CITY OF SALEM
DEPARTMENT OF PUBLIC WORKS
ADMINISTRATIVE RULES
CHAPTER 109
DIVISION 004 – STORMWATER SYSTEM

SECTION

TABLES

APPENDICES

4.1 - Introduction

(a) Objectives

The objectives of these Standards are to provide an effective stormwater system that will:

(1) Safely convey all drainage water from sources upslope to an approved storm system downslope, thus preventing the uncontrolled discharge of stormwater onto adjoining public or private property and protecting the safety and security of persons and property.

(2) Maintain and improve the water quality in, and the beneficial uses of, Salem's waterways, lakes, ponds, wetlands, and other natural drainage resources.

(3) Implement a stormwater management program reflecting the requirements associated with the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit, Oregon Department of Environmental Quality (DEQ) Total Maximum Daily Load (TMDL) Program, and the water quality needs of Salem's urban waterways.

(4) Protect Salem's natural resources by preserving stormwater quality and preventing erosion.

(5) Reduce stormwater runoff volumes by prioritizing stormwater interception, evapotranspiration, and infiltration.

(6) Construct stormwater facilities which are safe and economical to maintain, meet the service levels intended, and minimize life cycle costs.

(7) Provide for orderly development by routing and controlling the discharge of stormwater and providing adequate capacity for future development.

(8) Substantially maintain the runoff characteristics of the original, predeveloped drainage basin.

(9) Achieve stormwater management goals and performance standards through the application of Green Stormwater Infrastructure (GSI) to the Maximum Extent Feasible (MEF).

(b) Applicability

These Stormwater Design Standards shall govern all construction and upgrades to the City public stormwater system and privately-owned stormwater systems and include the collection, flow control, treatment, and conveyance of stormwater from both private property and from within the ROW or other City-owned and City-controlled property.

(c) How to Use These Standards

These Stormwater Design Standards provide the requirements for the design of stormwater infrastructure consisting of conveyance, treatment, and flow control systems. Salem Revised Code (SRC) Chapters 70 and 71 establish specific definitions; requirements for stormwater discharges to receiving waters (e.g., rivers, streams and creeks); and requirements for the use of GSI necessary to comply with the City's NPDES MS4 permit. These Stormwater Design Standards not only provide requirements for the design of stormwater facilities but also provide the framework to comply with key elements of SRC Chapters 70 and 71. The designer, however, must become familiar with SRC Chapters 70 and 71 since these Stormwater Design Standards do not address all requirements listed within the SRC.

When designing a stormwater system and using these Stormwater Design Standards the following key elements must be addressed and/or performed:

(1) Determine the type of project and threshold requirements. Project types subject to these Stormwater Design Standards, as defined in SRC Chapter 70, include Residential (RES) projects (new and replaced impervious area is 1,300 square feet (sf) or more, but less than 5,000 sf) and Large Projects (new and replaced impervious area equal to or greater than 5,000 sf).

Stormwater facility sizing for treatment and flow control can be reduced by using impervious area reduction techniques (Subsection 4.3 - (d) Impervious Area Reduction Techniques). However, use of such techniques does not change the applicability of these Stormwater Design Standards to qualifying project types and thresholds.

(2) Establish discharge requirements. Special attention needs to be given to points of discharge and the capacity of the downstream public conveyance systems. SRC Chapter 71 contains specific requirements related to these items. Section 4.4 - General Design Requirements describes approved points of discharge, downstream capacity analysis and other applicable design requirements.

(3) Conduct a site assessment. It is critical to perform a site assessment prior to land use to determine soil types and infiltration feasibility. The site assessment also supports the City's strategy for addressing low impact development (LID), including implementation of site planning techniques to minimize site disturbance, preserve existing vegetation, and minimize soil compaction. Measured and design infiltration rates must be confirmed to determine types and sizes of stormwater facilities required. Section 4.3 - Site Assessment and Planning defines the site assessment requirements.

(4) Ensure Green Stormwater Infrastructure to the Maximum Extent Feasible (GSI/MEF)

A. Green Stormwater Infrastructure (GSI). A stormwater facility that uses vegetation, soils, or natural processes to promote natural surface hydrologic functions through infiltration or evapotranspiration. Stormwater facilities designed for full infiltration (no underdrain) or partial infiltration (with underdrain) are considered GSI.

B. Maximum Extent Feasible (MEF). The extent to which a requirement or performance standard must be complied with as constrained by the physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts. For compliance with SRC 71.100, MEF means using GSI to meet performance standards for treatment by infiltrating and treating the water quality design storm.

C. SRC Chapter 71 requires the use of GSI to the MEF for RES projects and Large projects.

D. To fully meet the stormwater performance standards (Section 4.5 - Performance Standards and Design Methods), unless infiltration infeasibility criteria apply (Subsection 4.3 - (b) Infiltration Feasibility), GSI must be used. GSI may be designed as an infiltration facility (fully retaining or infiltrating the design storm event) or partial infiltration facility (promoting infiltration but designed with an underdrain to discharge stormwater runoff exceeding the infiltration capacity of the native soil) depending on the design infiltration rate of native soil. Stormwater facilities qualifying as GSI are detailed in Subsection 4.6 - (b) Stormwater Facility Design Criteria (GSI) and identified with a parenthetical (GSI).

E. Although site constraints, limitations in engineering design, and financial costs should rarely restrict the ability to meet stormwater performance standards, the City recognizes that some projects may require a Design Exception to the City's stormwater performance standards. Appendix 4E establishes the criteria for obtaining design exceptions related to implementation of GSI.

(5) Select and design of stormwater facilities. Depending on infiltration feasibility of a site (Subsection 4.3 - (b) Infiltration Feasibility), stormwater facilities must be selected, sized and designed to meet the water quality and flow control performance standards.

RES and Large Projects with 10,000 sf or less of new and replaced impervious surface may size stormwater facilities using the Simplified Sizing Method; all projects with greater than 10,000 sf of new and replaced impervious surface require the Engineered Method to size stormwater facilities (Subsection 4.5 - (b) Sizing Methods).

The designer is encouraged to utilize combined stormwater facilities to meet both the water quality and flow control performance standards where possible. If the project involves a Land Division, Subsection 4.4 - Land Division Alternatives presents options for utilizing unified facilities, individual facilities, dispersed facilities in the right-of-way (ROW), or single larger facilities to provide for treatment and flow control.

(6) Design the conveyance system. The conveyance system must be designed to carry offsite and onsite stormwater to the approved point of discharge. They must also meet the requirements of the Stormwater Master Plan, provide for the future development of up gradient property, and extend to the upslope boundaries. In some cases, stormwater conveyance may need to extend through an easement to reach the downstream point of discharge. Section 4.9 - Conveyance Systems outlines conveyance system design criteria.

(d) Stormwater Management Exemptions

(1) Project exemptions listed below are not applicable to erosion and sediment control or source control requirements as outlined in SRC Chapter 71 or 75.

(2) The following project types are exempt from the water quality and flow control performance standards, as outlined in Subsection 4.5 - (a) Performance Standards and Design Storms (see also SRC Chapter 71.095(a)(2)(A) and 71.100(a)(2)(A)):

A. Maintenance, repair, or installation of underground or overhead utility facilities that includes replacing the ground surface with in-kind material or materials with similar runoff characteristics. By way of illustration, but not of limitation, this includes maintenance, repair, and installation of pipes, conduits, and vaults.

B. The following road maintenance practices:

(i). Pothole and square cut patching;

(ii). Overlaying existing asphalt or concrete or brick pavement with asphalt or concrete without expanding the area of coverage;

(iii). Shoulder grading;

(iv). Reshaping or re-grading drainage ditches;

(v). Crack sealing;

(vi). Replacing existing impervious surface down to earth material; and

(vii). Vegetation maintenance.

C. Projects in the ROW under the control of another governmental body, if:

(i). The governmental body uses best management practices consistent with that government body's own stormwater management program and NPDES permit; and

(ii). The best management practices are at least as stringent as those required by this chapter and rules pursuant thereto.

(3) The following project types are exempt from the flow control performance standard, as outlined in Subsection 4.5 - (a) Performance Standards and Design Storms (see also SRC Chapter 71.095(a)(2)(A)).

A. RES projects meeting threshold requirements as outlined in Subsection 4.2 - (a) Residential (RES) Projects.

B. Large projects discharging directly into a flow control exemption area as defined in SRC 70.005, when all the following conditions are met:

(i). Portions of the development site that do not discharge directly to the flow control exemption area are isolated and provided with an independent flow control system;

(ii). Any erodible elements of the man-made conveyance system must be adequately stabilized to prevent erosion under the conditions noted below;

(iii). The conveyance system meets one of following criteria:

a. The project site is drained by a private conveyance system that comprises entirely man-made conveyance elements (e.g., pipes, culverts, outfall protection, etc.) and extends to the ordinary high-water line of the flow control exempt water body; or

b. The conveyance system between the project site and the flow control exempt water body is public and has sufficient hydraulic capacity to convey discharge from future buildout conditions (under current zoning) of the site, and the existing development condition from the remaining drainage area contributing to the conveyance system, as outlined in the downstream analysis.

4.2 - Project Thresholds

(a) Residential (RES) Projects

RES projects are defined in the SRC Chapter 71 as any residential development including single family dwellings, townhouses, two-family uses, three- and four-family uses, and/or accessory dwelling units where the total new pervious pavement, new impervious surface, and replaced impervious surface is 1,300 sf or more but less than 5,000 sf.

RES projects shall be designed and constructed to meet the water quality performance standard using GSI to the MEF except where stormwater facilities have already been constructed through a Land Division per SRC Chapter 71 to serve the lot or parcel. RES projects 5,000 sf and greater are considered a large project.

(b) Large Projects

Large projects are defined in SRC Chapter 71 as projects where the individual or combined new impervious surface, replaced impervious surface, or pervious pavement is 5,000 sf or more. Large projects are required to meet the water quality and flow control performance standards, and adherence to the water quality performance standard shall include the use of GSI.

(c) All Projects

See SRC Chapter 71 and Chapter 75 for other requirements for all projects regardless of size, such as source control, erosion control, discharge to wetlands, preserving trees, providing landscaping, etc. Projects that are adjacent to an existing open channel waterway or within the 100-year floodplain of any waterway must meet the requirements of SRC Chapter 601.

4.3 - Site Assessment and Planning

(a) Site Assessment Checklist

These Stormwater Design Standards are intended to guide site-specific stormwater improvements that prioritize retention/infiltration and applications of GSI/MEF to meet stormwater performance standards. Use of these Stormwater Design Standards requires an understanding of project features and physical attributes of the site, to identify soil infiltration capabilities and constraints upfront in the land use process and inform stormwater management facility selection and sizing.

All projects subject to these Stormwater Design Standards shall require the completion of the *Site Assessment Checklist*, identified in Appendix 4A.3, which requires documentation of site information, a Preliminary Site Plan, and documentation of infiltration feasibility. The *Site Assessment Checklist* also requires the preliminary selection and sizing of stormwater management facilities.

The *Site Assessment Checklist* shall be submitted with the Land Use Application. In lieu of a Preliminary Drainage Report, supporting calculations can be attached to the *Site Assessment Checklist* for large projects not seeking Design Exceptions from standards and/or projects that are unable to provide infiltration information at the time of land use and are setting aside area (i.e., 10% of total new and replaced impervious surface) for stormwater management. The following LID practices are required to be reflected on the *Site Assessment Checklist* and Preliminary Site Plan.

(1) Preserve Existing Trees and Vegetation: Existing trees and native vegetation must be preserved per SRC Chapter 808–Preservation of Trees and Vegetation and SRC Chapter 86-Trees on City-owned Property. The Preliminary Site Plan must identify all trees and native vegetation that are being retained.

(2) Minimize Site Disturbance: Site design and construction must minimize ground disturbing activities and retain the undisturbed state of the duff layer, topsoil, and native vegetation where feasible. Impervious development areas must be minimized, preserving natural features.

Reducing the amount of total new and replaced impervious surface will reduce the development's impact on the site and the size of required stormwater facilities. The Preliminary Site Plan must delineate protected areas and reflect areas to remain undisturbed during construction.

(3) Minimize Soil Compaction: Soil compaction in areas where stormwater facilities will be located, specifically GSI that are designed for full or partial infiltration, shall be avoided during construction. These footprint areas must be protected with barriers or other means during construction. No vehicle traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of the infiltration area.

The Preliminary Site Plan shall reflect the anticipated locations of stormwater facilities and clearly indicate temporary fencing around the stormwater facility footprint areas, as well as proposed revegetation.

(b) Infiltration Feasibility

All RES projects and Large projects are required to meet the City's stormwater performance standards using GSI to the MEF. However, certain site conditions may prevent the use of stormwater facilities that incorporate infiltration into design, regardless of the soil infiltration capacity.

Table 4-1 outlines criteria prohibiting the use of GSI, regardless of soil infiltration. Infiltration infeasibility must be documented on the *Site Assessment Checklist* and supporting information provided. Filtration facilities, which include lined facilities, will instead be required to meet the water quality performance standard.

Table 4-1: Infiltration Infeasibility Criteria

Criteria	Standard
Steep Slopes and Landslide Hazards	Infiltration or partial infiltration facilities are prohibited on slopes 20% or greater. Filtration facilities will be required to meet the water quality performance standard. Infiltration or partial infiltration facilities proposed on or adjacent to slopes 15% or greater or identified as Category B or C Moderate/High landslide risk pursuant to SRC Chapter 810 will require a Geotechnical Engineering Report prepared by a Certified Engineering Geologist and Geotechnical Engineer to determine the suitability for infiltration facilities as well as an applicable setback of an infiltration facility from the top or toe of slope. As a guideline, for facilities proposed on or adjacent to slopes 15% or greater, the greater of a 50 ft setback or 4H:1V upward projection from the toe of to the slope to the proposed high-water point in the facility may be used to determine a required setback from the top of slope.

Table 4-1: Infiltration Infeasibility Criteria	
Criteria	**Standard**
Seasonal High Groundwater Table	Infiltration or partial infiltration facilities are prohibited on sites with less than 3 ft of vertical separation between the bottom of the facility (i.e., bottom of drain rock layer) and seasonal high ground water elevation. A geological investigation and report or summary of findings is required to identify the seasonally high groundwater level. The summary of findings may include details from well log history, infiltration testing, and observations from a qualified professional.
Contaminated Soils	Infiltration or partial infiltration facilities are prohibited on sites with contaminated soils. See Administrative Rule 109-012°Stormwater Source Control for an overview of contaminated soils. Potential resources for identifying contaminated sites include but are not limited to the following: • Leaking Underground Storage Tank database: **Oregon DEQ: Land Quality-Tanks-LUST-Search Leaking Underground Storage Tank Cleanup Site Database (state.or.us)** • Environmental Cleanup Site Information database: **Department of Environmental Quality: Environmental Cleanup Site Information Database: Environmental Cleanup: State of Oregon** • Facility Provider Map: **Oregon Dept. of Environmental Quality (state.or.us)**
Fill Soils	Infiltration or partial infiltration facilities are prohibited on unconsolidated fill soils deeper than 5 ft as measured from the highest finish grade adjacent to the proposed facility. An exception may be made if a stamped geotechnical report indicates suitable stability for an unlined facility.
Adjacent to Domestic Wells	Infiltration or partial infiltration facilities are prohibited within a 100-ft buffer around domestic wells to maintain consistency with Oregon Administrative Rules protections for public wells.

(c) Infiltration Testing

To accurately determine the location, size and capacity of stormwater facilities, it is necessary to know the measured and design infiltration rate of the soil at the facility location. Infiltration testing data, in accordance with the requirements listed in Appendix 4C–Infiltration Testing, must be submitted for all proposed stormwater facilities to confirm adherence to the stormwater performance standards.

The city has approved two types of infiltration testing; the Basic and Professional Infiltration Tests. Infiltration testing requirements vary depending on the type of project:

(1) RES Projects and Large Projects with 10,000 sf or less of new plus replaced impervious area: On-site infiltration testing is recommended. For these projects, the Basic Method Infiltration Test may be used. This testing method does not require a licensed professional.

(2) Large Projects with greater than or equal to 10,000 sf of new plus replaced impervious area: Professional infiltration testing is required in the general location of the proposed stormwater facility(ies).

(3) For RES projects and Large projects using the Simplified Method for sizing, Natural Resource Conservation Service (NRCS) Soil Survey data may be used to obtain an approximate design infiltration rate. The *Site Assessment Checklist* and *Simplified Sizing Form* (see Appendix 4A) requires the identification of NRCS Soil Types and

applicable design infiltration rates if used in lieu of onsite infiltration testing. However, actual site conditions may be significantly different from those estimates and so onsite infiltration testing is encouraged.

(4) For Large projects, a Geotechnical Engineering Report (see SRC 810–Landscape Hazards) is required to confirm suitability for infiltration or partial infiltration facilities and evaluate setbacks for design applications to ensure slopes and structures are not impacted by water infiltration.

(d) Impervious Area Reduction Techniques

Impervious area reduction techniques, authorized in SRC Chapter 71 and described as follows, can be applied to reduce the amount of runoff generated from a project site subject to these Stormwater Design Standards. However, implementation of these techniques does not change the threshold designation associated with these Stormwater Design Standards.

(1) Amending Soils in Disturbed Areas: Amending soils in areas where they have been disturbed will reduce the amount of runoff volume as calculated through the hydrologic analysis. For unamended disturbed areas, the curve numbers in Appendix 4D, Table 4D-7 for "Streets and Roads: Dirt (including right-of-way and unamended soils" shall be used in the hydrologic calculations. If the soils in the area have been amended, the curve numbers for "Open Space: Good condition and amended soils" can be used. The three alternatives for amending soils in disturbed areas include:

A. Scrape off the topsoil to a depth of 8 inches minimum, stockpile on site, and replace after construction without compaction. The stockpile area must meet all the requirements for erosion prevention and sediment control.

B. Import a topsoil mix for the disturbed areas with silt, clay, sand and compost in equal proportions. Topsoil specifications are included in Appendix 4G-Key Material Specifications. Place this mixture over the disturbed area to a depth of 8 inches uncompacted. For Large projects, the disturbed area shall be scarified for a minimum depth of 6 inches prior to placing the topsoil mix.

C. Amend the top eight inches of native topsoil which has been disturbed by tilling in three inches of compost that meets the requirements in Appendix 4G-Key Material Specifications. If surface ponding is occurring after tilling in compost, add sand and re-till until infiltration performance is improved and ponding no longer occurs.

(2) Impervious Area Reduction Facilities: Each impervious area reduction facility can only be used to manage stormwater runoff from its footprint area. Sizing cannot accommodate stormwater run on from additional contributing new or replaced impervious area.

A. Pervious Pavement: No additional stormwater quality treatment or flow control is required for pervious pavement areas, assuming design infiltration rates

and design criteria meet minimum standards. Design details for Pervious Pavement are contained in Subsection 4.6 - (b) Stormwater Facility Design Criteria (GSI).

B. Green Roofs: No additional stormwater quality treatment is required for green roof areas. For flow control purposes, 50% of the green roof surface area may be subtracted from the total impervious areas used in hydrologic calculations. Design details for Green Roofs are contained in Subsection 4.6 - (b) Stormwater Facility Design Criteria (GSI).

4.4 - General Design Requirements

This section provides the general requirements common to all projects. All projects must also meet the applicable requirements in Administrative Rules 109 Division 011−Operation and Maintenance of Stormwater Facilities and Administrative Rule 109 Division 012−Stormwater Source Control. Design criteria for stormwater facilities are provided in Section 4.6 - Design Criteria for Stormwater Facilities.

(a) Prioritize Infiltration

Infiltration testing requirements are included in Appendix 4C−Infiltration Testing. Infiltration testing is required in accordance with the Site Assessment and Planning process outlined in Section 4.3 - Site Assessment and Planning.

If on-site infiltration testing demonstrates the design infiltration rate of the soil is 0.5 inch/hour or greater, the stormwater facility (GSI) shall be designed as an infiltration facility and sized to infiltrate the water quality design storm event at a minimum.

If the design infiltration rate is less than 0.5 inch/hour, the stormwater facility (GSI) shall be designed as a partial infiltration facility and sized to manage the water quality design storm event at a minimum. These facilities are like an infiltration facility with the addition of a perforated collection pipe running the length of the facility, located at the top of the drain rock layer to encourage infiltration to the extent possible. The perforated pipe collects the runoff passing through the growing medium and drains to an approved point of discharge.

If infiltration infeasibility criteria (Table 4-1: Infiltration Infeasibility Criteria) are met, the stormwater facility shall be designed as a filtration facility. Filtration facilities provide treatment solely by filtering runoff through the soil or other media. Filtration facilities may be designed with an impermeable liner to prevent any drainage water infiltrating into the ground. Filtration facilities are designed with an outlet to drain to an approved point of discharge.

(b) Source Control

All development and redevelopment projects, regardless of size, which have a potential for pollution-generating activities as defined in SRC Chapter 70, need source control in addition to any required stormwater facilities. Project sites where pollution generating activities are

planned (see SRC Chapter 71.075), or may occur, shall follow the requirements of these Stormwater Design Standards in addition to the requirements provided in Administrative Rule 109-012–Stormwater Source Control.

Reporting requirements for stormwater source control are included in Appendix 4A–Stormwater Submittal Requirements.

(c) Approved Point of Discharge

The point of discharge for any surface drainage generated from a development may be a storm drainpipe, open channel, waterway, wetland, or other approved facility. In addition to the point of discharge, all projects must identify a stormwater facility overflow route for stormwater in the event the stormwater facility fails, or rainfall exceeds the facility's design capacity. This overflow route must be shown on the preliminary and final site plan. The City shall approve all points of discharge.

Identification (mapping) of the approved point of discharge and stormwater facility overflow route are included in Appendix 4A–Stormwater Submittal Requirements.

(d) Downstream Capacity Analysis

SRC Chapter 71 requires large projects to provide additional stormwater facilities or improvements to the public stormwater system if insufficient capacity exists downstream to convey the discharge.

When downstream capacity issues are identified through operational knowledge, flood complaint calls, or the Stormwater Master Plan, the developer will be responsible for performing an analysis of the downstream stormwater system, and either making the needed capacity improvements, providing additional on-site detention, or providing other means to mitigate the downstream impacts.

Projects that meet flow control exemption requirements as outlined in Subsection 4.1 - (d) - Stormwater Management Exemptions may not be exempt from the downstream capacity analysis.

If the downstream analysis crosses the jurisdictional boundary of another agency with the authority to manage surface water, that agency shall be notified by the Engineer of Record (EOR) and given an opportunity to review and comment on the analysis.

Reporting requirements for the downstream capacity analysis are included in Appendix 4A–Stormwater Submittal Requirements.

A downstream capacity analysis shall:

(1) Be based on peak flow capacity at the point of discharge, based on the applicable design storm consistent (Section 4.9 - Conveyance Systems).

(2) Evaluate the system's conveyance capacity from the point of discharge to a point 1/4 mile downstream or to a distance where the project site contributes less than 15% of the upstream drainage basin area, whichever is greater.

(3) Use the Manning's Formula for evaluating the capacity of pipes, ditches, and waterways. Backwater effect shall be included in determining capacity for waterways with drainage areas greater than 250 acres, using HEC-RAS or an equivalent computer modeling software.

(e) Land Division Alternatives

Land division shall be designed with stormwater facilities suitable to serve the entire development under full build-out conditions. Proper function of the stormwater facility(ies) under interim development conditions must be demonstrated. Stormwater facilities may be dispersed, unified, or individual as described below, or in some combination thereof.

(1) Dispersed facilities in the ROW: Multiple smaller stormwater facilities designed to accept stormwater from private property and from the ROW and are in the ROW. After final approval and acceptance of these facilities, the City will assume Operation and Maintenance (O&M). Alternatives and design requirements for City-owned facilities in the ROW are discussed in Subsection 4.6 - (a) -Stormwater Facility Overview.

(2) Unified facilities: One (or several) large stormwater facilities designed for the total contribution of stormwater from both the ROW and private property. After final approval and acceptance of these facilities, the City will assume O&M. An access easement shall be granted to the City where needed to maintain the facilities. Public stormwater facilities must be located within the public ROW or on property deeded to the City.

(3) Individual facilities: One (or several) small stormwater facilities designed for the contribution of stormwater from private property only. Land divisions of three or fewer lots may utilize individual facilities serving single lots if the design is intended to solely detain or treat private property drainage water. Individual stormwater facilities are not permitted in land divisions of four or more residential lots.

Reporting requirements associated with the application of dispersed, unified, or individual stormwater facilities shall be documented in accordance with the Preliminary Engineering Report requirements as outlined in Appendix 4A-Stormwater Submittal Requirements.

(f) As-Builts

All stormwater facilities (City-owned and private) shall be field verified to demonstrate they meet all design parameters including, but not limited to, storage volume, slope, overflow elevation, etc. at the completion of construction. As-built drawings for all stormwater facilities (City-owned and private) shall be submitted in accordance with the requirements in Division 002−Drafting and Drawing Standards. As-builts are not required for stormwater

facilities designed and constructed using the Simplified Method. City staff will inspect the facilities to confirm the design parameters and City requirements have been met.

(g) Design Exceptions and Fee-in-Lieu

All stormwater runoff originating from and/or draining to any proposed large project shall be detained, controlled, and/or conveyed in accordance with these Stormwater Design Standards. When existing conditions make stormwater treatment or flow control impractical for all or a portion of a proposed development, the City may permit compensatory storage volume to be provided in another location within the drainage basin or require payment of a fee-in-lieu for such facilities per SRC Chapter 71 and in accordance with Appendix 4E.

(h) Other Design Considerations

The following are items which are not required per SRC Chapter 71 but may be considered when designing stormwater facilities.

(1) Incorporate the stormwater facilities into the site's landscaping features as practical and feasible to minimize the impact on the available green space.

(2) Utilize construction techniques and landscape designs that minimize soil compaction and preserve the existing soil permeability.

(3) Integrate pervious, porous, or permeable pavement on private property where practicable, to minimize surface runoff and reduce the amount of total new or replaced impervious area requiring management in a stormwater facility.

(4) Provide stormwater facilities that are non-operator dependent, are reliable, minimize operation and maintenance, and address the range of potential impacts resulting from multiple site uses and properties.

4.5 - Performance Standards and Design Methods

(a) Performance Standards and Design Storms

In accordance with these Stormwater Design Standards, applicants must demonstrate that the proposed stormwater facilities meet water quality and flow control performance standards. RES and Large projects are required to meet the water quality performance standard. Large projects are required to meet the flow control performance standard.

Table 4-2 identifies the 24-hour rainfall totals associated with applicable design storm events to meet the water quality and flow control performance standards.

Table 4-2: Salem Design Storm Events

Recurrence Interval (years)	Water Quality	2	5	10	25	50	100
24-Hour Depth (inches)	1.38	2.2	2.7	3.2	3.6	4.1	4.4

(1) Water Quality. Stormwater facilities shall be designed and installed to treat all new and replaced impervious surface from the project site as well as flows discharging to the facility from other areas, including existing impervious surfaces and offsite areas, when the other areas and flows cannot be separated or bypassed.

As specified in SRC Chapter 71, stormwater facilities meeting the water quality performance standard must be designed to treat at least 80% of the average annual runoff, with a goal of 80% total suspended solids removal. Properly designed stormwater facilities as outlined in these Stormwater Design Standards utilizing the water quality design storm event meet this requirement.

Adherence to the water quality performance standards shall rely on the following stormwater facilities, listed below in order of prioritization, to manage the City's water quality design storm event:

A. Infiltration using GSI in accordance with the infiltration rate guidelines outlined in Subsection 4.4 - (a) Prioritize Infiltration.

B. Treatment using vegetated filtration facilities.

C. Treatment using manufactured or proprietary filtration facilities in accordance with guidelines in Appendix 4E.

D. Offsite mitigation/ fee-in-lieu in accordance with guidelines in Appendix 4E.

(2) Flow Control. Stormwater facilities shall be designed and installed to manage flow from all new and redeveloped impervious surfaces from the project site, as well as flows discharging to the facility from other areas, including existing impervious surfaces and offsite areas, when the other areas and flows cannot be separated or bypassed.

Stormwater facilities shall be designed to match the post-development peak runoff rates to the pre-developed peak runoff rates for the design storm events described below. Regardless of the existing pre-developed surface conditions, the land surface characteristics for calculating pre-developed peak flows must be based on curve numbers reflecting "City of Salem Pre-development" per Appendix 4D, Table 4D-6.

All development shall use these curve numbers for determining the pre-development runoff conditions using the predominate NRCS soil type for the project area.

