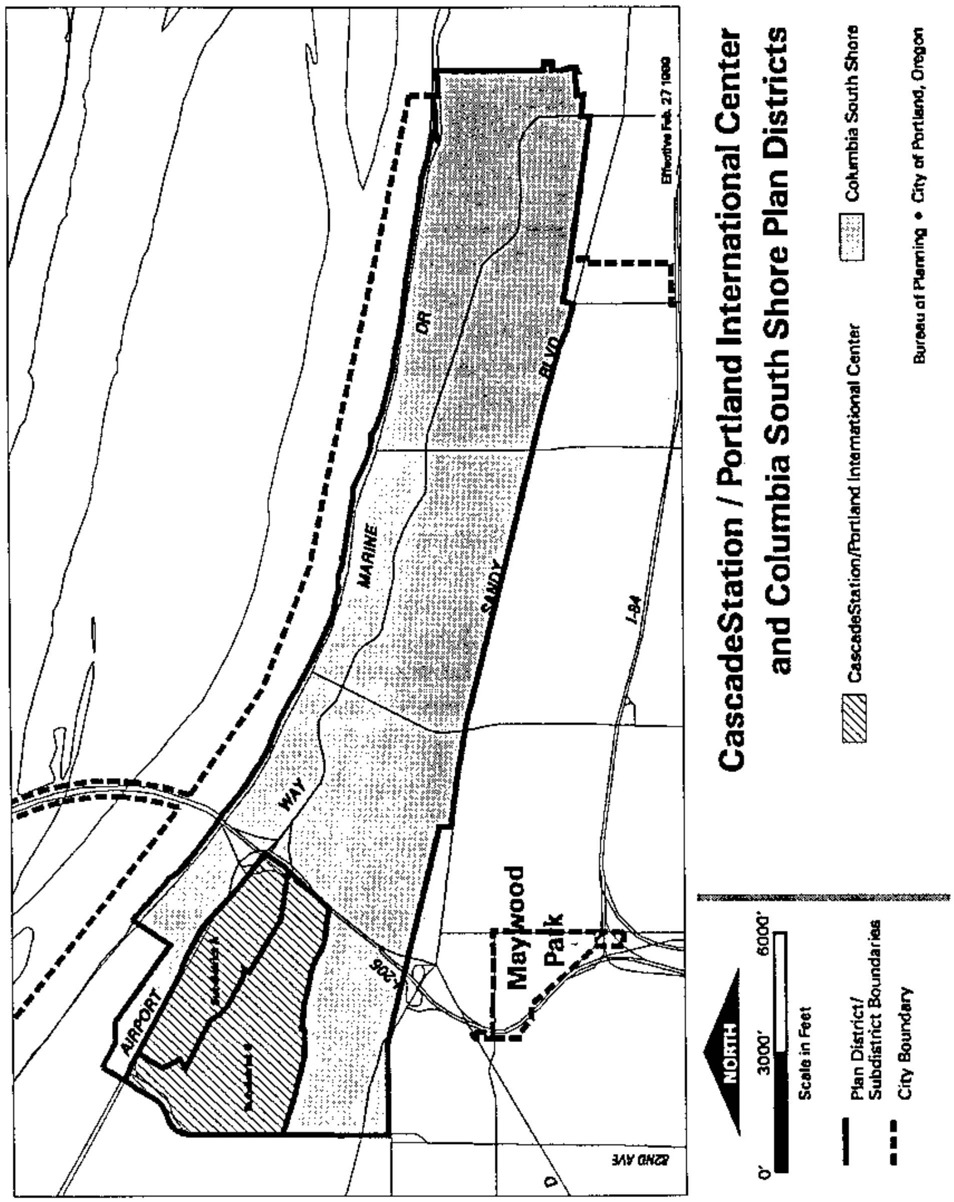


EXHIBIT 2-33
CASCADE STATION/ PORTLAND INTERNATIONAL CENTER AND COLUMBIA SOUTH SHORE PLAN DISTRICTS



Public Infiltration Sump System

Public Sump System Design Requirements

- Public sump systems shall be designed to handle **twice** the flow from the calculated design storm.
- A maximum of two sumps shall be used in series, unless approved by BES.
- The minimum distance between sumps shall be 25 feet.
- The desired distance between the sump and sedimentation manhole is 25 feet. This figure is a guideline and depends on site conditions.
- Sumps shall not be located within 200 feet from the tops of slopes more than 10 feet high and steeper than 2h: 1v.
- The sump depth shall be 30 feet, unless otherwise approved by BES.
- The sedimentation manhole depth shall be 10 feet.
- The diameter of pipe between the sump and sedimentation manhole shall be 12 inches. (Note: The pipe leaving the sedimentation manhole is fitted with a 90-degree short-radius elbow; see **Exhibit 2-32.**)
- See the City of Portland's *Sewer Design Manual* for acceptable pipe material types between the sump and sedimentation manhole.
- Sumps shall not be located in areas with a constant or seasonally high groundwater table, or shallow bedrock. The bottom of the sump shall be at least 10 feet above the seasonal high water table, and at least 3 feet above bedrock.

SUMP TESTING

Soil conditions are critical to the success of sump systems. The use of sumps will not be approved without supporting geotechnical evidence and a documented sump test to demonstrate they will work in the particular area of interest. The geotechnical evidence shall include test sump data to provide information about local underground soil conditions and the potential infiltration capacity of the surrounding soil. Before being accepted by the City, all public sumps shall be tested after construction to ensure they meet or exceed the design capacity. The following sump testing procedure shall be used and must be shown on the construction plans of all public works sump projects:

Public Infiltration Sump System

SUMP NOTES
Design flows reflect a factor of safety of 2.
All sumps shall be tested by the contractor as directed and approved by the city inspector.
Sump testing shall take place after sump construction is complete and before the construction of the sedimentation manhole. Should a sump test fail to verify adequate capacity, an additional sump, constructed in series with the first sump (a maximum of two sumps per system) shall be required, as approved by BES. Should a test of two sumps in series fail to verify adequate capacity, an alternative public stormwater destination shall be required, as approved by BES.
Notify BES inspector, or BES construction office at (503) 823-5728, at least 48 hours before beginning sump testing. A BES representative must be present during all sump capacity tests.
Contractor shall contact the City Water Bureau, or applicable water district, to arrange for sump test water supply. Contractor shall be responsible for obtaining necessary permits, authorization, and any fees.
Contractor may lease sump testing equipment from BES Materials Testing Laboratory, subject to leasing conditions and fees. Contact the laboratory, located at 1405 N River, at (503) 823-2340. Similar testing equipment from any vendor may be used, as approved by BES.
Provide water flow from fire hydrants to sump being tested using 8-inch nominal diameter pipe. Deliver clean potable water to sump. Introduction of sediment is not acceptable and may result in failure of sump capacity test and reconstruction of sump.
Fill sump with water at an initial rate of 300 gallons per minute (gpm) and record water elevation below sump manhole lid, every five minutes. When water surface reaches a constant elevation, increase flow rate to sump to 600 gpm. Record water surface elevations every five minutes. Continue to increase flow rate 300 gpm each time water surface elevation stabilizes, until maximum capacity is reached.
Immediately upon completion of the sump test, provide BES inspector with recorded test data. Contractor shall sign the results and submit to the BES inspector.
The closest fire hydrant for sump testing is located at the intersection of _____________ & ____________. Contact the Water Bureau to apply for a hydrant use permit.

Public Infiltration Sump System

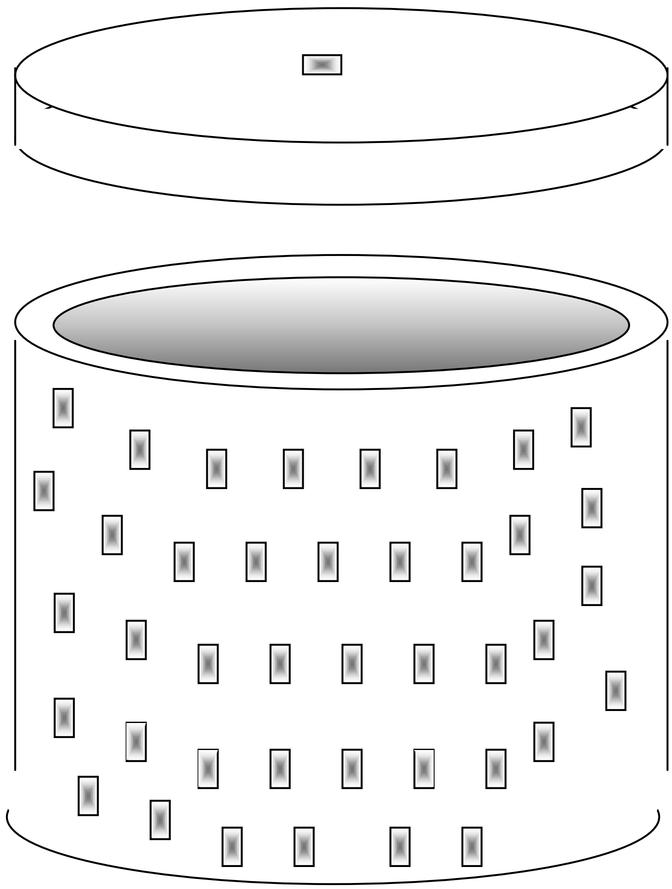
Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Sump and sedimentation manhole location with setbacks to curb, right-of-way lines, and other existing and proposed utilities.
2) Rim and bottom elevation.
3) The sump and sedimentation manhole shall reference the City of Portland standard plan numbers.
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Operations and Maintenance requirements: The applicant or contractor is required to maintain the public infiltration sump system for two years after construction is complete and signed-off by BES. Turbid runoff from construction sites shall not be allowed to enter the system at any time. The sedimentation manhole shall be cleaned prior to BES acceptance of ownership and maintenance.

Private Drywell



Stormwater Management Goals Achieved	**Acceptable Sizing Methodologies**
Pollution Reduction……….………………..	NA
√ Flow Control…………………………………	PRES
√ Destination/ Disposal………………………	PRES

This facility is classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

Notes: 1) Private drywells can be used to manage stormwater from private property.

Private Drywell

Description: Private drywells can be used as stormwater disposal points by collecting and recharging stormwater runoff into the ground. The use of drywells is highly dependent on soil type and elevation of the groundwater table.

> **Note:** DEQ identifies drywells as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of drywells that serve rooftops only. All drywells, with the exception of those that drain residential rooftops only, must be registered with DEQ prior to City permit issuance.
>
> More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**
>
> For technical questions call the DEQ UIC Program at 503-229-5886. For copies of applications or forms call 503-229-5189.

Drywells are recognized as a stormwater disposal point, but they are not intended to be used to meet pollution reduction requirements. Unless a drywell used exclusively for roof runoff, pollution reduction facilities must be used to receive runoff before it enters the drywell. If used for residential streets with less than 1,000 average daily trips, or non-vehicular access areas such as pedestrian plazas, a spill control manhole per **Exhibit 2-26** may be used to meet pollution reduction requirements.

Drywell systems are prohibited from use within the Columbia South Shore and Cascade Station/ Portland International Center Plan Districts (see **Exhibit 2-33**). Drywells are also prohibited where permanent or seasonally shallow groundwater will exist within 10 feet of the bottom of the drywell.

Private Drywell Design and Sizing Method

Soil conditions are critical to the success of drywells. Because of this, the use of drywells must be pre-approved by the Environmental Soils section of BDS. Supporting geotechnical evidence and a documented drywell test may be required to demonstrate that drywells will work in the project area. Drywells shall not be located in areas with a constant or seasonally high groundwater table.

Private Drywell

Exhibit 2-34 shall be used to design private drywells, after BDS approval has been given. To use this chart, the impervious surface area flowing to the proposed drywell must be known. The gray boxes corresponding to combinations of drywell diameter and depth may be used. Any other combinations of drywell diameter and depth will need to be pre-approved by BDS, and drywell testing may be required in accordance with the drywell testing procedure below.

> **Note:** Developers should refer to OAR 340, Division 44, "Construction and Use of Waste Disposal Wells or Other Underground Injection Activities" for additional design and regulatory requirements.

Drywell Testing Procedure

Equipment Needed:

- Water supply capable of filling drywell
- 25-foot tape measure
- Stopwatch
- Flashlight

Procedure: In the presence of a City Building Inspector:

1) Place the measuring tape against drywell wall, measuring to the bottom of drywell. Secure in place for the duration of the test.

2) Fill the drywell with clean potable water. Document water level before starting stopwatch.

3) Shut off water supply and start stopwatch.

4) Stop stopwatch when water level has dropped by 5 feet. Document this elapsed time.

5) Compare this time to the "Maximum Time in Minutes for Water to Drop by 5 feet in Drywell" from **Table B of Exhibit 2-35**. The diameter of the drywell and square footage of impervious site area that will flow into the drywell must be known to determine drawdown time.

   If the elapsed time is less than the time shown on the chart, one (1) drywell is sufficient. If the elapsed time is greater than the time shown on the chart, divide the elapsed time by the chart time and round to the nearest whole number. This is the number of drywells that will be required.

Private Drywell

Exhibit 2-34: Drywell Sizing

Once approval has been given by BDS for on-site infiltration of stormwater, the following chart shall be used to select the number and size of drywells.

Impervious Area (sq-ft)	28" Diameter				48" Diameter				60" Diameter			
	Drywell Depth				Drywell Depth				Drywell Depth			
	5'	10'	15'	20'	5'	10'	15'	20'	5'	10'	15'	20'
1000												
2000												
3000												
4000												
5000												
6000												
7000												
8000												
9000												
10000												
11000												
12000												
13000												
14000												
15000												
16000												
17000												
18000												
19000												
20000												

Private Drywell

Exhibit 2-35: Drywell Testing

Table A: Minimum Infiltration Rate Required in Gallons per Minute

Impervious Area (sq-ft)	28" Diameter				48" Diameter				60" Diameter			
	Drywell Depth				Drywell Depth				Drywell Depth			
	5'	10'	15'	20'	5'	10'	15'	20'	5'	10'	15'	20'
1000	53	53	53	53	53	53	53	53	53	53	53	53
2000	106	106	106	106	106	106	106	106	106	106	106	106
3000	159	159	159	159	159	159	159	159	159	159	159	159
4000	212	212	212	212	212	212	212	212	212	212	212	212
5000	265	265	265	265	265	265	265	265	265	265	265	265
6000	318	318	318	318	318	318	318	318	318	318	318	318
7000	371	371	371	371	371	371	371	371	371	371	371	371
8000	424	424	424	424	424	424	424	424	424	424	424	424
9000	477	477	477	477	477	477	477	477	477	477	477	477
10000	530	530	530	530	530	530	530	530	530	530	530	530
11000	583	583	583	583	583	583	583	583	583	583	583	583
12000	636	636	636	636	636	636	636	636	636	636	636	636
13000	689	689	689	689	689	689	689	689	689	689	689	689
14000	742	742	742	742	742	742	742	742	742	742	742	742
15000	795	795	795	795	795	795	795	795	795	795	795	795
16000	848	848	848	848	848	848	848	848	848	848	848	848
17000	901	901	901	901	901	901	901	901	901	901	901	901
18000	954	954	954	954	954	954	954	954	954	954	954	954
19000	1007	1007	1007	1007	1007	1007	1007	1007	1007	1007	1007	1007
20000	1060	1060	1060	1060	1060	1060	1060	1060	1060	1060	1060	1060

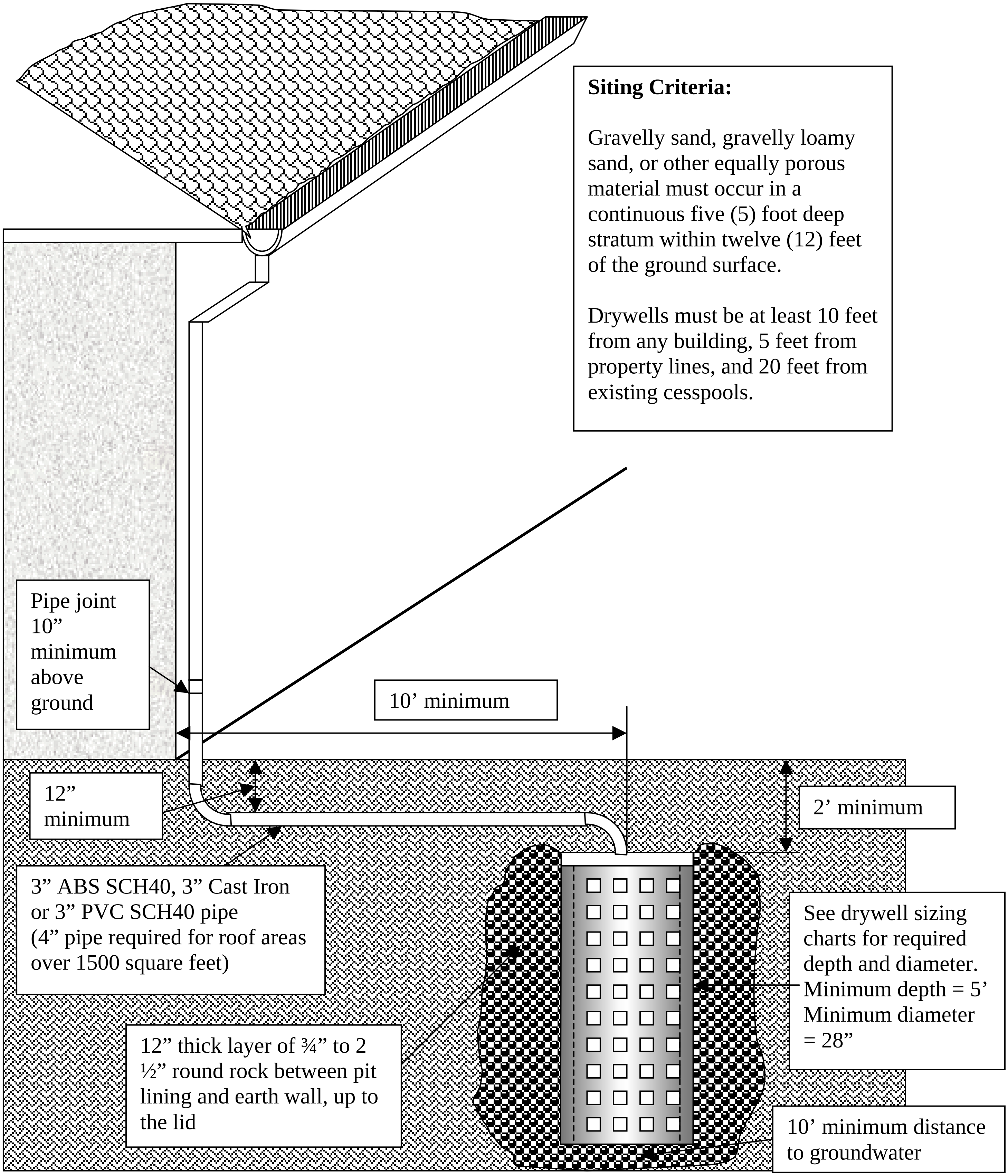
Table B: Maximum Time in Seconds for Water to Drop by 5 feet in Drywell

Impervious Area (sq-ft)	28" Diameter				48" Diameter				60" Diameter			
	Drywell Depth				Drywell Depth				Drywell Depth			
	5'	10'	15'	20'	5'	10'	15'	20'	5'	10'	15'	20'
1000	180	180	180	180	534	534	534	534	828	828	828	828
2000	90	90	90	90	270	270	270	270	414	414	414	414
3000	60	60	60	60	180	180	180	180	276	276	276	276
4000	48	48	48	48	132	132	132	132	210	210	210	210
5000	36	36	36	36	108	108	108	108	168	168	168	168
6000	30	30	30	30	90	90	90	90	138	138	138	138
7000	24	24	24	24	78	78	78	78	120	120	120	120
8000	24	24	24	24	66	66	66	66	102	102	102	102
9000	18	18	18	18	60	60	60	60	90	90	90	90
10000	18	18	18	18	54	54	54	54	84	84	84	84
11000	18	18	18	18	48	48	48	48	78	78	78	78
12000	18	18	18	18	42	42	42	42	72	72	72	72
13000	12	12	12	12	42	42	42	42	66	66	66	66
14000	12	12	12	12	36	36	36	36	60	60	60	60
15000	12	12	12	12	36	36	36	36	54	54	54	54
16000	12	12	12	12	36	36	36	36	54	54	54	54
17000	12	12	12	12	30	30	30	30	48	48	48	48
18000	12	12	12	12	30	30	30	30	48	48	48	48
19000	12	12	12	12	30	30	30	30	42	42	42	42
20000	12	12	12	12	24	24	24	24	42	42	42	42

(Rational Method, Safety Factor of 2)

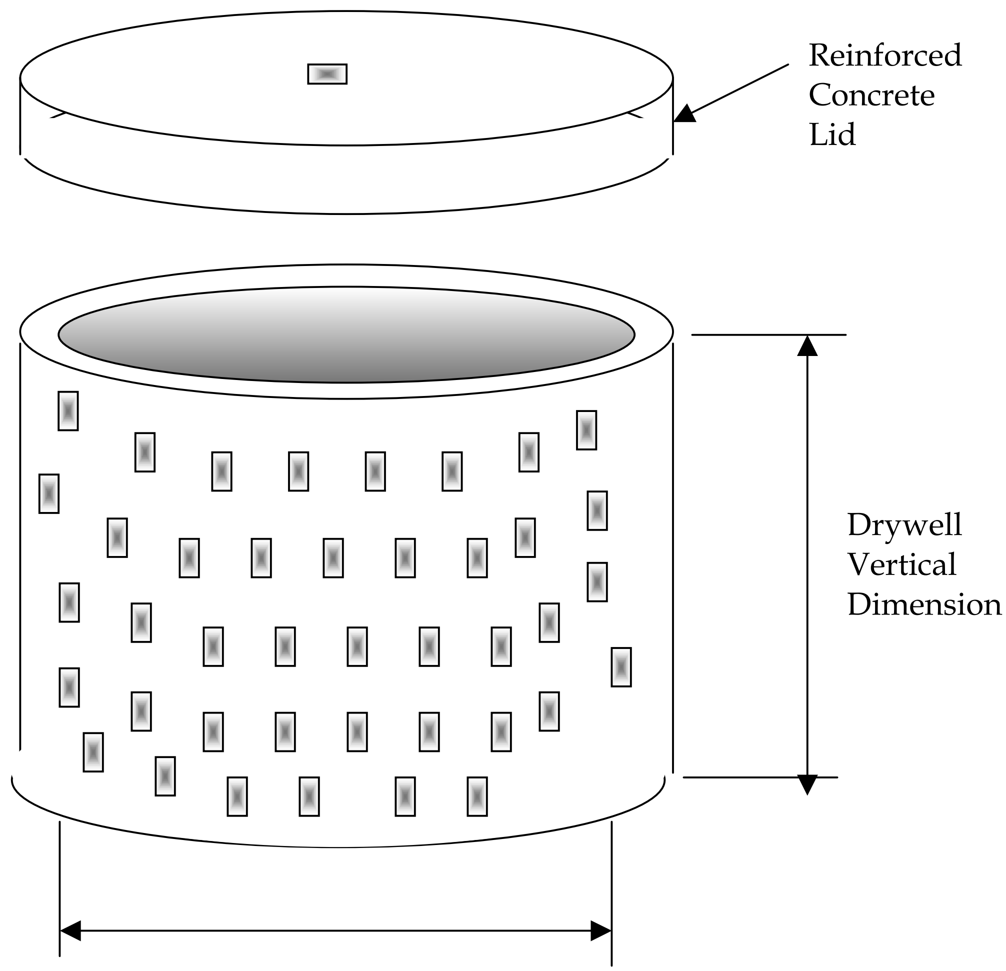
Private Drywell

Exhibit 2-36: Private Reinforced Concrete Drywell Typical Configuration



Private Drywell

Exhibit 2-37: Typical Private Drywell:



Inside Diameter

Private Drywell

Checklist of minimal information to be shown on the permit drawings:

(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1) Facility location with setbacks from property lines and structures.
2) Depth and diameter of drywell.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Inspection requirements and schedule: The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

Facility Component	Inspection Requirement
Drywell excavation	
Piping	Call for inspection
Drywell installation & backfill	Cal for inspection

Operations and Maintenance requirements: See **Chapter 3.0**.

*** Link to drywell O&M form**

Chapter 3.0
OPERATIONS & MAINTENANCE

Summary of Chapter 3.0

This chapter presents operation and maintenance (O&M) requirements for the stormwater management facilities in this manual. It includes:

3.1 Applicability of O&M requirements
3.2 O&M submittal requirements
  3.2.1 for private facilities
  3.2.2 for public facilities
3.3 O&M Plan Enforcement

- **Form O&M**
- **Example of Form O&M**
- **Inspection Log Sample**
- **Facility-specific O&M plans**

To Use This Chapter:

1) After using **Chapters 1.0** and **2.0** to complete a stormwater management design for the project, fill out **Form O&M**.
2) Form O&M includes a blank section to insert a **site plan**, or attach a separate site plan sheet showing the location of the stormwater management facilities on the site, sources of stormwater runoff, and ultimate stormwater disposal point.
3) For **private** facilities: Record a copy of **Form O&M** and the **site plan** with the applicable county Department of Assessment and Taxation.
4) Submit a recorded copy of these sheets, along with the **facility-specific O&M plan** for each stormwater management facility used on-site, with the permit application. The O&M activities listed on the facility-specific O&M forms, which will be on file with BES, may later be revised with BES approval.
5) For **public** facilities: Submit a copy of an O&M plan with the public works permit application. County recording of this plan is not necessary.

Note: Enforcement rules regarding the inspection, operations, and maintenance of stormwater management facilities can be found in the *BES Enforcement Administrative Rules*, not included in this manual. Contact Dawn Hottenroth at 503-823-7767 for a copy of this document.

3.1 APPLICABILITY

The operations and maintenance (O&M) requirements in this chapter apply to:

- All stormwater management facilities and related facility components identified in **Chapter 2.0**.

  Exceptions: 1) Developments treating less than 1,000 square-feet of impervious surface with new trees do not need to submit or record O&M plans for the new trees used as simplified approaches.

  2) O&M plans do not need to be submitted for existing tree canopy.

- City personnel are responsible for the operations and maintenance of capital improvement projects. These CIP projects may or may not include requirements for maintenance in the contract specifications when contractors are hired to perform work.

This chapter provides a **facility-specific O&M plan** that identifies the O&M requirements for each type of facility included in this manual. If a stormwater facility that is not included in this manual is used (such as a manufactured stormwater treatment technology) it is still necessary to prepare and submit an O&M plan, along with facility-specific O&M activities that complies with the requirements of this chapter.

3.2 O&M SUBMITTAL REQUIREMENTS

3.2.1 Requirements for Privately Maintained Facilities

Form O&M: Operations & Maintenance Plan (see page 3-6) identifies the owner's name, address, and phone number, the site address, financial method used to cover future operation and maintenance, and parties responsible for inspecting and maintaining the facility. It also provides a space to insert a site plan to identify the location of the facility on the site, sources of runoff entering the facility, and ultimate stormwater disposal point. This form must be included with every private stormwater management facility permit application, and must be recorded with the applicable county before permit issuance.

Facility-specific O&M plans (see page 3-9 through 3-32) identify the specific O&M activities that are required for each type of stormwater management facility. The appropriate plans must be attached to **Form O&M** and submitted as part of the stormwater management facility permit application. The facility-specific O&M plans do not have to be recorded with the county. This allows the future stormwater management facility owner to revise O&M activities, with BES approval, without the need to re-record the O&M plan with the county.

The facility-specific O&M activities for private facilities may be modified any time after permit issuance. This is optional, and is intended to give the owner an opportunity to adjust maintenance needs according to site-specific history and conditions. Proposed modifications to the O&M plan must be submitted to BES for review and approval.

City Code requires an **Inspection and Maintenance Log** to be kept by facility owners. In general, the log should note all inspection dates, the facility components that were inspected, and any maintenance or repairs made. The facility-specific O&M plans can serve as a checklist for what should be included in the log (e.g. the facility elements that need to be inspected, frequency of inspection, conditions that indicate maintenance is needed, etc.). See page 3-8 for an **inspection and maintenance log sample**.

3.2.2 Requirements for City-Maintained Facilities

A stormwater management facility that receives stormwater runoff from a public right-of-way shall become a public (City-maintained) facility unless the right-of-way is not part of the City's road maintenance system. Facilities that will become City-maintained must be constructed under a public works permit.

For facilities built under a public works permit a preliminary O&M plan shall be submitted before construction, as part of the applicant's public works permit application package. **Form O&M** and **facility-specific O&M plans** may be used to serve as the O&M plan. In addition, the applicant shall demonstrate on the public works plans that the City can achieve the specified O&M activities. This may involve the construction of maintenance access roads and the dedication of public access easements.

Contractors building facilities under a public works permit are responsible for maintaining all site stormwater management features, including their associated vegetative components, during a 2-year maintenance warranty period.

At the end of this period, BES requires a modified O&M plan for all site features, based on experience with the site over the 2 years**.** Final facility sign-off will not be given until the modified O&M plan has been submitted. Contractors working directly for the City shall follow the specifications in their contracts.

3.3 O&M PLAN ENFORCEMENT

City code Chapter 17.38 requires that all stormwater management facilities, constructed to comply with the requirements of this manual, must be properly operated and maintained for the life of the facility. City staff has the right and responsibility to inspect facilities to assure they are being properly operated and maintained. It is the intent of BES to use education and technical assistance to ensure the proper O&M of private facilities. Administrative rules and procedures regarding BES inspection and enforcement activities for assurance of proper O&M can be found in the BES Enforcement Administrative Rules package, not included in this manual. For a copy of this document, contact Dawn Hottenroth at 503-823-7767.

FORM O&M: OPERATIONS & MAINTENANCE PLAN INSTRUCTIONS

The following are instructions to prepare and file Form O&M: Operations & Maintenance Plan for a stormwater management facility.

City of Portland Code Section 17.38.040 states that "All new development, redevelopment, plats, site plans, building permits or public works projects, as a condition of approval, shall be required to submit an operation and maintenance plan for the required stormwater quality and quantity control facilities for review and approval by the Bureau of Environmental Services."

Failure to properly operate or maintain the water quality or quantity control facility according to the operation and maintenance plan may result in a civil penalty, as specified in 17.38.045: Enforcement.

A copy of the operation and maintenance plan shall be filed with the Bureau of Environmental Services. Completed O&M Plans shall be submitted to:

Document Services
1900 SW Fourth Ave., Suite 5000
Portland, OR 97201

The operation and maintenance plan shall be recorded and filed with the appropriate county Department of Assessment and Taxation. The O&M plan must be recorded in the county where the property site is located. Form O&M with a site plan must be recorded. Additional plans of the facility and facility-specific O&M activities will be retained at the Portland Building – 1200 SW 5th Avenue, Room 1000.

Before recording the O&M plan, the applicant shall sign the form, and the signature shall be notarized. When completed accurately, this form meets the recording requirements in Multnomah, Clackamas, and Washington Counties. The notarized O&M plan may be submitted in person or mailed, along with payment of the applicable fees, to the appropriate county. Each county provides a web site and telephone number with recorded information to answer commonly asked questions about the recording procedures.

County Recorder's Office Addresses and Fees
(as of June 2001)

Multnomah
Multnomah County Recorder
Room 158
501 SE Hawthorne St.
Portland, OR 97214
Http://www.co.multnomah.or.us/at/services.html
Phone: 503-988-3326
$19 first page, $5 each additional page

Washington
Washington County Recording Office
155 N. First Ave.
Suite 130, MS 9
Hillsboro, OR 97124
Http://www.co.washington.or.us/deptmts/at/recordng/record.htm
Phone: 503-846-8751
$22 first page, $5 each additional page

Clackamas
Clackamas County Recording Division
104 11th St.
Oregon City, OR 97045
Http://www.co.clackamas.or.us/recording/legible.htm
Phone: 503-655-8661
$26 first page, $5 each additional page

FORM O&M: OPERATIONS & MAINTENANCE PLAN

INSTRUCTIONS (PAGE 2)

1: Fill out Form O&M (Page 3-6)

Project building application number: City staff will insert this number.

Owner: Print the name of the property owner.

Phone no.: Print the area code and 7-digit phone number of the property owner.

Mailing address: Print the property owner's mailing address, including zip code. After the plan is recorded with the county recorder's office, a copy of the recorded O&M Plan will be mailed to this address. The City will also use this address if further correspondence is required.

Site address: Print the address of the property where the stormwater management facility is located.

Site legal description: Print the property's legal description. Property legal descriptions may be obtained from the county assessor's office.

Signature: Sign the O&M plan form under "filer" in the presence of a notary.

Site plan: Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), the sources of runoff entering the stormwater facility, and where stormwater will be discharged to after leaving the facility. The site plan can be inserted on Form O&M or included as a separate sheet.

Description of the financial method used to cover future operations and maintenance:
Check the appropriate box.

Party (ies) responsible for maintenance:
Provide the name, address, and phone number (both daytime and after-hours numbers) for the person or company who shall be responsible for maintaining or directly supervising the maintenance of the stormwater facilities described in the O&M Plan.

Maintenance practices and schedule for the stormwater management facility:
Provide the date the O&M Plan was prepared, the date the plan was revised (if applicable), and the month and year of the stormwater management facility installation. Provide the name, firm (if applicable), and address of the person who prepared the O&M Plan.

FORM O&M: OPERATIONS & MAINTENANCE PLAN

REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

Project Building Application No.	*For official county use only*
Owner's Name **Phone No.** (area code required) **(_______) _______ - ___________**	
Mailing Address (RETURN ADDRESS FOR RECORDER**)**	
Site Address	
Site Legal Description	

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

____

Filer

NOTARIZATION: GIVEN under my hand and official seal
this ________ day of ____________________ , ___________.

Notary Public in and for the State of Oregon:

My Appointment Expires on:

O&M PLAN REQUIRED INFORMATION:

1) Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility.

The stormwater management facility located on this site plan is a required condition of building permit approval for the identified property. The owner of the identified property is required to operate and maintain this facility in accordance with the O&M plan on file with the City of Portland, Bureau of Environmental Services. The requirement to operate and maintain this facility in accordance with the on-file O&M plan is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the Bureau of Environmental Services. The O&M plan for this facility is available at the Bureau of Environmental Services, located at 1120 SW 5th Avenue, Room 1000, Portland, Oregon, between the hours of 8 a.m. and 5 p.m., Monday through Friday. Call (503) 823-7761 for assistance.

Site Plan (insert here or include separate sheet):

2) Description of the financial method used to cover future operations and maintenance. ***Check One:***

❑ Homeowner Association ❑ Property Owner Account ❑ Other (*describe*)____

3) Party (ies) responsible for maintenance (only if other than owner).

Daytime Phone No. (area code required)(_____) ______ - ______	Emergency/After-Hours Contact Phone No. (_____) _____ - _______
Maintenance Contact & Address	

4) Maintenance practices and schedule for the stormwater facility is included in the facility-specific O&M plan filed with the Bureau of Environmental Services, City of Portland. The operation and maintenance practices are based on the publication date of the City of Portland's Stormwater Management Manual.

Preparation Date _____ / ____ / _______	Revision Date ______ / ____ / _______	Estimated Date of Installation *(month/year)* ___ / ___

Prepared By____

FORM O&M: OPERATIONS & MAINTENANCE PLAN (Example)

REQUIRED IN ACCORDANCE WITH CITY CODE CHAPTER 17.38

Project Building Application No.	*For official county use only*
Owner's Name John Doe **Phone No.** (area code required) (_503_) _555_ - _5555__	
Mailing Address (RETURN ADDRESS FOR RECORDER) **XXX NW XXX Street, Portland, OR XXXXX**	
Site Address **XXX NW XXX Street, Portland, OR XXXXX**	
Site Legal Description **Section XX, Township XX, Range XX, Tax Lot XX**	

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

John Doe
____
Filer

NOTARIZATION: GIVEN under my hand and official seal

this ________ day of ____________________ , ___________.

Notary Public in and for the State of Oregon:

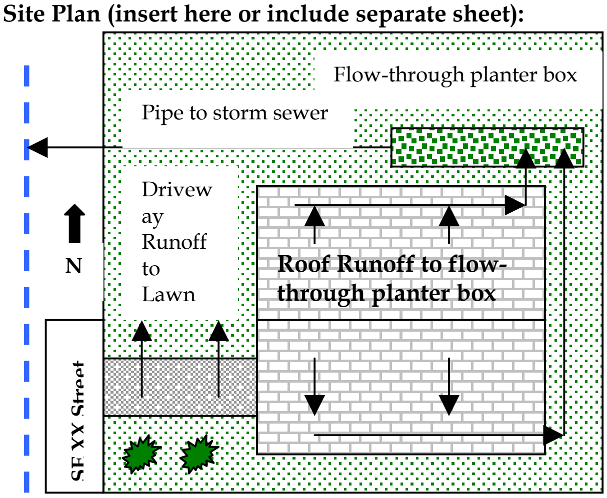
My Appointment Expires on:

O&M PLAN REQUIRED INFORMATION:

1) Site Plan. Include a site plan showing the facility location (in relation to building structures or other permanent monuments on the site), sources of runoff entering the facility, and where stormwater will be discharged to after leaving the facility.

The stormwater management facility located on this site plan is a required condition of building permit approval for the identified property. The owner of the identified property is required to operate and maintain this facility in accordance with the O&M plan on file with the City of Portland, Bureau of Environmental Services. The requirement to operate and maintain this facility in accordance with the on-file O&M plan is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the Bureau of Environmental Services. The O&M plan for this facility is available at the Bureau of Environmental Services, located at 1120 SW 5th Avenue, Room 1000, Portland, Oregon, between the hours of 8 a.m. and 5 p.m., Monday through Friday. Call (503) 823-7761 for assistance.

Site Plan (insert here or include separate sheet):



2) Description of the financial method used to cover future operations and maintenance. ***Check One:***

❑ Homeowner Association   X Property Owner Account   ❑ Other *(describe)*________________________________

3) Party (ies) responsible for maintenance (only if other than owner). **Owner Responsible**

Daytime Phone No. (area code required) **(503) xxx--xxxx**	Emergency/After-Hours Contact Phone No. **(503) xxx-xxxx**

Maintenance Contact & Address **Garden Guy Landscaping XXX NE XX Street Portland, OR 97XXX**

4) Maintenance practices and schedule for the stormwater facility is included in the facility-specific O&M plan filed with the Bureau of Environmental Services, City of Portland. The operation and maintenance practices are based on the publication date of the City of Portland's Stormwater Management Manual.

Preparation Date **XX/ XX /200X**	Revision Date ______ / ____ / ________	Estimated Date of Installation *(month/year)* **XX /XXXX**

Prepared By **John Doe**____

STORMWATER MANAGEMENT FACILITY INSPECTION & MAINTENANCE LOG (SAMPLE)

Property Address:

Inspection Date:

Inspection Time:

Inspected By:

Approximate Date/Time of Last Rainfall:

Type of Stormwater Management Facility:

Location of Facility on Site (In relation to buildings or other permanent structures):

Water levels and observations (Oil sheen, smell, turbidity, etc.):

Sediment accumulation & record of sediment removal:

Condition of vegetation (Height, survival rates, invasive species present, etc.) & record of replacement and management (mowing, weeding, etc.):

Condition of physical properties such as inlets, outlets, piping, fences, irrigation facilities, and side slopes. Record damaged items and replacement activities:

Presence of insects or vectors. Record control activities:

Identify safety hazards present. Record resolution activities:

FACILITY-SPECIFIC OPERATIONS AND MAINTENANCE PLANS

Ecoroofs and Roof Gardens

Operations & Maintenance Plan

Ecoroofs and Roof Gardens are vegetated roof systems that retain and filter stormwater and provide aesthetic and energy conservation benefits. All facility components, including soil substrate or growth medium, vegetation, drains, irrigation systems (if applicable), membranes, and roof structure shall be inspected for proper operations, integrity of the waterproofing, and structural stability throughout the life of the ecoroof or roof garden. All elements shall be inspected once a month from April through September. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Soil Substrate/ Growing Medium shall be inspected for evidence of erosion from wind or water.

- If erosion channels are evident, they shall be stabilized with additional soil substrate/growth medium and covered with additional plants.

Ecoroof System Structural Components shall be operated and maintained in accordance with manufacturer's requirements. Drain Inlets shall be kept unrestricted.

- Inlet pipe shall be cleared when soil substrate, vegetation, debris or other materials clog the drain inlet. Sources of sediment and debris shall be identified and corrected.
- Determine if drain inlet pipe is in good condition and correct as needed.

Debris and Litter shall be removed to prevent clogging of inlet drains and interference with plant growth.

Vegetation shall be maintained to provide 90% plant cover.

- During the Establishment Period, plants shall be replaced once per month as needed. During the long-term period, dead plants shall generally be replaced once per year in the fall months.
- Fallen leaves and debris from deciduous plant foliage shall be removed.
- Nuisance and prohibited vegetation from the Portland Plant List shall be removed when discovered.
- Dead vegetation shall be removed and replaced with new plants.
- Weeding shall be manual with no herbicides or pesticides used. Weeds shall be removed regularly and not allowed to accumulate.
- Fertilization is not necessary and fertilizers shall not be applied.
- During drought conditions, mulch or shade cloth may be applied to prevent excess solar damage and water loss.
- Mowing of grasses shall occur as needed. Clippings shall be removed.

Irrigation can be accomplished either through hand watering or automatic sprinkler systems. If automatic sprinklers are used, manufacturers' instructions for operations and maintenance shall be followed.

- During the Establishment Period (1-3 years), water sufficient to assure plant establishment and not to exceed ¼ inch of water once every 3 days shall be applied.
- During the long-term period (3+ years), water sufficient to maintain plant cover and not to exceed ¼ inch of water once every 14 days shall be applied.

Spill Prevention measures from mechanical systems located on roofs shall be exercised when handling substances that can contaminate stormwater.

- Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining ecoroofs shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access and Safety to the ecoroof shall be safe and efficient.

- Egress and ingress routes shall be maintained to design standards. Walkways shall be clear of obstructions and maintained to design standards.

Aesthetics of the ecoroof shall be maintained as an asset to the property owner and community.

- Evidence of damage or vandalism shall be repaired and accumulation of trash or debris shall be removed upon discovery.

Insects shall not be harbored at the ecoroof.

- Standing water creating an environment for development of insect larvae shall be eliminated by manual means. Chemical sprays shall not be used.

Contained Planters

Operations & Maintenance Plan

Contained planters are designed to intercept rainfall that would normally fall on impervious surfaces. In this respect contained planters convert impervious surfaces to pervious ones, decreasing the amount of stormwater runoff from a site. Water should drain through the planter within 3-4 hours after a storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation and 2 times per year thereafter. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Filter Media consisting of sand or topsoil shall allow stormwater to percolate uniformly through the planter.

- The planter shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates.
- Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged.
- Litter and debris shall be removed routinely (e.g., no less than quarterly) and upon discovery.

Planter shall contain filter media and vegetation.

- Structural deficiencies in the planter including rot, cracks, and failure shall be repaired.

Planter Reservoir receives and detains storm water prior to infiltration. If water does not drain from reservoir within 3-4 hours of storm event, sources of clogging shall be identified and corrected. Topsoil may need to be amended with sand or replaced all together.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- Mulch shall be replenished at least annually.
- Planter vegetation shall be irrigated to ensure survival.
- Vegetation, large shrubs or trees that limit access or interfere with planter operation shall be pruned or removed.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance and prohibited vegetation from the Portland Plant List shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species (measured in a 10 x 10 foot plot) shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within a specific timeframe, e.g., 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.

Training and/or written guidance information for operating and maintaining planters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the stormwater planter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.

- Obstacles preventing maintenance personnel and/or equipment access to the stormwater planter shall be removed.
- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored at the stormwater planter. Pest control measures shall be taken when insects/rodents are found to be present.

- Standing water creating an environment for development of insect larvae shall be eliminated.
- If sprays are considered, then a mosquito larvicide, such as Bacillus thurengensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the stormwater planter shall be filled and compacted.

Pervious Pavement
Operations & Maintenance Plan

Pervious pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil or being collected in underlying drain pipes and being discharged off-site. There are many types of pervious pavement including plastic rings planted with grass, stone or concrete blocks with pore spaces backfilled with gravel or sand, porous asphalt, and porous concrete. Pervious pavement accepts only precipitation, not stormwater runoff. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Surface: In most pervious pavement design, the pavement itself acts as pretreatment to the stone reservoir below. The surface shall be kept clean and free of leaves, debris, and sediment. The surface shall not be overlaid with an impermeable paving surface

- Regular sweeping shall be implemented for porous asphalt or concrete systems.

Overflows or Emergency Spillways are used in the event that the facility's infiltration capacity is exceeded. Overflow devices shall be inspected for obstructions or debris, which shall be removed upon discovery Overflow or emergency spillways shall be capable of transporting high flows of stormwater to an approved stormwater receiving system.

- Sources of erosion damage shall be identified and controlled when native soil is exposed near the overflow structure.

Vegetation (where applicable) shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Vegetation, such as trees and shrubs, should not be located in or around the pervious pavement because roots from trees can penetrate the pavement, and leaves from deciduous trees and shrubs can increase the risk of clogging the surface.

- Vegetation and large shrubs/trees that limit access or interfere with porous pavement operation shall be pruned.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Poisonous, nuisance, dead or odor producing vegetation shall be removed immediately.
- Grass shall be mowed to less than four inches and grass clippings shall be bagged and removed.
- Irrigation shall be provided as needed.

Source Control measures prevent pollutants from mixing with stormwater. Typical non-structural control measures include raking and removing leaves, street sweeping, vacuum sweeping, limited and controlled application of pesticides and fertilizers, and other good house keeping practices.

Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater. A spill prevention plan shall be implemented at all non-residential sites and in areas where there is likelihood of spills from hazardous materials. However, virtually all sites, including residential and commercial, present potential danger from spills. All homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, solvents, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining pervious pavement shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the pervious pavement shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.
Obstacles preventing maintenance personnel and/or equipment access to the porous pavement shall be removed.
Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored at the pervious pavement. Pest control measures shall be taken when insects/rodents are found to be present.

- Standing water creating an environment for development of insect larvae shall be eliminated.
- If sprays are considered, then a mosquito larvicide, such as Bacillus thurengensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the pervious pavement shall be filled and compacted.

If used at this site, the following will be applicable:

Signage may serve to educate people about the importance or function of the site's stormwater protection measures. It may also discourage behaviors that adversely affect stormwater protection measures. For example, if debris is a problem, a sign reminding people not to litter may partially solve the problem. Broken or defaced signs shall be replaced/repaired.

Vegetated, Grassy, and Street Swales Operations & Maintenance Plan
Swales are planted or grassed open channels that trap pollutants by filtering and slowing flows, allowing particles to settle out. The swale should drain within 48 hours of a storm event. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:
Swale Inlet (such as curb cuts or pipes) shall maintain a calm flow of water entering the swale. • Source of erosion shall be identified and controlled when native soil is exposed or erosion channels are forming. • Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4" thick or so thick as to damage or kill vegetation. • Inlet shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected. • Rock splash pads shall be replenished to prevent erosion.
Side Slopes shall be maintained to prevent erosion that introduces sediment into the swale. • Slopes shall be stabilized and planted using appropriate erosion control measures when native soil is exposed or erosion channels are forming.
Swale Media shall allow stormwater to percolate uniformly through the landscape swale. If the swale does not drain within 48 hours, it shall be tilled and replanted according to design specifications. • Annual or semi-annual tilling shall be implemented if compaction or clogging continues. • Debris in quantities that inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.
Swale Outlet shall maintain sheet flow of water exiting swale unless a collection drain is used. Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming. • Outlets such as drains and overland flow paths shall be cleared when 50% of the conveyance capacity is plugged. • Sources of sediment and debris shall be identified and corrected.
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Mulch shall be replenished as needed to ensure survival of vegetation. • Vegetation, large shrubs or trees that interfere with landscape swale operation shall be pruned. • Fallen leaves and debris from deciduous plant foliage shall be removed. • Grassy swales shall be mowed to keep grass 4" to 9" in height. • Nuisance and prohibited vegetation from the Portland Plant List (such as blackberries and English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced. • Dead vegetation and woody material shall be removed to maintain less than 10% of area coverage or when swale function is impaired. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining swales shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.
Access to the swale shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. • Obstacles preventing maintenance personnel and/or equipment access to the swale shall be removed. • Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
Insects & Rodents shall not be harbored in the swale. Pest control measures shall be taken when insects/rodents are found to be present. • If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. • Holes in the ground located in and around the swale shall be filled.
If used at this site, the following will be applicable:
Check Dams shall control and distribute flow. • Causes for altered water flow shall be identified, and obstructions cleared upon discovery. • Causes for channelization shall be identified and repaired.

Vegetated Filters

Operations & Maintenance Plan

Vegetated filters are gently sloped vegetated areas that stormwater runoff is directed to flow and filter through. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Flow control is achieved using the relatively large surface area and check dams. Pollutants are removed through infiltration and sedimentation. The vegetative filter should drain within 48 hours of storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Flow Spreader shall allow runoff to enter the vegetative filter as predominantly sheet flow.

- Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming.
- Sediment build-up near or exceeding 2” in depth shall be removed.

Filter Inlet shall assure unrestricted stormwater flow to the vegetative filter.

- Sources of erosion shall be identified and controlled when native soil is exposed or erosion channels are present.
- Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Inlet shall be cleared when conveyance capacity is plugged.
- Rock splash pads shall be replenished to prevent erosion.

Filter Media shall allow stormwater to percolate uniformly through the vegetative filter.

- If the vegetative filter does not drain within 48 hours, it shall be regraded and replanted according to design specifications. Established trees shall not be removed or harmed in this process.
- Debris in quantities more than 2” deep or sufficient to inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.

Check Dams shall direct and control flow.

- Causes for altered water flow and channelization shall be identified, and obstructions cleared upon discovery.
- Cracks, rot, and structural damage shall be repaired.

Filter Outlet shall allow water to exit the vegetative filter as sheet flow, unless a collection drainpipe is used.

- Sources of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are deeper than 2 inches.
- Outlet shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance and prohibited vegetation from the Portland Plant List (such as blackberries and English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when vegetative filter function is impaired. Vegetation shall be replaced immediately to control erosion where soils are exposed and within 3 months to maintain cover density.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining vegetated filters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the vegetative filter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards.
Obstacles preventing maintenance personnel and/or equipment access to the facility shall be removed.
Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored in the vegetated filter. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the vegetated filter shall be filled.

Infiltration and Flow-Through Planters Operations & Maintenance Plan
Planters are designed to allow runoff to filter through layers of topsoil (thus capturing pollutants) and then either infiltrate into the native soils (infiltration planter) or be collected in a pipe to be discharged off-site (flow-through planter). The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil. The flow-through planter is designed with an impervious bottom or is placed on an impervious surface. Water should drain through the planter within 3-4 hours after a storm event. All facility components and vegetation shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:
Downspout from rooftop or sheet flow from paving allows unimpeded stormwater flow to the planter. • Debris shall be removed routinely (e.g., no less than every 6 months) and upon discovery. • Damaged pipe shall be repaired upon discovery.
Splash Blocks prevent splashing against adjacent structures and convey water without disrupting media. • Any deficiencies in structure such as cracking, rotting, and failure shall be repaired.
Planter Reservoir receives and detains storm water prior to infiltration. Water should drain from reservoir within 3-4 hours of storm event. • Sources of clogging shall be identified and corrected. • Topsoil may need to be amended with sand or replaced all together.
Filter Media consisting of sand, gravel, and topsoil shall allow stormwater to percolate uniformly through the planter. The planter shall be excavated and cleaned, and gravel or soil shall be replaced to correct low infiltration rates. • Holes that are not consistent with the design and allow water to flow directly through the planter to the ground shall be plugged. • Sediment accumulation shall be hand removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation. • Litter and debris shall be removed routinely (e.g., no less than quarterly) and upon discovery.
Planter shall contain filter media and vegetation. • Structural deficiencies in the planter including rot, cracks, and failure shall be repaired.
Overflow Pipe safely conveys flow exceeding reservoir capacity to an approved stormwater receiving system. • Overflow pipe shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged. • Damaged pipe shall be repaired or replaced upon discovery.
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. • Mulch shall be replenished at least annually. • Vegetation, large shrubs or trees that limit access or interfere with planter operation shall be pruned or removed. • Fallen leaves and debris from deciduous plant foliage shall be raked and removed. • Nuisance or prohibited vegetation from the Portland Plant List shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced. • Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within a specific timeframe, e.g., 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining stormwater planters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.
Access to the stormwater planter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. • Obstacles preventing maintenance personnel and/or equipment access to the stormwater planter shall be removed. • Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
Insects & Rodents shall not be harbored in the stormwater planter. Pest control measures shall be taken when insects/rodents are found to be present. If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. Holes in the ground located in and around the stormwater planter shall be filled and compacted.

Vegetated Infiltration Basins
Operations & Maintenance Plan

A **vegetated Infiltration Basin** is a vegetated depression created by excavation, berms, or small dams to provide for short-term ponding of surface water until it percolates into the soil. The basin shall infiltrate stormwater within 24 hours. All facility components and vegetation shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Basin Inlet shall assure unrestricted stormwater flow to the vegetated basin.

- Sources of erosion shall be identified and controlled when native soil is exposed or erosion channels are present.
- Inlet shall be cleared when conveyance capacity is plugged.
- Rock splash pads shall be replenished to prevent erosion.

Embankment, Dikes, Berms & Side Slopes retain water in the infiltration basin.

- Structural deficiencies shall be corrected upon discovery:
- Slopes shall be stabilized using appropriate erosion control measures when soil is exposed/ flow channels are forming.
- Sources of erosion damage shall be identified and controlled.

Overflow or Emergency Spillway conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow shall be cleared when 25% of the conveyance capacity is plugged.
- Sources of erosion damage shall be identified and controlled when soil is exposed.
- Rocks or other armament shall be replaced when only one layer of rock exists.

Filter Media shall allow stormwater to percolate uniformly through the infiltration basin. If water remains 36-48 hours after storm, sources of possible clogging shall be identified and corrected.

- Basin shall be raked and, if necessary, soil shall be excavated, and cleaned or replaced.

Sediment/ Debris Management shall prevent loss of infiltration basin volume caused by sedimentation. Gauges located at the opposite ends of the basin shall be maintained to monitor sedimentation.

- Sediment and debris exceeding 4" in depth shall be removed every 2-5 years or sooner if performance is affected.
- Restricted sources of sediment and debris, such as discarded lawn clippings, shall be identified and prevented.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- Mulch shall be replenished as needed to ensure healthy plant growth.
- Vegetation, large shrubs or trees that limit access or interfere with basin operation shall be pruned or removed.
- Grass shall be mowed to 4"-9" high and grass clippings shall be removed no less than 2 times per year.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or prohibited vegetation from the Portland Plant List (such as blackberries or English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when infiltration basin function is impaired. Vegetation shall be replaced within 3 months, or immediately if required to control erosion.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining vegetated infiltration basins shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the infiltration basin shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.

- Obstacles preventing maintenance personnel and/or equipment access to the infiltration basin shall be removed.
- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored in the infiltration basin. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the infiltration basin shall be filled.

If used at this site, the following will be applicable:

Fences shall be maintained to preserve their functionality and appearance.

- Collapsed fences shall be restored to an upright position, jdamaged fences shall be repaired or replaced.

Sand Filters

Operations & Maintenance Plan

Sand filters consist of a layer of sand in a structural box used to trap pollutants. The water filters through the sand and then flows into the surrounding soils or an underdrain system that conveys the filtered stormwater to a discharge point. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Filter Inlet shall allow water to uniformly enter the sand filter as calm flow, in a manner that prevents erosion.

- Inlet shall be cleared of sediment and debris when 40% of the conveyance capacity is plugged.
- Source of erosion shall be identified and controlled when native soil is exposed or erosion channels are forming.
- Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4 inches thick or so thick as to damage or kill vegetation.
- Rock splash pads shall be replenished to prevent erosion.

Reservoir receives and detains stormwater prior to infiltration. If water does not drain within 2-3 hours of storm event, sources of clogging shall be identified and correction action taken.

- Debris in quantities more than 1 cu ft or sufficient to inhibit operation shall be removed routinely (e.g., no less than quarterly), or upon discovery.
- Structural deficiencies in the sand filter box including rot, cracks, and failure shall be repaired upon discovery.

Filter Media shall allow to stormwater to percolate uniformly through the sand filter. If water remains 36-48 hours after storm, sources of possible clogging shall be identified and corrected.

- Sand filter shall be raked and if necessary, the sand/gravel shall be excavated, and cleaned or replaced.
- Sources of restricted sediment or debris (such as discarded lawn clippings) shall be identified and prevented.
- Debris in quantities sufficient to inhibit operation shall be removed no less than quarterly, or upon discovery.
- Holes that are not consistent with the design structure and allow water to flow directly through the sand filter to the ground shall be filled.

Underdrain Piping (where applicable) shall provide drainage from the sand filter, and **Cleanouts** (where applicable) located on laterals and manifolds shall be free of obstruction, and accessible from the surface.

- Underdrain piping shall be cleared of sediment and debris when conveyance capacity is plugged. Cleanouts may have been constructed for this purpose.
- Obstructions shall be removed from cleanouts without disturbing the filter media.

Overflow or Emergency Spillway conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow spillway shall be cleared of sediment and debris when 50% of the conveyance capacity is plugged.
- Source of erosion damage shall be identified and controlled when erosion channels are forming.
- Rocks or other armament shall be replaced when sand is exposed and eroding from wind or rain.

Vegetation

- Vegetation, large shrubs or trees that limit access or interfere with sand filter operation shall be pruned.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or prohibited vegetation from the Portland Plant List (such as blackberries or English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater.
Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining sand filters shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the sand filter shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable.

- Obstacles preventing maintenance personnel and/or equipment access to the facility shall be removed.
- Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Insects & Rodents shall not be harbored in the sand filter. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the sand filter shall be filled.

Soakage Trenches

Operations & Maintenance Plan

Soakage Trenches consist of drain rock and sand, and receive stormwater from roof downspouts and/or area drains. There are various components within the system - piping, silt basin and the trench itself. The **Conveyance Piping** consists of an inlet pipe (downspout or area drain), an outlet pipe located between the silt basin and the soakage trench, and a perforated pipe, located on top of the aggregate bed of the soakage trench. The **Silt Basin** is a structure receiving runoff from an inlet pipe and conveying it to the soakage trench. The silt basin serves as the pre-treatment system for the soakage trench, removing sediments and other debris that can impact its proper functioning. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first two years from the date of installation, then two times per year afterwards, or within 48 hours after each major storm. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Soakage trench infiltration: If water is noticed on top of the trench within 48 hours of a major storm, the soakage trench may be clogged.

- Check for debris/sediment accumulation, rake and remove and evaluate upland causes (erosion, surface or roof debris, etc
- Assess the condition of the aggregate and the filter fabric in the trench. If there is sediment in the aggregate, excavate and replace.
- If there is a tear in the filter fabric, repair or replace.

