CITY OF GRESHAM

WATER QUALITY MANUAL

DECEMBER 2003

STORMWATER DIVISION
DEPARTMENT OF ENVIRONMENTAL SERVICES

Minor edits included December 2010

Section 5.0 Constructed Marshes

Section 6.0 Parking Treatment Control Requirements

Section 7.0 Flow By-Pass Facilities

Section 8.0 Stormwater Infiltration Facilities

Section 9.0 Maintenance Agreement

Tables

Figures

Appendices

How to Use this Manual

Before using this manual, you should have a tentative site plan that shows, at a minimum, the following information: the location of the site, the development proposal, impervious surface square-footages, slopes, waterways, soil type and other physical conditions at the site, and pollutants of concern from activities or future uses that will occur at the site. You should also have an idea of where stormwater runoff from the site will eventually be discharged.

The components of your site plan outlined above (and described in Section 1.0 and 2.0) must be detailed in the required Stormwater Quality Control Plan. A checklist for developing this plan is provided in Section 2.0.

Other tools created for the reader's convenience are the two flow charts in this Overview that illustrate 1) the City's Development Process for obtaining a permit and 2) "How to Use this Manual" flowchart.

Manual Organization

This *Manual* provides information needed for meeting the stormwater quality treatment requirements as prescribed in the *Gresham Community Development Code* (GDC), *Gresham Revised Code(GRC) and the Gresham Public Works Standards (GPWS)*. It is organized in nine sections plus eight appendices. Brief descriptions of what to find in each section are provided for the reader's convenience.

SUMMARY OF MANUAL CONTENTS

Section 1.0: Introduction/ General Policies and Procedures, outlines the purpose and applicability of this manual. It outlines exceptions and special circumstances to the requirements, control plan requirements, treatment standards, acceptable methods, determination of ownership and maintenance, site design approval, and overarching regulations with Gresham specifics.

Section 2.0: Stormwater Management Planning, provides guidance for selecting facilities in order to develop the Stormwater Quality Control Plan.

Section 3.0: Flow-Through Water Quality Treatment Facilities, provides a discussion of various filtering and adsorption BMPs including: biofiltration swales, vegetated swales, flow-through planter boxes, vegetated filter strips, sand filters, sand filter vaults and linear sand filters.

Section 4.0: Detention-Based Water Quality Treatment Facilities, provides a discussion of various BMPs that are intended to control water flow and have settling characteristics including: wet ponds, wet extended detention ponds, dry extended detention ponds and wet vaults.

Section 5.0: Constructed Marshes, provides a discussion of the requirements for various types of marshes for treatment and flow control including: shallow marshes, a pond/marsh system and an extended detention marsh.

Section 6.0: Parking Treatment Control Requirements, provides additional discussion of the types of BMPs and additional pretreatment and maintenance requirements that are necessary to properly protect water quality from parking lot runoff and pollutant loading.

Section 7.0: Flow By-Pass Facilities, discusses the options for site designers who are determining whether a site should have a flow by-pass system that is off-line and on-line.

Section 8.0: Stormwater Infiltration Facilities, discusses the requirements for site designers who may want to consider infiltration methods as a method of stormwater treatment. BMP facilities discussed include: drywells, infiltration trenches, infiltration planter boxes, soakage trenches, and porous pavement.

Section 9.0: Maintenance Agreements, discusses the requirements for site owners to maintain private stormwater BMP facilities.

Development Process Overview

Apply for Pre-App

Applicant is provided with:

- Applicable development codes
- Existing infrastructure
- Requirements of development clarified:
  - Detention requirements, downstream and upstream
  - Drainage basin-specific requirements, i.e., TMDL
  - Water quality treatment requirements
- Approved point of discharge

Developer submits plans for completeness

Contents of Completeness

Contents for providing complete application can be found in:

6.0201 Typical subdivision
7.0202 Commercial/Industrial

Design Review

When the application is deemed complete, a set of conditions of approval is drafted.
Typical conditions include requirements for:

- Erosion management plan
- Treatment and detention systems
- Maintenance agreements
- Maintenance access
- Public Works Standards
- Etc.

Pre-Design Meeting

Submit plans for Plan Review

Plans submitted for plan review must meet all conditions of approval. Include final stormwater detention, stormwater quality and maintenance plans.

Approved Plans

Preconstruction Meeting

Precon meeting is attended by:

- Developer
- Developer's Engineer
- Development Engineering
- Contractor
- Public Works Inspector
- Public Utilities Staff

Notice to Proceed

Construction

Final Inspection

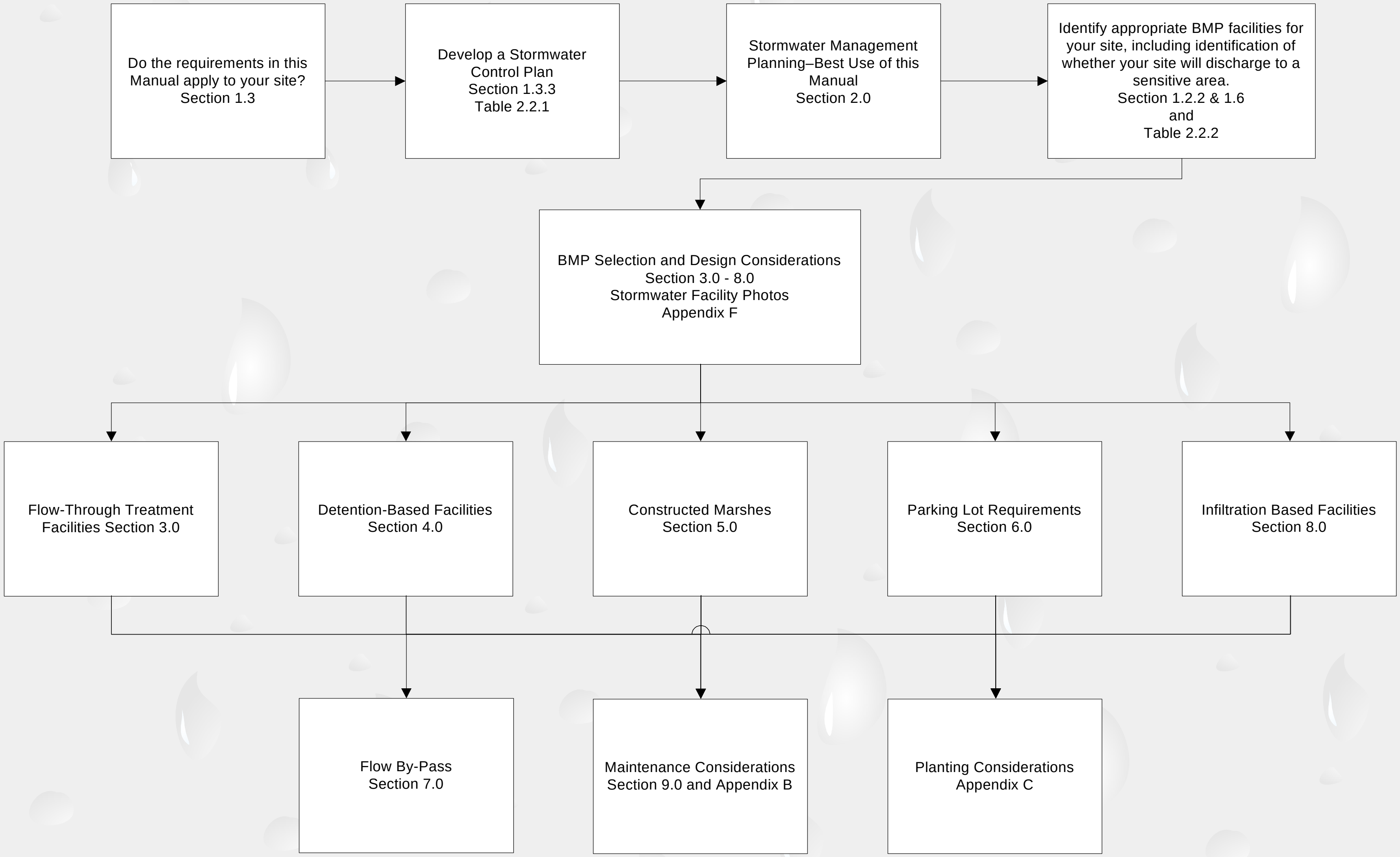
Ownership & Operation by the City

2-Year Warranty Inspection

Facilities Acceptance

This Development Review Process flowchart represents a very simplified version of actual process. It is limited to this manual and is an overview only. It is not meant to replace other supercede other process and/or permitting needs not mentioned but required.