A. The post-development peak runoff rate from one-half of the 2-year, 24-hour design storm event must be equal to or less than the predevelopment peak runoff rate for one-half of the 2-year, 24-hour storm design storm event; and

B. The post-development peak runoff rate from the 10-year, 24-hour design storm event must be equal to or less than the predevelopment peak runoff rate from the 10-year, 24-hour storm event; and

C. The post-development peak runoff rate from the 25-year, 24-hour storm event must be equal to or less than the predevelopment peak runoff rate from the 25-year, 24-hour storm event; and

D. The post-development peak runoff rate from the 100-year, 24-hour storm event must be equal to or less than the predevelopment peak runoff rate from the 100-year, 24-hour storm event.

(3) Additional Design Considerations.

A. Combined and Multi-Use Facilities. Stormwater facilities that can be designed as a combined facility to meet the water quality and flow control performance standards are encouraged. Multiple use stormwater facilities (i.e., parks, fields) are also encouraged if such design complies with other requirements of these Stormwater Design Standards.

B. Impervious Area Reduction Techniques. Impervious area reduction facilities as outlined in Subsection 4.3 - (d) Impervious Area Reduction Techniques can be used to reduce the size of stormwater facilities to meet the water quality and flow control performance standards. However, implementation of these techniques does not change the threshold designation associated with these Stormwater Design Standards.

C. Off-Site Runoff. Onsite stormwater facilities (including conveyance, treatment, flow control, and emergency overflow elements) must be properly designed to address treatment and conveyance of off-site runoff through the site. Specifically, if flow from the off-site areas cannot be separated or bypassed, then the onsite stormwater facilities must be designed to treat the total onsite and off-site contributing impervious area, and the stormwater facilities must be designed to convey the total onsite and offsite flow through the flow control facility.

D. Safety. All aspects of public health, safety, maintenance, nuisance abatement, and vector control must be considered in every stormwater facility. The impact of potential system failure must be analyzed for effects to the proposed development, adjacent properties, elements of onsite and off-site private stormwater systems, and elements of the public drainage system.

(b) Sizing Methods

There are two methods for sizing stormwater facilities: the Simplified Method and the Engineered Method.

(1) Simplified Method. The Simplified Method is allowed in the design of stormwater facilities for RES Projects and Large Projects with 10,000 sf or less (0.23 acre) of new/or replaced impervious area, including but not limited to roofs, patios, parking areas, and driveways. This method is most appropriate for private, small-scale commercial or residential development where no drainage water from City-

owned property is conveyed through the system. Stormwater facilities designed using the Simplified Method are not required to be stamped by an engineer.

The Simplified Method uses a surface area ratio calculation to size the stormwater facilities. The amount of new or replaced impervious area is calculated, and multiplied by a sizing factor that varies by facility types. The Simplified Sizing Form, included in Appendix 4A, includes sizing factors to meet both the water quality performance standard and the combined water quality/ flow control performance standard. For Large Projects using the Simplified Method solely to meet the water quality performance standard, separate flow control calculations per the Engineered Method will be required.

The Simplified Method is not allowed for the design of stormwater facilities that manage drainage water from City-owned property. The Simplified Method may only be used for projects where the facilities will be privately-owned and maintained and not located in the ROW or on property deeded to the City.

Reporting requirements for the Simplified Sizing Method are included in Appendix 4A-Stormwater Submittal Requirements. The *Simplified Sizing Form* must be submitted to the City as part of the Land Use submittal while a final *Simplified Sizing Form*, reflecting final contributing areas and facility selection, is required for the Final Design submittal.

(2) Engineered Method. The Engineered Method may be used to design RES or Large Projects where more detailed hydrologic calculations allow the stormwater facility to be sized more accurately than with the Simplified Method. The Engineered Method is required to design Large Projects with greater than 10,000 sf (0.23 acres) of new and/or replaced impervious surface and for all City-owned stormwater facilities located in the ROW or on property that will be deeded to the City. This methodology shall be performed by a licensed Professional Engineer.

The Engineered Method consists of sizing stormwater facilities by applying hydraulic and hydrologic engineering calculations to determine runoff, flow, volume, storage, conveyance capacity, etc.

To size stormwater facilities according to the Engineered Method, drainage areas contributing to each stormwater facility must be delineated and new and replaced impervious surface areas calculated. Design flows and volumes shall be determined using the methods described in sizing calculations below. Additional information and supporting documentation for these methods can be found in Appendix 4D−Hydrologic Analysis.

For every project, the total new and replaced impervious area shall include but is not limited to, all streets, driveways, walkways, redeveloped areas, covered areas and tentative building footprints based on the allowed building coverage and setbacks per the zoning code. All hydrologic analyses must include the drainage area of the site

being evaluated and all upstream contributing area including areas outside the proposed development site.

The drainage area requiring stormwater facilities designed to meet treatment or flow control performance standards may be reduced if impervious area reduction techniques identified in Subsection 4.3 - (d) Impervious Area Reduction Techniques are applied.

The Engineered Method shall be submitted as part of the Stormwater Management Report. A Preliminary Stormwater Management Report containing preliminary sizing calculations is required as part of the Land Use submittal, and a Final Stormwater Management Report and finalized calculations are required for the Final Design submittal.

(c) Sizing Calculations

(1) Volume-Based Sizing. With use of the Engineered Method, a volume-based sizing method is allowable for sizing GSI (infiltration or partial infiltration) or filtration (lined) stormwater facilities to meet the water quality performance standard. It can be also used to meet the flow control performance standard if full infiltration up to the 100-year event is possible.

Post-development runoff rates and volumes associated with inflow to the stormwater facility shall be calculated based on the applicable design storm per Table 4-2: Salem Design Storm Events using the Santa Barbara Urban Hydrograph (SBUH) Method, Natural Resource Conservation Service (NRCS) TR 55, or other approved method. Coefficients and curve numbers used must be consistent with Appendix 4D. Sizing criteria associated with the stormwater facilities is outlined in Section 4.6 - Design Criteria for Stormwater Facilities.

The stormwater facility may either be sized based on storage of the runoff volume for the design storm event in the stormwater facility itself or be sized based on the flow rate through the facility as determined by the Darcy equation (see below). If the Darcy equation is used, the size of the infiltration, partial infiltration, or filtration (lined) facility is determined by the stormwater facility footprint area associated with the peak water surface elevation at 100% ponding depth, prior to overflow. This equation cannot be used for facilities without underdrains.

$$\boldsymbol{Q = kiA = k\left(\frac{d + D}{D}\right) \times A \times \left(\frac{1}{43,200}\right)}$$

Where:

- *Q = Outflow (cfs)*
- *k = Design infiltration rate of the native soil (for infiltration facilities) or growing medium (3-inches per hour, for partial infiltration or filtration [lined] facilities)*
- *d = Depth of water above growing medium (inches)*
- *D = Depth of growing medium (inches)*
- *A = Bottom wetted surface area (sf)*

Use of an underdrain is required for partial infiltration and filtration (lined) facilities. Additional flow control to meet the flow control performance standard may be provided by an orifice control if needed.

(2) Hydrograph-Based Sizing. With use of the engineered method, hydrograph-based sizing is applicable for sizing GSI (infiltration or partial infiltration), filtration stormwater facilities, and flow control stormwater facilities to meet the water quality and flow control performance standards. Stormwater runoff rates and volumes to the stormwater facility shall be based on the applicable design storm per Table 4-2: Salem Design Storm Events and the associated predevelopment and post-development runoff calculations.

Using the hydrograph method, the physical characteristics of the site and the design storm shall be used to determine the magnitude, volume, and duration of the runoff hydrographs. Calculation of stormwater runoff for stormwater treatment and flow control shall be analyzed using the Santa Barbara Urban Hydrograph (SBUH) Method, Natural Resource Conservation Service (NRCS) TR 55, or the Stormwater Management Model SWMM.

The Soil Conservation Service Type 1-A, 24-hour rainfall distribution, shall be used in all applications. A more detailed description of the hydrologic methods and parameters to be used to fulfill these Stormwater Design Standards is provided in Appendix 4D–Hydrologic Analysis.

A. Pre-Development Conditions. A homogeneous drainage basin area will be assumed, regardless of the current conditions, when determining the peak runoff for pre-development conditions.

The runoff characteristics for calculating allowable outflow are based on the combination of woods and grassland. These curve numbers have been calculated and provided in Appendix 4D, Table 4D-7, "City of Salem Pre-development." These curve numbers shall always be used for determining pre-development flow condition selected for the predominate soil type where the project is located.

Predeveloped time of concentration sheet flow roughness coefficients shall be based on the predeveloped surface types listed in Appendix 4D, Table 4D-4. Pre-developed time of concentration shallow concentrated flow velocity shall be based on the slope and condition "Brushy Ground with Some Trees," per Appendix 4D, Table 4D-5.

B. Post-Development Conditions. A runoff hydrograph shall be created from an accurate characterization of the post-development site conditions. The runoff hydrograph shall include the contributing pervious and impervious areas along with their associated runoff curve numbers. Subbasins shall be delineated and routed together.

C. Additional Flow Control Sizing Requirements.

(i). When treatment facilities are located downstream of flow control facilities, a pretreatment structure will be required. Approved pretreatment structures are provided in Appendix 4F.

(ii). As an alternative, if a manhole with snout and sump is used for pretreatment, the sump volume to be provided is 20 cubic feet per 1.0 cfs of contributing flow from the conveyance design storm.

(iii). All stormwater runoff originating from and/or draining to any proposed large project shall be detained, controlled, and/or conveyed in accordance with these Stormwater Design Standards. When existing conditions make stormwater flow control impractical for all or a portion of a proposed development, the City may permit compensatory storage volume to be provided in another location within the drainage basin or require payment of a fee-in-lieu for such facilities per SRC Chapter 71.

When flow control facilities are intended to detain runoff from phased development, calculations shall be provided which demonstrate that the flow control requirements are met for each interim phase, based on contributing drainage basins, as well as for the full buildout condition.

D. Off-Site Stormwater Flow. The flow of stormwater from off-site of the development must be considered. If this water cannot be separated or bypassed, then the flow control facility shall be designed for the total flow on and off-site (SRC Chapter 71).

E. Outlet Control. Outflow is typically restricted through multiple orifices, usually located within a manhole or other junction structure (see Standard Plan 251).

Orifices shall be 1/4-inch or greater in size. The size of the orifice shall be established based on the following equation:

$$\mathbf{D} = \sqrt{\frac{\mathbf{36.88\,Q}}{\sqrt{\mathbf{H}}}}$$

Where:

D = Orifice diameter (inches)

Q = Allowable outflow (cfs)

H = Hydraulic Head, (feet)

If a weir is required, sizing for a Rectangular Notched Sharp Crested Weir is based on the following equation:

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

Where:
Q = Weir discharge (cfs)
C = 3.27 + 0.40 x 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)

Sizing for a V-Notched Sharp Crested Weir is based on the following equation:

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

Where:
Q = Weir discharge (cfs)
C_d = Contraction coefficient (feet; use 2.5 for 90° weir)
θ = Internal angle of notch (degrees)
H = Height from weir bottom to crest (feet)

NOTE
For weirs notched out of circular risers, length is the portion of the riser circumference. The length of the weir shall not exceed 50% of the pipe's circumference.

4.6 - Design Criteria for Stormwater Facilities

This section presents design criteria for stormwater facilities sized to meet the water quality and flow control performance standards.

(a) Stormwater Facility Overview

Table 4-3 identifies the stormwater facilities included in these Stormwater Design Standards and references the associated subsection where design criteria are included.

GSI facilities shall be prioritized to meet the water quality performance standard as site conditions allow and may be designed as infiltration or partial infiltration facilities. Filtration facilities shall be used to meet the water quality performance standard in applications where infiltration is infeasible. Many stormwater facilities can be designed as a combination facility to meet both water quality and flow control performance standards.

Table 4-3: Stormwater Facility Categories and Applications				
Stormwater Facility Type	**GSI Facility[1]**	**Filtration Facility[2]**	**Design for Flow Control**	**Private Application Only**
Section 4.6(b)(1)-Planter				
Infiltration Planter	X		X	
Partial Infiltration Planter	X		X	
Lined Planter		X	X	
Section 4.6(b)(2)-Rain Garden				
Infiltration Rain Garden	X		X	
Partial Infiltration Rain Garden	X		X	
Lined Rain Garden		X	X	
Section 4.6(b)(3)–Flow Dispersion	X		X	
Section 4.6(b)(4)-Subsurface Infiltration				
Soakage Trench	X		X	
Leach Line	X		N/A	X
Drywell	X		X	X
Manufactured Chamber Technology	X		X	X
Section 4.6(b)(5)-Pervious Pavement[3]	X		X	X
Section 4.6(b)(6)-Green Roofs[3]	X			
Section 4.6(b)(7)-Constructed Wetland Treatment Systems				
Treatment Wetland	X		X	
Subsurface Gravel Wetland	X		X	
Section 4.6(c)(1)-Vegetated Swales		X		
Section 4.6(c)(2)-Vegetated Filter Strips		X		
Section 4.6(c)(3)-Manufactured Treatment Technologies		X		X
Section 4.6(d)(1)-Dry Ponds			X	
Section 4.6(d)(2)-Structural Flow Control Facilities			X	

1. Provides treatment and flow control through infiltration or evapotranspiration.
2. Provides treatment but does NOT promote infiltration or evapotranspiration.
3. Characterized as an Impervious Area Reduction Facility

(1) City-Owned System Conditions and Applications. This section provides stormwater facility sizing and design criteria specific to stormwater facility applications on City-owned or City-managed property including stormwater facilities within the ROW. The following general design considerations apply to City-owned or City-managed stormwater facility applications.

A. The Engineered Method must be used for sizing stormwater facilities in the ROW and any other City-owned stormwater facility.

B. Stormwater facilities can be located behind the curb or designed as a curb extension.

C. Stormwater facilities can be designed for areas where on street parking is allowed or where it is prohibited.

D. Fire hydrants must be located at least 5 feet away from the nearest point of any stormwater facility.

E. Other utilities must be located outside the boundaries of the stormwater facility. Water services that cross under the stormwater facility must be sleeved (see Standard Plan 247).

F. Elevations must be shown on the plans for all inlets, check dams, overflow, and sidewalks to ensure stormwater flows through the stormwater facility and cannot back up or flood, and the stormwater facility will fill and operate as designed.

G. The minimum width of a planter in the ROW shall be increased to at least four feet if street trees are placed in a planter as part of the landscaping requirements. Wider planters are desired for the continued viability of most species of street trees.

(2) Private System Conditions and Applications. This section provides stormwater facility sizing and design criteria specific to stormwater facility applications approved for use only on private property. These stormwater facilities are categorized as subsurface infiltration facilities and include soakage trenches, leach lines, manufactured chamber technologies, and drywells; their use is highly dependent on soil type, soil infiltration rates, and seasonal high groundwater. They are considered GSI and typically designed as infiltration facilities to meet both the water quality and flow control performance standards.

The following general design considerations apply to private, infiltration facility applications:

A. The design infiltration rate must be 0.5 inches per hour or greater.

B. Infiltration testing in the immediate vicinity of the facility is required. Infiltration testing and reporting requirements are included in Appendix 4C–Infiltration Testing.

C. The required storage capacity of the facility shall be determined by subtracting the volume of water that can infiltrate out of the facility within the required drawdown period from the volume of runoff from the contributing basin for each facility design.

D. A pretreatment structure is highly recommended and may be required by DEQ, depending on the impervious area being served, prior to discharging into these types of facilities. Refer to OAR 340, Division 44–Construction and Use of Waste Disposal Wells or Other Underground Injection Activities, for additional design and regulatory requirements.

NOTES
DEQ has identified many subsurface infiltration facilities including soakage trenches and 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 the DEQ. Since the UIC Program states that these types of facilities can have a direct impact on groundwater, stormwater pretreatment is required before discharging stormwater to them (unless they are used exclusively for residential roof runoff from three units or less). For more information about the UIC requirement visit DEQ's website:

http:// www.deq.state.or.us/wq/uic/uic.htm.

For technical questions call the DEQ-UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189. Any modification to a soakage trench or drywell that functions as a UIC must have prior approval from DEQ before modifications are made.

(b) Stormwater Facility Design Criteria (GSI)

Stormwater facilities described in this section are defined as GSI facilities, as they meet the water quality performance standard using infiltration or partial infiltration. If the design infiltration rate is 0.5 inch per hour or greater, GSI facilities must be designed as an infiltration facility and infiltrate the water quality design storm event. If the design infiltration rate is less than 0.5 inch per hour, GSI facilities may be designed as a partial infiltration facility to manage the water quality design storm event.

Standardized setbacks for GSI facilities are provided in Table 4-4.

Table 4-4: Minimum Setback Requirements for GSI Facilities		
Stormwater Facility Type[1]	**Setback from**	**Distance (ft)**
Infiltration or Partial Infiltration Facility	Building foundation	10
	Property line (downslope)	5
	Property line (upslope or same grade)	0
	Septic system or drain field	100
	Domestic wells	100
1. The list of GSI facilities can be found in Table 4-3: Stormwater Facility Categories and Applications. These setback requirements do not apply to Green Roofs.		

(1) Planters (GSI).

A. Detail Reference (see Standard Plans)

215–Infiltration/ Partial Infiltration Planter
216–Filtration Planter
221–Facility Overflow Configuration

B. Description

Planters are smaller structural landscaped reservoirs used to collect, filter, and (where feasible) infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter growing medium before infiltrating into the ground below or piped to an approved point of discharge.

Planters can be used to meet the water quality or water quality and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms). Planters meeting the definition of GSI are designed as infiltration (no underdrain) or partial infiltration facilities (designed with an underdrain).

Stormwater planters may also be lined, meeting the definition of a filtration facility as opposed to GSI. Design criteria for infiltration, partial infiltration and lined planters are provided below.

C. General Sizing Requirements

(i). For infiltration planters, the design infiltration rate is the measured (native soil) infiltration rate with a factor of safety of two applied. For partial infiltration or lined filtration planters, the design infiltration rate is the growing media design infiltration rate of 3 inches per hour.

(ii). The outflow equals the design infiltration rate times the wetted bottom (invert) surface area of the facility.

(iii). The planter storage volume consists of the rock storage beneath the growing medium, assuming a 40% void ratio and the volume above the growing medium to the overflow. Growing medium is assumed

saturated for purposes of sizing. The storage volume shall contain the design storm runoff volume or the design storm hydrograph inflow less outflow, depending on the sizing methodology used.

(iv). All stormwater managed by the planter must drain from the storage reservoir (bottom of drain rock) within 48 hours after the design storm event ends.

(v). The size of the planter is determined by the wetted bottom surface area associated with the peak water surface elevation prior to overflow.

(vi). Additional flow control may be provided by an orifice outlet if needed.

D. Piping Requirements

(i). In streets or parking lots, stormwater may flow directly into the planter via curb openings.

(ii). An overflow to an approved point of discharge is required for all stormwater facilities. On private property, the overflow drain and piping must meet OPSC requirements and shall direct excess stormwater to an approved point of discharge as identified on the final site plan.

(iii). Within the ROW, the overflow drain and piping must meet the Public Works Design Standards and shall direct excess stormwater to an approved point of discharge.

(iv). Trees and large shrubs shall not be planted in portions of the stormwater facilities that include perforated underdrains or filter fabric, to reduce the potential for damage to these parts of the facility.

E. General Design Criteria

(i). Minimum bottom width: 30-inch (infiltration or partial infiltration planter); 18 inches (filtration planter).

(ii). Minimum depth of growing media: 18-inch (either infiltration, partial infiltration, or lined planter)

(iii). Allowable ponding depth (from top of growing media to overflow elevation): 12 inches (per Simplified Method); 6-18 inches (per Engineered Method)

(iv). Drain Rock Depth: 18 inches (per Simplified Method); 0-48 inches (per Engineered Method). A filtration planter may utilize 12 inches of drain rock.

(v). Minimum Freeboard: 2 inches

(vi). All planters shall be set back a minimum of 5 feet from property lines and easements; if a lined planter is used and the adjoining property is at the same grade or upslope from the facility, there are no setback

requirements from the property lines (Table 4-7: Minimum Setback Requirements for Filtration Facilities.

(2) Rain Gardens (GSI).

A. Detail Reference (see Standard Plans)

217–Rain Garden
221–Facility Overflow Configuration

B. Description

Rain gardens are landscaped reservoirs or depressions in the ground surface used to collect, filter, and/or infiltrate stormwater runoff. In rain gardens, pollutants settle and filter out as the water percolates through the growing medium, then infiltrates into the ground below or piped to an approved point of discharge. Numerous design variations of shape and planting scheme can be used to fit the design to a particular site.

Rain gardens can be used to meet the water quality or water quality and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms). Rain gardens meeting the definition of GSI are designed as infiltration or partial infiltration facilities. Rain gardens may also be lined, meeting the definition of a filtration facility. Design criteria for infiltration, partial infiltration and lined rain gardens are provided below.

C. General Sizing Requirements

(i). For infiltration rain gardens, the design infiltration rate is the measured (native soil) infiltration rate with a factor of safety of two applied. For partial infiltration or lined filtration rain gardens, the design infiltration rate is the growing media design infiltration rate of 3-inches per hour.

(ii). The outflow equals the infiltration rate times the wetted bottom (invert) surface area of the facility. For rain gardens with a side slope, the wetted bottom surface area shall reflect the rain garden surface area at 75% ponding depth.[1]

(iii). The storage volume consists of the rock storage beneath the growing medium, assuming a 40% void ratio and the volume above the growing medium to the overflow. Growing medium is assumed saturated for purposes of sizing. The storage volume shall contain the design storm runoff volume or the design storm hydrograph inflow less outflow, depending on the sizing methodology used.

(iv). All stormwater managed by the rain garden must drain from the storage reservoir (bottom of drain rock) within 48 hours after a design storm event ends.

[1] City of Portland in their Presumptive Approach Calculator (Aiona et al, 2020).

(v). The size of the rain garden is determined by the facility top area (including freeboard) associated with the peak water surface elevation at 100% ponding depth, prior to overflow.

D. Piping Requirements

(i). In streets or parking lots, stormwater may flow directly into the rain garden facility via curb openings.

(ii). An overflow to an approved point of discharge is required for all rain garden facilities.

(iii). On private property, the overflow drain and piping must meet OPSC requirements and shall direct excess stormwater to an approved point of discharge as identified on the final site plan.

(iv). Within the ROW, overflow piping must meet the Public Works Design Standards and shall direct excess stormwater to an approved point of discharge.

(v). Trees and large shrubs shall not be planted in portions of the stormwater facilities that include perforated underdrains or filter fabric, to reduce the potential for damage to these parts of the facility.

E. General Design Criteria

(i). Minimum bottom width: 24 inches

(ii). Minimum depth of growing media: 18 inches

(iii). Allowable ponding depth (from top of growing media to overflow elevation): 12 inches (per Simplified Method); 6-18 inches (per Engineered Method)

(iv). Drain Rock Depth: 18 inches (per Simplified Method); 0-48 inches (per Engineered Method). A filtration rain garden may utilize 12 inches of drain rock.

(v). Minimum Freeboard: 2 inches (if facility is set into ground or if there is an adjacent curb); 6 inches (if freeboard is provided by an earthen berm)

(vi). Maximum Side Slope: 3:1 within the facility

(3) Flow Dispersion (GSI).

A. Detail References (see Standard Plans)

220–Check Dam Details
252–Splash Block
253–Crushed Rock Pad
254–10-foot Dispersion Trench
255–Large (50-foot) Dispersion Trench
256–Sheet Flow Dispersion

B. Description

Flow dispersion utilizes the natural capacity of vegetated surfaces to mitigate runoff quantity and quality impacts associated with impervious surfaces, such as driveways, parking areas, and roofs.

Flow dispersion can be used to meet the water quality and flow control performance standard (Section 4.5(a)–Performance Standards and Design Storms). All flow dispersion is designed as an infiltration facility and must qualify as one of the methods summarized in Table 4-5.

Table 4-5: Summary of Approved Dispersion Methods

Flow Dispersion Method	Flow Path Length, ft	Maximum Impervious Surface
Splash Block	100	700 sq ft
Crushed Rock Pad	100	700 sq ft
	200	1,400 sq ft
10-foot Dispersion Trench	100	1,400 sq ft
	200	2,800 sq ft
Large (50-foot) Dispersion Trench	100	5,000 sq ft
	200	10,000 sq ft
Sheet Flow Dispersion	25	15-ft strip width
	100	25-ft strip width
	200	50-ft strip width

C. General Sizing and Design Criteria

The total area of the impervious surface being dispersed must not exceed 15% of the total post construction vegetated area. The dispersion area being utilized must be delineated on the site plan and designated as the approved point of discharge.

A vegetated flow path at least 100 feet in length must be available along the flow path that runoff will follow upon discharge from a dispersion device. The vegetated flow path must meet all the following criteria:

(i). A minimum design infiltration rate of 0.5 inch per hour is required to use flow dispersion.

(ii). The flow path must be a vegetated surface.

(iii). The flow path must be onsite or in an offsite easement area reserved for dispersion.

(iv). The slope of the flow path must be at least 1% but no steeper than 15%.

(v). The flow path must be located between the dispersion device and any downstream drainage feature such as a pipe, ditch, stream, river, pond, lake, or wetland.

(vi). For sites with septic systems, the flow path must be located downslope of any primary and reserve drain field areas.

(vii). The area of vegetated surface used for full dispersion must be delineated as a flow dispersion area on the site plan. The flow dispersion area is subject to the following limitations:

c. All trees within the dispersion area at the time of permit application shall be retained, aside from the removal of dangerous and diseased trees.

d. The area may include previously cleared areas replanted by the proposed project.

e. The dispersion area may be used for passive recreation and related facilities.

D. Application-Specific Design Criteria

(i). Splash Block

a. Splash blocks may be used to disperse the runoff collected from small amounts of roof area and discharged via a downspout.

b. No more than 700 sf of roof area may be drained to a single splash block.

c. The splash block must have at least 50 ft of separation between adjacent flow paths for the entire 100 ft.

(ii). Crushed Rock Pad

a. Crushed rock pads may be used to disperse the runoff collected from up to 1,400 sf of impervious area and discharged via a vegetated flow path.

b. Pads shall consist of crushed rock, 2 feet wide (perpendicular to flow) by 3 feet long by 6 inches deep.

c. Rock shall be crushed, open-graded 3 inches to 1½ inches, washed, open-graded rock.

d. No more than 700 sf of impervious surface may be drained to a single rock pad dispersing to a vegetated flow path of 100 feet; no more than 1,400 sf of impervious surface may be drained to a single rock pad dispersing to a vegetated flow path of 200 feet.

e. When multiple rock pads are used, there must be at least 50 feet of separation between rock pads and adjacent flow paths for the entire length of the flow path.

(iii). Dispersion Trenches

There are two types of dispersion trench designs that can be used to disperse flows, the 10-foot Dispersion Trench and the Large (50-foot) Dispersion Trench.

a. All trenches are filled with ¾-inch to 1½-inch open-graded washed rock.

b. All trenches must be placed at least 10 feet from any building foundation and must be as parallel as possible to the contour of the ground.

c. The uphill grade to the trench must be no more than 20% and downhill flow path must be no more than 15%. The minimum grade of the flow path must be greater than 1%.

d. Trench (and grade board, if required) must be level.

e. Specific design requirements associated with the 10-foot Dispersion Trench are as follows:

1. The trench shall be 10 feet long and at least 2 feet wide by 18-inches deep.
2. The four-inch perforated pipe must be buried at least 6 inches beneath the trench surface.
3. The 10-foot trench length is the maximum allowed without a notch grade board.
4. No more than 1,400 sf of impervious area may be drained to a single 10-foot trench dispersing to a vegetated flow path of 100 feet; no more than 2,800 sf of impervious surface may be drained to a single 10-foot trench dispersing to a vegetated flow path of 200 feet.
5. The trench must be lined with filter fabric.

f. Specific design requirements associated with the Large (50-foot) Dispersion Trench with notch board is as follows:

1. The trench shall be greater than 10 feet and less than 50 feet long with a notch grade board, and be at least 28-inches wide by 24-inches deep.
2. The notched pressure-treated grade board is 2 inches wide by a minimum of 12-inches deep, with "v" notches placed 18-inches on center that are 2-inches wide by 2-inches deep.
3. At least four, 4-inch by 4-inch support posts must be secured to the notched grade board with two galvanized bolts and spaced evenly along the length of the trench.
4. The perforated pipe must be 4 to 6 inches in diameter, placed at a minimum of 6 inches from the bottom and 1 foot from either side of the trench.
5. The influent pipe shall be connected to a catch basin with a solid cover that locks.
6. The maximum in-flow is 0.5 CFS per trench.
7. The pipes must have at least two clean out wyes (one in either direction from catch basin) and end caps.
8. The trench must be lined with filter fabric.
9. The 50-foot trench length is the longest allowed.
10. No more than 5,000 sf of impervious area may be drained to a single 10-foot trench dispersing to a vegetated flow path of 100 feet; no more than 10,000 sf of impervious surface may be drained to a single 50 foot trench dispersing to a vegetated flow path of 200 feet.