Conveyance Piping: If water ponds over the trench for more than 48 hours after a major storm and no other cause if identified, it may be necessary to remove the filter fabric to determine if the perforated pipe is clogged with sediment or debris.

- Any debris or algae growth located on top of the soakage trench should be removed and disposed of properly.
- If the piping has settled more than 1-inch, add fill material. If there are cracks or releases, replace or repair the pipe. If there are signs of erosion around the pipe, this may be an indication of water seeping due to a crack or break.

Silt Basin: If water remains in the soakage trench for 36-48 hours after storm, check for sediment accumulation in the silt basin

- If less than 50% capacity remains in the basin or 6” of sediment has accumulated, remove and dispose the sediment.

Spill Prevention*:* Virtually all sites, including residential and commercial, present dangers from spills. All homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect groundwater if spilled. It is important to exercise caution when handling substances that can contaminate stormwater.

- Activities that pose the chance of hazardous material spills shall not take place near soakage trenches.

A **Shut-Off Valve or Flow-Blocking Mechanism** may have been required with the construction of the soakage trench to temporarily prevent stormwater from flowing into it, in the event of an accidental toxic material spill. This may also involve mats kept on-site that can be used to cover inlet drains in parking lots. The shut-off valve shall remain in good working order, or if mats or other flow-blocking mechanisms are used, they shall be kept in stock on-site.

Training and/or written guidance information for operating and maintaining soakage trenches shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the soakage trench is required for efficient maintenance. Egress and ingress routes will be maintained to design standards at inspections.

Insects & Rodents shall not be harbored in the soakage trench. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the soakage trench shall be filled.

Wet, Extended Wet Detention, and Dry Detention Ponds

Operations & Maintenance Plan

Wet Ponds are constructed ponds with a permanent pool of water. Pollutants are removed from stormwater through gravitational settling and biologic processes. **Extended Wet Ponds** are constructed ponds with a permanent pool of water and open storage space above for short-term detention of large storm events. Pollutants are removed from stormwater through gravitational settling and biologic processes. **Dry Detention Ponds** are constructed ponds with temporary storage for the detention of large storm events. The stormwater is stored and released slowly over a matter of hours. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Pond Inlet shall assure unrestricted stormwater flow to the wet pond.

- Inlet pipe shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
- Determine if pipe is in good condition:
  - If more than 1 inch of settlement, add fill material and compact soils.
  - If alignment is faulty, correct alignment.
  - If cracks or openings exist indicated by evidence of erosion at leaks, repair or replace pipe as needed.

Forebay traps coarse sediments, reduces incoming velocity, and distributes runoff evenly over the wet pond. A minimum 1-foot freeboard shall be maintained.

- Sediment buildup exceeding 50% of the facility capacity shall be removed every 2-5 years, or sooner if performance is being affected.

Embankment, Dikes, Berms & Side Slopes retain water in the wet pond.

- Slopes shall be stabilized using appropriate erosion control measures when native soil is exposed or erosion channels are forming.
- Structural deficiencies shall be corrected upon discovery:
  - If cracks exist, repair or replace structure.
  - If erosion channels deeper than 2 inches exist, stabilize surface. Sources of erosion damage shall be identified and controlled.

Control Devices (e.g., weirs, baffles, etc.) shall direct and reduce flow velocity. Structural deficiencies shall be corrected upon discovery:

- If cracks exist, repair or replace structure.

Overflow Structure conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow structure shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
- Sources of erosion damage shall be identified and controlled when native soil is exposed at the top of overflow structure or erosion channels are forming.
- Rocks or other armoring shall be replaced when only one layer of rock exists above native soil.

Sediment & Debris Management shall prevent loss of wet pond volume caused by sedimentation.

- Wet ponds shall be dredged when 1 foot of sediment accumulates in the pond.
- Gauges located at the opposite ends of the wet pond shall be maintained to monitor sedimentation. Gauges shall be checked 2 times per year.
- Sources of restricted sediment or debris, such as discarded lawn clippings, shall be identified and prevented.
- Debris in quantities sufficient to inhibit operation shall be removed routinely, e.g. no less than quarterly, or upon discovery.

Wet, Extended Wet Detention, and Dry Detention Ponds Operations & Maintenance Plan
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion and minimizing solar exposure of open water areas. • Mulch shall be replenished at least annually. • Vegetation, large shrubs or trees that limit access or interfere with wet pond operation shall be pruned or removed. • Grass (where applicable) shall be mowed to 4"-9" high and grass clippings shall be removed. • Fallen leaves and debris from deciduous plant foliage shall be raked and removed. • Nuisance or prohibited vegetation from the Portland Plant List (such as blackberries or English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced. • Dead vegetation shall be removed to maintain less than 10% of area coverage or when wet pond function is impaired. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed. • Vegetation producing foul odors shall be eliminated.
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining ponds shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.
Access to the wet pond shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. • Obstacles preventing maintenance personnel and/or equipment access to the wet pond shall be removed. • Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
Insects & Rodents shall not be harbored in the pond. Pest control measures shall be taken when insects/rodents are found to be present. • If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. • Holes in the ground located in and around the pond shall be filled.
If used at this site, the following will be applicable:
Signage shall clearly convey information. • Broken or defaced signs shall be replaced or repaired.
Fences shall be maintained to preserve their functionality and appearance. • Collapsed fences shall be restored to an upright position. • Jagged edges and damaged fences and shall be repaired or replaced.

Constructed Treatment Wetlands

Operations & Maintenance Plan

Constructed Treatment Wetlands remove pollutants through several processes: sedimentation, filtration, and biological processes. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Wetland Inlet shall assure unrestricted stormwater flow to the wetland.

- Inlet pipe shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
- Determine if pipe is in good condition:
  - If more than 1 inch of settlement, add fill material and compact soils.
  - If alignment is faulty, correct alignment.
  - If cracks or openings exist indicated by evidence of erosion at leaks, repair or replace pipe as needed.

Forebay traps coarse sediments, reduces incoming velocity, and distributes runoff evenly over the wetland. A minimum 1-foot freeboard shall be maintained.

- Sediment buildup exceeding 50% of the facility capacity shall be removed every 2-5 years, or sooner if performance is being affected.

Embankment, Dikes, Berms & Side Slopes retain water in the wetland.

- Slopes shall be stabilized using appropriate erosion control measures when native soil is exposed or erosion channels are forming.
- Structural deficiencies shall be corrected upon discovery:
  - If cracks exist, repair or replace structure.
  - If erosion channels deeper than 2 inches exist, stabilize surface. Sources of erosion damage shall be identified and controlled.

Control Devices (e.g., weirs, baffles, etc.) shall direct and reduce flow velocity.

- Structural deficiencies shall be corrected upon discovery:
- If cracks exist, repair or replace structure.

Overflow Structure conveys flow exceeding reservoir capacity to an approved stormwater receiving system.

- Overflow structure shall be cleared when 50% of the conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
- Sources of erosion damage shall be identified and controlled when native soil is exposed at the top of overflow structure or erosion channels are forming.
- Rocks or other armament shall be replaced when only one layer of rock exists above native soil.

Sediment & Debris Management shall prevent loss of wetland volume caused by sedimentation.

- Wetlands shall be dredged when 1 foot of sediment accumulates.
- Gauges located at the opposite ends of the wetland shall be maintained to monitor sedimentation. Gauges shall be checked 2 times per year.
- Sources of restricted sediment or debris, such as discarded lawn clippings, shall be identified and prevented.
- Debris in quantities sufficient to inhibit operation shall be removed routinely, e.g. no less than quarterly, or upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion and minimizing solar exposure of open water areas.

- Mulch shall be replenished when needed.
- Vegetation, large shrubs or trees that limit access or interfere with wetland operation shall be pruned.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or prohibited vegetation from the Portland Plant List (such as blackberries or English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when wetland function is impaired. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
- Vegetation producing foul odors shall be eliminated.

Constructed Treatment Wetlands Operations & Maintenance Plan
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining treatment wetlands shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.
Access to the wetland shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. • Obstacles preventing maintenance personnel and/or equipment access to the wetland shall be removed. • Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
Insects & Rodents shall not be harbored in the constructed treatment wetland. Pest control measures shall be taken when insects/rodents are found to be present. • If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. • Holes in the ground located in and around the constructed treatment wetland shall be filled.
If used at this site, the following will be applicable:
Signage shall clearly convey information. • Broken or defaced signs shall be replaced or repaired.
Fences shall be maintained to preserve their functionality and appearance. • Collapsed fences shall be restored to an upright position. • Jagged edges and damaged fences and shall be repaired or replaced.

Underground Detention Tanks, Vaults, and Pipes

Operations & Maintenance Plan

Underground detention tanks, vaults, and pipes are designed to fill with stormwater during large storm events, slowly releasing it over a number of hours. There are numerous components to each system. **Drain Inlet Pipes** convey stormwater into the detention facility. The **detention Chamber** is the structure in which stormwater accumulates during a storm event. **Orifice Structure/ Outlet Drain Pipe** restricts the flow out of the detention chamber, allowing it to fill up and slowly drain out. The orifice structure is located at the downstream end of the detention chamber. Underground facilities shall be inspected quarterly and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Drain Inlet Pipes shall be inspected for clogging or leaks where it enters the vault or basin during every inspection and cleanout.

- Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Detention Chamber shall be inspected for cracks or damage during each inspection.

- The detention chamber shall be cleaned out yearly or after an inch of sediment has accumulated. If there is a valve on the outlet pipe it shall be closed otherwise the outlet shall be plugged prior to cleanout. Grit and sediment that has settled to the bottom of the chamber shall be removed during each cleaning.
- Water and sediment in the detention chamber shall be removed, tested, and disposed of in accordance with regulations.
- Cleaning shall be done without use of detergents or surfactants. A pressure washer may be used if necessary.

Orifice Structure/ Outlet Drain Pipe shall be inspected for clogging during unit inspections/cleanouts.

- Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Vegetation such as trees should not be located in or around the detention facility because roots from trees can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging the intake pipe.

- Large shrubs or trees that are likely to interfere with detention facility operation shall be identified at each inspection then removed.

Source Control measures typically include structural and non-structural controls. Non-structural controls can include street sweeping and other good house keeping practices. It is often easier to prevent pollutants from entering stormwater than to remove them.

- Source control measures shall be inspected and maintained (where applicable).

Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important for everyone to exercise caution when handling substances that can contaminate stormwater.
Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

Training and/or written guidance information for operating and maintaining detention facilities shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the detention facility is required for efficient maintenance.
Egress and ingress routes shall be open and maintained to design standards.

Signage may serve to educate people about the importance or function of the site's stormwater protection measures. Signs may also discourage behavior that adversely impacts the stormwater protection measures and encourages behavior that enhances or preserves stormwater quality. If debris is a problem, a sign reminding people not to litter may partially solve the problem.
Signage (where applicable) will be maintained and repaired as needed during or shortly after inspections.

Insects & Rodents shall not be harbored in the detention facility. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the detention facility shall be filled.

Drywells

Operations & Maintenance Plan

Drywells are designed to infiltrate stormwater into the ground. Stormwater is piped to drywells from roof downspouts or pollution control facilities such as swales or planters. The pollution control facility is designed to settle out sediments and separate oils and greases from the water before releasing it through a pipe to the drywell. This prolongs the life of the drywell and helps to prevent the contamination of soils and groundwater. The drywell is a concrete or plastic manhole section with many small holes in the sides to allow stormwater to infiltrate into the surrounding soil. The drywell system shall be inspected and cleaned quarterly and within 48 hours after each major storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Stormwater Drain Pipe shall be inspected for clogging or leaks where it enters the drywell.

- Debris/sediment that is found to clog the pipe shall be removed and disposed of in accordance with applicable federal and state requirements.

Drywell shall be inspected during each cleanout. Ponding around the catch basins or sedimentation manhole or drywell lids may indicate that the drywell is failing due to siltation, or the clogging of the sediment pores surrounding the drywell. Clogged drywells must be replaced.

Vegetation such as trees should not be located in or around the drywell because roots from trees can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging the intake pipe.

- Large shrubs or trees that are likely to interfere with operation will be identified at each inspection and removed.

Source Control measures typically include structural and non-structural controls. Non-structural controls can include parking lot or street sweeping and other good house keeping practices. It is often easier to prevent pollutants from entering stormwater than to remove them.

- Source control measures shall be inspected and maintained (where applicable).

Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, solvents, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater.
Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

A **Shut-Off Valve or Flow-Blocking Mechanism** may have been required with the construction of the drywell to temporarily prevent stormwater from flowing into it, in the event of an accidental toxic material spill. This may also involve mats kept on-site that can be used to cover inlet drains in parking lots. The shut-off valve shall remain in good working order, or if mats or other flow-blocking mechanisms are used, they shall be kept in stock on-site.

Training and/or written guidance information for operating and maintaining drywell systems shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the drywell is required for efficient maintenance. Egress and ingress routes shall be open and maintained to design standards.

Insects & Rodents shall not be harbored in the drywell. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the drywell shall be filled.

Signage may serve to educate people about the importance or function of the site's stormwater protection measures. Signs may also discourage behavior that adversely impacts the stormwater protection measures and encourages behavior that enhances or preserves stormwater quality. If debris is a problem, a sign reminding people not to litter may partially solve the problem.
Signage (where applicable) shall be maintained and repaired as needed during or shortly after inspections.

Spill Control Manholes

Operations & Maintenance Plan

Spill Control Manholes operate using the principal that oil and water are immiscible (do not mix) and have different densities. Oil, being less dense than water, floats to the surface. The spill control manhole shall be inspected and cleaned quarterly. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

- **Stormwater Drain Inlet Pipe** shall be inspected for clogging or leaks where it enters the manhole during every inspection and cleanout. Debris/sediment that is found to clog the inlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Manhole Chamber shall be inspected for cracks or damage during each inspection.

- The manhole shall be cleaned out quarterly. Cleanout shall be done in a manner to minimize the amount of trapped oil entering the outlet pipe. If there is a valve on the outlet pipe it shall be closed otherwise the outlet will be plugged prior to cleanout.
- Water and oil shall be removed, tested, and disposed of in accordance with regulations. Grit and sediment that has settled to the bottom of the chamber shall be removed during each cleaning
- Cleaning shall be done without use of detergents or surfactants. A pressure washer may be used if necessary.

Absorbent Pillows and Pads (where applicable) absorb oil from the separation chamber.

- Replacement shall occur at least twice a year, in the spring and fall, or as necessary to retain oil-absorbing function.

Stormwater Drain Outlet Pipe shall be inspected for clogging or leaks where it exits the manhole. Particular attention shall be paid to ensure that the joint where the tee joins the outlet pipe is watertight.

- Debris/sediment that is found to clog the outlet shall be removed, tested, and disposed of in accordance with applicable federal and state requirements.

Vegetation such as trees should not be located in or around the spill control manhole because roots can penetrate the unit body, and leaves from deciduous trees and shrubs can increase the risk of clogging.

- Large shrubs or trees that are likely to interfere with manhole operation shall be identified at each inspection and removed.

Source Control measures typically include structural and non-structural controls. Non-structural controls can include street sweeping and other good house keeping practices.

- Source control measures shall be inspected and maintained.

Spill Prevention procedures require high-risk site users to reduce the risk of spills. However, virtually all sites, including residential and commercial, present dangers from spills. Homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, nail polish remover, pesticides, and cleaning aids that can adversely affect storm water if spilled. It is important to exercise caution when handling substances that can contaminate stormwater.
Spill prevention procedures shall be implemented in areas where there is likelihood of spills from hazardous materials.

Training and/or written guidance information for operating and maintaining spill control manholes shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.

Access to the spill control manhole is required for efficient maintenance. Egress and ingress routes shall be open and maintained to design standards.

Insects & Rodents shall not be harbored in the spill control manhole. Pest control measures shall be taken when insects/rodents are found to be present.

- If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor.
- Holes in the ground located in and around the manhole shall be filled.

Signage may serve to educate people about the importance or function of the site's stormwater protection measures. Signage (where applicable) shall be maintained and repaired as needed during or shortly after inspections.

New Evergreen and Deciduous Trees Operations & Maintenance Plan
Trees intercept rainfall and therefore provide a level of pollution reduction and flow control. They also provide shade, helping to cool stormwater runoff. Trees used to meet stormwater management requirements shall be kept on a site and maintained properly to ensure continued stormwater benefits. Trees shall be inspected 2 times a year and within 48 hours of a major wind or storm event. The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:
Leaves and Debris from the tree shall be regularly raked and disposed of. • Fallen leaves and debris from deciduous plant foliage shall be raked and removed. • Poisonous and nuisance vegetation around the tree shall be removed when discovered. • Dead vegetation shall be pruned from the tree on a regular basis.
Irrigation shall be implemented during the establishment period to ensure tree survival. Hand watering is preferred, but a drip-irrigation system may be used.
Protection of the tree trunk and roots shall ensure tree survival. Care should be taken when digging near tree roots.
Replacement of dead trees shall be with a comparable species if it dies or must be removed for any another reason. The replacement tree shall be a minimum of 6' tall.
Insects & Rodents shall not be harbored in or around the trees. Pest control measures shall be taken when insects/rodents are found to be present. • If sprays are considered, then a mosquito larvicide, such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. • Holes in the ground located in and around the trees shall be filled.

Chapter 4.0
SOURCE CONTROLS

Summary of Chapter 4.0

This chapter presents storm and sanitary source controls required for site uses and characteristics that generate, or have the potential to generate, specific pollutants of concern.

To Use This Chapter:

1) Determine if the project has any of the characteristics or site uses listed in **Section 4.1.1**.
2) If so, go to the applicable section for that characteristic or site use and follow the requirements to design source controls for the project.
3) The site use may require a **Source Control Installations and/or a Special Requests form** to be submitted with the permit application.

4.1 INTRODUCTION AND APPLICABILITY

Some site characteristics and uses may generate specific pollutants of concern or levels of pollution that are not addressed solely through implementation of the pollution reduction measures identified in Chapter 2.0. The site characteristics and uses in this chapter have been identified as potential sources for chronic loadings or acute releases of pollutants such as oil and grease, toxic hydrocarbons, heavy metals, toxic compounds, solvents, abnormal pH levels, nutrients, organics, bacteria, chemicals, and suspended solids. This chapter presents source controls for managing these pollutants at their source.

Stormwater discharge benchmarks for pollutants exist in NPDES industrial stormwater general permits issued by the State of Oregon for facilities with industrial activities that are exposed to rainfall and stormwater runoff. The state also has water quality standards listed in Oregon Administrative Rules (OAR) 340 Division 041 for discharges to surface waters.

City Code 17.39 lists prohibited discharges to the City's storm sewer system. The City used the state standards and industrial stormwater NPDES benchmarks in developing the manual's listed source controls so stormwater discharges can better meet those criteria. Section 4.1.1 lists the site uses and characteristics that are subject to the requirements of this chapter and will therefore be subject to BES Source Control review. Sections 4.2 through 4.9 then provide detailed information about the required source controls.

These source controls apply to all projects with the defined uses or characteristics listed in Section 4.1.1 including: new development, redevelopment, tenant improvements or those existing sites proposing new off-site discharges. With tenant improvements, only those areas of a structure or activity area that are being disturbed under the permit are required to make the structural changes identified in this chapter. With new off-site discharges only those proposed areas draining off-site will be subject to these regulations.

The requirements of this chapter are in addition to the applicable destination/disposal, pollution reduction, and flow control requirements identified in Chapter 1.0. Development sites discharging to combined sewers are required to provide pollution reduction and flow control for stormwater in accordance with the standards outlined in **Chapter 1.0**, and on-site storm and sanitary flows shall remain separated until the connection point off-site.

For all structural source controls, a **Source Control Installations Form**, located at the end of this chapter, shall be submitted as part of the building permit application packet. Applicants may propose alternatives to the source controls identified in this chapter. In that case, the applicant shall complete the **Special Requests Form**, located at the end of this chapter. Proposal of an alternative source control or alternative design element will require an additional review process and may delay issuance of related building or public works permits.

Note: Developments citing special circumstances (see **Chapter 1.0, Section 1.11**) are not exempt from the source control requirements of this chapter.

4.1.1 Site Uses and Characteristics That Trigger Source Controls

Projects with the following site uses and characteristics are subject to the requirements of this chapter:

- Fuel Dispensing Facilities and Surrounding Traffic Areas (**Section 4.2**)
- Above-Ground Storage of Liquid Materials (**Section 4.3**)
- Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 4.4**)
- Exterior Storage of Bulk Materials (**Section 4.5**)
- Material Transfer Areas/Loading Docks (**Section 4.6**)
- Equipment and/or Vehicle Washing Facilities (**Section 4.7**)
- Stormwater and Groundwater Management For Development On Land With Suspected or Known Contamination (**Section 4.8**)
- Covered Vehicle Parking Areas (**Section 4.9**)

Detailed descriptions of these site uses and characteristics can be found in each applicable section. Definitions of terms used in Sections 4.2 through 4.9 are provided in **Section 1.3**.

Applicants are required to address all of the site characteristics and uses listed in Sections 4.2 through 4.9. For example, if a development includes both a fuel dispensing area and a vehicle washing facility, the source controls in both Sections 4.2 and 4.7 will apply.

4.1.2 Goals and Objectives for Source Control

The specific source control requirements are based on the following goals and objectives:

1) Prevent stormwater pollution by eliminating pathways that may introduce pollutants into stormwater.

2) Protect soil, groundwater, and surface water by capturing acute releases and reducing chronic contamination of the environment.

3) Segregate stormwater and wastewater flows to minimize additions to the sanitary and combined sewer systems.

4) Direct wastewater discharges and areas with the potential for relatively consistent wastewater discharges (such as vehicle washing facilities) to the sanitary or combined sewer system.

5) Direct areas that have the potential for acute releases or accidental spills, and are not expected to regularly receive flow or require water use (such as covered fuel islands or covered containment areas) to an approved method of containment or disposal.

6) Safely contain spills on-site, avoiding preventable discharges to sanitary or combined sewers, surface water bodies, or underground injection control structures (UICs).

7) Emphasize structural controls over operational procedures. Structural controls are not operator dependent and are considered to provide more permanent and reliable source control. Any proposals for operation-based source controls need to describe the long-term viability of the maintenance program.

4.1.3 Signage Requirements

Informational signage is required for some site uses and activities that have the potential to contaminate stormwater. Signage addresses good housekeeping rules and provides emergency response measures in case of an accidental spill.

All signage shall conform to the requirements described in the following box. Signage requirements for specific activities are noted in applicable sections, and spill signage examples can be found at the end of this chapter.

Signs shall be located and plainly visible from all activity areas. More than one sign may be needed to accommodate larger activity areas. Signs shall be water-resistant. They shall include the following information:

- Safety precautions
- Immediate spill response procedures—for example: "Turn the valve located at..." or "Use absorbent materials"
- Emergency contact(s) and telephone number(s)—for example: "Call 911" and "City of Portland (BES) Spill Response Number 503-823-7180"

Signs may need to be in more than one language if required to effectively communicate with employees and delivery personnel.

Any applicable spill response supplies need to be clearly marked and located where the signage is posted and near the high-risk activity area. More than one spill response kit may be necessary to accommodate larger activity areas.

4.1.4 Request for Alternative Method of Source Control

Applicants may request an alternative method of source control by notifying BES's Source Control Division in writing, specifying the reason for the request and supporting it with technical and factual data. The **Special Requests Form**, located at the end of this chapter, shall be used to request the alternative. All requests shall be given directly to the BES Source Control plans examiner reviewing the plans.

The BES Source Control plans examiner will check the submitted form and supporting information for completeness and forward the request to his or her supervisor for review and decision. The applicant should expect to be contacted within five (5) working days, unless additional documentation is needed.

If the request cannot be satisfied with this process, the tier one appeal process as described in **Appendix A** may be implemented by the applicant.

4.1.5 Additional Requirements

Conformance with this chapter's requirements does not relieve the applicant of other applicable local, state, or federal regulatory or permit requirements. This chapter is intended to complement any additional requirements, and is not expected to conflict with, exclude, or replace those requirements. In case of a conflict, the most stringent local, state, or federal regulations generally apply. Any conflict will be resolved by a

City review representative in consultation with appropriate agencies. Some of the more common additional requirements that may apply are summarized below.

SPILL RESPONSE SUPPLIES

The City expects spill response supplies, such as absorbent material and protective clothing, to be available at all potential spill areas. Employees should be familiar with the site's operations and maintenance plan and/or proper spill cleanup procedures.

STORMWATER AND WASTEWATER DISCHARGE PERMITS

Some facilities may be required to obtain a State of Oregon NPDES industrial stormwater permit before discharging to the City's separated storm sewer system or to waters of the state. Applicants may also be required to obtain an industrial wastewater permit for discharges to the sanitary sewer system. Facilities subject to these requirements are generally commercial or industrial. Typical discharges include process wastewater, cooling water, or other discharges generated by some of the sources in this chapter that drain to a City sewer system (storm, sanitary, or combined). (Contact BES's Industrial Source Control Division at 503-823-7122 for a list of current sanitary sewer discharge limits.)

An evaluation will be done during the building permit review process to determine if an industrial discharge permit is required. If a permit is required, the industrial permit application process will be independent of the building permit review/issuance process. However, building permit applications may have to be revised to accommodate industrial permitting compliance requirements (e.g., sampling points, pretreatment facilities). Please note that if industrial permitting is not applicable at the time of building permit submittal, changes in regulations could trigger industrial permitting requirements in the future.

OREGON DEQ UNDERGROUND INJECTION CONTROL (UIC) REGULATIONS

The Oregon Department of Environmental Quality (DEQ) identifies drywells, sumps, and piped soakage trenches as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. Because the UIC Program states that these types of wells may have a direct impact on groundwater, registration or permitting with DEQ is required. Site uses that are classified as high risk under this chapter are generally not allowed to use UICs for stormwater disposal. See **Section 1.4.4** for additional information.

Additional City of Portland and DEQ permit requirements may apply. Contact BES's Industrial Source Control Division at 503-823-7122 for additional information about stormwater or wastewater discharges to City-owned sanitary, stormwater, or combined sewer systems.

COLUMBIA SOUTH SHORE WELLHEAD PROTECTION PROGRAM

Storage, use, and transportation of hazardous/toxic materials in designated groundwater resource protection areas are regulated under the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003).

OTHER LOCAL, STATE, AND FEDERAL REGULATIONS

The requirements presented in this chapter do not exclude or replace the requirements of other applicable codes or regulations, such as the hazardous substances storage requirements of articles 79 and 80 of the Oregon State Fire Code; the spill prevention control and containment (SPCC) regulations of 40 CFR 112 (EPA); the Resource Conservation and Recovery Act (RCRA); or any other applicable local, state, or federal regulations or permit requirements.

4.2 FUEL DISPENSING FACILITIES AND SURROUNDING TRAFFIC AREAS

4.2.1 Applicability

The requirements in this section apply to all development where vehicles, equipment, or tanks are refueled on the premises; whether a large-sized gas station, a single-pump maintenance yard, or a small-sized fuel tank. A fuel dispensing facility is defined as the area where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above- or below-ground fuel tanks, fuel pumps, and the surrounding pad). Propane tanks are exempt from these requirements.

4.2.2 Requirements

1) COVER

The fuel dispensing area shall be covered with a permanent canopy, roof, or awning so precipitation cannot come in contact with the fueling activity area. Rainfall shall be directed from the cover to a stormwater disposal point that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

2) PAVEMENT

A paved fueling pad of asphalt or concrete shall be placed under and around the fueling activity area and shall meet all applicable building code requirements. Sizing of the paved area shall be adequate to cover the activity area, including placement and number of the vehicles or pieces of equipment to be fueled by each pump. Fuel pumps shall be located a minimum of 7 feet from the edge of the fueling pad.

3) DRAINAGE

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains. This will prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer or authorized pretreatment facility.

Surrounding runoff shall be directed away from the hydraulically isolated fueling pad to a stormwater disposal point that meets all stormwater management requirements of this manual and other applicable code requirements.

4) SIGNAGE

Signage shall be provided at the fuel dispensing area and shall be plainly visible from all fueling activity areas. Detailed signage information is located in **Section 4.1.3**.

5) SPILL CONTROL MANHOLE

A spill control manhole shall be installed on the discharge line of the fueling pad (before the domestic waste line tie-in). The tee section shall extend 18 inches below the outlet elevation, and 60 cubic feet of dead storage volume shall be provided below the outlet elevation for storage of oil, grease, and solids. The manhole shall be located on private property. For more information about spill control manholes, see **Exhibit 2-26**.

6) SHUT-OFF VALVES

Shut off valves are required to protect City sewer systems or onsite infiltration facilities from spill risks from chemicals and other constituents that provide a danger for widespread contamination, system damages, or risk to the public health.

A) **Shut-off valves** are required for any of the following situations:

- Site or activity areas are exposed to corrosives or oxidizers that can harm conveyance system components (such as, but not limited to, battery acid).

- Substances (such as, but not limited to, oil and grease) that do not settle or remain in one location, and are capable of being dissolved in or float on water. These substances can spread rapidly into downstream conveyance and disposal systems, causing widespread impacts and difficult cleanup situations.

- Substances that are known to infiltrate through soils and contaminate groundwater.

B) **Traffic pathways that surround fueling pads are considered high-use/high-risk areas and will require a valve on the storm drainage system.** Valves installed on storm drainage systems shall be installed downstream of all applicable private stormwater quality facilities to accommodate spill containment. These valves shall be left open to facilitate stormwater flows during normal conditions, and immediately closed in the event of a spill.

C) **Fueling pads require a valve downstream of the spill control manhole.** Valves installed on sanitary sewer systems shall be installed before the domestic waste line tie-in. These valves shall be kept closed, and opened only to allow incidental drainage activities that do not pose a threat or risk to the disposal point system. The valve shall be closed immediately after drainage activities are completed.

Shut-off valves shall be located on private property and downstream of the exposed area's collection system. All valves shall be installed and maintained as per manufacturers recommendations. For more information about shut-off valves and associated valve boxes, contact the City's Commercial Plumbing Department at 503-823-7302.

7) ADDITIONAL REQUIREMENTS

A) A **Source Control Installations Form**, located in Section 4.10, shall be submitted as part of the building permit application to facilitate tracking of spill control manhole and shut-off valve installations.

B) **Installation, alterations, or removal of above-ground fuel tanks larger than 55 gallons, and any related equipment,** are subject to additional permitting requirements by the Portland Fire Marshall's Office. For technical questions and permitting, call the Fire Marshall's Office Permit Center at 503-823-3712, or visit the center at 1300 SE Gideon, Portland, Oregon 97202.

C) **Bulk fuel terminals, also known as tank farms,** require the following:

- Secondary containment equal to 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

- A separate containment area for all valves, pumps, and coupling areas, with sub-bermed areas either in front of or inside the main containment areas. These sub-bermed areas shall have rain shields and be directed to a City sanitary sewer system for disposal. If no City sanitary sewer is available, drainage shall be directed to a temporary holding facility for proper disposal and may require a water pollution control facility (WPCF) permit from the Water Quality Division of DEQ.

- An impervious floor within all containment areas. Floors shall be sealed to prevent spills from contaminating the groundwater.

- Truck loading and off-loading areas. These areas shall follow cover, pavement, drainage, spill control, and shut-off valve requirements identified for fuel dispensing facilities.

- Shut-off valves installed for the drainage of the tank yard. The valves shall be installed downstream of the drainage system of the primary containment area and kept closed. Valves installed for the drainage of the truck pad and sub-bermed containment areas shall be installed on the sanitary waste line downstream of the spill control manhole.

- A batch discharge authorization before draining a containment area. This authorization will determine appropriate disposal methods, identify pretreatment requirements (if applicable), and authorize the discharge. Pretreatment may be required for oil and grease removal, and testing may be required to establish the specific characteristics of the discharge.

D) **Underground fuel tanks** less than 4,000 gallons in size are subject to additional permitting requirements by DEQ, and tanks larger than 4,000 gallons are referred to the federal Environmental Protection Agency (EPA). For technical questions and permitting, call DEQ's Northwest Region main office at 503-229-5263 and ask for the Underground Storage Tank Permitting Department.

8) EXCEPTIONS

A) **The requirement to cover the fuel dispensing area** can be appealed if the fuel dispensing area is generally used to service oversized equipment (e.g., cranes) that cannot maneuver under a roof or canopy. A **Special Requests form**, located in Section 4.10, shall be submitted as part of the building permit application to evaluate exception qualifications.

B) **Propane tanks** are exempt from the requirements of this section.

C) **Existing fueling areas** are not required to install source controls identified in this section if the scope of work is limited to the following:

1. A new canopy installation over an existing fuel pad that is not being upgraded.
2. An underground tank replacement for compliance with state regulations.
3. The replacement of a fuel pump on an existing fuel pad that is not being upgraded.

If any improvements are made to the fueling activity area and/or pad, such as regrading or surface replacement, retrofits are required to comply with all fueling activity source controls identified in this chapter.

4.3 ABOVE-GROUND STORAGE OF LIQUID MATERIALS

4.3.1 Applicability

The requirements in this section apply to all development where there is any exterior storage of liquid chemicals, food products, waste oils, solvents, process wastewaters, or petroleum products in above-ground containers, in quantities of 50 gallons or more. This includes both permanent storage and temporary storage areas. Underground storage tanks or installations requiring a water pollution control facility (WPCF) permit are exempt from these requirements, but must go through DEQ's WPCF permit process.

4.3.2 Requirements

1) CONTAINMENT

Liquid materials shall be stored and contained in such a manner that if the container(s) is ruptured, the contents will not discharge, flow, or be washed into a receiving system. A containment device and/or structure for accidental spills shall have enough capacity to capture a minimum of 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

Double-walled containers are generally exempt from these spill containment requirements.

Quantity thresholds of products that are generally exempt from these spill containment measures are:

- Janitorial and cleaning supplies of less than 100 pounds net weight or 15 gallons net volume. These supplies shall be packaged for consumer use in containers of five gallons or less or having a net weight of less than 30 pounds per container. This does not include cleaners or solvents used for cleaning machinery or motor vehicle and machine parts.

- Office and stationary supplies less than 100 pounds net weight. These supplies shall be packaged for consumer use in containers sized less than 5 gallons in size or 30 pounds in weight.

2) COVER

Storage containers (other than tanks) shall be completely covered so rainfall cannot come in contact with them. Runoff shall be directed from the cover to a stormwater disposal point that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

3) PAVEMENT

A paved storage area is required unless otherwise approved by BES's Industrial Source Control Division staff. The storage area shall be paved with asphalt or concrete and shall meet all applicable building code requirements. Sizing of the paved areas shall be adequate to cover the area intended for storage. The applicant shall clearly identify any requested alternative method by submitting a **Special Requests Form**, located at the end of this chapter.

4) DRAINAGE

All paved storage areas shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater run-on to a storage area.

Covered storage areas: Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the contained area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer or authorized pretreatment facility.

Uncovered storage areas with containment: Water will accumulate in uncovered storage areas during and after rain. Any *contaminated* water cannot simply be drained from the area. It must be collected, inspected, and possibly tested at the expense of the property owner before proper disposal can be determined. Frequent draining may be required during the wet season, which may prove costly. Some type of monitoring may also be needed to determine the characteristics and level of contamination of the stormwater.

All discharges to the sanitary sewer shall be considered batch discharges and shall require approval and pretreatment prior to discharge. Pretreatment requirements shall be set as part of the discharge approval process, based on the types and quantities of material to be discharged. A discharge evaluation shall be performed before connection to a sanitary sewer. Testing may be required to establish characteristics of the wastewater or contaminated stormwater and to verify that local discharge limits are not exceeded. For batch discharge applications, call BES's Industrial Source Control Division at 503-823-5320.

5) SIGNAGE

Signage shall be provided at the liquid storage area and shall be plainly visible from all surrounding activity areas. Detailed information is located in **Section 4.1.3.**

6) ADDITIONAL REQUIREMENTS

A) A **Source Control Installations Form**, located in Section 4.10, shall be submitted as part of the building permit application to facilitate tracking of containment and shut-off valve installations.

B) **Covered storage areas:** A shut-off valve may be required for the covered storage area if the applicant elects to install drainage facilities to an approved City sanitary sewer. BES will make this determination based on the type of material stored and the proposed system receiving the discharge.

Uncovered storage areas: A shut-off valve shall be installed in the storage area so excess stormwater can be drained out of the activity area and directed either to the storm drainage facilities (*if clean*) or into the City sanitary sewer or authorized pretreatment facility (*if contaminated*). Except when excess stormwater is being discharged, the valve shall always be kept closed so any spills within the activity area can be effectively contained.

C) **Storage of hazardous materials** located in designated groundwater resource protection areas is subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003).

D) **Tank farms** shall follow the criteria established for bulk fuel terminals in **Section 4.2**. Exceptions may be granted, based on the product being stored. Requests for an exception will require an additional review process and may delay issuance of related building permits.

E) **Storage of reactive, ignitable, or flammable liquids** shall comply with the Uniform Fire Code as adopted by the State of Oregon. Source controls presented in this section are intended to complement, not conflict with, current fire code requirements. None of these requirements shall exclude or supersede any other requirements in this manual, other City permit requirements, or state and federal laws pertaining to water quality. Contact the Portland Fire Bureau (503-823-7366) and/or BES's Industrial Source Control Division (503-823-7122) for further information and requirements.

4.4 SOLID WASTE STORAGE AREAS, CONTAINERS, AND TRASH COMPACTORS

4.4.1 Applicability

The requirements in this section apply to all commercial and industrial development with facilities that store solid wastes (both food and non-food wastes). A solid waste storage area is a place where solid waste containers are collectively stored. Solid waste containers include compactors, dumpsters, and garbage cans. Requirements of this section also apply to activity areas used to collect and store refuse or recyclable materials, such as can or bottle return stations and debris collection areas.

This section applies to multi-family residential sites of three or more units if a shared trash collection area is proposed. However, the requirements of this section do not apply to single-family homes or debris collection areas used for the temporary storage of wood pallets or cardboard.

4.4.2 Requirements

The following design requirements apply for approval of solid waste storage and handling activity areas in the City of Portland. The text below clarifies each requirement.

ACTIVITY/ USE	REQUIREMENTS			
	(1) Cover	(2) Pavement	(3) Isolation	(4) Drainage
Multi-family (with shared trash areas)	X	X	X	X*
Commercial	X	X	X	X
Industrial	X	X	X	X
Compactors (regardless of use)		X	X	X
Can and bottle return stations	X	X	X	X

* If gravity service to the sanitary sewer lines cannot be obtained, a special request can be made to direct the drainage from the hydraulically isolated activity area to the development's stormwater pollution reduction facility. This applies only to multi-family uses. For more information, refer to **Additional Requirements** below.

1) COVER

A permanent canopy, roof, or awning shall be provided to cover the solid waste storage activity area and shall be constructed to cover the activity area so rainfall cannot come in contact with the waste materials being stored. The cover shall be sized relative to the perimeter of the hydraulically isolated activity area it is to cover. Runoff shall be directed from the cover to a stormwater disposal point that meets all applicable code requirements.

2) PAVEMENT

A paved waste storage area is required when a structural cover or trash compactor is used. The area shall be paved with asphalt or concrete and meet all applicable building code requirements. Sizing of the paved area shall adequately cover the activity area intended for refuse storage, or the trash compactor(s) and associated equipment.

3) ISOLATION

Hydraulic isolation shall be provided for the solid waste storage activity area and shall be designed to prevent uncontaminated stormwater runoff from entering the area and carrying pollutants away. Runoff occurring outside the hydraulically isolated area shall be directed to a stormwater disposal point that meets all applicable code requirements. This can be achieved by reverse grading at the perimeter of an activity area, perimeter curbing or berming, or the use of area drains to collect and divert runoff.

4) DRAINAGE

Drainage shall be provided for the hydraulically isolated solid waste storage area and directed to an approved city <u>sanitary sewer</u> or authorized pretreatment facility. A sanitary sewer drain is required for those areas that may be subject to refuse or suspected pollutants that pose a risk if the structural integrity of the trash receptacle is damaged or if its contents are exposed to rainfall.

<u>Non-gravity Option</u>
Activity areas that do not have gravity sanitary sewer service may be allowed to install a pressurized system. With these types of installations, the following items shall e provided at the time of building permit application:

1) Verification or evidence that gravity service cannot be obtained.
2) Details of an electronic sump pump system equipped with a float switch.
3) A completed Discharge Authorization (DAR) form.

Pressurized system installations are considered "permanent equipment" and deemed the property owner's liability in the event of system failure or if the property becomes vacated.

The Bureau of Development Services (BDS) Commercial Plumbing Division will review all sump pump or sewage ejector installations for compliance with the Uniform Plumbing Code and Oregon State Plumbing Specialty Code. The BES Source Control Division will review for compliance with this chapter of the *Stormwater Management Manual.*

5) ADDITIONAL REQUIREMENTS

Multi-family developments with shared trash areas may be allowed an alternative to the sanitary drain for the hydraulically isolated solid waste storage area. This activity area may be allowed to drain to the site's privately owned and operated stormwater pollution reduction facility if gravity service to the sanitary sewer pipe of the development cannot be obtained. For the alternative to be considered, information showing that gravity service cannot be obtained and a completed **Special Requests Form** shall be submitted. All other requirements previously outlined for multi-family uses shall apply.

4.5 EXTERIOR STORAGE OF BULK MATERIALS

4.5.1 Applicability

The requirements of this section apply to developments that stockpile or store materials in outdoor containers that may erode or have negative stormwater impacts. The materials are separated into three categories, based on risk assessments for each material stored: high-risk, low-risk, and exempt. These include, but are not limited to, the following general types of materials:

High-Risk Materials	Low-Risk Materials	Exempt Materials
• Recycling materials with potential effluent • Corrosive materials (e.g., lead-acid batteries) • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human wastes	• Recycling materials without potential effluent • Scrap or salvage goods • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products without potential effluent • Unwashed gravel/rock • Compost • Asphalt	• Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Clean concrete products (blocks, pipe, etc.) • Glass products (new, non-recycled) • Inert products

Materials with any of the following characteristics are exempt from the requirements of this section:

- Have no measurable solubility or mobility in water <u>and</u> no hazardous, toxic, or flammable properties.
- Exist in a gaseous form at ambient temperature.
- Are contained in a manner that prevents contact with stormwater (excluding pesticides and fertilizers).

4.5.2 Requirements

1) COVER

Low-risk materials shall be covered with a temporary plastic film or sheeting at a minimum.

High-risk materials shall be permanently covered with a canopy or roof to prevent stormwater contact and minimize the quantity of rainfall entering the storage area. Runoff shall be directed from the cover to a stormwater disposal point that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

2) PAVEMENT

Low-risk material storage areas are not required to be paved.

High-risk material storage areas shall be paved beneath the structural cover. Sizing of the paved area shall adequately cover the activity area intended for storage.

3) DRAINAGE

Low-risk material storage areas are typically allowed in areas served by standard stormwater management systems. However, all erodible materials being stored must be protected from rainfall.

If materials are erodible, a structural containment barrier shall be placed on at least three sides of every stockpile. The barrier shall be tall enough to prevent run-on of uncontaminated stormwater into the storage area and migration of the stored materials as a result of being blown or washed away. If the area under the stockpile is paved, the barrier can be constructed of asphalt berms, concrete curbing, or retaining walls. If the area under the stockpile is unpaved, sunken retaining walls or ecology blocks can be used. The applicant shall clearly identify the method of containment on the building plans.

For **high-risk** material storage areas, the paved area beneath the structural cover shall be hydraulically isolated through grading, structural containment berms or walls, or perimeter drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the contained area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer or authorized pretreatment facility.

4) ADDITIONAL REQUIREMENTS

A) A **Source Control Installations Form**, located in Section 4.10, shall be submitted as part of the building permit application to facilitate tracking of containment, sampling manholes, and shut-off valve installations.

B) **Storage of pesticides and fertilizers** may need to comply with specific regulations outlined by DEQ. For answers to technical questions, call DEQ's Northwest Region main office at 503-229-5263.

C) **A sampling manhole** or other suitable stormwater monitoring access point may be required to monitor stormwater runoff from the storage area. This may apply to certain types of storage activities and materials or if an alternative source control is proposed. This requirement complies with City Code Chapter 17.39.080, which requires appropriate stormwater disposal. BES Source Control staff will review for applicability of this requirement.

D) **Signage** shall be provided at the storage area if hazardous materials or other materials of concern are stored. Signage shall be located so it is plainly visible from all storage activity areas. More than one sign may be needed to accommodate large storage areas. Detailed information and examples are provided in Section 4.1.3.

E) **A shut-off valve** may be required for the structurally covered storage area if the applicant elects to install drainage facilities to an approved City sanitary sewer. BES will make this determination based on the type of material stored and the proposed system receiving the discharge.

F) **Storage of hazardous materials** that are toxic, carcinogenic, or halogenated solvents (within designated groundwater protection areas) are subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003).

4.6 MATERIAL TRANSFER AREAS/LOADING DOCKS

4.6.1 Applicability

The requirements in this section apply to all developments proposing the installation of new material transfer areas, or structural alterations to existing material transfer areas (e.g., access ramp regrading, leveler installations).

Two standard types of material transfer areas associated with buildings are:

1) Loading/unloading facilities with docks
2) Large bay doors without docks

The requirements apply to all material transfer areas, including loading/unloading docks, bay doors, and any other building access point(s) with the following characteristics:

- The area is designed (size, width, etc.) to accommodate a truck or trailer being backed up to or into it, and

- The area is expected to be used specifically to receive or distribute materials to and from trucks or trailers.

The requirements may not apply to areas that are used only for mid-sized to small-sized passenger vehicles and that are restricted (by lease agreements or other regulatory requirements) to storing, transporting, or using materials that are classified as domestic use. Examples of domestic uses include primary educational facilities (elementary, middle, or high school), buildings used for temporary storage (a lease agreement will need to be provided), and churches. Contact BES's Industrial Source Control Division at 503-823-7122 for help in determining if requirements apply.

4.6.2 Requirements

1) PAVEMENT

A paved material transfer area of asphalt or concrete shall be placed underneath and around the loading and unloading activity area and shall meet all applicable building code requirements. This will reduce the potential for soil contamination with potential impacts on groundwater, and will help control any acute or chronic release of materials present in these areas.

3) ISOLATION

Loading Docks

The first 3 feet of the paved area, measured from the building or dock face, shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away.

Bay Doors and Other Interior Transfer Areas

Bay doors and other interior transfer areas shall be designed so that stormwater runoff does not enter the building. This can be accomplished by grading or drains.

3) DRAINAGE

Loading Docks

Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer or authorized pretreatment facility. Surrounding runoff and drainage from the access ramp shall be directed away from the hydraulically isolated area to a stormwater disposal point that meets all applicable requirements of this manual.

Non-Gravity Option

Activity areas that cannot achieve gravity sanitary sewer service may be allowed to install a pressurized system. With these types of installations, the following items shall be provided at the time of building permit application:

1) Proof that gravity sanitary sewer service cannot be obtained.
2) Details of an electronic sump pump system equipped with a float switch.
3) A completed **Source Control Installations Form.**

Pressurized system installations are considered "permanent equipment" and deemed the property owner's liability in the event of system failure or if the property becomes vacated.

The Bureau of Development Services (BDS) Commercial Plumbing Division will review all sump pump or sewage ejector installations for compliance with the Uniform Plumbing Code and Oregon State Plumbing Specialty Code. The BES Source Control Division will review for compliance with this chapter of the *Stormwater Management Manual*.

Bay Doors and Other Interior Transfer Areas

Because interior material transfer areas are not expected to accumulate precipitation, installation of floor drains is not required or recommended. It is preferable to handle these areas with a dry mop or absorbent material. If interior floor drains are installed, they shall be plumbed to an approved City sanitary sewer or authorized pretreatment facility.

4) SIGNAGE

Signage shall be provided at the material transfer area and shall be plainly visible from all surrounding activity areas. Detailed information and examples are located in **Section 4.1.3.**

5) ADDITIONAL REQUIREMENTS

A) A **Source Control Installations Form**, located at the end of this chapter, shall be submitted as part of the building permit application to facilitate tracking of shut-off valve installations.

B) **Bay doors and other interior transfer areas** shall provide a 10-foot "no obstruction zone" beyond the entrance within the building. This will allow the transfer of materials to occur with the truck or trailer end placed at least 5 feet inside the building, with an additional staging area of 5 feet beyond that. The "no obstruction" zone shall be clearly identified on the building plan at the time of the building permit application, and shall be painted at the facility with a bright or fluorescent floor paint.

C) A **shut-off valve** may be required for the sanitary drainage facilities of the material transfer area. BES will make this determination, based on the type of material being transferred and the proposed system receiving the discharge.

Shut-off valves are required to protect the City sewer system or on-site infiltration facilities from spills of chemicals and other constituents that may provide a danger of widespread contamination, system damage, or risk to public health.

Shut-off valves are required for any of the following situations:

1) Site activity areas that are exposed to corrosives or oxidizers that can harm conveyance system components (such as battery acid).

2) Substances (such as oil and grease) that do not settle or remain in one location, and are capable of being dissolved in or float on top of water. These substances can spread rapidly into downstream systems, causing widespread impacts and difficult clean-up situations.

3) Substances that are known to infiltrate through soils and contaminate groundwater.

Valves located in material transfer areas are typically left open to facilitate drainage during normal conditions, and immediately closed in the event of a spill.

Prior to transfer activities of harmful substances, the valves shall be closed and reopened only after the transfer is complete. The shut-off valves must be located on private property and downstream of the exposed area's collection system.

All valves shall be installed and maintained in accordance with manufacturer specifications. For more information about shut-off valves and associated valve boxes, contact the Bureau of Development Services (BDS) Commercial Plumbing Department at 503-823-7302.

C) **Transport and handling of hazardous materials** that are toxic, carcinogenic, or halogenated solvents (located in designated groundwater protection areas) are subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003).

5) EXCEPTIONS

Drainage: The requirement for drainage from the hydraulically isolated area of the loading dock to be directed to an approved City sanitary sewer or authorized pretreatment facility may be waived if BES determines there is no gravity sanitary service available and an appropriately sized, underground temporary storage structure (such as a catch basin with no outlet or dead-end sump) is provided. For the exception and alternative to be considered, information showing that gravity service cannot be obtained and a completed **Special Requests Form** shall be submitted.

4.7 EQUIPMENT AND/OR VEHICLE WASHING FACILITIES

4.7.1 Applicability

The requirements in this section apply to all development with a designated equipment and/or vehicle washing or steam cleaning area. This includes smaller activity areas, such as wheel-washing stations. Single-family and duplex residential sites are exempt.

4.7.2 Requirements

1) COVER

The washing area shall be covered with a permanent canopy or roof so precipitation cannot come in contact with the washing activity area. Precipitation shall be directed from the cover to a stormwater disposal point that meets all applicable code requirements.

- **Covers 10 feet high or less** shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.

- **Covers higher than 10 feet** shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.

2) PAVEMENT

A paved wash pad of asphalt or concrete shall be placed under and around the washing activity area and shall meet all applicable building code requirements. Sizing of the paved area shall adequately cover the activity area, including the placement of the vehicle or piece of equipment to be cleaned.

3) DRAINAGE

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to an approved City sanitary sewer or authorized pretreatment facility. Surrounding runoff shall be directed away from the hydraulically isolated washing pad to a stormwater disposal point that meets all applicable requirements of this manual.

4) OIL CONTROLS

All vehicle and equipment washing activities will be reviewed for needed oil controls to comply with the City's sanitary sewer discharge limits. The following design criteria are established for oil/water separators discharging to a sanitary sewer:

A) Washing Areas Protected with a Cover or Located Inside a Structure

1) Baffled oil/water separators and spill control (SC-type) separators shall not be allowed for use with equipment and/or vehicle washing applications. *Note: Activities and processes of a washing facility change over time, and the introduction of heat and surfactants may occur.*

2. Coalescing plate separators shall be designed to achieve 100-ppm non-polar oil and grease in the effluent from the peak flow generated by the washing activity. Testing information must be submitted by the manufacturer of the unit that supports the 100-ppm effluent standard at the calculated flow rate.

   a. Standard flow from a 5/8" hose is estimated to be 10 gpm.
   b. For specially designed washing units, check the vendor specifications for maximum flow rates.

2) Any pumping devices shall be installed downstream of the separator to prevent oil emulsification.

3) Separator details must be shown on the building plans submitted at the time of building permit application and shall match manufacturer specifications and details, including the unit flow rate, effluent water quality, and maximum process flow rate.

B) Washing Areas Exposed to Rainfall (by exception only)

1) Washing areas exposed to rainfall will be accepted by exception only. Stormwater volume charges will be applicable because the City will charge the owner stormwater volume charges for the stormwater discharged to separated sanitary sewer systems. The stormwater volume charges will be based on the impervious area and average rainfall, or by the installation of a discharge meter. The discharge will be charged at sanitary sewer volume rates (City Code Chapter 17.36.010 (A)(2)).

2) Oil/water separators shall be installed with a high-flow bypass to route flows greater than the operational rate around the unit, unless the operational rate exceeds the flow rate generated by a 10-year storm, as calculated with the Rational Method ($Q=C*I*A$, $I=2.86''/hr$ for 10-year storm).

C) On-site Wash Recycling Systems

Wash recycling systems may be used for oil control as long as they can meet effluent discharge limits for the City's sanitary sewer system. A detail of the wash recycling system and vendor specifications identifying effluent efficiencies shall be submitted as part of the building plans at the time of building permit application.

5) EXCEPTIONS

A) Permanent Cover: If a washing activity area is generally used to service oversized equipment that cannot maneuver under a roof or canopy (cranes, sail boats, etc.) an exception to the roof or canopy requirement will be granted. A **Special Requests form**, located in Section 4.10, shall be submitted as part of the building permit application to evaluate exception qualifications.

B) Sanitary Sewer Connection: If an evaporation unit is installed as part of a wash recycling system, an exception to the sanitary sewer connection will be granted. NOTE: The cover requirement cannot be waived for evaporation units because of the sizing and capacity limitations of the individual units. A **Special Requests form**, located in Section 4.10, shall be submitted as part of the building permit application to evaluate exception qualifications.

4.8 STORMWATER AND GROUNDWATER MANAGEMENT FOR DEVELOPMENT ON LAND WITH SUSPECTED OR KNOWN CONTAMINATION

4.8.1 Applicability

The requirements in this section apply to all development projects that disturb property at risk, suspected, or known to contain pollutants in the soil or groundwater. This includes development that is surrounded by properties found to have trace pollutants. These requirements will also be applied to any property that is seeking to make a new connection to a Public storm system (whether a public separated storm sewer or a public underground injection structure, such as a sump) from a property that is at risk, suspected, or known to contain pollutants in the soil or groundwater. To avoid confusion with references to water quality pollutant throughout this manual, this section refers to pollutants as **contaminants** and/or **contamination**.

Because of local, state, and federal regulations, special handling and management of site soils, groundwater, and surface drainage may be necessary. As a result of these regulations, sites with suspected or known contamination require a more detailed review process and may delay issuance of related building permits. Applicants are advised to contact source control staff early on in the plan design process (before plan submittal) if they are aware or suspect the site has contaminants or is adjacent to a contaminated site.

To research contaminant information, refer to DEQ's facility profiler database, which can be found at: http://deq12.deq.state.or.us

If records indicate that a No Further Action (NFA) or Record of Decision (ROD) exists for your site, you must contact DEQ prior to pre- and post-construction activities to ensure conditions of record are not violated. For technical questions related to site contamination and clean-up, contact the Land Quality Division of DEQ.

All regulatory divisions or departments of DEQ referenced in this section can be reached by calling DEQ's Northwest Region Office at 503-229-5263.

Even if a site is not included in DEQ's tracking database, this does not mean that contamination may not be present. At a minimum, if a site has a history of commercial or industrial use, a Phase I site assessment should be performed prior to design.

Contaminants have the potential to become entrained and transported through exposure to construction activities and post-construction design elements of a development. The requirements in this section apply to:

- Excavation and stockpiling of contaminated soils (soil management)
- Disposal or re-use facilities related to groundwater, foundation or footing drains, interior floor drains in basements or sub-grade structures, construction dewatering, and surface stormwater treatment and conveyance systems

4.8.2 Requirements

Stormwater and groundwater discharges from sites suspected of contamination, whether proposed as a temporary construction connection or as permanent connection to any public system, will require a special authorization from BES. After reviewing the proposal and a characterization of the contaminants from the site, BES Source Control Division may make one of the following decisions:

- ➢ Approve discharges with restrictions such as described in these pages or as is necessary given the nature of the discharge.
- ➢ Require the applicant to obtain an NPDES permit from DEQ for the anticipated discharge prior to connection.
- ➢ Require that the applicant become part of BES' Industrial Pre-treatment Program.
- ➢ Deny the request to use the City storm or sump system.
- ➢ Allow unrestricted connection to the city storm sewers, with a testing point for future monitoring.

Contaminants, media, and site conditions are unique to each parcel of land. Sites at risk for contamination shall therefore be reviewed on a case-by-case basis.

1) SOIL MANAGEMENT

Stockpiles of contaminated soils shall be covered with temporary plastic film or sheeting to prevent stormwater from coming into contact with them.

Stockpile perimeters shall have a containment barrier on all four sides of every stockpile to prevent stormwater run-on and material run-off. Barriers can consist of concrete curbing, silt fencing, or other berming material, depending on the activity, size, and resources available.

Areas under stockpiles of contaminated soils are not required to be paved. However, an impervious layer shall be placed beneath the stockpile to protect uncontaminated areas from potential leachate.

2) CONSTRUCTION DEWATERING

All construction dewatering discharges resulting from groundwater or precipitation (rainfall) will be evaluated for contamination before disposal methods can be approved.

Laboratory analysis reports will be required, as defined in this chapter.

A temporary sampling point may be necessary. The temporary sampling point will be agreed upon between the City staff member processing the batch discharge authorization and the applicant.

Source control requirements will be identified as part of the review process of the laboratory analysis reports and the building permit application. Source controls, sampling points, and the disposal point shall be identified on the erosion control plan of the building permit application.

If on-site infiltration is the proposed method for disposal, authorizations are required from the Bureau of Development Services (BDS) and the Land Quality Division of DEQ. Infiltration systems for construction dewatering shall be located and maintained on private property, outside the public rights-of-way.

If on-site (proposed as a privately owned and maintained facility) underground injection control structure (UIC) is the proposed method for disposal, authorizations are required from BDS and the Water Quality Division of DEQ. All UICs shall be located and maintained on private property, outside the public rights-of-way.

If a public sanitary system is the proposed method of disposal, authorizations are required from BES and will be allowed only if extensive pretreatment is implemented and the discharge is approved through the BES appeal process. All groundwater and surface water discharges to a sanitary sewer system shall meet local discharge limits and will be subject to discharge volume charges. Discharges will be charged at sanitary sewer volume rates, as stated in City Code, Chapter 17.36.010(A)(2).