How to use this manual



Section 1.0 Introduction

The City of Gresham is committed to enhancing, protecting and maintaining the livability of the community and the quality of the water. It is no longer possible to ignore the connection between urban development and degraded water quality. Extensive monitoring over the years demonstrates that our streams do not meet state water quality standards, and do not adequately support native salmon populations or other beneficial uses. The strategy for reversing these trends in order to meet the water quality standards will be multi-faceted. One facet is to think differently about how new development and redevelopment occur.

1.1 Objective of the Manual

The objective of the *Water Quality Manual* (*Manual*) is to provide details of the measures necessary to control the quality of stormwater generated from new development and redevelopment. The *Manual* illustrates and describes stormwater management principles and techniques that are aimed at achieving water quality goals, while preserving or mimicking the natural hydrologic cycle.

This *Manual* illustrates and describes stormwater management principles and techniques that are aimed at achieving water quality goals, while preserving or mimicking the natural hydrologic cycle.

This *Manual* provides developers and design professionals with specific requirements for reducing the impacts of stormwater runoff (water quantity) and pollution (water quality) resulting from new development and redevelopment within the City of Gresham, but it is not meant to be a complete step-by-step design manual. This allows design professionals maximum flexibility in designing facilities to meet a specific site's needs.

This *Manual* is intended for use by developers and site design professionals to address stormwater issues.

The *Manual's* requirements apply to all public or private development and redevelopment that does not fall under the exceptions listed in Section 1.3.1. The authority for the Manual's requirements are derived from the *Gresham Community Development Code (GDC), Gresham Revised Code (GRC) and Gresham Public Works Standards (GPWS)* and describes the minimum requirements for compliance. However, the manager may modify the requirements of this *Manual* in writing, if necessary, to ensure compliance with state and federal law.

The City has made every effort to present the most up-to-date information available. The information presented herein is for basic design information and general guidance. It is not intended to provide in-depth design details. Only facilities with proven, tested pollutant removal efficiencies are included. Evolving technical advances will be closely monitored and the updates will be incorporated appropriately.

1.2 Stormwater Management in the City of Gresham

Stormwater runoff includes all water originating from rainfall that ultimately flows into drainage facilities, rivers, streams, ponds, lakes and wetlands, or flows from springs and seeps, as well as shallow groundwater. The City believes that stormwater management can be best achieved through public education, pollution prevention, and with appropriate use of best management practices (BMPs) at the source.

While the stormwater quantity and quality can be managed through "regional" facilities, many public agencies have found that accomplishing a regional management approach is both cost prohibitive and politically thorny. Further mitigating against regional facilities, there are advantages of "on-site" management that cannot be realized through a regional approach. Pollution prevention and natural infiltration are examples of these advantages.

1.2.1 On-site BMPs

Gresham's stormwater management approach emphasizes on-site treatment and infiltration wherever possible. Refer to the city's Green Development and Green Street Manuals on the city's website at:

www.greshamoregon.gov

Documents

Facilities constructed to meet the design criteria in this *Manual* meet the City's treatment standards per GDC Section 9.0522.

For construction erosion

The guiding philosophy of stormwater management in the City of Gresham is to require and achieve on-site management wherever possible, and to supplement this approach with regional treatment facilities in order to address stormwater generated from areas where on-site facilities are not possible. Acceptable on-site low impact/green development practice BMPs are provided in the city's Green Development Practice Manual and Green Street Standards shall be used a first priority in BMP selection. If these BMPs are proven to be impractical the BMPs listed Sections 3.0 through 8.0 of this *Manual* shall be utilized as a second priority.

Stormwater runoff shall be treated prior to discharge into the public stormwater system, which is defined to include the waters of the State. (See GDC Section 9.0520 for complete requirements, which are described in Sections 1.3 through 1.5 of this *Manual).* Another aspect of stormwater treatment is the City's Underground Injection Control (UIC) Program, which is discussed in Sections 1.7.3 and 8.0 of this *Manual*.

Under the federal Safe Drinking Water Act, the Columbia Southshore Wellfield area was established and is generally described in Section 1.7.2 of this *Manual*. A map of the defined area is included in *Appendix G*; the area includes all properties within the Gresham city limit north of I-84. **Due to the complexity of the requirements and to ensure programmatic compliance, the reader is strongly encouraged to review the *Wellhead Protection Program Reference Manual* which is available from the City of Portland's web page or by contacting the Water Division at 503-618-2668.**

1.2.2 Sensitive Areas

The City considers **"sensitive areas"** to be water bodies that have established total maximum daily loads (TMDLs); or that appear on the Department of Environmental Quality's 303(d) list; or that are eligible for listing based on available data; or that have "pollutants of concern" noted, but are not yet on the 303 (d) list or those waterbodies that discharge to any water body meeting any of the parameters described above. In addition, areas with high groundwater levels may also be considered sensitive.

Discharge into sensitive areas must utilize appropriate BMPs that address the specific pollutants of concern as listed for that water body (or water body that it discharges into) or that will address the pollutants likely generated at full build out, in order to protect high groundwater areas from contamination.

All of the parameters described above are referred to as "pollutants of concern" and are listed for each watershed in Gresham and included in Section 1.6 of this *Manual*. **For guidance on facility selection based on pollutants of concern, refer to Table 2.2.2.**

1.3 Stormwater Control Requirements

The City and private property owners are responsible for meeting stormwater treatment requirements. This *Manual* offers guidance to currently approved methods of achieving water quality control requirements. Even with advances in the field of stormwater treatment technologies, site design still requires careful engineering and planning in order to best utilize BMPs that will address the commonly predictable stormwater problems of a development.

Therefore, it is essential that the **site planner** and **design engineer** consider a site's future use and provide solutions for any predictable water quality problems. It is also essential that sites be designed with the intent to minimize the impervious surfaces and maximize infiltration methods to the fullest extent possible.

1.3.1 Applicability: Exceptions

As stated in the GDC Section 9.0520, the requirements of this *Manual* apply to all development, with the following exceptions:

A. Development **that will add or replace less than 1,000 square feet of impervious area.**

B. Sites where it is infeasible to install on-site stormwater quality facilities. (see **Section 9.0522**)

C. Developments where the City has identified an existing public stormwater quality facility that satisfies the requirements of the Water Quality Manual prior to discharge to a stream or wetland.

1.3.2 Special Circumstances

Unless the proposed development or redevelopment site falls under the exceptions listed in Section 1.3.1, the City's policy is to have stormwater quality treatment accomplished on-site. No exceptions to meeting the stormwater management obligations are allowed.

On-site mitigation facilities are defined in GRC 3.20.015. These facilities shall be privately owned and maintained. Section 1.4 of this

The Watershed Division Manager approves or denies whether a proposed development or redevelopment meets the Exceptions in Section 1.3.1 for Special Circumstances applications.

Manual explains this in greater detail. Applicants who cite special circumstances (Exceptions B or C in Section 1.3.1) shall submit a written description of conditions that apply. The Watershed Division will determine if all or a portion of the stormwater management obligations may be fulfilled off-site.

The City may approve payment from the developer to compensate the City for the capital costs for building off-site facilities, **only** in areas where regional facilities are constructed according to the Stormwater Master Plan and fees have been identified.[1] In all cases, on-site stormwater management shall be achieved to the maximum extent practicable before any off-site facilities or fees will be allowed. **On-site techniques that are cited as "cost prohibitive" will not be accepted as "infeasible".**

Submissions of special circumstances will delineate the following:

1. The applicant shall account for the disposition of all stormwater runoff from the site.
2. All off-site facilities shall include improvements necessary to prevent water quality degradation or system capacity problems in conveyance of the extra stormwater flows.

In reviewing the applicant's plan submittal, the City will use the following criteria:

1. Has the applicant made maximum use of on-site approaches identified in this *Manual*?[2]
2. If the pollution reduction standards have not been met, does the plan include the maximum practicable amount of pollution reduction that can occur on this site?
3. If the flow control standards have not been met, does the plan include the maximum practicable amount of flow control that can occur on this site?
4. If criteria 2 or 3 apply, has a fee been paid to allow for construction and maintenance of an offsite private or public facility?

Once the plan has been submitted, the City will follow the steps outlined in the GDC Section 11.0200 in order to make a decision. The procedure for filing an appeal to a decision is outlined in GDC Section 11.0500.

[1] Off-site facilities are basin-specific. As of July 2003, there are only two regional facilities either designed or planned to be designed in the City.

[2] On-site techniques that are cited as "cost prohibitive" will not be accepted as "infeasible".