(iv). Sheet Flow Dispersion

a. Concentrated runoff from the impervious surface is not permitted. Runoff must consist of uniform sheet flow.

b. The edge of the impervious surface and the ground adjacent to or immediately below the edge must be level or sloped no more than 5% along the edge.

c. A 2-foot-wide, 6-inch-deep, strip of crushed rock or the extended base course of a road or driveway must be provided at or below the edge of the impervious strip to facilitate dispersal of runoff.

d. No more than a 15-foot-wide strip of impervious surface may be sheet flowed in this manner when dispersing to a vegetated flow path of 25 feet.

e. No more than a 25-foot-wide strip of impervious surface may be sheet flowed in this manner when dispersing to a vegetated flow path of 100 feet.

f. No more than a 50-foot-wide strip of impervious surface may be sheet flowed in this manner when dispersing to a vegetated flow path of 200 feet.

NOTES REGARDING FLOW DISPERSION FACILITIES
Protection*: Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.*

Check Dams*: Utilize cross section for check dams in Standard Plan 220–Check Dam Details. Check dams to be equal to the width of the filter strip and 3-5 inches in height. Required every 10-feet where slope exceeds 5%.*

(4) Subsurface Infiltration Facilities (GSI).

A. Detail Reference (see Standard Plans)

212–Trash Trap and Leach Line Plan
213–Trash Trap and Leach Line Details
249–Soakage and Storm Chamber Retention
250–Drywell

B. Description

Subsurface infiltration facilities include soakage trenches, leach lines, drywells and manufactured chamber technologies. These facilities can manage runoff from private property only. They cannot accept runoff from the ROW and are not permissible for public ownership. These facilities are defined by DEQ as Underground Injection Controls (UICs) and may require installation of approved pretreatment and registration with DEQ.

A soakage trench is a shallow trench in permeable soil that is backfilled with washed drain rock and lined with filter fabric. The trench surface may be covered with grass, rock, or plantings. A soakage trench can be used to provide stormwater discharge by collecting and recharging stormwater runoff into the ground. A leach line is a type of soakage trench applicable to residential roof runoff.

Manufactured chamber technologies function similarly to the soakage trench or leach line but provide more storage and can be used in locations with more limited infiltration. They are typically configured using corrugated plastic stormwater chambers constructed of high-density polypropylene or polyethylene. They are arched systems that can be rated for H-10 or H-20 loading, depending on the manufacturer, amount of cover, and type of cover. Manufactured chamber technologies can be installed and covered by an impervious surface layer.

Drywells are subsurface structures (e.g., cylinder or vault) with perforated sides and/or bottom, used to infiltrate stormwater into the ground. These facilities are vertical in nature, which prevents their use in areas that have limited infiltration because of seasonal high groundwater or a shallow infiltration barrier such as dense clay, or fragipan layer, as determined by a geotechnical engineer.

Subsurface infiltration facilities can be used to meet the water quality and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms). Facilities are typically designed as infiltration facilities, but if designed as a partial infiltration facility adherence to the flow control performance standard is required via orifice and outlet piping as needed.

C. General Sizing Requirements

(i). The maximum impervious area to be served by a soakage trench or leach line is 10,000 sf. If sized in accordance with the Simplified Method, the required trench depth is 30 inches.

(ii). The maximum impervious area to be served by a drywell is 12,000 sf.

(iii). A manufactured chamber can be used to serve an impervious area of any size.

(iv). The drawdown time for drywell design when full shall not exceed 12 hours.

(v). The minimum drawdown time for a soakage trench, leach line, or manufactured chamber technology for the applicable design storm event is 48 hours.

D. Piping Requirements

(i). The piping to any subsurface infiltration facility must have minimum cover of 12 inches measured from the top of pipe to finished grade.

(ii). Cleanouts shall be installed as required by the OPSC.

E. General Design Criteria

(i). All subsurface infiltration facilities shall be constructed in native soil and shall not be subject to vehicular traffic or construction work that will compact the soil and reduce the permeability.

(ii). The bottom of the subsurface infiltration facilities shall be level, or clay check dams may be used to prevent water from collecting near the downstream end.

(iii). Subsurface infiltration facilities are prohibited where permanent or seasonally high groundwater will exist within 5 feet of the bottom of the facility.

(iv). For manufactured chamber systems, 6 inches of washed drain rock is required below the chamber. The manufacturer's requirements shall be followed regarding the design and construction of these facilities.

(v). Trees and large shrubs shall not be planted over subsurface infiltration facilities to reduce the potential for damage to the facility.

(5) Pervious Pavement (GSI)

A. Detail Reference (see Standard Plans)

No detail currently.

B. Description

Pervious pavement means pervious concrete, porous asphalt, or permeable paver blocks that infiltrate drainage water. Pervious pavement is approved for use on private streets, driveways, and parking lots. Pervious pavement has not yet been approved for use in the ROW and will only be reviewed on a case-by-case application when proposed in ROW areas outside the travel lanes.

Pervious pavement is classified as an impervious area reduction facility, meaning it is designed to only receive direct rainfall and not runoff from surrounding impervious areas. As an impervious area reduction facility, it can be used to meet the water quality and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms).

C. General Sizing Requirements

The minimum design infiltration rate is 0.1 in/hr. Adherence to this minimum infiltration rate assumes pervious pavement will meet the water quality and flow control performance standards through full infiltration.

D. Piping Requirements

An underdrain system shall be employed to direct excess water to an approved disposal point when:

(i). The native soil is not capable of infiltrating at a rate adequate to prevent water from the 100-year, 24-hour storm from filling the gravel layer and backing up into the pavement layer; or

(ii). The slope of the paving surface and gravel base layer may cause water to accumulate and fill the gravel layer quickly in the lower area.

E. General Design Requirements

(i). Must meet all applicable State and City building codes.

(ii). Pervious pavement systems shall be designed and constructed in accordance with City of Portland Pervious Street Standards or approved equal.

(iii). A safety overflow mechanism, such as an inlet drain, catch basin, curb opening, or other approved method, shall be provided to prevent ponding if the surface is clogged with sediment or debris.

(iv). Other paving systems may be reviewed on a case-by-case basis for pervious designation and appropriate use and must show the ability to pass water quickly through the pavement layer.

(v). Pervious pavement shall not be used in areas within the 100-year floodplain.

(vi). Pervious pavement shall not be installed on slopes that exceed 6%.

(6) Green Roofs (GSI)

A. Detail Reference (see Standard Plans)

224–Green Roof

B. Description

A green roof system is comprised of waterproof material covered with a soil and vegetative layer. A green roof is classified as an impervious area reduction facility and can be used in place of a traditional roofing system to manage impervious area by capturing, treating, and depending on the season, evapotranspirating a portion of precipitation. Additionally, green roofs help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff during the warm months of the year.

As an impervious area reduction facility, green roofs can be used to meet the water quality and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms). Green roofs meet the water quality performance standard, and provide a 50% reduction in impervious area, equivalent to half the area of the green roof, for the purpose of flow control.

C. General Sizing and Design Requirements

(i). Minimum soil growing medium: 4 inches

(ii). Structural roof support:

a. Must be sufficient to hold the additional weight of the green roof (approximately 10 to 25 pounds per square foot [psf] saturated weight, depending on the vegetation and growth medium used), in addition to snow load requirements.

b. Engineer shall address the structural requirements and submit calculations with the design drawings for review. Review and approval of the structural components of the building is the responsibility of the City's Building and Safety Division.

(iii). Waterproof membranes shall be constructed of modified asphalts, synthetic rubber (EPDM), hypolan (CPSE), or reinforced PVC. Some materials require root barriers and other protective materials.

(iv). Root barriers may be required depending on the waterproof membrane selected. Most modified asphalts require a root barrier, while EPDM and reinforced PVC do not. Manufacturer recommendations shall be followed regarding selection of root barriers for the specific waterproof membranes.

(v). Growing Medium (Soil)

a. The growing medium is generally 2 to 6 inches thick and well drained. It weighs 10 to 25 psf when saturated.

b. A simple mix of one-fourth topsoil, one-fourth compost, and one-half pumice perlite is sufficient for most applications. Some manufacturers have their own growing medium specifications.

(vi). Vegetation

a. Drought-tolerant plants, requiring little or no irrigation after establishment, shall be used.

b. Plants and plant spacing shall be used that allow the growth to thoroughly cover the soil. At least 90% of the surface area shall be covered after 2 years.

c. Plants shall be selected that are self-sustaining, without the need for fertilizers, pesticides, or herbicides; low-maintenance, requiring little or no mowing or trimming; and perennial or self-sowing. Refer to Appendix 4B for landscaping requirements.

d. Plants shall be fire resistant. A mix of sedum and succulent plant communities possess many of these attributes. Herbs, forbs, grasses, and other low groundcovers also can be used to provide additional benefits and aesthetics.

(vii). Gravel Ballast

a. Gravel ballast may be placed along the perimeter of the roof and at air vents or other vertical elements. The need for ballast will depend on operational and structural design issues. In most cases, very little, if any, ballast is needed.

b. Gravel ballast can also be used to provide periodic maintenance.

c. If a root barrier is used, gravel ballast must extend under the gravel ballast and growth medium, and up the side of the vertical elements.

D. Piping Requirements

(i). An underdrain system and overflow to an approved point of discharge are required.

(ii). The drainage layer may include filter fabric, manufactured perforated plastic sheets, gravel, or be the growing medium itself.

(iii). An approved discharge location must be identified for every green roof and a drain(s) provided.

(7) Constructed Wetland Treatment Systems (GSI)

A. Detail Reference (see Standard Plans):

222 – Treatment Wetland

223 – Subsurface Gravel Wetland

B. Description

Constructed wetlands are stormwater facilities that use vegetation, hydric soils, and their associated microbial assemblages to provide treatment and promote infiltration and/or evapotranspiration of surface drainage. Wetlands are generally inundated or saturated by surface and/or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation that survives in saturated or hydric soil conditions. The United States Army Corps of Engineers (USACE) and Department of State Lands (DSL) regulate natural wetlands. Natural wetlands must be protected and cannot be used as stormwater treatment facilities.

Constructed wetland systems include Treatment Wetlands and Subsurface Gravel Wetlands. Treatment wetlands manage larger contributing drainage areas at least 10 acres in size. A Subsurface Gravel Wetland is a horizontal-flow filtration system that approximates the look and function of a natural wetland, effectively removing sediments and other stormwater pollutants but can be used for smaller (approximately 1 acre or more) contributing drainage areas.

Both constructed wetland systems can be designed as a partial infiltration facility to meet the water quality treatment and flow control performance standard (Subsection 4.5 - (a) Performance Standards and Design Storms).

C. General Sizing and Design Requirements

(i). To meet the flow control performance standard, a detailed hydraulic analysis must be performed by a Professional Engineer, showing compliance with flow control requirements.

(ii). A design team with experience in hydrology, wetland plants, and engineering shall be used to design a constructed wetland.

(iii). A water budget analysis shall be performed with the design of the constructed wetland facility.

(iv). Two staff gauges shall be installed at opposite ends of the bottom of the constructed wetland to enable maintenance staff to measure the depth of accumulated sediment.

(v). Access routes to the wetland for maintenance purposes must be shown on the plans. See access easement requirements in Administrative Rules Division 001- General.

(vi). Flow through the constructed wetland facility shall be distributed as uniformly as possible across the wetland and ponded section.

(vii). An overflow mechanism to an approved point of discharge is required.

(viii). An emergency overflow shall be provided. The emergency overflow shall be designed for the 100 year, 24-hour storm and be capable of conveying the stormwater without causing damage to the facility or surrounding property.

(ix). Soil Suitability

a. Constructed wetland systems are appropriate for NRCS type C and D soils. Infiltration rates shall be 0.5 inches per hour or less.

b. Topsoil shall be used within the top 12 inches of the constructed wetland facilities, or the soil shall be amended to support plant growth.

c. A certified soil scientist, or a person with suitable wetland design training and expertise, shall evaluate the soils at the bottom of the facility to confirm that they are suitable for wetland vegetation planting.

D. Application-Specific Design Criteria

(i). Treatment Wetlands

a. For stormwater treatment, the wet portion or permanent pool of the wetland shall have a residence time of at least 36 hours, calculated as the treatment design storm volume divided by the average facility outflow rate.

b. The geometry, surface area, and volume of the Treatment Wetland shall be designed to match the components listed in Table 4-6. Component values may vary by up to 2% (plus or minus) of the listed values.

1. **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. The approximate water depth shall be 3 ft plus an additional 0.5 ft for sediment accumulation.

2. **Micropool**: A deep (4 to 6 ft) pool placed at the outlet of a stormwater wetland forebay.
3. **Dead Zone Storage**: The additional storage volume provided to allow for sediment accumulation. For a Treatment Wetland, the additional storage is provided in the Forebay.
4. **Deep-Water**: The area within a stormwater wetland that has a water depth greater than 18 inches.
5. **Deep Wetland**: The area within a stormwater wetland that has a water depth between 6 and 18 inches.
6. **Shallow Wetland**: The area within a stormwater wetland that has a water depth less than 6 inches.
7. **Slopes**: Max vegetated side slope: 5H:1V; maximum slopes within wetland: 20%

Table 4-6: Treatment Wetland Design Requirements

Design Component	Percent of Design Volume (Approximate)	Percent of the Facility Surface Area (Approximate)
Forebay	10	5
Micropool	10	5
Deep Water (> 18”)	50	40
Deep Wetland (6”–18”)	20	25
Shallow Wetland (<6”)	10	25

(ii). Subsurface Gravel Wetland

a. Subsurface Gravel Wetlands are suitable for projects with a minimum of one acre of impervious surfaces. The shape of the wetland can be configured to match the specific site conditions.

b. The subsurface gravel storage shall have a residence time based on the stormwater volume (calculated as the treatment design storm volume divided by the average facility outflow rate) of no less than 24 hours.

c. The Subsurface Gravel Wetland shall be designed so that ponded water is drained within 48 hours.

1. **Forebay**: Shallow area used to trap any coarse sediment which escaped the upstream pretreatment manhole, reduces

incoming velocity, and helps distribute runoff evenly over the wetland. Runoff exits the forebay through a perforated standpipe and flows into the vegetated treatment basin.

2. **Vegetated Treatment Basins**: Water flows evenly over the vegetated treatment basins, where it is treated through a variety of physical, chemical, and biological processes.
3. **Perforated Riser Pipes**: Water in the vegetated treatment basins is conveyed to the subsurface gravel layer through perforated riser pipes. This ensures the gravel subsurface area fills quickly.
4. **Subsurface Gravel Layer**: Biological processes with anaerobic microbes take place in this layer along with the uptake of pollutants by the vegetative root system. Physical and chemical treatment, through the trapping of contaminants, occurs on and within the gravel filter media and root mat.
5. **Outlet Structure**: The outlet structure is used for flow control and to regulate the level of water within the wetland. The outlet elevation shall be set to ensure the soil stays wet but water is not ponded on the surface of the wetland.

(c) Stormwater Facility Design Criteria (Filtration Facilities)

Stormwater facilities described in this section are defined as filtration facilities, as they meet the water quality performance standard but do not use infiltration. If infiltration is determined to be infeasible in accordance with Subsection 4.3 - (b) Infiltration Feasibility, a filtration facility must be used. Filtration facilities include vegetated swales, filter strips, and manufactured treatment technology. Lined planters and lined raingardens also qualify as filtration facilities.

Filtration facilities require additional flow control facilities to meet flow control performance standards. Filtration facilities must be configured offline using a flow splitter/ bypass to treat the volume of water generated by the water quality design storm or sized to manage the total contributing runoff volume without impacting the stormwater facility treatment functionality. Standardized setbacks for filtration facilities are listed in Table 4-7.

Table 4-7: Minimum Setback Requirements for Filtration Facilities

Stormwater Facility Type[1]	Setback from	Distance (ft)
Filtration Facility (Unlined)	Building foundation	10
	Property line (downslope)	5
	Property line (upslope or same grade)	0
	Building foundation	0

Filtration Facility (Lined)	Property line (downslope)	5
	Property line (upslope or same grade)	0
1. The list of filtration facilities can be found in Table 4-3: Stormwater Facility Categories and Applications. These setback requirements do not apply to GSI or flow control facilities.		

(1) Vegetated Swales.

A. Detail Reference (see Standard Plans):

202–Type 3 Catchbasin
220–Check Dam Details
232–Vegetated Swale–Plan View
233–Vegetated Swale–Section View

B. 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 flows through the facility. A collection/overflow system is required at the end of the swale. Vegetated swales can treat stormwater from parking lots, driveways, and other impervious surfaces.

A vegetated swale uses filtration to meet the water quality treatment performance standard. Vegetated swales intended to provide both water quality and conveyance must be designed to treat the water quality design storm and convey the applicable conveyance design storm event without erosion, consistent with Section 4.9 - Conveyance Systems.

C. General Sizing Requirements

Inflow to the facility shall consist of the design storm per the post-development runoff rate.

The vegetated swale width and profile shall be designed to convey runoff from the stormwater treatment design storm intensity based on the following design criteria:

(i). The maximum design velocity is 0.9 feet per second (fps) using the water quality design storm.

(ii). The minimum hydraulic residence time (time for flow to pass through the swale) is nine minutes.

(iii). Manning's "n" value of 0.25 for treatment and Manning's "n" value of 0.030 for conveyance.

(iv). Maximum Depth for the water quality storm event is 4 inches. The maximum conveyance depth is 12 inches.

(v). For facilities not protected by a high-flow storm diversion device, provide a minimum of 6 inches of freeboard above the water surface elevation for the conveyance design storm.

(vi). Velocities shall not exceed 3 fps for the conveyance design storm.

D. General Design Criteria

(i). A pretreatment structure shall be provided prior to the inlet of the facility to collect debris and sediment that enter the vegetated swale. Pretreatment structures are listed in Appendix 4F- List of Accepted Manufactured Stormwater Facilities.

(ii). Growing medium shall be used within the top 12 inches of the entire facility (including facility bottom, side slopes, and upland areas) as specified in Appendix 4G-Key Material Specifications.

(iii). A flow-spreading device shall be installed at the inlet to provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than six feet, a flow spreader shall be installed at least every 50 feet.

(iv). The minimum swale length is 100 feet. This requirement can be met with a segmented swale which is linked together so that the total length is 100 feet.

(v). To minimize flow channelization, the swale bottom shall be level, with uniform longitudinal slope.

NOTES REGARDING VEGETATED SWALES
Check Dams*: Shall be placed according to facility design. See Standard Plan 220–Check Dam Detail.*

Along Streets*: Protect subgrade with waterproof liner (30 mil. PVC or equal) along street edge to bottom of swale. See Standard Plan 233–ROW Swale–Section Views.*

(2) Vegetated Filter Strips (GSI).

A. Detail Reference (see Standard Plans):

218−Vegetated Filter Strips
220−Check Dam Details

B. Description

Vegetated filter strips are gently sloping areas used to filter, slow, and infiltrate sheet flow runoff used to receive the runoff from walkways and driveways. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Sheet flow is maintained using the relatively large surface area. Pollutants are removed through filtration and sedimentation.

A vegetated filter strip is a filtration facility used to meet the water quality treatment performance standard.

C. General Sizing Requirements

(i). Vegetated filter strips are appropriate for all soil types. Amended soils shall be used for the top 12 inches of the facility.

(ii). Filter strips shall have a minimum slope of half of 1% and a maximum slope of 10%. Filter strips shall have a uniform cross slope to ensure that flows are distributed evenly.

(iii). Stormwater shall enter the filter as sheet flow from an impervious surface.

(iv). Vegetated filter strips shall have on average a minimum width of 5 feet and a maximum width of 15 feet, measured in the direction of the flow.

(v). Filter strips shall be sized using a factor of 0.2 times the impervious area which sheet flows to the filter strip.

D. General Design Criteria

(i). Sod may only be used for RES projects and for filter strip installations along sidewalks per Appendix 4B–Landscape Requirements and Plants Lists for Stormwater Facilities.

(ii). Filter Strips shall be planted with a variety of trees, shrubs, and ground covers, including grasses per Appendix 4B–Landscape Requirements and Plant Lists for Stormwater Facilities.

(iii). An approved conveyance and disposal method will be required at the end of the filter strip.

(iv). Slopes greater than 5% within a Filter Strip require a series of check dams or terraces every 10 feet to slow flow through the facility.

NOTES REGARDING VEGETATED FILTER STRIPS
Check Dams*: Utilize cross section for check dams in Standard Plan 220–Check Dam Details. Check dams must be equal to the width of the filter strip and 3-5 inches in height.*

(3) Manufactured Treatment Technology.

A. Detail Reference

Not applicable.

B. Description

There are many types of manufactured treatment technology available for use today. Some of these systems are stand alone and meet the water quality

performance standards while other systems must be used in conjunction with pre-treatment systems.

A manufactured treatment technology is classified as a filtration facility to meet the water quality treatment performance standard. However, use of manufactured treatment technology versus other vegetated filtration facility is subject to approval under Appendix 4E.

C. General Sizing Requirements

Manufactured treatment technology sizing, design and construction is subject to vendor specifications and must be designed and installed in accordance with manufacturer's recommendations. In addition to design calculations, the following must be submitted with each manufactured stormwater treatment technology system or combination of systems:

(i). The pollution reduction capacity of the facility.

(ii). The flow-through conveyance capacity (i.e., maximum flow through the facility that will not agitate and release trapped pollutants).

(iii). An Operations and Maintenance plan in accordance with the manufacturer's recommendations for private facilities and Administrative Rule 109-011-Operations and Maintenance of Stormwater Facilities.

(iv). The maximum depth of any sump pump for a stormwater facility is 20 feet.

(v). The manufacturer of the technology must be contacted to verify the installation upon completion of construction.

(vi). The manufacturer of the technology may also be required to provide routine maintenance on the facility if the owner does not have the ability to provide maintenance.

NOTES REGARDING MANUFACTURED TREATMENT TECHNOLOGY

Manufactured Treatment Technologies will be treated as a Design Standard Exceptions per Administrative Rules–Division 001-General.

*A list of accepted Manufactured Treatment Technologies is provided in **Appendix 4F-List of Accepted Manufactured Stormwater Facilities** and have been approved by Washington Department of Ecology (Ecology).*

Regardless of Ecology approval, the City reserves the right to deny or approve Manufactured Treatment Systems as an Alternative Treatment Technologies.

(d) Stormwater Facility Design Criteria (Flow Control Facilities)

Stormwater facilities described in this section are defined as flow control facilities, as they meet the flow control performance standards, but do not utilize infiltration or meet water quality performance standards directly.

Flow control facilities require additional water quality facilities to meet the water quality performance standards or require GSI or filtration facilities to be designed into the flow control facility itself. For example, adding a raingarden to the bottom of a dry detention pond to infiltrate the water quality design storm event, thereby meeting the water quality performance standard. Flow control facilities include dry ponds and structural flow control facilities. Table 4-8 outlines applicable setback distances for all flow control facilities.

Table 4-8: Minimum Setback Requirements for Flow Control Facilities

Stormwater Quality Facility Type	Setback from	Distance (ft)
Dry Detention Ponds[1]	Building foundation	10
	Property line[1]	10
	Top of slope (>15%)[2]	200
	Well	100
	Below grade basements, vaults[3]	20
	Waterway top of bank	15
	Septic system or drain field	50
Structural Flow Control Facilities	Building foundation	0
	Property line	0

1. *Minimum distance from nearest property line: 10 feet to the edge of the maximum water surface elevation or 5 feet to the outside toe of the pond berm embankment, whichever is greater. The City may approve an exception if a stamped geotechnical report, confirming that a smaller setback is acceptable, is submitted.*
2. *The City may approve an exception if a stamped geotechnical report, confirming that a smaller setback is acceptable, is submitted.*
3. *Minimum distance from structures with below-grade basements, vaults, or where the water surface is above the bottom of the lowest elevation of a structure: a distance 4 times the height of the water surface above the lowest slab elevation (minimum distance of 20 feet).*

(1) Dry Detention Ponds.

A. Detail Reference (see Standard Plans)

219 – Dry Detention Pond

B. Description

Dry detention ponds are vegetated basins designed to fill during storm events and slowly release the water over a specified drawdown time. Wet ponds containing standing water for an extended period of time are not allowed. Dry detention ponds are encouraged to function as multi-purpose facility, such as integrated into open space or parks, provided that any alternative uses are compatible with the basic stormwater functions and operations and maintenance standards. In-stream ponds are not allowed.

A dry detention pond is a flow control facility that is used to meet the flow control performance standard. Dry detention ponds may be combined with a GSI or filtration facility to address the water quality performance standard.

C. General Sizing Requirements

(i). Slopes within the pond shall not exceed 3H:1V.

(ii). The distance between all inlets and the outlet shall be maximized to facilitate sedimentation.

(iii). The maximum water depth of the dry pond shall not exceed 6 feet. The first 2 feet of depth shall be distributed evenly around the perimeter of the pond.

(iv). Freeboard shall be the greater of 6 inches above the 100-year design water surface elevation or 1 foot above the 10-year water surface elevation.

(v). If a stormwater facility addressing the water quality performance standard is not provided, ponds shall be designed with an upstream pretreatment facility or sedimentation manhole having a down-turned elbow or tee riser outflow pipe to trap oils, sediments, and floatables.

D. Piping Requirements

(i). 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 sf of open surface area. 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.

(ii). The outlet orifice shall be designed to minimize clogging.

(iii). Inlet/outlet structures of all surface ponds shall be designed with suitable debris barriers and erosion control measures to adequately protect the outlet from sedimentation or other debris.

(iv). Flow control structures shall be accessible during facility full flow conditions.

(v). 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 crest of the structure.

a. The emergency overflow shall be designed to convey extreme event peak flows around the berm structure for discharge into the downstream conveyance system and sited to protect the structural integrity of the berm.

b. The emergency overflow is in addition to the overflow provided in the control structure.

c. The sub grade of the emergency overflow spillway shall be set at or above the 100-year overflow elevation of the control structure. It 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 these Design Standards and extend to the toe of each face of the berm embankment.

d. The emergency overflow spillway weir section shall be designed for the maximum design storm event for post-development conditions, using the following formula:

$$L = \frac{Q_{100}}{3.21H^{1.5}} - 2.4H$$

Where:

L = *Length of bottom of weir (feet)*

Q_{100} = *100-year pre-development flow rate (cfs)*

H = *Height of emergency overflow water surface (feet)*

E. General Design Criteria

(i). The top 12-inch layer of soil across the entire facility (including facility bottom, side slopes, and upland areas) must be replaced with imported topsoil before the facility is planted. Alternatively, this layer may be created with suitable topsoil from the site that is stripped, amended, and reused for the growing media.

(ii). An overflow to an approved point of discharge is required for dry ponds.

(iii). For dry ponds where a liner is proposed, in soils where groundwater may induce flotation and buoyancy, measures are required to counteract these forces. Measures that may be required include ballasting with concrete or earth backfill, providing concrete anchors or other counteractive measures. Calculations shall be provided which demonstrate the required stability.

(iv). Surrounding slopes to a dry pond shall not exceed 10%.

(v). Embankment and Soil Stabilization

a. Pond embankments greater than 4 feet in height shall be designed by a Geotechnical Engineer to ensure stability during pond full conditions.

b. Native soil on which the embankment is placed shall be evaluated by a Geotechnical Engineer to determine compaction

requirements and/or special measures required prior to placing embankment on native soil.

c. All pond embankments shall be constructed by excavating a key equal to 50% of the embankment height above the bottom of the pond, or as recommended by a Geotechnical Engineer.

d. Pond embankment slopes shall be a maximum (i.e., steepest) slope of 3H:1V on the upstream and downstream face.