If a public stormwater system (such as a public sump system or storm sewer) is the proposed method of disposal, evaluations of discharge to the City's storm or sump system will be based on whether discharges meet, or can be pretreated to meet, requirements of the City's NPDES or other state and federal regulations for the receiving system, either groundwater or surfacewater.

Discharges to a combined sewer system may be flow restricted and shall meet local discharge limits, as stated in City Code, Chapter 17.34, Administrative Rules. Water Quality rules will also be applicable.

If a receiving stream is the proposed method for disposal, authorizations are required from BDS, the U.S. Army Corp of Engineers, and both the Land Quality and Water Quality Divisions of DEQ.

For technical assistance on obtaining a batch discharge authorization for construction dewatering activities, contact the BES Industrial Source Control Division at 503-823-7122.

3) POST-CONSTRUCTION SURFACE DRAINAGE SYSTEMS

If on-site infiltration is the proposed method for disposal, authorizations are required from the Bureau of Development Services (BDS) and the Land Quality Division of DEQ. Private infiltration systems shall be located and maintained on private property, outside the public rights-of-way. If crossings of public rights-of-way are necessary, authorizations and permits are required from BES and Portland's Office of Transportation (PDOT).

If on-site underground injection control structure (UIC) is the proposed method for disposal, authorizations are required from BDS and the Water Quality Division of DEQ. Private UICs shall be located and maintained on private property, outside the public rights-of-way. If crossings of public rights-of-way are necessary, authorizations and permits are required from BES and PDOT.

If a receiving stream is the proposed method for disposal, authorizations are required from BDS, the Army Corp of Engineers, and both the Land Quality and Water Quality Divisions of DEQ.
If crossings of public rights-of-way are necessary, authorizations and permits are required from BES and PDOT.

If an off-site Public sewer system is the proposed method for disposal, authorization is required from BES. Evaluations for discharges from sites with suspected contamination will be based on the following:

a) Surface drainage systems that are not exposed to industrial activities, contaminated soils, or subsurface discharges are not expected to contain contaminants and do not pose a threat to Public infrastructure. All discharges to a public sewer system will need an additional sewer connection permit.

b) A permanent monitoring point may be required to ensure compliance with local discharge regulations. If monitoring is necessary, a permanent structure (such as a sampling manhole or flow-through vault) shall be installed on the discharge line of the subsurface drainage system.

4) POST-CONSTRUCTION WATER RECLAIM OR RE-USE SYSTEMS

Water reclamation or re-use systems provide innovative ways to use natural resources and save money. However, using groundwater as a resource from sites at risk of contamination may require additional source controls and environmental compliance regulations, depending on the nature of the contaminants and the extent of the remediation that has been completed.

Authorizations for re-use systems are required from the Bureau of Development Services (BDS), BES, the Oregon Water Resources Department, and DEQ.

If surface drainage systems are the proposed resource, discharges are not expected to contain contaminants and do not pose a threat to City infrastructure. Review will verify that there is no interaction between groundwater and the surface.

<u>Non-potable uses</u> for plumbing fixtures and industrial equipment (e.g., cooling towers or boilers) will require the following:

a) A discharge meter shall be installed on the outlet of the re-use system for sewer billing purposes.

b) Industrial equipment bleed-offs or drain valves shall have discharges routed to the sanitary waste line of the facility.

c) Overflows from the re-use system, prior to use, are not considered a wastewater and shall have discharges routed to the storm disposal system of the facility.

<u>Irrigation systems</u> may encourage transportation of contaminants and require authorization from the Land Quality Division of DEQ prior to installation.

If subsurface drainage systems are the proposed resource, discharges may contain contaminants and will be evaluated for contamination before disposal methods can be approved.

<u>Non- potable uses</u> for plumbing fixtures and industrial equipment (e.g., cooling towers or boilers) will require the following:

a) A discharge meter shall be installed on the outlet of the re-use system for sewer billing purposes.

b) Industrial equipment bleed-offs or drain valves shall have discharges routed to the sanitary waste line of the facility. Discharges shall meet local discharge limits, as stated in City Code, Chapter 17.34, Administrative Rules.

c) Because overflows from the re-use system, prior to use, may contain contaminants, the requirements stated under **Post-Construction Subsurface Drainage Systems** apply.

d) A permanent monitoring point may be required to ensure compliance with local discharge regulations. If monitoring is necessary, a permanent structure (such as a sampling manhole or flow-through vault) shall be installed on the discharge line of the subsurface drainage system.

Irrigation systems may encourage transportation of contaminants and require authorization from the Land Quality Division of DEQ prior to installation.

> If groundwater is proposed for commercial or industrial uses of a development (e.g., non-potable uses or irrigation) authorization or a permit is required from the Oregon Water Resources Department (WRD) prior to use.
>
> Minimum requirements that warrant a permit for industrial and commercial groundwater wells include, but are not limited to, irrigation of areas greater than ½ acre and use of more than 5,000 gallons per day of water. Unique groundwater reuse systems (anything other than a standard supply well installation) will be reviewed on a case-by-case basis to determine permitting requirements (if applicable).
>
> For assistance in obtaining authorization for the use of groundwater, contact WRD's Multnomah County Water Master at 503-722-1410. For more information on water rights and groundwater regulations, see the WRD website at: **www.wrd.state.or.us**

5) POST CONSTRUCTION SUBSURFACE DRAINAGE SYSTEMS

In an area at risk for contamination, structures proposed below grade can greatly impact and add unexpected costs to the surface drainage systems, water reclaim or re-use systems, and subsurface drainage systems of a project.

All surface, subsurface and re-use systems will be evaluated for contamination risks before disposal and re-use methods can be approved.

If on-site infiltration is the proposed method for disposal, authorizations are required from the Bureau of Development Services (BDS) and the Land Quality Division of DEQ.

Private infiltration systems shall be located and maintained on private property, outside the public rights-of-way. If crossings of public rights-of-way are necessary, authorizations and permits are required from BES and Portland's Office of Transportation (PDOT).

If on-site subsurface injection is the proposed method for disposal, authorizations are required from BDS and the Water Quality Division of DEQ.

Private subsurface injection systems (Underground injection controls) shall be located and maintained on private property, outside the public rights-of-way. If crossings of public rights-of-way are necessary, authorizations and permits are required from BES and PDOT.

If a receiving stream is the proposed method for disposal, authorizations are required from BDS, the U.S. Army Corp of Engineers, and both the Land Quality and Water Quality Divisions of DEQ. If crossings of public rights-of-way are necessary to obtain access to an approved discharge point of a receiving stream, authorizations and permits are required from BES and PDOT.

If a Public sewer system is the proposed method for disposal, authorization is still required from BES. A permanent monitoring point may also be required to ensure compliance with local discharge regulations.

6) LABORATORY ANALYSIS REPORTS

Laboratory analysis reports are required to identify the characteristics and levels of contamination in the soils and groundwater of a site.

An additional review process will be applied to these laboratory reports to determine regulatory authority and requirements. Testing and analysis are highly recommended prior to submitting building permit applications. DEQ permitting and/or review may be required if contaminants are found and the levels of contamination appear to exceed the City's local discharge regulations. This may delay issuance of related building permits.

Laboratory analysis reports shall include the following information:

a) Analysis reports shall identify the elevation of the seasonal water table and identify the depth of any perched water aquifers.

b) Analysis reports shall identify the method of laboratory testing, the detection level and analytical method for detection, and the depth of any found contaminants in the soils.

c) Minimum test parameters for baseline contaminants shall include metals (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, and zinc), TPH (total petroleum hydrocarbons), and BTEX (benzene, toluene, ethyl benzene and xylene).

d) Test parameters may be required to include other contaminants identified through historical data, research, and environmental assessments (as recommended under Section 4.8.1).

e) If post-construction subsurface drainage or dewatering systems are proposed to discharge to a City sump system, test parameters will be required to include parameters identified in the federal Safe Drinking Water Act. Discharges to any public UIC must meet the standards listed for each parameter. The parameters and standards regulated by the federal Safe Drinking Water Act can be found on the internet at: **www.epa.gov/safewater/mcl.html#mcls**

7) ADDITIONAL REQUIREMENTS

All structural controls in this section require a Source Control Installations form, located at the end of this chapter. Typical controls that would need a DAR form include containment areas, shut-off valves, and oil/water separators. If an applicant requests an alternative or exception to any of the source controls identified in this section, the applicant shall complete the **Special Requests form**, located at the end of this Chapter. These types of requests require an additional review process and may delay issuance of related building or public works permits.

4.9 COVERED VEHICLE PARKING AREAS

4.9.1 Applicability

The requirements in this section apply to all development with a covered vehicle parking area, except single-family and duplex residential sites. Existing parking structures are not required to retrofit unless the structure is being redeveloped. New parking structures are required to meet these requirements.

4.9.2 Requirements

1) DRAINAGE

Top Floor Drainage of a Multi-Level Parking Structure

Stormwater runoff from the top floor shall be directed to a stormwater disposal point that meets all water quality requirements of this manual and any other applicable code requirements.

Lower Floor Drainage of a Multi-Level Parking Structure

Significant amounts of precipitation are not expected to accumulate in covered vehicle parking areas, and drainage facilities are not required for the lower floors. If the applicant elects to install drainage facilities, the drainage from the lower floors shall be directed to an approved City sanitary sewer.

Adjacent, Uncovered Portions of the Site

The surrounding uncovered portions of the site shall be designed so stormwater does not enter the covered parking areas. This can be accomplished through grading or drains.

EXCEPTIONS

Single-level covers (canopies, overhangs, and carports) are exempt from the requirements of this section.

4.10 FORMS AND REFERENCE MATERIALS

Signage Examples:

Spill sign samples recommend PMS 185 red and black on white

SOURCE CONTROL INSTALLATIONS

This form is required for structural source controls that address site characteristics and facility uses at risk for source point pollutant releases that are regulated or prohibited by local, state, and federal regulations. This form will be utilized for tracking and inspection purposes.

Existing facilities proposing a new connection to a Public Storm or Sanitary system, with the characteristics and uses identified in Chapter 4 of the City's Stormwater Management Manual, will be subject to the same structural source controls as new development, redevelopment, and tenant improvements.

(Please Print)

FACILITY INFORMATION

Facility Name (if applicable): ______________________________

Facility Address or Location: ______________________________

Type of business/facility: ______________________________

Facility Contact or Owner: ____________________ Phone No.: ______________

APPLICANT INFORMATION

Applicant's Name: ____________________ Phone No.: ______________

Applicant's Mailing Address: ______________________________

STRUCTURAL SOURCE CONTROLS (*check all that apply*)

Building Permit No. (if applicable): ______________________________

- ☐ Oil/Water Separator
- ☐ Shut-off Valve on Storm Drainage Line
- ☐ Shut-off Valve on Sanitary Waste Line
- ☐ Collection Device w/ No Outlet
- ☐ Discharge Meter
- ☐ Containment Area
- ☐ Wall Valve for Containment Area
- ☐ Spill Control Manhole
- ☐ Sampling Structure
- ☐ Other: ______________

The following items need to accompany this form:

- A detail or vendor specification for each proposed source control, and
- A site plan of the facility/property clearly identifying the location of each structural source control in reference to a permanent structure, to help assist the Source Control Division in field verification. (*A hand-drawn sketch, not to scale, is acceptable as long as it is legible.*)

City Comments:

SPECIAL REQUESTS
for
Source Controls

This form is required if you are requesting alternatives to standard structural source controls, removal or abandonment of existing source controls, exception qualifications per Chapter 4 of the City's Stormwater Management Manual, or other special requests you would like reviewed by the Source Control Division.

Special requests will require an additional review process and may delay issuance of related building permits. If this request cannot be satisfied by the Special Requests process through the Source Control Division, the tier one appeal process, as described in **Appendix A** of the Stormwater Management Manual, may be implemented by the applicant.

(Please Print)

FACILITY INFORMATION

Facility Name (if applicable): ______________________________

Facility Address or Location: ______________________________

Type of business/facility: ______________________________

Facility Contact or Owner: ____________________ Phone No.: ____________

APPLICANT INFORMATION

Applicant's Name: ____________________ Phone No.: ____________

Applicant's Mailing Address: ______________________________

SPECIAL REQUEST

Building Permit No. (if applicable): ______________________________

☐ Request for an alternative source control method

☐ Request to remove or abandon existing structural source control(s)

☐ Request for review of EXCEPTION qualifications.

☐ Other: ______________________________

The following items need to accompany this form:

- A detail or vendor specification for each alternative source control, and
- A site plan of the facility/property clearly identifying the location on the site that will be impacted by this special request. Existing and proposed utilities may need to be shown to ensure regulatory compliance with local, state and federal regulations. (*A hand-drawn sketch, not to scale, is acceptable as long as it is legible*.)

Page 1 of 2

(SPECIAL REQUESTS FORM CONT.)

Provide a brief explanation for your request (*Use additional pages if necessary.*): ____________________

TO BE COMPLETED BY SOURCE CONTROL DIVISION Date Received:

☐ Approved ☐ Denied ☐ Other (*see comments below*)

Date: __________ Signature: ______________________________

City Comments:

Page 2 of 2

City of Portland
Stormwater Management Manual

September 1, 2004

Appendices:

Appendix A
CITY CODE CHAPTER 17.38,
POLICY FRAMEWORK, APPEALS AND UPDATE PROCESS

A.1 CITY CODE CHAPTER 17.38

17.38.015

B. Adoption of Rules.

1. During the public review, a designee of the Director shall hear testimony and receive written comments concerning the proposed rules. The Director shall review the recommendation of his or her designee, taking into consideration the comments received during the public review process and shall either adopt the proposal, modify or reject it.

2. If a substantial modification is made to the rules submitted for public review, the Director may adopt the modification as Interim Rules or shall provide an additional public review prior to adoption.

3. Unless otherwise stated, all rules shall be effective upon adoption by the Director and shall be filed in the Office of the Director.

C. Interim Rules.

1. Notwithstanding paragraphs 17.38.015 A. and B., an interim rule may be adopted without prior notice upon a finding that failure to act promptly will result in serious prejudice to the public interest or the interest of the affected parties. The rule should include the specific reasons for such prejudice.

2. Any rule adopted pursuant to this paragraph shall be effective for a period of not longer than 180 days.

3. After adoption, public notice of interim rules shall be given by publication in a newspaper of general circulation and notice sent to the Office of Neighborhood Involvement. Such notice shall include the location at which copies of the full set of the interim rules may be obtained.

D. Initial Rules. Notwithstanding sections 17.38.015 A-C. above, the rules contained in the Stormwater Management Manual filed with the Council in conjunction with Ordinance No. 173330 may be adopted by the Director without further public review.

17.38.020 Purpose.

The purpose of this Chapter is to provide for the effective management of stormwater and drainage, and to maintain and improve water quality in the Watercourses and Water Bodies within the City of Portland as described in 17.38.025.

17.38.025 Stormwater Management Policies and Standards.

A. Stormwater shall be managed as close as is practicable to development sites, and stormwater management shall avoid a net negative impact on nearby streams, wetlands, groundwater, and other waterbodies. All local, state and federal permit requirements related to implementation of stormwater management facilities must be met by the owner/operator prior to facility use. Surface water discharges from on-site facilities shall be conveyed via an approved drainage facility.

B. The quality of stormwater leaving the site after development shall be equal to or better than the quality of stormwater leaving the site before development, as much as is practicable, based on the following criteria:

1. Water quality control facilities required for development shall be designed, installed and maintained in accordance with the Stormwater Management Manual, which is based on achieving at least 70% removal of the Total Suspended Solids (TSS) from the flow entering the facility for the design storm specified in the Stormwater Management Manual or Administrative Rules.

2. Land use activities of particular concern as pollution sources shall be required to implement additional pollution controls, including, but not limited to, those management practices specified in the Stormwater Management Manual.

3. Development in a watershed that drains to streams with established Total Maximum Daily Load limitations, as provided under the Federal Clean Water Act, Oregon Law, Administrative Rules and other legal mechanisms shall assure that water quality control facilities meet the requirements for pollutants of concern, as stated in the Stormwater Management Manual.

4. Stormwater discharge, which is not practicable to fully treat as defined in sections 17.38.025 B.1-3. and the Stormwater Management Manual, shall either: be treated in an off-site facility or be given the option of paying a stormwater off-site management fee. The Bureau will employ a methodology for calculating the fee that is based upon an average unit cost of on-site facilities where such facilities would be effective. The stormwater off-site management fee collected will be placed in a mitigation account to be used to mitigate the impacts that arise from off-site discharge of stormwater runoff. Information relating to sites that are paying fees will be evaluated in planning for capital improvement projects.

5. Not withstanding section 17.38.025 B.4., for any parcel created after the effective date of this Chapter, stormwater shall be fully treated on-site or within the original parcel from which the new parcel was created, or in a privately developed off-site facility with sufficient capacity, as determined by the Bureau.

C. The quantity of stormwater leaving the site after development shall be equal to or less than the quantity of stormwater leaving the site before development, as much as is practicable, based on the following criteria:

1. Development shall mitigate all project impervious surfaces through retention and onsite infiltration to the maximum extent practicable. Where onsite retention is not possible, development shall detain stormwater through a combination of provisions that prevent an increased rate of flow leaving a site during a range of storm frequencies as specified in the Stormwater Management Manual.

2. The Director may exempt areas of the city from the requirement of 17.38.025 C.1. if flow control is not needed or desirable and if:

a. Stormwater is discharged to a large waterbody directly through a private outfall, or
b. Stormwater is discharged to a waterbody directly through a separated public storm sewer having adequate capacity to convey the additional flow.

3. Any development that contributes discharge to a tributary to the Willamette River, other than the Columbia Slough, shall design facilities such that the rate of flow discharging from water quantity control facilities for up to a two-year storm does not lengthen the period of time the channel sustains erosion-causing flows, as determined by the Bureau. .

4. Facilities shall be designed to safely convey the less frequent, higher flows through or around facilities without damage.

5. Stormwater quantity discharge which is not practicable to be managed as defined in 17.38.025 C.1. through 17.38.025 C.4. and the Stormwater Management Manual shall either: be managed in an off-site facility or be given the option of paying a stormwater off-site management fee. The Bureau will employ a methodology for calculating the fee that is based upon an average unit cost of on-site facilities where such facilities would be effective. The stormwater off-site management fee collected will be placed in a mitigation account to be used to mitigate the impacts that arise from off-site discharge of stormwater runoff. Information relating to sites that are paying fees will be evaluated in planning for capital improvement projects.

6. Not withstanding section 17.38.025 C.5., for any parcel created after the effective date of this chapter shall fully manage stormwater on-site or within the original parcel from which the new parcel was created, or in a privately developed off-site facility with sufficient capacity, as determined by the Bureau.

17.38.030 Definitions.

A. Approved Drainage System**.** A system approved by BES which, in general, shall adequately collect, convey, treat and or dispose of stormwater runoff or other site discharge. Approved systems shall meet all requirements and specifications laid out in this code or in any BES design guidance document plus any applicable plumbing code provisions relating to the piped portions of any system.

B. "Capacity". The capacity of a stormwater system shall mean the flow volume or rate that a facility (e.g., pipe, pond, vault, swale, ditch, drywell, etc.) is designed to safely contain, receive, convey, treat or infiltrate stormwater that meets a specific performance standard. There are different performance standards for treatment, detention, conveyance, and disposal. Example: Public storm sewer pipes are required to convey the 10-year storm without surcharge, and the 25-year storm without damage to property or endangering human life or public health. Public infiltration sumps are required to infiltrate the 10-year storm with a safety factor of two. Combined sewers that overflow during a 25-year storm are not considered to have adequate capacity.

C. "Combination Facilities". Systems that are designed to meet two or more of the multiple objectives of stormwater management.

D. "Director"**.** The Director of the Bureau of Environmental Services, or the Director's designee.

E. "Disposal". The ultimate discharge point for the stormwater from a site. Disposal points can include drywells and sumps, soakage trenches, ditches, drainageways, rivers and streams, off-site storm pipes, and off-site combination sewers.

F. "Drainageway". An open linear depression, whether constructed or natural, which functions for the collection and drainage of surface water. It may be permanently or temporarily inundated.

G. "Impervious Surface". Any constructed surface that has a runoff coefficient greater than 0.8 (as defined in the Sewer Design Manual, Chart 10 "Runoff Coefficients"). Note: Decks which do not retain water are considered pervious.

H. "Off-Site Stormwater Facility". Any stormwater management facility located outside the property boundaries of a specific development, but designed to reduce pollutants from and/ or control stormwater flows from that development.

I. "On-Site Stormwater Facility". Any stormwater management facility necessary to control stormwater within an individual development project and located within the project property boundaries.

J. "Pollutants of Concern". Watershed-specific parameters identified by the Oregon Department of Environmental Quality (DEQ) as having a negative impact on the receiving water body.

K. "Practicable". Available and capable of being done as determined by the Director, after taking into consideration cost, existing technology, and logistics in light of overall project purpose.

L. **"**Public Works Project"**.** Public works project means any development conducted or financed by a local, state, or federal governmental body and includes local improvements and public improvements, as defined in Title 17, PUBLIC IMPROVEMENTS.

M. "Redevelopment"**.** Development that requires demolition or complete removal of existing structures or impervious surfaces at a site and replacement with new development. Maintenance activities such as top-layer grinding and repavement are not considered redevelopment.

Interior remodeling projects are also not considered to be redevelopment. Utility trenches in streets are not considered redevelopment unless more than 50% of the street width is removed and re-paved.

N. "Site Map". For purposes of this code section, a site map shall show the stormwater management facility location in relation to building structures or other permanent monuments on the site. The site map shall depict location of sources of runoff entering the facility and the discharge point and type of receiving system for runoff leaving the facility.

O. "Stormwater Management". The overall culmination of techniques used to reduce pollutants from, detain, and/ or retain, and dispose of stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows, or to incorporate sustainable building practices by reusing stormwater, on a development site. Public health and safety, aesthetics, maintainability, capacity of the existing infrastructure and sustainability are important characteristics of a site's stormwater management plan.

P. "Stormwater Management Facility". A single technique used to treat, detain, and/or retain stormwater to best preserve or mimic the natural hydrologic cycle, or to fit within the capacity of existing infrastructure, on a development site.

Q. "Tract". A tract is a section of land set aside from development during the Land Division phase of development. Tract as used in this code section shall be the definition of tract as described in Title 33 of the City Code.

R. "Water Body"**.** Rivers, streams, sloughs, drainages including intermittent streams and seeps, and ponds, lakes, aquifers, wetlands, and coastal waters.

S. "Watercourse". Watercourse means a channel in which a flow of water occurs, either continuously or intermittently, and if the latter with some degree of regularity. Watercourses may be either natural of artificial.

T. **"**Water Quality Control/Pollution Reduction Facility"**.** Refers to any structure or drainageway or drainage device that is designed, constructed, and maintained to collect and filter, retain, or detain surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality. These facilities may include, but are not limited to, constructed wetlands, water quality swales, and ponds that are maintained as stormwater quality control facilities.

U. "Water Quantity Control Facility". Refers to any structure or drainage device that is designed, constructed, and maintained to collect, retain, infiltrate, or detain surface water runoff during and after a storm event for the purpose of controlling post-development quantity leaving the development site. These facilities may include, but are not limited to, constructed wetlands, infiltration basins, and wet ponds that are maintained as stormwater quantity or quality control facilities.

V. "Wetland"**.** An area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas except those constructed as water quality or quantity control facilities. Specific wetland designations shall be made by the Corps of Engineers and the Division of State Lands.

17.38.040 Stormwater Quality and Quantity Control Facilities Required.

No plat, site plan, building permit or public works project shall be approved unless the conditions of the plat, permit or plan approval require installation of permanent stormwater quality and quantity control facilities designed according to standards or guidelines established by the Director of the Bureau of Environmental Services and as specified in the City of Portland's Stormwater Management Manual.

A. Exemptions. The requirements of this Chapter for stormwater management do not apply to:

1. Development for which an application for development approval is accepted by the permitting agency prior to July 1, 1999 shall be subject to the requirements in place at the time of application.

2. Development, whether public or private, that does not result in impervious surface coverage or results in coverage that is de minimus, such as fences, environmental enhancement projects, buried pipelines or cables, and utility lines.

3. Transportation improvements which will not directly increase non-point source pollution or quantity of stormwater runoff once construction has been completed (i.e., pavement overlays).

4. Impervious surface created by a water quality or water quantity control facility. Paved or compacted gravel facility access and maintenance roads that extend beyond the facility itself are not exempted from treatment requirements.

B. Appeals. Any permit applicant aggrieved by a decision, interpretation, or determination made pursuant to the administration of the Stormwater Management Manual may appeal such action in accordance with 17.38.040 B.1. and B.2.

1. In order to provide for reasonable interpretation of the provisions of the Stormwater Management Manual, the Director shall establish an internal Administrative Appeals Committee and an External Appeals Board. The Commissioner in charge of the Bureau of Environmental Services shall appoint members of the External Appeals Board.

2. Applicants shall file appeals in accordance with the appeals process procedures specified in the Stormwater Management Manual.

C. Maintenance of Water Quality and Quantity Control Facilities.

1. All new development, redevelopment, plats, site plans, building permits or public works projects, as a condition of approval, shall be required to submit an operation and maintenance plan for the required stormwater quality and quantity control facilities for review and approval by the Bureau of Environmental Services. A water quality or quantity control facility that receives stormwater runoff from a public right-of-way shall be a public facility, unless the right-of-way is not part of the city road maintenance system.

a. The information required in the operation and maintenance plan shall satisfy the requirements of the Stormwater Management Manual (SWMM). Applicants are encouraged to use the O & M Plan template provided in the SWMM. The Plan shall include and not be limited to:

(1) Design plans of the specific facility and related parts, including design assumptions.

(2) A schedule for routine inspection, including post storm related inspections.

(3) A description of the various facility components, the observable trigger for maintenance, and the method of maintenance, including appropriate method of disposal of materials.

(4) The intended method of providing financing to cover future operations and maintenance.

(5) The party or parties responsible for the maintenance of the facility including the means of effecting contact, including contact means for emergency situations. The party may be an individual or an organization.

b. A maintenance log is required. The log shall provide a record of all site maintenance related activities. The log shall include the time and dates of facility inspections and specific maintenance activities. The log shall be available to City inspection staff upon request.

2. Failure to properly operate or maintain the water quality or quantity control facility according to the operation and maintenance plan may result in a civil penalty as specified in 17.38.045, Enforcement.

3. A copy of the operation and maintenance plan shall be filed with the Bureau of Environmental Services. Staff may require a site map to be recorded and filed with the appropriate county Department of Assessment and Taxation.

A.2 POLICY FRAMEWORK

The Stormwater Policy Advisory Committee (SPAC) was established in April 1996 at the direction of the City Commissioner of Public Works. SPAC members included representatives of City bureaus, the Homebuilders Association, Metro, the Oregon Department of Environmental Quality, watershed advocates, and the development community. The SPAC was charged with recommending stormwater management policies to the Bureau of Environmental Services (BES). In addressing stormwater issues, the SPAC also considered other City goals and policies for environmental protection, density, transportation, and economic development.

In July 1997, the SPAC submitted and City Council accepted policy recommendations for new development (*Final Recommendations: Stormwater Management Requirements for New Development*). Council directed BES to develop this *Stormwater Management Manual* to implement policy recommendations for development. The *Stormwater Management Manual* was adopted on July 1, 1999. The *Stormwater Management Manual* is part of BES's Administrative Rules, authorized by Portland City Code Chapter 17.38, adopted by the Director of BES following a public review process, and filed with the City Auditor as required by Portland City Code Chapter 1.07.

In spring 1999, the City Council established the Stormwater Advisory Committee (SAC), whose members represent environmental, development, engineering, business, and community interests. One of the SAC's tasks was to review and make recommendations regarding changes to the manual. The SAC presented its recommendations to Council in April 2000 and again in August 2002. In addition, a public review process was conducted to obtain public comment on the manual. The SAC recommendations, public comments where appropriate, and BES staff changes are incorporated into this revised manual.

The policies that form the basis for this manual are codified in City Code Chapter 17.38, which is restated above.

A.3 APPEALS PROCESS

BES's appeals process allows development applicants to appeal staff interpretation of the City Code and adopted policies and procedures that guide the review of development proposals. City Council has adopted the appeals process. Applicants may appeal any issue related to interpretation of the stormwater management policy. For example, an applicant may appeal staff assessment of a site's stormwater management level or a permit denial. Applicants may not appeal the content or requirements of the policy, or technical parameters such as design storms, coefficients, and other technical criteria through this appeals process.

This process is not intended to address requested changes to technical specifications as adopted in the *Portland Standard Construction Specifications* or the *Bureau of Environmental Services Sewer Design Manual*. In these cases, applicants should contact BES's Development Assistance (503-823-7761) to request consideration by the BES Standards and Practices Committee. The committee has a separate process to consider changes to technical standards, such as the use of new stormwater management technologies.

Note: "Special circumstances," as described in **Section 1.11**, are part of the standard application process and are not considered an appeal, unless the applicant is appealing denial of a special circumstance designation.

A.3.1 Tier One Appeal

Tier one is an appeal to BES's Administrative Appeals Committee, comprising the Chief Engineer, Development Services Manager, and Pollution Prevention Services Manager (or their designees). Applicants must notify BES of their appeal in writing, specifying the reason for the request and supporting their position with technical and factual data.

The Development Services Manager reviews all appeals applications for completeness. Once an application is complete, the process operates on a turnaround of 10 working days. The Development Services Manager schedules a meeting of the Administrative Appeals Committee and notifies the applicant of the meeting date, place, and time. The applicant may, but is not required to, attend the meeting. At the meeting, the Development Services Manager (or designee) presents a brief, cohesive overview of the questions and issues raised in the appeal. The applicant may briefly speak in support of the request. The committee reaches decisions by a majority opinion of the members. All decisions are recorded and mailed to the applicant.

A.3.2 Tier Two Appeal

Applicants not satisfied with the actions of the Administrative Appeals Committee may submit a written request for a hearing by BES's External Appeals Board. This five-member board is appointed by the Commissioner of Public Works to serve two-year terms. It also serves as the appeal board for the City's *Erosion Control Manual*, and may be convened for other appeals to BES staff decisions, as determined by BES's Director. The Development Services Manager performs administrative duties.

The Development Services Manager schedules a board meeting to occur within 14 days of receipt of the written request and notifies the applicant of the meeting date, place, and time. Public notice of the appeal request is given. A board meeting may not take place unless at least three members are present. The Development Services Manager presents a cohesive overview of the questions and issues raised in the appeal. The applicant, if present, may briefly address the board. Decisions are reached by a majority opinion of the board. All decisions are recorded and mailed to the applicant. Decisions of the board are binding.

A.4 UPDATE AND AMENDMENT PROCESS

This *Stormwater Management Manual* will be reviewed a minimum of every 3 years and updated as necessary. The review process will include:

- Consideration of changed and new technologies
- Review of appeals made during the preceding interval
- Review of requests for variances to standard design criteria for public and private facilities
- Review of all performance-based approaches approved since the last manual revision
- Review of recommendations from the Stormwater Advisory Committee
- Review of community comments and concerns
- Adjustment of internal review processes and submittal requirements
- Incorporation of new sections and issues

The amendment process will also include a mailing to interested persons to solicit suggestions for amendments or procedural changes; a public meeting to review amendments and solicit input; and documentation and explanation of any changes made.

Suggestions for changes and improvements can be made at any time and should be sent to:

Attn: Steve Fancher
City of Portland, BES
1120 SW 5th Ave., Room 1100
Portland, OR 97204

Any changes to the current stormwater management policies will require the approval of City Council. If changes to the manual are proposed, the Chief Engineer will distribute any proposed manual improvements to interested parties and internal staff no later than May 1 of the year the manual is to be revised. The amended manual will be approved by the Chief Engineer and Bureau Director no later than September 1 of the year the amendments will occur.

Appendix B

CITY OF PORTLAND, OREGON
BUREAU OF ENVIRONMENTAL SERVICES

VENDOR SUBMISSION GUIDANCE

FOR

EVALUATING STORMWATER TREATMENT TECHNOLOGIES

February 2001, Updated September 1, 2004

INDEX

VENDOR SUBMISSION GUIDANCE FOR EVALUATING STORMWATER TREATMENT TECHNOLOGIES

February 20, 2001, Updated September 1, 2004

I. Introduction

The City of Portland's Stormwater Management Manual provides stormwater pollution reduction requirements and guidance. BES specifies design criteria, such as pollution reduction storm intensity and volume, and facility performance goals. Facilities need to be designed to satisfy those criteria as stand-alone systems or as part of a treatment train approach.

Chapter 2.0 presents stormwater pollution reduction facility designs and includes a section on manufactured stormwater treatment technologies. Stormwater treatment technologies and the knowledge base around them are rapidly evolving, and as such no proprietary facility names are included in the Stormwater Management Manual. Rather, BES will keep an updated list of technologies that have been approved for stand-alone and pretreatment uses.

This guidance is designed to provide a process of designating approval levels for manufactured treatment technologies. To be approved for use as a stand-alone stormwater pollution reduction facility, the protocols of this document must be followed. Results must indicate that the facility performs to Portland's design standards (see Performance Criteria section below, and Data Evaluation section, Page B-14).

This guidance will also define "TSS (Total Suspended Solids) removal", and provide the equations necessary to calculate it. Portland's method for evaluating test results, which includes provisions for influent concentration, is also included (See Data Evaluation section, Page B-14).

II. Performance Criteria

DESIGN STORM

Flow rate-based pollution reduction facilities shall be sized to treat 90% of the average annual Portland runoff. When used with the Rational Method, the following rainfall intensities will result in flow rates that achieve this goal (see Appendix E of the Stormwater Management Manual).

Site's Time of Concentration (Minutes)	Rainfall Intensity (Inches per Hour)
5	0.19
10	0.16
20	0.13

REQUIRED POLLUTION REDUCITON PERFORMANCE GOALS

Basic Pollution Reduction Performance Goal

The basic pollution reduction performance goal for the entire city is 70% TSS (Total Suspended Solids) removal from 90% of the average annual runoff. TSS is defined as "matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter (larger than coarse sand, also see Distribution of Sediment Sizes Table, Page B-9).

Influent concentration of TSS is known to greatly impact the ability of a facility to remove 70% TSS, so it is important to specify limits to be used in performance tests. BES will use the "Line of Comparative

Performance©" method, developed by Dr. Gary Minton of Resource Planning Associates (See Charts 1 through 3 in the Data Evaluation section, Pages B-14 and 14) to determine whether or not a facility meets this requirement. These lines were generated from test data on the TSS removal efficiencies of grassy swales and sand filters and modified to account for Portland's 70% TSS removal standard. The premise behind using these lines of performance is that grassy swales and sand filters have been widely accepted as adequate-performing treatment facilities. These, as well as other treatment BMPs, remove a higher percentage of TSS with higher TSS influent concentrations. It is not fair or practical to require 70% TSS removal from clean stormwater. This method of evaluation, however, accounts for this dilemma. Manufactured technologies will not be expected to outperform grassy swales and sand filters, but data points must be comparable, with a certain percentage falling above the "Line of Comparative Performance©" for the facility to be accepted as a "Presumptive Approach" in the Stormwater Manual. As a low-level baseline, a facility must also achieve an effluent goal of no more than 20 mg/l TSS for low influent concentrations (< 70 mg/l).

TMDL Enhanced Performance Goal

Certain watersheds within the City of Portland have established TMDLs (Total Maximum Daily Loads). The TMDLs apply specific pollution control requirements to designated pollutants of concern. To ensure that new development does not contribute pollutants of concern to a TMDL watershed, pollution reduction facilities are required to demonstrate specific removal rates for those specific pollutants.

To be considered for use as a stand-alone facility in a TMDL watershed, a manufactured technology must demonstrate removal efficiencies for specific pollutants of concern, as well as TSS. See Section 1.5.2 of the Stormwater Management Manual for a current list of TMDL watersheds with corresponding pollutant parameters.

Oil and Grease Performance Goal

Certain site uses within the City of Portland, such as high-use or high-risk parking lots, require additional treatment for oil and grease. The Stormwater Manual currently only recognizes oil/water separators for the pretreatment of oil and grease. To be considered for use as an oil/water separator, a manufactured technology must demonstrate adequate performance. Adequate performance needs to include: the removal of oil droplets from 50 to 60 microns in size, and the ability to achieve effluent efficiencies of 10 ppm or mg/L for influent concentrations exceeding 50 ppm or mg/L.

Pretreatment Performance Goal

A facility may be approved for pretreatment use only. In this case, the facility would be constructed in conjunction with another pollution reduction facility as a "treatment train" to accomplish the basic or enhanced performance goal. To be approved as a pretreatment facility only, data pertaining to the assessment protocol should be submitted. However, the level of performance will not need to meet basic pollution reduction performance goals. The facility will need to demonstrate the ability to remove large debris and the larger range of TSS particle sizes (see Distribution of Sediment Sizes Chart on page B-9), as approved by BES.

REQUIRED PERFORMANCE

Manufactured technologies claiming effectiveness for the listed pollutants must demonstrate (based on data provided per the Technology Assessment Protocol described below) that the above treatment performance goals will be generally achieved. Facilities shall be designed to perform without maintenance for one full year. In addition, factors other than treatment performance are important and will be evaluated to determine appropriate use of the emerging technology. Technologies may be approved as "Presumptive Approaches", which are then presumed to comply with the City's basic pollution reduction performance goal, or as pre-treatment facilities, only accepted in combination with other facilities. Facilities demonstrating compliance with enhanced or oil and grease performance goals may be added to applicable

Stormwater Manual sections in future revisions. Facilities that don't demonstrate adequate maintainability (See Section E, Page B-11) will not be included in the Stormwater Management Manual and will not be accepted for use within the City.

III. Technology Assessment Protocol

This testing protocol is based on protocols developed by other jurisdictions in the northwest. The Washington Chapter of the American Public Works Association (APWA), the Washington Department of Ecology, the City of Olympia, and the City of Sacramento/ Sacramento County have all developed very similar protocols, and were all instrumental in the development of this one. In this document, BES has tailored various sections of these protocols to fit Portland's design standards. BES reserves the right to change or update this document at any time. As design standards change, compliance with this protocol does not "grandfather" any manufactured facilities into the Stormwater Manual. BES reserves the right to request additional information at any time, and may remove technologies from accepted status after gaining further experience with them, or as new data becomes available. If a vendor wishes to use a different protocol, it is highly recommended to submit protocol details to BES for review prior to initiating tests.

REQUIRED NUMBER AND TYPES OF STUDIES

For BES to adequately evaluate the performance of a facility, a sufficient number of data points, or tests, must be submitted by the manufacturer. The submission of at least 30 tests will be deemed adequate for review. A "test" is defined as a controlled study that meets the requirements set forth in this protocol and results in a single data point which can be plotted on an Influent TSS (mg/L) vs. Removal Efficiency (%) curve (see Chart 3, Page B-15). Removal efficiency shall be calculated using methods specified on page B-10 of this report. At least half of the tests must come from field installations; either field performance studies with real storms or field performance studies with artificial storms.

Testing by "Independent Entities"

Testing of technologies may be conducted by qualified "independent entities" such as consultants, universities, local, state, or federal agencies. Testing may also be sponsored by the manufacturers themselves, but actual sampling, testing, and laboratory reporting must come from a qualified laboratory.

A. FIELD PERFORMANCE STUDIES WITH REAL STORMS

For inclusion in the Stormwater Manual as a stand-alone "Presumptive Approach", at least 15 data points must be obtained from actual field installations. These can come from field studies with real or artificial storms. At least two different land-uses must be represented, including medium density residential, retail commercial, non-retail commercial, or industrial. Testing within transportation corridors, including public or private streets within these land-uses, is encouraged. The purpose of this is to obtain a range of influent concentrations representative of typical storm water runoff. While it is acknowledged to be more difficult and expensive than laboratory testing, field testing will ensure that situations existing in "real-life" will be mimicked to the maximum extent practicable.

The following storm characteristic requirements must be met for field tests with real storm events, and must be documented and submitted to BES for acceptance.

NUMBER AND CHARACTERISTICS OF SAMPLED STORMS

<u>Minimum Number of Sampled Storms</u>

For acceptance as a stand-alone "Presumptive Approach", 5 storm events from three different sites must be submitted for a total of 15 storms. Real or artificial storm events can be used. At least two different land-uses must be represented, from either medium density residential, retail commercial, non-retail commercial, or industrial. Testing within transportation corridors, including public or private streets within these land-uses, is encouraged. The purpose of this is to obtain a range of influent concentrations representative of typical storm water runoff. For possible acceptance as a pretreatment device, at least 5 storm events must be submitted. To represent seasonal differences if only real storms are used, the tests shall occur throughout the calendar year. No more than 70% of the real storms may be sampled during the dry season (May through September) or during the wet season (October through April).

<u>Minimum Storm Depth</u>

The minimum total storm depth shall be 0.12 inches. As a guideline, at least 50% of the sampled storms should exceed 0.42 inches, and at least 10% of the sampled storms should exceed 0.83 inches.

<u>Minimum Facility Flow Rate</u>

Obtain data for a range of flows, from 10 to 100% of the design flow for off-line facilities, and from 10 to 125% for facilities designed to be flow-through, on-line facilities. Exceeding the design flow will demonstrate the facility's ability to retain previously trapped pollutants during high-flow periods. This requirement will most likely be accomplished through field testing with artificial storms.

*<u>Start/ End of Storm Event</u>***:** A storm event is preceded and followed by at least six hours of dry weather.

<u>Minimum Runoff Duration</u>: 6 Hours.

<u>Minimum Average Rainfall Intensity</u>

Minimum average rainfall intensity shall be 0.02 inches/ hour. As a guideline, at least 50% of the storms should exceed 0.03 inches/ hour, and at least 10% should exceed 0.05 inches/ hour.

Maximum Average Rainfall Intensity: Maximum average rainfall intensity shall be 0.1 inches/ hour.

SAMPLING SPECIFICATIONS

<u>Type of Samples</u>

Flow-weighted composite samples (Event Mean Concentration or EMC), except pollutants or technologies for which grab sampling is mandated by sampling protocols. Document all sample types for BES review.

<u>Sampling Procedure</u>

To the maximum extent practicable, sample the entire runoff period. As a guideline, sample at least 75% of the total volume of each storm. The final composite sample shall comprise at least 10 influent and 10 effluent sub-samples collected throughout the storm. Plot sampling times on a copy of the runoff hydrograph.

<u>Sampling Locations</u>

If Method #1, 2, or 3 (Page B-10) is used to calculate Removal Efficiency: Collect influent samples and measurements of flow rates and volumes at a point upstream of the treatment system, before any flow bypasses. Collect effluent samples and measurements of flow rates and volumes at a point downstream of the treatment system after bypassed and treated flows are rejoined.

If Method #4 (Page 10) is used to calculate Removal Efficiency: Ensure that the unit has been thoroughly cleaned and all sediment removed prior to start of test. Collect influent samples and measurements of flow rates and volumes at a point upstream of the treatment system. Immediately after test, block incoming flows and remove collected pollution for analysis.

Document all sampling locations for BES review.

<u>Parameters of Interest</u>

Parameters of interest include: total suspended solids (TSS), total dissolved solids, BOD, temperature, pH, hardness, total recoverable and dissolved metals including zinc, copper, lead, and cadmium, total and ortho-phosphate, total nitrogen, total petroleum hydrocarbons (NWTPH-Dx and –Gx, silica gel), visible sheen, bacteria (E. coli), nitrate-N, and ammonia-N. The vendor may submit any additional parameters that are deemed to be relevant to facility performance.

The vendor should tailor its sampling procedure to support the treatment goal. To be included in the Stormwater Manual as a general "Presumptive Approach", TSS needs to be sampled. To be considered as an oil/ water separator, Total petroleum hydrocarbons (NWTPH-Dx and –Gx, silica gel) and visible sheen needs to be tested. To be considered for use in TMDL watersheds, other pollutants of concern must be addressed. Because pollution removal parameter requirements tend to change over time, it is in the vendor's best interest to evaluate as many pollutants as possible. Testing methods and procedures are not included in this document for all pollutants of interest, and therefore must be submitted to BES with any testing data.

<u>Sample Handling and Reporting</u>

The methods of sample preservation and analysis are to be documented and submitted with test results. A qualified laboratory shall analyze samples. Results shall be analyzed and reported by entities independent of the vendor. The report shall discuss any discarded samples, QA/QC, duplicates, and ignored data. Analyzation techniques should not employ very minute samples, such as the "10 ml technique".

ACCUMULATED SEDIMENT TESTING

At the end of the test period, remove, weigh, and analyze accumulated sediment. Evaluate the sediment for the following: total dry weight, moisture content, particle size distribution, organic content, TPH, total phosphorus, and total zinc, copper, cadmium, and lead. Analyze particle size distribution using both wet and dry sieve test procedures following ASTM methods. Analyzing particle size distribution is very important in determining a facility's ability to remove the full range of sediment sizes (see table on page B-9). Quantify or otherwise document gross solids (debris, litter, and other particles exceeding 1 mm in diameter) and oil accumulations.

GROSS SOLIDS TESTING

At the end of the test period, remove, weigh, and describe accumulated gross solids. Compare gross solids collected in the facility with gross solids bypassed downstream, measured through collection in mesh bags with one-millimeter openings.

RAINFALL MONITORING

Rainfall shall be measured at a representative site. Document site location and distance from facility.

GEOGRAPHIC SETTING

Sites in the Pacific Northwest (SCS Type 1A Rainfall Distribution) are preferred, but not required, as long as rainfall and runoff measurements are within tolerances specified on page B-7.

B. FIELD PERFORMANCE STUDIES WITH ARTIFICIAL STORMS

Field performance studies with artificial storms may be submitted by vendors. The procedures described above for "real" storms must be followed, and additional data on the methods used to calculate and field-distribute the artificial storms must be documented and submitted. An artificial hydrograph or series of constant flow rates must be formulated and followed during the field test. It is highly recommended that the vendor submit this artificial hydrograph to BES for review prior to field testing.

C. LABORATORY PERFORMANCE STUDIES

BES recognizes that laboratory testing provides useful information under controlled conditions. Vendors may submit laboratory performance studies for consideration. Up to one-half (15) of the performance studies may be performed in the laboratory.

Removal rates for tests using potable water, spiked with pollutants, have generally been shown to be higher than tests using “real” storm water. Real storm water is therefore preferred when laboratory testing is employed, and should be used for at least half of the tests. When real storm water is used, one performance study shall be comprised of at least 10 influent and 10 effluent samples collected throughout the testing period (treatment efficiency calculation method #1, Page B-10), or 10 influent samples collected throughout the testing period and one final captured load mass (treatment efficiency calculation method #4, Page B-10). Documentation of the method of acquisition of test water must be submitted to BES for approval.

Spiked test water may be used for up to seven studies. When spiked test water is used, one study shall consist of either; 1) a test performed on water loaded with the full range of particle sizes, or 2) a series of tests on each separate particle size. Treatment efficiency calculation method #4 on page B-10 shall be used in either case. TSS added to laboratory water shall conform to the particle size distribution shown in the table below. Documentation of the composition of test water must be submitted to BES for approval.

TABLE: DISTRIBUTION OF SEDIMENT SIZES (STANDARD SIEVE)

PARTICLE DIAMETER	% LESS THAN (WEIGHT)
< 1,000 micron	100%
< 707 micron (coarse sand)	95 to 100%
< 595 micron	90 to 95%
< 420 micron (medium sand)	85 to 90%
< 297 micron	80 to 85%
< 177 micron (fine sand)	75 to 80%
< 88 micron (very fine sand)	50 to 75%
< 44 micron (coarse silt)	25 to 50%
< 16 micron (medium silt)	0 to 25%
<8 micron (fine silt)	0%

D. TREATMENT EFFICIENCY

There are many different methods used to calculate treatment efficiency, four of which are shown below. Method #1 and #4 calculate efficiencies for individual storms, while method #2 and #3 calculate average efficiencies over a number of storms. While any of these described methods are acceptable for use, methods 1 and 4 require fewer storm events to be sampled and are therefore easier to perform. Describe which treatment efficiency methods below were used and include calculations. All are expressed as percentages. Any samples analyzed below detection limits may either be included at the detection limit, or be excluded (with a notation to that effect).

Method #1: Removal in each storm calculated as:

100(flow-weighted influent concentration – flow-weighted effluent concentration) / flow-weighted influent concentration

Where: All concentrations are averages of the 10 flow-weighted sub-samples.

Method #2: Aggregate removal of the storms sampled as:

100(A-B) / A

Where: A = (influent concentration Storm 1)(flow of Storm 1) + (influent concentration of Storm 2)(flow of Storm 2) +…(influent concentration of Storm N)(flow of Storm N)

B = (effluent concentration of Storm 1)(flow of Storm 1) + (effluent concentration of Storm 2)(flow of Storm 2) +…(effluent concentration of Storm N)(flow of Storm N)

Where concentrations are flow-weighted, and flow = average storm flow or total storm volume (vendor's choice).

Method #3: Efficiency based on geometric mean:

100(A-B) / A

Where: A = Geometric mean of all products of flow-weighted influent concentration times average storm flow or total storm volume.

B = Geometric mean of all products of flow-weighted effluent concentration times average storm flow or total storm volume.

Method #4: Removal in each storm calculated as:

Efficiency = 100(Captured load mass) / (Influent load mass over entire storm)

Where: Captured load mass = Mass of accumulated TSS in the treatment facility during testing period

Influent load mass over entire storm = Flow-weighted influent concentration times total storm volume through facility, or for laboratory tests with spiked water, total mass of added TSS. Note: TSS gradation must comply with table on page B-9.

E. FACTORS OTHER THAN TREATMENT PERFORMANCE

BES staff must make reasoned decisions about storm water treatment technologies. To do so, all relevant factors need to be evaluated, while recognizing the critical importance of the technology's verified treatment performance for a target group of pollutants. Given the limited experience with emerging technologies, this is an arena where "best professional judgement" based on the weight of evidence is appropriate. To be accepted as a publicly owned and maintained facility, the vendor must present the following data to BES's *Standards and Practices Committee*, and receive their official consent. To be accepted for use as private facilities, the vendor must submit the following data to the BES address on page B-13.

Applications

1) How does the facility work? How does it remove pollutants?
2) For which applications (e.g. land uses, pollutants) does the vendor recommend this technology? Why?
3) How many systems are installed in the United States? Provide at least three references with names and telephone numbers. Provide specific model numbers.
4) Provide information on at least three units owned and maintained by public municipalities and information on the oldest units installed to date. Provide specific model numbers.

Site Characteristics

5) Do any of these site characteristics or safety considerations favor or limit the technology's use: steep slopes, high groundwater, baseflows, soils, proximity to wells, septic systems and buildings, facility depth limits for access and safety, risk of hazardous materials spills, and driving head requirements? How?

Design Criteria

6) Pollutant removal at design flow and for representative storm water characteristics (e.g. TSS particle size distribution)
7) Stormwater constituent limitations, pollutants and other constituents, including fouling factors
8) Design hydraulics (treatment and hydraulic design flows, by-pass flow, hydraulic grade line, scour velocities, etc.)
9) Design residence time, vertical/ horizontal velocities, etc.
10) Specific flow rate for media
11) Head loss curves for media
12) Minimum contact time and minimum thickness for media
13) Design life of system or components of the system before major overhaul is projected; describe fully
14) Media specifications to ensure that adequate quality of each medium is supplied to the user at all times. A list of all the physical/ chemical and impurity specifications should be provided
15) Structural, water tightness, buoyancy, and constructability
16) Design sizing and cost information for units designed to perform without maintenance for one full-year, and over-designed to last three years before the first cleaning.
17) Pretreatment requirements if any
18) Materials used to construct facility

Construction

19) What role does the vendor take in design and construction? Will a vendor representative be available to the contractor in the field? A letter from the vendor is required with every facility accepted to be publicly owned and maintained. This letter must confirm that the facility is being designed per manufacturer specifications to meet City of Portland requirements.
20) List the steps taken to install the technology. How long does it take?
21) How are factors such as structural integrity, water tightness, and buoyancy addressed?
22) What types of problems can occur in designing and installing the technology?

23) How are potential problems diagnosed and corrected, and by whom?
24) If problems go uncorrected, how does this affect the technology's effectiveness? What will cause complete facility failure?
25) How available is the technology (e.g. where do the major components come from and how much lead-time is needed?)

Costs

26) Provide materials (capital) and installation costs for complete system(s), indicating total costs and costs per cfs treated (not per cfs hydraulic capacity)
27) What is estimated useful facility life before replacement is needed?

Operation and Maintenance: For a typical installation with typical stormwater, discuss each of the following:

28) How are inspections performed and how often?
29) How do you tell or forecast when maintenance will be needed, i.e., what is the "trigger" for determining when maintenance is needed and why?
30) How is maintenance performed? Specify equipment, materials, and man-hours necessary
31) Are all maintenance areas accessible by people and equipment? Are special equipment or methods needed for access? Any confined space entry areas?
32) What is the estimated maintenance frequency and on what information/ tests do you base this estimate?
33) What role does the vendor take in maintenance/ How much does the vendor charge for maintenance service?
34) Can the technology be damaged due to delayed maintenance, and if so, how is it restored?
35) How many years have you been in business? If vendor goes out of business or product model changes, how/ where will facility owner find needed parts, materials, and service?
36) Provide information on how other public jurisdictions clean and maintain their units.
37) Is there a standardized Operations and Maintenance plan available? If so, please provide a copy.

Reliability

38) Assuming the technology is designed and installed correctly, what factors can cause it not to perform as designed?
39) Can the technology add, transform, or release accumulated pollutants?
40) Does the filter medium decompose or is it subject to slime/ bacteria growth/
41) Is the technology sensitive to heavy or fine sediment loadings- is pretreatment required?
42) How is under-performance diagnosed and treated?
43) What is the warranty?
44) What initial/ ongoing user support is provided? Does the vendor charge for support?

Other Factors

45) Does the technology provide benefits or present challenges in other potentially relevant areas, such as groundwater recharge, thermal effects on surface waters, habitat creation, aesthetics, vectors, safety, community acceptance, and recreational use?

IV. REPORTING

Vendors seeking BES approval of manufactured stormwater treatment facilities must submit the specified test data in report format, and must include answers to the "Factors Other than Treatment Performance" section above. While treatment performance is the most obvious factor in determining facility acceptance, others such as maintainability and reliability are equally important.

All relevant data should be included in the report, including but not limited to: test site locations with maps, dates and times of sampling, topography maps outlining drainage basins, system plans showing all relevant stormwater piping and pollution reduction facilities, expected flow calculations for various storm events, beginning and end times of all storm events and samplings, rainfall data from specified rain gage, measured flows through the system at various times (submit calculated hydrographs), and history of the facility (when constructed, when last maintenance/ cleaning occurred, etc.). All data pertaining to characteristics of storms and sampling procedures must be submitted to show conformance with previous specifications.

All reports should be submitted to ATTN: Steve Fancher, PE
Bureau of Environmental Services, C.O.P.
1120 SW 5th Ave. Room 1100
Portland, OR 97204-1972

BES will evaluate the data and report findings to the vendor within 60 days of the submittal.

V. DATA EVALUATION

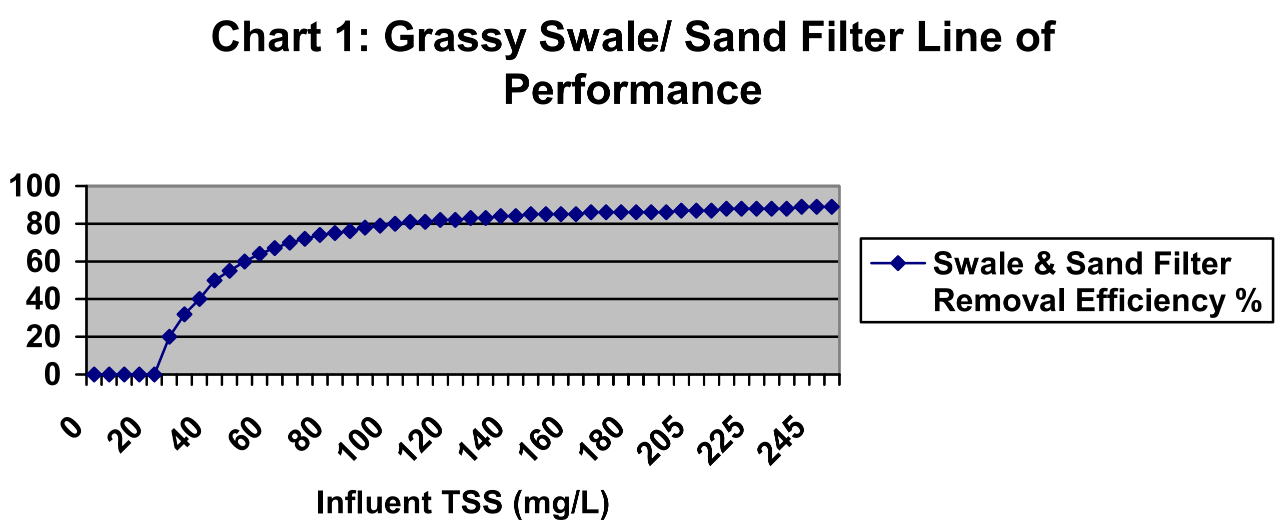
BES will evaluate the data submitted by the vendors, and group each technology into one or more of the following classifications:

- Presumptive Approach (TSS)
- Pretreatment Only
- Oil/ Water Separation
- Specific Pollutants of Concern (TMDL pollutants)
- Acceptable as Public Facility
- Private Facility Only
- Not Approved for Any Application
- Insufficient Information, Provide Additional Data

LINES OF COMPARABLE PERFORMANCE

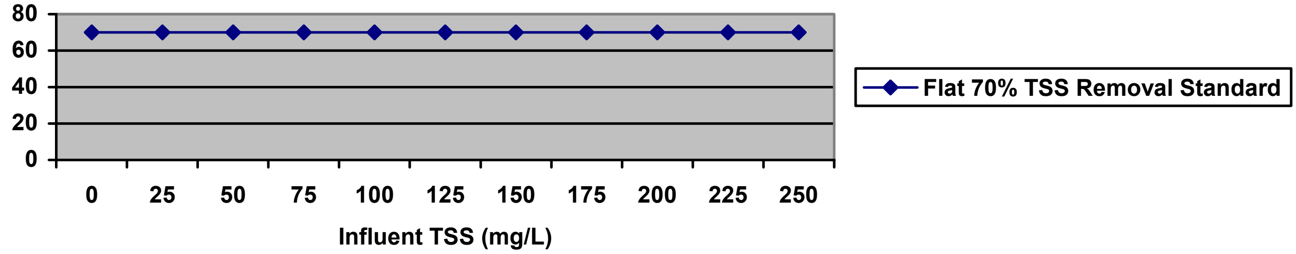
As mentioned earlier, BES will use the "Line of Comparative Performance©" method to evaluate a treatment technology's ability to remove TSS. The following table describes the data points that form the approximate grassy swale/ sand filter comparison line:

INFLUENT TSS (mg/L)	REMOVAL EFFICIENCY
20	0 %
25	20 %
50	60 %
75	74 %
100	80 %
125	83 %
150	85 %
175	87 %
200	88 %
250	89 %



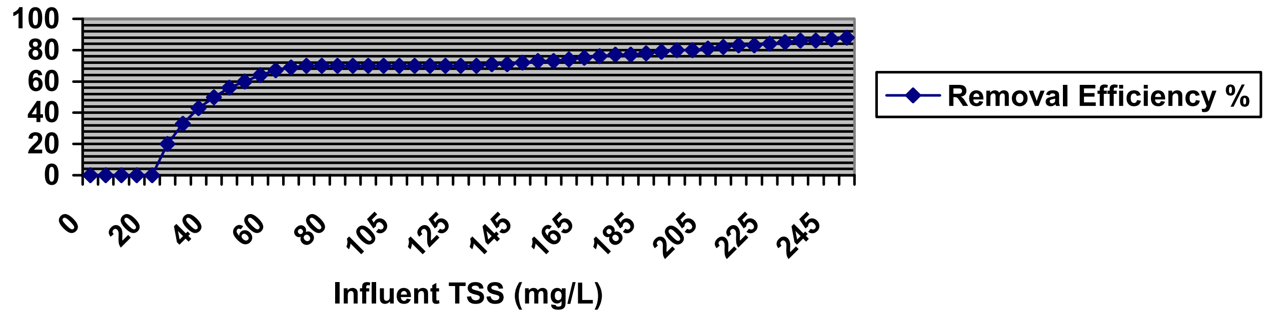
The following chart represents a flat “70% TSS Removal” standard:

Chart 2: Flat 70% TSS Removal Line



The following performance line is consistent with the City of Portland’s 70% TSS removal standard and takes into account influent TSS concentrations:

Chart 3: Portland's Modified Performance Standard Line



According to Section 403 Report to Congress, U.S. EPA, 1995, “Typical” stormwater contains about 100 mg/L TSS. This line specifies 70% TSS removal for a range 30% below and 30% above 100 mg/L. For every point with less than 70 mg/L influent TSS, it is assumed that the effluent will be the minimum allowed 20 mg/L. For influent concentrations greater than 130 mg/L, the points rise linearly to 88% removal at 250 mg/L, which is a point shared with the swale/ sand filter comparison line.