1.3.3 Stormwater Quality Control Plan Requirements

GDC Section 9.0521 requires that water quality must be addressed in the Stormwater Quality Control Plan, as described in the Water Quality Manual. Refer to Table 2.2.1: "Stormwater Quality Control Plan Checklist". **The following is required in the Stormwater Quality Control Plan:**

A. **A map showing the locations of the stormwater quality facilities** (including inlet and outlet structures) with relation to buildings and other structures, the storm sewer system for the site, and natural watercourses (e.g., streams, wetlands, bogs and marshes) affecting the site. It shall be the applicant's responsibility to delineate the boundary of any wetlands meeting the definition in GDC Section 3.0010.

B. **A topographic map delineating the drainage area** served by each stormwater quality facility, calculations and estimated volume to be captured and treated by each facility, the size and physical configuration (with supporting calculations) of each facility, and design of details for any flow bypass or diversion devices.

C. **Specifications for the stormwater quality facilities**, including construction and materials requirements, and manufacturer's data, as appropriate.

D. **A statement of the intended use of the site for full build-out conditions** and the appropriateness of the selected stormwater quality facilities for treating the stormwater pollutants expected in relation to that land use.

E. **The maintenance methods and frequencies necessary to ensure optimum performance** of the stormwater quality facilities over their projected life. Following a review of this information, the City shall work with the customer to determine maintenance responsibilities, and will require a maintenance agreement for the proposed stormwater quality facilities.

1.3.4 Drainage Requirements

All proposed site treatment and flow facilities must conform to the Design Standards as outlined in GPWS Section 2.0000: Storm Drainage and must be consistent with the Stormwater Master Plan, as determined by the Watershed Division Engineer.

1.3.5 Stormwater Quality Treatment Performance Standard

In a technical assessment of water quantity treatment options titled, "Methods for Evaluating Potential Water Quality Development Standards" by URS Corporation," the City determined what design volume and flow rates would reach 80% of the annual volume of stormwater runoff for a site. This technical memo describes the background for concluding that an 80% treatment standard will adequately protect water quality, while still being technologically feasible to implement. **Except for sites defined as exempt in Section 1.3.1, all new and redevelopment sites must follow the design criteria outlined below:**

A. **Detention based stormwater quality control:** The required design volume for detention-based control is equal to the entire runoff volume that would occur from a site with a 1.2-inch, 24-hour storm. The drawdown time for the entire volume must be greater than or equal to 48 hours. For the lower half of the detention volume, the drawdown time must be greater than 36 hours. Additional design criteria for inlet and outlet spacing and design, as well as guidelines for calculating volumes, are contained in the Public Works Standards.

B. **Flow-through based stormwater quality control:** the required design flow rate for treatment is the runoff that would be produced from a rainfall intensity of 0.2 inches/hour for on-line facilities, and 0.11 inches/hour for off-line facilities. This rate must be maintainable for a minimum of three hours. Additional design criteria for flow calculation, as well as specific treatment criteria for various types of stormwater facilities (e.g., infiltration and stormwater filters), are contained in the Public Works Standards.

C. **Combination detention based and flow-through based stormwater quality control:** Detention facilities may be combined with flow-through facilities. The applicant must show that the combined system could sufficiently treat stormwater runoff for the runoff produced by the flow-through treatment rates of 0.2 inches/hour (on-line facilities), occurring for a three-hour period.

D. **Stormwater quality facilities shall be selected for the site that are appropriate** to treat expected stormwater pollutants based on the intended use of the site under full build-out conditions.

Additionally per GPWS 2.0070, the City may determine that additional water quality controls are necessary in basins that drain to sensitive receiving waters or groundwater sources. These requirements may include larger facility designs, as well as, additional types of controls. **See Section 1.6 of this Manual for a discussion of pollutants of concern associated with each watershed in Gresham.**

1.3.6 Stormwater Quality Facilities

See sections 3.0 through 8.0 of this *Manual*. **For a discussion of proprietary facilities, see Section 1.5.1 of this *Manual*.**

- Detention and Sedimentation
- Filtration
- Retention/Infiltration
- Oil and Water Separation
- Proprietary Facilities

1.3.7 Erosion Control Requirements

Development of all sites and construction and installation of all facilities described in this *Manual* are subject to erosion control standards as defined in GDC 9.0514 and GPWS 2.0050 & 2.0051 and shall follow the specifications described in the City's *Erosion Prevention and Sediment Control Manual*. **All newly constructed water quality and detention facilities must be free from construction sediment and debris before final project approval will be granted by the City.**

1.4 Ownership and Maintenance of Facilities

Most facilities will remain private and require that a legal entity be established. See Section 9.0 for details.

The City's policy is to have stormwater quality treatment accomplished on-site. See GDC Section 9.0523 for the requirements for maintenance and inspection of private stormwater quality treatment facilities. Most facilities will remain private and require that a legal entity be established. Private stormwater quality/detention facilities are subject to periodic inspection by the City to ensure proper maintenance and performance. Requirements for Maintenance Agreements are discussed in Section 9.0 of this *Manual* and a sample Maintenance Agreement and facilities checklist is provided in *Appendix B*.

Once installed, proper maintenance of BMPs is key to achieving the ultimate goal of meeting water quality standards. As such, the number of BMPs accepted by the City are limited to those that the City has resources to maintain, should the need arise. See Section 1.5.1 in the *Manual* for more information about proprietary facility approval.

1.4.1 Private Ownership Exception

In situations where locating these facilities on private property is infeasible or impractical, these facilities may be located in the streets and/or on a private lot with public ownership through a public stormwater easement to allow for the eventual transfer of ownership to the City.

The Watershed Division Manager approves or denies private facility location in the public right-of-way.

Application to transfer ownership and approval by the City must be completed prior to the approval of development permits.

A. Ownership Transfer Conditions

In order for the City to consider transfer of ownership, the following conditions must apply:

- Facility must be located in a single-family subdivision.
- Facility must be located in a dedicated public stormwater easement.

B. Public Right-of-Way Requirements

When the above conditions are applicable, the developer may be granted permission by the Stormwater Division Manager to locate stormwater detention and water quality treatment facilities in public right-of-ways with the following conditions:

- No facilities shall be located in collectors and/or arterials.
- The stormwater facilities and access routes have been located within a dedicated public easement on private or commonly held property, within the public right-of-way, public easement, or on publicly owned property.
- Aboveground facilities are preferred over underground facilities. When it is infeasible to construct aboveground facilities, all underground facilities must be designed to minimize use of utility corridors. Vaults and pipes with diameters larger than 48" will typically not be permitted.
- Strict adherence to GPWS is required to allow for appropriate public and private runoff capacity and must be maintainable using publicly owned equipment with public maintenance access.
- Strict adherence to GDC Appendix 5, which outlines requirements for all facilities to be dedicated to the City.
- A maintenance plan must still be completed, even if ownership is transferred.

1.5 Design Approval

Development of a Stormwater Quality Control Plan early in the design process is encouraged, as this typically leads to more cost-effective designs.

The BMPs described in Sections 3.0 through 8.0 in this *Manual* will reduce pollutant loads in post-construction site runoff, provided that the facilities are properly designed, installed, and regularly maintained.

Many of the BMPs can be designed and/or sized to meet both water quality and quantity requirements for stormwater management.

Refer to the flow chart in the Overview of this *Manual* titled "Development Process Overview" to review the permit approval process. To review the permit approval process timeline refer to GDC Section 11.0211 through 11.0217.

1.5.1 Proprietary Facilities

A number of experimental and innovative facilities are becoming available. Site designers and developers are encouraged to consider new stormwater treatment technologies, as they become available. **However, the effectiveness of these proprietary facilities and the City's ability to maintain them are of utmost importance to the City. To this end, the City will follow, but is not limited to, the City of Portland's approved technology list, as the approved technology.** No specific equipment is listed with this document so as to not become out-dated. The developer needs to delineate the types of facilities proposed in the Stormwater Quality Control Plan (see Section 1.3.3) and seek City approval before finalizing the design. Additionally, these facilities must be maintained according to the manufacturer's instructions and will follow the access road requirements listed in Section 4.6.2. See also Section 9.0: Maintenance Agreement.

The City is committed to working cooperatively with developers and designers during the development review and permitting process. The end goal of this collaborative process between the City and the user of this *Manual* is to reduce stormwater impacts and enhance the livability of Gresham.