(vi). The use of retaining walls in ponds shall only be permitted if all of the following criteria are met:

a. Design must be prepared and stamped by a Professional Engineer registered in the State of Oregon;

b. Walls shall not exceed 4 feet in exposed height;

c. Perimeter walls shall not surround more than 50% of the facility; and,

d. The facility is accessible and maintainable with standard equipment utilized by the City for maintenance of the facility when the facility is City-owned.

e. Fencing shall be required on top of walls that exceed 30-inches in height (not including the footings). Fencing materials shall conform to Section 608.2.01 of the Standard Construction Specifications, modified as follows:

1. Fence fabric shall be vinyl-coated, black in color, in conformance with ASTM F668.
2. Fence tension wire shall be vinyl-coated, black in color, in conformance with ASTM F1664.
3. Railings and posts shall be at minimum Schedule 40 steel tubing in accordance with ASTM F1083, and be powder-coated, black in color, in conformance with ASTM F2408.
4. Facility fence and gates shall be fitted with polymer privacy insert slats in accordance with ASTM F3000, wood slats attached to the fence, or approved equal.

(vii). Pond 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.

(viii). Where maintenance access is provided along the top of berm, the minimum width of the top of berm shall be at least 15 feet and designed for all weather access.

NOTES REGARDING DRY DETENTION PONDS

All dry detention ponds to be maintained by the City shall be located on land dedicated to the City, within the ROW, or within a public stormwater easement dedicated to the City.

Dry detention ponds serving more than one tax lot, or designed to function as multi-use/recreational facilities, shall be located in a defined easement or designated open space.

(2) Structural Flow Control Facilities

A. Detail Reference (see Standard Plans)

248 A–Detention Tank
248 B–Detention Tank Details

B. Description

Structural flow control facilities include tanks, vaults, and oversized pipes provide underground storage of stormwater as part of a flow control system. They must be designed not only for their function as flow control facilities, but to withstand an environment of periodic inundation, potentially corrosive chemicals or electrochemical soil conditions, and heavy ground and surface loadings.

They must also be accessible for maintenance and located within 10 feet of the all-weather access road or roadway. Facilities in this section must be designed using acceptable hydrologic analysis to meet applicable flow control requirements. Additional facilities will be required to meet applicable stormwater treatment standards.

C. General Sizing Requirements

(i). Either a surface containment pond or a sedimentation manhole is required upstream of the structural detention facility. The bottom shall slope 0.1%.

(ii). Structural flow control facilities can be used in conjunction with dry ponds or parking lot detention basins, to provide initial or supplemental storage.

(iii). Two accessways into a structural flow control facility shall be required per Standard Plan 248A–Detention Tank and Standard Plan 248B–Detention Details and shall consist of a minimum 36-inch-diameter access entry cover. All access openings shall have round, solid locking lids.

(iv). Structural flow control facilities are permitted within the ROW. City-maintained structural flow control facilities that are not located within the ROW, shall be located on separate lots deeded to the City with access easements that are granted to the City as needed.

(v). Structural flow control facilities shall be located within 10 feet of an all-weather access road or roadway to allow easy maintenance access.

When located outside the ROW, access ports must be accessible by an all-weather access road conforming to the requirements in Division 001-General.

(vi). The minimum size for a detention pipe shall be 36 inches in diameter.

(vii). Parking lots may serve as an overflow area in a 100-year storm event to supplement structural flow control facilities. Parking lot overflow storage is only permissible on private property and located in a portion of the parking lot outside of ADA parking areas, drive aisles, and fire department access. Parking lot overflow storage must also meet the following design criteria:

a. Maximum depth of water surface on all parking lot surface overflow shall be 6 inches.

b. The slope on all parking lot surface overflow storage area shall be no less than 1% and no greater than 5% in areas designed for vehicular traffic.

c. The maximum water surface elevation of the parking lot pond shall be at least 1 foot below either the lowest habitable floor elevation or the lowest elevation of mechanical, electrical, or other equipment subject to damage by flooding, whichever is lower.

1. The 1-foot minimum clearance may be reduced if the detention overflow provides adequate protection from flood damage and approved by the City.
2. Where curbing within the parking lot is used for overflow storage, the maximum water surface shall be no higher than 0.25 feet below the top of curb, and type "C" curbing shall be used as shown in the Standard Plans.

D. General Design Criteria

(i). If the public collection system piping is also designed 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.

(ii). The minimum internal height of a structural flow control facility 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.

(iii). The placement of large diameter detention pipes must allow for the required separation from all other utilities. The installation shall not pose any crossing conflicts for other utilities, including services to individual properties.

(iv). Sedimentation manholes, installed for pretreatment for linear structural flow control facilities must be provided within 10 feet of service truck access, with a minimum manhole diameter of 48 inches. All manholes that are part of the structural flow control facility shall include sump pumps.

(v). Parking lot overflow storage, if used to supplement storage volume associated with use of a structural flow control facility, must be shown on the preliminary and final plan set and reflected in the O&M agreements (Subsection 4.8 - (a) Operations and Maintenance Requirements).

(vi). Pipes, fittings, and manholes for closed structural flow control facilities shall be built with material having a minimum 75-year design life regardless of on-site soil types. The constructed facilities shall be successfully tested for water tightness before being accepted by the City.

(vii). In soils where groundwater may induce flotation and buoyancy, measures are required to counteract these forces. Measures that may be required include ballasting with concrete or earth backfill, providing concrete anchors or other counteractive measures. Calculations shall be provided which demonstrate the required stability.

(viii). Structural detention facilities shall be placed on stable, consolidated native soil with suitable bedding. Tanks and vaults shall not be allowed in fill slopes unless recommended by a Geotechnical Engineer.

(ix). All structural flow control facilities will have an outlet structure and be documented in the Geotechnical Report.

(x). All flow control systems shall have positive gravity flow to the downstream gravity conveyance system.

4.7 - Planting and Landscaping Requirements

(a) Plant Material Landscaping Requirements

Green stormwater facilities and other facilities as required in this Division shall be landscaped with approved plant selection, soil amendments, fertilizers, permanent irrigation systems etc., per **Appendix 4B–Plant Material and Landscaping Requirements** for Stormwater Facilities. Final design plans shall include complete landscape and irrigation designs per **Appendix 4A–Stormwater Submittal Requirements**.

4.8 - Operations and Maintenance

(a) Operations and Maintenance Requirements

O&M requirements apply to all City-owned and private stormwater facilities and related facility components. Owners of private stormwater facilities are required to inspect and maintain their facilities regularly, as well as allow the City access for inspection.

In addition, privately-owned and maintained stormwater facilities require the submittal of a "Private Stormwater Facility Agreement" and a "Facility Maintenance Form" in accordance with the final design submittal. See **Appendix 4A–Stormwater Submittal Requirements** and Administrative Rule 109-011–Operations and Maintenance of Stormwater Facilities for further information.

(b) All Weather Access

All-weather vehicle access shall be provided to all stormwater facilities maintained by the City. The type of accessway surface (i.e., asphalt, concrete or gravel) will be determined as appropriate for the location, slope and expected operation and maintenance traffic on a case-by-case basis. All-weather access design and access easement requirements are described in Division 001–General.

4.9 - Conveyance Systems

(a) General Design Considerations

(1) Waterway conveyance systems shall be designed to accommodate fish passage.

(2) Existing waterways shall be retained except where culverts, bridges, or other closed systems are proposed and approved by the City.

(3) To help mitigate water temperature, the design shall provide shade trees along all open waterways.

(4) Conveyance systems shall be designed and constructed in compliance with requirements of all applicable Federal, State, and local agencies. Work within open waterways will normally require permit authorization from other agencies (see Division 001-General).

(5) The stormwater conveyance system shall be designed and constructed in accordance with floodplain management policies and regulations in accordance with SRC Chapter 601.

(6) The Rational Method may be used for sizing conveyance facilities and for determining the peak flow capacity of conveyance facilities with contributing drainage areas less than 10 acres. The minimum time of concentration shall be 5 minutes.

(b) Capacity

A conveyance system shall be sized to carry the design storm event flowing full as described in Table 4-9. The design storm event shall be based on either the size of the drainage area or the street classification, whichever is larger.

Table 4-9: Conveyance System Design Capacity

Element	Description	Design Storm Event Recurrence Interval (yrs)
Local Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	10
Local Storm Drains	Drainage area < 50 acres	10
Collector Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	25
Collector Sewers	Drainage area 50 to 250 acres	25
Arterial/ Parkway Streets	Streets, curbs, gutters, inlets, catch basins, collector drains	50
Trunk Sewer	Drainage area > 250 acres	50
Ditches and Culverts	Local streets	25
	Arterials and collector streets	50
Waterways	Without designated floodplain	50
	With designated floodplain	100
Bridges		100

(c) Conveyance Pipe

(1) Size Requirements. Mainline and connecting storm drains shall be not less than 10 inches inside diameter.

(2) Slope Requirements. All storm drains shall be laid on a grade which will produce a mean velocity (when flowing full) of at least 2.5 feet per second (fps). The minimum acceptable grade for various pipe sizes, assuming a Manning's Roughness Coefficient of 0.013, is shown in Table 4-10. The maximum grade is 20%.

Engineers may specify a storm drain pipe size that is no more than one size category larger than needed for the carrying capacity in order to meet grade requirements, i.e., a 12-inch pipe for a 10-inch pipe to achieve a decrease in slope.

Table 4-10: Minimum Pipe Grade	
Inside Pipe Diameter (inches)	**Minimum Grade (feet per 100 feet)**
8 (Private)	0.52
10	0.39
12	0.30
15	0.23
18	0.18
21	0.14
24	0.12
27	0.10
30 (and larger)	0.09

(3) Manning's Roughness Coefficient. New storm drains must be designed using Manning's pipe friction formula with a roughness coefficient of 0.013. The "n" value for existing pipes varies based on material, condition, interior wall configuration, and other related factors listed in Table 4-11. The values in the table below shall be used on existing pipes unless a lower value can be justified by inspection.

Table 4-11: Roughness Coefficients for Various Types of Pipes	
Manning's Roughness Coefficients	
Pipe Material	Range of "n" Values [1]
Plastic (PVC, HDPE)	0.009–0.013
Concrete	0.013–0.015
Ductile Iron	0.013–0.015
Cast Iron	0.013–0.015
Corrugated Metal	0.032
1. The lower range represents new pipe and pipe in good condition and the upper range represents pipe in fair condition. Pipe in poor condition will require greater "n" values as approved by the City.	

(4) Pipe Materials. Pipe materials for public storm drains shall conform to the City's Standard Construction Specifications. Acceptable pipe materials and abbreviations are as follows:

A. CHDPE-Corrugated High Density Polyethylene

B. CONC-Concrete

C. DI-Ductile Iron

D. HDPE-High Density Polyethylene

E. PVC-Polyvinyl Chloride

F. ABS-Acrylonitrile-Butadiene-Styrene

(5) Alignment and Location.

A. Storm drains shall be located in the ROW within 7 feet from curb face.

B. Storm drains shall be laid on a straight alignment between junctions.

C. Utility crossings shall be 90-degree angles and in no case, less than 70 degrees. Utility crossings with less than 6 inches of vertical separation shall be backfilled with controlled density backfill or other approved material.

D. Where storm drains parallel other utility pipe or conduit lines, the vertical and horizontal alignment shall permit future side connections of storm drains and avoid conflicts with parallel utilities without abrupt changes in vertical grade of main or connecting storm drains.

E. Storm drain alignments shall accommodate future planned projects such as street widening, changes in horizontal or vertical street alignment, and master plan water, sewer or other stormwater facilities.

(6) Cover Requirements.

A. All storm drains shall be laid at a depth sufficient to protect against damage by traffic and to drain building footings and under floors where practical. Depth is measured from top of pipe to finish grade at the storm drain alignment.

B. Minimum cover for all storm drainage pipes shall be 30 inches above the top of the pipe. Ductile iron pipes shall be used where 30 inches of cover cannot be achieved.

C. It must be demonstrated that the storm drain is at sufficient depth to properly drain the remainder of the upstream contributing basin.

(7) Junctions.

A. Junctions are required for the stormwater conveyance system wherever there is a change in grade, direction, or pipe size.

B. Storm drain pipe junctions shall be cleanouts, catch basins, manholes, or other approved junctions as shown on the Standard Plans.

C. Catch basins and cleanouts shall be used as junctions only with pipes less than 18 inches in diameter for depths up to 5 feet from rim to invert.

D. Piped storm drain systems shall have junctions located at intervals which do not exceed 500 feet.

E. Catch basin may connect to a storm drain without a junction when the connecting pipe is less than 20 feet long and a minimum of 12 inches in diameter and when the storm drain is not less than 18 inches in diameter.

F. Where an outlet pipe is larger than the inlet pipe, the elevations of the pipe crowns shall match. For all junctions with a sump pump, the outlet invert(s) shall be between 0.1 foot and 1 foot below the lowest inlet invert. All channelized manholes shall have a minimum drop across the manhole of 0.2 foot and meet the requirements of Standard Plan 101.

G. Junctions located outside the ROW shall be a minimum 48-inch diameter manhole. All junctions located outside of the ROW shall be provided with an access easement meeting the requirements provided in Division 001−General.

H. Manholes shall have an internal diameter based on the largest pipe diameter connected to the manhole per Table 4-12.

Table 4-12: Manhole Size

Manhole Diameter (Interior Diameter, inches)	Maximum Pipe Size (Diameter, inches) w/0° Deflection	Maximum Pipe Size (Diameter, inches) w/90° Deflection
48	18	15
60	30	18
72	42	30
84	54	36

(8) Catch Basins.

A. Inlets shall be designed to accept the appropriate size design storm flow (as defined in Table 4-3).

B. Inlet spread and capture calculations are required for all arterial and collector streets. Either the ODOT Hydraulics Manual, Chapter 13, **Appendix D−Hydrologic Analysis**, or the FHWA HEC-22 Urban Drainage Design Manual may be used for inlet spread and capture design criteria.

C. Where inlet spread and capture calculations are not required, inlets may be spaced at no greater than 400 feet.

D. No more than 0.1 cfs of non-captured flow is allowed downstream of the project limits.

E. Flow paths shall not cross intersections.

F. Type 4 catch basins are required on curbed streets that are less than 5% in running slope and shall be generally located along the ROW at private property boundaries (lot lines) in order to avoid driveways. Type 2 catch basins shall be used on curbed streets greater than 5% or where Type 4 catch basins cannot be used. Inlets shall not be located at driveways or pedestrian ramps.

G. Inlets shall be located along the gutter line or open channel flow-line. When streets are widened or otherwise modified, causing an inlet to be located outside a flow-line, the inlet shall be removed entirely and reconstructed with a cleanout, manhole, or other acceptable junction.

H. Type A inlets shall be required at sag locations. An overflow must be designed for an escape route to account for flows exceeding design capacity or inlet failure. Escape route must be designed to approved point of discharge.

(9) Subsurface Drainage. Subsurface drains shall be constructed with adequate erosion protection and shall discharge into the public storm drain system at a catch basin or manhole. Subsurface drains are required for all excavations and fills, with or without retaining walls, which exceed 4 feet vertically.

(d) Culverts

Criteria provided in this section for culvert design for open channel flow shall also apply to culverts placed in drainage ways and road side ditches.

(1) Culverts in Waterways.

A. New culverts shall be sized in conformance with the capacity requirements found in Table 4-9: Conveyance System Design Capacity.

B. Culverts placed in streams or creeks determined to be "Waters of the State" require approval from DSL and the USACE.

C. All culverts shall be designed for fish passage in accordance with ODFW guidance unless otherwise exempted by ODFW.

D. Crossing structures shall be designed with a foundation and three sides or oversized and buried in the open channel to maintain the natural channel bottom.

(2) Culverts in Ditches.

A. Headwater

For new culverts 18 inches in diameter or less, the maximum allowable design storm headwater elevation (measured from the inlet invert) shall not exceed 2.0 times the pipe diameter or three times the pipe diameter with a seepage collar.

For new culverts larger than 18 inches in diameter, the maximum allowable design storm headwater elevation (measured from the inlet invert) shall not exceed 1.5 times the pipe diameter.

B. Inlet

All street crossing culverts are required to be designed with a head wall.

For culverts 18 inches through 42 inches in diameter, the embankment around the culvert inlet shall be protected from erosion by armoring around the inlet with rock or other protection. The armoring shall extend upstream from the culvert a minimum of 5 feet and shall be as high as the designed headwater elevation.

C. Headwalls and Endwalls

Pipe headwalls, endwalls, or other approved end protection shall be required where pipe material, other than concrete or ductile iron, is exposed at an outlet or inlet or where required to provide slope stability. Details for the headwalls, endwalls, and other end protection shall be included in the construction drawings.

D. Outlets

For culverts 12-inches in diameter and larger, the receiving channel of the outlet shall be protected from erosion by a rock lining, bioengineering, or by some other type of energy dissipater.

Runoff exiting a development site shall be discharged with adequate energy dissipaters to prevent downstream damage.

E. Inlet and Outlet Control Analysis

The headwater depth for pipes under inlet or outlet control shall be determined using hydraulics software such as the FHWA program HY-8 or the nomographs contained in the ODOT Hydraulics Manual.

(e) Open Channels

(1) Design Requirements.

A. Design shall follow a natural curvilinear alignment, a 100-foot-minimum flow-line radius, and a low-flow channel designed to convey a minimum 2-year design storm.

B. Banks shall be designed with a minimum 1 foot of freeboard above the capacity design storm specified in Table 4-3: Stormwater Facility Categories and Applications.

(2) Slope Requirements. Bank slopes shall generally be no steeper than 3H:1V (three horizontal to one vertical). In a reach where 3H:1V side slopes are not feasible due to existing site conditions or other obstructions in the channel, the bank slope may steepen to 2H:1V and will require erosion protection. If the top of bank is a berm, the back slope shall generally be no steeper than 2H:1V and shall be graded to prevent localized ponding. In areas of potential instability, the City reserves the right to require grading to be designed by a Geotechnical Engineer.

(3) Manning's Roughness Coefficient. Manning's Roughness Coefficient ("n") shall generally comply with the ODOT Hydraulic Manual. Typical "n" value ranges are shown in Table 4-13. For new systems, use the design value listed in Table 4-13.

Table 4-13: Manning's Roughness Coefficients for Open Channels.

Type of Open Channel	Range of "n" Values	Design "n" Values
Concrete-Lined	0.012-0.018	0.015
Rock-Lined	0.025-0.045	0.040
Vegetated Swale Flowing Full	0.025-0.035	0.030
Earth Ditch	0.022-0.033	0.0225
Natural Waterway (Surface Width <100 feet)	0.025-0.06	0.035
Vegetated Floodplain	0.05-0.15	0.07

(4) Bank Stabilization. Open channel waterways shall be designed and constructed with temporary and permanent naturally vegetated bank stabilization measures in all locations. Specialized bank stabilization shall be considered as follows:

A. In waterways, natural bank stabilization measures (i.e., slope pull-back, willow mats, rock barbs, or re-vegetation with localized native plant species) shall be used.

B. Areas of extreme curvature, changes in channel cross-section, or low-flow channels with flow velocities exceeding three feet per second shall be designed and constructed with bank stabilization to allow for potential scouring from turbulent flows.

C. Post-construction bank stabilization shall minimize the potential for erosion or sedimentation in accordance with SRC Chapter 71.

(5) Outfalls to Ditches and Waterways.

A. Outfalls to open channels may require DSL and USACE permits. The EOR is responsible for obtaining necessary State and Federal permits and providing proof of approval to the City.

B. Outfalls shall be constructed to minimize the potential for erosion and other potential damage to the banks of the receiving open channel. Outfall designs shall prevent erosion and scouring upstream and downstream of the outfall structure.

C. Bank stabilization shall conform to Subsection 4.9(e)(4)−Bank Stabilization, and shall not reduce the carrying capacity of the water course. Bank stabilization designs shall consider the flow velocities of pipe outlets and the open channel for the design storm event. Where stones are placed within existing bank slopes, the bank shall typically be excavated a minimum of 18 inches or 1.5 times the size of the largest stone being used, whichever is greater.

D. Flow from the outfall structure shall be directed downstream, typically no less than 30 degrees from perpendicular to the waterway flow.

E. Outfalls shall be located at the ordinary high water elevation. The area between the ordinary high water level and the stream bed shall be stabilized with material to dissipate energy.

F. 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 10 fps. These shall be designed in accordance with the current edition of the ODOT Hydraulics Manual.

G. Outfalls may be inter-planted with willow stakes or other approved plantings every 2 feet on-center, to increase stability, reduce erosion, provide shading, and improve aesthetics. The direct flow path between the natural water body and the outfall shall be clear of trees.

H. Riprap protection, when required, shall be designed in accordance with the current edition of the ODOT Hydraulics Manual.

NOTES RELATED TO OPEN CHANNEL DRAINAGEWAYS
The surface configuration at the top of bank shall provide adequate accessibility for maintenance.
The flow-line slope is generally dictated by the natural contours. The minimum flow-line slope shall be 3% where feasible, but in no case shall the minimum flow velocity be less than 2 feet per second.

APPENDIX 4A
STORMWATER SUBMITTAL REQUIREMENTS

CITY OF SALEM
DEPARTMENT OF PUBLIC WORKS
ADMINISTRATIVE RULES
CHAPTER 109
DIVISION 004 APPENDIX A
STORMWATER SUBMITTAL REQUIREMENTS

SECTION

TABLES

4A.1 – LAND USE SUBMITTAL GUIDE

(a) Land Use Development Tiers

In accordance with the City of Salem's process for review of stormwater feasibility at time of land use, the following land use development tiers are identified. Based on the applicable tier designation, proposed development must submit the required information for review, associated with the assigned tier at time of the land use application.

Documents to be Submitted for Review	Tier 1	Tier 2	Tier 3	Tier 4
Preliminary Site Plan showing new and replaced impervious surfaces with point of stormwater discharge locations noted	X	X	X	X
Site Assessment and Planning Checklist (see Section 4A.3)		X	X	X
Simplified Sizing Form and Documentation (see Section 4A.4)		X		
Preliminary Stormwater Management Report and Documentation			X	X

Note: The X indicates if the document is required for that Tier.

(1) Tier 1: Any project with less than 5,000 square feet (SF) of new or replaced impervious surfaces (excluding residential projects), or residential projects with less than 1,300 SF of new or replaced impervious, or residential projects on lots created prior to 2014 that are not required to provide flow control or WQ treatment per SRC 71.085.

Note: No stormwater report, calculations, or stormwater design forms need to be provided for land use or final design review stages for projects that fall within this Tier.

(2) Tier 2: Any project using the Simplified Method (where the total new and replaced impervious surface is between 1,300 and 10,000 SF.)

(3) Tier 3: Any project using the Engineered Method (where the total new and replaced impervious surface is greater or equal to 1,300 SF for residential projects or 5,000 SF for Large Projects).

(4) Tier 4: Any project using the Engineered Method (where the total new and replaced impervious surface is greater or equal to 1,300 SF for residential projects and 5,000 SF for Large Projects) but the project does not meet all requirements listed in the PWDS and would require a Design Exception.

Note: Submit the Development Review Design Exception Request Form and all required information outlined on the form in accordance with PWDS Appendix 4E.

(b) Preliminary Site Plan Submittal Requirements

Preliminary Site Plan requirements are identified for consistency with land use submittal requirements in the *Salem Revised Code* (SRC) and in accordance with the land use development tiers described in Section 4A.1(A).

(1) The following information is required on the Preliminary Site Plan for Tier 1 Projects:

A. Project boundary and site information, including:

(i). Total site and project area

(ii). Property lines and appropriate dimensions with scale bar

(iii). Orientation relative to north.

B. Existing and proposed improvements including:

(i). Project layout and impervious areas

(ii). Proposed footprints of structures

(iii). Driveways, parking and circulation areas, sidewalks

(iv). Other new or replaced impervious surface

C. The proposed outfall / point of discharge from the site

(2) The following information is required on the Preliminary Site Plan for Tier 2, 3, and 4 Projects:

A. All information required under section (a) for Tier 1 projects

B. Existing and proposed public or private easements and rights-of-way

C. Elevations and topography

(i). Surveyed or aerial-based mapping with 2-foot intervals for slopes 0-25% slope and 10-foot intervals for steeper.

D. Existing and proposed utilities including:

(i). Any wells and/or on-site septic systems

(ii). Location of proposed connection points to existing municipal water, stormwater, and sewer services;

(iii). Franchise utility services (overhead and buried)

E. Existing and proposed surface drainage patterns, depicted with directional markings.

F. Disturbance areas and delineation of areas to remain undisturbed.

G. Existing and proposed surface materials (concrete, asphalt, grass, bark mulch, etc.)

H. Existing trees and vegetation to be protected pursuant to SRC Chapter 808 and proposed new or revegetation areas.

I. Intermittent and perennial creeks/streams/rivers and wetlands (labeled), FEMA floodplains and floodways, and existing stormwater system (pipes, ditches, outfalls)

J. NRCS Hydrologic Soil Coverage identified on site plans if more than one type is present on the development site

K. Proposed stormwater facility(ies) information, including:

(i). The type, location, and preliminary size and associated catchment areas

(ii). Dimensions

(iii). Proposed setbacks to existing and proposed property lines, building foundations and easements.

(iv). Typical/standard details

(v). Maintenance access routes

L. Conceptual grading plan to verify constructability of the stormwater facility(ies)

(c) Preliminary Simplified Sizing Form

The Simplified Method may be used to design stormwater facilities for Residential projects and Large projects where the total impervious area is 10,000 SF or less. Any project using the Simplified Method (Tier 2) shall submit a preliminary Simplified Sizing Form at land use, as reflected in **Appendix 4A.4**.

(d) Preliminary Stormwater Management Report Requirements

For projects where the impervious surface area is greater than 10,000 SF, the Engineered Method must be used to design the stormwater facilities. Projects where the impervious area is between 1,300 and 10,000 SF may also elect to use the Engineered Method.

Projects using the Engineered Method (Tier 3 or 4) shall submit a Preliminary Stormwater Management Report at land use unless the applicant is setting aside 10% of the total new and replaced impervious surface area for stormwater management. If area is being set aside, refer to the Site Assessment Checklist (**Appendix 4A.3**) for submittal requirements.

Requirements of a Preliminary Stormwater Management Report are outlined below.

1. Cover Sheet
    A. Project name and owner
    B. Site address
    C. Associated permit numbers, if available
    D. Submittal date
    E. Engineer of Record
    F. Firm Name and Address
    G. Contact information including phone numbers and email addresses
2. Engineer's Preliminary Certification and Statement
3. Project Overview and Description
    A. Size and location of project site (vicinity map)
    B. Brief description of the project scope and proposed improvements
    C. Brief description of the project vicinity in conjunction with major receiving waters and upstream contributing drainage areas.
    D. Description of the existing site conditions, sensitive areas, and waterways (in accordance with the Site Assessment Checklist, see **Appendix 4A.3**)
    E. Description of site constraints in accordance with the infiltration infeasibility criteria (in accordance with the Site Assessment Checklist, see **Appendix 4A.3**).
    F. Summary of proposed stormwater facilities, and conformance with performance standards requiring GSI to the MEF.
    G. Identification of any hazardous materials based on past use of the project site.
4. Infiltration Testing (see **Appendix 4C—Infiltration Testing**)
    A. Depth to Seasonal High Groundwater
    B. Measured infiltration rates and design infiltration rates (reflecting application of a factor of safety of 2.0 on the measured infiltration rates)
    C. Description of soil types and any other geologic features impacting stormwater infrastructure design
5. Analysis
    A. Summary of stormwater facility sizing methods and software used.

B. Design assumptions and critical variables and inputs including, but not limited to, curve numbers, coefficients, infiltration rates, grades, design storms, NRCS soil types, etc.

C. Hydrology Calculations (pre- and post-development)

D. Treatment and flow control facility sizing calculations

E. Tables of pre- and post-construction catchment areas to each stormwater facility (differentiate public vs. private, roof vs. pavement, and pervious vs. impervious). See example Table 4A-1 below.

F. Maps (or reference to the Preliminary Site Plan) illustrating the pre- and post-development catchment areas

6. Stormwater Facility Details/Exhibits

A. Pre- and post-development drainage basin delineation with existing and proposed topography.

B. Standard details reflecting plan and profile views of the proposed stormwater facilities.

Table 4A-1: Catchment and Facility Table Example

Catchment and Facility Table (*shows each catchment on proposed site as well as proposed facility)*

Catchment/ Facility ID	Source (roof/road/other)	Impervious Area (sf/ac)	Pervious Area (sf/ac)	Ownership (private/public)	Facility Type	Facility Size (sf/ac)	Curve #
AA							
BB							

4A.2– FINAL DESIGN SUBMITTAL GUIDE

Final stormwater treatment and flow control design submittals shall include the following information:

(a) <u>Submittal Items for all Methods</u>

The following submittal items are required at the final design submittal for any project that is required to provide stormwater management pursuant to Section 4A.1(A) (Tiers 2, 3, and 4 as identified at land use):

(1) Updated Site Plan(s)

A Final Site Plan(s) with a scale of 1″= 10′ (large projects may use a scale of 1″= 50′) is required. Information on the site plan shall be updated to match the final design of the project and include all required information for a Preliminary Site Plan within Section 4A.1(b). If applicable, the final plan shall include an Engineers certification.