To meet the City of Portland’s basic pollution reduction standard, at least 50% of a technology’s data points should fall above this line of performance, as approved by BES. Efficiency calculation methods on page B-9 and 10 shall be used to plot points on the chart. Facilities will be required to remove more than 70% for high (<130 mg/L) influent concentrations, while being allowed to remove less than 70% for low (<70 mg/L) influent concentrations. This will result in facilities being evaluated as they actually perform in the field, with those that average 70% TSS removal during the design storm of 0.83 inches over 24 hours receiving acceptable performance evaluations.

SAMPLE DATA COLLECTION SHEET

FIELD SITE #1

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

FIELD SITE #2

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

FIELD SITE #3

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

LABORATORY STUDIES WITH “REAL” STORMWATER

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 6= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 7= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 8= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

LABORATORY STUDIES WITH SPIKED WATER

TEST 1: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 2: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 3: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 4: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 5: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 6: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 7: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____

VI. REFERENCES

Washington Department of Ecology, "Draft 4: Vendor Submission Guidance for Evaluating Emerging Stormwater Treatment Technologies", October 2000

Puget Sound Watershed, "Final Draft: Protocol for the Acceptance of Unapproved Stormwater Treatment Technologies for Use in the Puget Sound Watershed", APWA Task Committee, November 1999

The County of Sacramento and Cities of Citrus Heights, Folsom, Galt, and Sacramento, "Investigation of Structural Control Measures for New Development", November 1999

Boyd, Gail, URS Corporation, personal communication

Technical Update #1

Subject: **Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies: Clarification Regarding "TSS" versus "SSC" Testing Methods**

Date: **July 5, 2001**

The recently released USGS policy regarding the collection and use of total suspended solids data in determining the suspended sediment load in stormwater runoff was recently brought to our attention. We have been reviewing the USGS "Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data" document dated August of 2000, and would like to clarify our sampling specifications, as listed in the above mentioned "Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies".

By using "Total Suspended Solids" or "TSS" terminology, we may have implied that the *Total Suspended Solids Analytical Method*, as described by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation should be used to analyze test samples. According to the USGS study (Water-Resources Investigations Report 00-4191 by John R. Gray, G. Douglas Glysson, Lisa M. Turcios, and Gregory E. Schwarz) this method, which uses predetermined sub-sample volumes from an original water sample obtained while the sample is being mixed, is fundamentally unreliable for the analysis of natural-water samples. Methods used in the withdrawal of an aliquot of the original sample are inconsistent and often non-representative of the sample.

The *Suspended-Sediment Concentration Analytical Method*, however, measures all sediment and the mass of the entire water-sediment mixture. ASTM Standard Test Method D 3977-97 lists three methods that result in a determination of SSC values in water and wastewater samples: Test Method A- Evaporation, Test Method B- Filtration, and Test Method C- Wet-sieving filtration. The percentage of sand-size and finer material can be determined as part of the SSC method, but not as part of the TSS method. Overall, the SSC method "produces relatively reliable results for samples of natural water, regardless of the amount or percentage of sand-size material in the samples".

We would like to see the *Suspended-Sediment Concentration Analytical Method* used, as described in ASTM D 3977-97 for analysis of suspended sediment load in stormwater runoff.

Appendix C
SANTA BARBARA URBAN HYDROGRAPH METHOD

INTRODUCTION

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District to determine a runoff hydrograph for an urbanized area. It is a simpler method than some other approaches, as it computes a hydrograph directly without going through intermediate steps (i.e., a unit hydrograph) to determine the runoff hydrograph.

The SBUH method is a popular method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the method approved by the Bureau of Environmental Services (BES) for determining runoff when doing flow control calculations.

ELEMENTS OF THE SBUH METHOD

The SBUH method depends on several variables:

- Pervious (A_p) and impervious (A_{imp}) land areas
- Time of concentration (T_c) calculations
- Runoff curve numbers (CN) applicable to the site
- Design storm

These elements shall all be presented as part of the submittal process for review by BES staff. In addition, maps showing the pre-development and post-development conditions shall be presented to BES to help in the review.

Land Area

The total area, including the pervious and impervious areas within a drainage basin, shall be quantified in order to evaluate critical contributing areas and the resulting site runoff. Each area within a basin shall be analyzed separately and their hydrographs combined to determine the total basin hydrograph. Areas shall be selected to represent homogenous land use/development units.

Time of Concentration

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed. (In this case, T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration.) T_c depends on several factors, including ground slope, ground roughness, and distance of flow. The following formula for determining T_c is found in BES's *Sewer Design Manual*.

Formulas

$T_c = T_{t1} + T_{c2} + T_{c3} + \ldots + T_{cn}$

$T_t = L/60V$ (Conversion of velocity to travel time)

$$T_t = \frac{0.42\,(nL)^{0.8}}{1.58(s)^{0.4}}$$ (Manning's kinematic solution for sheet flow less than 300 feet)

(Shallow concentrated flow for slopes less than 0.005 ft/ft. For steeper slopes, consult BES's Sewer Design Manual):

$V = 16.1345(s)^{0.5}$ (Unpaved surfaces)

$V = 20.3282(s)^{0.5}$ (Paved surfaces)

Where,

- T_t = travel time, minutes
- T_c = total time of concentration, minutes (minimum T_c = 5 minutes)
- L = flow length, feet
- V = average velocity of flow, feet per second
- n = Manning's roughness coefficient for various surfaces (see Chart 10 of the 1991 Sewer Design Manual)
- s = slope of the hydraulic grade line (land or watercourse slope), feet per foot

When calculating T_c, the following limitations apply:

- Overland sheet flow (flow across flat areas that does not form into channels or rivulets) shall not extend for more than 300 feet.
- For flow paths through closed conveyance facilities such as pipes and culverts, standard hydraulic formulas shall be used for establishing velocity and travel time. (See the *Sewer Design Manual* for more data on pipe flow rates and velocities.)
- Flow paths through lakes or wetlands may be assumed to be zero (i.e. $T_c = 0$).

Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to reduce diverse characteristics such as soil type, land usage, and vegetation into a single variable for doing runoff calculations. The runoff curve numbers approved by BES for water quantity/quality calculations are included as Table C-2 of this appendix.

The curve numbers presented in Table C-2 are for *wet* antecedent moisture conditions. Wet conditions assume previous rainstorms have reduced the capacity of soil to absorb water. Given the frequency of rainstorms in the Portland area, wet conditions are most likely, and give conservative hydrographic values.

Design Storm

The SBUH method also requires a design storm to perform the runoff calculations. For flow control calculations, BES uses a NRCS Type 1A 24-hour storm distribution. This storm is shown in Figure C-1 and Table C-4. The depth of rainfall for the 2 through 100-year storm events is shown below in Table C-1.

Table C-1
24-HOUR RAINFALL DEPTHS AT PORTLAND AIRPORT

Recurrence Interval, Years	2	5	10	25	100
24-Hour Depths, Inches	2.4	2.9	3.4	3.9	4.4

Table C-2
RUNOFF CURVE NUMBERS

Runoff curve numbers for urban areas*

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Runoff curve numbers for other agricultural lands*

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range-continuous forage for grazing					
<50% ground cover or heavily grazed with no mulch	Poor	68	79	86	89
50 to 75% ground cover and not heavily grazed	Fair	49	69	79	84
>75% ground cover and lightly or only occasionally grazed	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay	-	30	58	71	78
Brush--weed-grass mixture with brush as the major element					
<50% ground cover	Poor	48	67	77	83
50 to 75% ground cover	Fair	35	56	70	77
>75% ground cover	Good	30	48	65	73
Woods-grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79

Runoff curve numbers for other agricultural lands*

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Woods					
Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.	Poor	45	66	77	83
Woods are grazed but not burned, and some forest litter covers the soil.	Fair	36	60	73	79
Woods are protected from grazing, and litter and brush adequately cover the soil.	Good	30	55	70	77

Runoff curve numbers for Simplified Approaches**

Cover description		Curve numbers for hydrologic soil group			
Simplified Approaches	Hydrologic condition	A	B	C	D
Eco-roof	Good	n/a	61	n/a	n/a
Roof Garden	Good	n/a	48	n/a	n/a
Contained Planter Box	Good	n/a	48	n/a	n/a
Infiltration & Flow-Through Planter Box	Good	n/a	48	n/a	n/a
Pervious Pavement	-	76	85	89	n/a
Trees					
New and/or Existing Evergreen	-	36	60	73	79
New and/or Existing Deciduous	-	36	60	73	79

n/a - Does not apply, as design criteria for the relevant mitigation measures do not include the use of this soil type.
*Soil Conservation Service, *Urban Hydrology for Small Watersheds*, Technical Release 55, pp. 2.5-2.8, June 1986.
**CNs of various cover types were assigned to the Proposed Simplified Approaches with similar cover types as follows:

Eco-roof – assumed grass in good condition with soil type B.
Roof Garden – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Contained Planter Box – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Infiltration & Flow-Through Planter Box – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Pervious Pavement – assumed gravel.
Trees – assumed woods with fair hydrologic conditions.

Note: To determine hydrologic soil type, consult local USDA Soil Conservation Service Soil Survey.

TABLE C-3
NRCS HYDROLOGIC SOIL GROUP DESCRIPTIONS

NRCS Hydrologic Soil Group	Description
Group A	Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.
Group B	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
Group C	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.
Group D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a fragipan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Figure C-1 - NRCS 24-Hour Type 1A Hyetograph

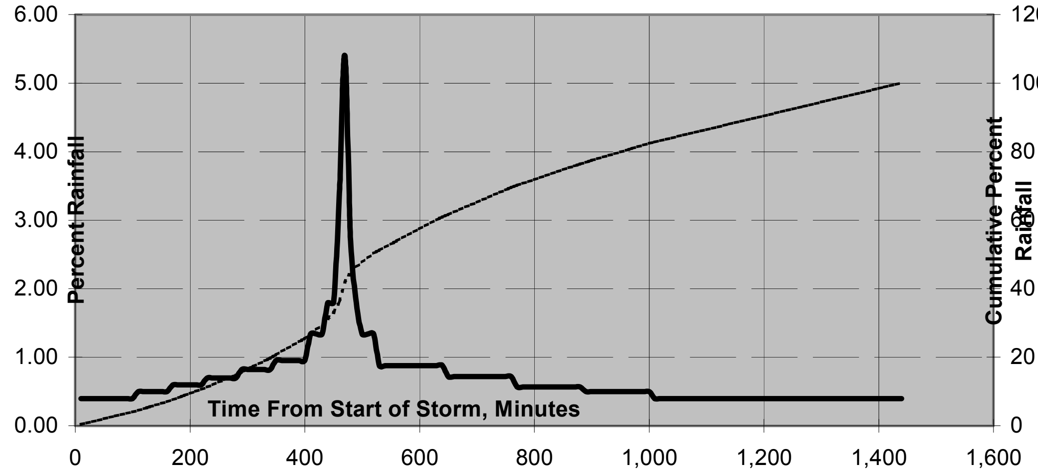


Table C-3 - NRCS Type 1A Hyetographic Distrubution - For Use In Water Quality/Quantity Design

Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall	Time From Start of Storm, Minutes	% Rainfall	Cumu-lative % Rainfall
0 - 10	0.40	0.40	360 - 370	0.95	22.57	720 - 730	0.72	67.40	1080 - 1090	0.40	86.00
10 - 20	0.40	0.80	370 - 380	0.95	23.52	730 - 740	0.72	68.12	1090 - 1100	0.40	86.40
20 - 30	0.40	1.20	380 - 390	0.95	24.47	740 - 750	0.72	68.84	1100 - 1110	0.40	86.80
30 - 40	0.40	1.60	390 - 400	0.95	25.42	750 - 760	0.72	69.56	1110 - 1120	0.40	87.20
40 - 50	0.40	2.00	400 - 410	1.34	26.76	760 - 770	0.57	70.13	1120 - 1130	0.40	87.60
50 - 60	0.40	2.40	410 - 420	1.34	28.10	770 - 780	0.57	70.70	1130 - 1140	0.40	88.00
60 - 70	0.40	2.80	420 - 430	1.34	29.44	780 - 790	0.57	71.27	1140 - 1150	0.40	88.40
70 - 80	0.40	3.20	430 - 440	1.80	31.24	790 - 800	0.57	71.84	1150 - 1160	0.40	88.80
80 - 90	0.40	3.60	440 - 450	1.80	33.04	800 - 810	0.57	72.41	1160 - 1170	0.40	89.20
90 - 100	0.40	4.00	450 - 460	3.40	36.44	810 - 820	0.57	72.98	1170 - 1180	0.40	89.60
100 - 110	0.50	4.50	460 - 470	5.40	41.84	820 - 830	0.57	73.55	1180 - 1190	0.40	90.00
110 - 120	0.50	5.00	470 - 480	2.70	44.54	830 - 840	0.57	74.12	1190 - 1200	0.40	90.40
120 - 130	0.50	5.50	480 - 490	1.80	46.34	840 - 850	0.57	74.69	1200 - 1210	0.40	90.80
130 - 140	0.50	6.00	490 - 500	1.34	47.68	850 - 860	0.57	75.26	1210 - 1220	0.40	91.20
140 - 150	0.50	6.50	500 - 510	1.34	49.02	860 - 870	0.57	75.83	1220 - 1230	0.40	91.60
150 - 160	0.50	7.00	510 - 520	1.34	50.36	870 - 880	0.57	76.40	1230 - 1240	0.40	92.00
160 - 170	0.60	7.60	520 - 530	0.88	51.24	880 - 890	0.50	76.90	1240 - 1250	0.40	92.40
170 - 180	0.60	8.20	530 - 540	0.88	52.12	890 - 900	0.50	77.40	1250 - 1260	0.40	92.80
180 - 190	0.60	8.80	540 - 550	0.88	53.00	900 - 910	0.50	77.90	1260 - 1270	0.40	93.20
190 - 200	0.60	9.40	550 - 560	0.88	53.88	910 - 920	0.50	78.40	1270 - 1280	0.40	93.60
200 - 210	0.60	10.00	560 - 570	0.88	54.76	920 - 930	0.50	78.90	1280 - 1290	0.40	94.00
210 - 220	0.60	10.60	570 - 580	0.88	55.64	930 - 940	0.50	79.40	1290 - 1300	0.40	94.40
220 - 230	0.70	11.30	580 - 590	0.88	56.52	940 - 950	0.50	79.90	1300 - 1310	0.40	94.80
230 - 240	0.70	12.00	590 - 600	0.88	57.40	950 - 960	0.50	80.40	1310 - 1320	0.40	95.20
240 - 250	0.70	12.70	600 - 610	0.88	58.28	960 - 970	0.50	80.90	1320 - 1330	0.40	95.60
250 - 260	0.70	13.40	610 - 620	0.88	59.16	970 - 980	0.50	81.40	1330 - 1340	0.40	96.00
260 - 270	0.70	14.10	620 - 630	0.88	60.04	980 - 990	0.50	81.90	1340 - 1350	0.40	96.40
270 - 280	0.70	14.80	630 - 640	0.88	60.92	990 - 1000	0.50	82.40	1350 - 1360	0.40	96.80
280 - 290	0.82	15.62	640 - 650	0.72	61.64	1000 - 1010	0.40	82.80	1360 - 1370	0.40	97.20
290 - 300	0.82	16.44	650 - 660	0.72	62.36	1010 - 1020	0.40	83.20	1370 - 1380	0.40	97.60
300 - 310	0.82	17.26	660 - 670	0.72	63.08	1020 - 1030	0.40	83.60	1380 - 1390	0.40	98.00
310 - 320	0.82	18.08	670 - 680	0.72	63.80	1030 - 1040	0.40	84.00	1390 - 1400	0.40	98.40
320 - 330	0.82	18.90	680 - 690	0.72	64.52	1040 - 1050	0.40	84.40	1400 - 1410	0.40	98.80
330 - 340	0.82	19.72	690 - 700	0.72	65.24	1050 - 1060	0.40	84.80	1410 - 1420	0.40	99.20
340 - 350	0.95	20.67	700 - 710	0.72	65.96	1060 - 1070	0.40	85.20	1420 - 1430	0.40	99.60
350 - 360	0.95	21.62	710 - 720	0.72	66.68	1070 - 1080	0.40	85.60	1430 - 1440	0.40	100.00

Appendix D
SIMPLIFIED APPROACH SIZING CALCULATIONS

The spreadsheet columns are described below:

Column (1)	Time in Minutes
Column (2)	Inflow for Storm Event (25-Year Detention Storm 3.9"/24 hours) and Contributing Impervious Area (1 acre)
Column (3)	Inflow (cf) = Inflow (cfs) x 60 x 10
Column (4)	Inflow (in) = Inflow (cf) x 12 / 43,560
Column (5)	Cumulative Inflow (in) = inflow (in) + Cumulative inflow (in) of previous step
Column (6)	Max Outflow (cfs) = Facility Area (sf) x Infiltration Rate (ft/s) **Note: Infiltration rate is assumed to be 2.5"/hr in this case. Also, for simplicity head is not taken into account.**
Column (7)	Cumulative Outflow (cf) = outflow (cfs) x 10 x 60 + cumulative outflow (cf) of previous step
Column (8)	Inflow – Outflow (cfs) = Column 2 inflow (cfs) – Column 6 outflow (cfs)
Column (9)	Incremental inflow – outflow (cf) = inflow – outflow (cfs) x 10 x 60
Column (10)	Cumulative inflow – outflow (cf) = If incremental inflow – outflow (cf) + cumulative inflow – outflow (cf) of previous step is less than 0, 0; else = incremental inflow – outflow (cf) + cumulative inflow – outflow (cf) of previous time step
Column (11)	Cumulative depth (in) = cumulative inflow – outflow (cf) x 12 / Facility Area (sf) **Note that cumulative depth does not exceed 6 inches in this case, which would result in an overflow condition. When modeling for detention purposes, overflow is allowed, but only at pre-developed peak rates. When modeling for pollution reduction, the entire post-developed runoff rate from the pollution reduction storm must be infiltrated without overflow.** **Resulting swale square-footage is 3,940, which when divided by the 43,560 square-foot impervious surface equals the 0.09 sizing factor.**

Spreadsheet Illustrating Vegetated Swale Sizing: 43,560 sq-ft imp. 25 yr storm **Swale Square Footage=** **3940**

B Soil Infiltration Rate=2.5"/hr= .21 ft/hr= **0.00006 ft/s**

(1) Time (min)	(2) Inflow (cfs)	(3) Inflow Volume (cf)	(4) Inflow Volume (in)	(5) Cumulative Inflow (in)	(6) Max Outflow (cfs)	(7) Cumulative Outflow Vol. (cf)	(8) Inflow - Outflow (cfs)	(9) Incremental Inflow - Outflow (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Cumulative Depth (in)
0	0	0	0.00	0.00	0.2364	0	-0.2364	-141.84	0	0
10	0	0	0.00	0.00	0.2364	141.84	-0.2364	-141.84	0	0
20	0	0	0.00	0.00	0.2364	283.68	-0.2364	-141.84	0	0
30	0	0	0.00	0.00	0.2364	425.52	-0.2364	-141.84	0	0
40	0.01	6	0.00	0.00	0.2364	567.36	-0.2264	-135.84	0	0
50	0.02	12	0.00	0.00	0.2364	709.2	-0.2164	-129.84	0	0
60	0.03	18	0.00	0.01	0.2364	851.04	-0.2064	-123.84	0	0
70	0.03	18	0.00	0.01	0.2364	992.88	-0.2064	-123.84	0	0
80	0.04	24	0.01	0.02	0.2364	1134.72	-0.1964	-117.84	0	0
90	0.05	30	0.01	0.03	0.2364	1276.56	-0.1864	-111.84	0	0
100	0.05	30	0.01	0.04	0.2364	1418.4	-0.1864	-111.84	0	0
110	0.06	36	0.01	0.05	0.2364	1560.24	-0.1764	-105.84	0	0
120	0.08	48	0.01	0.06	0.2364	1702.08	-0.1564	-93.84	0	0
130	0.08	48	0.01	0.07	0.2364	1843.92	-0.1564	-93.84	0	0
140	0.08	48	0.01	0.09	0.2364	1985.76	-0.1564	-93.84	0	0

150	0.09	54	0.01	0.10	0.2364	2127.6	-0.1464	-87.84	0	0
160	0.09	54	0.01	0.12	0.2364	2269.44	-0.1464	-87.84	0	0
170	0.1	60	0.02	0.13	0.2364	2411.28	-0.1364	-81.84	0	0
180	0.11	66	0.02	0.15	0.2364	2553.12	-0.1264	-75.84	0	0
190	0.12	72	0.02	0.17	0.2364	2694.96	-0.1164	-69.84	0	0
200	0.12	72	0.02	0.19	0.2364	2836.8	-0.1164	-69.84	0	0
210	0.12	72	0.02	0.21	0.2364	2978.64	-0.1164	-69.84	0	0
220	0.12	72	0.02	0.23	0.2364	3120.48	-0.1164	-69.84	0	0
230	0.13	78	0.02	0.25	0.2364	3262.32	-0.1064	-63.84	0	0
240	0.15	90	0.02	0.28	0.2364	3404.16	-0.0864	-51.84	0	0
250	0.15	90	0.02	0.30	0.2364	3546	-0.0864	-51.84	0	0
260	0.15	90	0.02	0.33	0.2364	3687.84	-0.0864	-51.84	0	0
270	0.15	90	0.02	0.35	0.2364	3829.68	-0.0864	-51.84	0	0
280	0.15	90	0.02	0.38	0.2364	3971.52	-0.0864	-51.84	0	0
290	0.17	102	0.03	0.40	0.2364	4113.36	-0.0664	-39.84	0	0
300	0.18	108	0.03	0.43	0.2364	4255.2	-0.0564	-33.84	0	0
310	0.18	108	0.03	0.46	0.2364	4397.04	-0.0564	-33.84	0	0
320	0.18	108	0.03	0.49	0.2364	4538.88	-0.0564	-33.84	0	0
330	0.18	108	0.03	0.52	0.2364	4680.72	-0.0564	-33.84	0	0
340	0.18	108	0.03	0.55	0.2364	4822.56	-0.0564	-33.84	0	0
350	0.2	120	0.03	0.59	0.2364	4964.4	-0.0364	-21.84	0	0
360	0.21	126	0.03	0.62	0.2364	5106.24	-0.0264	-15.84	0	0
370	0.21	126	0.03	0.66	0.2364	5248.08	-0.0264	-15.84	0	0
380	0.22	132	0.04	0.69	0.2364	5389.92	-0.0164	-9.84	0	0
390	0.22	132	0.04	0.73	0.2364	5531.76	-0.0164	-9.84	0	0
400	0.22	132	0.04	0.77	0.2364	5673.6	-0.0164	-9.84	0	0
410	0.26	156	0.04	0.81	0.2364	5815.44	0.0236	14.16	14.16	0.04830213
420	0.31	186	0.05	0.86	0.2364	5957.28	0.0736	44.16	58.32	0.19893928
430	0.31	186	0.05	0.91	0.2364	6099.12	0.0736	44.16	102.48	0.34957644
440	0.36	216	0.06	0.97	0.2364	6240.96	0.1236	74.16	176.64	0.60254862
450	0.42	252	0.07	1.04	0.2364	6382.8	0.1836	110.16	286.8	0.97832284
460	0.6	360	0.10	1.14	0.2364	6524.64	0.3636	218.16	504.96	1.72250314
470	1.02	612	0.17	1.31	0.2364	6666.48	0.7836	470.16	975.12	3.32629766
480	0.94	564	0.16	1.46	0.2364	6808.32	0.7036	422.16	1397.28	4.76635614
490	0.52	312	0.09	1.55	0.2364	6950.16	0.2836	170.16	1567.44	5.34680040
500	0.37	222	0.06	1.61	0.2364	7092	0.1336	80.16	1647.6	5.62023959
510	0.31	186	0.05	1.66	0.2364	7233.84	0.0736	44.16	1691.76	5.77087675
520	0.31	186	0.05	1.71	0.2364	7375.68	0.0736	44.16	1735.92	5.92151390
530	0.26	156	0.04	1.76	0.2364	7517.52	0.0236	14.16	1750.08	5.96981604
540	0.21	126	0.03	1.79	0.2364	7659.36	-0.0264	-15.84	1734.24	5.91578314
550	0.21	126	0.03	1.82	0.2364	7801.2	-0.0264	-15.84	1718.4	5.86175025
560	0.21	126	0.03	1.86	0.2364	7943.04	-0.0264	-15.84	1702.56	5.80771736
570	0.21	126	0.03	1.89	0.2364	8084.88	-0.0264	-15.84	1686.72	5.75368446
580	0.21	126	0.03	1.93	0.2364	8226.72	-0.0264	-15.84	1670.88	5.69965157
590	0.21	126	0.03	1.96	0.2364	8368.56	-0.0264	-15.84	1655.04	5.64561868
600	0.21	126	0.03	2.00	0.2364	8510.4	-0.0264	-15.84	1639.2	5.59158578
610	0.21	126	0.03	2.03	0.2364	8652.24	-0.0264	-15.84	1623.36	5.53755289
620	0.21	126	0.03	2.07	0.2364	8794.08	-0.0264	-15.84	1607.52	5.48352
630	0.21	126	0.03	2.10	0.2364	8935.92	-0.0264	-15.84	1591.68	5.42948710
640	0.21	126	0.03	2.14	0.2364	9077.76	-0.0264	-15.84	1575.84	5.37545421
650	0.19	114	0.03	2.17	0.2364	9219.6	-0.0464	-27.84	1548	5.28048731
660	0.17	102	0.03	2.20	0.2364	9361.44	-0.0664	-39.84	1508.16	5.14458639
670	0.17	102	0.03	2.22	0.2364	9503.28	-0.0664	-39.84	1468.32	5.00868548
680	0.17	102	0.03	2.25	0.2364	9645.12	-0.0664	-39.84	1428.48	4.87278456
690	0.17	102	0.03	2.28	0.2364	9786.96	-0.0664	-39.84	1388.64	4.73688365
700	0.17	102	0.03	2.31	0.2364	9928.8	-0.0664	-39.84	1348.8	4.60098274
710	0.17	102	0.03	2.34	0.2364	10070.64	-0.0664	-39.84	1308.96	4.46508182
720	0.17	102	0.03	2.37	0.2364	10212.48	-0.0664	-39.84	1269.12	4.32918091
730	0.17	102	0.03	2.39	0.2364	10354.32	-0.0664	-39.84	1229.28	4.19328
740	0.17	102	0.03	2.42	0.2364	10496.16	-0.0664	-39.84	1189.44	4.05737908
750	0.17	102	0.03	2.45	0.2364	10638	-0.0664	-39.84	1149.6	3.92147817
760	0.17	102	0.03	2.48	0.2364	10779.84	-0.0664	-39.84	1109.76	3.78557725
770	0.15	90	0.02	2.50	0.2364	10921.68	-0.0864	-51.84	1057.92	3.60874233
780	0.13	78	0.02	2.52	0.2364	11063.52	-0.1064	-63.84	994.08	3.39097340
790	0.13	78	0.02	2.55	0.2364	11205.36	-0.1064	-63.84	930.24	3.17320446
800	0.13	78	0.02	2.57	0.2364	11347.2	-0.1064	-63.84	866.4	2.95543553
810	0.13	78	0.02	2.59	0.2364	11489.04	-0.1064	-63.84	802.56	2.73766659
820	0.13	78	0.02	2.61	0.2364	11630.88	-0.1064	-63.84	738.72	2.51989766
830	0.13	78	0.02	2.63	0.2364	11772.72	-0.1064	-63.84	674.88	2.30212873
840	0.13	78	0.02	2.65	0.2364	11914.56	-0.1064	-63.84	611.04	2.08435979

850	0.13	78	0.02	2.67	0.2364	12056.4	-0.1064	-63.84	547.2	1.86659086
860	0.13	78	0.02	2.70	0.2364	12198.24	-0.1064	-63.84	483.36	1.64882192
870	0.13	78	0.02	2.72	0.2364	12340.08	-0.1064	-63.84	419.52	1.43105299
880	0.13	78	0.02	2.74	0.2364	12481.92	-0.1064	-63.84	355.68	1.21328406
890	0.13	78	0.02	2.76	0.2364	12623.76	-0.1064	-63.84	291.84	0.99551512
900	0.12	72	0.02	2.78	0.2364	12765.6	-0.1164	-69.84	222	0.75727918
910	0.12	72	0.02	2.80	0.2364	12907.44	-0.1164	-69.84	152.16	0.51904324
920	0.12	72	0.02	2.82	0.2364	13049.28	-0.1164	-69.84	82.32	0.28080731
930	0.12	72	0.02	2.84	0.2364	13191.12	-0.1164	-69.84	12.48	0.04257137
940	0.12	72	0.02	2.86	0.2364	13332.96	-0.1164	-69.84	0	0
950	0.12	72	0.02	2.88	0.2364	13474.8	-0.1164	-69.84	0	0
960	0.12	72	0.02	2.90	0.2364	13616.64	-0.1164	-69.84	0	0
970	0.12	72	0.02	2.92	0.2364	13758.48	-0.1164	-69.84	0	0
980	0.12	72	0.02	2.94	0.2364	13900.32	-0.1164	-69.84	0	0
990	0.12	72	0.02	2.96	0.2364	14042.16	-0.1164	-69.84	0	0
1000	0.12	72	0.02	2.98	0.2364	14184	-0.1164	-69.84	0	0
1010	0.11	66	0.02	3.00	0.2364	14325.84	-0.1264	-75.84	0	0
1020	0.09	54	0.01	3.01	0.2364	14467.68	-0.1464	-87.84	0	0
1030	0.09	54	0.01	3.03	0.2364	14609.52	-0.1464	-87.84	0	0
1040	0.09	54	0.01	3.04	0.2364	14751.36	-0.1464	-87.84	0	0
1050	0.09	54	0.01	3.06	0.2364	14893.2	-0.1464	-87.84	0	0
1060	0.09	54	0.01	3.07	0.2364	15035.04	-0.1464	-87.84	0	0
1070	0.09	54	0.01	3.09	0.2364	15176.88	-0.1464	-87.84	0	0
1080	0.09	54	0.01	3.10	0.2364	15318.72	-0.1464	-87.84	0	0
1090	0.09	54	0.01	3.12	0.2364	15460.56	-0.1464	-87.84	0	0
1100	0.09	54	0.01	3.13	0.2364	15602.4	-0.1464	-87.84	0	0
1110	0.09	54	0.01	3.15	0.2364	15744.24	-0.1464	-87.84	0	0
1120	0.09	54	0.01	3.16	0.2364	15886.08	-0.1464	-87.84	0	0
1130	0.09	54	0.01	3.18	0.2364	16027.92	-0.1464	-87.84	0	0
1140	0.09	54	0.01	3.19	0.2364	16169.76	-0.1464	-87.84	0	0
1150	0.09	54	0.01	3.20	0.2364	16311.6	-0.1464	-87.84	0	0
1160	0.09	54	0.01	3.22	0.2364	16453.44	-0.1464	-87.84	0	0
1170	0.09	54	0.01	3.23	0.2364	16595.28	-0.1464	-87.84	0	0
1180	0.09	54	0.01	3.25	0.2364	16737.12	-0.1464	-87.84	0	0
1190	0.09	54	0.01	3.26	0.2364	16878.96	-0.1464	-87.84	0	0
1200	0.09	54	0.01	3.28	0.2364	17020.8	-0.1464	-87.84	0	0
1210	0.09	54	0.01	3.29	0.2364	17162.64	-0.1464	-87.84	0	0
1220	0.09	54	0.01	3.31	0.2364	17304.48	-0.1464	-87.84	0	0
1230	0.09	54	0.01	3.32	0.2364	17446.32	-0.1464	-87.84	0	0
1240	0.09	54	0.01	3.34	0.2364	17588.16	-0.1464	-87.84	0	0
1250	0.09	54	0.01	3.35	0.2364	17730	-0.1464	-87.84	0	0
1260	0.09	54	0.01	3.37	0.2364	17871.84	-0.1464	-87.84	0	0
1270	0.09	54	0.01	3.38	0.2364	18013.68	-0.1464	-87.84	0	0
1280	0.09	54	0.01	3.40	0.2364	18155.52	-0.1464	-87.84	0	0
1290	0.09	54	0.01	3.41	0.2364	18297.36	-0.1464	-87.84	0	0
1300	0.09	54	0.01	3.43	0.2364	18439.2	-0.1464	-87.84	0	0
1310	0.09	54	0.01	3.44	0.2364	18581.04	-0.1464	-87.84	0	0
1320	0.09	54	0.01	3.46	0.2364	18722.88	-0.1464	-87.84	0	0
1330	0.09	54	0.01	3.47	0.2364	18864.72	-0.1464	-87.84	0	0
1340	0.09	54	0.01	3.49	0.2364	19006.56	-0.1464	-87.84	0	0
1350	0.09	54	0.01	3.50	0.2364	19148.4	-0.1464	-87.84	0	0
1360	0.09	54	0.01	3.52	0.2364	19290.24	-0.1464	-87.84	0	0
1370	0.09	54	0.01	3.53	0.2364	19432.08	-0.1464	-87.84	0	0
1380	0.09	54	0.01	3.55	0.2364	19573.92	-0.1464	-87.84	0	0
1390	0.09	54	0.01	3.56	0.2364	19715.76	-0.1464	-87.84	0	0
1400	0.09	54	0.01	3.58	0.2364	19857.6	-0.1464	-87.84	0	0
1410	0.09	54	0.01	3.59	0.2364	19999.44	-0.1464	-87.84	0	0
1420	0.09	54	0.01	3.61	0.2364	20141.28	-0.1464	-87.84	0	0
1430	0.09	54	0.01	3.62	0.2364	20283.12	-0.1464	-87.84	0	0
1440	0.09	54	0.01	3.64	0.2364	20424.96	-0.1464	-87.84	0	0
1450	0.05	30	0.01	3.64	0.2364	20566.8	-0.1864	-111.84	0	0
1460	0	0	0.00	3.64	0.2364	20566.8	-0.2364	-141.84	0	0

Appendix E

STORMWATER POLLUTION REDUCTION STORM DEVELOPMENT METHODOLOGY

May 20, 2004 (Updated for September 1, 2004 Stormwater Management Manual Revision)

INTRODUCTION

The development of design storms for the sizing of stormwater pollution reduction (treatment) facilities generally involves a statistical analysis of local rainfall data, whereas a certain storm volume, duration, and peak intensity (or rainfall distribution) is identified to achieve a predetermined treatment volume goal. This treatment volume goal will vary from jurisdiction to jurisdiction, but is generally 80 to 95% of the average annual runoff. It can be linked to each jurisdiction's municipal stormwater discharge permit (MS4 permit) definition of MEP (maximum extent practicable) as it relates to the removal of pollutants from stormwater. This definition is rarely clear, but justification for the treatment volume goal generally involves social/political, economic, and environmental considerations. Without a firm grasp on the environmental consideration at this time (i.e. what percentage of average annual runoff volume needs to be treated such that the effluent water quality isn't harmful to fish or aquatic systems or groundwater resources?), the economic and social/political considerations are most widely used. An optimization model can be developed to determine a treatment volume that will result in the "biggest bang for the buck", or the point at which additional percentage points of annual treatment volume begin to require a disproportionately large increase in treatment facility size (see attached Figure 4). However the treatment volume goal is justified, the link to how treatment facilities are actually sized, and whether they end up achieving the intended goal, can be lost in translation.

TREATMENT VOLUME GOAL

Before the adoption of the September 2004 Stormwater Management Manual revision, Portland relied on a single treatment storm methodology, using a storm of 0.83 inches over 24 hours (NRCS Type 1A rainfall distribution). Used since 1994, the original intent of this design storm was to: 1) treat the "first-flush" or first 0.5 inches of runoff from all storm events and 2) pass 100% of 95% of all storm events through the treatment facility. There did not seem to be a direct environmental or economic justification for choosing 95% of storm events at the time. The justification was mainly social/political in that it sounded like a reasonable standard.

The City of Eugene uses a treatment goal of 80% of the average annual runoff, and the justification seems to be both social/political and economic, as an attempt was made to choose a treatment intensity at the "knee" of an intensity versus percentage of annual runoff volume treated curve. Gresham also uses 80% of the average annual runoff, with a similar justification (URS performed both studies). The Washington State Department of Ecology (and thus many other jurisdictions in Washington) uses 91%, and claims that an economic analysis was performed to justify the goal.

Rather than stating a treatment volume goal without a link to environmental or economic considerations, Portland has chosen to consider economic factors to provide the most "bank for the buck". From a social/political and environmental perspective it is also desirable to set a minimum value to this goal. A continuous simulation analysis, summarized as Figure 4, has been performed on multiple years of rainfall data to determine the percentage of average annual rainfall that should be treated to maximize treatment efficiency. This analysis indicates a knee in the curve somewhere between 80 and 85 percent of the average annual volume. It may not be desirable to set the treatment goal directly at the economically optimal point, as stormwater treatment facilities do not always operate at their optimal design flow rates. Filters blind over time, or swales accumulate sediments that decrease the effective treatment flow rate through them. A margin of safety should be incorporated into the treatment volume goal. For these reasons, the City of Portland has chosen to set its treatment volume goal at 90% of the average annual rainfall volume.

TREATMENT STORM ANALYSIS

Over the past several years, Portland's 0.83" storm and justification have been questioned by other northwest jurisdictions. Agencies such as NOAA Fisheries are unsure which stormwater management regulations to use in the Pacific Northwest, as from an outside perspective the water quality storms and overall treatment goals used by various jurisdictions seem to vary dramatically. On the surface, Washington State DOE appears to use a treatment volume roughly double that of Portland's, although with the incorporation of the Vb/Vr (volume of basin / volume of runoff) factor they are basically equal (both result in the use of 2/3rd of the 2-year, 24-hour storm volume). The City of Eugene uses 1.4"/ 24 hours, and the City of Gresham uses 1.2"/12 hours. Their treatment storm volumes appear greater than Portland's (1.4" and 1.2" compared with 0.83"), but with the incorporation of the Vb/Vr ratio, are actually less (1.4" and 1.2" compared with 1.66").

While the City of Eugene uses 1.4"/ 24 hours for volume based treatment facilities, they use the intensities of 0.13"/hr and 0.22"/hr (for off-line and on-line facilities, respectively) for flow rate based facilities. These dual sizing standards result in treatment of 80% of the average annual runoff for rate based facilities, and 100% treatment of the 80th percentile storm for volume based facilities. At this time it is unclear how the treatment of X% of the average annual runoff with rate based systems is comparable to treating the Xth percentile storm with volume based facilities. Rather than sizing to the Xth percentile storm for volume based facilities, it is recommended to use a different methodology (see discussion under Volume Based Treatment Systems). In either case, the need for separate rate and volume based facility sizing standards is clear if the treatment volume goal is to remain consistent.

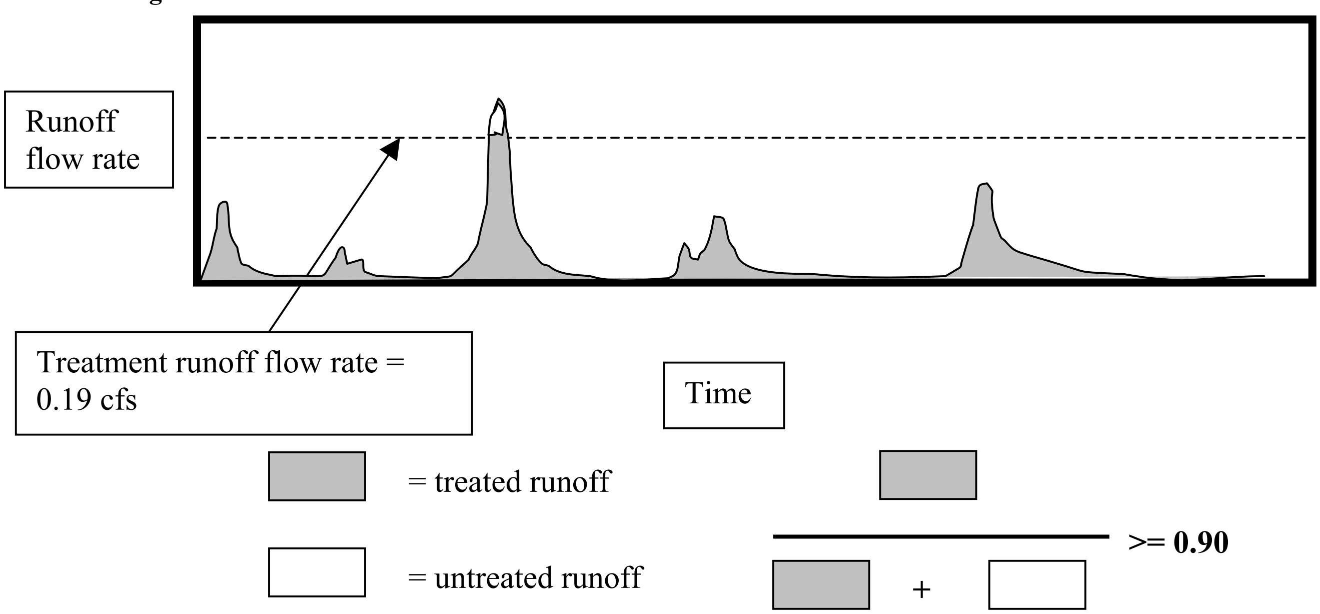
RATE BASED TREATMENT SYSTEMS

Stormwater treatment systems can be divided into two categories based on the methods used to size them: rate (or flow) and volume (or detention) based systems. Rate based systems used in Portland include swales, sand filters, and Stormfilter cartridge systems. Rate based systems remove pollutants with physical processes that settle or filter particulates as the flow passes through the system. The actual volume of the facility doesn't play a major role in the pollutant removal process, as there isn't a significant detention period for the water to remain in the system for any length of time.

A continuous simulation model can easily be used to determine the average annual runoff volume percentage treated by a rate based system. An assumption is that 100% of the runoff less than or equal to the peak treatment flow rate is fully treated, while the flows that exceed the peak treatment flow rate receive no treatment. Different assumptions can be made for on and off-line treatment systems. Likewise, an analysis of continuous rainfall intensity data can determine the average annual rainfall volume that is associated with a particular range of rainfall intensities. This type of analysis was completed for four different rain gages representing the different quadrants of Portland, and is summarized in Exhibit 5. 5, 10 and 20-minute intensities were analyzed to determine the intensities associated with the 90% rainfall volume goal. For 5-minute intensities, rainfall intensities of 0.19 inches per hour or less were determined to account for 90% of the average annual rainfall volume.

Eugene performed an analysis on 50 years of Eugene Airport rainfall data and also concluded that a rainfall intensity of 0.19"/hr would be needed to treat 90% of the average annual runoff volume.

Figure 1: Continuous simulation determination of 90% treatment flow rate



VOLUME BASED TREATMENT SYSTEMS

Unlike rate based systems, volume (or detention) based systems provide a significant storage volume for water to accumulate and be detained for a period of time. Pollutants are removed through physical (settlement) and/or biological processes. Volume based facilities used in Portland include wet ponds and wetlands. Unlike rate based systems, it is not easy to model volume based systems with continuous simulation models or rainfall analysis. Storm detention time needs to be factored into the model, and the mixing of water within the facility from one storm to the next creates a complex process that cannot be simulated accurately at this time. The currently accepted methodology used to size volume based treatment facilities (in Portland's SWMM, Gary Minton's *Stormwater Treatment* textbook, and many other jurisdictions) is to set the wet portion of the pond or wetland (permanent pool) equal to the full volume of runoff generated by the predetermined water quality storm, and apply a safety factor (Vb/Vr ratio).

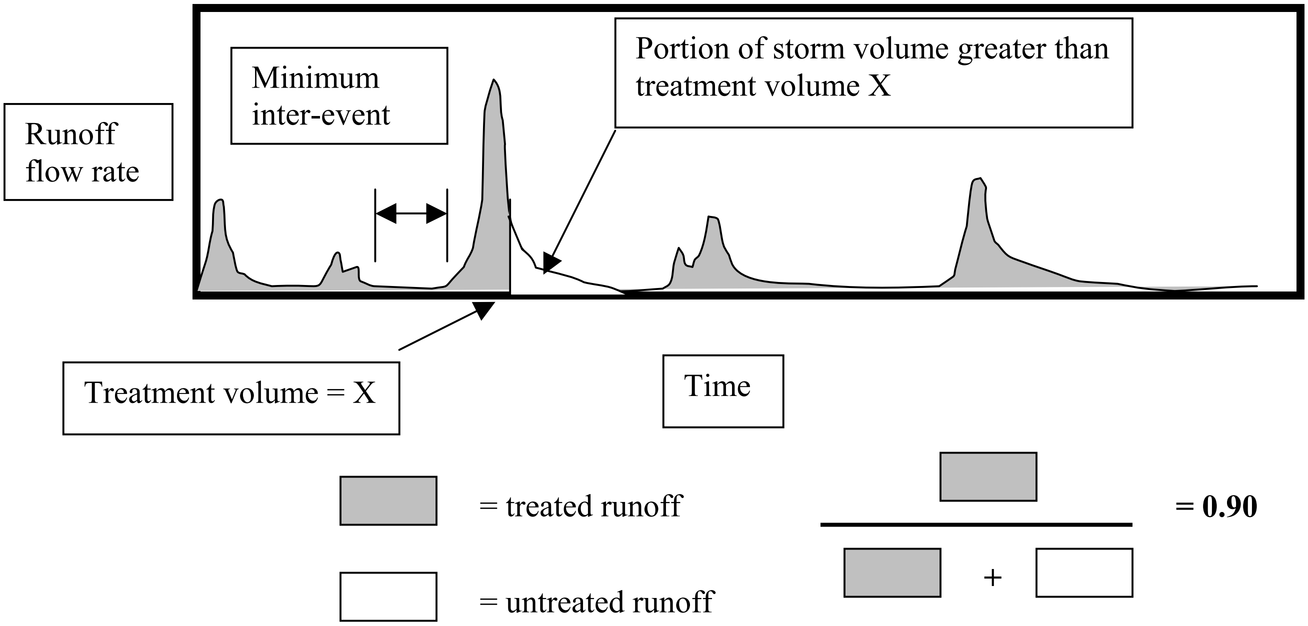
The volumes of most jurisdictions' water quality storms are set at their average annual treatment volume goal. For example, if the goal is to treat 80% of the average annual flow volume, the treatment storm depth is set to the 80% percentile storm. Eugene's goal is to treat 80% of the average annual volume. Their water quality storm is 1.4"/24 hours, which is equal to the 80th percentile storm. 80% of their storm events have a depth of 1.4 inches or less. In Portland's case, the 0.83" storm is not equal to the 90th percentile storm. An estimate would put it somewhere between the 60th and 65th percentile storm. This had been compensated for in the September 2002 Stormwater Management Manual by requiring volume-based facilities to use twice the volume of runoff generated by the 0.83" storm, or a Vb/Vr ratio of 2, but this factor should most likely be a function of soil type. In a recent version of *Stormwater Treatment Northwest* (Vol 9, No 4), Gary Minton and Roger Sutherland suggest that Pacific Northwest monitoring data indicates that a Vb/Vr ration of 1 may be adequate to achieve a TSS removal of 80%.

The City of Eugene has performed an analysis on 50 years of Eugene Airport rainfall data, and concluded that 90% of rainfall events are less than 2.4 inches in depth. Hourly rainfall intensity data was used in the analysis, storm depths of 0.01 inches or less were eliminated from the analysis, and a minimum inter-event time of 6 hours was used. A slight change in the modeling assumptions has a significant impact on the outcome. In the December 2003 issue of *Stormwater Treatment Northwest*, Gary Minton stated that an analysis he did of 24-hour rainfall data from the Seattle-Tacoma International Airport indicated that with a storm depth of about 1.35 inches, 90% of the runoff would be treated over time. The specific assumptions that were used in Dr. Minton's analysis are not known, but he was not using the 90th percentile Seattle-Tacoma storm. The Washington State Department of Ecology's Western Washington Stormwater Manual targets the capture of 91% of the average annual runoff for water quality, which they equate to two-thirds of a 2-year storm event (roughly 1.65 inches). Again, this storm event is not equivalent to the 91st percentile Western Washington storm.

A way of modeling the rainfall that could result in a clearer link to the treatment goal may be to determine the volume of a wet basin that will result in an average storm detention time of 24, 36, or 48 hours, depending on the anticipated TSS settling velocity in the vicinity of the site. The assumed inter-event time could be adjusted to ensure that enough detention time is provided between each storm event. An assumption could be made that storms with total volumes less than the "90% treatment storm" would receive 100% treatment. Storms with total volumes greater than the "90% treatment storm" would receive partial treatment- 100% treatment for the volume equal to the 90% storm volume, and 0 treatment for the volume greater than the 90%

storm volume. This may be overly conservative, as some very long, drawn-out storms (>24 hours) with total volumes greater than the designated treatment volume, may in fact receive greater than 24 hours of detention time for the entire storm, or 100% effective treatment.

Figure 2: Continuous simulation determination of 90% treatment volume



CONCLUSION AND RECOMMENDATION

The Portland water quality design storm shall be stated as a volume treatment goal- e.g. "90% of the average annual runoff shall be treated", and will be clarified by stating the peak rainfall intensity, and total volume components. This achieves two things:

1) Volume based facilities and rate based facilities will be theoretically sized to achieve treatment of the same percentage of average annual runoff volume.
2) With the treatment rainfall intensity already given, the SBUH or other hydrograph based hydrologic analysis method won't be needed to size rate based treatment facilities, simplifying the design process. Rather, the Rational Method can be used to calculate the runoff treatment flow rate, based on the site's time of concentration.

To achieve the treatment of 90% of the average annual rainfall volume, rate based facilities must be sized to treat rainfall at 0.19 inches per hour for sites with 5-minute time of concentration or less, 0.16 inches per hour for sites with a 10-minute time of concentration, and 0.13 inches per hour for sites with a 20-minute time of concentration.

For volume based facilities, Portland shall continue to size wet basins using 0.83 inches of rainfall over 24 hours (NRCS Type 1A rainfall distribution), with a Vb/Vr ratio of 2. Further analysis will be completed during the September 2007 Stormwater Management Manual revision process.

There should no longer be the perception of extreme water quality design storm discrepancies between Portland's Stormwater Management Manual and the Department of Ecology's Stormwater Management Manual for Western Washington, answering questions raised by NOAA Fisheries during review of Portland's manual.

In the long term, as more is learned about the capabilities of stormwater treatment facilities and their relationship to environmental, economic, and social considerations, Portland's treatment storm characteristics shall be re-analyzed and compared with those of other local jurisdictions periodically to determine if changes are necessary.

Figure 3: Water Quality Design Storm Pacific Northwest Comparison

Jurisdiction	Average Annual Rainfall (inches)	Treatment Goal (average annual runoff %)	WQ Storm Volume (inches) Vr	Volume Based Facility Sizing Factor	WQ Storm Duration (hours)	WQ Storm Intensity for Off-Line Facilities (in/hr)	WQ Storm Intensity for On-Line Facilities (in/hr)
City Of Gresham	37.4	80	1.2	1	12	0.11	0.20
City Of Eugene	46.6	80	1.4	1	24	0.13	0.22
City Of Corvallis	43.2	90	0.90, 0.3 mean ann. storm for wet ponds	3	24	Not Specified: 0.90" storm peak 10 min intensity (per NRCS 1A dist.) = 0.29 in/hr	
Clean Water Services-Oregon	36	85	0.36	1	4	WQ Volume / 4 hours = 0.09 in/hr	
DOE Western Washington SWMM	Varies 36-46	91	"6-month storm volume"- Varies	1	24	91% treatment: varies by jurisdiction, HSPF continuous simulation, different on & off-line	
City Of Tacoma	37.6	91	"6-month storm volume"	1	24	91% treatment, HSPF continuous simulation, different on & off-line	
City Of Seattle	38.6	Not Clear	"Mean annual storm" = 0.47	1	24	6-month storm (64% of 2-year storm or 1.08 inches) peak 10-min intensity using SBUH = 0.35 in/hr	
King County-Washington	38.6	95	"Mean annual storm" = 0.47- 0.65	3	24	60% of 2-yr storm flow rate using KCRTS continuous simulation, or 64% of 2-yr storm flow rate using SBUH	
Oregon State DEQ	Varies 37 approx. average	Not Clear	2-year storm: 2.4" in Portland	1	24	Not Specified: 2.4" storm peak 10 min intensity (per NRCS 1A dist.) = 0.78 in/hr	
City Of Portland (1996-Sept. 2004)	36	Not Clear: 95% Claim	0.83	2	24	Not Specified: 0.83" storm peak 10 min intensity (per NRCS 1A dist.) = 0.27 in/hr	
City Of Portland (Recom-mended for Sept. 2004)	36	90	90% Ave. annual treatment volume*	1 if Vr = 1.7, 2 if Vr = 0.83	24	90% treatment as shown by continuous simulation (see Figure 5) = 0.19 to 0.13 in/hr, depending on site's TofC	

* As defined by the recommended analysis of 24 years of Portland rainfall data, assuming a minimum inter-event time of 12 hours and minimum rainfall amount of 0.01 inches (see Figure 6). Portion of storm volume below specified treatment volume receives 100% treatment, portion of storm volume above specified treatment volume receives 0% treatment.

Figure 4: Rainfall Intensity Versus Percentage of Annual Rainfall Volume 8/12/2004
Rainfall data taken from each of four Portland quadrants, then averaged. Fancher

5-minute intensity in/hr	% Annual Rainfall Volume
0	0
0.01	7
0.02	14
0.03	21
0.04	28
0.05	35
0.06	42
0.07	48.5
0.08	55.5
0.09	62.5
0.1	69.5
0.11	76.5
0.12	83.5
0.13	84.5
0.14	85.5
0.15	86
0.16	87
0.17	88
0.18	89
0.19	90
0.2	90.5
0.21	91.5
0.22	92.5
0.23	93
0.24	94
0.25	95
0.3	96
0.4	98
0.5	98

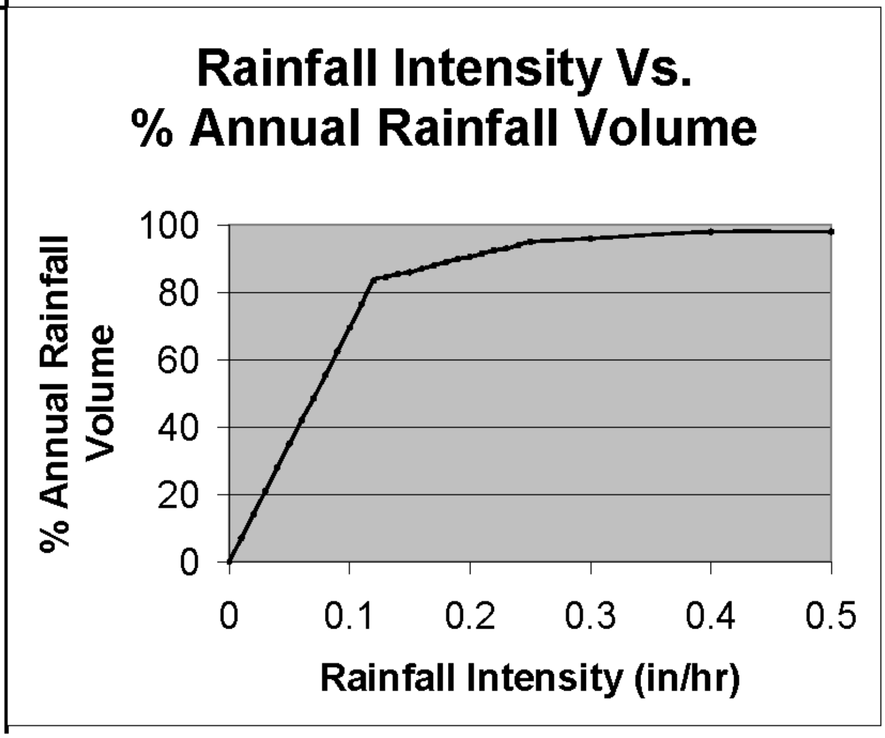


Figure 5: BES Stormwater Pollution Reduction
Storm Analysis
April 30, 2004

Intensities Resulting in Treatment of 90% of Rainfall Volume (in/hr)
Assumption: Percentage of rainfall less intense than specified intensity receives 100% treatment, percentage of rainfall more intense than specified intensity receives 0 treatment.

5 minute intensity NW	0.19	Average = 0.19 in/hr
5 minute intensity SW	0.19	
5 minute intensity SE	0.20	
5 minute intensity NE	0.19	
10 minute intensity NW	0.15	Average = 0.16 in/hr
10 minute intensity SW	0.15	
10 minute intensity SE	0.165	
10 minute intensity NE	0.16	
20 minute intensity NW	0.13	Average = 0.13 in/hr
20 minute intensity SW	0.12	
20 minute intensity SE	0.14	
20 minute intensity NE	0.135	

Figure 6: BES Stormwater Pollution Reduction Storm Analysis April 30, 2004

Volumes Resulting in Treatment of 90% of Rainfall Volume (in/hr)
Assumptions: Percentage of storm volume less than specified volume receives 100% treatment, percentage of storm volume greater than specified volume receives 0 treatment. Storm event is defined by a minimum of 0.01 inches of rainfall with a minimum inter-event period of 12 hours.