1.6 Gresham's Drainage Basins

The purpose of this section is to summarize stormwater management issues that are specific to each drainage basin. There are four drainage basins (watersheds) within the City of Gresham boundaries. **These are Fairview Creek, Johnson Creek, Kelly/Burlingame Creek, and West Gresham (Columbia Slough) Drainage Basins.** Figures 1.6 A-D illustrate these watershed drainage boundaries and related soil survey information. These maps are for illustration purposes only and should not be assumed to represent any specific site conditions. For the reader's convenience, a table of the soil codes and names has been provided in *Appendix A*.

Development sites that discharge into waterbodies that are "water quality limited" or have noted "pollutants of concern" must also comply with pollutant removal requirements specific to that waterbody.

The site developer is responsible for complying with current DEQ 303 (d) listings.

1.6.1 Gresham's Water Quality Limited Waterbodies

As required by the federal Clean Water Act, the DEQ developed the 303(d) list, which is subject to public review and must be approved by EPA. **Within the City of Gresham (as of October 2003), this list includes Fairview Creek, Johnson Creek, Kelly Creek and Columbia Slough. The stormwater quality control plan must adequately address each pollutant of concern for sensitive areas as discussed in Section 1.2.2. The pollutants of concern are described in Section 1.6.2 through 1.6.5.**

The City of Gresham Watershed Engineer approves the stormwater quality control plan. Refer to Table 2.2.2 for guidance in BMP selection.

The list identifies the impacted beneficial uses and pollutants of concern for each of the waterbodies.

Furthermore, OAR 340-041-026(3)(C) provides that if a segment is listed for one or more pollutants, new or increased discharges of that pollutant, however minimal, are prohibited on that listed segment until DEQ establishes the relevant total maximum daily load (TMDL).

TMDLs describe the amount of each pollutant a waterway can carry and still comply with water quality standards. Presently, the entire Columbia Slough, including the headwaters reach at Fairview Lake has established TMDLs but no TMDL implementation plan has been developed. Johnson Creek TMDLs are expected to be established by December 2003. Moreover, if the permitted limits appear nevertheless to allow the stream segment to exceed its water quality standards, existing permits must be adjusted downward.

1.6.2 Fairview Creek

303(d) listings are provided as guidance only. For complete information visit DEQ's website at:

www.oregon.gov/deq/

Water Quality Program

or call 503-229-6804.

Fairview Creek begins in an extensive wetlands area south of Division Street and flows through varying levels of urbanization. Drainage from the southerly wetlands area is generally high-density residential and open space. From the east 800 plus acres, it flows through a mix of residential & commercial and extends to Hogan Road. Fairview Creek runs north to Glisan Street then through the City of Fairview and, eventually discharges into Fairview Lake, which drains into the Columbia Slough. Fairview Creek watershed encompasses approximately 4 square miles, of which 2 square miles are within Gresham city limit.

Fairview Creek is on the 303(d) list for exceeding numerical standards that were developed to protect the beneficial uses. Table 1.6.2 below provides a simplified version of these 303(d) listings.

Table 1.6.2 Summary of 303(d) Listings and Pollutants of Concern

Waterbody	Parameters	Affected Beneficial Use
Fairview Creek	pH, Dissolved Oxygen	Resident fish and aquatic life
	Bacteria (Fecal coliform/E. coli)	Water contact recreation
	Temperature	Salmonid fish use (e.g., rearing, spawning, migration, etc.)
	Heavy Metals (Lead, Copper)	Resident fish and aquatic life

Source: DEQ website, Spring 2003, City of Gresham Water Quality Monitoring Data.

1.6.3 Johnson Creek

The Johnson Creek watershed encompasses 54 square miles and is a tributary to the Willamette River in Portland. Although Johnson Creek does not originate in Gresham, some of the upper reaches of the creek flow through the City of Gresham, an area that is approximately 26 square miles. Johnson Creek enters the Gresham city limits at approximately SE 252nd Avenue and SE Telford Road, flows in a northwesterly direction to Powell Boulevard and Main Avenue, then flows generally westward until it leaves the city limits near its intersection with SE 174th Avenue. Much of south Gresham, including the downtown area, is located in the Johnson Creek watershed.

Johnson Creek is on the 303(d) list for exceeding numerical standards that were developed to protect the beneficial uses. Table 1.6.3 below provides a simplified version of these 303(d) listings. As required by law, DEQ is currently in process of developing TMDLs for these listed parameters by December 2003.

Table 1.6.3 Summary of 303(d) Listings and Pollutants of Concern

Waterbody	Parameters	Affected Beneficial Use
Johnson Creek	Toxics (water) (Dieldrin, Toxaphene, Dioxins/Furans, DDT, Chlordane, PCB, PAH)	Resident fish and aquatic life/Human health hazard from fish consumption
	Bacteria (Fecal coliform/E. coli)	Water contact recreation
	Temperature	Salmonid fish use (e.g., rearing, spawning, migration, etc.)
	Dissolved Oxygen	Resident fish and aquatic life
	Heavy Metals (Zinc, Copper, Iron, Chromium, Lead)	Resident fish and aquatic life

Source: DEQ website, spring 2003, City of Gresham Water Quality Monitoring Data.

1.6.4 Kelly/Burlingame Creek

The Kelly Creek watershed drains a narrow 2,912 acre basin which is approximately 5 miles in length and 2 miles at its widest. Its major tributary, Burlingame Creek drains about 1,275 acres and is about 3.5 miles in length with over a mile of its center reach enclosed in storm sewer. Downstream of the confluence of Burlingame and Kelly Creeks, a pond at the Mount Hood Community College provides the primary control for discharge from the basin to Beaver Creek that ultimately discharges to the Sandy River. The basin is approximately 40 percent urban development; urban development will ultimately reach 80 percent of the total land area under current zoning.

Kelly Creek is on the 303(d) list for exceeding numerical standards that were developed to protect the beneficial uses. Burlingame Creek is not listed on the 303(d) list, but historical sampling has indicated that heavy metals, nutrients and bacteria are pollutants of concern. Table 1.6.4 below provides a simplified version of these 303(d) listings.

Table 1.6.4 Summary of 303(d) Listings and Pollutants of Concern		
Waterbody	**Parameters**	**Affected Beneficial Use**
Kelly Creek	Bacteria (E. coli)	Water contact recreation
	Nutrients, Dissolved Oxygen	Resident fish and aquatic life
	Heavy Metals (Lead, Copper)	Resident fish and aquatic life
	Temperature	Resident fish and aquatic life
Source: DEQ website, spring 2003, City of Gresham Water Quality Monitoring Data.		

1.6.5 West Gresham Basin (Columbia Slough)

The West Gresham area is mostly developed and comprises approximately 5.8 square miles in the northwest corner of the City. The northern half of the study area drains through approximately 28 miles of storm sewer pipes to the Columbia Slough. The southern half of the area drains to the subsurface through 373 dry wells. Multnomah County also owns and operates 239 additional dry wells located within the right-of-way in the major arterials of this area.

Columbia Slough is on the 303(d) list for exceeding numerical standards that were developed to protect the beneficial uses. Table 1.6.5 below provides a simplified version of these 303(d) listings. Additionally, DEQ has established TMDLs for certain listed parameters. Once appropriate wasteload and load allocations have been established, the TMDL implementation plan will be developed to meet established limits.

Table 1.6.5 Summary of 303(d) Listings, TMDLs and Pollutants of Concern		
Waterbody	**Parameters**	**Affected Beneficial Use**
Columbia Slough	Toxics (water) (Dieldrin, DDE, PCBs, DDT, 2,3,7,8 TCDD, Chlordane, Heptachlor, Isophorone, Phenanthrene, Acenapthene, Naphthalene)	Resident fish and aquatic life/Human health hazard from fish consumption
	Bacteria (Fecal coliform/E. coli)	Water contact recreation
	Temperature	Salmonid fish use (e.g., rearing, spawning, migration, etc.)
	Dissolved Oxygen, Phosphorus, pH, Chlorophyll a	Resident fish and aquatic life
	Heavy Metals (Lead, Iron, Manganese, Cadmium, Chromium)	Resident fish and aquatic life
Source: DEQ website, Spring 2003, City of Gresham Water Quality Monitoring Data.		

1.7 Water Quality Regulations

Water quality is regulated and protected through numerous federal laws and regulations, including the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA), which are the primary authorizing regulations for this document. The Oregon Department of Environmental Quality (DEQ) implements and enforces provisions of these federals acts.

NOAA Fisheries, US Fish and Wildlife Service (USFWS) and the Oregon Department of Fish and Wildlife (ODFW) also play a role in regulating Oregon water quality and aquatic habitat, through their listing of indigenous fish species as threatened or endangered. The Division of State Lands (DSL) inventories, monitors and has regulatory jurisdiction over wetlands.