(2) Finalized Cross Sections and Details of the Proposed Stormwater Facilities

Cross sections and details of the proposed stormwater facilities will be included with the plan set for the development. The plans shall show the elevations of inlets, outlets, and discharge points on the cross section(s) with arrows showing the direction of flow.

(3) Updated Infiltration Test Results (if applicable)

Updated Infiltration test results, if applicable, will be submitted using the appropriate forms found in **Appendix 4C—Infiltration Testing**.

(4) Landscaping Plans

Submittal of final landscaping plans is required prior to approval of the final facility construction drawings, but the submittal can be deferred until preliminary approval of the stormwater facility size and location.

The Landscaping Plan shall be designed in compliance with **Appendix 4B-Planting List for Stormwater Facilities** and contain the following information:

A. Planting plan and cross section for each stormwater facility(ies), including planting zones, plant layout, and distribution.

B. Plant legend including botanical name, common name, quantity, condition, size, spacing, and appropriate planting zone for each plant in each stormwater facility.

C. Soil preparation and planting details and notes.

D. Mulch, compost, soil amendment, and topsoil specifications and quantities.

E. Seed mixes, method, rates, and areas of application, if used.

F. A 2-year plant establishment schedule shall be provided with the landscape planting plan, describing the amount of water to be applied over a 2-year time and how that water will be distributed to the plant material. For City-owned or maintained owned stormwater facilities, permanent irrigation is required.

(5) Irrigation Plans

The Irrigation Plan shall be included in the design drawing set and contain the irrigation layout, material legend, details and notes. The Irrigation Plan for the stormwater facilities is required prior to final plan approval and shall not be deferred.

(6) Private Stormwater Facilities Agreement

The applicant must complete a Private Stormwater Facilities Agreement (PSFA) and sign and record the document in the appropriate County. This form can be found in Administrative Rule 109 Division 011—Operation and Maintenance of Stormwater Facilities.

(7) Operation and Maintenance Plan

An Operations and Maintenance (O&M) Plan shall be completed and submitted with the design submittal. O&M requirements for Basic Stormwater Facilities are included in Administrative Rule 109 Division 011—Operation and Maintenance of Stormwater Facilities.

(b) Additional Submittal Items for the Simplified Method

Any project using the Simplified Method shall provide a **final Simplified Sizing Form** per **Appendix 4A.4.**

The Simplified Sizing Form must reflect the final design assumptions and infiltration rates applicable to the sizing of stormwater facilities. The square footage for each facility, as computed on the form, shall be shown on the updated site plans.

(c) Additional Submittal Items for the Engineered Method

Any project using the Engineered Method shall provide a **Final Stormwater Management Report** that includes all items required for a preliminary stormwater management report in Section 4A.1(d) and the following information:

(1) Engineer's Final Certification and Statement

The EOR shall properly seal the document with their Oregon professional engineer stamp on the second page of the document.

(2) Updated Project Overview and Description

The Project Overview shall be updated to include and/or address the following additional information, as applicable:

A. Summary of how existing trees and native vegetation are impacted and/or preserved.

B. Regulatory permits required.

C. Identification of the escape/overflow route through or from the site for flows exceeding the 100-year storm event.

(3) Updated Stormwater Facility Details/Exhibits

The Final Stormwater Management Report shall include reference to all applicable stormwater facility details and exhibits that reflect final design considerations.

(4) Analysis

This section shall be updated to reflect final stormwater facility sizing and contain the following additional information:

A. Conveyance capacity calculations

B. Determination of the escape/overflow route and inundation level for flows exceeding the 100-year, 24-hour event. Results of this analysis shall be illustrated on a site map.

C. Inlet spread and capacity calculations, if applicable

D. Culvert headwater calculations, if applicable

E. Energy dissipater sizing calculations, if applicable

F. Pretreatment manhole sump calculations, if applicable

G. Any maps/ exhibits/ tables illustrating the final pre- and post-construction catchment areas to each stormwater facility.

H. Final comparison table of the flow rates for pre- and post-construction. The table must show that the project meets the flow control requirements set forth in Administrative Rule 109 Division 004—Stormwater System, see example Table 4A-2, below.

Table 4A-2: Pre vs. Post Construction Flow Rates Table Example

Pre vs. Post Construction Flow Rates						
Facility ID	Peak Flow Rate (cfs)					
	Half of the 2 Year Storm		10 Year Storm		100 Year Storm	
Project Site	Pre	Post	Pre	Post	Pre	Post
AA						
BB						

(d) Additional Submittal Requirements, if Applicable

The following additional submittal items may be required for a project utilizing the Simplified Method or Engineering Method and shall be submitted with the final design if applicable to the project.

(1) Source Control

Provide any site information for potential pollution generating activity at the site, as identified in SRC Chapter 70, and the required response plans identified in Administrative Rule 109 Division 012—Stormwater Source Control.

(2) Downstream Analysis Report

If a downstream analysis is required because a proposed project fails to meet the flow control performance standards in *Salem Revised Code*, the Director may require the developer to conduct analyses to ensure sufficient capacity exists downstream from the location where the drainage water is discharged from the site. The report shall identify any capacity issues that may result from the project/development runoff, and provide the supporting data and analysis as required and identified in this appendix. The report shall provide recommendations for mitigation of downstream capacity issues are identified.

(3) Open Channel Hydraulic Modeling

A. Where open channel hydraulic modeling is used in the downstream analysis, the following information shall be included in the report.

B. A site map showing the location of the project and the surrounding drainage basin.

C. A description of all calculations, references, and modeling used in the analysis.

D. A discussion of how Manning's n-values were determined, including photos of typical cross sections used in determining the n-values.

E. A description of the storm events used in the study and where the information was obtained.

F. A brief description of the physical condition and the estimated capacity of all existing drainage structures analyzed.

G. A list of any previous hydraulic analysis and references relied on for the current study.

H. Cross section plots for all cross sections, plotted at no more than two per 8½ x 11 sheets. Each cross section shall be scaled consistently and properly labeled with the cross-section number. Cross sections shall be perpendicular to the flow and waterway centerline. Sections shall be oriented left to right facing downstream and show the two-year, ten-year, and 100-year water surface elevations.

I. Delivery of model input and output files shall be included with the report package submittal.

J. Additional information may be required by the City, based on the size and complexity of the project.

(4) Floodway and Floodplain Analysis

If a Floodway/Floodplain Analysis is required as a condition of development, the following information shall be submitted in addition to the requirements listed in Section 4A.2(D)(2):

A. A description of how the upstream and downstream boundary conditions were established.

B. All proposed grading, culverts, bridges, drop structures, access ramps, etc., that are located within the floodplain must be shown and included in the modeling.

C. Description of the floodway analysis performed, and the data used.

D. Photographs of the existing study reach.

E. A table with existing and proposed water surface elevations and velocities at each cross section.

F. The 100-year floodplain and floodway lines shall be clearly shown on the map based on the modeling results and tied to the appropriate contour lines.

4A.3 – SITE ASSESSMENT AND PLANNING CHECKLIST

See below.

4A.4 – SIMPLIFIED SIZING FORM

See below.

SITE ASSESSMENT AND PLANNING CHECKLIST

✓	Information Needed	Attach Supporting Materials as needed	
Site Information			
	Contact Information	Point of Contact:	
		Phone Number:	
		Email Address:	
	Site Information	Site Address:	
		Site Area (acres/sq.ft):	
		Disturbance Area (acres/sq.ft):	
	Proposed Stormwater Design Methodology (check one)	☐	**Simplified** (applicable for sites less than or equal to 10,000 ft² new or replaced impervious surface) ○ Attach Preliminary Site Plan, Simplified Sizing Form, and supporting calculations per this checklist
		☐	**Engineered** (applicable for any site greater than or equal to 1,300 ft² new or replaced impervious surface) ○ Attach Preliminary Site Plan and supporting calculations or Preliminary Stormwater Management Report in accordance with land use tier definition.
		☐	**Area Set Aside** (applicable for any site greater than or equal to 1,300 ft² of new or replaced impervious surface that has reserved an area of 10% of the impervious surface for future stormwater facilities) ○ Attach Preliminary Site Plan showing area reserved and supporting calculations in accordance with land use tier definition. Note that a Stormwater Management Report will be required for design approval.
Site Assessment and Design Considerations *(Salem Administrative Rules, Division 004, Section 4.3)*			
	Preliminary Site Plan	*Attach engineered scale Preliminary Site Plan per Section 4A.1. and ensure the following additional information below is included.*	
	Soils Identify NRCS Hydrologic Soil Type(s) (*show on Preliminary Site Plan if multiple*):	**NRCS Soil Group**:	
	Groundwater	*Attach Geotechnical Engineering or geologist investigation documenting measured infiltration rates and seasonal high groundwater depth, if available.*	
	Hydrology – Conditions and Natural Features	Check if the following is present on site:	
		☐ Waterway	☐ Sensitive natural areas(s) (list): ☐ Floodplain / Floodway
	Minimize Site Disturbance	*Delineate protection areas on Preliminary Site Plan for areas to remain undisturbed during construction.*	
	Preserve Existing Vegetation	**Existing trees and native vegetation must be preserved unless approved for removal under SRC Chapter 808.** *Identify trees and native vegetation being retained on the Preliminary Site Plan.*	
	Minimize Soil Compaction	*Show temporary fencing around proposed green stormwater infrastructure (GSI) facilities and revegetation areas on the Preliminary Site Plan to minimize soil compaction and preserve existing soil permeability.*	
	Impervious Area Accounting	Summarize proposed new and replaced impervious areas and any proposed impervious area reduction methods below. Reflect areas and locations on the Preliminary Site Plan.	
		A.	Total proposed new/replaced impervious area (sq. ft.):
		B.	Area of proposed Green Roofs (sq. ft.):
		C.	Area of proposed pervious pavement (sq. ft.):
			Describe type of pavers or pavement proposed
		D	**Impervious area requiring stormwater treatment [A-(B+C)] (sq. ft.):**
		E.	**Impervious area requiring flow control [A - C -(0.5*B)] (sq. ft.):**

SITE ASSESSMENT AND PLANNING CHECKLIST

Infiltration Feasibility

Infeasibility Criteria

See PWDS Section **4.3(b)** for a description of these items

Use of infiltration or partial infiltration facilities (i.e., GSI) may limited by the following site conditions *(include documentation to demonstrate the limiting condition).*

Select applicable site conditions:

☐ Steep slopes (≥ 20%)	☐ Within a 100-foot buffer of a domestic well
☐ High seasonal groundwater (less than 3 feet vertical separation from stormwater facility bottom)	☐ Other as proposed in a design exception
☐ Fill Soils	☐ N/A
☐ Contaminated soils	

Infiltration Capacity
Determine soil capacity for onsite infiltration.

If the design infiltration rate is 0.5"/hr or greater, full infiltration of the water quality design storm is required using GSI.

If an infiltration test is performed, attach the documentation. ***See Appendix 4C for the approved infiltration testing methods.***

Test type (*check one*):	☐ Basic Method ☐ Professional Method
Measured Infiltration Rate (inches/hour):	
Design Infiltration Rate (inches/hour): (*Design infiltration rate reflects application of a factor of safety of 2.0 on the measured infiltration rate)*	
Is full onsite retention/infiltration up to the 100-year storm event proposed? *(applicable for design infiltration rates > 2.0 in/hr)*?	☐ Yes ☐ No

For Simplified Method only: If infiltration testing was not conducted, identify the preliminary design infiltration rate based on NRCS Hydrologic Soil Group (HSG) and associated design infiltration rate (see Simplified Sizing Form).

NRCS HSG:	
Design Infiltration Rate (inches/hour):	

Stormwater Management Facility Selection
(Salem Administrative Rules, Division 004, Section 4.6)

Preliminary Facility Selection/Sizing
Show proposed Stormwater Management Facilities on Preliminary Site Plan and check those that apply.

GSI Facilities: ☐ **Water Quality only** ☐ **Water Quality and Flow Control**

☐ Infiltration Planter	☐ Green Roof
☐ Partial Infiltration Planter	☐ Constructed Wetland Treatment System
☐ Infiltration Raingarden	☐ Soakage Trench/Drywell/Manufactured Chamber/Leach Line (Private Only)
☐ Partial Infiltration Raingarden	☐ Other: _____
☐ Flow Dispersion	
☐ Pervious Pavement	

Filtration facilities (*if use of GSI facilities is infeasible to meet the water quality performance standard)*:

☐ Lined Stormwater Planter	☐ Vegetated Filter Strip
☐ Lined Stormwater Raingarden	☐ Manufactured Treatment Technology
☐ Vegetated Swale	

Flow Control Facilities *(if use of GSI facilities is infeasible to meet flow control performance standards)*:

☐ Dry Detention Ponds	☐ Other (specify): _____
☐ Structural Flow Control Facilities	

SITE ASSESSMENT AND PLANNING CHECKLIST		
	GSI to the MEF Green Stormwater Infrastructure to be used to the Maximum Extent Feasible If a Preliminary Stormwater Management Report is not provided, attach sizing calculations for identified facilities.	**The City is required to use GSI to meet the water quality performance standard, at a minimum, based on technical feasibility and the design infiltration rates at the site.** *Indicate preliminary stormwater facility sizing and reflect the proposed facilities and footprint on the Preliminary Site Plan.*
		☐ **Infiltration Rates Confirmed.** If design infiltration rates **are confirmed or established per the NRCS HSG (Simplified Method only)**, calculate surface area of GSI to meet the water quality performance standard, as determined by the Simplified or Engineered method. List name and surface area of GSI (add additional rows as needed): Surface Area of GSI: Facility 1: _____ (sq. ft.) Facility 2: _____ (sq. ft.) Facility 3: _____ (sq. ft.)
		☐ **Infiltration Rates Not Confirmed.** If design infiltration rates are **not confirmed**, calculate the estimated stormwater facility surface area to meet the water quality and flow control performance standard based on the Area Set Aside method: Total new/replaced impervious area (sq. ft.) x 0.10 = _____ (sq. ft.)
	If Onsite Stormwater Management is Infeasible and/or Design Exceptions are required.	*If onsite stormwater management is not feasible, attach additional documentation needed per Appendix 4E and indicate proposed stormwater management approach.*
		☐ Offsite stormwater management facilities/regional facilities
		☐ Fee in Lieu, as determined by the City

OFFICE USE ONLY
DATE RECEIVED:

CITY OF Salem AT YOUR SERVICE

SIMPLIFIED SIZING FORM

DEVELOPMENT SERVICES DIVISION

CITY HALL / 555 LIBERTY STREET SE, ROOM 320 / SALEM, OR 97301-3513

SIMPLIFIED SIZING FORM 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 infiltration, treatment, and flow control requirements using GSI or filtration facilities.

This form is only for sites with **10,000 square feet** of a new or replaced impervious area or less.

Instructions	Site Information

Project Category

Note: Stormwater facilities for Residential Projects (1,300 square feet or greater but less than 5,000 square feet of new or replaced impervious surface) must be sized for water quality at a minimum.

Stormwater facilities for Large Projects (5,000 square feet or greater new or replaced impervious surface) must be sized for water quality and flow control.

Select the type of project:

☐ Residential (RES) Project

☐ Large Project

Site Area (refer to Site Assessment and Planning Checklist)

1. Enter square footage of new and/or replaced impervious site area.	(1) Total Impervious Area	_____ SF
2. Enter amount of impervious area reduction (e.g., *pervious pavement, green roofs).*	(2A) Pervious Pavement Area	_____ SF
	(2B) Green Roof Area	_____ SF
3. Subtract **(2A and 2B)** from **(1)** to calculate total impervious area requiring stormwater management facilities for treatment. **(3) = (1) – (2A + 2B)**	(3) Required Impervious Area requiring Treatment	_____ SF
4. Subtract **(2A)** and 50% of **(2B)** from **(1)** to calculate total impervious area requiring stormwater management facilities for flow control. **(4) = (1) – (2A) – 0.5*(2B)**	(4) Required Impervious Area requiring Flow Control	_____ SF

Stormwater Facilities

Select (check box) the desired stormwater facilities from rows **(a)** through **(h)** in **Column 1**, below.

Enter the square footage of new/replaced impervious area that will be managed by the respective stormwater management facility type in **Column 2**.

Multiply each impervious area from **Column 2** by the corresponding sizing factor (based on the measured infiltration rate) in **Column 3** and enter the result in **Column 4**. This is the facility surface area required.

SIMPLIFIED SIZING FORM FOR STORMWATER MANAGEMENT				
Column 1	**Column 2**	**Column 3**		**Column 4**
Stormwater Management Facility	**Impervious Area Managed**	**Design Infiltration Rate (in/hr)**	**Sizing Factor**	**Facility Surface Area**
Water Quality Only – *This section can be used for RES projects or Large Projects. If used for Large Projects, a flow control facility, sized in accordance with the Engineered Method, is required. Please refer to Section 4.6 for facility-specific design criteria applicable for design of stormwater facilities with the Simplified Method.*				
☐ a. Partial Infiltration / Lined Planter	_____ SF	☐ < 0.5	6% with Underdrain	_____ SF
☐ b. Infiltration Planter	_____ SF	☐ 0.5 – 0.74	6%	_____ SF
		☐ 0.75 – 0.99	4%	_____ SF
		☐ 1.00 – 1.99	3%	_____ SF
		☐ ≥ 2.00	2%	_____ SF
☐ c. Partial Infiltration / Lined Rain Garden	_____ SF	☐ < 0.50	8% with underdrain	_____ SF
☐ d. Infiltration Rain Garden	_____ SF	☐ 0.5 – 0.74	8%	_____ SF
		☐ 0.75 – 0.99	6%	_____ SF
		☐ 1.00 – 1.49	5%	_____ SF
		☐ 1.50 – 1.99	4%	_____ SF
		☐ ≥ 2.00	3%	_____ SF
☐ e. Soakage Trench/Leach Line (for residential roof runoff only)	_____ SF	☐ < 0.5	10%	_____ SF
		☐ 0.5 – 0.74	6%	_____ SF
		☐ 0.75 – 0.99	5%	_____ SF
		☐ 1.00 – 1.49	4%	_____ SF
		☐ 1.49 – 1.99	3%	_____ SF
		☐ ≥ 2.00	2%	_____ SF
Water Quality and Flow Control– *This section can be used for RES projects or Large Projects. Please refer to Section 4.6 for facility-specific design criteria applicable for design of stormwater facilities with the Simplified Method.*				
☐ f. Infiltration Planter	_____ SF	☐ 0.5 – 0.74	18%	_____ SF
		☐ 0.75 – 0.99	12%	_____ SF
		☐ 1.00 – 1.24	10%	_____ SF
		☐ 1.25 – 1.49	9%	_____ SF
	_____ SF	☐ 1.50 – 1.99	8%	_____ SF

SIMPLIFIED SIZING FORM FOR STORMWATER MANAGEMENT				
☐ f. Infiltration Planter (continued)	(continued)	☐ ≥ 2.00	7%	_____ SF
☐ g. Infiltration Raingarden (2' bottom width)	_____ SF	☐ 0.5 – 0.74	25%	_____ SF
		☐ 0.75 – 0.99	20%	_____ SF
		☐ 1.00 – 1.24	18%	_____ SF
		☐ 1.25 – 1.49	16%	_____ SF
		☐ 1.50 – 1.74	14%	_____ SF
		☐ 1.75 – 1.99	13%	_____ SF
		☐ ≥ 2.00	12%	_____ SF
☐ h. Infiltration Rain Garden (4' bottom width)	_____ SF	☐ 0.5 – 0.74	24%	_____ SF
		☐ 0.75 – 0.99	18%	_____ SF
		☐ 1.00 – 1.24	15%	_____ SF
		☐ 1.25 – 1.49	14%	_____ SF
		☐ 1.50 – 1.74	12%	_____ SF
		☐ 1.75 – 1.99	11%	_____ SF
		☐ ≥ 2.00	10%	_____ SF
Impervious Area Managed				
5. Total **Column 2** (**Rows a - h**) and enter the resulting "Total Impervious Area Managed" on line **(5). This must equal (3) + (4).**		(5) Total Impervious Area Managed		_____ SF

The following table of Natural Resources Conservation Service (NRCS) Hydrologic Soil Group infiltration rates is intended to be used as a reference guide in the circumstance that onsite infiltration testing is infeasible.

NRCS Saturated Hydraulic Conductivity Rates			
Hydrologic Soil Group	**Design Infiltration Rate (in/hr)**	**Hydrologic Soil Group**	**Design Infiltration Rate (in/hr)**
A	2.00	C	0.25
B	1.00	D	0.10
B/D	0.10	C/D	0.10

APPENDIX 4B
LANDSCAPE REQUIREMENTS AND PLANT LISTS FOR STORMWATER FACILITIES

CITY OF SALEM
DEPARTMENT OF PUBLIC WORKS
ADMINISTRATIVE RULES
CHAPTER 109
DIVISION 004 APPENDIX B
LANDSCAPE REQUIREMENTS AND PLANT LISTS FOR STORMWATER FACILITIES

SECTION

FIGURES

TABLES

4B.1 – GENERAL

The City encourages the use of native plants in stormwater facilities, since they are best suited to long-term survival in the local climate. Because all landscaping needs may not be met by native plants, some ornamental non-native plants may be acceptable for use. This appendix provides a list of native and non-native plants allowed for use in stormwater facilities constructed in the City.

Vegetation listed as invasive or nuisance in the City's Tree and Vegetation Technical Manual is strictly prohibited in drainage control facilities, as well as any plant listed on a noxious weed list for Oregon. The Tree and Vegetation Manual can also be found at https://www.cityofsalem.net/community/household/home-improvement/tree-removal-on-your-property.

Contact the City of Salem Parks Department Urban Forester for approved stormwater trees for planting in stormwater facilities in the ROW.

When submitting landscaping plans, provide the square footage for both the total facility area and the plantable area (total facility area minus areas that cannot be planted such as outfalls, beehive inlet grates, check dams, etc.).

4B.2 – PLANTING ZONES

Planting zones are used to define the various vegetation and planting requirements within a stormwater facility (see Figure 4B-1).

(a) Zone 1

The area of the stormwater facility from the bottom of the facility to the water surface elevation associated with the water quality design storm event. This area has moist to wet soils and plants located in this zone must tolerate intermittent inundation. Trees and large shrubs shall be avoided in this zone. [USACE National Wetland Plant List (NWPL), OBL/FACW]

(b) Zone 2

The area of the stormwater facility from the water surface elevation associated with the water quality design storm event to the maximum water surface elevation. This area typically has dry to moist soils, with the moist soils being located further down the side slopes. Plants in

this zone shall be drought tolerant and help stabilize the slopes through all seasons. [USACE NWPL, FAC]

(c) Zone 3

The area of the stormwater facility from the maximum water surface elevation to the outer edge of the stormwater facility and may include the upland area. This zone is typified by dry soils. Plants in this zone shall be drought tolerant. [USACE NWPL, FACU/ UPL/ NI]

(d) Landscaping in a dedicated stormwater facility tract

For stormwater facilities that are built on a dedicated stormwater facility tract, landscaping and irrigation must be provided for the entire lot. Landscaping outside the stormwater facility is intended for aesthetics and does not need to meet the same plant density requirements as landscaping inside the facility.

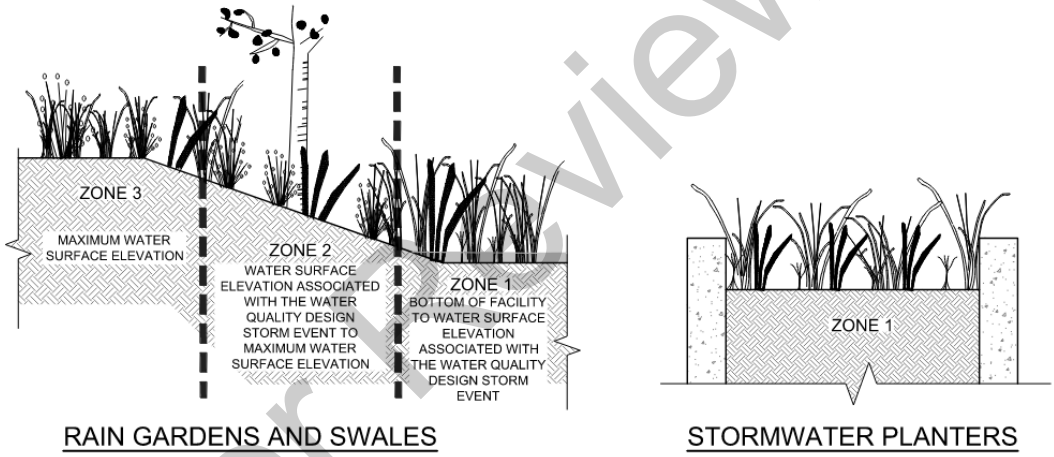

Figure 4B-1: Planting Zones

4B.3– PLANTING, LANDSCAPING, AND IRRIGATION REQUIREMENTS

The vegetation used in GSI facilities may also be used to meet other landscape requirements of the project. Stormwater facilities with vegetative plantings must meet the following requirements:

(a) General Requirements

(1) For all facilities located in riparian corridors and City-owned stormwater facilities, all plants shall be appropriate native species from the plant list contained in this appendix. For private stormwater facilities, non-native plant varieties may be used which are suitable for the planting zone specified in the facility design. Approved plant types are listed in Table 4B-2.

(2) Stormwater facilities located in the ROW are not permitted to use evergreen trees to meet landscaping requirements. Street trees in the ROW shall be located outside of planters and other GSI stormwater facilities unless otherwise approved by the Urban Forester and/or the Green Stormwater Infrastructure Supervisor. If street trees are placed in planters, the minimum width of the facility is 4 feet and the facility must be designed to allow the tree to grow to maturity without impacting any piping or the liner.

(3) All plantings in and adjacent to the ROW shall be appropriate for the area and are limited to 30 inches in height when in or near the vision and sight clearance areas. Select plants based on growing habits and long-term pruning and maintenance requirements; do not select plants that will outgrow the facility and become a nuisance by growing over the public sidewalks.

(b) Planting Materials

(1) Selected plant materials must be appropriate for soil, hydrologic, and other facility and site conditions.

(2) The density of plantings shall be consistent with the requirements listed in this appendix. The intent is for the plants to be dense enough when mature to minimize the growth of weeds and invasive species and reduce the amount of needed maintenance.

A. The combination of plant materials for the facilities shall be selected from the lists in this Appendix to provide a three-layer approach to enhance the long-term sustainability and viability of the scheme: 1) Trees shall have shrubs and/or groundcover beneath their canopy; 2) Shrubs shall have groundcover interplanted between them; 3) Groundcover shall be selected for viability in the Zone planted, and shall not require mowing (grasses shall be limited to easily-identified clumps of grass).

B. All zones must have a minimum of 50 percent evergreen species and herbaceous evergreen species and be integrated throughout the facility to increase filtration during winter months.

C. Perennial plants and bulbs may be planted to add seasonal color and variety, but any plants that go dormant in the winter may not be counted towards the minimum plant densities required for the water quality function of the stormwater facility.

(3) Consider the stormwater facility type when choosing plants:

A. Stormwater facilities less than 3 feet wide must not use plants that will become too large and outgrow the facility,

B. Lined stormwater facilities must not have large plants such as trees and shrubs that have aggressive root systems,

C. Stormwater facilities adjacent to buildings and other structures must not have plants that impact the buildings footings, windows, retaining walls, culverts, underground pipes and utilities, or other structures, and

D. Stormwater facilities using perforated pipes for an underdrain shall not have trees or large shrubs planted where the roots can impact the piped areas.

(4) The planting design shall minimize the need for herbicides, fertilizers, or pesticides at any time before, during, after construction, and on a long-term basis. Their use is strongly discouraged because of the potential negative impacts to waterways. If pesticides or herbicides are required, use the services of a licensed applicator and products approved for aquatic use. Any chemicals applied in City-owned facilities shall be in conformance with the City's Integrated Pest Management (IPM) Policy.