Place & Time	Total Rainfall (in)	Number of 12-hr Storms	Average Storm Size (in)	90% Treatment Storm Size (in)	Average 90% Treatment Storm Size (in)
NW 97-98	80.15	169	0.47	1.6	Average = 1.7 in
NW 90-91	65.5	163	0.40	1.3	
NW 83-84	83.9	202	0.42	1.9	
NW 80-81	95.37	247	0.39	2.1	
SW 97-98	73.85	176	0.42	1.4	Average = 1.7 in
SW 90-91	61.83	180	0.34	1.25	
SW 83-84	82.37	201	0.41	1.9	
SW 80-81	67.45	160	0.42	2.1	
SE 97-98	74.41	185	0.40	1.6	Average = 1.8 in
SE 90-91	63.71	184	0.35	1.3	
SE 83-84	82.75	192	0.43	2.0	
SE 80-81	65.41	163	0.40	2.3	
NE 97-98	74.00	180	0.41	1.4	Average = 1.7 in
NE 90-91	64.62	176	0.37	1.2	
NE 83-84	72.27	217	0.33	1.7	
NE 80-81	65.37	188	0.35	2.3	

MEMORANDUM

TO: Greg Gescher, CP&P Supervisor

FROM: Bruce Moser, Project Manager

DATE: December 15, 2003

SUBJECT: **Stormwater Quality Facility Design Storm**

This memo reviews the stormwater quality design storm event for the City of Corvallis, and recommends using a NRCS Type 1A storm event of 0.9 inch in 24 hours.

Background

NPDES Phase 1 and 2 Stormwater regulations require agencies to implement stormwater quality treatment by the use of best management practices. NPDES Phase 1 and 2 Permits do not include a specific requirement for meeting a design storm and treatment level. The State of Oregon DEQ has not established stormwater quality criteria for NPDES Phase 1 for receiving streams that are not water quality limited (TMDLs have not been established).

The Corvallis SWMP includes the requirement to retrofit all existing stormwater outfalls with water quality facilities, and to require new development to install stormwater quality facilities. The SWMP includes Technical Memorandum No. 3, dated Nov. 10, 1999, in which Brown&Caldwell staff recommended that the City of Corvallis use 2/3's of the 2 year, 24 hour rainfall event, or 1.67 inches for 24 hours for the stormwater treatment design storm event. This level of treatment exceeds the level other agencies in Oregon are currently using.

Discussion

Agencies in Oregon that have NPDES stormwater permits have established differing criteria for the stormwater quality design storm event to capture and treat. Agencies have reviewed local rainfall data to determine the level of storm event to capture that represents a percentage of the total rainfall. This methodology is based on the assumption that the majority of pollutants are mobilized and transported prior to the peak of a large rainfall event. Several stormwater quality studies have substantiated this assumption.

The process for review of rainfall data involves review of historical rainfall events to establish a level of 24 hour precipitation that represents a given percentage of the total volume of rainfall. The City of Portland has established design criteria of 95% of total stormwater runoff is to be treated to remove 70% of Total Suspended Solids (TSS). The design storm to capture has been established as 0.83 inches in 24 hours, using NRCS Type 1A curve. The City of Eugene has established the design criteria of 90% of total stormwater runoff to be treated, but the TSS removal criteria is not mentioned. City of Eugene staff assume that a properly designed stormwater quality BMP will remove 80% of TSS. City of Eugene has established the design storm as 0.21 inches in one hour for on-line facilities, and 0.12 inches in one hour for off-line facilities. This is based on using 1.0 inch in 24 hour as the design storm, using the NRCS Type 1A curve. The on-line facilities have a greater design storm based on the assumption that the effectiveness of an on-line facility will be impacted by flow when compared to an off-line facility.

Establishing Stormwater Quality Treatment Design Storm Event for Corvallis

The design rainfall event and treatment level is not currently identified under existing or anticipated regulatory requirements for the City of Corvallis. The SWMP does not specify treatment levels, but community input frequently referenced the water quality requirements that larger Oregon cities were meeting. A reasonable expectation for the implementation of stormwater quality facilities in Corvallis would be meeting community standards established in other Oregon cities that require stormwater treatment.

The stormwater receiving streams in Corvallis do not have established TMDL's, and none are anticipated to be implemented in the foreseeable future. In addition, the EPA Implementation Plan for Corvallis has not established a water quality treatment requirement with the exception of water temperature.

The methodology for developing the storm event for design treatment levels for the City of Corvallis uses review of historical daily rainfall over the last 42 years from the Hyslop rainfall gage (located 4 miles north of Corvallis) to determine the 24 hour event that would provide 90% capture for treatment. The 42 year historical data was tabulated to establish the average yearly rainfall of 43.20 inches. The amount of yearly rainfall that equals 90% of this yearly rainfall is 38.87 inches. The next step of the methodology was to establish a daily rainfall amount that collectively meets the 38.88 inches over the 42 years of data. The historical rainfall data was input to a spreadsheet "if, then" command to record all daily rainfall less than or equal to 0.9 inches. Rainfall greater than 0.9 inches was converted to 0.9 inches for the 24 hour period. The data was again tabulated and averaged to determine the yearly average rainfall amount, which was calculated to be 38.99 inches. This level nearly matches the target the yearly average for 90% rainfall of 38.88 inches.

The following table compares the annual average rainfall and design storm events for Portland, Corvallis, and Eugene.

City	Portland	Corvallis	Eugene
Annual Ave. Rainfall (inches)	37.07	43.20	50.90
24 Hr. Design Storm (inch/24 hour)	0.83	0.90	1.00

Recommendation

Based on review of other agency design storm methodology and review of local rainfall data, the stormwater quality design storm event for the City of Corvallis is recommended to be 0.9 inches in 24 hours, using the NRCS Type 1A distribution curve.

X:\Divisions\Engineering\Capital Planning&Projects\Projects\Stormwater CIP 03-04\doc\memo on stormwater quality design storm event.wpd

CleanWater Services Our commit

Home > D&C Standards 04-09

Design & Construction Standards

Clean Water Services Design and Construction Standards co
the administrative and technical requirements for the design
of sanitary and surface water management systems which ar
of residential or commercial development. The new Design a
Standards Resolution and Order 04-9 (R&O 04-9) became e
March 1, 2004 and replaces the previous version of the stan
11.

Unless otherwise specifically identified in the land use condit
new development submittals within the District's boundaries-
development within cities--should comply with R&O 04-9.

- **Click here to view or download Resolution and Or (PDF).**
- **AutoCAD users may click here for PNG files. A CD containing PDF files of the document is also avail purchase at Clean Water Services Permit Counter, Street, Suite 270, Hillsboro. The cost for the CD is**
- **Click here for language changes January 6, 2004.**
- **You may also access Resolution and Order 03-11 January 1, 2005.**

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APPENDIX B:
WATER QUALITY & QUANTITY
FACILITY DESIGN

1.0 GENERAL REQUIREMENTS FOR WATER QUALITY AND QUANTITY FACILITIES

1.1 Erosion Protection

a. Inlets to water quality and quantity facilities shall be protected from erosive flows through the use of an energy dissipater or rip rap stilling basin of appropriate size based on flow velocities. Flow shall be evenly distributed across the treatment area.

b. All exposed areas of water quality and quantity facilities shall be protected using coconut or jute matting. Coconut matting or high density jute matting (Geojute Plus or approved equal) shall be used in the treatment area of swales and below the WQV levels of ponds. Low density jute matting (Econojute or approved equal) may be used on all other zones.

1.2 Vegetation

a. Vegetation shall be in accordance with the Appendix D: Landscape Requirements.

b. No invasive species shall be planted or permitted to remain within the facility which may affect its function, including, but not limited to the following:

1. Himalayan blackberry (Rubus discolor)
2. Reed canarygrass (Phalaris arundinacea)
3. Teasel (Dipsacus fullonum)
4. English Ivy (Hedra helix)
5. Nightshade (Solanum sp.)
6. Clematis (Clematis ligusticifolia and C. vitabla)
7. Cattail (Typhus latifolia)
8. Thistle (Cirsium arvense and C. vulgare)
9. Scotch Broom (Cytisus scoparius)

8) A vehicle turnaround shall be provided when the access road exceed 40' in length.

2.0 WATER QUALITY FACILITY DESIGN

This section presents methodology for designing water quality facilities.

2.1 Water Quality Volumes and Flows

(Reproduced from Appendix A: Hydrology and Hydraulics; Section 1)

The water quality storm is the storm required by regulations to be treated. The storm defines both the volume and rate of runoff.

a. Water Quality Storm: Total precipitation of 0.36 inches falling in 4 hours with a storm return period of 96 hours.

b. Water quality volume (WQV) is the volume of water that is produced by the water quality storm.

c. Water Quality Volume (WQV): 0.36-inches over 100-percent of the new impervious area.

$$\text{Water Quality Volume (cf)} = \frac{0.36(\text{in}) \times \text{Area (sf)}}{12\ (\text{in/ft})}$$

d. Water Quality Flow (WQF): The average design flow anticipated from the water quality storm.

$$\text{Water Quality Flow (cfs)} = \frac{\text{Water Quality Volume (cf)}}{14{,}400\ \text{Sec}}$$

Or

$$\text{Water Quality Flow (cfs)} = \frac{0.36(\text{in}) \times \text{Area (sf)}}{12(\text{in/ft})(4\ \text{hr})(60\ \text{min/hr})(60\ \text{sec/min})}$$

2.2 Pretreatment

a. Pretreatment Required

Sheet flow of impervious surfaces into water quality facilities will not be allowed without pretreatment. Incoming flows to the water quality facility must be pretreated using a water quality manhole in accordance with section 2.3 or other pre-treatment method as approved by the District/City. Other methods of pretreatment may include proprietary devices, filter

Stormwater Management Manual for Western Washington

Volume I - Minimum Technical Requirements and Site Planning
Volume II - Construction Stormwater Pollution Prevention
Volume III - Hydrologic Analysis and Flow Control Design/BMPs
Volume IV - Source Control BMPs
Volume V - Runoff Treatment BMPs

Prepared by:

Washington State Department of Ecology
Water Quality Program

August 2001
Publication Numbers 99-11 through 99-15
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Chapter 4 - General Requirements for Stormwater Facilities

Note: All Figures in Chapter 4 are courtesy of King County

This chapter addresses general requirements for treatment facilities. Requirements discussed in this chapter include design volumes and flows, sequencing of facilities, liners, and hydraulic structures for splitting or dispersing flows.

4.1 Design Volume and Flow

4.1.1 Water Quality Design Storm Volume

The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm).

Wetpool facilities are sized based upon use of the NRCS (formerly known as SCS) curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm. Treatment facilities sized by this simple runoff volume-based approach are the same size whether they precede detention, follow detention, or are integral with the detention facility (i.e., a combined detention and wetpool facility).

Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Appendix I-B of Volume I. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Volume III.

4.1.2 Water Quality Design Flow Rate

***Downstream of Detention Facilities*: The full 2-year release rate from the detention facility.**

An approved continuous runoff model should identify the 2-year return frequency flow rate discharged by a detention facility that is designed to meet the flow duration standard.

***Preceding Detention Facilities or when Detention Facilities are not required*: The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated.** Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80 percent TSS removal).

- *Off-line facilities*: For treatment facilities not preceded by an equalization or storage basin, and when runoff flow rates exceed the water quality design flow rate, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the higher incremental portion of flow rates are bypassed around a treatment facility. Ecology encourages design of systems that engage a bypass at higher flow rates provided the reduction in pollutant loading exceeds that achieved with bypass at the water quality design flow rate.

  Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of a continuous runoff model is treated to the applicable performance goals (e.g., 80 percent TSS removal at the water quality design flow rate and 80 percent TSS removal on an annual average basis).

- *On-line facilities*: Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met.

Estimation of Water Quality Design Flow Rate for Facilities Preceding Detention or when Detention Facilities are not required:

Until a continuous runoff model is available that identifies the water quality design flow rate directly, that flow rate shall be estimated using Table 4.1, and its following directions for use:

Step 1 Determine whether to use the 15-minute time series or the 1-hour time series. At the time of publication, all BMPs except wetpool-types should use the 15-minute time series.

Step 2 Determine the ratio corresponding with the effective impervious surface associated with the project. For effective impervious areas between two 5 percent increments displayed in the table, a straight line interpolation may be used, or use the higher 5 percent increment value.

Step 3 Multiply the 2-year return frequency flow for the post-developed site, as predicted by an approved continuous runoff model, by the ratio determined above.

City of Tacoma
Surface Water Management Manual

Volume I
Minimum Technical Requirements and Site Planning

Prepared by:

Tacoma Public Works
Environmental Services

January 2003

related natural resources. Based upon gross level applications of continuous runoff modeling and assumptions concerning minimum flows needed to maintain beneficial uses, watersheds must retain the majority of their natural vegetation cover and soils, and developments must meet the Flow Control Minimum Requirement of this chapter, in order to avoid significant natural resource degradation in lowland streams.

The Roof Downspout Control BMPs described in Chapter 3 of Volume III, and the Dispersion and Soil Quality BMPs in Chapter 5 of Volume V are insufficient to prevent significant hydrologic disruptions and impacts to streams and their natural resources. Therefore, Ecology has suggested that the City and other local governments should look for opportunities to encourage and require additional BMPs such as those in Sections 5.2 through 5.4 of Volume V through updates to their site development standards and land use plans.

3.5.6 Minimum Requirement #6: Runoff Treatment

Thresholds

The following require construction of stormwater treatment facilities (see Table 3.1):

- **Projects in which the total of effective pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or**
- **Projects in which the total of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.**

Treatment Facility Sizing

Water Quality Design Storm Volume: The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm.

Water Quality Design Flow Rate:

- ***Preceding Detention Facilities or when Detention Facilities are not required*: The flow rate at or below which 91% of the runoff volume will be treated, as estimated by an approved continuous runoff model. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate.**
- **Volume V includes performance goals for Basic, Enhanced, Phosphorus, and Oil Control treatment, and a menu of facility options for each treatment type. Treatment facilities that are**

Stormwater Treatment Technical Requirements Manual

Issued November 2000

City of Seattle

Title 22.800 Stormwater, Grading & Drainage Control Code

Volume 1: Source Control Technical Requirements Manual
Volume 2: Construction Stormwater Control Technical Requirements Manual
Volume 3: Flow Control Technical Requirements Manual
Volume 4: Stormwater Treatment Technical Requirements Manual

concentration. TC depends on several factors, including ground slope, ground roughness, and distance of flow.

The Soil Conservation Service (SCS) runoff curve number to be used with the SBUH method shall be 98 for impervious surfaces, and 85 or greater for pervious surfaces unless one of the following conditions is met:

- A lower SCS curve number is justified for an area incorporating one or more site design options (see City of Seattle Directors' Rule for Flow Control), or
- A soil report by an experiences geotechnical/civil engineer indicates site soils are sufficiently pervious to allow a smaller SCS curve number to be used.

In the City of Seattle, the design storm used by the SBUH method *for design of treatment facilities* is based on a *standard* SCS Type 1A storm event hyetograph where, during the peak 10-minute period, 5.40% of the total rainfall occurs. Note that *for design of flow control facilities*, a *modified* SBUH method is used where 9.92% of the rainfall occurs during the ten-minute period at the peak of the storm event (see Appendix A).

Water Quality Design Flow

Flow-through treatment structures, such as biofiltration facilities, media filtration facilities, and oil control facilities, must be sized based on runoff from the 6-month, 24-hour storm event, which has a rainfall runoff volume of 1.08 inches. This value is based on the assumption that the 6-month, 24-hour storm volume is 64% of the volume of the 2-year, 24-hour storm event.[4] For these types of facilities, water quality design flow, Q_{wq}, is equal to the peak flow (measured in cfs). Using the SBUH method, this peak occurs during the ten-minute interval between 470 and 480 minutes, when 5.40% of the total rainfall volume occurs. Additional information on the SBUH method is provided in Appendix A. For *storage* treatment facilities, such as wetponds, wetvaults, and stormwater wetlands, sizing is based on the volume of runoff from the *mean annual storm event*, which for Seattle is 0.47 inches. Additional information on determining water quality design flows for storage treatment facilities is contained in Chapter 4.

2.2 SEQUENCE OF FACILITIES

As specified in the water quality menus, where more than one water quality facility is used, the order is often prescribed. This is because the specific pollutant removal role of the second or third facility in a treatment train often assumes that significant solids settling has already occurred. For example, phosphorus removal using a two-facility treatment train relies on the second facility (sand filter) to remove a finer fraction of solids than those removed by the first facility.

There is a larger question, however, of whether water quality facilities should be placed upstream or downstream of detention facilities. In general, all water quality facilities may be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. Not all water quality facilities, however, can be located

[4] Ref: Stormwater Management Manual for the Puget Sound Basin; The Technical Manual (1992). Publication 91-75, Washington State Department of Ecology, Olympia. Washington.

**********FEBRUARY 2004 UPDATE DRAFT**********

Strike-Out-and-Underline Revisions

CHAPTER 6

WATER QUALITY DESIGN

KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

*9/1/98

6.2 GENERAL REQUIREMENTS FOR WQ FACILITIES

This section presents the general requirements for water quality (WQ) facilities. When detail in the WQ designs is lacking, refer to Chapter 5 for guidance. In cases where requirements are extremely costly, a less expensive alternative that is functionally equivalent in terms of performance, environmental effects, health and safety, and maintenance can be sought through the adjustment process (see Section 1.4).

Use of Metal Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. High zinc concentrations, sometimes in the range that can be toxic to aquatic life, have been observed in the region.[12] Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other metals, such as aluminum or stainless steel, or plastics are available, they should be used.

6.2.1 WATER QUALITY DESIGN FLOWS

Water Quality Design Flow

The water quality design flow is defined as follows:

- *Preceding detention*: **60% of the developed two-year peak flow rate, as determined using the KCRTS model** with 15-minute time steps calibrated to site conditions (see Chapter 3). *Note: If KCRTS is not being used on a project, the WQ design flow may also be estimated using 64% of the 2-year 24-hour precipitation in the SBUH model.*[13]
- *Downstream of detention*: The full **2-year release rate from the detention facility**.

The KCRTS model will typically be used to compute the WQ design flow. When examining the peak flow rates associated with various runoff volumes, it was found that detained flows and undetained flows must be described differently. However, unlike peak flows, the KCRTS model computation of volume of runoff is unaffected by whether or not the runoff is detained. Therefore, facilities such as wetponds, which are sized by a simple volume-based approach that does not route flows through a detention ~~pond~~facility, are the same size whether they precede or follow detention.

Note that facilities which are sized based on volume and which include routing of flows through a detention ~~pond~~facility, such as the detailed sand filter method, are significantly smaller when located downstream of detention, even though the same volume of water is treated in either situation. This is because the detention ~~pond~~facility routing sequence stores peaks within the pond and releases them at a slow rate, reducing the size of the sand filter pond subsequently needed (the volume needed to store the peaks need not be provided again in the sand filter pond).

Flow Volume to be Treated

When water quality treatment is required pursuant to the core and special requirements of this manual, it is intended that a minimum of **95% of the annual average runoff volume** in the (8 year) time series, as determined with the KCRTS model, be treated. Designs using the WQ design flow (as discussed above) will treat this minimum volume.

Treatable Flows

As stated in Chapter 1, only runoff from target pollution-generating surfaces must be treated using the water quality facility options indicated in the applicable water quality menu. These surfaces include both

[12] Finlayson, 1990. Unpublished data from reconnaissance of Metro Park and Ride lot stormwater characteristics.

[13] The Department of Ecology WQ design flow is based on the flow predicted by the SBUH model for 64% of the 2-year 24-hour precipitation. This is roughly equivalent to the WQ design flows given here for the KCRTS model.

6.4.1.1 METHODS OF ANALYSIS

This section describes methods of analysis for the following two wetpond sizes:

- **Basic wetpond** (see below)
- **Large wetpond** (see page 6-73).

❑ BASIC WETPOND

The primary design factor that determines a wetpond's **particulate removal efficiency** is the volume of the wetpool in relation to the volume of stormwater runoff from the *mean annual storm*.[25] The larger the wetpond volume in relation to the volume of runoff, the greater the potential for pollutant removal. Also important are the avoidance of short-circuiting and the promotion of plug flow. *Plug flow* describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are as follows:

- Dissipating energy at the inlet
- Providing a large length-to-width ratio
- Providing a broad surface for water exchange across cells rather than a constricted area.

Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Wetponds designed using the method below (with the volume = $3V_r$) and the required design criteria in Section 6.6.2.2 are expected to meet the Basic WQ menu goal of 80% TSS removal. The actual performance of a wetpond may vary, however, due to a number of factors, including design features, maintenance frequency, storm characteristics, pond algae dynamics, and waterfowl use.

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume factor (*f*). A basic wetpond requires a volume factor of 3. This means that the required wetpond volume is 3 times the volume of runoff V_r from the mean annual storm (see Steps 2 and 3).

Step 2: Determine rainfall (*R*) for the mean annual storm. The rainfall for the mean annual storm R is obtained by locating the project site on Figure 6.4.1.A (p. 6-71) and interpolating between isopluvials. Convert to feet for use in Equation (6-13).

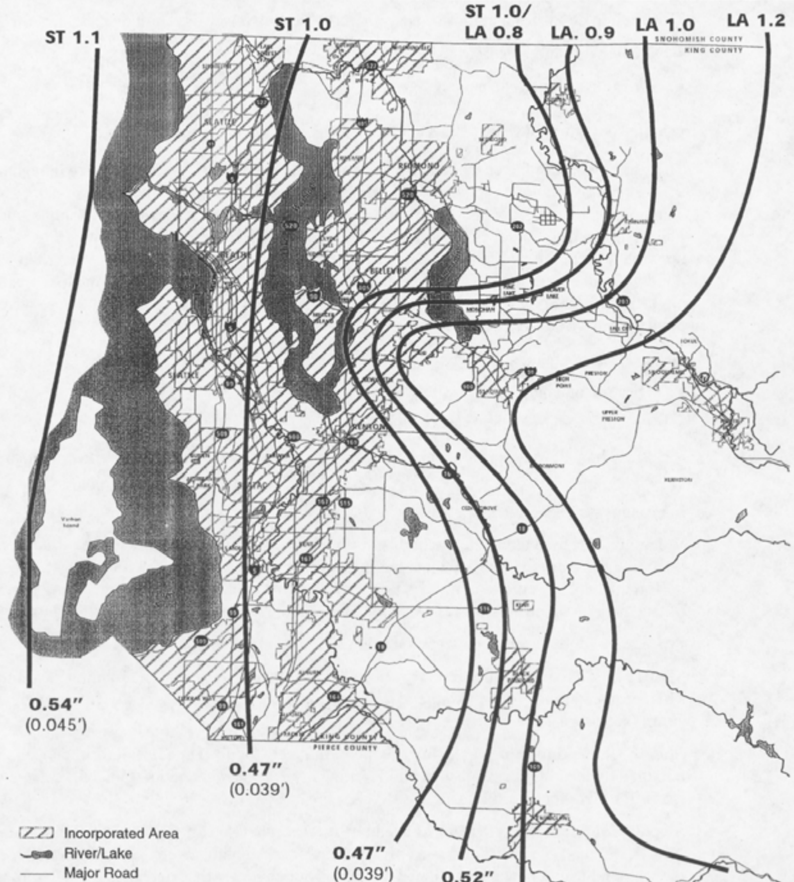
Step 3: Calculate runoff from the mean annual storm (V_r) for the developed site. The runoff volume V_r is the amount of rainfall that runs off a particular set of land covers. To determine V_r, each portion of the wetpond tributary area is assigned to one of four cover types, each having a different runoff coefficient: impervious surface, till grass, till forest, or outwash.

- **Impervious surface** is a compacted surface, such as pavement, gravel, soil, or other hard surfaces, as well as open water bodies. *Note: The effective impervious computations given in Chapter 3, Table 3.2.2.~~D~~ E may be used, unless more detailed information is available ~~if desired~~.*

- **Till grass** is post-development grass or landscaped area and onsite forested land on till soil that are not permanently in sensitive area buffers or covenants. *Till* is soil that does not drain readily and, as a

[25] The *mean annual storm* is a statistically derived rainfall event defined by the U.S. Environmental Protection Agency in "Results of the Nationwide Urban Runoff Program", 1986. It is defined as the annual rainfall divided by the number of storm events in the year. The NURP studies refer to pond sizing using a V_b/V_r ratio: the ratio of the pond volume V_b to the volume of runoff from the mean annual storm V_r. This is equivalent to using a volume factor f times V_r.

FIGURE 6.4.1.A PRECIPITATION FOR MEAN ANNUAL STORM IN INCHES (FEET)



NOTE: Areas east of the easternmost isopluvial should use 0.65 inches unless rainfall data is available for the location of interest

[24] The mean annual storm is a conceptual storm found by dividing the annual precipitation by the total number of storm events per year

result, generates large amounts of runoff. For this application, till soil types include Buckley and bedrock soils, and alluvial and outwash soils that have a seasonally high water table or are underlain at a shallow depth (less than 5 feet) by glacial till. U.S. Soil Conservation Service (SCS) hydrologic soil groups that are classified as till soils include a few B, most C, and all D soils. See Chapter 3 for classification of specific SCS soil types.

Appendix F
FACILITY PLANTING & SOIL RECOMMENDATIONS

F.1 RECOMMENDED PLANT LISTS

Ecoroof Recommended Plants:

Note: For additional descriptions of these plants visit the Bureau of Environmental Services website, www.cleanrivers-pdx.org. For Roof Garden plants, BES recommends using drought tolerant, self-sustaining native trees, shrubs and ecoroof plants.

Sedums and Succulents

Delosperma cooperi,	Ice plant
Delosperma nubegenum,	Ice plant
Sedum acre	Stonecrop
**Sedum album*	White Stonecrop
**Sedum telephium* varieties including 'Autumn Joy' and 'Variegatum'	Stonecrop
Sedum divergens	Stonecrop
Sedum hispanicum	Stonecrop
Sedum kamtschaticum	Stonecrop
**Sedum oreganum*	Oregon Stonecrop
Sedum sexangular	Stonecrop
**Sedum spathilifolium*	Stonecrop
**Sedum spurium* varieties	Stonecrop
**Sempervivum tectorum,*	Hens and Chicks

Herbaceous

Achillea millefolium,	Common Yarrow
Achillea ageratifolia,	Greek Yarrow
Achillea tomentosum,	Wooly Yarrow
Arenaria montana,	Sandwort
Artemesia 'Silver mound',	Artemesia
Aurinia saxatilis,	Alyssum saxatile
**Cerastium,*	Snow-in-Summer
Dianthus alwoodii,	Pink
Dianthus deltoides,	Maiden Pink
Erigeron discoideus,	Fleabane
Festuca glauca,	Blue Fescue
Fragaria vesca,	Woodland Strawberry
Gazania linearis var. 'CO gold',	Gazania
**Gilia capitata,*	Globe gilia

Lobularia maritima,	Sweet alyssum
Nierembergia repens,	Cup Flower
**Polypodium glycrrhiza,*	Licorice Fern
**Polystichum munitum,*	Sword Fern
Potentilla nepalensis,	Nepal Cinquefoil
Potentilla nuemaniana,	Cinquefoil
Thymus serphyllum,	Mother of Thyme
Thymus vulgaris,	Common Thyme
Veronica liwanensis,	Speedwell

* Indicates that BES has observed these plants surviving in ecoroof areas that do not receive summer irrigation. Most of these locations have moderate to deep shade. To date these plants appear very stressed by the end of summer, but they have comeback each year. It is likely that many of the other plants listed above could survive in such conditions without irrigation.

Contained Planter Box, Infiltration Planter Box, and Flow-Through Planter Box Recommended Plants:

Note: Generally, plants requiring **moist-wet** conditions are preferred for flow-through facilities; plants requiring **moist to dry** conditions are preferred for infiltration facilities.

Shrubs

Ceanothus velutinus,	Snowbrush- moist-dry
Cornus sericea,	Redtwig Dogwood- moist-wet
Gaultheria shallon,	Salal- moist-dry
Mahonia (or Berberis) aquifolium,	Tall Oregon Grape-moist-dry
Mahonia nervosa,	Dull Oregon Grape– moist-dry
Physocarpus capitatus,	Pacific Ninebark- moist-wet
Ribes sanguineum,	Red-flowering Current- moist-dry
Rosa gymnocarpa,	Baldhip Rose– moist-dry
Rosa nutkana,	Nootka Rose– moist-dry
Rosa pisocarpa,	Swamp Rose– moist-dry
Rubus parviflorus,	Thimbleberry– moist-dry
Symphoricarpos alba,	Common Snowberry- moist-dry
Viburnum edule,	Highbush Cranberry; Squashberry- moist

Large Shrubs/ Small Trees

Acer circinatum,	Vine Maple– moist-wet
Amelanchier alnifolia,	Western Saskatoon Serviceberry-dry
Crataegus douglasii (or *C. suksdorfii*),	Douglas' Black Hawthorn– moist-wet
Malus fusca,	Pacific Crab Apple– moist-wet
Oemleria cerasiformis,	Indian Plum– moist-dry
Philadelphus lewisii,	Mock Orange– moist-dry
Prunus emarginata (or *P. virginiana*),	Bitter Cherry- moist
Rhamnus purshiana,	Cascara– dry-wet
Salix hookeriana,	Piper's Willow– moist-wet
Salix scouleriana,	Scoulers Willow- moist-wet
Salix sessilifolia,	Soft leafed Willow– moist-wet
Salix sitchensis,	Sitka Willow– moist-wet
Spiraea douglasii,	Douglas Spiraea– moist-wet

Grass and Grass-Like Plants

Beckmannia syzigachne,	American Slough Grass– moist-wet
Bromus carinatus,	California Brome Grass- moist-dry
Bromus sitchensis,	Alaska Brome– moist-dry
Bromus vulgaris,	Columbia Brome Grass– moist-dry

Camassia quamash,	Common Camas-moist
Carex aperta,	Columbia Sedge– moist-wet
Carex deweyanna,	Dewey Sedge– moist-wet
Carex obnupta,	Slough Sedge- moist-wet
Carex stipata,	Sawbeak Sedge– moist-wet
Deschampsia cespitosa,	Tufted Hairgrass- moist-dry
Eleocharis acicularis,	Needle Spike-Rush- moist-wet
Eleocharis ovata,	Ovate Spike-Rush- moist-wet
Eleocharis palustris,	Creeping Spike-Rush- moist-wet
Elymus glaucus,	Blue Wildrye– moist-dry
Festuca occidentalis,	Western Fescue Grass– moist-dry
Festuca rubra var. commutata,	Western Red Fescue– moist-dry
Glycera occidentalis,	Western Mannagrass– moist-wet
Iris douglasiana,	Douglas Iris– moist-dry
Iris tenax,	Oregon Iris– moist-dry
Juncus effusus var. pacificus	Common Rush– moist-wet
Juncus effufus var. gracilis	Common Rush– moist-wet
Juncus ensifolius,	Dagger-leaf Rush- moist-wet
Juncus patens,	Grooved Rush, Spreading Rush, - moist-wet
Juncus tenuis,	Slender Rush– moist-wet
Scirpus acutus,	Hardstem Bulrush- moist-wet
Scirpus microcarpus,	Small Fruited Bulrush- moist-wet
Sedum oreganum,	Oregon Sedum- dry
Sisyrinchium idahoense (or *S.angustifolium; S. bellum*),	Blue-eyed Grass– moist
Sisyrinchium douglasii,	Purple-Eyed Grass-moist

Ferns: Moist Shade

Athyrium felix-femina,	Lady Fern
Blechnum spicant,	Deer Fern
Polypodium glycrrhiza,	Licorice Fern
Polystichum munitum,	Sword Fern
Pteridium aquilinum,	Bracken Fern

Vegetated Swale and Vegetated Filter Strip Recommended Plants:

Planting zones
Swale bottom to 1.5 ft. up the side slope = wet to moist
Side slopes from 1.5 – 3 ft. = moist to dry
Side slopes above 3 ft. and upland = dry

Grasses and Groundcovers - Wet to Moist

Carex aperta,	Columbia Sedge
Carex obnupta,	Slough Sedge
Scirpus microcarpus,	Small flowered (or fruited) Bulrush
Hordeum brachyantherum,	Meadow Barley
Juncus effusus var. pacificus	Common Rush– moist-wet
Juncus effufus var. gracilis	Common Rush– moist-wet
Juncus ensifolius,	Dagger-leaf Rush
Juncus oxymeris,	Pointed Rush
Juncus tenuis,	Slender Rush
Juncus patens,	Grooved Rush; Spreading Rush
Glyceria occidentalis,	Manna Grass

Ferns: Moist shade

Blechnum spicant,	Deer Fern
Polypodium gycrrhiza,	Licorice Fern
Polystichum munitum,	Sword Fern

Moist to dry

Arctostaphyllos uva-ursi,	Kinnick-innick Aster
Aster suspicatus,	Douglas' Aster
Bromus carinatus,	California Brome Grass
Bromus sitchensis,	Alaska Brome
Bromus vulgaris,	Columbia Brome Grass
Lupinus micranthus,	Small Flowered Lupine
Sisyrinchium idahoense,	Blue-eyed Grass
Camassia quamash,	Common Camas
Festuca occidentalis,	Western Fescue Grass
Deschampsia caespitosa,	Tufted Hairgrass
Elymus glaucus,	Blue Wildrye
Fragaria vesca or *F. virginiana,*	Woodland strawberry or Wild strawberry
Sisyrinchium idahoense,	Blue-eyed Grass

Shrubs- varying zones

Cornus sericea,	Redtwig Dogwood- moist-wet
Gaultheria shallon,	Salal- dry

Mahonia aquifolium,	Tall Oregon Grape- moist -dry
Mahonia nervosa,	Dull Oregon Grape- moist-dry
Physocarpus capitatus,	Pacific Ninebark- moist-wet
Ribes sanguineum,	Red-flowering Current-dry
Rosa gymnocarpa,	Baldhip Rose– moist -dry
Rosa nutkana,	Nootka Rose– moist-dry
Rosa pisocarpa,	Swamp Rose– moist-dry
Spiraea betulifolia,	Shiny-leaf Spiraea - dry
Symphoricarpos alba,	Common Snowberry- moist-dry
Viburnum edule,	Highbush Cranberry; Squashberry- moist -dry

Large Shrub/Small Tree– varying zones

Acer circinatum,	Vine Maple- moist-wet
Amelanchier alnifolia,	Western Saskatoon Serviceberry- dry
Ceanothus sanguineus,	Oregon Redstem Ceanothus- moist-dry
Corylus cornuta,	Western Beaked Hazelnut- moist-dry
Crataegus douglasii,	Douglas' Black Hawthorn- moist
Holodiscus discolor,	Oceanspray- moist-dry
Malus fusca,	Pacific Crab Apple- moist-wet
Oemleria cerasiformis,	Indian Plum; Osoberry- moist-wet
Philadelphis lewesii,	Mock Orange- moist-dry
Prunus emarginata or *P.Virginiana*	Bitter or Choke Cherry- moist
Rhamnus purshiana,	Cascara- dry-wet
Rosa nutkana,	Nootka Rose- moist-dry
Rubus parviflorus,	Thimbleberry- moist-dry
Salix fluviatalis,	Columbia Willow- moist-wet
Salix hookeriana,	Piper's Willow- moist-wet
Salix lucida (or S. *lasiandra*),	Pacific Willow- moist-wet
Salix scouleriana,	Scoulers Willow-moist-wet
Salix sessilifolia,	Soft leafed Willow- moist-wet
Salix sitchensis,	Sitka Willow- moist-wet
Sambucus cerulea,	Blue Elderberry- moist- dry
Sambucus racemosa,	Red Elderberry- moist- dry

Conifer and Evergreen Trees- varying zones

Abies grandis,	Grand Fir- moist-dry
Arbutus menziesii,	Madrone- dry
Pinus monticola,	Western White Pine- moist-dry
Pinus ponderaosa,	Ponderosa Pine- dry
Pseudotsuga menziesii,	Douglas Fir- moist-dry
Thuja plicata,	Western Red Cedar- moist-wet
Tsuga heterophylla,	Western hemlock-moist

Deciduous Trees- varying zones

Acer macrophyllum,	Big leaf Maple- moist-dry
Alnus rubra,	Red Alder - moist-wet
Amelanchier alnifolia,	Serviceberry - dry
Cornus nuttallii,	Western Flowering Dogwood– moist-dry
Fraxinus latifolia,	Oregon Ash - moist-wet
Populus balsamifera,	Black Cottonwood – moist-wet
Quercus chrysolopsis,	Canyon Live Oak - dry
Quercus garryana,	Oregon White Oak – moist-dry

Grassy Swale Recommended Seed Mixes:

See **Exhibit F-1** for grass seed recommendations and specifications.

Vegetated Infiltration Basin and Dry Detention Pond Recommended Plants:

Planting zones
Basin bottom to 1.5 ft. up the side slope = moist
Side slopes from 1.5 – 3 ft. = moist to dry
Side slopes above 3 ft. and upland = dry

Note: These plants are recommended based on experience and/or literature review. For soils with slow infiltration rates (< 2 inches per hour) moist to wet plants are preferable; for soils with higher infiltration rates moist to dry plants are preferable.

Grasses and groundcovers: See **Exhibit F-1** for grass seed recommendations and specifications.

Moist –

Beckmannia syzigachne,	American Slough Grass
Carex aperta,	Columbia Sedge
Carex densa,	Dense Sedge
Carex deweyana,	Dewey Sedge
Carex hendersonii,	Henderson Sedge
Carex obnupta,	Slough Sedge
Carex stipata,	Sawbeak Sedge
Carex vesicaria,	Inflated Sedge
Eleocharis acicularis,	Needle Spike-rush
Eleocharis ovata,	Ovate Spike-rush
Eleocharis palustris,	Creeping Spike-rush
Juncus effusus,	Common/Soft Rush
Juncus ensifolius,	Dagger-leaf Rush
Juncus patens,	Grooved Rush; Spreading Rush
Juncus tenuis,	Slender Rush
Scirpus acutus,	Hardstem Bulrush
Scirpus americanus,	Three-square or American Bulrush
Scirpus microcarpus,	Small Fruited Bulrush

Moist to Dry

Aster suspicatus,	Douglas' Aster
Bromus carinatus,	California Brome Grass
Bromus sitchensis,	Alaska Brome

Bromus vulgaris,	Columbia Brome Grass
Camassia quamash,	Common Camas
Festuca occidentalis,	Western Fescue Grass
Deschampsia caespitosa,	Tufted Hairgrass
Elymus glaucus,	Blue Wildrye
Fragaria vesca or F. virginiana,	Woodland strawberry or Wild strawberry
Hordeum brachyantherum,	Meadow Barley
Iris tenax,	Oregon Iris
Lupinus micranthus,	Small Flowered Lupine
Sisyrinchium idahoense,	Blue-eyed Grass

Ferns: Moist shade

Blechnum spicant,	Deer Fern
Polypodium gycrrhiza,	Licorice Fern
Polystichum munitum,	Sword Fern
Athyrium felix-femina,	Lady Fern

Shrubs: moist

Cornus sericea,	Red-stemmed or Red-osier Dogwood
Salix hookeriana,	Hookers Willow
Salix lucida var. 'lasiandra',	Pacific Willow
Salix sitchensis,	Sitka Willow
Salix scouleriana,	Scouler's Willow
Salix fluviatalis,	Columbia Willow
Sambucus racemosa,	Red Elderberry
Physocarpis capitatus,	Pacific Ninebark
Spiraea douglasii,	Douglas Spirea
Crataegus douglasii,	Black Hawthorn
Rhamnus purshiana,	Cascara
Rubus spectabilis,	Salmonberry
Rosa pisocarpa,	Swamp Rose

Shrubs: (moist-dry)

Acer circinatum,	Vine maple
Ceanothus sanguineous,	Oregon Redstem Ceanothus
Ceanothus velutinus,	Snowbrush
Corylus cornuta,	Western Beaked Hazelnut
Gautheria shallon,	Salal
Holodiscus discolor,	Oceanspray
Mahonia aquifolium,	Tall Oregon Grape
Mahonia nervosa,	Dull Oregon Grape
Philadelphus lewisii,	Mock Orange
Ribes sanguineum,	Red Flowering Currant

Rosa gymnocarpa,	Baldhip Rose
Rosa nutkana,	Nootka Rose
Rubus parviflorus,	Thimbleberry
Spiraea betulifolia,	Shiny-leaf Spiraea
Symphoricarpus albus,	Snowberry
Viburnum edule,	Highbush Cranberry

Trees

Conifer and Evergreen Trees- varying zones

Abies Grandis,	Grand Fir- moist-dry
Arbutus menziesii,	Madrone- dry
Castanopsis chrysopylla,	Chinquapin- dry
Pinus monticola,	Western White Pine- moist-dry
Pinus Ponderaosa,	Ponderosa Pine- dry
Pseudotsuga menziesii,	Douglas Fir- moist-dry
Thuja plicata,	Western Red Cedar- moist-wet (prefers shade)
Tsuga heterophylla,	Western hemlock- moist

Deciduous Trees- varying zones

Acer macrophyllum,	Big leaf Maple – moist-dry
Alnus rubra,	Red Alder - moist-wet
Amelanchier alnifolia,	Serviceberry - dry
Cornus nuttalii,	Western Flowering Dogwood – moist-dry
Fraxinus latifolia,	Oregon Ash - moist-wet
Malus fusca,	Pacific crabapple - moist-wet
Oemleria cerasiformis,	Indian Plum - moist-dry
Populus balsamifera,	Black Cottonwood – moist-wet
Quercus garryana,	Oregon White Oak – moist-dry

Wet and Extended Wet Pond Recommended Plants:

Planting zones
Shallow water to 1 ft. up the side slope = wet to saturated
Side slopes from 1 – 3 ft. = moist to dry
Side slopes above 3 ft. and upland = dry

Wetland herbaceous plants (aquatic and emergent)
Emergent wet to saturated zone

Alisma plantago-aquatica,	Water Plantain
Carex obnupta,	Slough Sedge
Eleocharis ovata,	Ovate Spike rush
Eleocharis palustris,	Creeping Spike rush
**Lemna minor*,	Common Lesser Duckweed*
Myosotis laxa,	Small-flowered Forget-me-not
**Potamogeton natans*,	Floating-leafed Pondweed
**Sagittaria latifolia*,	Broadleaf Arrowhead; Wapato
Scirpus acutus,	Hardstem Bulrush
Sparganium emersum,	Narrowleaf Bureed

Moist to wet zone

Alopecurus geniculatus,	Water foxtail
Beckmannia syzigachne,	American Slough Grass
Carex aperta,	Columbia Sedge
Carex deweyana,	Dewey Sedge
Juncus effusus,	Common/Soft Rush
Juncus ensifolius,	Dagger-leaf Rush
Juncus oxymeris,	Pointed Rush
Juncus tenuis,	Slender Rush
Juncus patens,	Grooved Rush; Spreading Rush
Lupinus polyphyllus,	Large-leaved Lupine
Scirpus microcarpus,	Small flowered (or fruited) Bulrush

Grasses and Groundcovers: varying zones, see **Exhibit F-1** for grass seed recommendations and specifications.

Aster suspicatus,	Douglas' Aster- moist
Bidens cernua,	Nodding Beggarticks- moist -wet
Bromus sitchensis,	Alaska Brome- moist-dry
Camassia quamash,	Common Camas- moist
Deschampsia caespitosa,	Tufted Hairgrass- moist-dry
Elymus glaucus,	Blue Wildrye- moist-dry
Fragaria vesca or *F. virginiana*,	Woodland strawberry or wild strawberry- moist-dry

Glyceria occidentalis,	Western Mannagrass- moist-wet
Hordeum brachyantherum,	Meadow Barley- moist
Sisyrinchium idahoense,	Blue-eyed Grass- moist
Viola palustris,	Marsh Violet- moist- wet
Veronica americana,	Speedwell- moist-wet

Shrub: moist to saturated zones

Acer circinatum,	Vine Maple
Blechnum spicant,	Deer Fern
Cornus sericea,	Red-stemmed dogwood
Crateagus douglasii,	Black Hawthorn
Rhamnus purshiana,	Cascara
Rubus spectabilis,	Salmonberry
Rosa gymnocarpa,	Baldhip Rose
Rosa pisocarpa,	Swamp Rose
Oemlaria cerasiformis,	Indian Plum
Physocarpis capitatus,	Pacific Ninebark
Polystichum munitum,	Sword fern
Prunus emarginata,	Bitter Cherry
Salix fluviatalis,	Columbia Willow
Salix hookeriana,	Hookers Willow
Salix sitchensis,	Sitka Willow

Shrub: moist to dry zones

Mahonia aquifolium,	Tall Oregon Grape
Mahonia nervosa,	Dull Oregon Grape
Rosa nutkana,	Nootka Rose
Rubus parviflorus,	Thimbleberry
Spiraea betulifolia,	Shiny-leaf Spiraea
Symphoricarpus alba,	Snowberry
Sambucus racemosa,	Red Elderberry
Spiraea douglasii,	Douglas Spiraea
Viburnum edule,	Highbush Cranberry; Squashberry

Shrub dry zones

Corylus cornuta,	Western Beaked Hazelnut
Holodiscus discolor,	Oceanspray
Lonicera involucrata,	Black twinberry (moist-dry)
Mahonia aquifolium,	Tall Oregon Grape
Philadelphis lewesii,	Mock Orange
Ribes sanguineum,	Red Flowering Currant
Salix scouleriana,	Scouler's Willow

Conifer and Evergreen Trees - varying zones

Abies grandis,	Grand Fir- moist-dry
Arbutus menziesii,	Madrone- dry
Castinopsis chrysophylla,	Chinquapin- dry
Pinus ponderosa,	Ponderosa Pine- dry
Pinus monticola,	Western White Pine- dry-moist
Pseudotsuga menziesii,	Douglas Fir- moist-dry
Sequoia sempervirons,	Coast Redwood- moist
Thuja plicata,	Western Red Cedar- moist-wet
Tsuga heterophylla,	Western Hemlock- moist

Deciduous Trees - varying zones

Acer macrophyllum,	Big leaf Maple- moist- dry
Alnus rubra,	Red Alder- moist-wet
Amelanchier alnifolia,	Serviceberry- dry
Cornus nuttalii,	Western Flowering Dogwood- moist-dry
Fraxinus latifolia,	Oregon Ash- moist-wet
Malus fusca,	Pacific crabapple- moist-wet
Oemleria cerasiformis,	Indian Plum- moist-dry
Populus balsamifera,	Black Cottonwood- moist-wet
Salix lucida var.' lasiandra',	Pacific Willow- moist-wet
Quercus cyrsolepsis,	Canyon Live Oak- dry
Quercus garryana,	Oregon White Oak- moist-dry

SEED SPECIFICATIONS FOR STORMWATER MANAGEMENT MANUAL

Species listed below should only be used in the listed moisture regime for optimal success. *Sow rates for* ***small seeded mixes*** *shall contain a* ***minimum of 20 lbs/per acre in combination*** *for stormwater management facilities and* ***30 lbs/acre for erosion control*** *purposes.* ***Sow rates for large/medium seeded*** *mixes should contain a* ***minimum of 25 lbs per acre*** *in combination for stormwater management facilities and 40 pounds per acre* ***for erosion control*** *purposes.*

Common name	Scientific Name	Optimal Sow Season	Matrix or to add diversity?	Swale or Pond Sow Rate (Hand)	Erosion Control Sow Rate	Moisture	Exposure	Seed size	Commercial accessibility of local eco-type
Grasses									
American sloughgrass	Beckmannia syzigachne	fall/spring	D	2 lbs/ac	NR	inundated to wet	sun	medium	easy to medium, Willamette Valley
Blue wildrye	Elymus glaucus	early fall/spring	**M**	**25 lbs/ac**	40 lbs/acre	xeric to mesic	sun to shade	large	easy, Portland Metro
California brome	Bromus carinatus	early fall/spring	**M**	**25 lbs/ac**	40 lbs/acre	xeric to mesic	sun	large	easy, Portland Metro
California oatgrass	Danthonia californica	fall/spring	**M**	**30 lbs/ac**	NR		sun	large	easy to medium, Willamette Valley
Columbia brome	Bromus vulgaris	fall/spring	D	5 lbs/ac	NR	xeric to mesic	shade	large	medium, Portland Metro
Junegrass	Koeleria macrantha	fall/spring	**M**	**20 lbs/ac**	NR	xeric to mesic	sun	small	easy to medium, PDX or Willamette Valley
Meadow barley	Hordeum brachyantheru	early fall/spring	**M**	**25 lbs/ac**	40 lbs/acre	wet to mesic	sun	large	easy to medium, Willamette Valley
Pine bluegrass	Poa secunda								
Rice cutgrass	Leersia oryzoides	fall/spring	D	5 lbs/ac	NR	inundated to wet	sun	medium	medium to difficult, Portland Metro
Roemer's fescue	Festuca roemeri	fall/spring	D	2 lbs/ac	NR	xeric to mesic	sun	small	difficult, Willamette Valley
Sitka brome	Bromus sitchensis	early fall/spring	**M**	**25 lbs/ac**	40 lbs/acre	wet to mesic	sun/shade	large	easy, Willamette Valley
Slender hairgrass	Deschampsia elongata	early fall/spring	**M**	**20 lbs/ac**	30 lbs/acre	wet to xeric	sun	small	easy, Portland Metro
Slender wheatgrass	Elymus trachycaulus	early fall/spring	**M**	**25 lbs/ac**	40 lbs/acre	xeric to mesic	sun	large	medium to difficult, Willamette Valley
Spike bentgrass	Agrostis exarata	early fall/spring	D	5 lbs/ac	30 lbs/acre	saturated to wet	sun	small	easy to medium, Portland Metro
Tall mannagrass	Glyceria elata	fall/spring	D	2 lbs/ac	NR	saturated to mesic	shade	small	medium to difficult, Portland Metro
Tufted hairgrass	Deschampsia cespitosa	fall/spring	D	2 lbs/ac	NR	saturated to wet	sun	small	easy, Willamette Valley
Water foxtail	Alopecuris geniculatus	fall/spring	**M**	**25 lbs/ac**	NR	inundated to wet	sun	medium	easy, PDX or Willamette Valley
Western fescue	Festuca occidentalis	fall/spring	**M**	**20 lbs/ac**	NR	xeric to mesic	sun	small	medium to difficult, Willamette Valley
Western mannagrass	Glyceria occidentalis	fall/spring	**M**	**25 lbs/ac**	NR	saturated to wet	sun	medium	easy to medium, Willamette Valley
Sedges, Rushes - soil moisture as indicated into summer months									
Carex obnupta	Slough sedge	fall/spring	D	2 lbs/ac	NR	inundated to mesic	sun/shade	medium	medium to difficult, PDX
Carex scoparia	Pointed broom sedge	fall/spring	D	2 lbs/ac	NR	wet to mesic	sun	medium	medium to difficult, PDX
Carex stipata	Sawbeak sedge	fall/spring	D	2 lbs/ac	NR	inundated to mesic	sun	medium	medium, Willamette Valley
Eleocharis ovata	Ovate spikerush	fall/spring	D	1 lb/ac	NR	inundated to wet	sun	small	easy, PDX or Willamette Valley
Eleocharis palustris	Creeping spikerush	fall/spring	D	2 lbs/ac	NR	inundated to wet	sun	small	easy to medium, Willamette Valley
Juncus acuminatus	Tapertip rush	fall/spring	D	0.25 lbs/ac	NR	inundated to wet	sun	small	medium, Willamette Valley, PDX
Juncus bufonius	Toad rush	fall/spring	D	0.25 lbs/ac	NR	wet to mesic	sun	small	medium, Willamette Valley
Juncus patens	Spreading rush	fall/spring	D	0.50 lb/ac	NR	wet to mesic	sun/shade	small	easy, PDX
Forbs									
Achillea millefolium	Western Yarrow	fall	D	0.25 lbs/ac	NR	wet to mesic	sun	medium	easy, PDX or Willamette Valley
Aquilegia formosa	Western Columbine	fall	D	1.0 lb/ac	NR	wet to mesic	sun	medium	easy to medium, Willamette Valley
Alisma media	Water plantain	fall/spring	D	1.0 lb/ac	NR	inundated to wet	sun	medium	easy to medium, Willamette Valley
Collomia grandiflora	Large flowered collomia	fall/spring	D	.50 lbs/ac	NR	xeric to mesic	sun	small	medium to difficult, Willamette Valley
Collinsia rattanii	Blue eyed mary	fall/spring	D	.25 lbs/ac	NR	xeric to mesic	sun	small	medium to difficult, Willamette Valley
Epilobium densiflora	Dense spike primrose	fall	D	1.0 lb/ac	NR	wet to mesic	sun	small	medium, Willamette Valley
Eriophyllum lanatum	Wooly sunshine	fall	D	1.0 lb/ac	NR	wet to mesic	sun	medium	easy to medium, Willamette Valley
Gilia capitata	Blue gilia	fall/spring	D	2 lbs/acre	1 lb/ac (w/	xeric to mesic	sun	medium	medium, Willamette Valley
Lotus purshianus	Spanish clover	fall	D	2 lbs/acre	1 lb/ac (w/	xeric to mesic	sun	medium	medium, Willamette Valley
Lupinus albicaulis	Sickle keel lupine	fall	D	1 lb/ac	1 lb/ac (w/	xeric to mesic	sun	large	medium, Willamette Valley
Iris tenax	Oregon Iris	fall	D	2 lbs/ac	NR	xeric to mesic	sun	large	easy to medium, Willamette Valley
Camassia quamash	Common camas	fall	D	1 lb/ac	NR	wet to mesic	sun	medium	easy to medium, Willamette Valley
Camassia quamash va	Great camas	fall	D	1 lb/ac	NR	wet to mesic	sun	medium	easy to medium, Willamette Valley
Lupinus micranthus	Small flowered lupine	fall	D	1 lb/ac	NR	xeric to mesic	sun	medium	medium to difficult, Willamette Valley
Ranunculus occidental	Western buttercup	fall	D	1 lb/ac	NR	xeric to mesic	sun	medium	medium to difficult, Willamette Valley
Sidalcea campestris	Checker mallow	fall	D	1 lb/ac	NR	xeric to mesic	sun	large	medium to difficult, Willamette Valley
Lupinus rivularis	Stream lupine	fall	D	1 lb/ac	1 lb/ac (w/	xeric to mesic	sun	large	medium, Willamette Valley
Plagiobothrys figuratus	Popcorn flower	fall/spring	D	1.0 lb/ac	NR	inundated to wet	sun	small	medium to difficult, Willamette Valley
Prunella vulgaris var. la	Self heal	fall/spring	D	2 lbs/ac	1 lb/ac (w/	wet to mesic	sun/shade	medium	easy to medium, PDX or Willamette Valley
Solidago canadensis	Goldenrod	fall	D	0.50 lbs/ac	NR	xeric to mesic	sun	small	easy to medium, PDX or Willamette Valley
Recommended Non-Native Cover Crop Species									
Festuca rubra var. com	Chewings fescue	year round	M	20 lbs/ac	30-40				n/a
Triticum spp.	Wheat	year round	M	50 lbs/ac	60				n/a
Avena spp.	Oats	year round	M	50 lbs/ac	60				n/a
Regreen	Sterile wheat hybrid	year round	M	40 lbs/ac	50				n/a
Agropyron spp.	Wheatgrass	year round	M	30 lbs/acre	40				A. trachycaulus (W.V. source)

Nuisance Grass Species not recommended for use on Erosion Control or Stormwater Projects

Species	***Common name***	***State Listed Noxious Weed?***	***City***
Agropyron repens	Quackgrass	yes (B-list)	Nuisance List Portland Plant List
Alopecuris pratensis	Meadow foxtail	no	Nuisance List Portland Plant List
Anthoxanthum odoratu	Sweet vernal grass	no	Nuisance List Portland Plant List
Arrhenatherum elatius	Tall oatgrass	no	Nuisance List Portland Plant List
Brachypodium sylvatic	False brome	yes (B-list)	Nuisance List Portland Plant List
Bromus diandrus	Ripgut	no	Nuisance List Portland Plant List
Bromus hordaceus	Smooth brome	no	Nuisance List Portland Plant List
Bromus inermis	Smooth brome	no	Nuisance List Portland Plant List
Bromus japonicus	Japanese brome	no	Nuisance List Portland Plant List
Bromus sterilis	Poverty grass	no	Nuisance List Portland Plant List
Bromus tectorum	Cheatgrass	no	Nuisance List Portland Plant List
Festuca arundinacea	Tall fescue	no	Nuisance List Portland Plant List
Holcus lanatus	Velvet grass	no	Nuisance List Portland Plant List
Lolium multiflorum	Annual ryegrass	no	Nuisance List Portland Plant List
Phalaria arundinacea	Reed canary grass	no	Nuisance List Portland Plant List
Phalaris aquatica	Harding grass	no	Nuisance List Portland Plant List
Phleum pratensis	Timothy	no	Nuisance List Portland Plant List
Phragmites australis	Common reed	no	Nuisance List Portland Plant List
Vulpia myoros	Rat-tailed fescue	no	Nuisance List Portland Plant List

F.2 DESIGN CONCEPTS AND PRINCIPLES

The Bureau of Environmental Services (BES) requires developers to design stormwater facilities in project landscape areas, using surface retention facilities such as those shown in the simplified approach. The resulting integrated stormwater landscape can meet many, if not all, of Title 33 landscape requirements, applicable plan district requirements, and Title 17 requirements. The benefits of integrated designs include construction cost savings, combined maintenance, aesthetic benefits, and the greater likelihood of maintaining long-term functionality. A well-designed and established landscape will also prevent post-construction soil erosion. These approaches can also help reduce urban heat island effects and contribute to other sustainable principles.

An integrated design may require changing the size of some site elements. For example, Title 33.266 parking code allows parking layout and dimensions to be designed to allow more space for simplified approach facilities. Also see Parking lot Design Tips in Chapter 2 of this document.

In order to integrate stormwater management with the project landscape areas, it is essential that impervious surface grading be directed toward the stormwater facility areas. Surface stormwater facilities also must be depressed to allow sheet flow into the area. Since these design approaches are still new to many construction contractors it is advisable to clearly show these details in cross section and plan view drawings.

Pollution Prevention

Stormwater pollution prevention practices related to landscaping can be categorized into two broad categories:

- Toxic Substance Use Reduction
- Pollutant Source Reduction

Toxic Substance Use Reduction

Projects shall be designed to minimize the need for toxic or potentially polluting materials such as herbicides, pesticides, fertilizers, or petroleum based fuels within the facility area before, during, and after construction. Use of these materials creates the risk of spills, misuse, and future draining or leaching of pollutants into facilities or the surrounding area. (*For information about alternatives, contact Metro's Alternatives to Pesticides Program at 503-797-1811.*)

Pollutant Source Reduction

Materials that could leach pollutants or pose a hazard to people and wildlife shall not be used as components of a stormwater facility. Some examples of these materials are chemically treated railroad ties and lumber and galvanized metals. Many alternatives to these materials are available.