The following subsections provide abbreviated descriptions of relevant regulations and how they impact Gresham, specifically. The reader is encouraged to research specific regulations for detailed information.

The following section summarizes aspects of local, state and federal regulations that authorize or direct the requirements in this manual.

Go to the DEQ website for more regulatory information:

www.oregon.gov/deq/

Select Water Quality Division, then TMDL or Drinking Water or UIC for specific program information.

1.7.1 The Clean Water Act and Oregon's 303(d) List

The federal CWA requires states to undertake specific activities to protect the quality of their rivers, streams, lakes and estuaries. In Oregon, DEQ has the responsibility for developing standards that protect beneficial uses such as drinking water, cold-water fisheries, aesthetics, recreation, agriculture and other uses. The state monitors water quality and reviews available data and information to determine if the standards are being met. DEQ's standards include parameters such as bacteria, pH, turbidity, dissolved oxygen, temperature, total dissolved gas, certain toxic and carcinogenic compounds, habitat and flow modification, and aquatic weeds or algae that affect aquatic life. The implications from this regulation to the user of this *Manual* are detailed in Sections 1.6.1 through 1.6.5.

1.7.2 Safe Drinking Water Act of 1974 (SDWA) – Wellhead Wellfield Protection Program

Go to the City of Portland website for more information and to obtain a copy of the *Columbia South Shore Wellfield Wellhead Protection Program Reference Manual.*

Contact the city of Gresham Water Division: 503-618-2668

The 1974 federal SDWA addresses non-point and point sources of pollution through a provision requiring states and local agencies to establish wellhead protection zones to safeguard groundwater drinking water systems.

In Gresham, this area is based on a groundwater model simulation of the 30-year time of travel to the production wells of the Columbia South Shore Groundwater Resource Wellhead Protection Area (See *Appendix: G*). This area is subject to BMPs aimed at providing appropriate levels of protection as described in the *Wellhead Protection Program Reference Manual.*

1.7.3 Safe Drinking Water Act of 1974 (SDWA) – Underground Injection Control (UIC) Program

The DEQ also administers the UIC Program in Oregon, as mandated by the federal Safe Drinking Water Act in order to ensure groundwater protection. Refer to OAR Chapter 340, Division 44. An underground injection is any system, structure or activity that is created to place fluid below the ground or sub-surface.

For technical questions call DEQ- UIC Program at 503-229-5945, and for copies of applications or forms call 503-229-5189.

See also www.oregon.gov/deq/

Water Quality Division

All stormwater infiltration sumps within the City of Gresham are classified as Class V UIC and must be registered with and meet regulatory requirements of DEQ. Please note that registration (for new construction of and modifications to existing drywells) submittals to DEQ must be 60 to 90 days prior to construction to allow for potentially requested design changes in order to meet rule authorization requirements.

UICs that require a permit or treatment train using BMPs not on the approved list per Section 1.5.1 are not acceptable to the City. For information regarding UIC design standards, refer to Section 8.0 of this *Manual.*

1.7.4 National Pollutant Discharge Elimination System (NPDES)

In 1987, amendments to the CWA required the EPA to address discharges from Municipal Separate Storm Sewer Systems (MS4), which originate as urban stormwater runoff, using the NPDES permit as the regulatory mechanism.

Loss or degradation of habitat resulting from land development can be considered a take, and the jurisdiction that permitted or allowed the offending development can be held liable for the take.

The City's NPDES MS4 permit focus on the implementation of best management practices (BMPs) to improve the water quality of stormwater discharges. **These BMPs are described in the Stormwater Management Plan and are categorized into five major areas:**

- Structural and Non-structural Controls for Residential/Commercial Areas
- Controls for Illicit Discharges and Improper Waste Disposal
- Controls for Industrial and Similar Facilities
- Construction Site Controls
- System Planning Controls

1.7.5 Endangered Species Act (ESA)

The decline of salmon within the Pacific Northwest has caused the NOAA Fisheries to list 26 salmon and steelhead populations or evolutionary significant units (ESUs) in Oregon, Washington, California, and Idaho as *threatened* or *endangered* under the ESA. **For the City of Gresham, all stormwater discharges to either a stream with listed species or to a tributary of a stream with listed species must be treated.**

ESA prohibits the "taking" of a member of any species listed as *endangered*, and allows the USFWS or NOAA to impose the same prohibitions for any species listed as *threatened*. The ESA defines "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." *Take* has also been defined to include the intentional or negligent act of habitat modification that significantly impairs essential behavioral patterns such as breeding, spawning, rearing, migrating, feeding, or sheltering, and which results in death or injury of a protected species.

Go to USFWS and NOAA Fisheries' websites for more information on ESA:

http://www.fws.gov/

http://www.nwr.noaa.gov/

Loss or degradation of habitat resulting from land development can be considered a *take*, and the jurisdiction that permitted or allowed the offending development can be held liable for the *take*. The ESA provides for third-party lawsuits, so private citizens alleging that *take* has occurred because of land development can sue.

The BMPs described in this *Manual,* when properly implemented, will help developers and the City of Gresham limit negative impacts to listed salmon and steelhead.

1.7.6 Federal Emergency Management Agency and the National Flood Insurance Program

In Gresham, the Federal Emergency Management Agency (FEMA) exercises regulatory control over development occurring in flood areas. The National Flood Insurance Program (NFIP) is a federal program that allows property owners to purchase flood insurance protection.

While FEMA regulations are not specifically geared toward the issue of water quality, because regulatory measures may indirectly support broader efforts to protect water quality, they are mentioned here.

GDC Section 5.0400 describes HCA requirements.

Required setbacks from streams and wetlands vary from 15 to 200 feet.

1.7.7 Metro Urban Growth Boundary Functional Plan—Title 3

As a part of the Metro Urban Growth Management Functional Plan, Metro code 3.07.310-3.07.370, Title 3 requires adoption of Habitat Conservation Area(HCA) Performance Standards. To comply with this requirement, Gresham has adopted the HCA Overlay in the Community Development Code to provide protection of local streams and wetlands.

The overlay requires new development to provide setback of certain distances from a nearby stream or wetland. **The specific setback is dependent upon whether the land adjacent to the stream or wetland has a slope less than or greater than 25%.**

See the complete description of Metro's UGB Functional Plan at:

www.oregonmetro.gov

1.7.8 Oregon's Statewide Planning Goal 5-- Natural Resources, Scenic and Historic Areas and Open Spaces

The requirements of this Plan and Guidelines are described in OAR 660-015-0000 (5). This plan encourages local governments to:

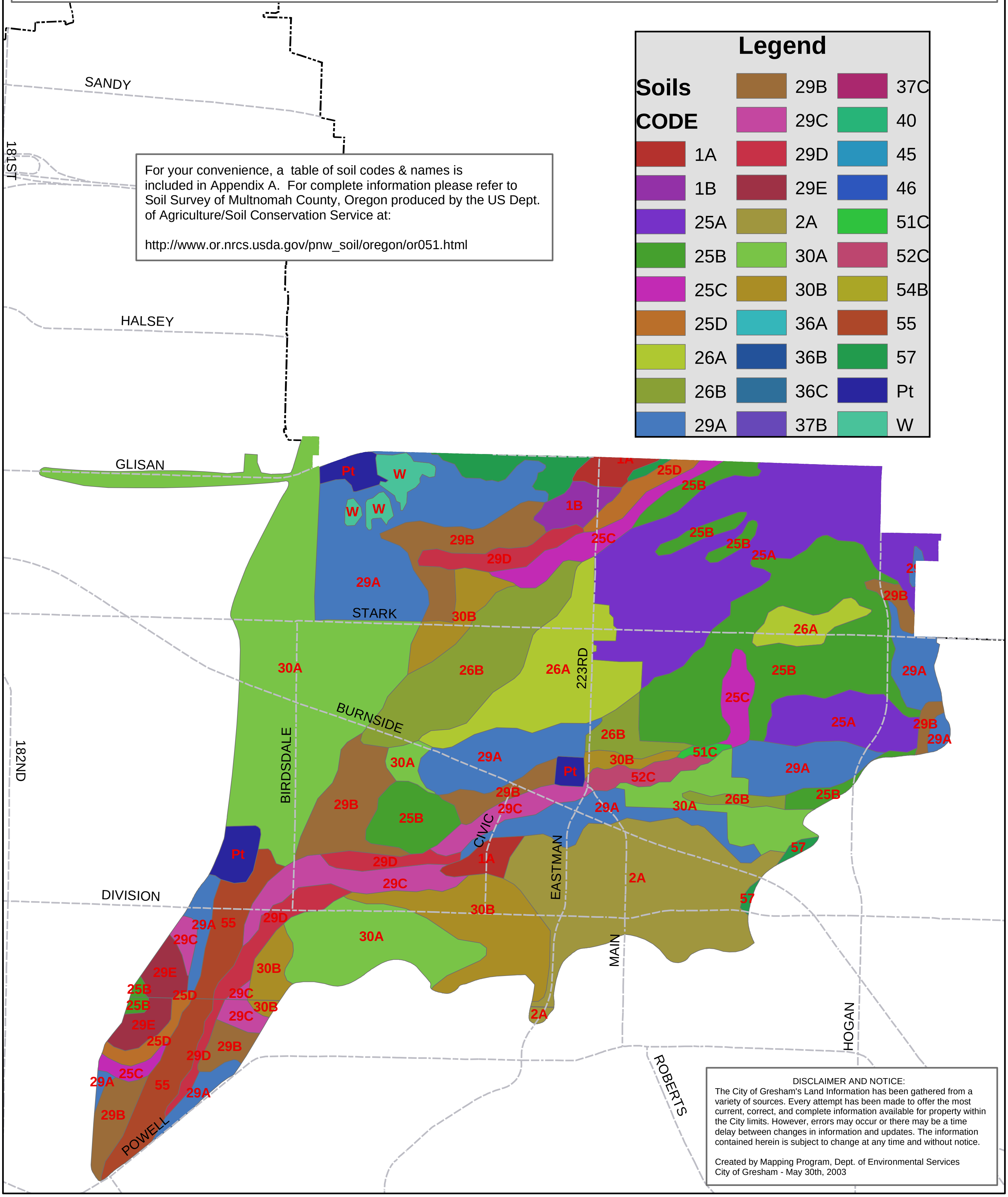
- Inventory open spaces, corridors, wetlands, rivers and streams, groundwater and natural resources.
- Plan for the appropriate measures to be taken to protect and maintain the various resources and open spaces.
- Implement via fees, easements, cluster developments, preferential assessment, development rights acquisition, or similar techniques.

See the complete description of Oregon's Statewide Plan at:

www.oregon.gov/lcd/

At the writing of this *Manual*, the City is working toward the inclusion of Goal 5 goals in the Master Plan and is focused on enhancing the livability of Gresham through long-term development strategies. The expected completion date of incorporation has not yet been determined.

Figure 1.6 A Map of Fairview Creek Watershed with Soils Survey



For your convenience, a table of soil codes & names is included in Appendix A. For complete information please refer to Soil Survey of Multnomah County, Oregon produced by the US Dept. of Agriculture/Soil Conservation Service at:

http://www.or.nrcs.usda.gov/pnw_soil/oregon/or051.html

DISCLAIMER AND NOTICE:
The City of Gresham's Land Information has been gathered from a variety of sources. Every attempt has been made to offer the most current, correct, and complete information available for property within the City limits. However, errors may occur or there may be a time delay between changes in information and updates. The information contained herein is subject to change at any time and without notice.

Created by Mapping Program, Dept. of Environmental Services
City of Gresham - May 30th, 2003