(c) Irrigation, Landscaping, and Maintenance

(1) Plants, landscape materials, soils, and irrigation systems must be inspected during and at the end of construction to determine conformance with the approved design, confirm that the City standards and specifications have been met, and that the vegetation is healthy and viable. Any portions not meeting the requirements will need to be replaced and re-established prior to substantial completion of the project and the City will accept or reject them at the end of construction when the project is substantially complete.

(2) Maintenance procedures for plant establishment, such as control of invasive weeds, animal and vandal damage, mulching, re-staking, watering, and mesh or tube protection replacement, etc. are needed to ensure plant survival and shall be provided with the design submittal.

(3) Certified weed-free native grass or native wildflower seed shall be applied at the rates specified by the supplier for facility types that allow for seeding. If plant establishment cannot be achieved with seeding by the time construction of the stormwater facility has been completed, the design shall provide for planting the area with wildflower sod, plugs, container plants, or other methods to establish the vegetation and protect the facility against erosion before water is allowed to enter the facility.

(4) All stormwater facilities shall be designed so long-term frequent irrigation is not needed. However, permanent irrigation is required for all City-owned stormwater facilities. Planting and irrigation plans submitted for City-owned stormwater facilities on a dedicated stormwater tract shall include irrigation for the entire landscaped area, not just the stormwater facility. For stormwater facilities that are located on private property where no permanent irrigation will be provided, a 2-year plant establishment schedule must be provided with the landscape planting plan, describing the amount of water to be applied over a 2-year time period and how that water will be distributed to the plant material.

(5) Growing medium shall be placed at a minimum depth of 12 inches over native soil across the entire facility (including facility bottom, side slopes, and upland areas), unless otherwise noted in the Standard Plans. See Appendix 4G–Key Material Specifications for details on topsoil, organic soil amendment, and growing medium requirements.

(6) A 3-inch layer of round rock (¾" to 1" in diameter) shall be specified over the growing medium between the plantings in Planting Zone 1. Rock shall taper around each planting to avoid smothering the plant base. Organic mulch specified as a cover material, such as bark or compost shall be placed at a depth of 2- to 3-inches above the high-water mark, in Planting Zones 2 or 3. Organic mulch shall not be placed such that it may enter waterways or clog facility inlets or outlets.

4B.4 – PLANT INSTALLATION

Any stormwater facilities being used during the construction phase as a temporary sedimentation basin must delay placing soil and growing media or installing permanent vegetation until the stormwater facility is no longer being used for erosion control purposes. Sediment removal, growing media replacement, and vegetation replacement will likely be required prior to City acceptance if the stormwater facility is finished prior to construction being complete.

Plants shall be installed as soon as feasible after placing and grading the soil and growing media in order to minimize erosion and compaction. As much as possible, planting shall be done in the early fall for optimal plant survival.

Table 4B-1: Plant Spacing for Grasses, Rushes, and Sedges

Container Size	Spacing
Plug (9 cubic inch) 50 cell tray, deep	9-inch on center, tri-space
4-inch pot	9-inch on center, tri-space
1-gallon container	12-inch on center, tri-space
Seeding – dry detention ponds and filter strips only	See **Section 4B.10** for seeding rates

4B.5 – PLANTING REQUIREMENTS - PLANTERS

(a) Planting Zones

(1) Planters have only one plant zone, Zone 1. Approved plants for planters are listed in Table 4B-2.

(b) Planting Requirements

(1) Plants shall be spaced evenly. Use the spacing identified in Table 4B-1 for the plants selected.

(2) The following plant quantities and sizes shall be installed per each 100 square feet (sf) of surface area:

A. Woody Plants:

(i). Four shrubs/small trees: 3-gallon container or equivalent. Trees can only be used to meet this requirement if approval has been given to use them in the planter, and care must be taken to not plant in or near any vision and sight clearance areas.
- OR -

(ii). Six shrubs: 1-gallon container or equivalent.

B. Herbaceous Plants: 100 percent coverage of remaining plantable area must be achieved with appropriate plant species for each Zone as listed in Table 4B-2.

4B.6 – PLANTING REQUIREMENTS - RAIN GARDENS, VEGETATED FILTER STRIP, AND VEGETATED SWALES

(a) Planting Zones

(1) These facilities have three planting zones (1−3). Plants approved for use in these facilities are included in Table 4B-2.

(b) Planting Requirements

(1) Minimum plant material quantities per 100 sf of facility area are as follows:

A. Woody Plants: One evergreen or deciduous tree or group of shrubs planted on the perimeter.

(i). Evergreen trees: Minimum height: 6 feet.
- OR -

(ii). Deciduous trees: Minimum caliper: 1½-inches at 6 inches above base.
- OR -

(iii). Four large shrubs/small trees: 3-gallon container or equivalent.
- OR -

(iv). Six shrubs: 1 gallon container or equivalent.

B. Herbaceous Plants: 100 percent coverage of remaining plantable area must be achieved with plants species for that Zone as listed in Table 4B-2.

4B.7 – PLANTING REQUIREMENTS - DRY DETENTION POND

(a) Planting Zones

(1) These facilities have three planting zones (1−3). Plants approved for use in these facilities are included in Table 4B-2.

(b) Planting Requirements

(1) For soils with slow infiltration rates (less than two inches per hour) moist to wet plants are preferable; for soils with higher infiltration rates moist to dry plants are preferable. At least 50 percent of the facility shall be planted with grasses, rushes, or sedges. If the dry detention pond is combined with a GSI or filtration facility to address the water quality performance standard, the portion of the facility designed for water quality treatment shall be planted in accordance with the planting requirements for the applicable GSI or infiltration facility type.

(2) Minimum plant material quantities per 250 sf of basin area shall be as follows:

A. Woody Plants: One evergreen or deciduous tree or group of shrubs planted on the perimeter:

(i). Evergreen trees: Minimum height: 6-feet.
- OR -

(ii). Deciduous trees: Minimum caliper: 1½ inches at 6-inches above base.
- OR -

(iii). Four large shrubs/small trees: 3-gallon container or equivalent.
- OR -

(iv). Six shrubs: 1-gallon container or equivalent.

B. Herbaceous Plants: 100 percent coverage of remaining plantable area must be achieved with plants species for that Zone as listed in Table 4B-2, and as stated above at least 50 percent of the dry detention pond must be from the Grasses, Rushes, Sedges category of Table 4B-2.

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		Proposed Facility Type					Characteristics		
Botanic Name, Common Name	Zone	Planters	Rain Garden	Filter Strip	Swale	Dry Detention Pond	Potential Height	O.C. Spacing	Evergreen (E) or Deciduous (D)
Grasses, Sedges, and Rushes [1]									
Agrostis exarata Spike Bentgrass	1, 2	•	•	•	•	•	3′	1′	D
Beckmannia syzigachne American Slough Grass	1	•	•	•	•		3′	1′	D
Bromus carinatus California Brome Grass	3		•	•	•	•	2′	1′	D
Bromus sitchensis Alaska Brome	3		•	•	•	•	5′	1′	D
Bromus vulgaris Columbia Brome Grass	3		•	•	•	•	2′	1′	D
Carex densa Dense Sedge	1	•	•	•	•		2′	1′	E
Carex deweyana Dewey Sedge	2		•	•	•	•	2′	1′	E
Carex hendersonii Henderson Sedge	2				•	•	3′	1′	E
Carex obnupta Slough Sedge	1	•	•	•	•		4′	2′	E
Carex stipata Sawbeak Sedge	1	•	•	•	•		3′	1′	E
Carex tumulicola Foothill Sedge	2, 3				•	•	2′	1′	E
Danthonia californica California Oatgrass	2		•	•	•		3′	1′	D
Deschampsia caespitosa Tufted Hairgrass	1, 2	•	•	•	•	•	4′	2′	D
Deschampsia elongata Slender Hairgrass	1, 2	•	•	•	•	•	1′	1′	D
Eleocharis acicularis Needle Spike-Rush	1	•	•	•	•		1′	1′	E
Eleocharis ovata Ovate Spike-Rush	1	•	•	•	•		1.5′	1′	E
Eleocharis palustris Creeping Spike-Rush	1	•	•	•	•		3′	1′	E
Elymus glaucus Blue Wildrye	2, 3		•	•	•	•	3′	1′	D
Elymus trachycaulus Slender Wheatgrass	2, 3						3′	1′	D
Festuca occidentalis Western Fescue Grass	3		•	•	•	•	3′	1′	D
Festuca roemeri* var. *roemeri Roemer's Fescue	3	•	•	•	•	•	2′	1′	D
Festuca rubra* var. *commutata Western Red Fescue	2, 3						3′	1′	D
Glyceria occidentalis Western Mannagrass	1	•	•	•	•		5′	1′	D
Hordeum brachyantherum Meadow Barley	1, 2		•	•	•	•	3′	1′	D
Juncus acuminatus Tapertip Rush	1	•	•	•	•		3′	1′	E
Juncus effusus* var. *gracilis Common or Lamp Rush	1	•	•	•	•		3′	1′	E

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		**Proposed Facility Type**					**Characteristics**		
Botanic Name, Common Name	**Zone**	**Planters**	**Rain Garden**	**Filter Strip**	**Swale**	**Dry Detention Pond**	**Potential Height**	**O.C. Spacing**	**Evergreen (E) or Deciduous (D)**
Juncus effusus* var. *pacificus Common or Pacific Rush	1	•	•	•	•		3′	1′	E
Juncus ensifolius Dagger-leaf Rush	1	•	•	•	•	•	2′	1′	E
Juncus oxymeris Pointed Rush	1	•	•	•	•		3′	1′	E
Juncus patens Grooved Rush, Spreading Rush	1	•	•	•	•	•	2′	1′	E
Juncus tenuis, Slender Rush	1, 2	•	•	•	•	•	2′	1′	E
Juncus unilateralis One-sided Rush	1	•	•	•	•		2′	1′	E
Koeleria (Aira) macrantha Junegrass	2, 3		•	•	•	•	2′	1′	D
Scirpus acutus, Hardstem Bulrush	1	•	•	•	•		5′	4′	E
Scirpus americanus Three-square or American Bulrush	1	•	•	•	•		3′	1′	E
Groundcover [(1)]									
Arctostaphylos uva-ursi Kinnikinnik	3		•	•	•	•	1′+	1′	E
Fragaria vesca Woodland strawberry	2, 3		•	•	•	•	1′+	1′	E
Fragaria chiloensis Beach Strawberry	2, 3	•	•	•	•		0.5’	1.5’	E
Fragaria virginiana Wild strawberry	2, 3		•	•	•	•	1′+	1′	E
Forbs (Herbaceous Plants) [(1)]									
Achillea millefolium Western Yarrow	2, 3				•	•	3′	1′	E
Alisma plantago-aquatica Water Plantain	1	•	•	•	•		1′	1′	D
Allium acuminatum Hooker’s Onion	2, 3		•			•	1′	1′	D
Allium amplectens Slim Leaf Onion	2, 3		•			•	1′	1′	D
Aquilegia formosa Western Columbine	2, 3		•		•	•	3′	1′	D
Asarum canadense Wild Ginger	1	•	•	•	•		1’	1’	E
Asclepias speciosa Showy Milkweed	2, 3		•		•		4’	1.5’	D
Aster subspicatus Douglas’ Aster	1, 2	•	•	•	•	•	3′	1′	D
Bidens cernua Nodding Beggartick	1	•	•	•	•	•	3′+	1′	D
Brodiaea coronaria Harvest Brodiaea	1, 2	•	•			•	1′	1′	D
Camassia leichtlinii Great Camas	1, 2	•	•	•	•	•	3′	1′	D

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		Proposed Facility Type					Characteristics		
Botanic Name, Common Name	Zone	Planters	Rain Garden	Filter Strip	Swale	Dry Detention Pond	Potential Height	O.C. Spacing	Evergreen (E) or Deciduous (D)
Camassia quamash Common Camas	1, 2	•	•	•	•	•	3′	1′	D
Clarkia amoena Farewell to Spring [A]	2, 3					•	3′	1′	D
Clarkia purpurea Four Spot Godetia [A]	2, 3					•	2′	1′	D
Collinsia rattanii Blue-eyed Mary [A]	2, 3					•	2′	1′	D
Collomia grandiflora Large-flowered Collomia [A]	2, 3					•	2′	1′	D
Coreopsis grandifolia Tickseed	2,3		•		•		2’	1’	D
Dicentra Formosa Pacific Bleeding Heart	1					•	1’	1’	D
Dichelostemma congestum Ookow	2, 3					•	2′	1′	D
Downingia elegans Calico Flower [A]	1	•	•	•	•	•	1′	1′	D
Epilobium densiflorum Denseflower Willow-herb	1	•				•	2′	1′	D
Eriophyllum lanatum Woolly Sunflower	3					•	2′	1′	D
Eriophyllum lanatum var. integrifolium Oregon Sunshine	3		•		•	•	2‘	1’	D
Erythranthe guttatus Yellow Monkeyflower	1, 2	•	•	•	•		0.5’	2’	D
Erythronium oregonum Oregon Fawn Lily	2, 3		•		•	•	2’	0.5’	D
Erythronium ‘Pagoda’ Dog Tooth Violet	2, 3		•		•	•	4’	0.5’	D
Fritillaria camschatcensis Chocolate Lily	2, 3		•		•	•	2’	0.5’	D
Geum macrophyllum Large-leaf Avens	2		•	•	•		2′	1′	D
Gilia capitata Bluefield Gilia	3		•	•	•	•	2′	1′	D
Grindelia integrifolia Gumweed	1, 2	•				•	3′	1′	D
Iris douglasiana Douglas Iris	2, 3		•	•	•	•	2’	1’	D
Iris tenax Oregon Iris	2, 3		•	•	•	•	2′	1′	D
Lilium columbianum Columbia Lily	2, 3		•		•	•	3’	1’	D
Lilium lancifolium Tiger Lily	2, 3		•		•	•	4’	1’	D
Lotus purshiana Spanish Clover	1	•					2′	1′	D
Lupinus albicaulis Sickle-keeled Lupine	2, 3					•	5′	3′	D
Lupinus micranthus Small-flowered Lupine [A]	2, 3					•	1′	1′	D

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		**Proposed Facility Type**					**Characteristics**		
Botanic Name, Common Name	**Zone**	**Planters**	**Rain Garden**	**Filter Strip**	**Swale**	**Dry Detention Pond**	**Potential Height**	**O.C. Spacing**	**Evergreen (E) or Deciduous (D)**
Lupinus polyphyllus Bigleaf Lupine	2		•	•	•		3′	1′	D
Lupinus rivularis Stream Lupine	2						3′	1′	D
Madia elegans Common Madia [A]	2, 3					•	3′	1′	D
Mimulus lewisii Purple Monkeyflower	1, 2	•	•	•	•		0.5’	2’	D
Plagiobothrys figuratus Fragrant Popcorn-flower [A]	1	•	•	•	•	•	1′	1′	D
Plagiobothrys scouleri Scouler's Popcorn flower [A]	1	•	•	•	•	•	1′	1′	D
Potentilla gracilis Slender Cinquefoil	2		•		•	•	2′	1′	D
Prunella vulgaris* var. *lanceolata Lance Selfheal	3					•	1′	1′	E
Ranaunculus occidentalis Western Buttercup	1	•					2′	1′	D
Ranunculus orthorhyncus Straightbeak Buttercup	1	•					3′	1′	D
Sanguisorba annua (occidentalis) Prairie Burnet [A]	3					•	2′	1′	D
Saxifraga occidentalis Western Rockbreaker	3					•	1′	1′	E
Sidalcea campestris Meadow Checker-mallow	3					•	4′	1′	D
Sidalcea virgata Rose Checkermallow	3					•	3’	1’	D
Sisyrinchium douglasii Purple-Eyed Grass	2, 3		•	•	•	•	1′	1′	D
Sisyrinchium calfornicum Golden-eyed Grass	1	•	•	•	•		1′	1′	D
Sisyrinchium idahoense Idaho Blue-eyed Grass	1	•	•	•	•		1′	1′	D
Solidago canadensis Canadian Goldenrod	3					•	5′	1′	D
Symphyotrichum (Aster) hallii Hall's Aster	2, 3		•	•	•	•	2′	1′	D
Athyrium filix-femina Lady Fern	2	•				•	3′	2′	E
Blechnum spicant Deer Fern	2	•	•	•	•	•	3′	4′	E
Polypodium glycyrrhiza Licorice Fern	2	•	•	•	•	•	1′	1′	E
Polystichum munitum Sword Fern	2, 3	•	•	•	•	•	5′	4′	E
Shrubs									
Cornus sericea ‘Arctic Fire’ Redtwig Dogwood	1, 2	•	•	•	•	•	5’	4’	D
Cornus sericea ‘Kelseyi’ Kelseyi Dogwood	1, 2	•	•	•	•	•	3’	2.5	D
Gaultheria shallon Salal	2, 3		•	•	•	•	5′	2′	E

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		**Proposed Facility Type**					**Characteristics**		
Botanic Name, Common Name	**Zone**	**Planters**	**Rain Garden**	**Filter Strip**	**Swale**	**Dry Detention Pond**	**Potential Height**	**O.C. Spacing**	**Evergreen (E) or Deciduous (D)**
Mahonia aquifolium Tall Oregon Grape	2, 3		•	•	•	•	6′	4′	E
Mahonia nervosa Dull Oregon Grape	2, 3		•	•	•	•	2′	2′	E
Mahonia repens Creeping Oregon Grape	2, 3	•	•	•	•		2’	2’	E
Rosa rugosa Purple Pavement Rose	2, 3		•	•	•	•	6’	5’	D
Spiraea douglasii Douglas Spiraea	1, 2		•	•	•	•	6′	4′	D
Symphoricarpos albus Common Snowberry	2, 3	•	•	•	•	•	5′	2′	D
Large Shrubs / Small Trees (20 feet and under)									
Acer circinatum Vine Maple	2, 3	•	•	•	•		20′	12′	D
Amelanchier alnifolia Western Saskatoon Serviceberry	2, 3		•	•	•		9′	12′	D
Arctospathylos Adans. Manzanita	3		•		•	•	12’	11’	E
Ceanothus cuneatus Buckbrush	3		•	•	•	•	9′	12′	E
Ceanothus integerrimus Deerbrush	2, 3		•	•	•	•	12′	12′	E
Ceanothus sanguineous Oregon Redstem Ceanothus	3		•	•	•	•	12′	10′	D
Ceanothus velutinus Snowbrush	2, 3		•	•	•	•	10′	10′	E
Cornus sericea ‘Flaviramea’ Yellowtwig Dogwood	1, 2	•	•	•	•	•	8’	8’	D
Cornus sericea Red-osier or Redtwig Dogwood	1, 2	•	•	•	•	•	14′	12′	D
Corylus cornuta Western Beaked Hazelnut	3		•	•	•		13′	12′	D
Holodiscus discolor Oceanspray	3		•	•	•		15′	6′	D
Lonicera involucrata Twinberry	2, 3		•	•	•	•	15’	8’	D
Magnolia virginiana ‘Jim Wilson’ Sweetbay Magnolia	2, 3		•	•	•	•	15’	10’	E
Oemleria cerasiformis Indian Plum; Osoberry	1, 2	•	•	•	•		15′	6′	D
Philadelphus lewisii Mock Orange	1, 2	•	•	•	•	•	10′	4′	D
Physocarpus capitatus Pacific Ninebark	1	•	•	•	•	•	12′	6′	D
Rhododendron occidentale Western Azalea	2, 3		•	•	•	•	15’	10’	E
Ribes sanguineum Red-flowering Currant	2, 3		•	•	•	•	10′	4′	D
Rosa nutkana Nootka Rose	2		•	•	•	•	8′	4′	D

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		**Proposed Facility Type**					**Characteristics**		
Botanic Name, Common Name	**Zone**	**Planters**	**Rain Garden**	**Filter Strip**	**Swale**	**Dry Detention Pond**	**Potential Height**	**O.C. Spacing**	**Evergreen (E) or Deciduous (D)**
Rosa pisocarpa Swamp Rose	2		•	•	•	•	8′	4′	D
Rubus parviflorus Thimbleberry	2, 3		•	•	•	•	7′	4′	D
Rubus spectabilis Salmonberry	1, 2	•	•	•	•	•	10′	6′	D
Salix fluviatilis Columbia Willow	1		•	•	•		18′	12′	D
Salix hookeriana Piper's Willow	1	•	•	•	•		18′	12′	D
Salix purpurea Purple Willow	1		•	•	•		15’	12’	D
Sambucus cerulea Blue Elderberry	2, 3		•	•	•		13′	12′	D
Sambucus racemosa Red Elderberry	2, 3		•	•	•		15′	12′	D
Vaccinium ovatum Evergreen Huckleberry	2, 3				•	•	8’	5’	E
Viburnum edule Highbush Cranberry, Squashberry	1, 2	•	•	•	•	•	9′	6′	D
Conifer and Evergreen Trees									
Abies grandis Grand Fir	3		•	•	•	•	100′+	12′	E
Arbutus menziesii Pacific Madrone	3		•	•	•	•	100′+	12′	E
Calocedrus decurrens Incense cedar	3		•	•	•	•	100′+	12′	E
Castanopsis chrysophylla Chinquapin	3					•	100′+	12′	E
Pinus contorta Shore Pine	3		•	•	•	•	45’	12’	E
Pinus monticola Western White Pine	3		•	•	•	•	100′+	12′	E
Pinus ponderosa Ponderosa Pine	3		•	•	•	•	100′+	12′	E
Pseudotsuga menziesii Douglas Fir	2,3		•	•	•	•	100′+	12′	E
Thuja plicata Western Red Cedar	2, 3		•	•	•	•	200′+	12′	E
Tsuga mertensiana Mountain hemlock	3		•	•	•	•	45’+	12’	E
Tsuga heterophylla Western hemlock	2, 3		•	•	•	•	100′+	12′	E
Deciduous Trees									
Acer macrophyllum Big leaf Maple	2, 3		•	•	•	•	100′	12′	D
Alnus rhombifolia White Alder	1		•	•	•	•	80′	12′	D
Alnus rubra Red Alder	1, 2		•	•	•	•	120′	12′	D
Betula nigra 'Dura Heat' **River Birch**	1, 2		•	•	•	•	40’	15’	D

Table 4B-2: Approved Plant Species for Stormwater Facilities									
Plant Name		**Proposed Facility Type**					**Characteristics**		
Botanic Name, Common Name	**Zone**	**Planters**	**Rain Garden**	**Filter Strip**	**Swale**	**Dry Detention Pond**	**Potential Height**	**O.C. Spacing**	**Evergreen (E) or Deciduous (D)**
Cornus nuttallii Western Flowering Dogwood/Pacific Dogwood	2		•	•	•	•	60′	12′	D
Crataegus douglasii (or C. suksdorfii) Douglas Black Hawthorn	2		•	•	•		30′	20′	D
Malus fusca Pacific Crab Apple	1, 2	•	•	•	•		40′	12′	D
***Morella californica* Pacific Wax Myrtle**	2, 3	•	•	•	•	•	30’	15’	E
Nyssa sylvatica ‘Afterburner’ Black Tupelo/Blackgum	1, 2		•	•	•	•	50’	25’	D
Nyssa sylvatica ‘Wildfire’ Black Tupelo/Blackgum	1, 2		•	•	•	•	50’	25’	D
Nyssa sylvatica ‘Green Gable’ Black Tupelo/Blackgum	1, 2		•	•	•	•	50’	25’	D
Populus balsamifera Black Cottonwood	2		•	•	•	•	100′+	12′	D
Prunus emarginata or P.Virginiana, Bitter or Choke Cherry	1	•	•	•	•		50′	12′	D
Rhamnus purshiana Cascara	1, 2	•	•	•	•		30′	12′	D
***Quercus bicolor*, Swamp White Oak**	1, 2	•	•	•	•	•	70’	30’	D
***Quercus shumardii*, Swamp Red Oak**	2, 3	•	•	•	•	•	60’	30’	D
Quercus garryana Oregon White Oak	3		•	•	•	•	80′	12′	D
Quercus kelloggii California Black Oak	3		•	•	•	•	80′	12′	D
Salix lucida (or S. lasiandra) Pacific Willow	1		•	•	•		60′	12′	D
Salix scouleriana Scouler’s Willow	1	•	•	•	•		30′	12′	D
Salix sessilifolia Soft-leafed Willow	1	•	•	•	•		24′	12′	D
Salix sitchensis Sitka Willow	1	•	•	•	•		25′	12′	D
***Sambucas nigra ssp. Carulea*, Blue Elderberry**	2, 3		•	•		•	30’	12’	D
[A] Annual Plant. Limit use in Planting Zone 1 and 2, due to minimal soil retention capabilities.									
[(1)] *On Center Spacing assumes the use of mature plants in one-gallon containers. If less mature plants are used, spacing between plants will be reduced in accordance with* Table 4B-1.									

4B.8 – PLANTING REQUIREMENTS-CONSTRUCTED TREATMENT AND SUBSURFACE GRAVEL WETLANDS

(a) Planting Zones

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.

(b) Planting Requirements

Facility area is equivalent to the area of the wetland, including bottom and side slopes, plus a 10-foot buffer around the wetland.

(1) City-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 City-maintained facilities.

(2) Minimum plant material quantities per 200 sf of the facility area are as follows:

A. Woody Plants: One evergreen or deciduous tree.

(i). Evergreen trees: Minimum height: 6-feet.
- OR -

(ii). Deciduous trees: Minimum caliper: 1½ inches at 6-inches above base.
- OR -

(iii). Four large shrubs/small trees: 3-gallon container or equivalent.
- OR -

(iv). Six shrubs: 1-gallon container or equivalent.

B. Herbaceous Plants:

(i). One plant per 12-inches on center, triangular spacing.

(ii). Minimum container size: 4-inch pot.

(iii). 100 percent coverage of remaining plantable area must be achieved with plants species for that Zone, including Aquatic and Emergent plants as required below, as listed in Table 4B-2.

C. Aquatic and Emergent Wetland Plants:

(i). One plant per 2 sf of a pond emergent plant zone. The emergent plant zone is closest to the shore, where grasses, sedges and rushes provide shelter for frogs, birds, mammals, algae, protozoan, worms, insects, snails and small fish.

(ii). The emergent plant zone shall be at least 25 percent of the total pond water surface area.