Soils

Soil analysis shall be conducted **within the stormwater facility area** to determine the viability of soils to assure healthy tree and vegetation growth and to provide adequate infiltration rates through the topsoil, or soil in these areas shall be amended. These tests can help the designer specify appropriate levels and types of soil amendments.

Projects should stockpile existing topsoil for re-use on the site to minimize the need to import topsoil. Appropriate erosion control measures, as required by the City's *Erosion Control Manual*, shall be used. Soil analysis tests shall be performed on stockpiled soil if it will be used within the facility area.

Topsoil is not required to be placed in the bottom of wet ponds or constructed wetland areas having a permanent pool depth of 6" or more. At the time of final inspection all surface area soils shall be covered with plants and/or mulch sufficient to prevent erosion.

Site Preparation and Grading

Unwanted vegetation in the facility area shall be removed during site preparation with equipment appropriate for the type of material encountered and site conditions. It is recommended that the maximum amount of pre-existing native vegetation be retained and protected.

No material storage or heavy equipment is allowed within the stormwater facility area after site clearing and grading has been completed, except to excavate and grade as needed to build the facility.

After the facility area is cleared and graded, all disturbed subsoil shall be tilled before capping with 18 inches of topsoil. If existing areas surrounding the stormwater facility are disturbed by construction, the top 18 inches of soil shall be tilled. No tilling shall occur within the drip line of existing trees. After tilling is completed, no other construction traffic shall be allowed in the area, except for planting and related work.

All construction and other debris shall be removed before topsoil is placed. Unless otherwise specified, the City will expect the landscape contractor to be responsible for final grading and for ensuring that surface and stormwater runoff flows are functioning as designed.

Mulch

Approved mulching materials and practices include organic materials such as compost, bark mulch, leaves, sawdust, straw, or wood shavings, as well as small river gravel, pumice, or other inert materials, applied in a 1-foot radius (measured from the center of the plant) around specific trees or shrubs. For ground cover plantings, the mulch shall be applied to cover all soil between plants. Care should be exercised to use the appropriate amount of mulch. Over-use can cause excessive nutrients to leach into the facility. Mulch shall be weed-free. Manure mulching and high-fertilizer hydroseeding are prohibited in a facility area during and after construction.

Irrigation

Permanent irrigation systems are not allowed for BES maintained facilities, unless approved by BES. Temporary irrigation systems or alternative methods of irrigation for landscape establishment shall be specified. Permanent irrigation systems are allowed for private facilities, but designers are encouraged to minimize the need for permanent irrigation. Innovative methods for watering vegetation are encouraged, such as the use of cisterns and air conditioning condensate.

Facility Screening

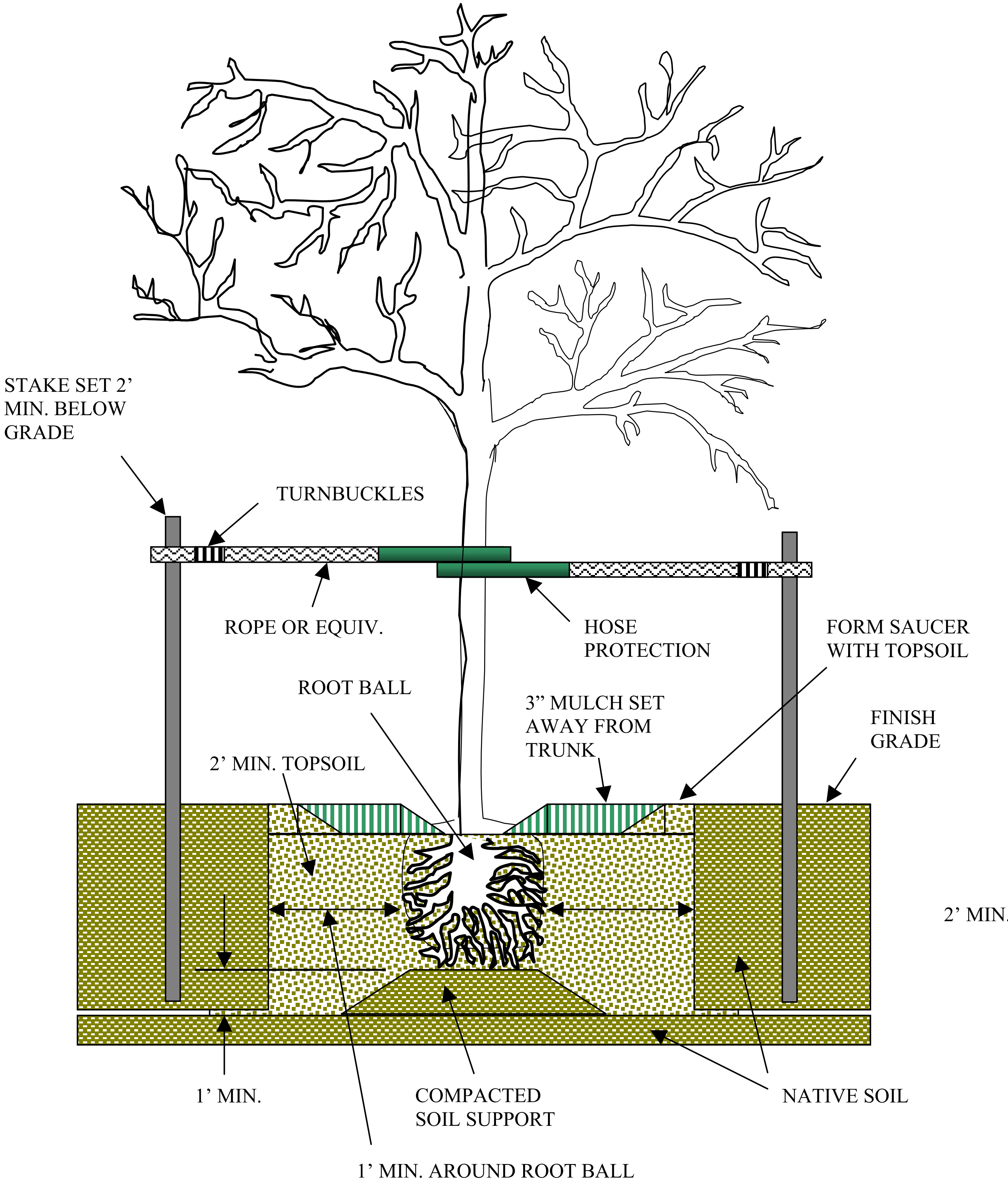
Facility elements such as chain link fences, concrete bulkheads, outfalls, rip-rap, gabions, large steel grates, steep side slopes, manhole covers/vault lids, berm embankments planted only with grasses, exposed pipe, blank retaining walls greater than 2 feet high, and access roads are generally not aesthetic. When these elements are part of City-maintained facilities or private facilities that face public right-of-way or other private property, BES requires them to be screened with plant materials. The quantities of landscape materials that are required by this chapter have been estimated to provide sufficient screening in most of the stormwater facilities. Attention will need to be paid to site conditions that may require adjustments in planting layout and/or the need for additional trees and shrubs. It is not the intent of this screening requirement to dictate a specific solution such as a linear hedge. Designers are encouraged to integrate the facility landscaping with the screening objective. Designers can also use more decorative materials providing they are attractive and meet the intent of city code requirements such as L2, L3, or L4 standards as specified in City Code Title 33.248.

Commercial Sources for Native Plant Material

Bareroot (Seedling) Trees/ Shrubs	
Balance Restoration Nursery	541-942-5530 (fax & phone)
Wallace Hansen Nursery	503-581-2638, fax 503-581-9957
D.L. Phipps State Forest Nursery	541-584-2214, fax 541-584-2326
Brooks Tree Farm	503-393-6300, fax 503-393-0827
Mineral Springs Ornamentals	503-852-6129, fax 503-852-6553
Mt. Jefferson Farms	503-363-0467, fax 503-362-5248
Northwest Native Plants	503-632-7079, fax 503-632-7087
Seven Oaks Native Nursery	541-757-6620 (fax & phone)
Bosky Dell Natives	503-638-5945, fax 503-638-8047
Container Material	
Northwest Native Plants	503-632-7079, fax 503-632-7087
Seven Oaks Native Nursery	541-757-6620 (fax & phone)
Bosky Dell Natives	503-638-5945, fax 503-638-8047
Watershed Gardenworks	360-423-6456
Emergent Plugs	
Balance Restoration Nursery	541-942-5530 (fax & phone)
Seven Oaks Native Nursery	541-757-6620 (fax & phone)
Watershed Gardenworks	360-423-6456
Native Seed	
Pacific Northwest Natives	541-928-8239
Mid-Valley Farms	541-936-6061
North American Revegetation	541-928-9095
Triangle Farms	503-873-5190
Oregon Heritage Farms	503-628-2775

Note: This list is not all-inclusive and is only up-to-date at the time of this manual's release. If you are interested in being added to this list notify Steve Fancher at stevef@bes.ci.portland.or.us. For a more inclusive list of nurseries that supply native plants, contact: www.tardigrade.org/natives/nurseries.html. For an updated database of commercial native seed availability in the Pacific Northwest, contact: www.nativeseednetwork.org.

Tree Planting Detail for Trees of 3” Caliper or Larger, usually used for street trees applications. This detail is not required for smaller trees. However, all trees must be secured sufficiently at the time of planting and throughout the warranty period to assure that the tree is well established.



Portland Plant List

A detailed plant list, including habitat types (i.e. wetland, riparian, forested slopes, thicket, grass and rocky) can be found at:

http://www.portlandonline.com/planning/index.cfm?c=35517

Parking Lot Trees

BES has included the parking lot tree list to assist designers in selection of trees most appropriate for the potentially numerous micro-climates that might exist in parking lots and often associated proximity to building walls. It is likely that most parking lots will be hot in summer months until the trees become established. BES has attempted to point out native species in the list and provide their suitability to various conditions.

Trees are listed by the scientific name of the species first, then the common name. Where applicable, names of cultivars are presented in single quote marks with the common name.

The recommended minimum clearance from the pavement provides guidance on the amount of planting space each tree needs. It is expressed as the distance from the center of the planted tree trunk to the nearest paved surface. Comments provide guidance as to best applications of the different trees and additional information that may help in tree selection. For example, some trees are well suited to landscaped areas that will receive stormwater runoff, while others may not tolerate the additional moisture from runoff, largely depending on the soil.

There are two tables. The first consists of trees that are not native to the Portland area and the second consists of native trees listed on the Portland Plant List.

Non-native trees

Species name	Common Name	Minimum Distance from Pavement	Comments
Abies amabilis	Silver Fir	4 feet	Conifer, evergreen. Native to Oregon Cascades.
Acer campestre	Hedge maple	2 feet	Broadleaf, deciduous.
Acer rubrum	Red maple 'Embers Red,' 'October Glory,' 'Red Sunset,' 'Gerling,' 'Autumn Flame'	3 feet	Broadleaf, deciduous. Good for stormwater facilities

Species name	Common Name	Minimum Distance from Pavement	Comments
Acer saccharum	Sugar Maple (Except 'Legacy')	3 feet	Broadleaf, deciduous.
Calocedrus decurrens	Incense Cedar	3 feet	Conifer, evergreen Drought tolerant
Carpinus betulus	European Hornbeam	2 feet	Broadleaf, deciduous. Shade tolerant.
Celtis occidentalis	Hackberry	3 feet	Broadleaf, deciduous.
Cercidiphyllum japonicum	Katsura Tree	3 feet	Broadleaf, deciduous. Prefers well-drained soils Needs summer irrigation
Cladrastis kentuckea	Yellowwood	3 feet	Broadleaf, deciduous. Prefers summer irrigation and well-drained soil.
Cornus kousa var. *chinensis*	Chinese Dogwood	3 feet	Broadleaf, deciduous. Small tree. Fruits, but is not messy. Needs summer water.
Crataegus x *lavallei*	Lavalle Hawthorn	2 feet	Broadleaf, deciduous. Fruit can be messy.
Fagus grandifolia	American Beech	4 feet	Broadleaf, deciduous.
Fagus sylvatica	European Beech	4 feet	Broadleaf, deciduous.
Fagus sylvatica	European Beech 'Roseo-marginata,' 'Tricolor'	3 feet	Broadleaf, deciduous.
Fraxinus americana	White Ash	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Fraxinus excelsior	European Ash	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Fraxinus pennsylvanica	Green Ash 'Marshall,' 'Patmore,' 'Summit,' 'Urbanite'	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Ginkgo biloba	Ginkgo 'Shangri-la,' 'Saratoga'	3 feet	Measured as a broadleaf; deciduous. Use the male only. Female produces messy, smelly fruit.
Liquidambar styraciflua	Sweetgum	4 feet	Broadleaf, deciduous.
Liriodendron tulipifera	Tulip Tree or Tulip Poplar	4 feet	Broadleaf, deciduous.
Magnolia grandiflora	Southern Magnolia	4 feet	Broadleaf, evergreen.
Magnolia kobus	Kobus Magnolia	2 feet	Broadleaf, deciduous.
Metasequoia	Dawn Redwood	4 feet	Conifer, deciduous.

Species name	Common Name	Minimum Distance from Pavement	Comments
glyptostroboides			
Nothofagus dombeyi	South American Beech or Southern Beech	3 feet	Broadleaf, evergreen.
Nothofagus obliqua	Roble Beech	3 feet	Broadleaf, deciduous.
Nyssa sylvatica	Black Gum or Black Tupelo	3 feet	Broadleaf, deciduous. Good for stormwater facilities.
Ostrya virginiana	American Hornbeam	2 feet	Broadleaf, deciduous.
Pinus contorta	Shore Pine	3 feet	Conifer, evergreen. A smaller tree.
Pinus monticola	Western White Pine	3 feet	Conifer, evergreen.
Quercus bicolor	Swamp White Oak	3 feet	Broadleaf, deciduous. Tolerates wet soil.
Quercus coccinea	Scarlet Oak	3 feet	Broadleaf, deciduous. Intolerant of wet soil.
Quercus frainetto	Hungarian Oak 'Forest Green'	3 feet	Broadleaf, deciduous.
Quercus nigra	Water Oak	3 feet	Broadleaf, evergreen. Tolerates wet conditions.
Quercus phellos	Willow Oak	3 feet	Broadleaf, deciduous.
Quercus robur	English Oak	3 feet	Broadleaf, deciduous.
Quercus rubra	Northern Red Oak	4 feet	Broadleaf, deciduous.
Quercus velutina	Black Oak	4 feet	Broadleaf, deciduous.
Sequoia sempervirens	Coast Redwood	6 feet	Conifer, evergreen. Grows very tall.
Sequoiadendron giganteum	Giant Sequoia	8 feet	Conifer, evergreen. Trunk quickly becomes massive, needs ample space.
Sophora japonica	Japanese Pagoda Tree	3 feet	Broadleaf, deciduous.
Taxodium distichum	Bald Cypress	4 feet	Conifer, deciduous. Tolerates extremely wet conditions, but does not require it.
Umbellularia californica	California Laurel, Oregon Myrtle, Bay	4 feet	Broadleaf, evergreen. Drought tolerant.
Zelkova serrata	Sawleaf Zelkova 'Green Vase,' 'Halka,' 'Village Green'	3 feet	Broadleaf, deciduous.

Native Parking Lot Trees from the Portland Plant List

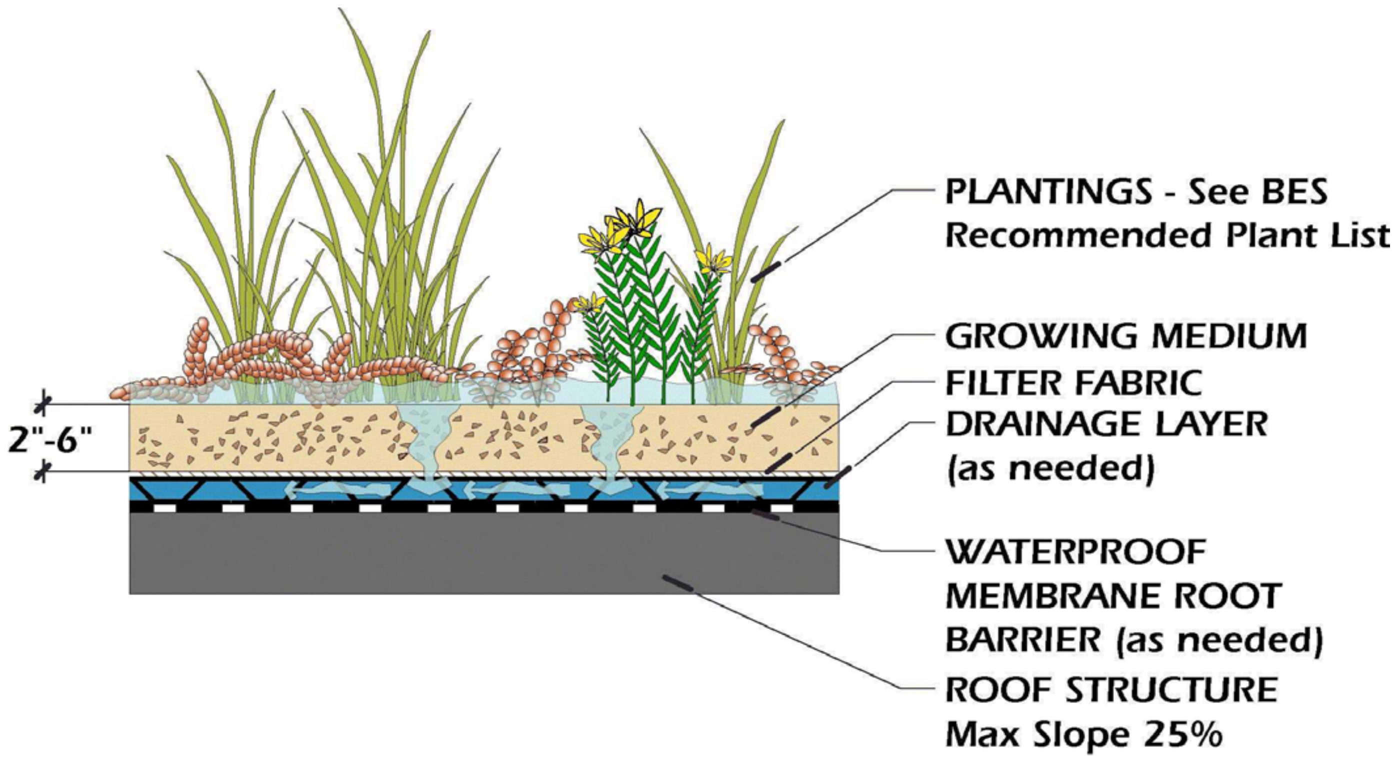
Species Name	Common Name	Minimum Distance from Pavement	Comments
Abies grandis	Grand Fir	4 feet	Conifer, evergreen. Can grow very tall.
Acer macrophyllum	Big Leaf Maple	4 feet	Broadleaf, deciduous.
Alnus rubra	Red Alder	3 feet	Broadleaf, deciduous. Moisture loving. ***Short live species.*** *
Crataegus douglasii, var. douglasii	Black Hawthorn, wetland form	3 feet	Broadleaf, deciduous. A smaller tree. Wetland form tolerates wet areas.
Fraxinus latifolia	Oregon Ash	3 feet	Broadleaf, deciduous. Tolerates wet conditions.
Pinus ponderosa, ssp. Valley	Ponderosa Pine, Valley subspecies	4 feet	Conifer, evergreen. Prefers drier conditions, but Valley subspecies is adapted to Willamette Valley climate.
Pseudotsuga menziesii	Douglas Fir	4 feet	Conifer, evergreen. Can grow very tall.
Quercus garryana	Oregon White Oak	4 feet	Broadleaf, deciduous. Drought tolerant.
Rhamnus purshiana	Cascara	3 feet	Broadleaf, deciduous. A smaller tree.
Thuja plicata	Western Red Cedar	4 feet	Conifer, evergreen. Prefers moist conditions and some shade. **Does not do well in direct sunlight, Shade tolerant**
Thuja plicata	Western Red Cedar 'Hogan'	4 feet	Conifer, evergreen. Prefers moist conditions and some shade. 'Hogan' is a narrow-growing variety.

* According to the "Western Tree Book" maximum age of a Red Alder is thought to be 100 years. Relatively speaking these trees have a life span sufficient for urban parking lot swales. A report by the Portland Planning Bureau in 1997 indicated that the life expectancy of most trees in non-residential areas was 20-40 years.

Appendix G

Supplemental Drawings and Example Landscaping Plans

September 2004 Stormwater Management Manual

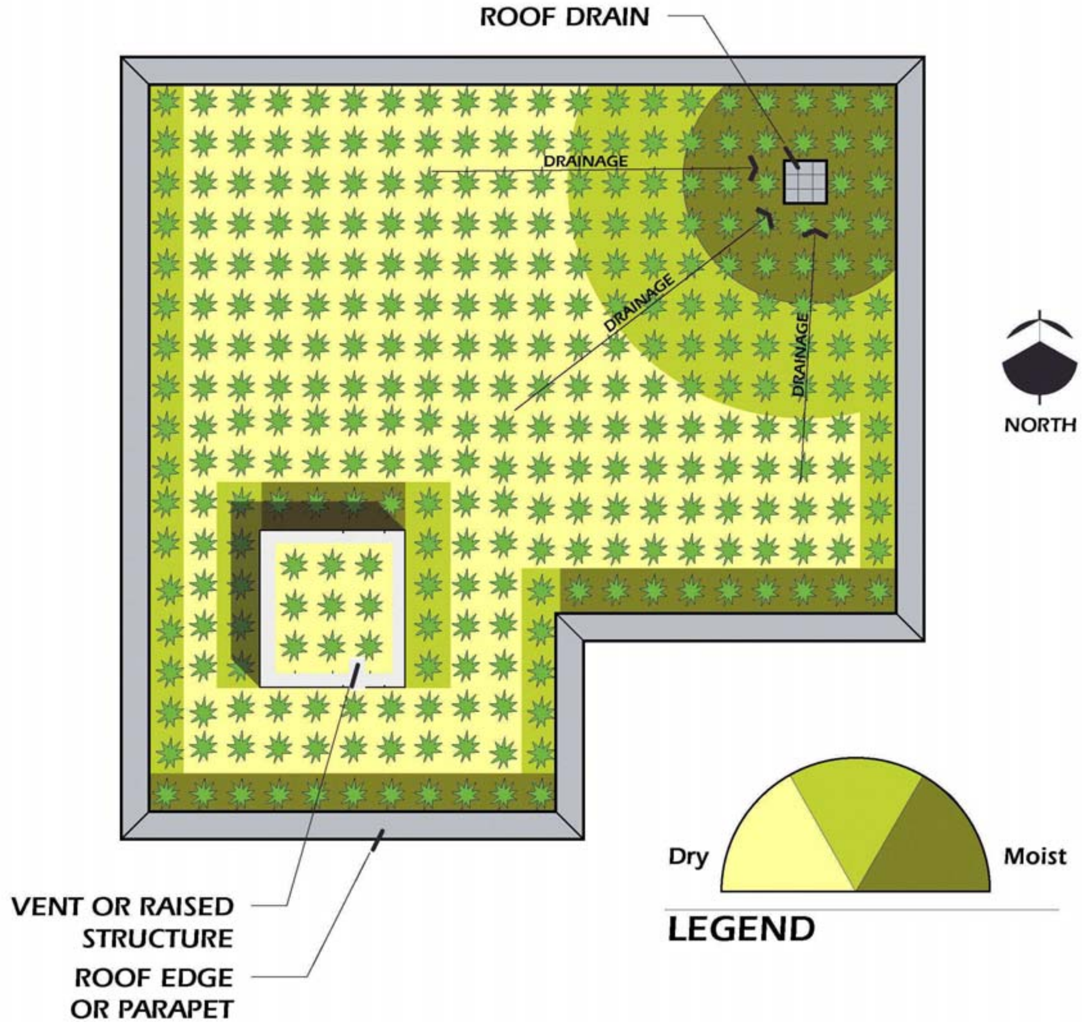


SIMPLIFIED APPROACH DESIGN CRITERIA

Eco-roof

7/26v/02

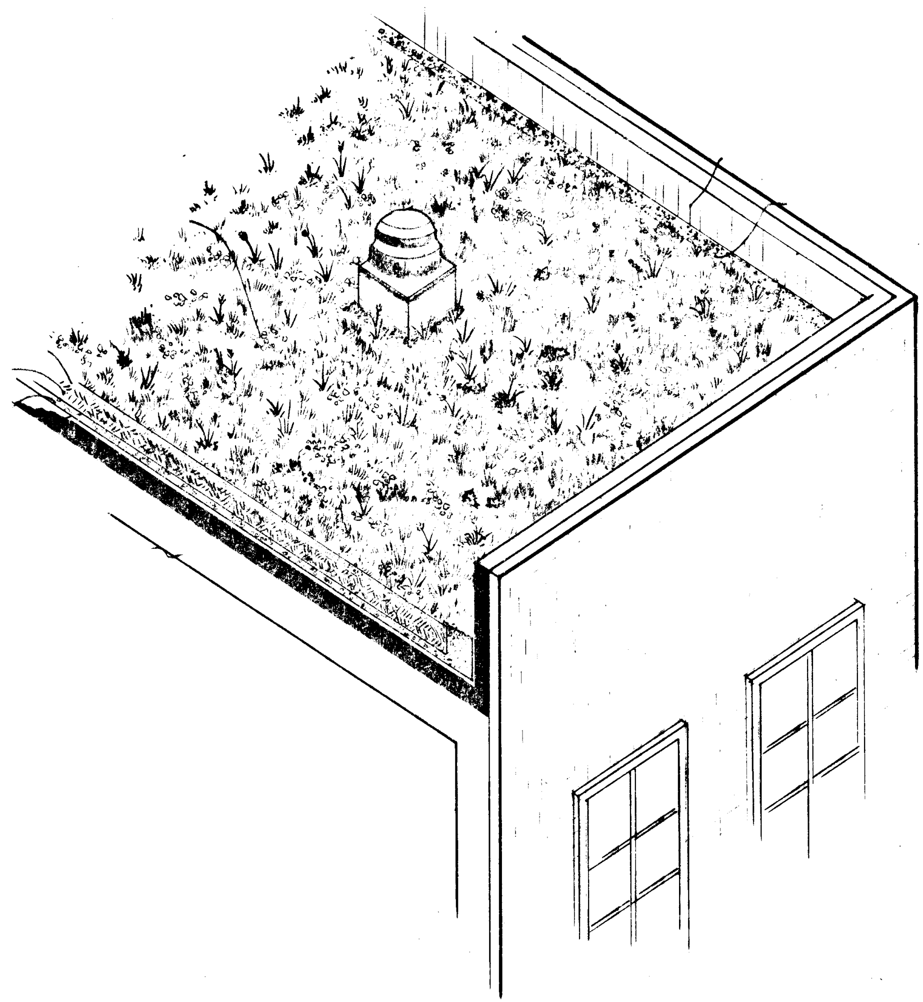
PLANTINGS:
See BES Recommended
Plant List

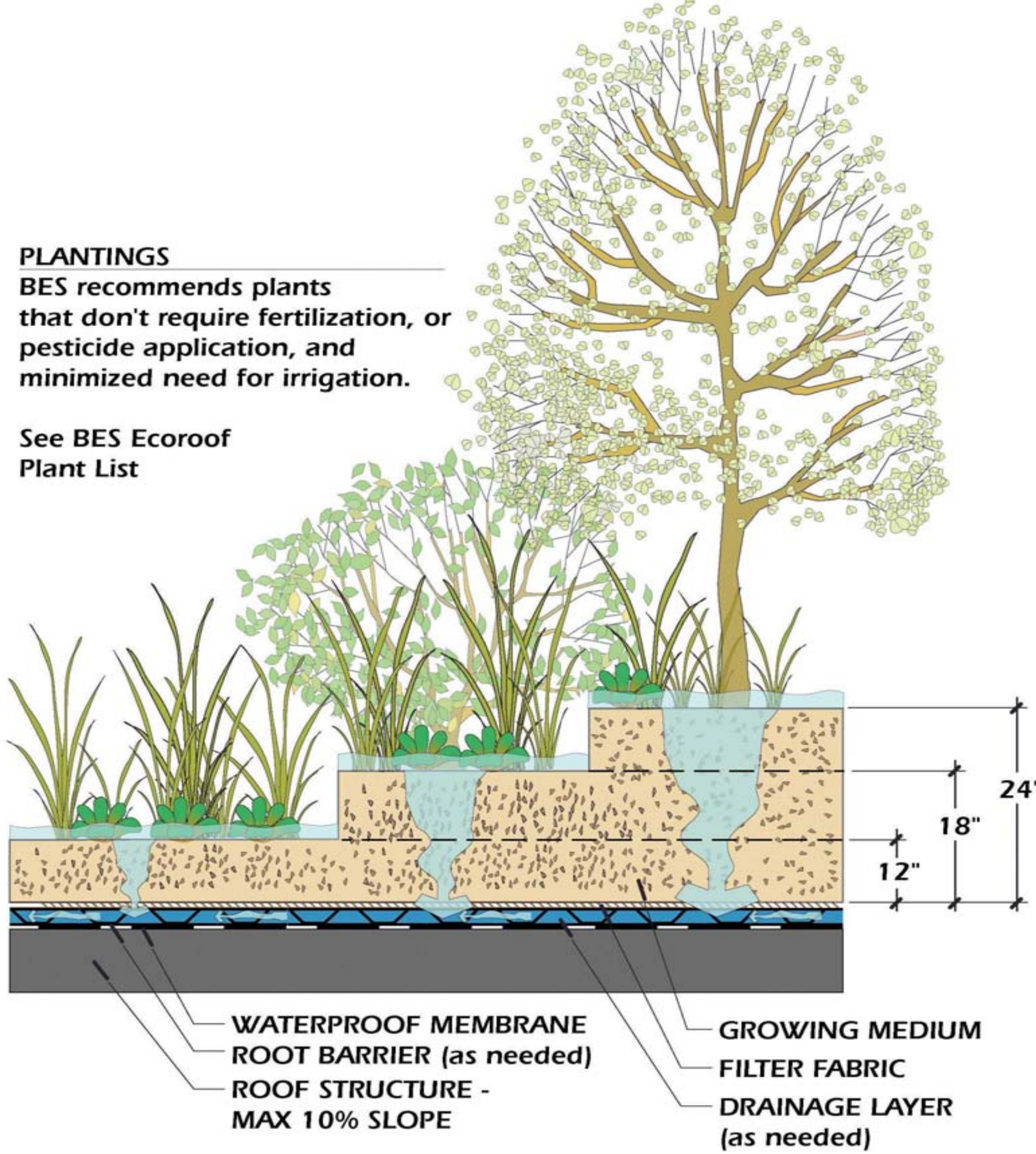


Ecoroof Evaporation Diagram

7/26/02

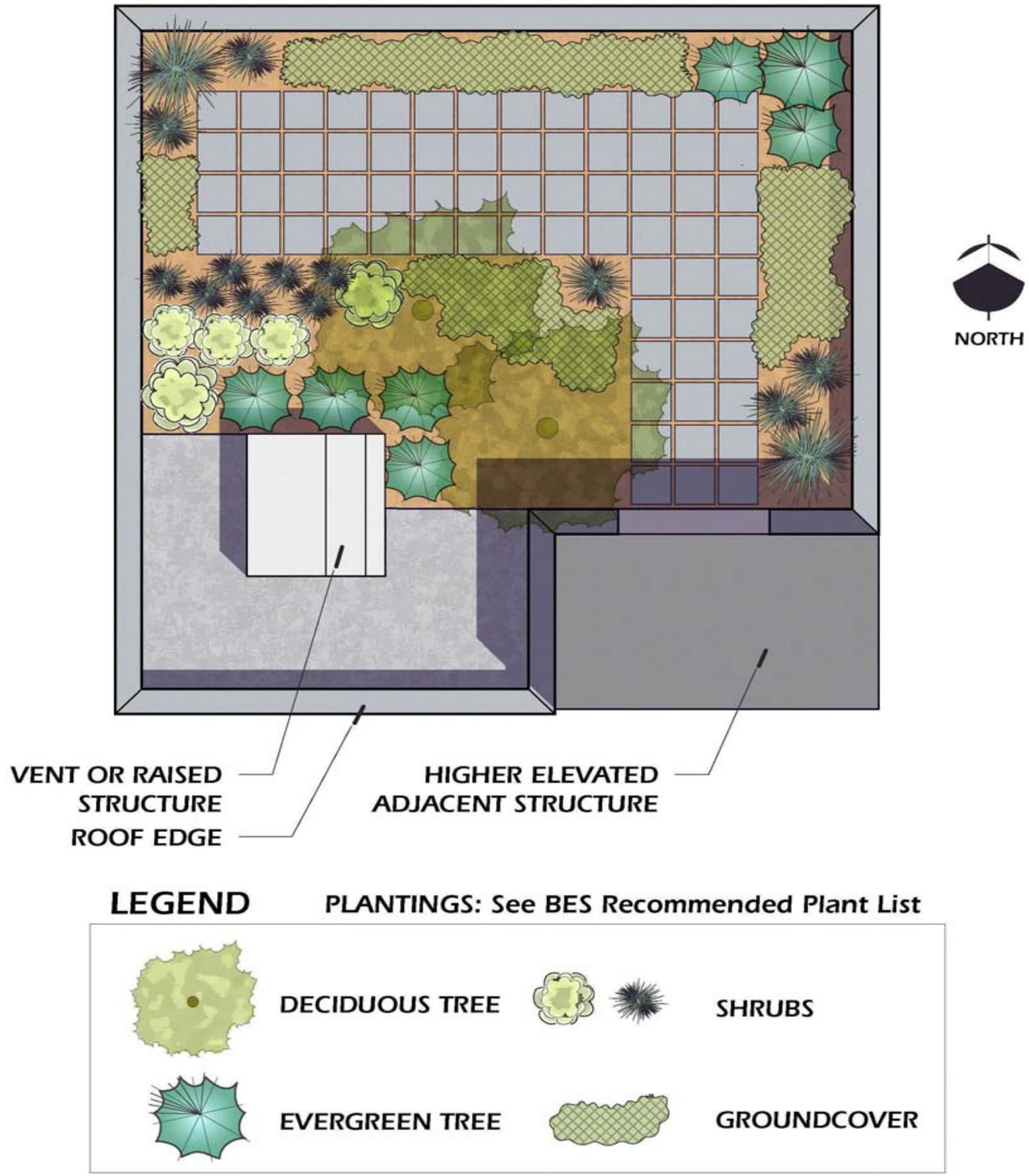
Eco-Roof





Roof Garden

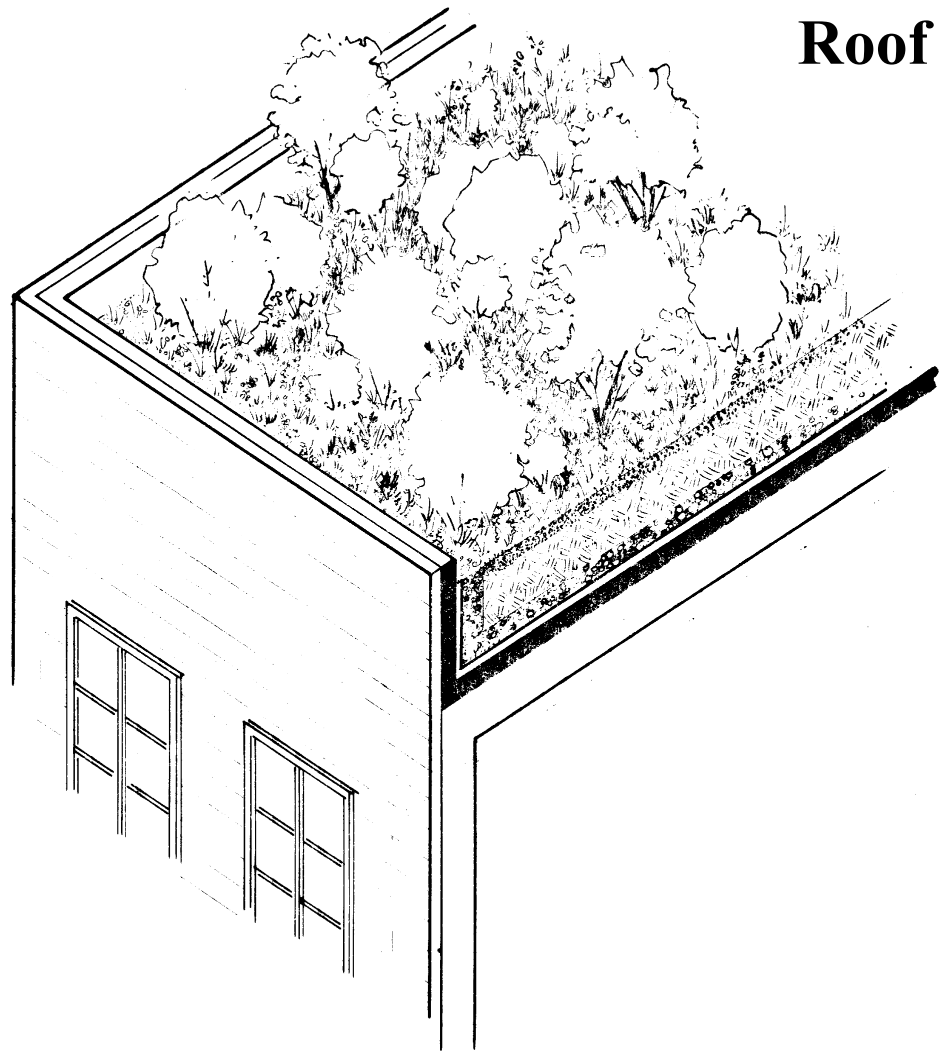
7/26/02

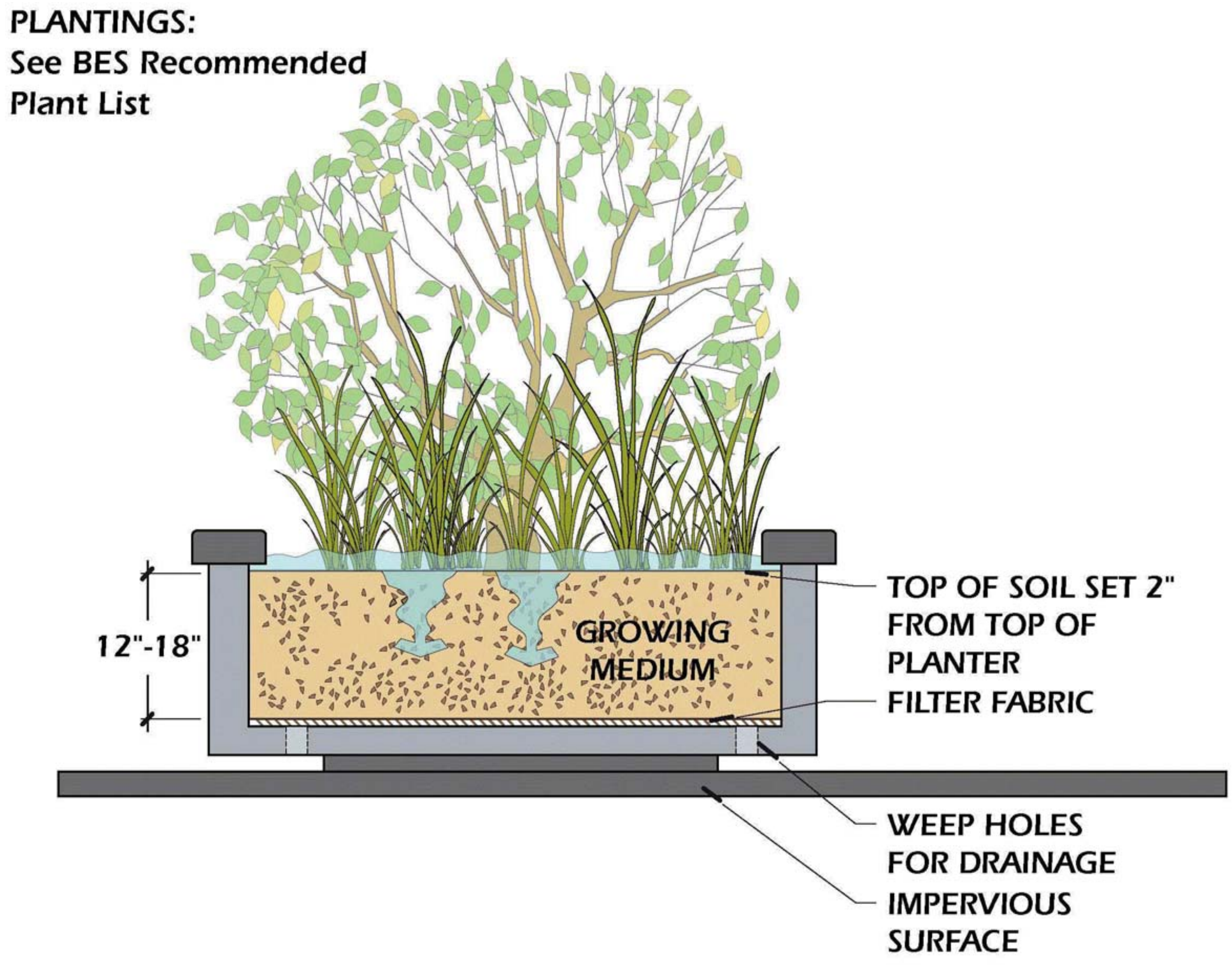


Roof Garden Plan

7/26/02

Roof Garden

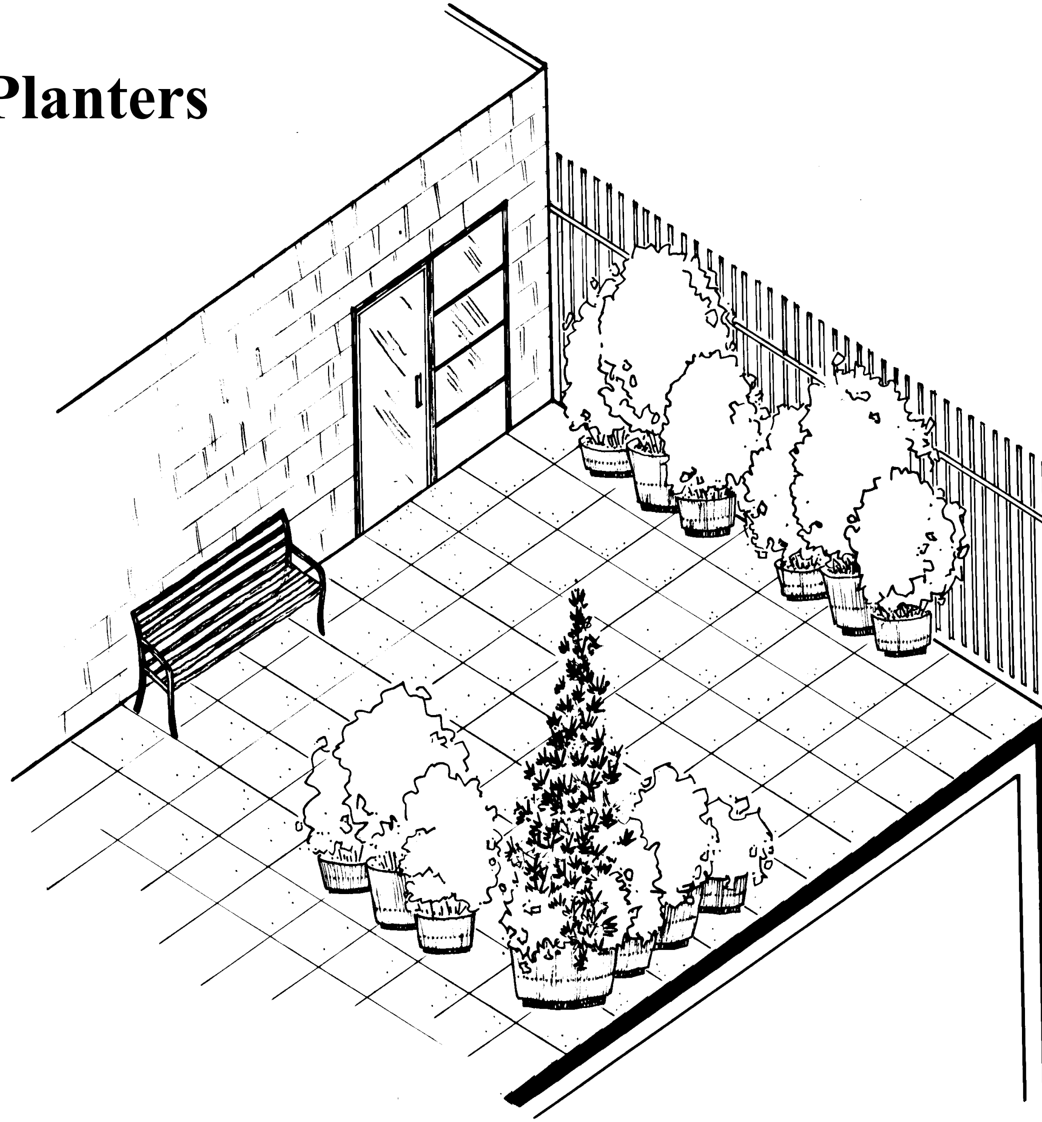




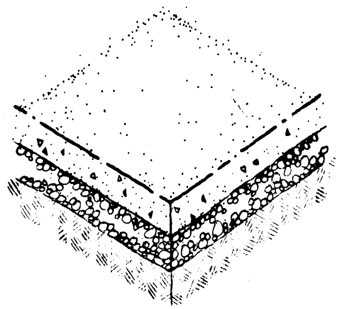
Contained Planter Box

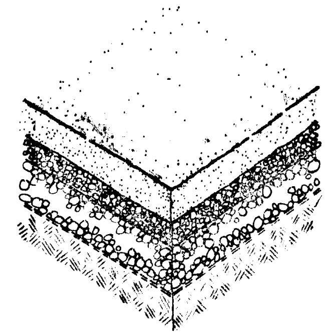
7/26/02

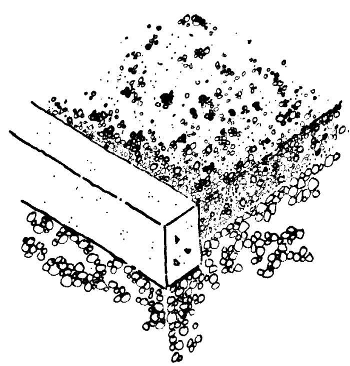
Contained Planters

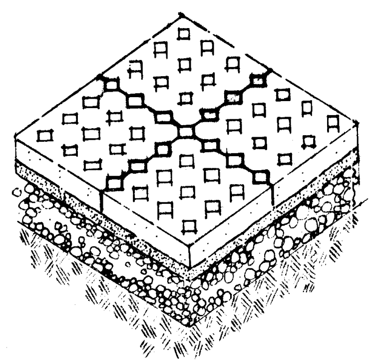


Porous Pavement

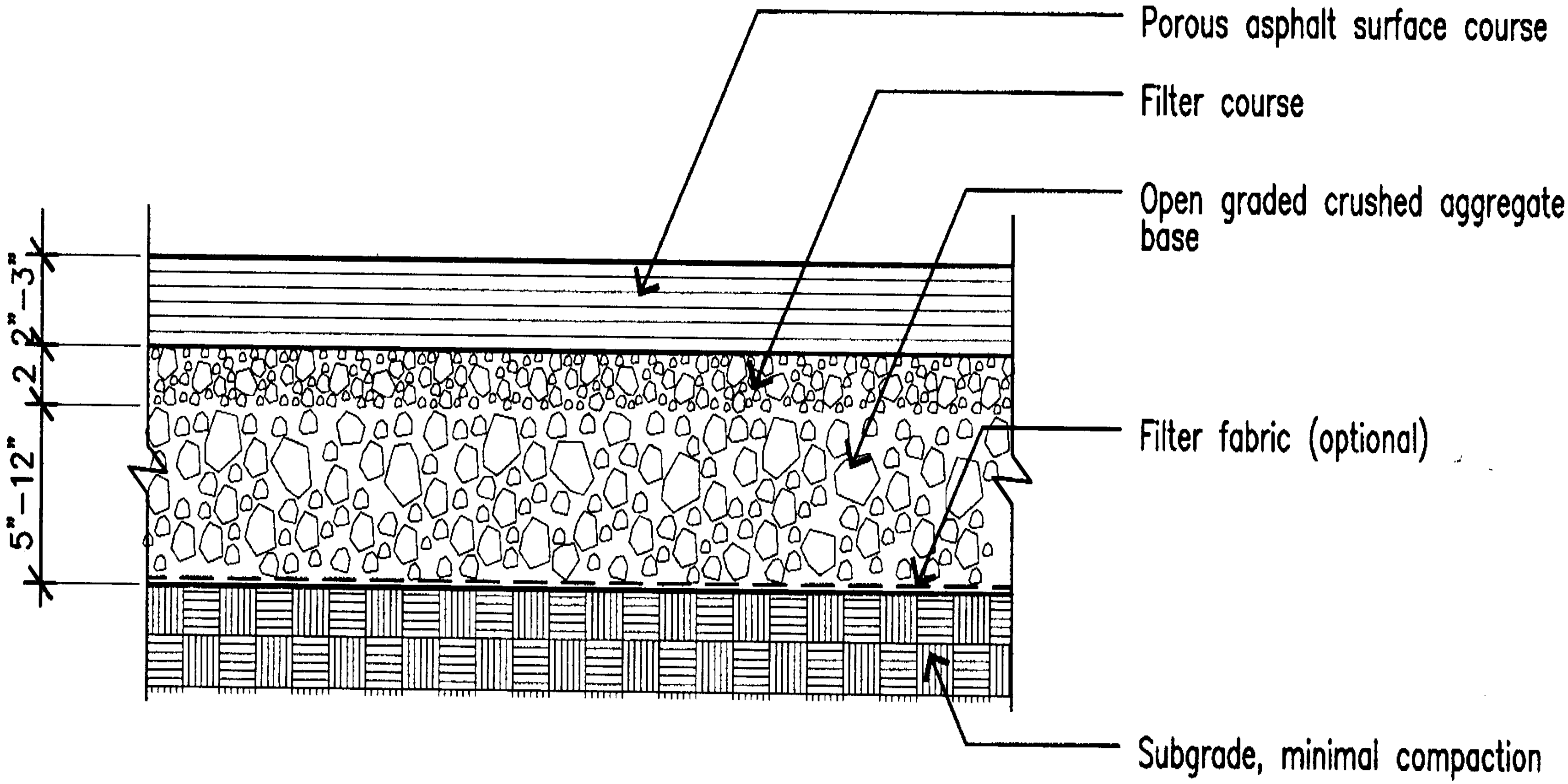




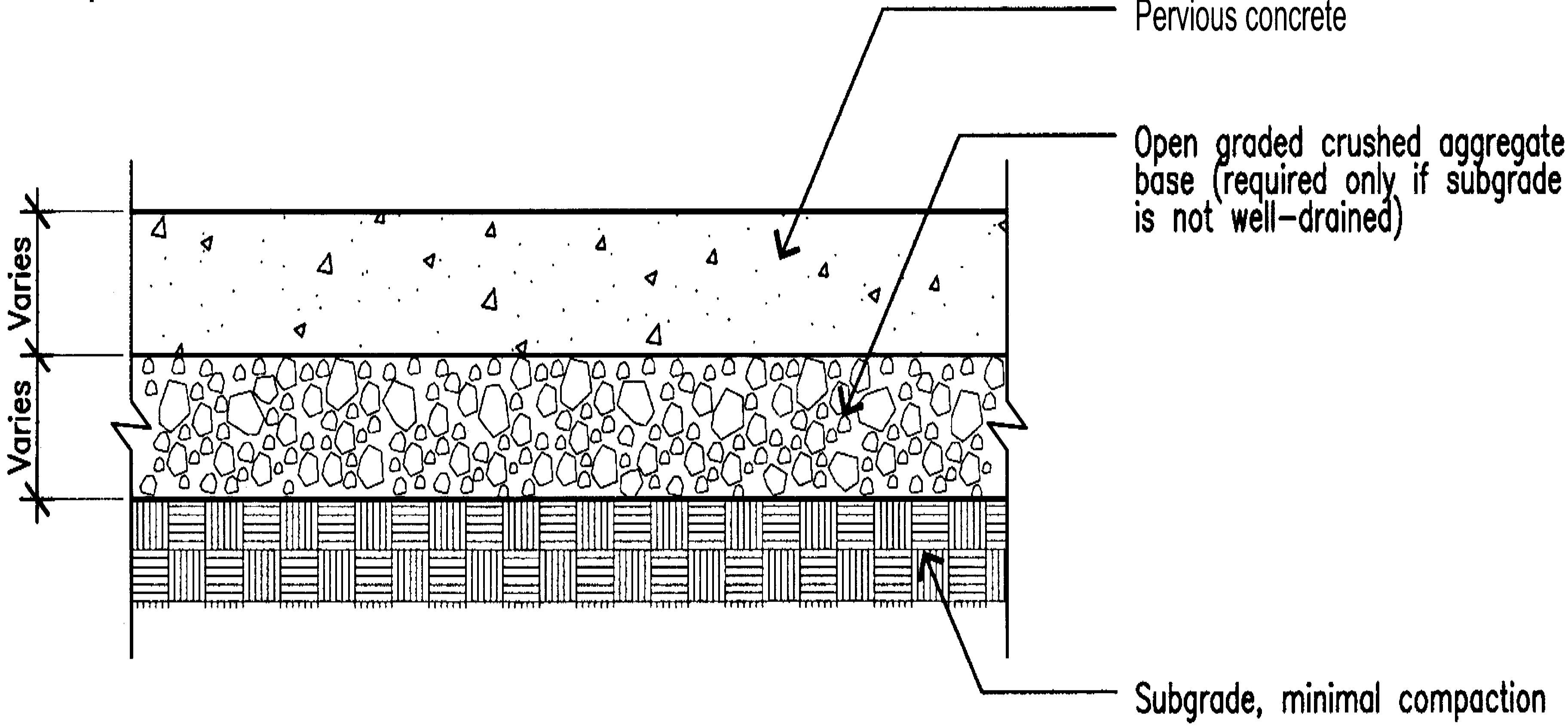




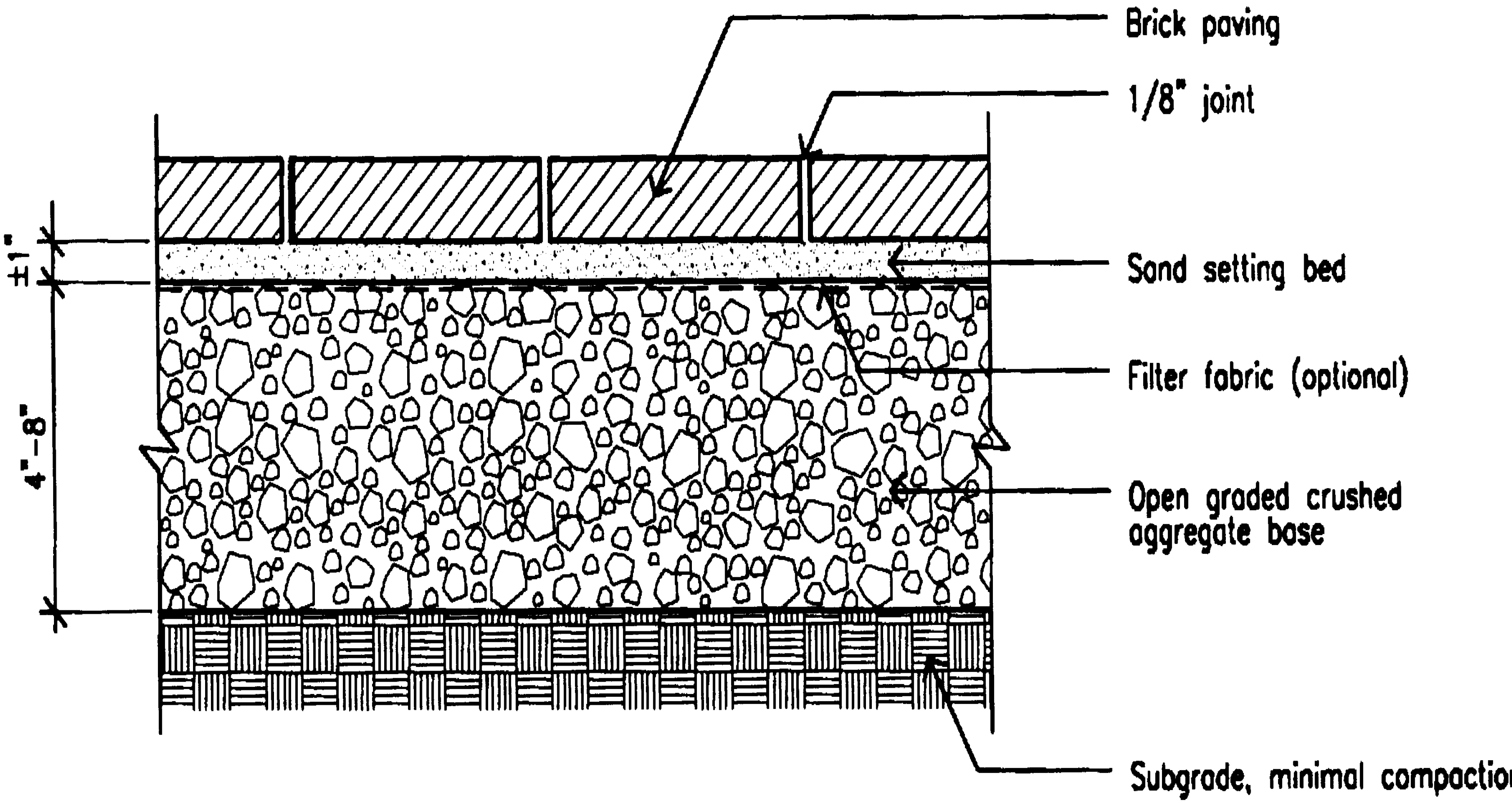
porous asphalt



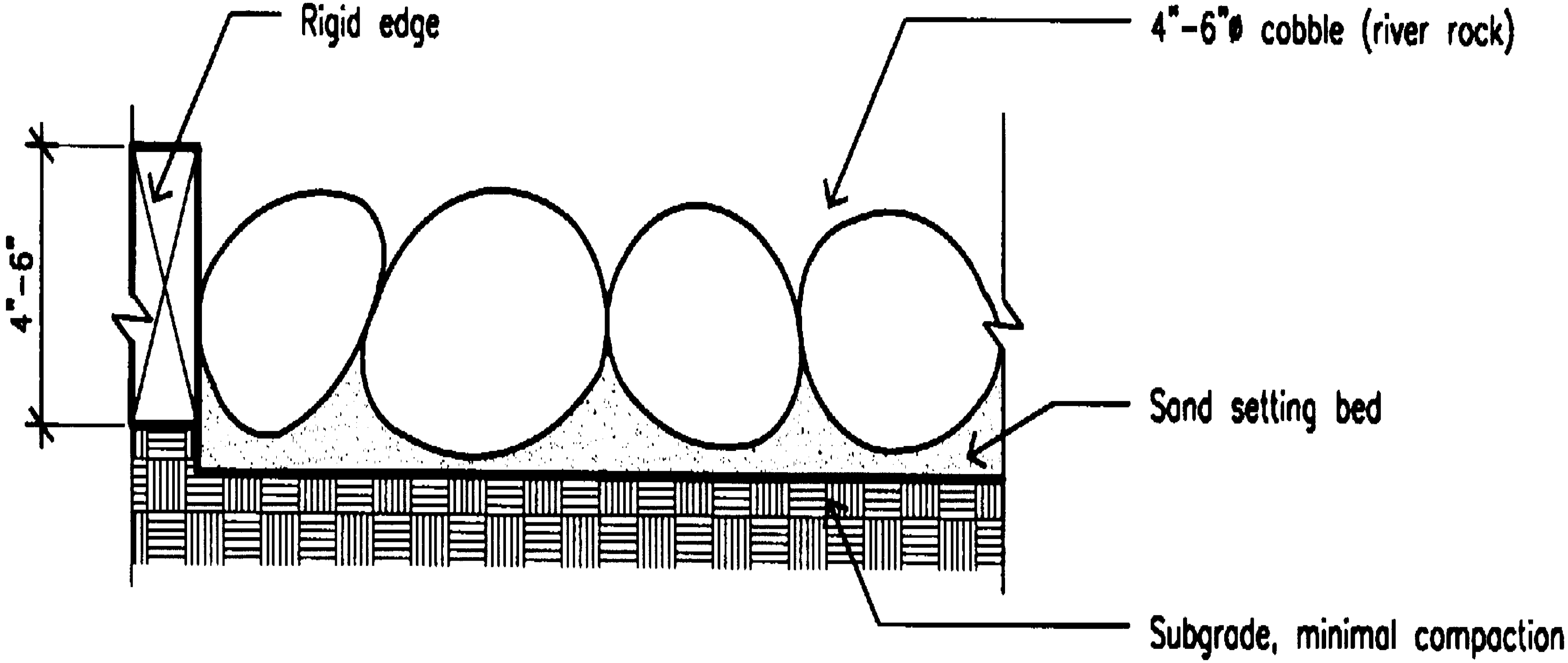
pervious concrete



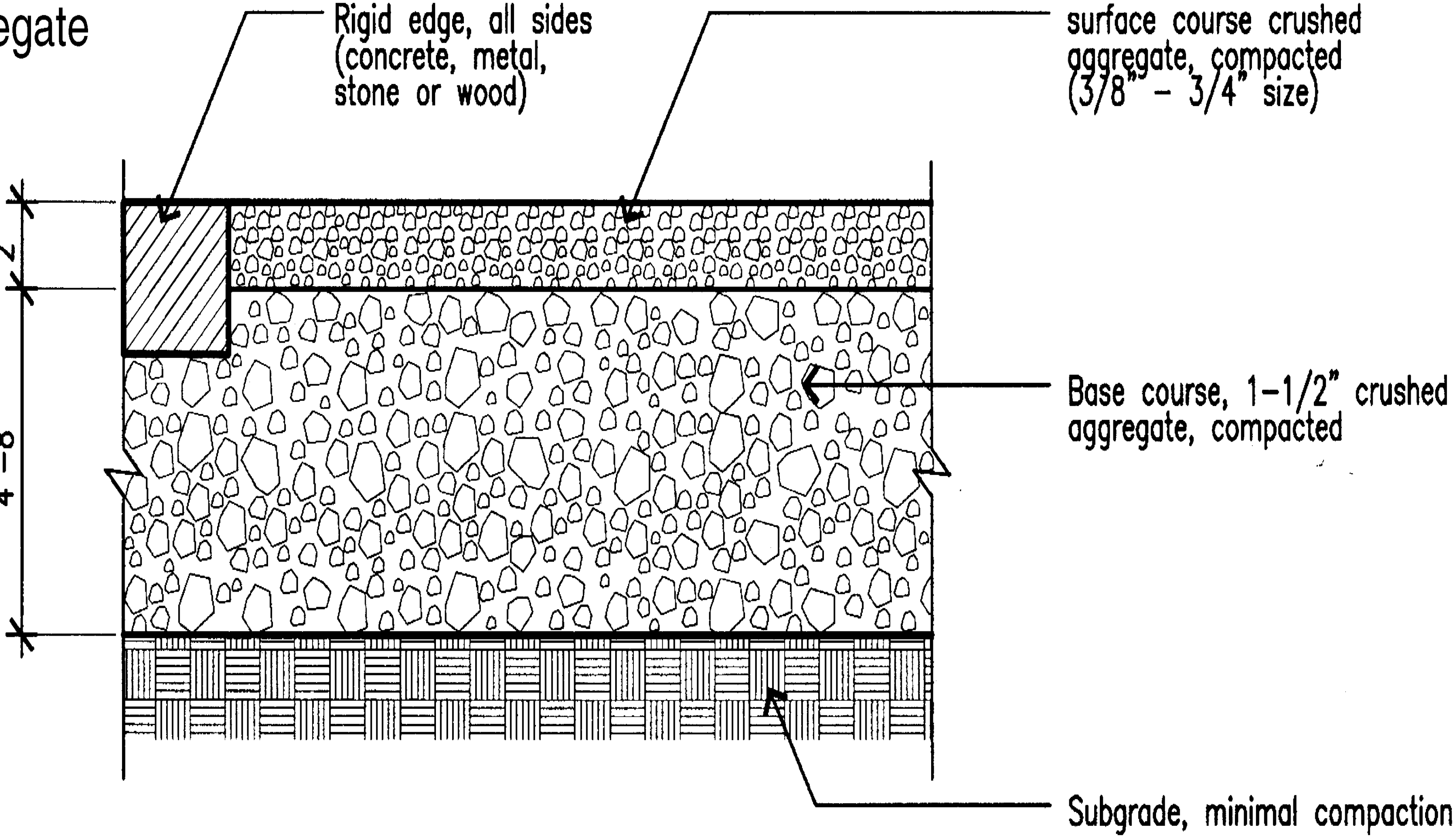
brick


Brick paving
1/8" joint
Sand setting bed
Filter fabric (optional)
Open graded crushed aggregate base
Subgrade, minimal compaction
±1"
4"–8"