Figure of 1.6 B Map of Johnson Creek Watershed with Soils Survey

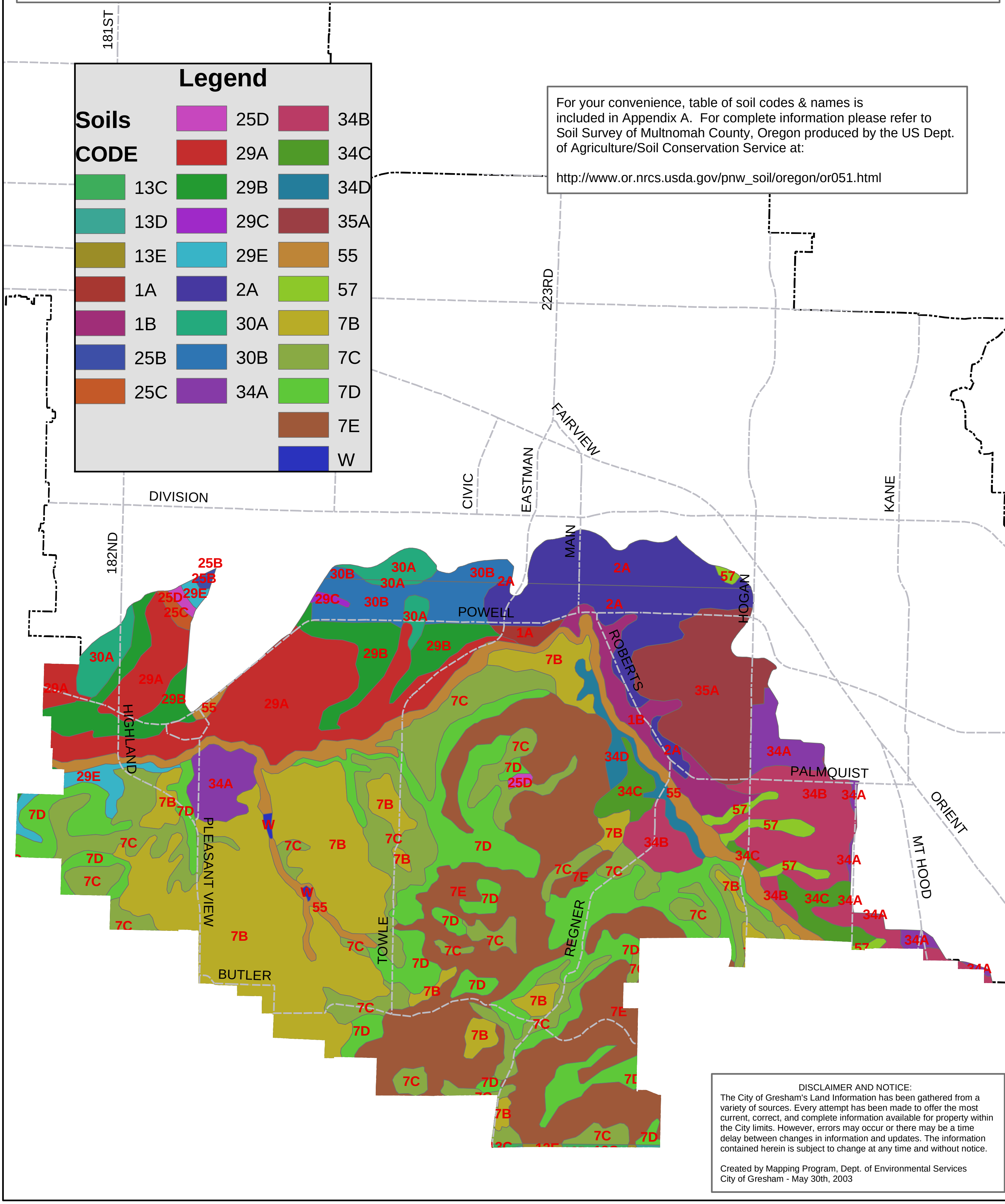


Figure 1.6 C Map of Kelly/Burlingame Creek Watershed with Soils Survey

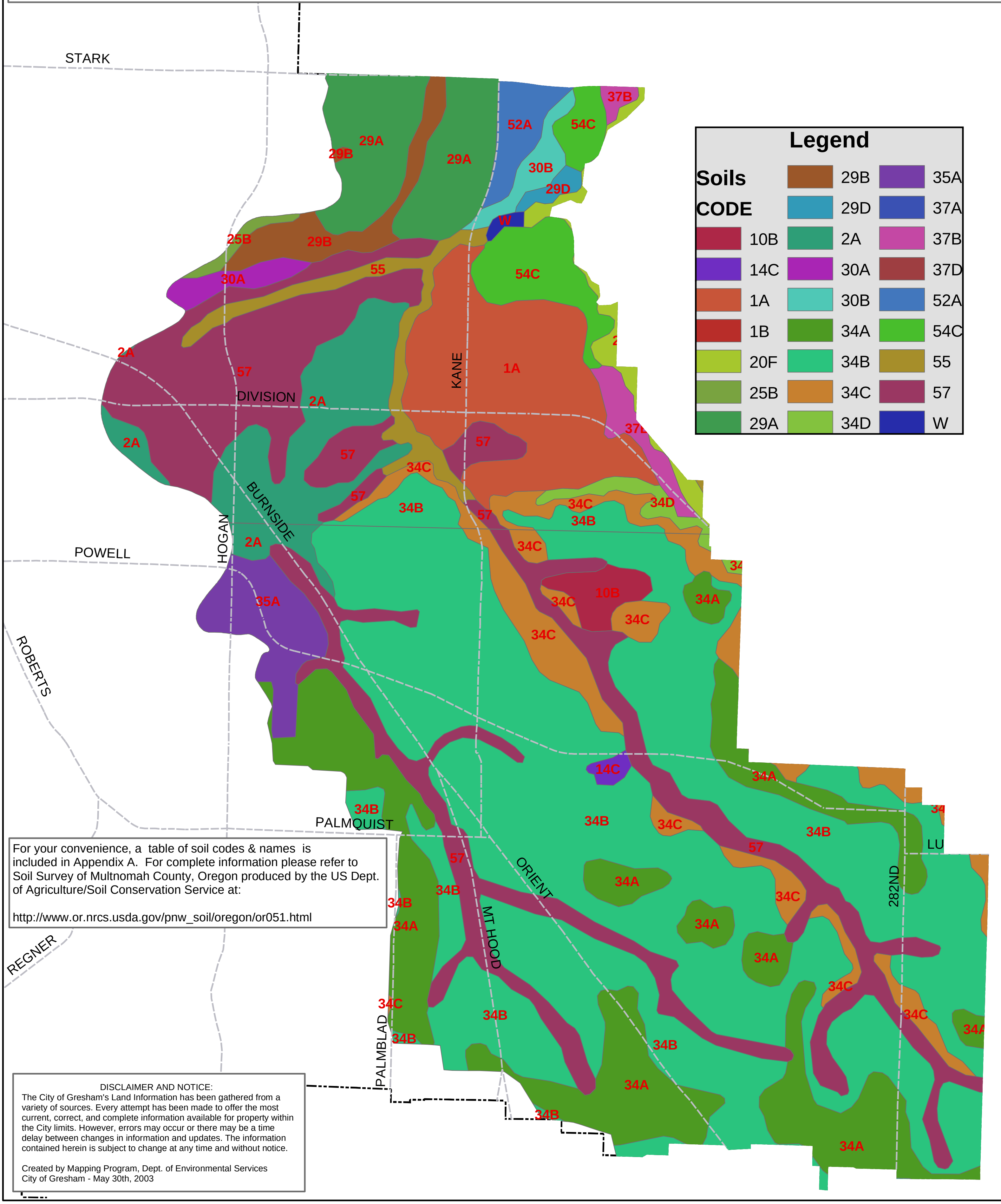
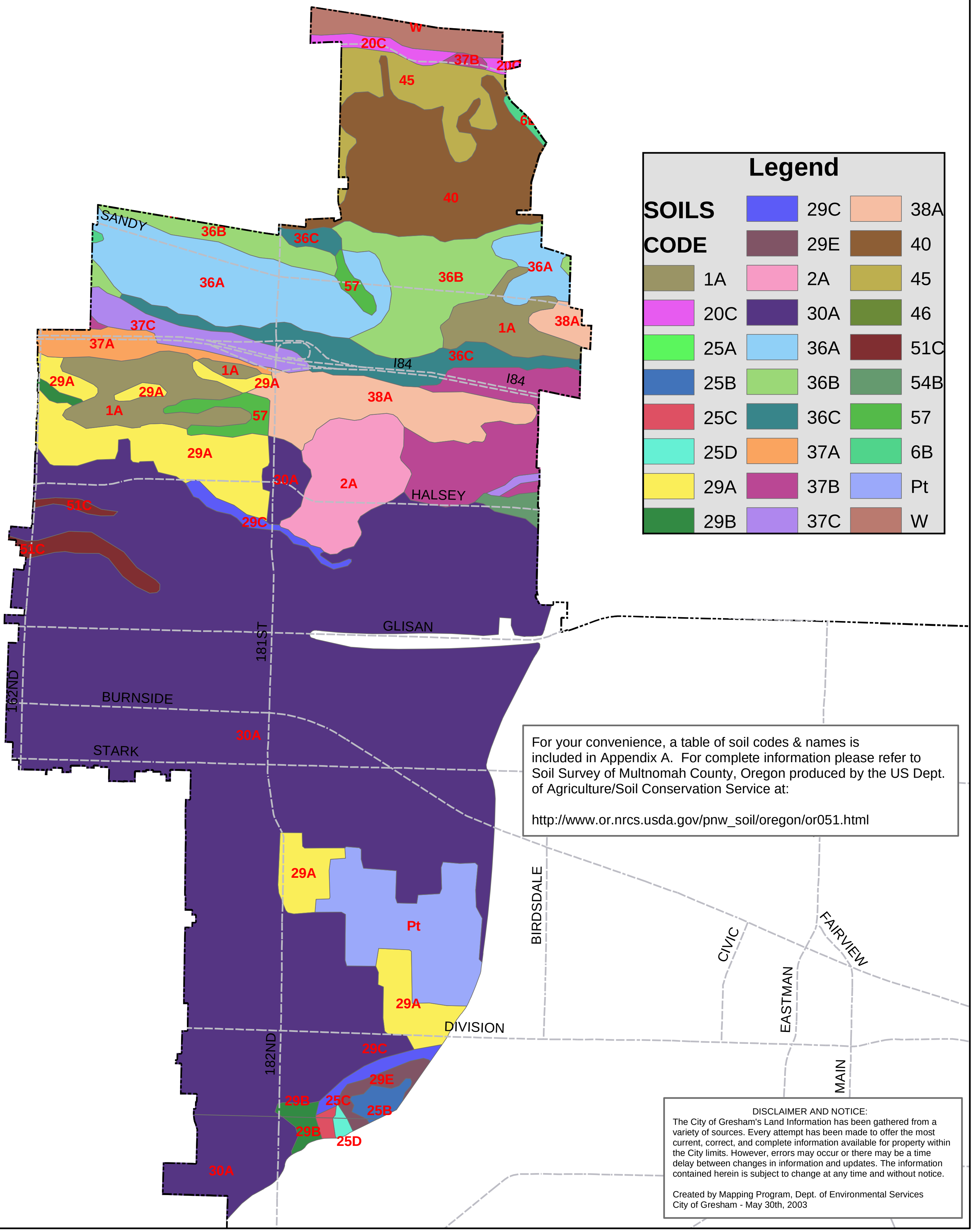


Figure 1.6 D Map of West Gresham Basin (Columbia Slough) Watershed with Soils Survey



For your convenience, a table of soil codes & names is included in Appendix A. For complete information please refer to Soil Survey of Multnomah County, Oregon produced by the US Dept. of Agriculture/Soil Conservation Service at:

http://www.or.nrcs.usda.gov/pnw_soil/oregon/or051.html

Created by Mapping Program, Dept. of Environmental Services
City of Gresham - May 30th, 2003

Section 2.0 Stormwater Management Planning

2.1 What You Will Need

The purpose of this section is to provide guidance for selecting facilities in order to develop your Stormwater Quality Control Plan. See Section 1.3.3 of this Manual for plan content description. Refer also to the flow chart in the Overview titled "How to Use this Manual."

The City's pollution control strategy is to emphasize pollution prevention first, through the application of source control and proper installation and maintenance of BMPs. This is especially true for commercial and industrial users where there is a greater likelihood of hazardous substance use that could potentially contaminate surface and groundwater, if not managed properly, and where maintenance of on-site treatment facilities is the responsibility of the property owner.

The users are encouraged to have at least the following information available while implementing this *Manual*:

- Project site location and proposed point of discharge
- Downstream capacity
- Total impervious area
- Site specific soil information
- Pollutants of concern based on future build-out conditions and drainage basin
- Low impact development measures to be used
- Proposed protective measures for streamside buffers and existing wetlands
- Total number and size (in acres) of drainage areas within your project site
- Parking lot size considerations

2.2 Appropriate BMP Facility Selection

Table 2.2.1: Stormwater Control Plan Checklist has been provided for ease of reference when creating the Stormwater Control Plan.

To select appropriate BMP Facilities for your site, you will need to understand the overall topography of your site and its location within one Gresham's four watersheds. Each watershed has a list of "pollutants of concern" as described in Table 2.2.2 and defined in Section 1.2.2. Additionally, descriptions of each watershed can be found in Section 1.6 of this *Manual*.

By using Table 2.2.2, users of this manual will be able to understand the pollutants of concern associated with their site's watershed, appropriate applications for each stormwater BMP facility and the maximum drainage area that any one single facility can treat effectively. Keep in mind, that depending on the overall site topography and impervious surface installations, you may need to combine several types of facilities to meet both quantity and quality treatment standards.