(iii). Plants approved for wetland areas are listed below in Table 4B-3:

Table 4B-3: Wetlands Plant List	
Herbaceous Plants (Aquatic and Emergent): Zone 1- Emergent Wet to Saturated	
Alisma plantago-aquatica Water Plantain	**Potamogeton natans* Floating-leaf Pondweed
Carex obnupta Slough Sedge	**Sagittaria latifolia* Broadleaf Arrowhead, Wapato
Eleocharis ovata Ovate Spike rush	*Scirpus acutus* Hardstem Bulrush
Eleocharis palustris Creeping Spike rush	*Sparganium emersum* Narrowleaf Bur-reed
**Lemna minor* Common Lesser Duckweed*	*Veronica americana* American Speedwell
Myosotis laxa Small-flowered Forget-me-not	*Juncus effusus var. pacificus* Common Rush
Zone 1- Moist to Wet Zone	
Alopecurus geniculatus Water foxtail	*Juncus effusus* var. *pacificus* Common Rush or Pacific Rush
Beckmannia syzigachne American Slough Grass	*Juncus ensifolius* Dagger-leaf Rush
Carex densa Dense Sedge	*Juncus oxymeris* Pointed Rush
Carex deweyana Dewey Sedge	*Juncus tenuis* Slender Rush
Carex hendersonii Henderson Sedge	*Juncus patens* Grooved Rush; Spreading Rush
Carex obnupta Slough Sedge	*Juncus unilateralis* One-sided Rush
Carex stipata Sawbeak Sedge	*Lupinus polyphyllus* Large-leaved Lupine
Juncus acuminatus Tapertip Rush	*Chronolect's tabernaemontani* Softstem bulrush
Juncus effusus var. *gracilis* Common Rush or Lamp Rush	
Grasses and Groundcovers: Varying Zones. See Seed and Sowing Rates for Stormwater Facilities (Section 4B.10—Forbs and Section 4B.11—Grasses) or use plant spacing in Table 4B-1.	
Arctostaphylos uva-ursi Kinnikinnik; dry	*Festuca roemeri* var. *roemeri* Roemer's Fescue; dry
Aster hallii Hall's Aster; moist-dry	*Glyceria occidentalis* Western Mannagrass; moist-wet
Aster subspicatus Douglas' Aster; moist-dry	*Iris tenax* Oregon Iris; moist-dry
Bidens cernua, Nodding Beggartick; moist-wet	*Koeleria macrantha* Junegrass; moist-dry
Bromus carinatus California Brome Grass; moist-dry	*Lupinus micranthus* Small Flowered Lupine; moist-dry
Bromus sitchensis Alaska Brome; moist-dry	*Lupinus polyphyllus* Large Leaf Lupine; moist-dry
Bromus vulgaris Columbia Brome Grass; moist-dry	*Lupinus rivularis* Riverbank Lupine; moist-dry
Danthonia californica California Oatgrass; moist-dry	*Potentilla gracilis* var. *gracilis* Graceful Cinquefoil; moist-dry
	Sisyrinchium idahoense Blue-eyed Grass; moist-dry
Shrubs: Moist to Saturated Zones 1, 2	
Acer circinatum Vine Maple	*Rosa pisocarpa* Swamp Rose
Blechnum spicant Deer Fern	*Rubus spectabilis* Salmonberry
Cornus sericea Red-stemmed dogwood	*Salix fluviatilis* Columbia Willow
Physocarpus capitatus Pacific Ninebark	*Salix hookeriana* Hookers Willow
Polystichum munitum Sword fern	*Salix sitchensis* Sitka Willow
Rhamnus purshiana Cascara	*Viburnum edule* Highbush Cranberry; Squashberry
Spiraea douglasii Douglas Spiraea	

Table 4B-3: Wetlands Plant List	
Shrubs: Moist to Dry Zones 2, 3	
Crateagus douglasii Black Hawthorn	
Lonicera involucrata Black twinberry	*Rubus parviflorus* Thimbleberry
Mahonia aquifolium Tall Oregon Grape	*Sambucus racemosa* Red Elderberry
Mahonia nervosa Dull Oregon Grape	*Spiraea betulifolia* Birch leaf Spiraea
Oemlaria cerasiformis Indian Plum	*Spiraea lucida* Shiny leaf Spiraea
Prunus emarginata Bitter Cherry	*Symphoricarpus albus*, Snowberry
Shrubs: Dry Zone 3	
Ceanothus cuneatus Buckbrush	*Philadelphus lewisii* Mock Orange
Ceanothus integerrimus Deerbrush	*Ribes sanguineum* Red Flowering Currant
Corylus cornuta Western Beaked Hazelnut	*Salix scouleriana* Scouler's Willow
Holodiscus discolor Oceanspray	
Trees: Conifer and Evergreen Trees: Varying Zones	
Abies grandis Grand Fir; moist-dry	*Pinus ponderosa* Ponderosa Pine; dry
Arbutus menziesii Madrone; dry	*Pseudotsuga menziesii* Douglas Fir; moist-dry
Calocedrus decurrens Incense Cedar; dry	*Sequoia sempervirens* Coast Redwood; moist
Pinus monticola Western White Pine; dry-moist	*Thuja plicata* Western Red Cedar; moist-dry
Deciduous Trees: Varying Zones	
Acer macrophyllum, Big leaf Maple; moist- dry	***Malus fusca*** Pacific Crabapple; moist-wet
Alnus rhombifolia White Alder; moist-wet	***Oemleria cerasiformis*** Indian Plum; moist-dry
Alnus rubra Red Alder; moist-wet	***Populus balsamifera*** Black Cottonwood-; moist-wet
Amelanchier alnifolia Serviceberry; dry	***Quercus garryana*** Oregon White Oak; moist-dry
Cornus nuttalii Western Flowering Dogwood/Pacific Dogwood; moist-dry	***Quercus kelloggii*** California Black Oak; dry
Fraxinus latifolia Oregon Ash; moist-wet	***Salix lucida* var. *lasiandra*** Pacific Willow; moist-wet

4B.9 – GREEN ROOF PLANTS LIST

Table 4B-4: Green Roof Plants List

Plant Name	Characteristics					
Botanic name, Common Name	NW Native	Evergreen	Potential Height	O.C. Spacing	Full Sun	Partial Shade
Sedums and Succulents						
Delosperma ssp., Ice Plant	N	Y	4”		•	
Malephora crocea var. *purpureo crocea* 'TequilaSunrise'	N	Y	10”		•	
Sedum ‘Autumn Joy’	N	N	24”		•	
Sedum acre, Biting Stonecrop	N	Y	2”		•	
Sedum album, White Stonecrop	N	Y	3”		•	
Sedum divergens, Pacific Stonecrop	N	Y	3”		•	
Sedum hispanicum, Spanish Stonecrop	N	Y	3”		•	
Sedum kamtschaticum, Kirinso	N	N	6”		•	
Sedum oreganum, Oregon Stonecrop	Y	Y	4”		•	•
Sedum sexangular, Tasteless Stonecrop	N	Y	4”		•	
Sedum spathulifolium, Stonecrop	Y	Y	4”		•	
Sedum spurium, Two-row Stonecrop	N	Y	6”		•	•
Sempervivum tectorum, Hens and Chicks	N	Y	6”		•	
Herbaceous Plants						
Achillea millefolium, Common Yarrow	N	N	36”		•	
Achillea tomentosa, Wooly Yarrow	N	N	8”		•	
Arenaria Montana, Sandwort	N	N	4”		•	
Artemesia ‘Silver Mound’, Artemesia	N	N	12”		•	
Aurinia saxatilis, Compacta	N	N	6”		•	
Castilleja foliosa, Indian Paintbrush	Y	N	10”		•	
Dianthus ssp.	N	N	12”		•	•
Erigeron discoideus, Fleabane	N	N	12”		•	•
Festuca glauca, Blue Fescue	N	Y	12”		•	•
Fragaria chiloensis, Coastal Strawberry	Y	Y	10”		•	•

Table 4B-4: Green Roof Plants List						
Plant Name	**Characteristics**					
Botanic name, Common Name	**NW Native**	**Evergreen**	**Potential Height**	**O.C. Spacing**	**Full Sun**	**Partial Shade**
Fragaria virginiana, Wild Strawberry	Y	Y	10”		•	•
Gaillardia aristata, Birds-eye gilia	N	N	20”		•	•
Gazania linearis ‘CO Gold’, Gazania	N	N	6”		•	
Gilia capitata, Blue Thimble Flower	Y	N	12”		•	
Koelaria macrantha, June Grass	N	N	24”		•	•
Linaria reticulate, Purplenet Toadflax	N	N	20”		•	
Lobularia maritime, Sweet Alyssum	N	N	12”		•	
Polypodium glycrrhiza, Licorice Fern	Y	Y	12”		•	•
Polystichum munitum, Sword Fern	Y	Y	24”		•	•
Potentilla napalensis, Nepal Cinquefoil	N	N	14”		•	•
Potentilla neumanniana, Cinquefoil	N	N	14”		•	
Thymus serphyllum, Creeping Thyme	N	N	3”		•	
Veronica liwanensis, Speedwell	N	N	2”		•	•

4B.10 – SEED AND SOWING RATES FOR STORMWATER FACILITIES: FORBS

Table 4B-5: Seed and Sowing Rates for Stormwater Facilities: Forbs

Scientific Name	Common Name	Sowing Season	Sow Rate (hand)	Zone
Achillea millefolium	Western yarrow	Fall	0.25 lbs/ac	1, 2
Alisma media	Water plantain	Fall/Spring	1.0 lb/ac	1
Aquilegia formosa	Western columbine	Fall	1.0 lb/ac	1, 2
Camassia leichtlinii	Great camas	Fall	1 lb/ac	1, 2
Camassia quamash	Common camas	Fall	1 lb/ac	1, 2
Clarkia amoena	Farewell to Spring	Fall-early Spring	0.25-1 lb/ac	2, 3
Clarkia purpurea	Four Spot godetia	Fall-early Spring	0.25-1 lb/ac	2, 3
Collinsia rattanii	Blue-eyed mary	Fall/Spring	0.25 lbs/ac	2, 3
Collomia grandiflora	Large-flowered collomia	Fall/Spring	0.5 lbs/ac	2, 3
Epilobium densiflorum	Denseflower willow-herb	Fall	1.0 lb/ac	1, 2
Eriophyllum lanatum	Woolly sunflower	Fall	1.0 lb/ac	1, 2
Geum macrophyllum	Large-leaf avens	Fall-early Spring	0.25-1 lb/ac	1, 2
Gilia capitata	Bluefield gilia	Fall-early Spring	2 lbs/ac	2, 3
Grindelia integrifolia	Gumweed	Fall-early Spring	0.25-1 lb/ac	2, 3
Iris tenax	Oregon iris	Fall	2 lbs/ac	2, 3
Lotus purshiana	Spanish clover	Fall	2 lbs/ac	2, 3
Lupinus albicaulis	Sickle-keeled lupine	Fall	1 lb/ac	2, 3
Lupinus micranthus	Small-flowered lupine	Fall	1 lb/ac	2, 3
Lupinus rivularis	Stream lupine	Fall	1 lb/ac	2, 3
Madia elegans	Common madia	Fall-early Spring	0.25-1 lb/ac	2, 3
Plagiobothrys figuratus	Fragrant popcorn-flower	Fall-early Spring	1 lb/ac	1
Plagiobothrys scouleri	Scouler's popcorn flower	Fall-early Spring	0.25-1 lb/ac	1
Potentilla gracilis	Slender cinquefoil	Fall-early Spring	0.25-1 lb/ac	1, 2
Prunella vulgaris var. lanceolata	Lance selfheal	Fall-early Spring	2 lbs/ac	1, 2
Ranaunculus occidentalis	Western buttercup	Fall	1 lb/ac	2, 3
Ranunculus orthorhyncus	Straightbeak buttercup	Fall-early Spring	0.25-1 lb/ac	1, 2
Sanguisorba annua (occidentalis)	Praire burnet	Fall-early Spring	0.25-1 lb/ac	1, 2
Saxifraga occidentalis	Western Rockbreaker	Fall-early Spring	0.25-1 lb/ac	1, 2
Sidalcea campestris	Meadow checker-mallow	Fall	1 lb/ac	2, 3
Sisyrinchium calfornicum	Golden-eyed grass	Fall	0.25-1 lb/ac	2, 3
Sisyrinchium idahoense	Blue-eyed grass	Fall	0.25-1 lb/ac	2, 3
Solidago canadensis	Canada goldenrod	Fall	0.50 lbs/ac	2, 3
Symphyotrichum (Aster) hallii	Hall's aster	Fall-early Spring	1 lb/ac	2, 3

APPENDIX 4C
INFILTRATION TESTING

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INFILTRATION TESTING

SECTION

FIGURES

TABLES

4C.1 – GENERAL

To properly size and locate a stormwater facility, it is necessary to characterize the soil infiltration rate at the specific location of the proposed stormwater facility. All projects that require a stormwater facility must evaluate existing site conditions and determine if the infiltration rate is adequate to support the proposed stormwater facility.

There are two alternatives for meeting the infiltration testing requirements depending on the size and type of project. These include:

(a) The Basic Method—Open Pit Infiltration Test

The **Basic Method** open pit infiltration test is only allowed for Residential Projects and Large Projects on private property in which the total new pervious pavement, new impervious surface, and replaced impervious surface is 10,000 square feet or less. The Basic Method open pit infiltration test is applicable to stormwater facility sizing using the Simple Method.

(b) Professional Method Infiltration Testing

The **Professional Method** infiltration testing is applicable for Large Projects with greater than or equal to 10,000 square feet of new impervious surface, replaced impervious surface, or new pervious pavement, individually or combined, on private property; or a project with greater than or equal to 10,000 square feet of new impervious surface, replaced impervious surface, or new pervious pavement, individually or combined, in the public right-of-way. Professional Method Infiltration Testing is applicable to stormwater facility sizing using the Engineered Method.

The City reserves the right to require additional testing, if needed.

4C.2 – BASIC METHOD – OPEN PIT INFILTRATION TEST

(a) Description

The purpose of the **Basic Method** infiltration test is to provide a simple method for the non-professional design of stormwater facilities on Residential Projects. The results of infiltration testing must be documented on the **Basic Method Report Form** (see Table 4C-2). For Large Projects, the Professional Method infiltration testing will be used and is found in **4C.3–PROFESSIONAL METHOD INFILTRATION TEST**.

The intent of the open pit infiltration test is to determine the measured infiltration rate for the site, in order to calculate a design infiltration rate. If the design infiltration rate is 0.5 inches/hour or greater, infiltration of the water quality design event is required. A licensed professional is not required when conducting the **Basic Method** infiltration test.

(b) Basic Method Instructions

(1) A simple open pit infiltration test is required for each stormwater facility designed through the Simplified Method (see Section 4.5(b)(1)). The test should be in the location where the stormwater facility is proposed or within the direct vicinity.

(2) Excavate a test hole to the depth where the bottom of the stormwater facility will be located or 4 feet, whichever is deeper. The test hole can be excavated with small excavation equipment or by hand using a shovel, auger, or post hole digger.

(3) If a layer hard enough to prevent further excavation is encountered, or if noticeable moisture/water is encountered in the soil, stop and measure this depth from the surface and record it on the Simplified Method Form (see Appendix 4A.4). Proceed with the test at this depth.

(4) Fill the hole with water to a height of about 6 inches from the bottom of the hole (or to one-half the maximum depth of the proposed facility), and record the exact time. Check the water level at regular intervals (every one minute for fast-draining soils to every ten minutes for slower-draining soils) for a minimum of one hour or until all of the water has infiltrated. Record the distance the water has dropped from the top edge of the hole.

(5) Repeat this process two more times, for a total of three rounds of testing. These tests should be performed as close together as possible to portray the soil's ability to infiltrate at different levels of saturation accurately. The third test provides the best measure of the saturated infiltration rate.

(6) For each test pit required, submit all three testing results with the date, duration, drop in water height, and conversion into inches per hour.

(7) Infiltration facilities shall be used for infiltration rates greater than 0.5 inches. Filtration facilities shall be used for infiltration rates less than 0.5 inches per hour. Facilities can be sized using the simplified method based on infiltration rate results from the basic test.

4C.3 – PROFESSIONAL METHOD INFILTRATION TEST

The Professional Method must be used for all Large Projects. A qualified professional must exercise judgment in the selection of the infiltration test method based on the site conditions. The three acceptable infiltration methods used to determine a design infiltration rate are:

1. Encased Falling Head.
2. Double-Ring Infiltrometer.
3. Open Pit Falling Head.

(a) General Criteria

(1) Testing must be conducted or observed by a qualified professional. A qualified professional may be either a Professional Engineer (PE), Registered Geologist (RG), or Certified Engineering Geologist (CEG) licensed in the State of Oregon.

(2) The location and depth of the test shall be performed at the proposed facility location and depth.

(3) Boring logs should be provided as supporting information with the infiltration and depth to groundwater tests.

(b) Depth and Location of Required Tests

(1) Infiltration tests shall be performed at the base elevation of the proposed facility.

(2) If a confining layer, or soil with a greater percentage of fines, is observed during the subsurface investigation to be within 4 feet of the bottom of the planned infiltration system, the testing shall be conducted within that confining layer.

(3) Tests must be performed in the immediate vicinity of the proposed stormwater facility. Exceptions can be made to the test location provided the qualified professional can support that the strata are consistent from the proposed facility to the test location.

(4) For relatively deep stormwater facilities, a hollow stem auger with an electronic measuring tape can be used, provided there is an adequate seal between the auger and the native soil.

(c) Minimum Number of Infiltration Tests

At least one infiltration test is required for any potential location where a public or private stormwater facility will be sited. For large and/or linear facilities, an additional infiltration test shall be conducted every 100 feet. The City will accept a recommended infiltration rate from a Geotechnical Engineer or other qualified professional for a large facility where more than three infiltration tests are required.

(d) Encased Falling Head Test

The encased falling head procedure is based on a modification of the EPA Falling Head Percolation Test Procedure (*Onsite Wastewater Treatment and Disposal Systems Design Manual,* EPA/625/1-80-012, 1980). The most significant modification is that this test is performed with a 6-inch casing that is embedded approximately six inches into the native soil. The goal of this field test is to evaluate the vertical infiltration rate through a six-inch plug of soil, without allowing any lateral infiltration. The test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

(1) Embed a solid 6-inch-diameter casing into the native soil at the elevation of the proposed facility bottom (see Figure 4C- 1). Ensure that the embedment provides a

good seal around the pipe casing so that percolation will be limited to the 6-inch plug of the material within the casing. This method can also be applied to testing within hollow stem augers, provided the driller and tester are reasonably certain that a good seal has been achieved between the soil and auger. If an adequate seal cannot be obtained, the open pit falling head procedure shall be used.

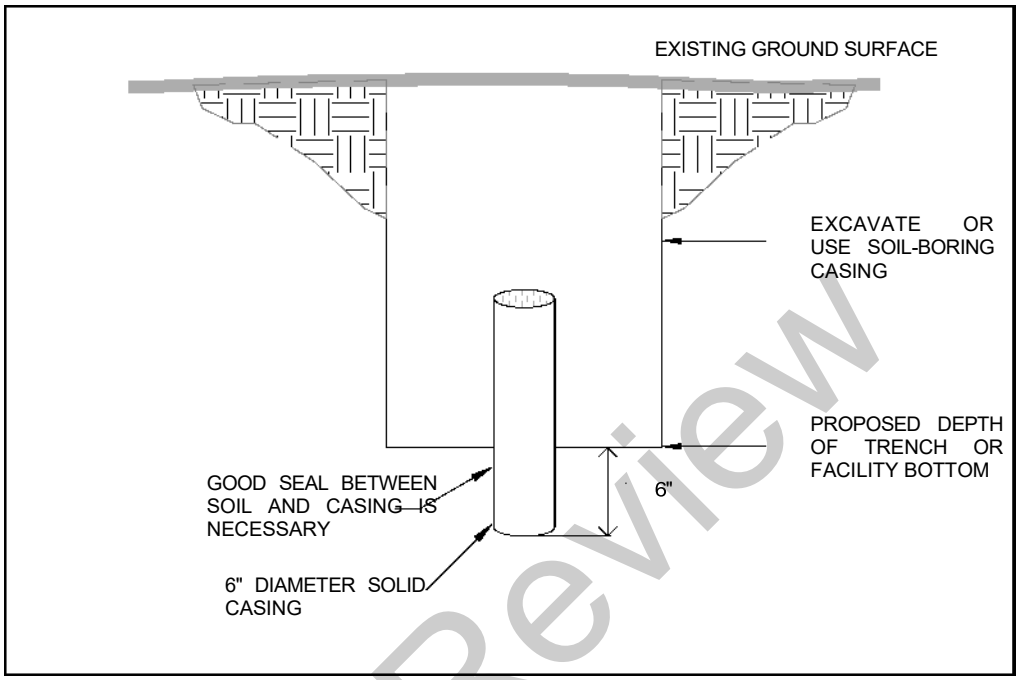

Figure 4C- 1: Encased Falling Head Procedure

(2) A 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scour and sloughing.

(3) Fill the pipe with clean water a minimum of 1 foot above the soil to be tested, and maintain this depth for at least 4 hours (or overnight if clay soils are present) to presoak the native material.

A. Percolation rate measurements must be made after 15 hours and no more than 30 hours after the soaking period begins. It is important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained. Any soil that sloughed into the hole during the soaking period must be removed and the water level shall be adjusted to 6 inches above the added gravel (or eight inches above the bottom of the hole).

B. In sandy soils with little or no clay, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

C. To conduct the first trial of the test, fill the pipe to approximately six inches above the soil and measure the water level to the nearest 0.01 foot (⅛ inch). The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.

D. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has drained. The infiltration test is continued until the measured infiltration rate between two successive trials does not vary by more than 5 percent. At least three trials must be conducted. After each trial, the water level is readjusted to the 6-inch level. Enter results into the Data Table (see Table 4C-2). At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

E. The result of the last water level drop is used to calculate the tested infiltration rate. The final rate must be reported in inches per hour.

F. Upon completion of the testing, the casings must be immediately pulled, and the test pit must be backfilled.

(e) Double Ring Infiltrometer Test

The double-ring infiltrometer test procedure must conform to ASTM 3385-94. The test is performed within two concentric casings embedded and sealed to the native soils. The outer ring maintains a volume of water to diminish the potential of lateral infiltration through the center casing. The volume of water added to the center ring to maintain a static water level is used to calculate the infiltration rate. The double-ring infiltrometer is appropriate only in soils where an adequate seal can be established.

This test may be difficult to perform where the tested soil strata are in a pit, since careful regulation of the static volumes is necessary.

(f) Open Pit Falling Head Test

The Open Pit Falling Head test is applicable where site conditions prevent a good seal between the native soil and the infiltration equipment used in the other professional methods. The procedure is based on the Environmental Protection Agency (EPA) Falling Head Percolation Test Procedure (*Onsite Wastewater Treatment and Disposal Systems Design Manual,* EPA/625/1-80-012, 1980). The test is performed in an open excavation and therefore is a test of the combination of vertical and lateral infiltration.

(1) Excavate an approximately 2-foot by 2-foot-wide hole into the native soil to the bottom elevation of the proposed facility. The test can be conducted in a machine-excavated pit or a hand-dug pit using a shovel, posthole digger, or hand auger. If smooth augering tools or a smooth excavation bucket is used, scratch the sides and bottom of

the hole with a sharp-pointed instrument, and remove the loose material from the bottom of the test hole.

(2) A 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scour and sloughing.

(3) Fill the hole with clean water a minimum of one foot above the soil to be tested, and maintain this depth of water for at least four hours (or overnight if clay soils are present) to presoak the native material.

(4) Percolation rate measurements must be made after 15 hours and no more than 30 hours after the soaking period begins. It is important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained. Any soil that sloughed into the hole during the soaking period must be removed and the water level shall be adjusted to six inches above the added gravel (or 8 inches above the bottom of the hole).

(5) In sandy soils with little or no clay, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than ten minutes, the test can proceed immediately.

(6) The measurements should be made with reference to a fixed point. A lath placed in the test pit prior to filling or a sturdy beam across the top of the pit are convenient reference points. The tester and excavator should conduct all testing in accordance with OSHA regulations.

(7) Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has drained. At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

(8) Successive trials must be run until the measured infiltration rate between two successive trials does not vary by more than 5 percent. At least three trials must be conducted. After each trial, the water level is readjusted to the 12-inch level. Enter results into the data table (See Table 4C-2).

(9) The results of the last water level drop are used to calculate the tested infiltration rate. The final rate must be reported in inches per hour. See the calculation following Table 4C-2.

(10) For very rapidly draining soils, it may not be possible to maintain a water head above the bottom of the test pit. If the infiltration rate meets or exceeds the flow of water into the test pit, conduct the test in the following manner:

A. Approximate the area over which the water is infiltrating.

B. Using a water meter, bucket, or other device, measure the rate of water discharging into the test pit.

C. Calculate the infiltration rate by dividing the rate of discharge (cubic inches per hour) by the area over which it is infiltrating (square inches).

(11) Upon completion of the testing, the excavation must be backfilled.

4C.4 – REPORTING REQUIREMENTS

(a) Basic Method Reporting Requirements

For the basic method the following information shall be submitted with the project's submittals.

(1) Site plan showing the location of each test performed.

(2) Infiltration test data table (see Table 4C-2).

(3) Infiltration test results in inches per hour.

(b) Professional Method Reporting Requirements

For Large Projects where the professional method is used, the following information shall be submitted with the project's submittals.

(1) Location and depth of excavation. The excavation should be deep enough to verify that there is a 3-foot separation between the final depth of the facility (rock gallery) and the seasonal high groundwater or soil layer that could reduce the infiltration rate.

(2) Summary and discussion of infiltration testing procedure, including number of tests, amounts of water used in each test (inches, gallons, etc.), and time of each test. Testing is required to show that an accurate rate was achieved.

(3) A discussion of how the test was performed including (based on the test performed):

A. Encased falling head.

(i). Pipe type.

(ii). Embedment depth.

(iii). Size of pipe.

B. Double ring infiltrometer.

(i). Pipe type.

(ii). Embedment depth.

(iii). Size of pipe.

C. Open pit (size of area).

D. Soil types with depth.

(4) A statement of whether groundwater was encountered. If groundwater was encountered, the measured depth to groundwater, groundwater observations, estimated depth to seasonal high groundwater, and the seasonal correction factor used to derive this depth.

A. Infiltration results in in/hr and a resulting Measured Infiltration Rate.

B. Test results for each location recorded on a form similar to that shown in Table 4C-1.

C. The stamp of the qualified professional who is submitting the report.

Table 4C-1: Infiltration Test Data Table Example

Location: Lot 105, Low Point Heights Subdivision	Date: 6/28/2010	Test Hole Number: 3
Depth to bottom of hole: 57 in.	Diameter of hole: 0.5 ft	Test Method: Encased Falling Head
Tester's Name: C.J. Tester Tester's Company: Tester Company		Tester's Contact Number: 555-1212

Depth, ft	Soil Texture
0-0.5	Black Top Soil
0.5-1.0	Brown SM
1.0-2.2	Brown ML
2.2-5.1	Brown CL

Time	Time interval, min.	Measurement, ft	Drop in water level, ft	Percolation rate, in/hr	Remarks
9:00	0	3.75	-		Filled with 6"
9:20	20	3.83	0.08		
9:40	20	3.91	0.08	2.88	
10:00	20	3.98	0.07	2.52	
10:20	20	4.04	0.06	2.16	
10:40	20	4.11	0.07	2.52	
11:00	20	4.17	0.06	2.16	
11:20	20	4.225	0.055	1.98	
					Adjusted to 6" level for Trial #2

Calculation is performed for each water level drop
= (Drop in water level/Time interval) x conversion
= 0.055 feet/20 minutes x (12 inches/foot) x (60 minutes/hour)
= 1.98 inches per hour

Note: For the professional method the design infiltration rate of two successive trials must have a difference of 5% or less.

Table 4C-2: Infiltration Test Data Table		
Location:	Date:	Test Hole Number:
Depth to bottom of hole:	Diameter of hole:	Test Method:
Tester's Name: Tester's Company:		Tester's Contact Number:

Depth, feet	Soil Texture

Time	Time interval, min.	Measurement, ft	Drop in water level, ft	Percolation rate, in/hr	Remarks

APPENDIX 4D
STORMWATER SYSTEM-HYDROLOGIC ANALYSIS

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STORMWATER SYSTEM—HYDROLOGIC ANALYSIS

SECTION

FIGURES

TABLES

4D.1 - GENERAL

Stormwater facilities design flows and volumes required in accordance with these Design Standards shall be determined using the methods described in this appendix.

4D.2 - RATIONAL METHOD

(a) Application

The rational method may be used for analyzing small drainage basins, 10 acres or less in size, with the following restrictions:

(1) May only be used for determining the peak flow for determining the required capacity of conveyance elements.

(2) The time of concentration shall be a minimum of 5 minutes.

(3) For areas larger than 10 acres in size, one of the hydrograph methods listed in the next section shall be used to determine the peak flow conditions.

(b) Rational Method Equation

The rational method calculation shall be made as follows:

$$Q = C_y \, x \, C_{av} \, x \, I \, x \, A$$

Where:

Q	=	Peak flow (cubic feet/second)
C_y	=	Runoff Coefficient adjustment factor (see Subsection 4D.2(d)—Runoff Coefficient Adjustment Factor)
C_{av}	=	Average Runoff Coefficient
I	=	Rainfall Intensity (inches/hour)
A	=	Drainage Area (acres)

(c) Runoff Coefficient "C"

The runoff coefficient is difficult to estimate because it represents the interaction of many complex factors including surface ponding, infiltration, antecedent moisture, ground cover conditions, ground slopes, and soil type. The actual runoff coefficient for a given drainage basin can best be approximated by calculating a weighted average of all distinct surface types:

$$C_{av} = \frac{\sum C_x A_x}{A_{total}}$$

Table 4D-1: Typical Runoff Coefficients "C"			
Developed Surface Types	Flat 0% to 2%	Rolling 2% to 10%	Hilly Over 10%
Impervious Areas	0.9	0.9	0.9
Gravel Pavement	0.5	0.55	0.6
Landscape Areas (Except Lawns)	0.3	0.35	0.4
Lawns	0.17	0.22	0.35
Pre-developed Surface Types			
Meadow, Pasture, or Farm	0.25	0.3	0.35
Mixed	0.15	0.2	0.25
Woodland and Forest	0.1	0.15	0.2
Development Types			
Commercial Development	0.8	0.85	0.9
Industrial Development, Heavy	0.7	0.8	0.9
Dense Residential (over 6 units/acre)	0.7	0.75	0.8
Industrial Development, Light	0.6	0.7	0.8
Normal Residential (3 to 6 units/acre)	0.5	0.55	0.6
Light Residential (1 to 3 units/acre)	0.35	0.4	0.45
Parks	0.15	0.2	0.25

(d) Runoff Coefficient Adjustment Factor

The runoff coefficients listed in Table 4D-1, above, are applicable for a storm with a recurrence interval of ten years or less. Less frequent, higher intensity storms require adjusted runoff coefficients because infiltration and other losses have a proportionally smaller effect on runoff. Runoff coefficient adjustment factors (C_y) for storms of different recurrence intervals are listed in Table 4D-2.