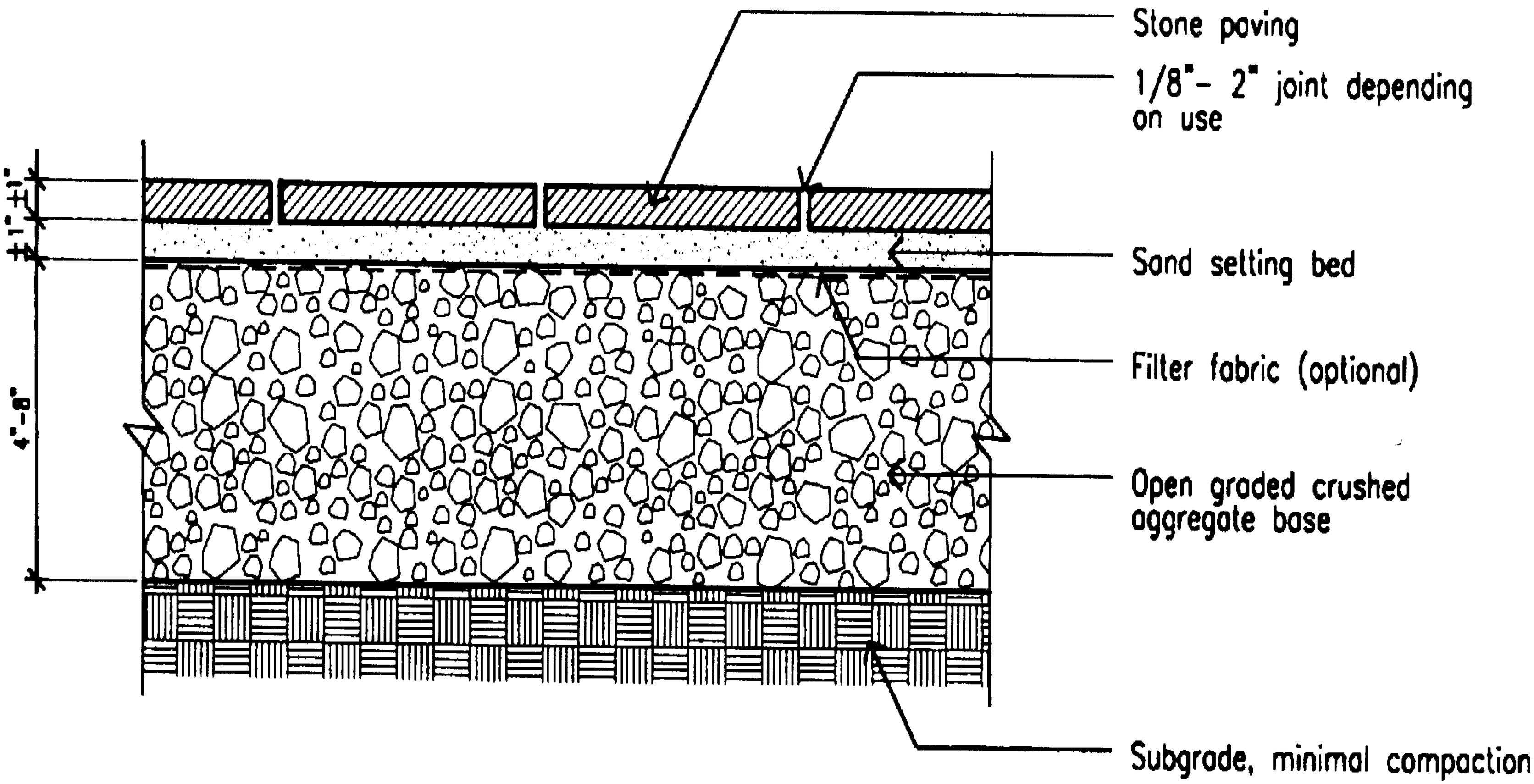
cobbles


Rigid edge
4"–6"ø cobble (river rock)
4"–6"
Sand setting bed
Subgrade, minimal compaction

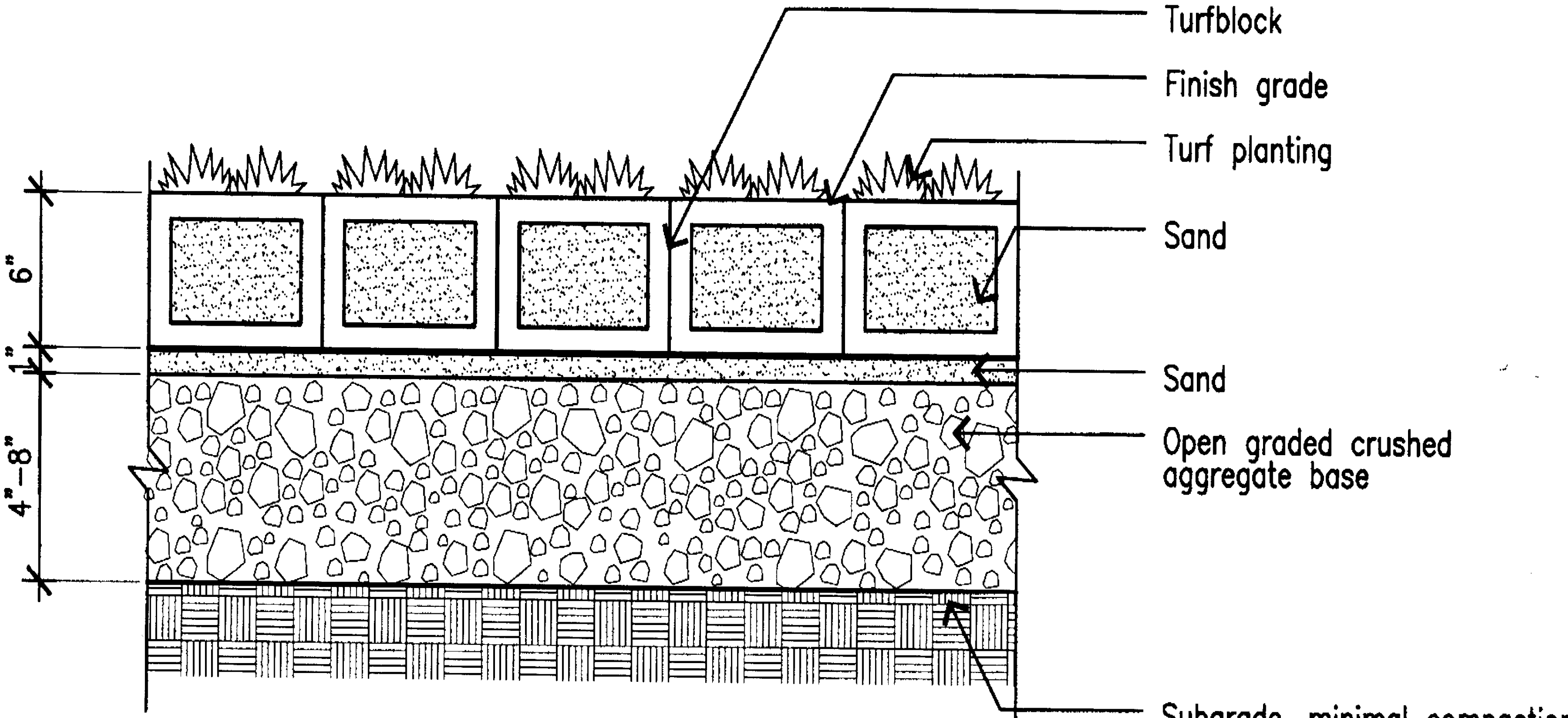
crushed aggregate



natural stone

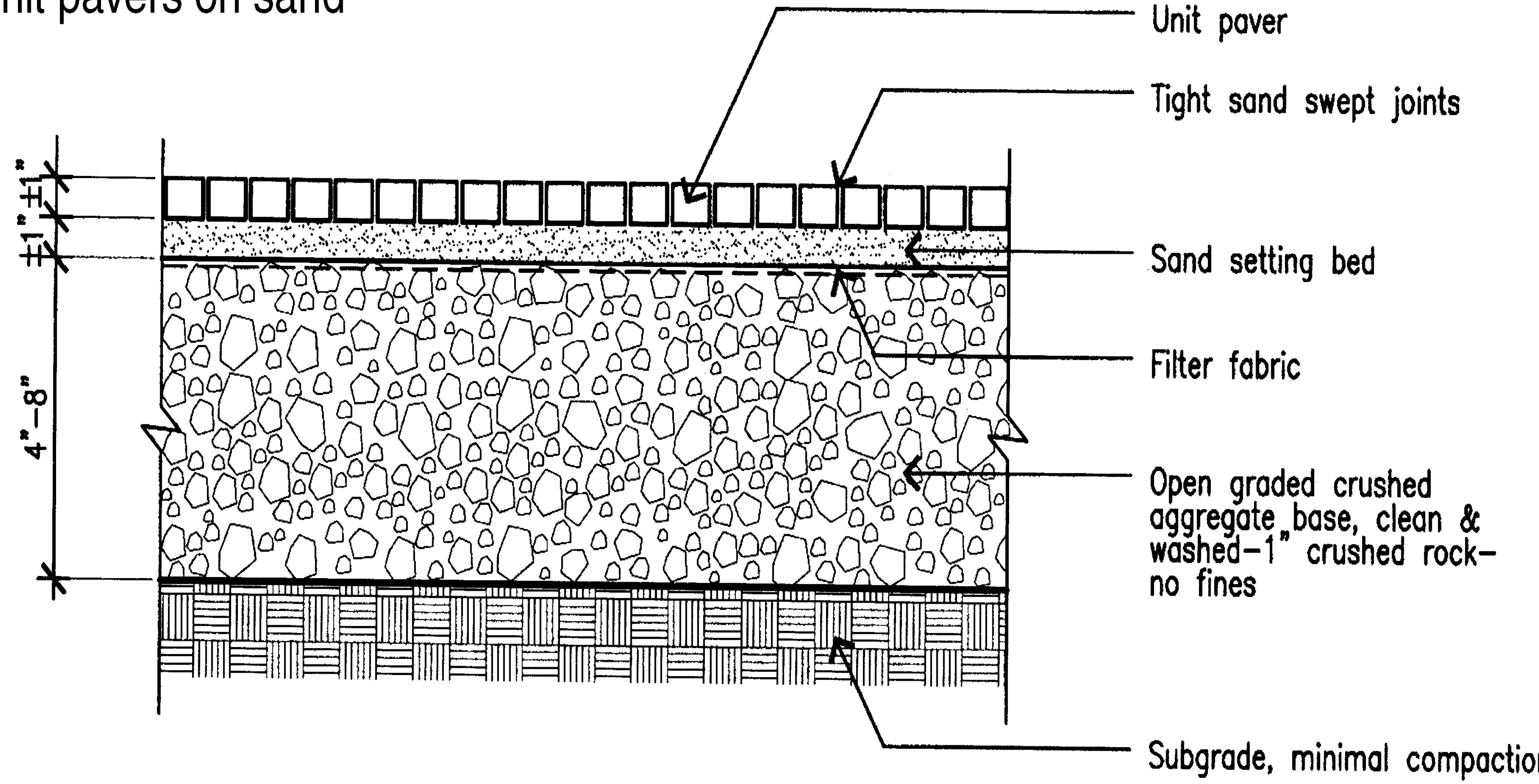


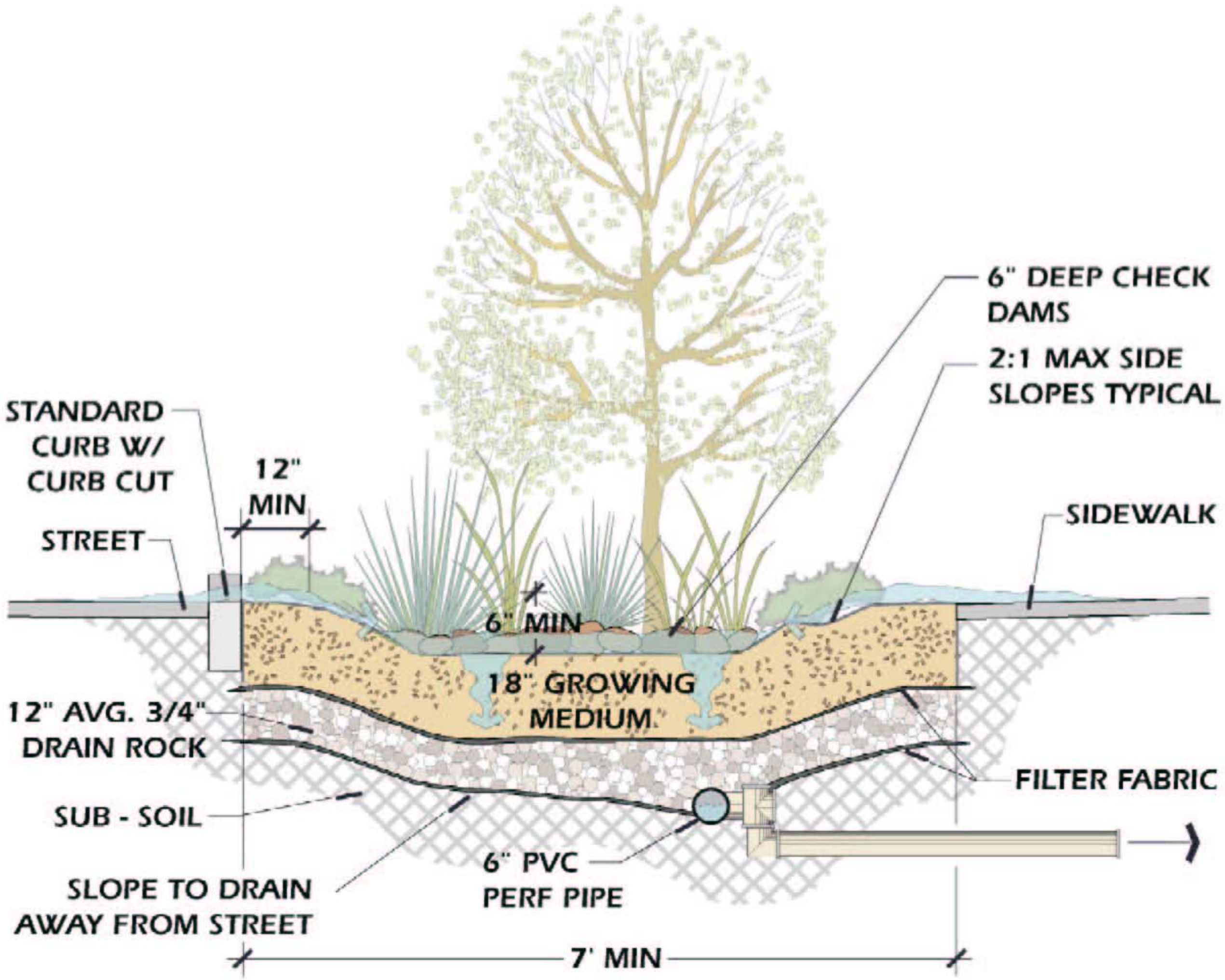
Turf block



Turfblock
Finish grade
Turf planting
Sand
Sand
Open graded crushed aggregate base
Subgrade, minimal compaction
6"
1"
4"–8"

unit pavers on sand

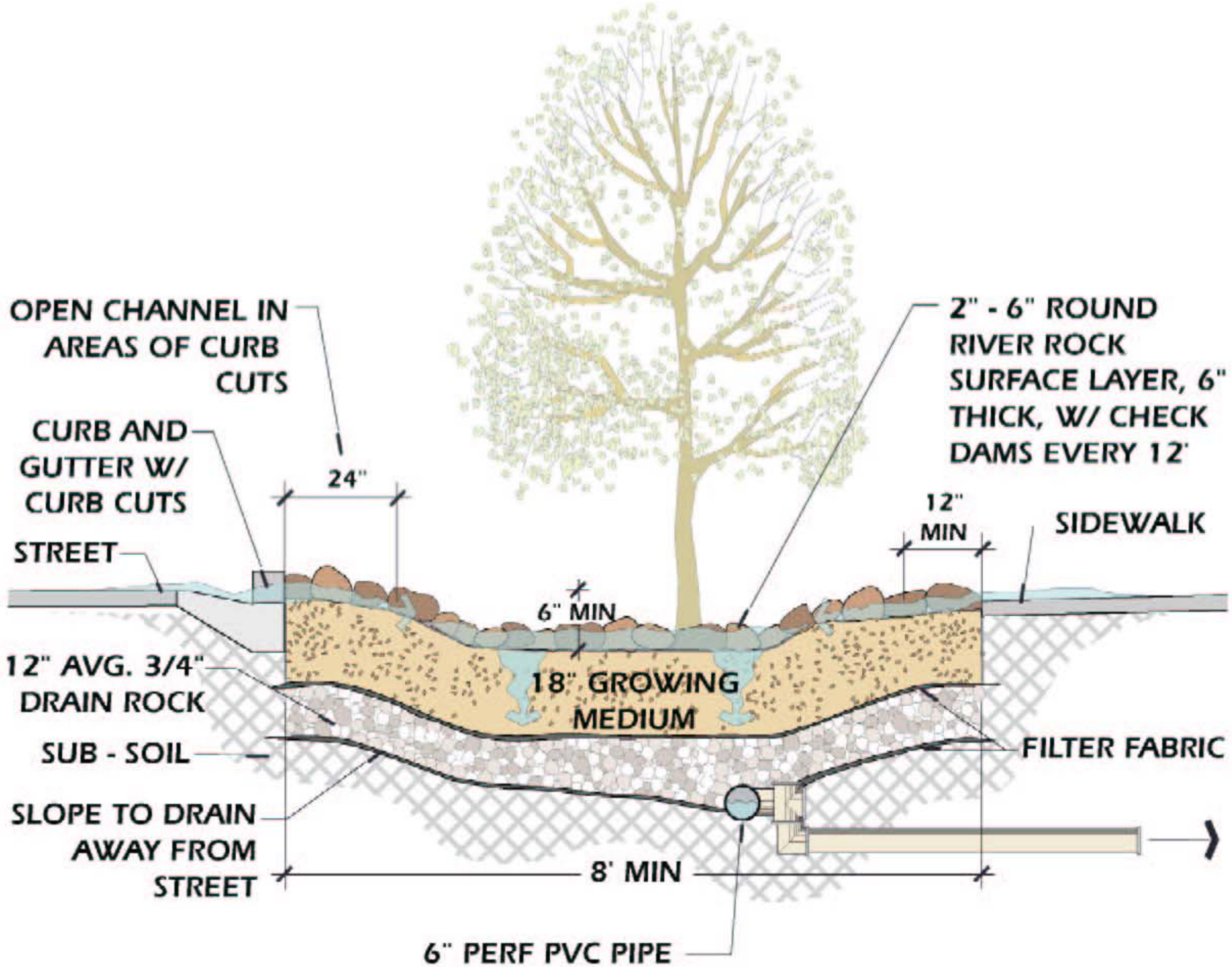




SIMPLIFIED APPROACH DESIGN CRITERIA

Lowered Planter Strip - Private Street Design

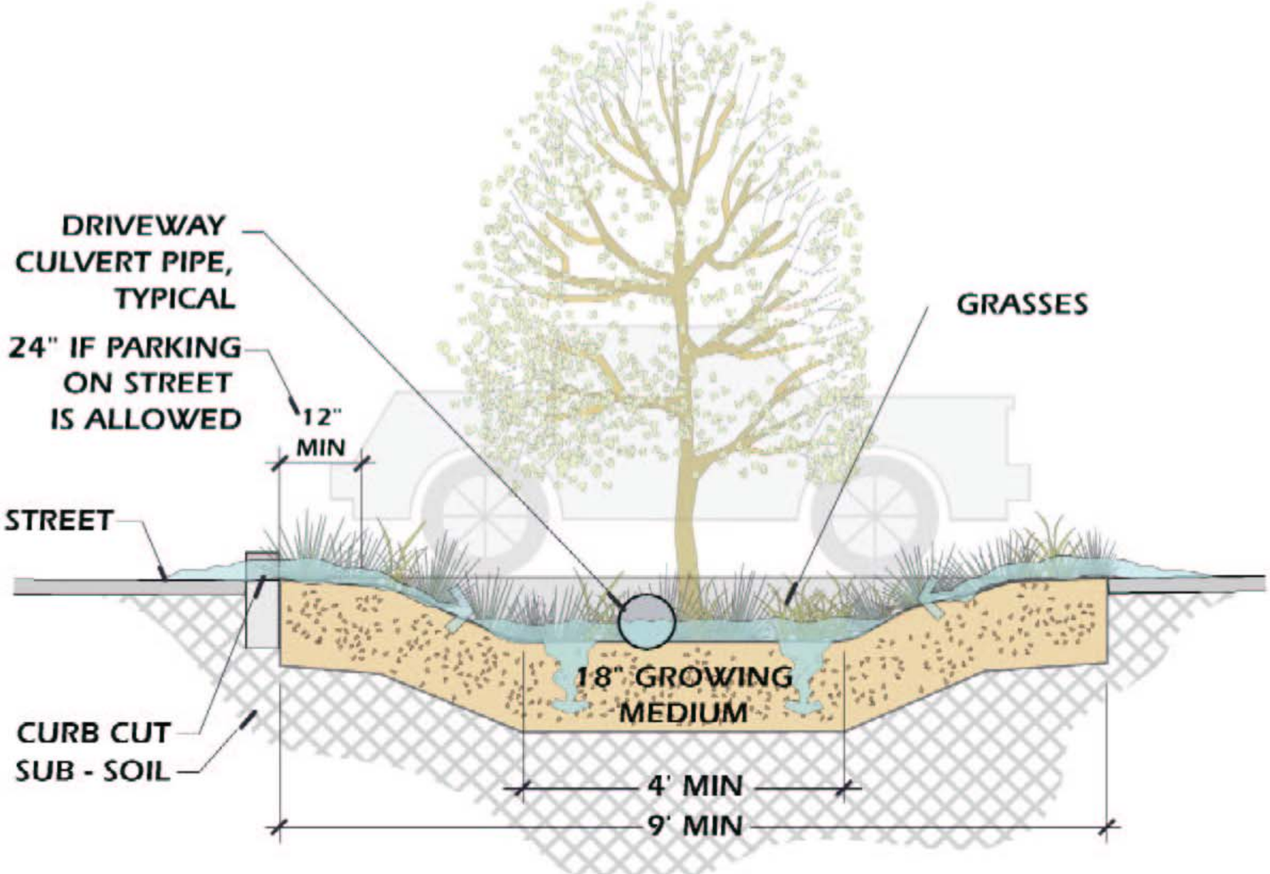
7/8/02



SIMPLIFIED APPROACH DESIGN CRITERIA

Lowered Planter Strip - Parking Allowed

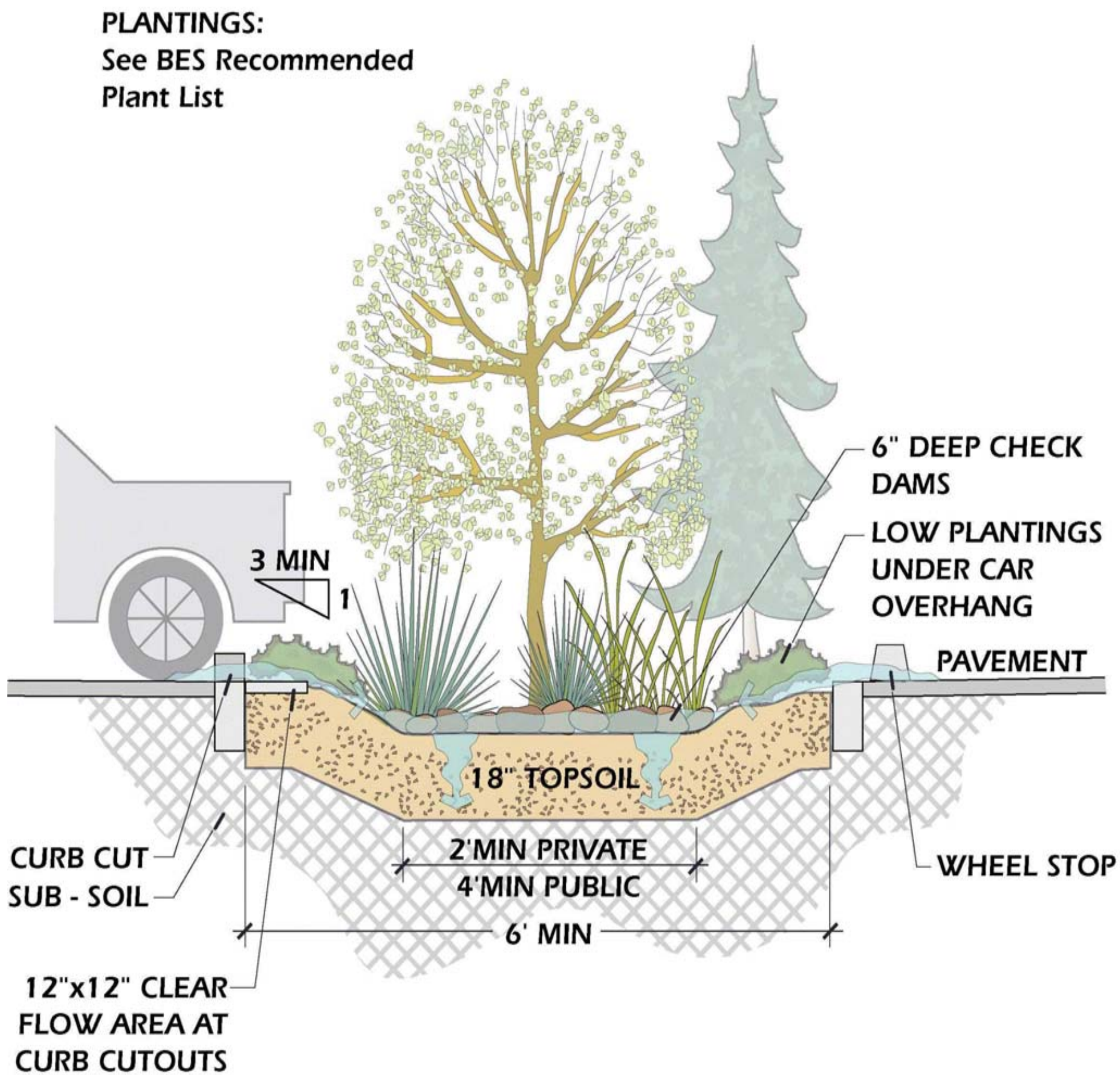
7/8/02



SIMPLIFIED APPROACH DESIGN CRITERIA

Side Swale - Cross Section

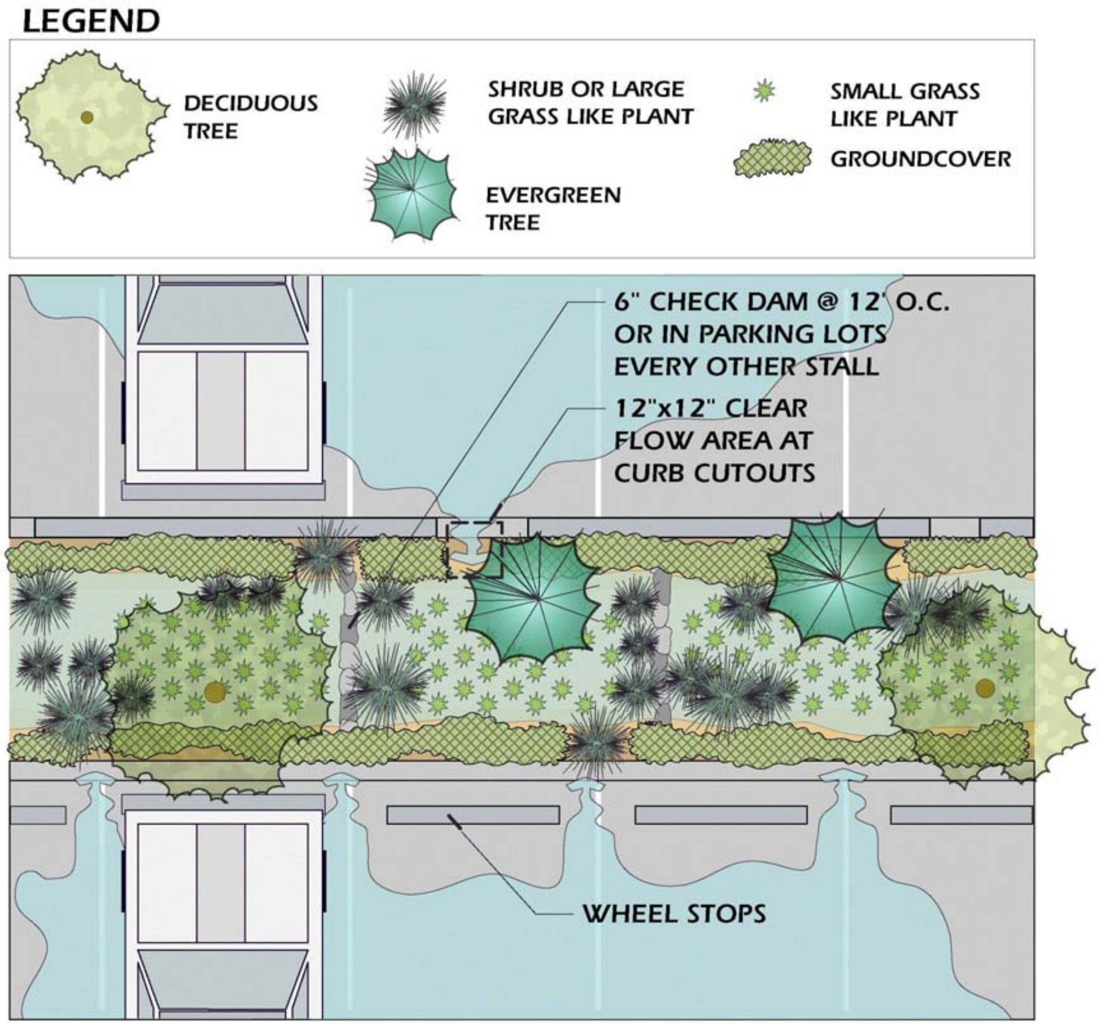
7/8/02



Vegetated Swale

Parking Lot Application

7/26/02



Swale Area = Approx. 400 sq. ft.
(Not to Scale)

Notes:

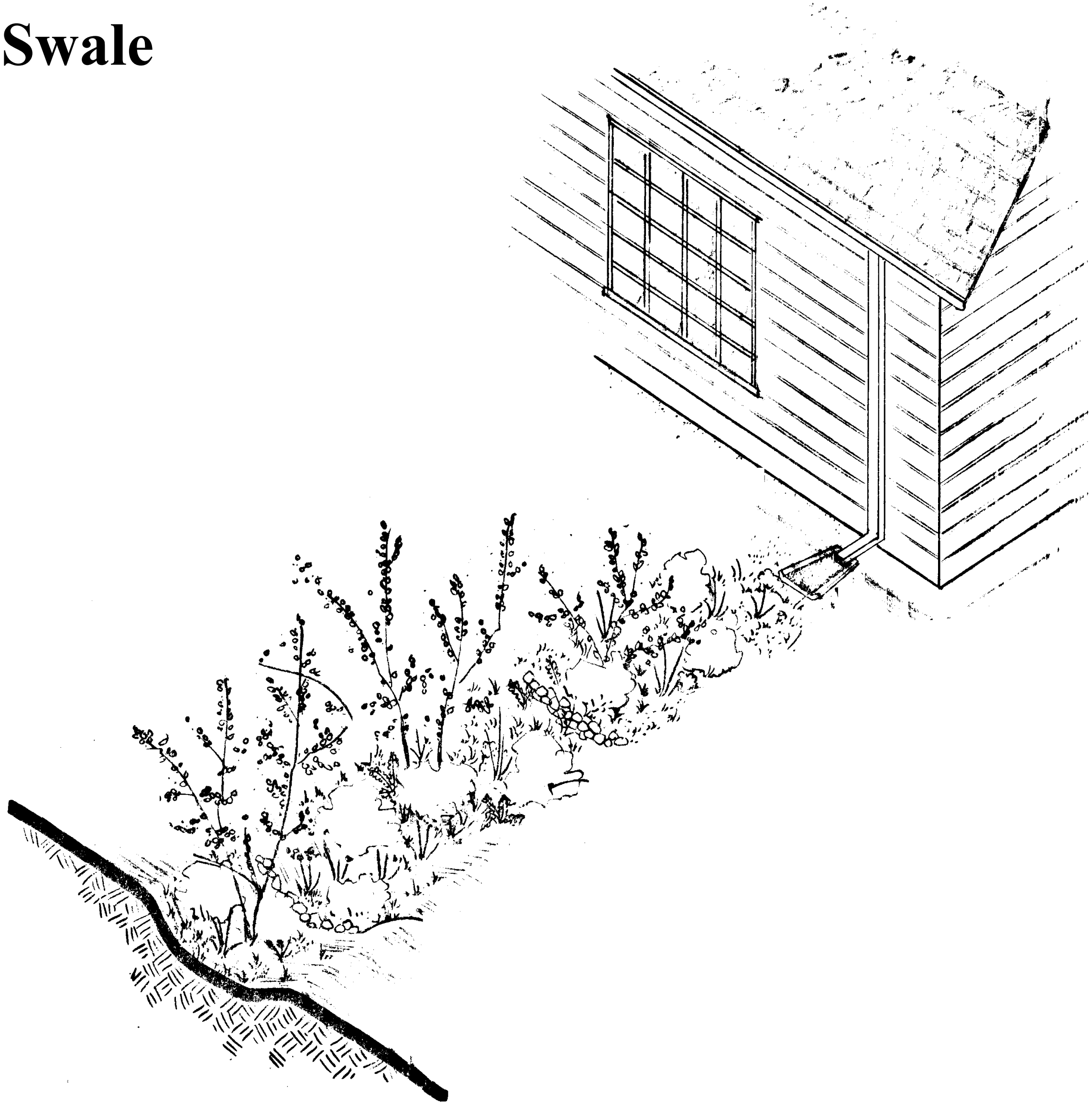
1. At least 50% of the facility shall be planted with grasses or grass-like plants, primarily in the flow path.
2. Large grass like plants can be considered as shrubs.
   See BES recommended plant list and parking lot tree list and plant quantity requirements.

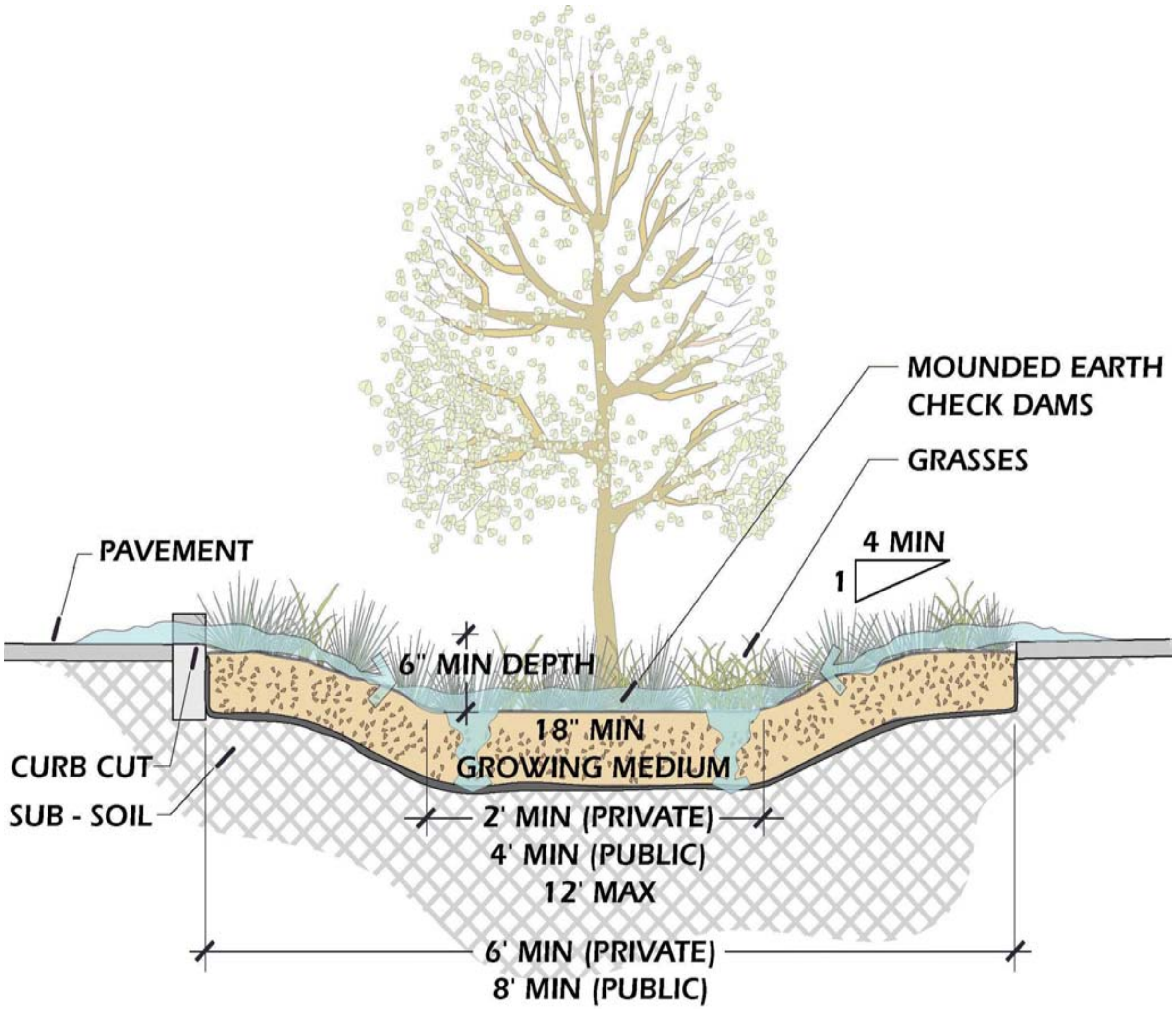
Vegetated Swale - Plan

Parking Lot Application

7/26/02

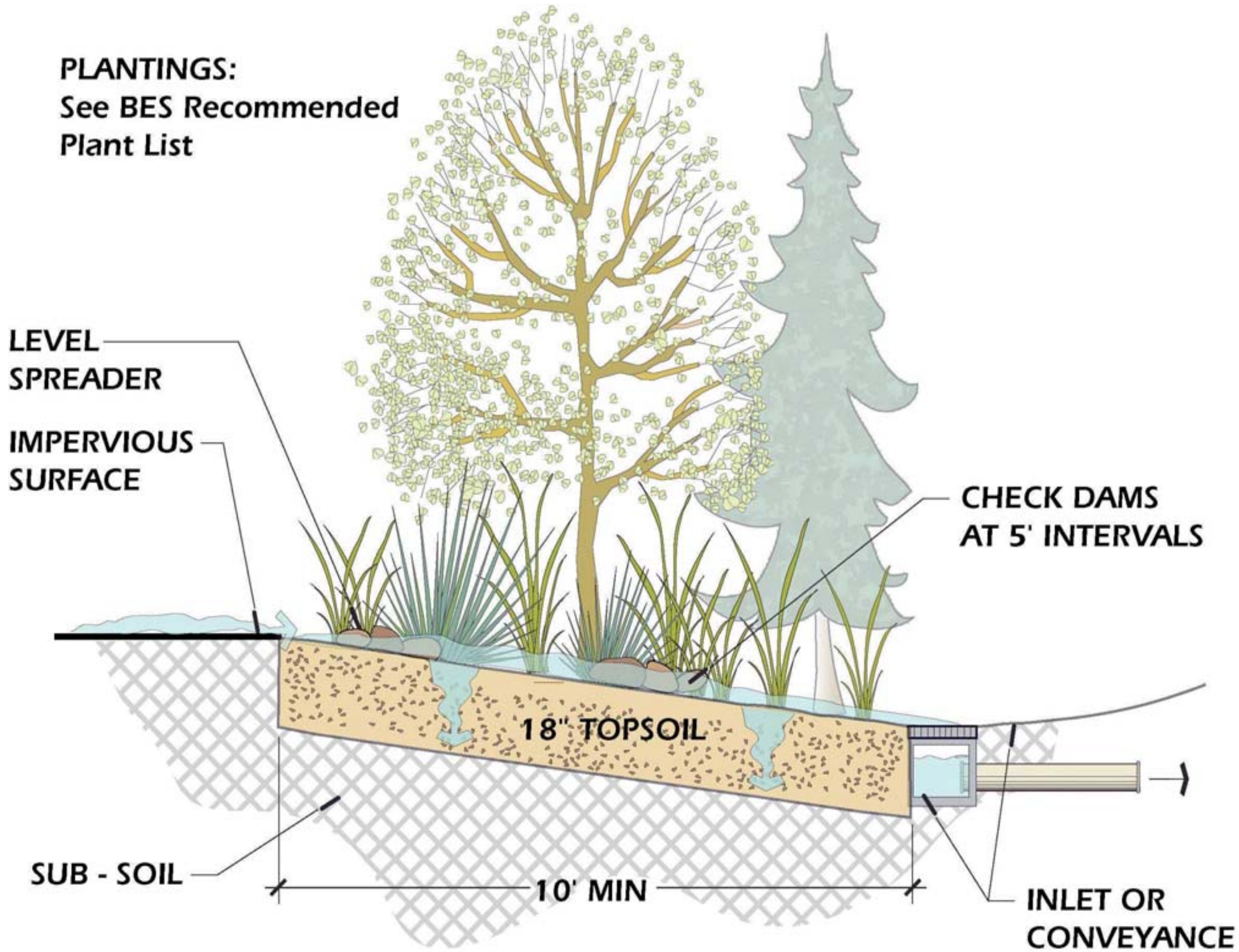
Vegetated Swale





Grassy Swale

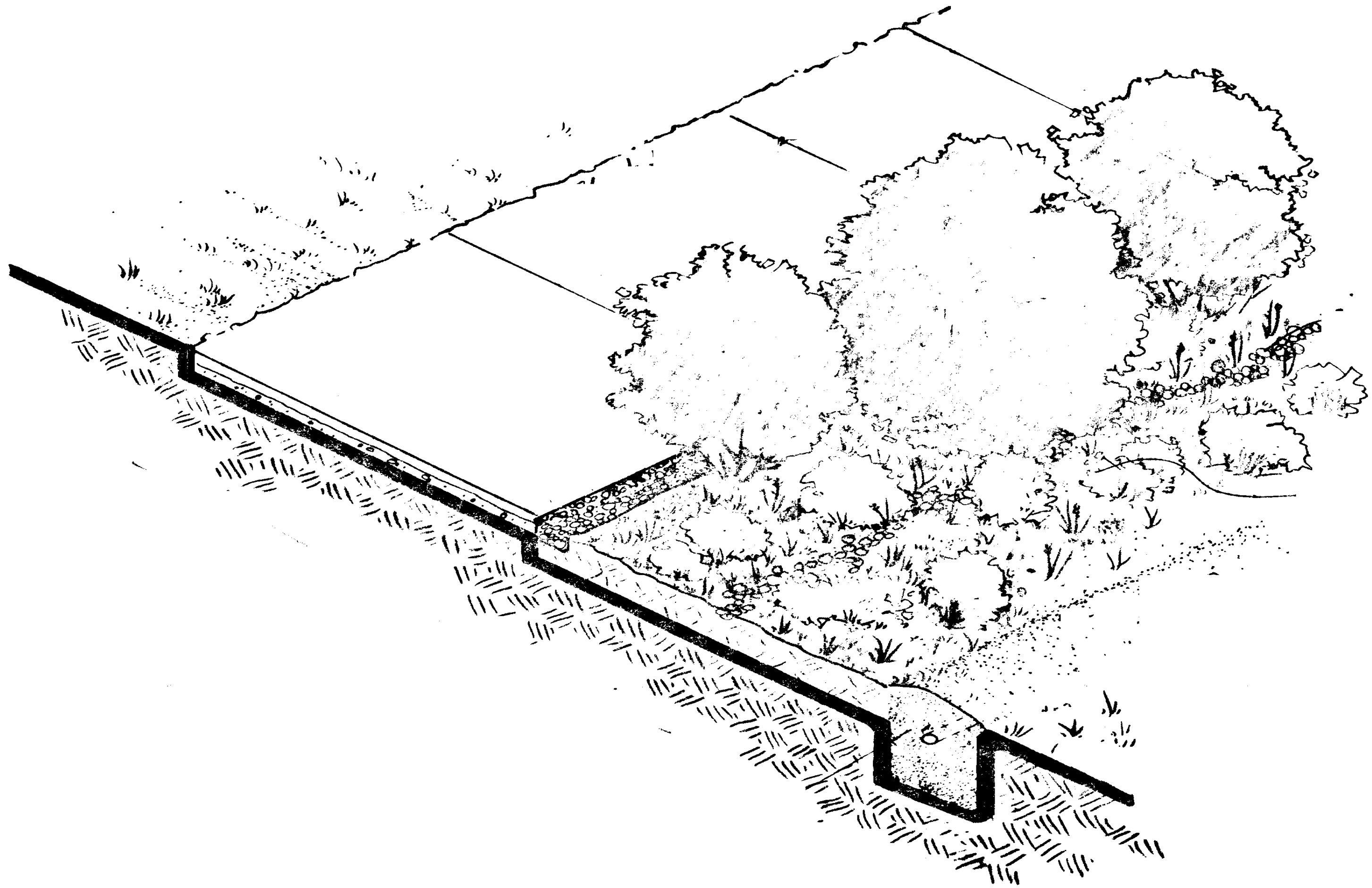
7/26/02

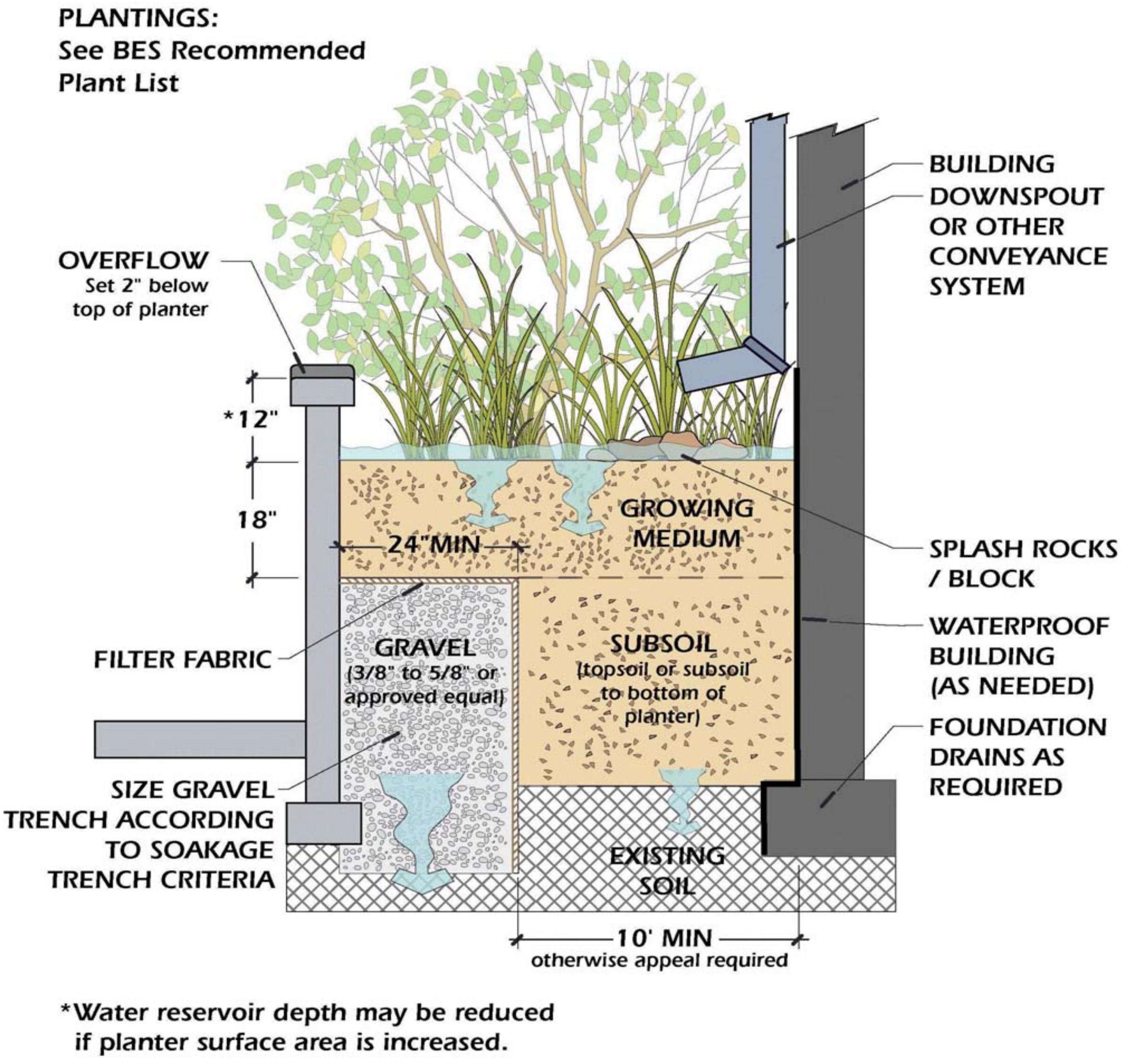


Vegetated Filter

7/26/02

Vegetated Filter

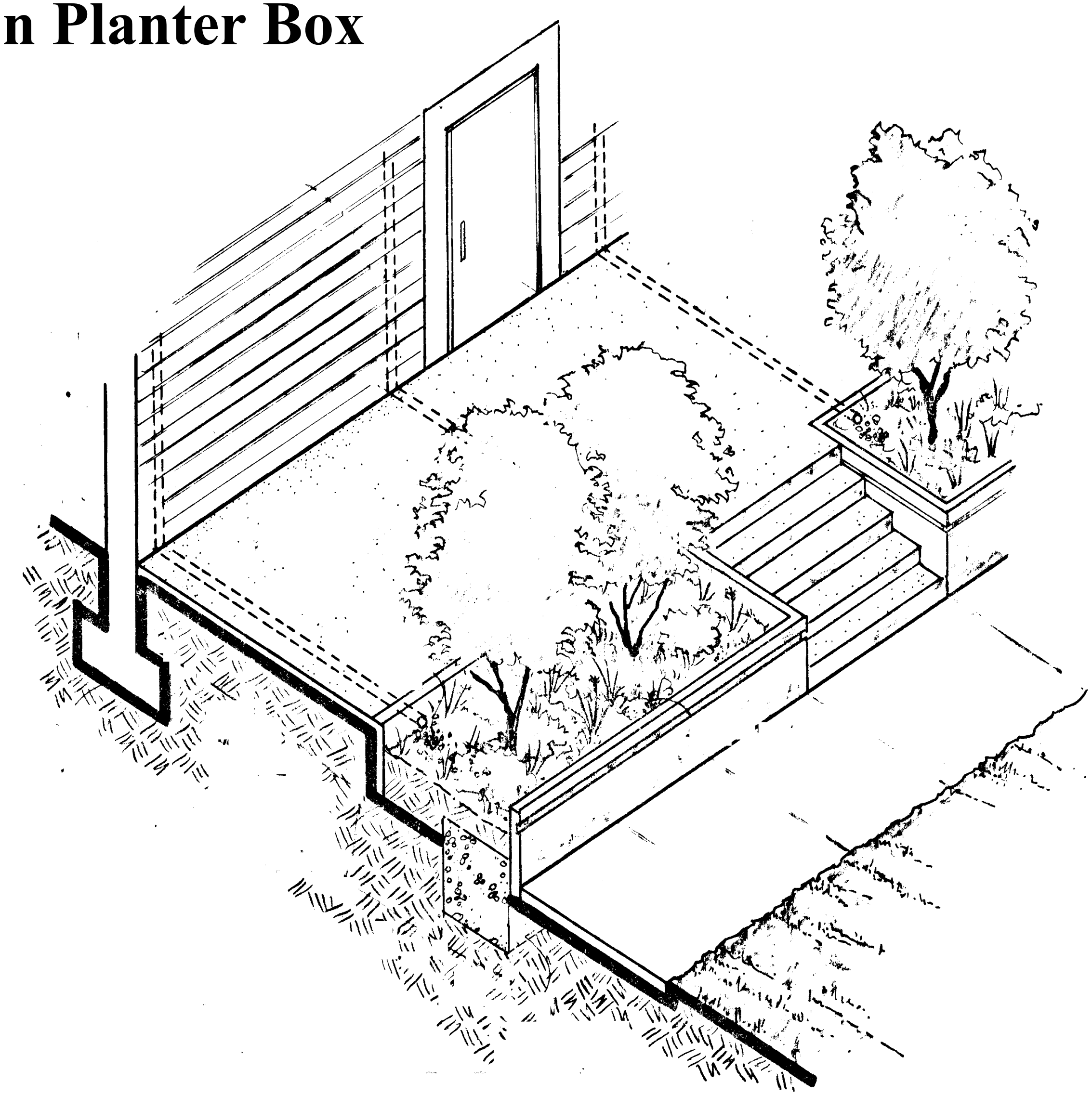


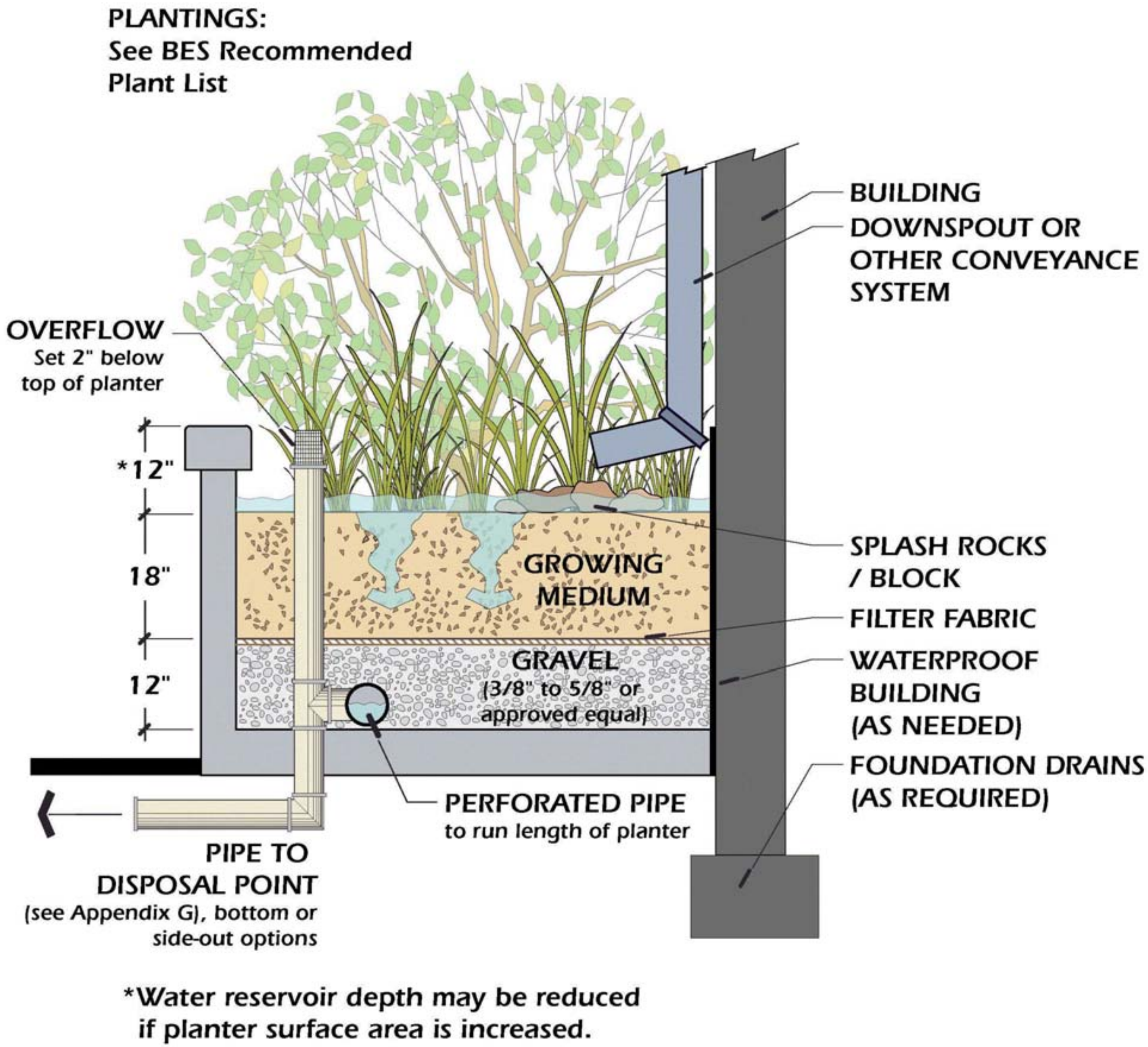


Infiltration Planter

7/26/02

Infiltration Planter Box





Flow-Through Planter Box

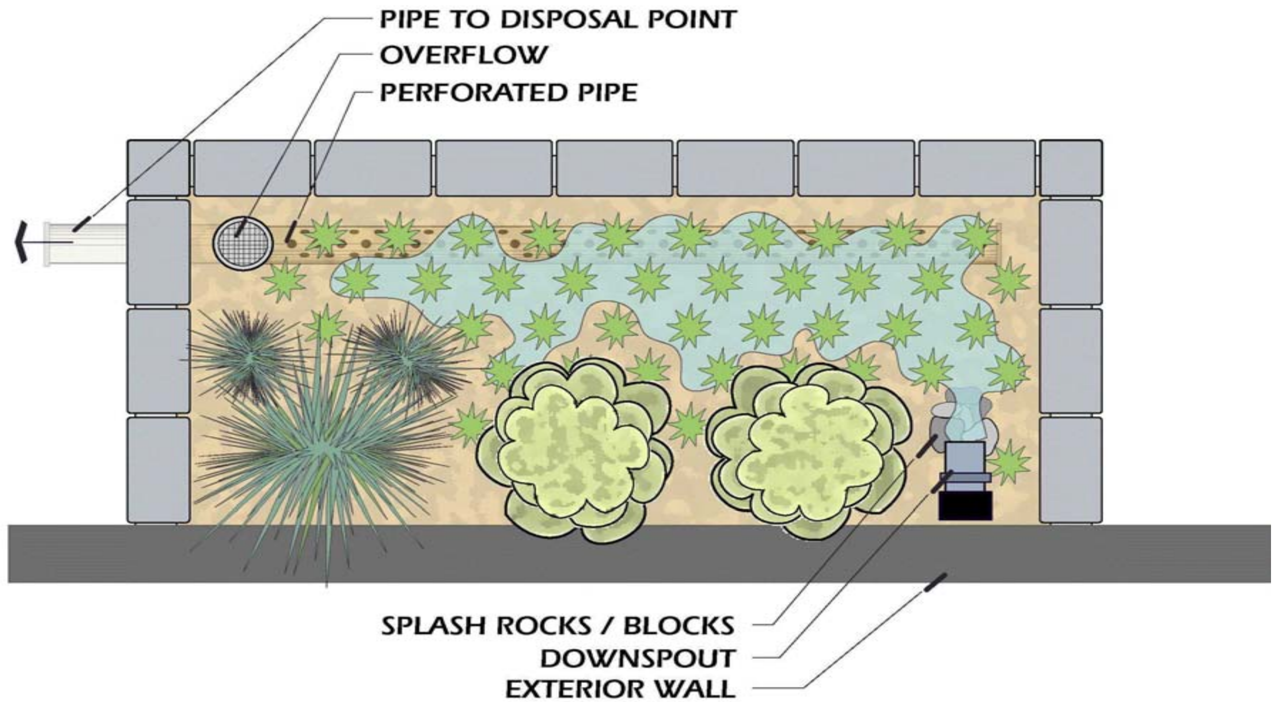
7/26/02

LEGEND


Large Shrub / Small Tree


Shrub / Large Grasslike Plants


Groundcover and Grass / Grasslike Plants



Planter Area = Approx. 50 sq. ft.