Table 4D-2: Runoff Coefficient Adjustment Factor	
Recurrence Interval	**Runoff Coefficient Adjustment Factor (cy)**
10 years or less	1.0
25 years	1.1
50 years	1.2
100 years	1.25

(e) Rainfall Intensity "I"

The cumulative rainfall intensity shall be derived from Figure 4D-1. The design storm interval is typically based on the longest time of concentration for the drainage basin.

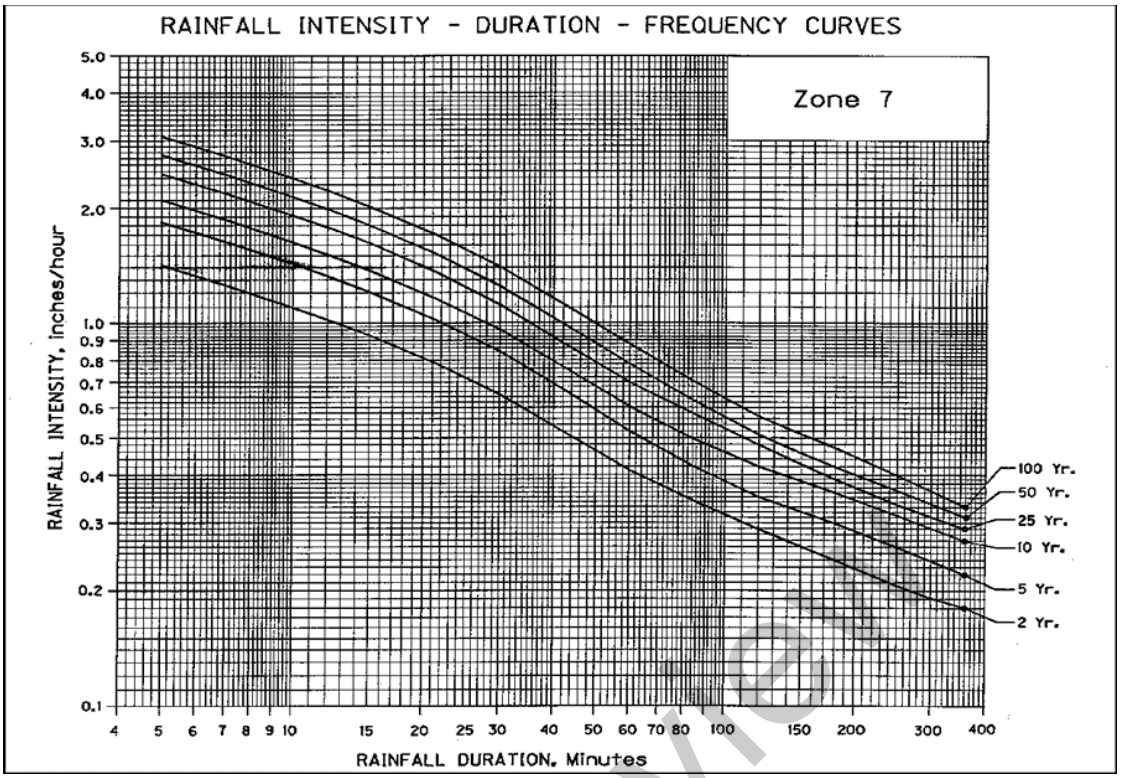

Figure 4D-1: Rainfall Intensity—Duration—Frequency Curves

4D.3 - HYDROGRAPH METHODS

(a) Application

Hydrograph methods can be used to determine the design flows and volumes for stormwater facilities when using the Engineered Method.

(b) General

The physical characteristics of the site and the design storm shall be used to determine the magnitude, volume, and duration of the runoff hydrograph. The SBUH, NRCS TR-55 method, or SWMM may be used. If a software package is utilized, documentation of the software's processing and methodology shall be submitted with the results, along with all assumptions and input values. The typical input information needed for one of these hydrograph methods is:

(1) 24-hour Type 1-A rainfall distribution.

(2) Total 24-hour rainfall amount.

(3) Basin area characteristics.

(4) Curve Number (CN).

(5) Time of Concentration.

(c) Rainfall Distribution

The rainfall distribution to use within the City is the design storm for a 24-hour duration based on the standard NRCS Type 1A rainfall distribution. This distribution is contained in Table 4D-6.

(d) Rainfall Depth

Table 4D-3 contains the 24-hour rainfall totals that shall be used in determining the runoff hydrograph for various sized storm events.

Table 4D-3: Salem Rainfall Amount Based on the Storm Size

24-Hour Rainfall Depths for Salem, Oregon						
Recurrence Interval, years	2	5	10	25	50	100
24-Hour Depths, inches	2.2	2.7	3.2	3.6	4.1	4.4

(e) Drainage Basin Area Characteristics

For the highest degree of accuracy in hydrograph analysis, proper selection of homogeneous drainage basin is needed. Significant differences in land use within a given drainage basin must be addressed by dividing the drainage basin area into sub-basins with similar land use and/or runoff characteristics. Hydrographs should be computed for each sub-basin area and superimposed to form the total runoff hydrograph for the drainage basin.

(f) Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to consolidate diverse characteristics such as soil type, land usage, and vegetation into a single variable for computing runoff. Runoff CNs to be used in the hydrograph methods are included in Table 4D-7.

The following factors shall be considered when choosing a CN:

(1) Many factors can affect the CN value for a given land use. For example, the movement of heavy equipment over bare ground may compact the soil so that it has a lower infiltration rate and greater runoff potential.

(2) CN values may be weighted by area when they apply to similar pervious areas (within 20 CN points). High CN areas shall not be combined with low CN areas, unless the low CN areas constitute less than 15 percent of the sub-basin.

(3) Normal antecedent soil moisture values shall be assumed for design.

4D.4 - TIME OF CONCENTRATION (T_C)

Calculations for time of concentration should be divided into three segments: sheet flow, shallow concentrated flow, and channel/pipe flow. Up to the first 100 feet of overland flow, the sheet flow time of concentration can be calculated with the kinematic wave equation:

$$\textbf{Sheet Flow } T_c = \frac{0.93L^{0.6}n^{0.6}}{I^{0.4}S^{0.3}}$$

Where:

T_c = Flow Time (minutes)

L = Overland Flow Length (feet), typically 100 feet

n = Manning's Roughness Coefficient (See Table 4D-4)

I = Rainfall Intensity (inches/hour) (See Figure 4D-1)

S = Average Slope of Overland Area (foot/foot)

Mannings roughness coefficients for overland sheet flow are listed in Table 4D-4.

Table 4D-4: Manning's Roughness Coefficients for Overland Sheet Flow

Surface Types:	n
Impervious Areas	0.014
Gravel Pavement	0.02
Developed: Landscape Areas (Except Lawns)	0.08
Undeveloped: Meadow, Pasture, or Farm	0.15
Developed: Lawns	0.24
Pre-developed: Mixed	0.30
Pre-developed: Woodland and Forest	0.40
Development Types:	**n**
Commercial Development	0.015
Industrial Development, Heavy	0.04
Industrial Development, Light	0.05
Dense Residential (over 6 units/acre)	0.08
Normal Residential (3 to 6 units/acre)	0.20
Light Residential (1 to 3 units/acre)	0.30
Parks	0.40

For overland flow distances greater than 100 feet, sheet flow typically becomes shallow concentrated flow. The average velocity for shallow concentrated flow can be determined from the velocity equation $V=k_s(s_o)^{0.5}$, in which the average velocity is a function of watercourse slope and surface type. Refer to Table 4D-5 for k_s values.

Time of concentration is the ratio of flow length to flow velocity, T_c=L/60V or as combined in the equation below.

$$\textbf{Shallow Concentrated Flow } T_c = \frac{L}{60(k_s)(s_o)\text{^}0.5}$$

Where:

L = Flow Length (feet)

k_s = Velocity Factor Coefficient

S_o = Slope of Land Segment (feet/feet)

Table 4D-5: Velocity Factor Coefficients k_s	
Shallow Concentrated Flow	k_s
Forest with Heavy Ground Litter and Meadows (n=0.10)	3
Brushy Ground with Some Trees (n=0.060) City of Salem Predevelopment Condition	5
Fallow or Minimum Tillage Cultivation (n=0.040)	8
High Grass (n=0.035)	9
Short Grass, Pasture and Lawns (n=0.030)	11
Nearly Bare Ground (n=0.025)	13
Paved and Gravel Areas	27

For open channel or piped flow components of time of concentration, Manning's equation should be used to estimate average flow velocity.

$$\textbf{Manning's Equation } V = \left(\frac{1.49}{n}\right) R^{2/3}\sqrt{S}$$

Where:

n = Manning's Roughness Coefficient

R = Hydraulic Radius (feet)

S = Channel or Pipe Slope (feet/feet)

Once the average flow velocity is calculated, the open channel or piped flow time of concentration can be calculated as follows:

$$\textbf{Open Channel Flow or Pipe Flow } T_c = \frac{L}{V}$$

Where:

T_c = Flow Time (seconds)

L = Flow Length (feet)

V = Flow Velocity (feet/second)

Finally, the combined time of concentration can be calculated as the sum of the sheet flow Tc, shallow concentrated flow Tc, and the open channel or piped flow Tc.

Table 4D-6: NRCS 24-Hour Type 1A Rainfall Distribution											
Time from Start of Storm Minutes	% Rainfall	Cumulative % Rainfall	Time from Start of Storm Minutes	% Rainfall	Cumulative % Rainfall	Time from Start of Storm Minutes	% Rainfall	Cumulative % Rainfall	Time from Start of Storm Minutes	% Rainfall	Cumulative % Rainfall
10	0.40	0.40	370	0.95	22.57	730	0.72	67.40	1090	0.40	86.00
20	0.40	0.80	380	0.95	23.52	740	0.72	68.12	1100	0.40	86.40
30	0.40	1.20	390	0.95	24.47	750	0.72	68.84	1110	0.40	86.80
40	0.40	1.60	400	0.95	25.42	760	0.72	69.56	1120	0.40	87.20
50	0.40	2.00	410	1.34	26.76	770	0.57	70.13	1130	0.40	87.60
60	0.40	2.40	420	1.34	28.10	780	0.57	70.70	1140	0.40	88.00
70	0.40	2.80	430	1.34	29.44	790	0.57	71.27	1150	0.40	88.40
80	0.40	3.20	440	1.80	31.24	800	0.57	71.84	1160	0.40	88.80
90	0.40	3.60	450	1.80	33.04	810	0.57	72.41	1170	0.40	89.20
100	0.40	4.00	460	3.40	36.44	820	0.57	72.98	1180	0.40	89.60
110	0.50	4.50	470	5.40	41.84	830	0.57	73.55	1190	0.40	90.00
120	0.50	5.00	480	2.70	44.54	840	0.57	74.12	1200	0.40	90.40
130	0.50	5.50	490	1.80	46.34	850	0.57	74.69	1210	0.40	90.80
140	0.50	6.00	500	1.34	47.68	860	0.57	75.26	1220	0.40	91.20
150	0.50	6.50	510	1.34	49.02	870	0.57	75.83	1230	0.40	91.60
160	0.50	7.00	520	1.34	50.36	880	0.57	76.40	1240	0.40	92.00
170	0.60	7.60	530	0.88	51.24	890	0.50	76.90	1250	0.40	92.40
180	0.60	8.20	540	0.88	52.12	900	0.50	77.40	1260	0.40	92.80
190	0.60	8.80	550	0.88	53.00	910	0.50	77.90	1270	0.40	93.20
200	0.60	9.40	560	0.88	53.88	920	0.50	78.40	1280	0.40	93.60
210	0.60	10.00	570	0.88	54.76	930	0.50	78.90	1290	0.40	94.00
220	0.60	10.60	580	0.88	55.64	940	0.50	79.40	1300	0.40	94.40
230	0.70	11.30	590	0.88	56.52	950	0.50	79.90	1310	0.40	94.80
240	0.70	12.00	600	0.88	57.40	960	0.50	80.40	1320	0.40	95.20
250	0.70	12.70	610	0.88	58.28	970	0.50	80.90	1330	0.40	95.60
260	0.70	13.40	620	0.88	59.16	980	0.50	81.40	1340	0.40	96.00
270	0.70	14.10	630	0.88	60.04	990	0.50	81.90	1350	0.40	96.40
280	0.70	14.80	640	0.88	60.92	1000	0.50	82.40	1360	0.40	96.80
290	0.82	15.62	650	0.72	61.64	1010	0.40	82.80	1370	0.40	97.20
300	0.82	16.44	660	0.72	62.36	1020	0.40	83.20	1380	0.40	97.60
310	0.82	17.26	670	0.72	63.08	1030	0.40	83.60	1390	0.40	98.00
320	0.82	18.08	680	0.72	36.80	1040	0.40	84.00	1400	0.40	98.40
330	0.82	18.90	690	0.72	64.52	1050	0.40	84.40	1410	0.40	98.80
340	0.82	19.72	700	0.72	65.24	1060	0.40	84.80	1420	0.40	99.20
350	0.95	20.67	710	0.72	65.96	1070	0.40	85.20	1430	0.40	99.60
360	0.95	21.62	720	0.72	66.68	1080	0.40	85.60	1440	0.40	100.00

Table 4D-7: Runoff Curve Numbers					
		CN For Hydrologic Soil Group			
Cover Description		**A**	**B**	**C**	**D**
Urban Areas	*Source: NRCS TR55 Table 2-2a (1986)*				
	% Impervious				
Open Space					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 70%)		49	69	79	84
Good condition (grass cover >75%) and amended soils		39	61	74	80
City of Salem Pre-development		**32**	**58**	**72**	**79**
Impervious Areas					
Paved parking lots, roofs, driveways (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 and unamended soils)		72	82	87	89
Urban Districts					
Commercial	85	89	92	94	92
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size:					
1/8 acres 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
Agricultural Lands	*Source: NRCS TR55 Table 2-2c (1986)*				
	Hydrologic Condition				
Pasture, grassland, or range- combined 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	80
	Good	32	58	72	79

Table 4D-7: Runoff Curve Numbers					
		CN For Hydrologic Soil Group			
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 covers the soil	Good	30	55	70	77

4D.5 – SANTA BARBARA URBAN HYDROGRAPH (SBUH) METHOD

The SBUH method is an acceptable hydrograph method for flow control design. It involves a five step process. Methodology for steps one through four is described in Subsection 4D.3-HYDROGRAPH METHODS and Subsection 4D.4-TIME OF CONCENTRATION (T_C).

Determining runoff using the SBUH method requires the use of a calculator or spreadsheet program. King County, Washington's Surface Water Design Manual includes a description of the calculation steps and example spreadsheet.[1]

Inputs include:

1. Basins Areas in acres.
2. Precipitation for 24-hour storm events in inches.
3. Soil Characteristics for CN.
4. Travel time for basin in minutes.
5. Application

The SBUH method may be used for analyzing urban drainage basins up to 100 acres or less in size:

[1] Surface Water Design Manual, King County, Washington's (1990, Revised 1995)

(a) SBUH Method Equations

Abstract Runoff Value $$S = \left(\frac{1000}{CN}\right) - 10$$

Runoff Depth $$D(t) = \frac{\left(pt - 0.2(S)\right)^2}{(pt + 0.8(S))}$$

Total Runoff $$R(t) = D(t) - D(t-1)$$

Instantaneous Hydrograph $$I(t) = \frac{60.5\left(R(t)\right)A}{dt}$$

Design Flow Rate $$Q(t+1) = Q(t) + w(I(t) = I(t+1) - 2Q(t))$$

Where:

CN = Curve number

Pt = Precipitation for the time increment—24 hour MRI

A = Basin area in acres

dt = Time interval in 10 minutes

W = Dt/($2T_C$+dt)

T_C = Time of concentration for the drainage basin

D(t) = Depth of runoff at time (t)

R(t) = Total runoff depth (both impervious and pervious runoffs) at time D(t), in inches (also known as precipitation excess)

I(t) = Instantaneous Hydrograph at each time step D(t), in cfs

(b) Storage Determination

Inflow–Outflow=Change in Storage $$[(I_1+I_2)/2]-[(O_1+O_2)/2] = S_1-S_2$$

Where:

I = Inflow at Time 1 and Time 2

O = Outflow at Time 1 and Time 2

S = Storage at Time 1 and Time 2

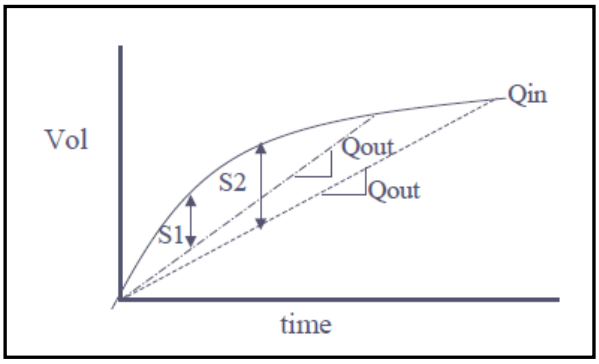

Figure 4D-2: Increased Storage Volume (S) Due to Increased Time

The time interval, Δt, must be consistent with the time interval used in developing the inflow hydrograph. The time interval used for a 24-hour storm is 10 minutes. The terms I1, I2, O1, and S1 are known from the inflow hydrograph and from the storage and outflow values of the previous time step. The unknowns O2 and S2 can be solved interactively from the given stage-storage and stage-discharge curves.

Table 4D-8: NRCS Hydrologic Soil Group Descriptions

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 a 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.

APPENDIX 4E
RESERVED FOR FUTURE USE

APPENDIX 4F
LIST OF ACCEPTED MANUFACTURED STORMWATER FACILITIES

CITY OF SALEM
DEPARTMENT OF PUBLIC WORKS
ADMINISTRATIVE RULES
CHAPTER 109
DIVISION 004 APPENDIX F
LIST OF ACCEPTED MANUFACTURED STORMWATER FACILITIES

SECTION

TABLES

4F.1 – GENERAL

This appendix contains the list of manufactured stormwater facilities accepted for use in the City for both **Basic Treatment and Pretreatment** to satisfy the requirements for stormwater treatment when sized in accordance with the manufacturer's recommendations and these Design Standards.

4F.2 – DEFINITIONS

(a) Basic Treatment.

(1) Eighty percent removal of total suspended solids should be achieved.

(b) Pretreatment

(1) Fifty percent removal of total suspended solids should be achieved.

(2) Typically installed upstream of infiltration treatment facilities and where pretreatment is needed to assure the and extend performance of a downstream basic treatment facility.

4F.3 – BASIC TREATMENT

Devices listed in Table 4F-1 are for **Basic Treatment** to be used to satisfy the requirements for stormwater treatment when sized in accordance with the manufacturer's recommendations and the Design Standards.

Table 4F-1: Approved Manufactured Stormwater Products – Basic Treatment

Product	Private Facilities	Public Facilities
Advanced Drainage Systems – BayFilter	x	x
Contech Engineered Solutions, LLC. – StormFilter	x	x
Contech Engineered Solutions, LLC. – Filterra System	x	
Contech Engineered Solutions, LLC. – Filterra Bioscape	x	x
Contech Engineered Solutions, LLC. – Modular Wetlands Linear	x	
Contech Engineered Solutions, LLC. – Modular Wetland Round	x	x
Hydro International – Up-Flo Filter	x	x
Hydro International – StormScape	x	
Oldcastle Infrastructure, Inc. – PerkFilter	x	
Oldcastle Infrastructure, Inc. – BioPod Biofilter	x	
Oldcastle Infrastructure, Inc. – BoxlessBioPod Biofilter	x	x

4F.4 – PRETREATMENT

Devices listed in Table 4F-2 for **Pre-treatment** may be used to remove sediment and debris from stormwater prior to entering a treatment or combined facility. These structures do not meet the requirements for a stormwater treatment only and must be used as part of a treatment train.

Table 4F-2: Approved Manufactured Stormwater Products – Pretreatment

Product	Private Facilities	Public Facilities
Advanced Drainage Systems – BaySeparator	x	x
AquaShield, Inc. – Aqua-Swirl System	x	x
Contech Engineered Solutions, LLC. – Vortechs System	x	x
Hydro International – Downstream Defender	x	x
Imbrium Systems – Stormceptor	x	x

APPENDIX 4G
KEY MATERIAL SPECIFICATIONS

CITY OF SALEM
DEPARTMENT OF PUBLIC WORKS
ADMINISTRATIVE RULES
CHAPTER 109
DIVISION 004 APPENDIX G
KEY MATERIAL SPECIFICATIONS

SECTION

TABLES

4G.1 – GENERAL

This appendix contains specifications to be used for key materials used in stormwater facilities.

4G.2 – TOPSOIL

Imported topsoil shall be used that is fertile, friable, and representative of local (Willamette Valley) productive soil furnished from part of a soil profile commonly referred to as the "A" horizon, typically ranging in depth from 3 to 12 inches, free of clods or other inorganic matter larger than three inches in any dimension, not frozen or muddy, with pH 5.8 to 7.0. Gravel portion (particles larger than 2 mm) shall not exceed 15 percent of total volume.

Topsoil shall be amended to correct nutrient deficiencies in accordance with the soil analysis report provided by the City.

Topsoil, when tested according to AASHTO T 88, shall meet the following limits:

Table 4G-1: Standard Sieve Analysis

Particle Size Range	Percent Retained (by Weight)
Larger than 2"	0
2"– ¾"	0-5
¾"–No. 4	0-20
No. 4 or less	0-100

Of the fraction passing the No. 4 sieve, excluding organic material, furnish topsoil that conforms to the following limits:

Table 4G-2: Hydrometer Analysis

Particle Size Range	Percent (by Weight)
No. 4 – No. 200	5–70% (Retained)
No. 200 – 2 µm	20–80% (Retained)
Less than 2 µm	5–30% (Passing)

4G.3 – ORGANIC SOIL AMENDMENT

Furnish soil amendments that are derived from plant material and provided by a member of the US Composting Council Seal of Testing Assurances (STA) program. See www.compostingcouncil.org for a list of providers in Oregon.

The organic soil amendment shall be the by-product of the biological degradation and transformation of plant-derived material under conditions designed to promote aerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have no visible free water and produce no dust when handled. It shall meet the following criteria, as reported by the US Composting Council STA Compost Technical Data Sheet to be provided by the supplier.

1. 100 percent of the soil amendment material must pass through a ½-inch screen.
2. The pH of the soil amendment material must be between 6.0 and 8.0.
3. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) must be less than 1.0 percent by weight.
4. The organic matter content must be between 35 and 65 percent.
5. Soluble salt content must be less than 6.0 mmhos/cm.
6. Germination (an indicator of maturity) must be greater than 80 percent.
7. Stability must be between classes six and seven.
8. Carbon/nitrogen ratio must be less than 25:1.
9. Trace metals test result must be "pass."

A particle gradation analysis of the soil amendment shall be conducted in conformance with ASTM C117/C136 (AASHTO T11/T27) and documented for City approval, before delivery to the Site. The analysis shall include the following sieve sizes and the material shall meet the following gradation criteria:

Table 4G-3: Gradation Criteria

Sieve Size	Percent Passing
1-inch	100
#4	75–100
#10	40–100
#40	15–40
#100	5–25
#200	5–15

Documentation for the three analyses of the organic soil amendment material as described in Subsection 207.2.10 of the Contract Document. Planting Mixture with calculated coefficient of uniformity; organic matter content; and pH, must be provided to the City prior to blending the planting mixture. The analysis shall be performed by an accredited laboratory with certification maintained current. The date of the analysis shall be no more than 90 calendar days prior to the date of the submittal. The report shall include the name/address of the laboratory, laboratory phone and email contact information; and test data, including the date and name of the test procedure.

A Compost Technical Data Sheet from the supplier of the soil amendment shall be provided. The analysis and report must be consistent with the sampling and reporting requirements of the US Composting Council Seal of Testing Assurance (STA) program. The analysis shall be performed and reported by an approved independent STA program laboratory. The STA laboratory report must also include compost end use instructions, as a means to better inform the City.

4G.4 – GROWING MEDIUM

Furnish imported growing medium for vegetated stormwater facilities conforming to the following:

(a) General Composition

The medium shall be a mix of loamy soil, sand, and compost, 30-40 percent compost (by volume) and the following:

(1) The material shall be loose and friable.

(2) It shall be well mixed and homogenous.

(3) It shall be free of wood pieces, plastic, and other foreign matter.

(4) It shall have no visible free water.

(b) Analysis Requirements for the Blended Material

(1) Particle Gradation. A particle gradation analysis of the blended material, including compost, shall be conducted in conformance with ASTM C117/C136 (AASHTO T11/T27). The analysis shall include the following sieve sizes: 1-inch, ⅜-inch, #4, #10, #20, #40, #60, #100, #200. The gradation of the blend shall meet the following gradation criteria.

Table 4G-4: Particle Gradation

Sieve Size	Percent Passing
1-inch	100
#4	75-100
#10	40-100
#40	15-50
#100	5-25
#200	5-15

The blend shall have a Coefficient of Uniformity (D60/D10) equal to or greater than six to ensure that it is well graded (has a broad range of particle sizes). The coefficient is the ratio of two particle diameters on a grain-size distribution curve; it is

the particle diameter at 60 percent passing divided by the particle diameter at 10 percent passing.

(2) Organic Matter Content. An analysis of soil organic matter content shall be conducted in conformance with ASTM D2974 (loss on ignition test). The soil organic matter content shall be a minimum of 10 percent, as reported by that test.

(3) Power of Hydrogen (pH). The pH of the blended material shall be tested and have a pH of 5.0 to 8.0.

(c) General Requirements for the Blended Material

(1) The material shall be loose and friable, placed in the facility in such a manner to ensure that the soil has settled enough to keep it in place but not compacted to a point that will result in poor drainage, poor plant establishment, or anaerobic conditions. After placement, material can be watered to help with natural settling and then more material placed if needed.

(2) It shall be well mixed and homogenous.

(3) It shall be free of wood pieces, plastic, and other foreign matter.

(4) It shall have no visible free water present in the material.

(d) Compost

The compost shall be derived from plant material and provided by a member of the STA program. See www.compostingcouncil.org for a list of providers in Salem. The compost shall be the result of the biological degradation and transformation of plant derived materials under conditions designed to promote aerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have no visible free water and produce no dust when handled. It shall meet the following criteria, as reported by the US Composting Council STA Compost Technical Data Sheet provided by the vendor.

(1) 100 percent of the material must pass through a ½-inch screen.

(2) The pH of the material shall be between 6.0 and 8.0.

(3) Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0 percent by weight.

(4) The organic matter content shall be between 35 and 65 percent.

(5) Soluble salt content shall be less than 6.0 mmhos/cm.

(6) Germination (an indicator of maturity) shall be greater than 80 percent.

(7) Stability shall be between classes five and seven.

(8) Carbon/nitrogen ratio shall be less than 25:1.

(9) Trace metals test result = "pass."

4G.5 – BALLAST AGGREGATES

Furnish ballast aggregates of 4 inches to 2 inches as shown. Use clean, hard, durable aggregates, reasonably well graded from the maximum to minimum size.

4G.6 – DRAIN ROCK

Drain rock shall meet the requirements of the *Oregon Standard Specifications for Construction (OSSC), current version* by the Oregon Department of Transportation for 1½" to ¾" Granular Drain Backfill Material 00430.11.

4G.7 – FILTER ROCK

Filter rock shall meet the requirements of the *Oregon Standard Specifications for Construction (OSSC), current version* by the Oregon Department of Transportation for ¾"to ½" Granular Drain Backfill Material 00430.11.

4G.8 – DRAINAGE GEOTEXTILE

Drainage Geotextile shall be Type 1, Certification Level B, meeting the requirements of the *Oregon Standard Specifications for Construction (OSSC), current version* by the Oregon Department of Transportation 02320.

4G.9 – ROCK MULCH

Rock mulch (round rock) shall meet the requirements of the *Oregon Standard Specifications for Construction (OSSC), current version* by the Oregon Department of Transportation for round 3/8" to No. 4 pea gravel or round 2" to 3/8" Rock Mulch 01040.20(d).

4G.10 – IMPERMEABLE LINER

Material shall be 30 mil High Density Polyethylene (HDPE) geomembrane, textured on both sides or approved equal. An experienced firm regularly engaged in manufacturing textured HDPE shall manufacture the geomembrane.