Not to Scale

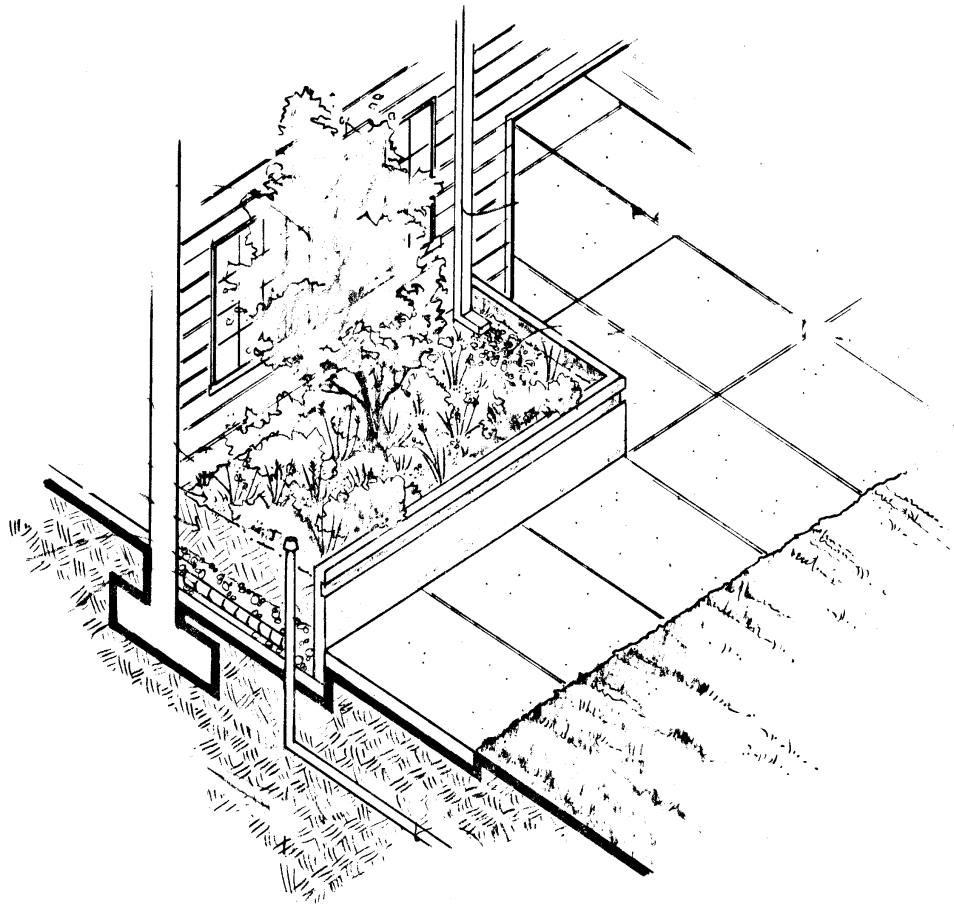
Notes:

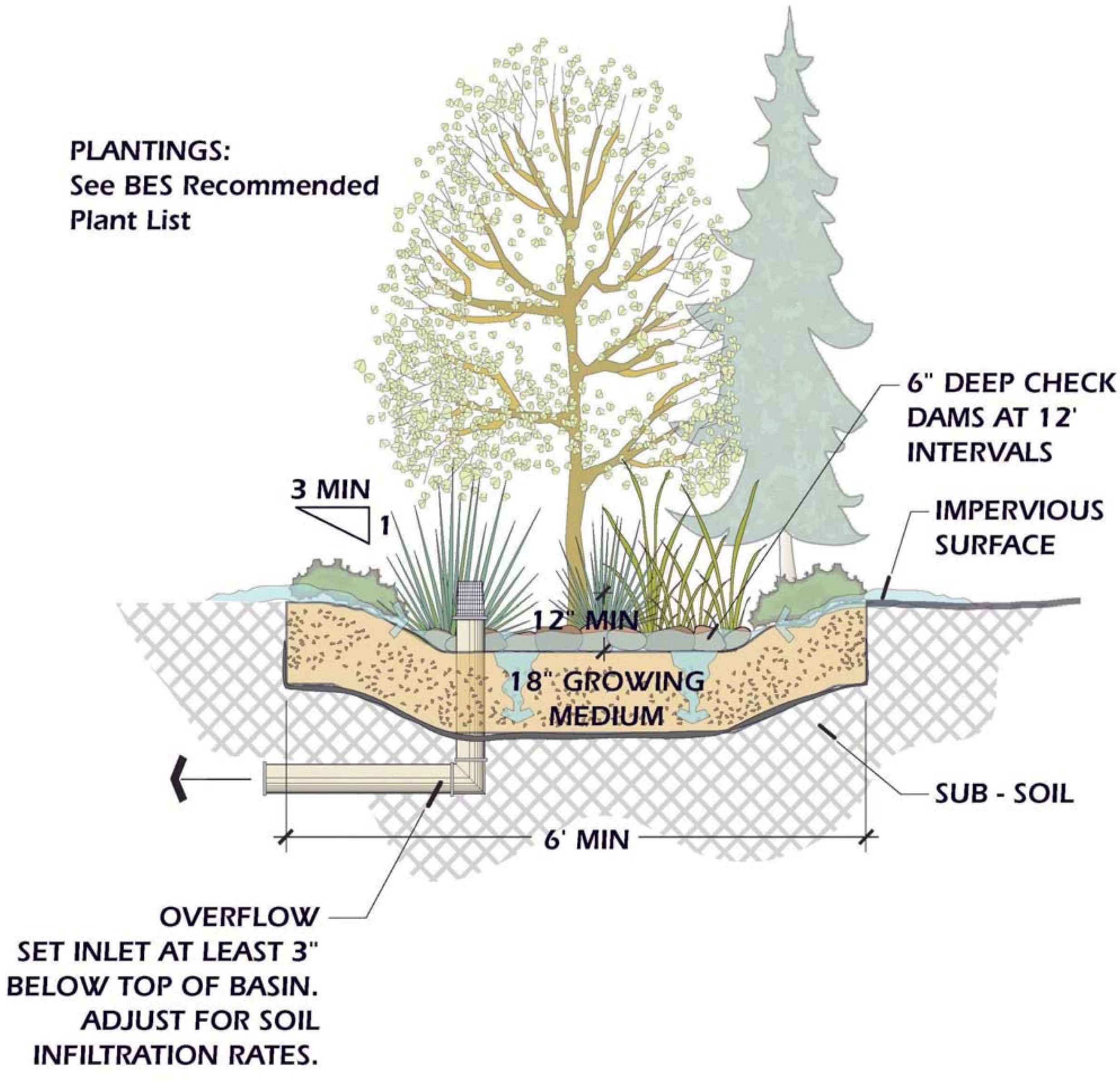
1. At least 50% of the facility shall be planted with grasses or grass-like plants, primarily in the flow path. Large grass like plants can be considered as shrubs.
2. See BES recommended plant list, and quantity requirements.

Flow-Through Planter - Plan

7/26/02

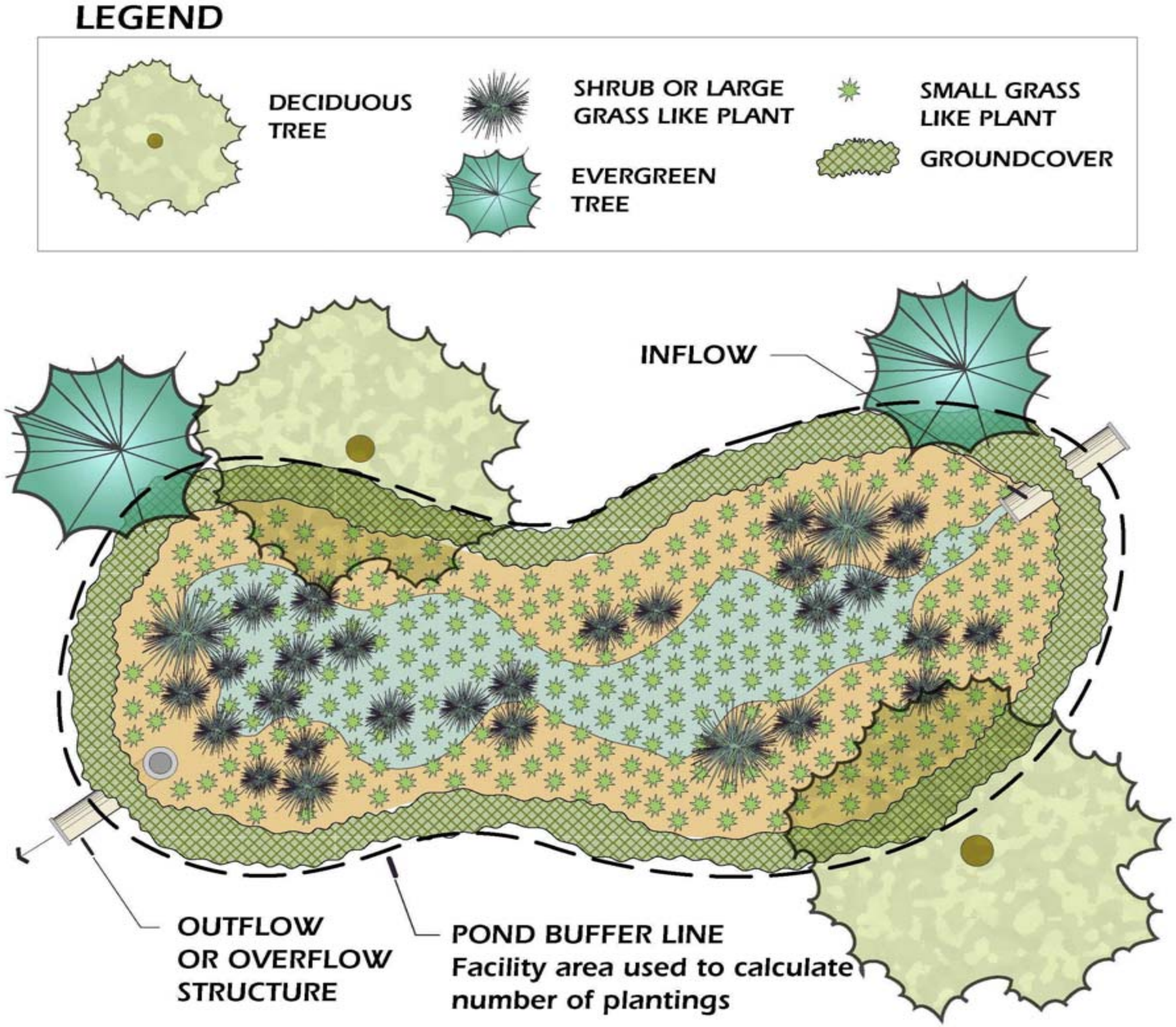
Flow-Through Planter Box





Vegetated Infiltration Basin

7/26/02



Swale Area = Approx. 1000 sq. ft.
(Not to Scale)

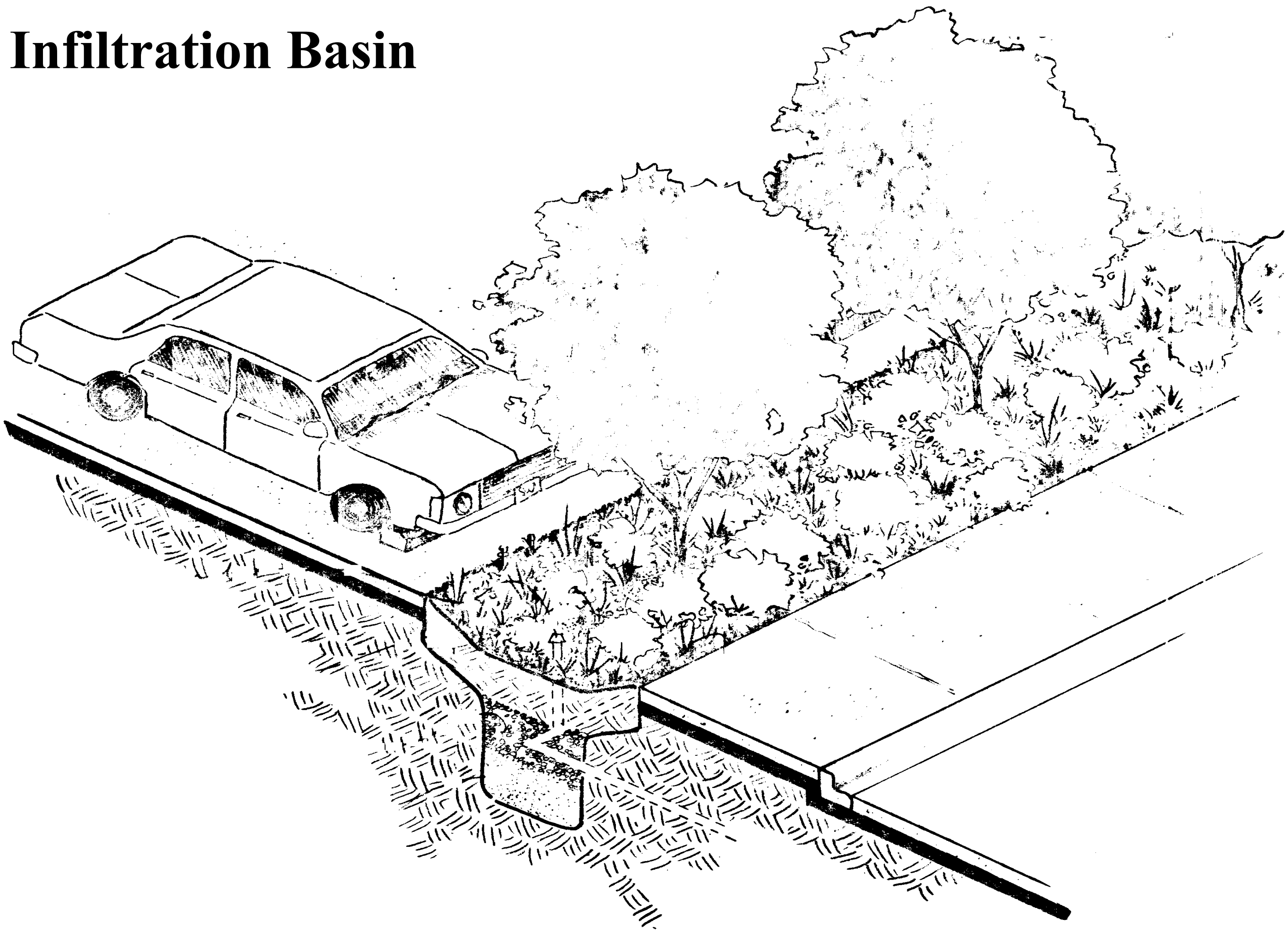
Notes:

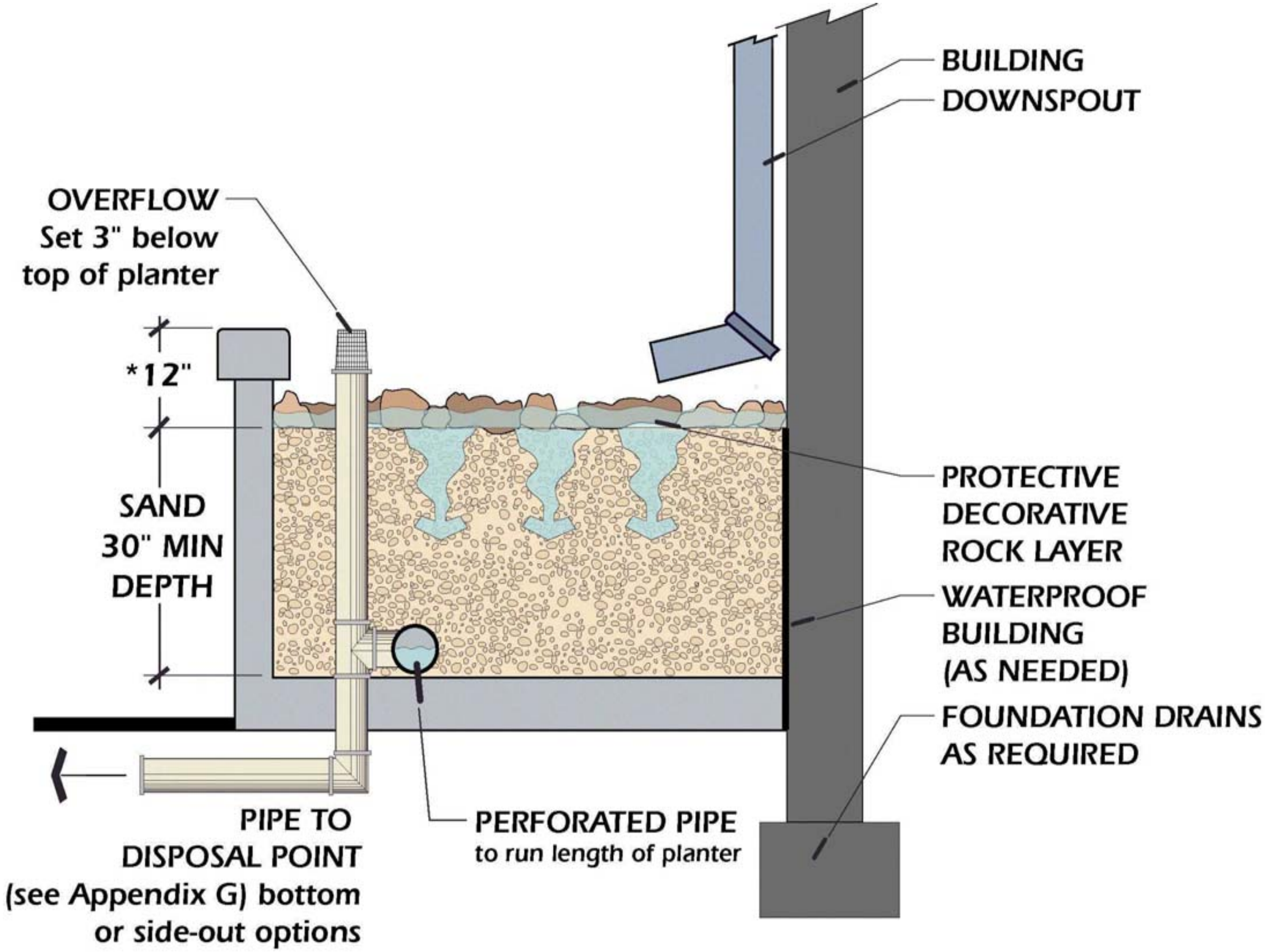
1. At least 50% of the facility shall be planted with grasses or grass-like plants, primarily in the flow path, or basin bottom.
2. Large grass like plants can be considered as shrubs. See BES recommended plant list and parking lot tree list.

Vegetated Infiltration Basin or Detention Pond - Plan

7/26/02

Vegetated Infiltration Basin





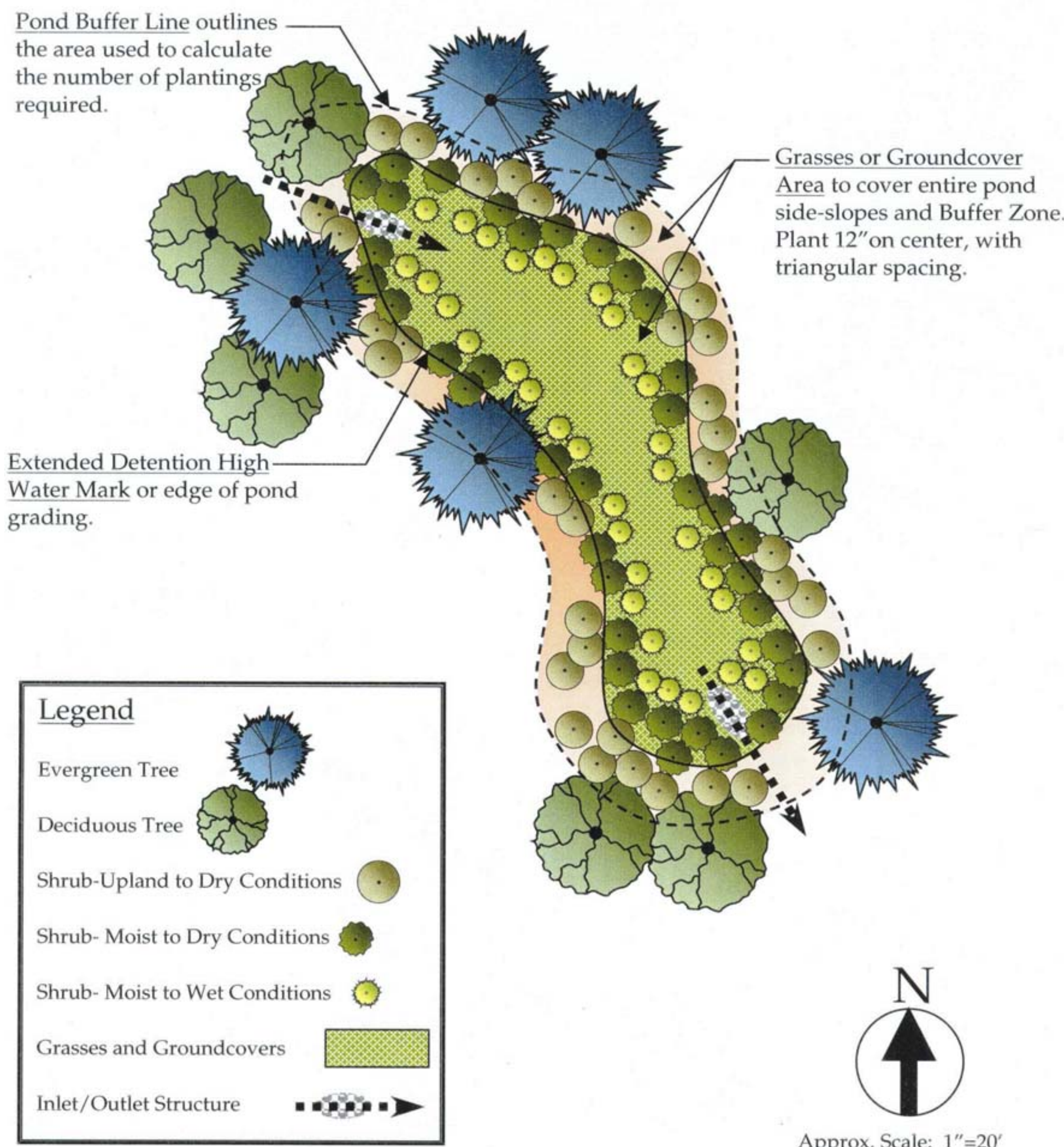
*Water reservoir depth may be reduced if planter surface area is increased.

Sand Filter Planter

7/26/02

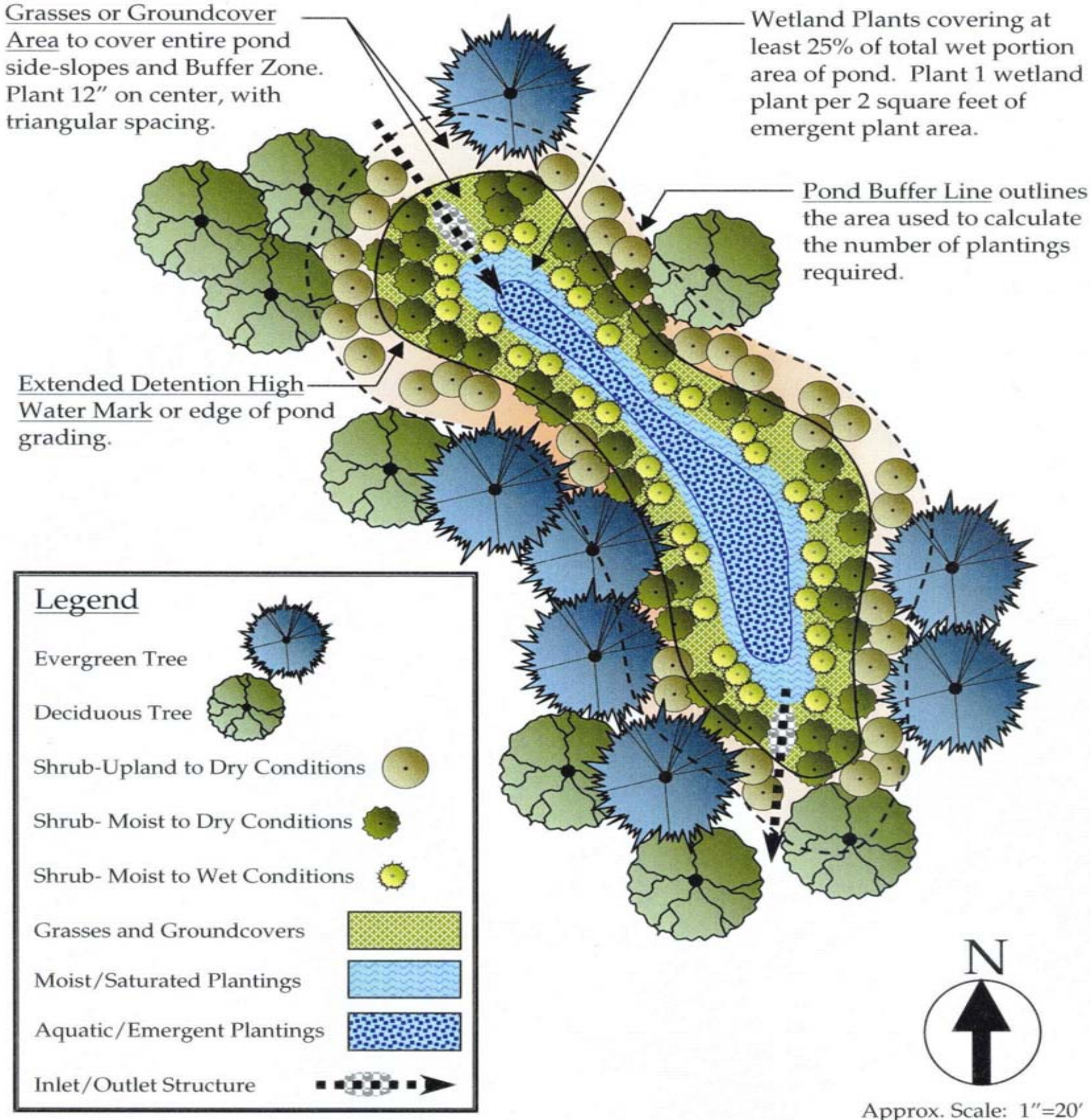
Dry Detention Ponds

The plan below illustrates a typical planting plan for an approximately 3,500 square foot dry detention pond. This plan is diagrammatic use only. The actual project site condition may require designers to consider numerous other pond configurations and planting layouts.



Wet and Extended Wet Ponds

The plan below illustrates a typical planting plan for an approximately 3,500 square foot wet or extended wet pond. This plan is diagrammatic use only. The actual project site condition may require designers to consider numerous other pond configurations and planting layouts.



Appendix H

Stormwater Management Facility Photos

September 2004 Stormwater Management Manual

Parking Lot Examples

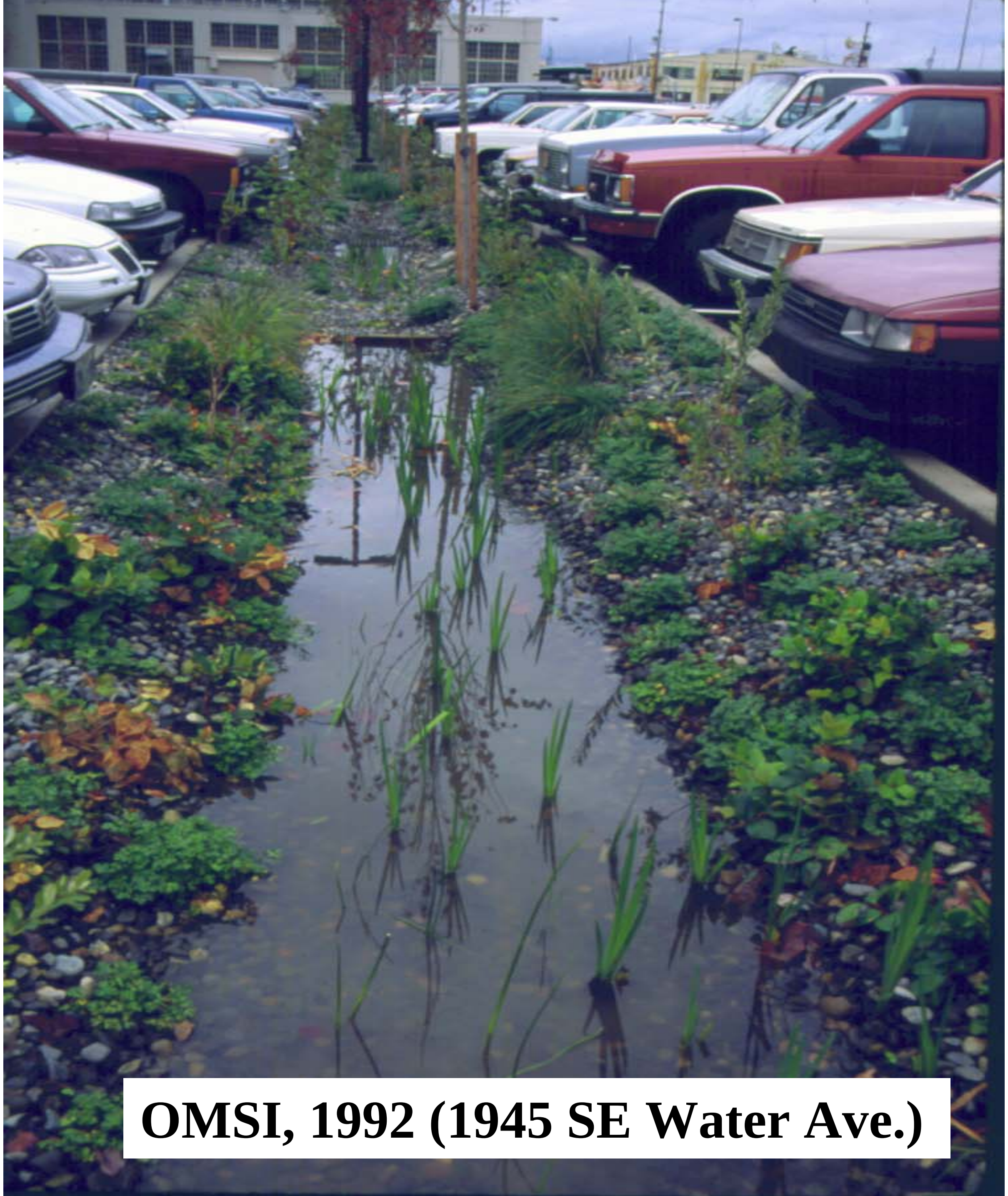
Glencoe Elementary School Parking Lot (825 SE 51st)

Glencoe Elementary School Parking Lot (825 SE 51st)

Glencoe Elementary School Parking Lot (825 SE 51st)

Glencoe Elementary School Parking Lot (825 SE 51st)

PCC Annex (SE Water Ave.)



OMSI, 1992 (1945 SE Water Ave.)

Troutdale Arata Creek School Site

Street Examples

Site Location	Page/ Slide
NE 35th Pl. & Siskiyou	11-16
SE 56th & Ankeny	17-19
N Leadbetter Road	20,21
SW Lodi Lane (& Shattuck) Subdivision	22
Seattle Street Edge Alternative Project	23-25
Seattle- Cascade & Broadview	26

NE 35th Pl & Siskiyou St.

NE 35th Pl & Siskiyou St.

NE 35th Pl & Siskiyou St.

NE 35th Pl & Siskiyou St.

NE 35th Pl & Siskiyou St.

NE 35th Pl & Siskiyou St.

SE 56th Ave. & Ankeny St.

SE 56th Ave. & Ankeny St.

SE 56th Ave. & Ankeny St.

N Leadbetter Road street swale w/ overflow catch basin & curb slots

N Leadbetter Road street swale w/ overflow catch basin & curb spillway

North side of SW Lodi Lane (& Shattuck), sand filter/ street swale

Seattle's Street Edge Alternatives Program

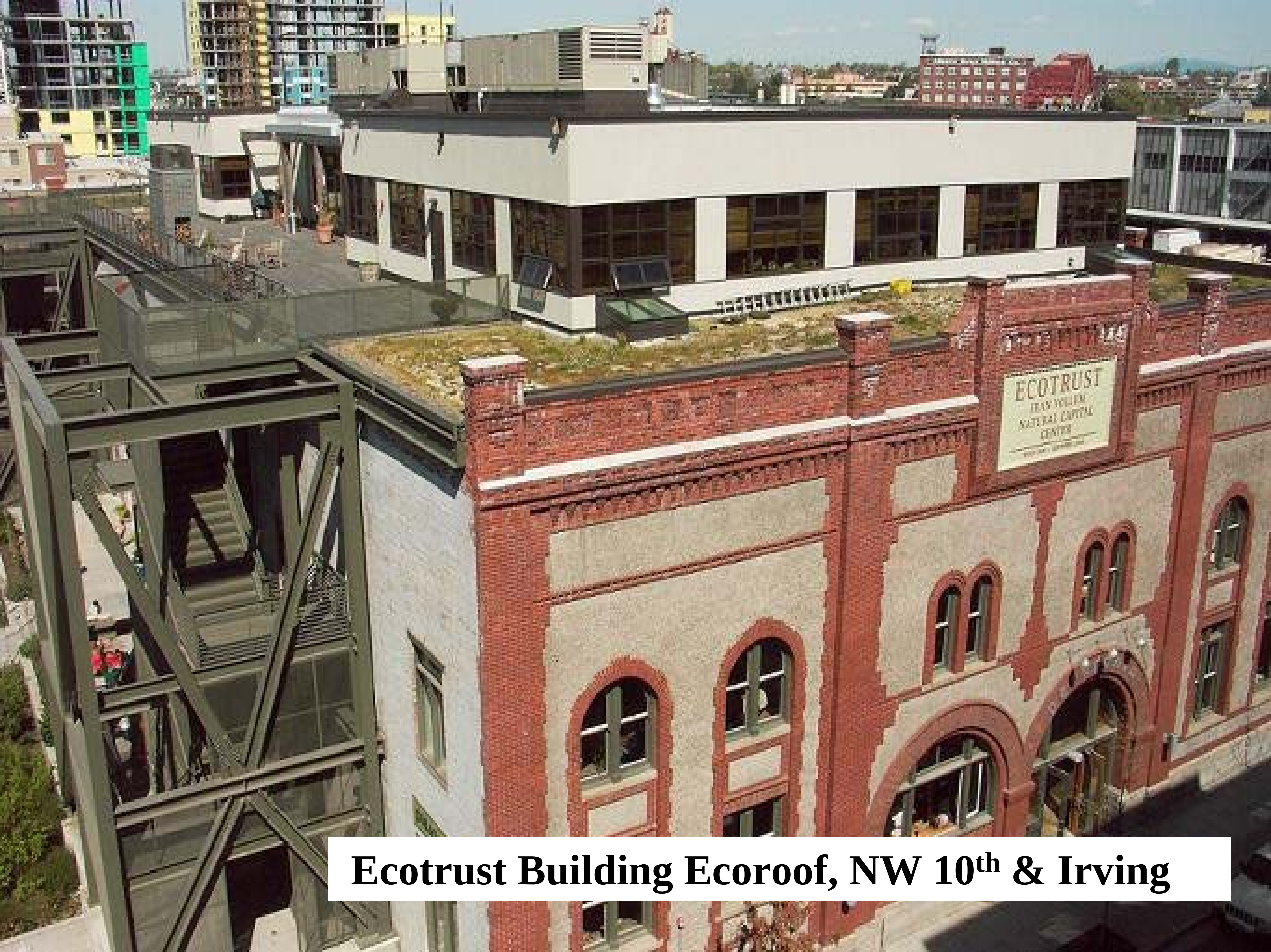
After Completion - January 2001

Seattle’s Street Edge Alternatives Program

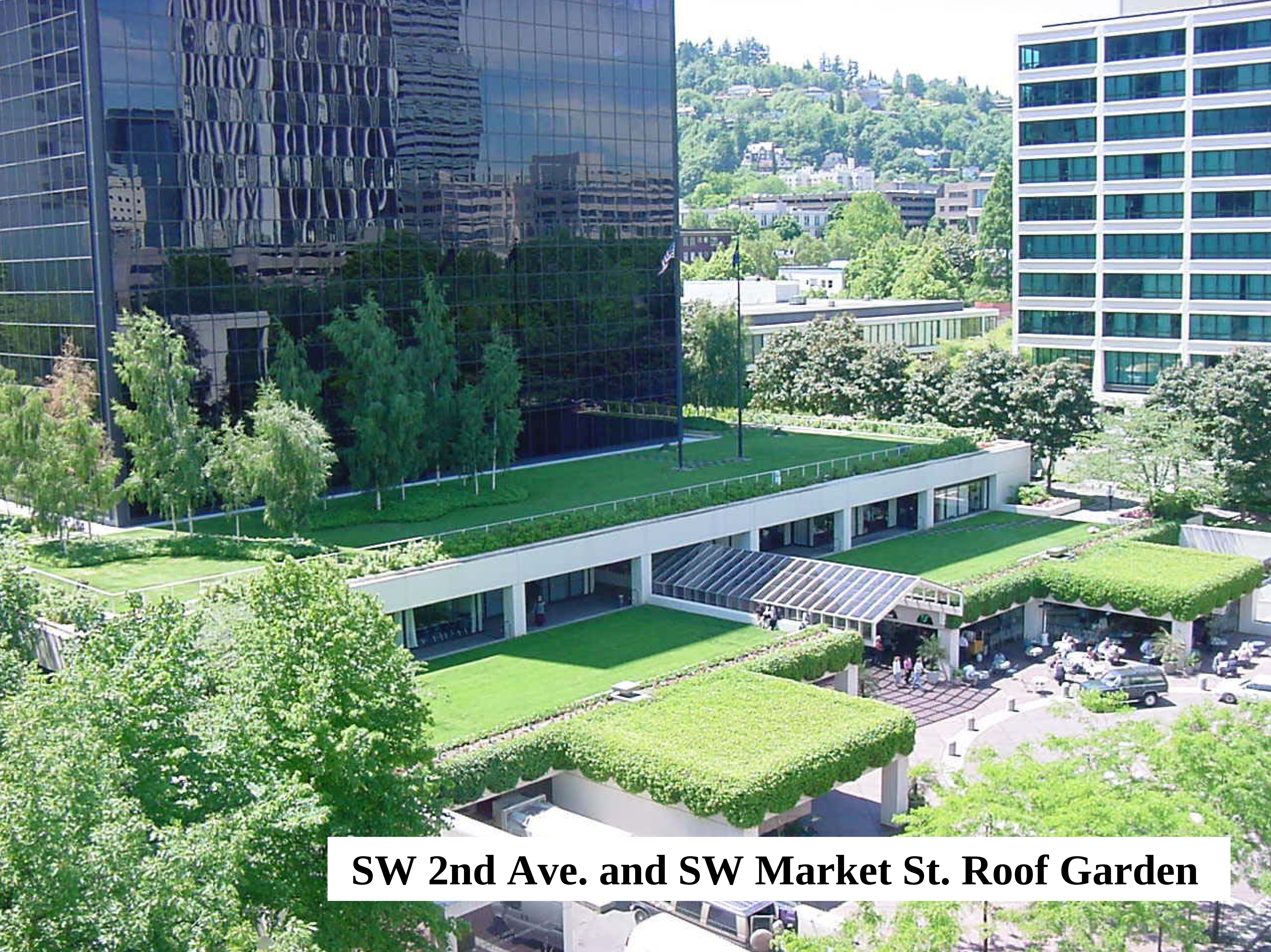
Seattle’s Street Edge Alternatives Program

Seattle’s Street Edge Alternatives Program, Cascade & Broadview

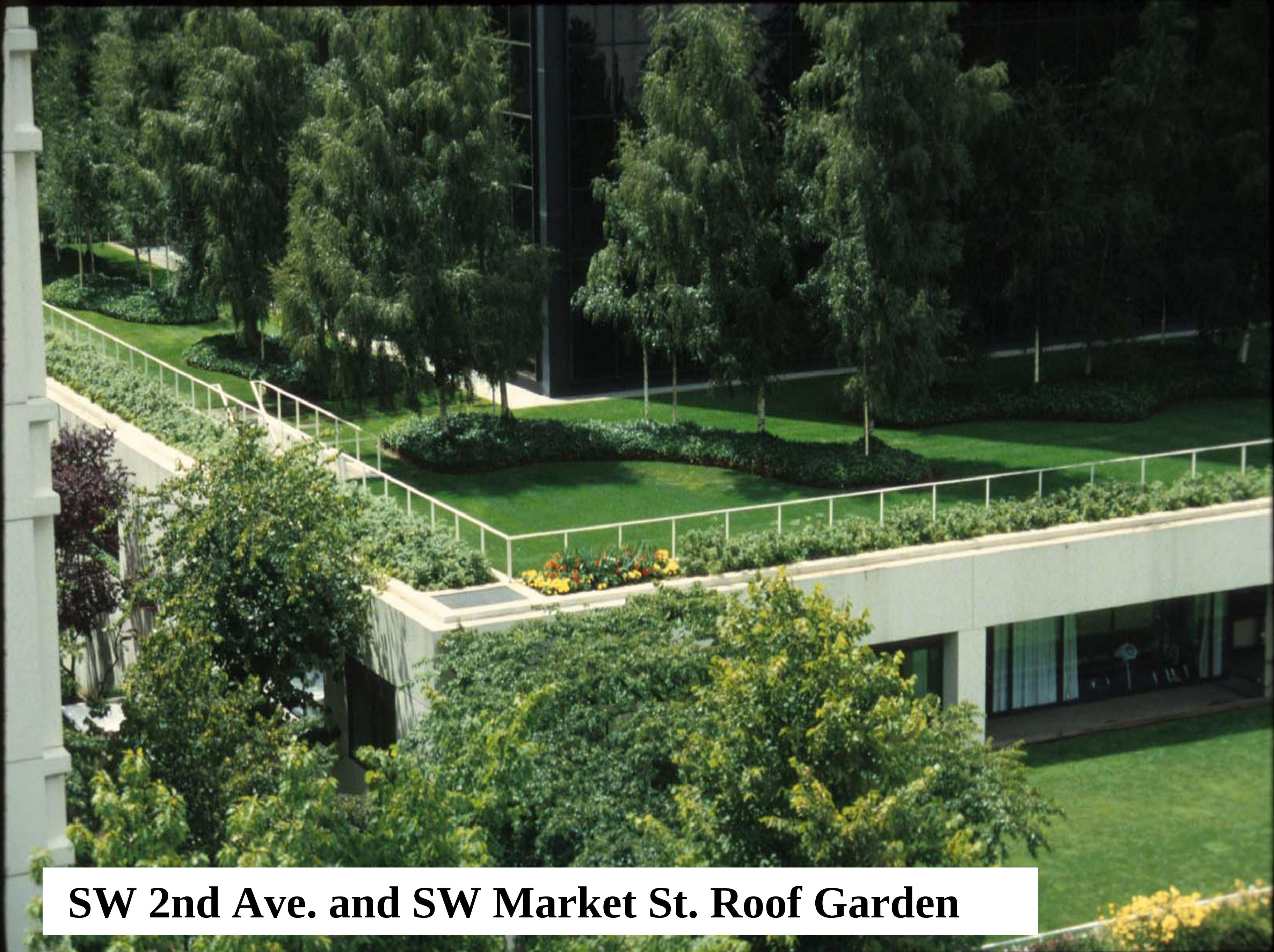
Ecoroofs and Roof Gardens



Ecotrust Building Ecoroof, NW 10th & Irving



SW 2nd Ave. and SW Market St. Roof Garden



SW 2nd Ave. and SW Market St. Roof Garden

Hamilton Apartments Ecoroof (1212 SW Clay St.)

Hamilton Apartments Ecoroof (1212 SW Clay St.)

Multnomah County Ecoroof (501 SE Hawthorne)

2021 SE Clinton St. Ecoroof

Buckman Terrace Ecoroof (303 NE 16th Ave.)

Buckman Terrace Ecoroof (303 NE 16th Ave.)

Pervious Pavement

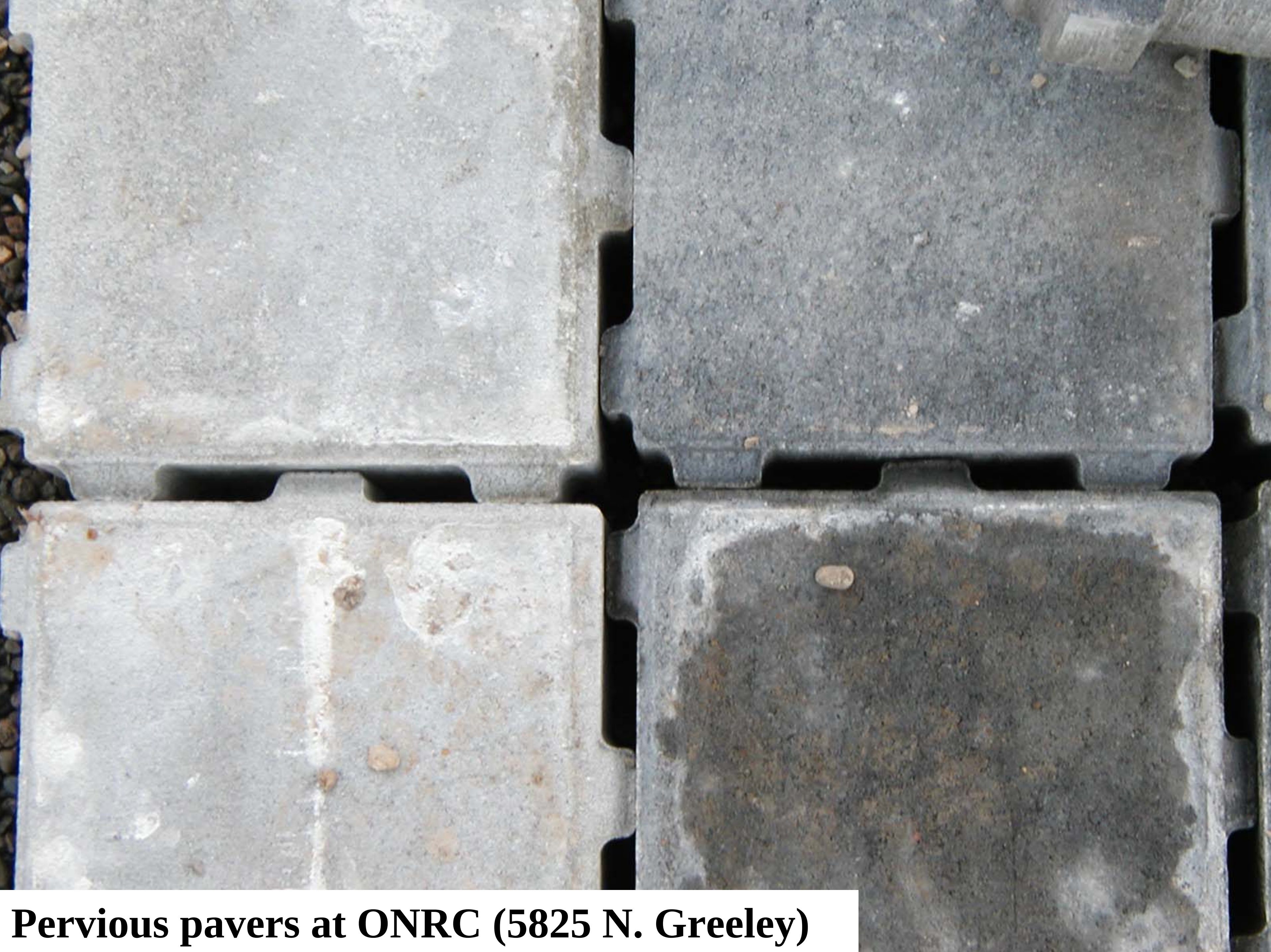
Multnomah Arts Center Eco-Stone Parking Lot

Multnomah Arts Center Eco-Stone Parking Lot

Installation of Eco-Loc Paver Parking Lot in Washington

Installation of Eco-Loc Paver Parking Lot in Washington

Pervious pavers at ONRC (5825 N. Greeley)



Pervious pavers at ONRC (5825 N. Greeley)

Core-Sample of Pervious Concrete, Dyed Brown

Pervious concrete installation at NE 94th & Broadway pump station site

Clean Water Services' pervious concrete parking lot in Beaverton

Clean Water Services Pervious Concrete Parking Lot

Pervious Asphalt installation near SE 162nd & Foster

Pervious pavement parking lot at unknown location

Vegetated Swales

Hawthorne Ridge Subdivision (SE 162nd, South of Foster)

OMSI Vegetated Swale (1945 SE Water Ave.)

BES Water Pollution Control Lab (6543 N. Burlington)

Grassy Swales

Reed College (SE 28th Ave.)

Russell Pond Site (NE 88th Ave. and Freemont Dr.)

SW Scholls Ferry Road

Vegetated Filters

SW Community Center (6820 SW 45th Ave.)

Contained Planters

1100 block of bus mall, downtown Portland

Federal Building (1200 block of SW 3rd Ave.)

Infiltration Planters

Site Location	Page/ Slide
Wattles Boys and Girls Club (9330 SE Harold	64
Portland State University	65-67

Wattles Boys and Girls Club (9330 SE Harold)

Portland State University

Portland State University

Portland State University

Flow-Through Planters

Buckman Terrace Apartments (303 NE 16th Ave.)

Buckman Terrace Apartments (303 NE 16th Ave.)

Ritzdorf Apartments (SE 12th Ave. & SE Belmont St.)

Liberty Center Parking Garage (650 NE Holladay)

Liberty Center Parking Garage (650 NE Holladay)

Liberty Center Parking Garage (650 NE Holladay)

Flow-through planter test in New Zealand

Flow-through planter test in New Zealand

Vegetated Infiltration Basins

Buckman Heights courtyard infiltration basins (430 NE 16th Ave.)

Buckman Heights courtyard infiltration basin (430 NE 16th Ave.)

Buckman Heights courtyard planter overflow (430 NE 16th Ave.)

Glencoe Elementary School (825 SE 51st)

Glencoe Elementary School (825 SE 51st)

Macintyre Estates Subdivision (SE 139th & Steele)

Macintyre Estates Subdivision (SE 139th & Steele)

Wattles Boys and Girls Club (9330 SE Harold)

Sand Filters

Site Location	Page/ Slide
Cascade Station (NE Airport Way & I-205)	87, 88

Cascade Station (NE Airport Way & I-205)

Cascade Station (NE Airport Way & I-205)

Soakage Trenches

Site Location	Page/ Slide
7123 SE Powell	90, 91
Unknown location	92

7123 SE
Powell

7123 SE Powell

Unknown location

Wet & Extended Wet Detention Ponds

BES Water Pollution Control Lab (6543 N. Burlington)

BES Water Pollution Control Lab (6543 N. Burlington)

DaVinci Middle School (2508 NE Everett)

DaVinci Middle School (2508 NE Everett)

Mill Pond (NW Mill Pond Rd., Forest Heights Subdivision)

Troutdale Arata Creek School Site

Hawthorne Ridge Subdivision (SE 162nd, S. of Foster)

Constructed Treatment Wetlands

Site Location	Page/ Slide
Russell Pond Site (NE 88th & Freemont)	102

Russell Pond Site (NE 88th Ave. and Freemont)

Tree Credit Examples


SEP 16 2000

JAN 4 2001

STOP
SEP 27 2000

DEC 17 2000

Buckman Terrace tree preservation and at grade infiltration planter (303 NE 16th Ave.)

Rainwater Harvesting

Cistern at ONRC (5825 N. Greeley)

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