Appropriate applications and design factors vary from watershed to watershed because of variance associated with pollutants of concern, site-specific characteristics, maintenance plans, land use types, etc. There are no one-size-fits-all BMPs. The designer should carefully review all of the factors before selecting BMPs.

Table 2.2.1: Stormwater Quality Control Plan Checklist:

- ☐ Identify the natural watercourses such as streams, bogs and wetlands that are present on or near your site.
- ☐ Identify the drainage area(s) on your site.
- ☐ Identify the proposed future build-out use for your site.
- ☐ Identify Low Impact/Green Development BMPs for your site as described in the *Green Development Practices Manual* and *Green Street Standards, as applicable.* (www.greshamoregon.gov Documents)
- ☐ Identify the watershed that your site lays within using Section 1.6, then refer to Table 2.2.2 "Recommended Stormwater Facilities Based on Pollutants and Site Conditions."
- ☐ Identify possible "pollutants of concern" that might be generated from your site and consider appropriate stormwater BMP facilities to pretreat and control these pollutants. (Table 2.2.2).
- ☐ Refer to the soil maps in Figures 1.6 A-D to determine the soil type(s) existing within your site in order to ascertain the viability of stormwater infiltration facilities or other BMP types. Refer to Appendix A for a list of soil codes and names. This is an abbreviated list for the user's convenience. To obtain complete soil descriptions from the source visit: http://www.or.nrcs.usda.gov/pnw_soil/oregon/or051.html.
- ☐ Refer to Section 1.3.5 of this *Manual* for the Stormwater Quality Treatment Performance Standard.
- ☐ Identify the number, types and locations of stormwater BMP facilities that will be necessary to treat and capture stormwater for each drainage area.
- ☐ Provide the stormwater calculations, volume treated and captured, facility size and physical configuration (with supporting calculations) for each facility, and the design details for any flow bypass or diversion devices.
- ☐ Include the construction materials to be utilized and facility design specifications.
- ☐ Include the proposed maintenance plan and frequencies needed to assure optimum performance for the stormwater BMP facilities.
- ☐ File a Maintenance Agreement with the City as discussed in Section 9.0 and *Appendix B.*

2.3 Low Impact/Green Development Practices

2.3.1 Overview

The advantages of low-impact development (LID) practices have been well documented for protecting the health of an urban watershed. Gresham's first priority for water quality and quantity management is to utilize LID best management practices in order to minimize stormwater runoff generated from developed sites. This can also be proactively achieved by minimizing impervious area that is planned as part of the development.

With some forethought and site planning relating to changes in surface flows and infiltration that may occur on a development site, the site planner and developer have significant opportunities to implement low impact development techniques that will not only improve water quality, but also have the potential to be a significant reduction in implementation costs, e.g., not installing hard structures such as pipes, curbs and gutters. Additionally, low impact development practices offer a developer greater flexibility relating to the overall use of space on a site, for example potentially eliminating the need to install a stormwater pond—at a much greater use of space and financial cost.

When managing on-site stormwater, surface infiltration and evapotranspiration are two simple examples of LID practices and are the <u>first priority</u> of the City for stormwater control and treatment. **Refer to the city's *Green Development Practices Manual* for BMP selection.**

Surface infiltration or "flow-through" facilities are discussed in Section 3.0. Subsurface infiltration methods are regulated by the State; are discussed in Section 8.0; have the potential to contaminate groundwater and are the <u>last priority</u> as a stormwater control.

2.3.2 Reduction of Impervious Surfaces

Examples include:

- Use of porous pavement, see Section 3.3.6
- Use of pavers for fringe and overflow parking
- Creation of joint or shared parking
- Multi-level parking structures
- Request a reduction in parking requirements from the City Planning Division
- Build multi-story buildings
- Plan "skinny" streets (See ***City of Gresham Green Street Standards***)
- Use of curbless streets on interior private streets that utilize swales as conveyance/infiltration
- Use of concave medians & landscaped traffic calming features
- Utilize "cluster" development to allow for maximization of green space within a site

2.3.3 Alternative Landscaping Practices

Evapotranspiration can best be achieved through retaining existing trees and/or planting new trees, as well as maintaining vegetative groundcover. This aspect of

LID practices is addressed through the City's tree ordinance and erosion control requirements. The following are general recommendations:

- Plant large canopy trees, particularly conifers, rather than ornamentals or deciduous trees, whenever possible
- Consider installation of rainwater catchment systems rather than piped roof connections to the curb/catch basin system
- Utilize rain gardens in natural and manmade depressions in order to facilitate holding and infiltration onsite
- Install planter boxes, see Section 3.3.4
- Preserve undeveloped green spaces adjacent to common areas, playgrounds, etc.

2.3.4 Additional Resources

- Clean Water Services *Low Impact Development Approach Handbook*: www.cleanwaterservices.org
- Low Impact Development Center, Inc. Publications: www.lowimpactdevelopment.org
- *Low Impact Development Technical Guidance Manual for Puget Sound*: your.kingcounty.gov/solidwaste/greenbuilding/documents/Low_Impact_Development-manual.pdf
- Metro's Nature-Friendly Development: www.oregonmetro.gov
- City of Portland's *Stormwater Management Manual* www.portlandonline.com

Table 2.2.2

Selection of Stormwater Quality Facilities Based on Site Conditions

Stormwater Quality Facility	Contributing Drainage Area	Design Factors	Inappropriate Applications	Maintenance Requirements
Flow-through Water Quality Treatment Facilities – Section 3.0				
biofiltration swale & vegetated swale	up to 10 acres	• soil types B, C, or D (A with soil amendment) • slopes up to 4%, or 6% if check dams are used • flow velocity < 1.0 fps	• areas with high oil and grease concentrations • shaded areas • grades > 6% • soluble P removal • bacteria removal	• maintain vegetation (monthly) • remove debris (monthly) • remove sediment (annually) • inspect inlet and outlet (monthly)
vegetated filter strip	parking lots, driveways, roads, generally not more than 1,000 sq ft	• soil types B, C, or D (A with soil amendment) • slopes from 1% to 15% • flow velocity < 0.5 fps	• areas where runoff velocities are high and flow is concentrated • shaded areas	• maintain vegetation (monthly) • remove debris (monthly) • remove sediment (annually) • inspect inlet and outlet (monthly)
Flow-through planter box & infiltration planter box	Rooftops less than 15,000 SF	• soil types A & B • designed with impervious bottom or placed on impervious surface or infiltrates into soils • self-sustaining vegetation • minimum planter width is 18 to 30 inches, depending on type	• Discharge from any source other than a rooftop • Infiltration to UIC is not allowed without additional treatment	• maintain vegetation (monthly) • remove debris (monthly) • remove sediment (annually) • inspect inlet and outlet (monthly)
sand filter, sand filter vault, and linear sand filter	3-80 acres	• suitable for all soil types • facility should be off-line • pre-treatment of sediments required • impermeable liner may be required where groundwater protection is mandated	• areas where debris, heavy sediment loads, or oil and grease may clog the sand • nitrate removal	• remove debris (monthly) • remove sediment (annually) • inspect inlet and outlet (annually) • inspect filter media (monthly) • replace sand layer (1-2 years)
Detention-Based Water Quality Treatment Facilities – Section 4.0				
wet pond	5-150 acres	• adequate base flow • soil types B, C, or D (a liner may be required for soil type A) • spill containment required for industrial sites • shade permanent pool to reduce water temperature	• total nitrogen & nitrate removal • total P removal	• maintain landscaping (monthly) • remove debris (monthly) • remove sediment (monthly) • inspect inlet and outlet (annually)
wet Extended Detention (ED) pond	3-150 acres	• adequate base flow • soil types B, C, or D (a liner may be required for soil type A) • spill containment required for industrial sites • shade permanent pool to reduce water temperature	• total nitrogen removal • copper removal	• maintain landscaping (monthly) • remove debris (monthly) • remove sediment (monthly) • inspect inlet and outlet (annually)

Table 2.2.2
Selection of Stormwater Quality Facilities Based on Site Conditions

Stormwater Quality Facility	Contributing Drainage Area	Design Factors	Inappropriate Applications	Maintenance Requirements
dry ED pond	5-150 acres, other types of treatment may be required depending on pollutants of concern	• soil types B, C, or D (a liner may be required for soil type A) • spill containment required for industrial sites	• nitrate removal • heavy metal removal • soluble P removal	• maintain landscaping (monthly) • remove debris (monthly) • remove sediment (monthly) • inspect inlet and outlet (annually)
wet vault	< 10 acres, unless combined with other detention facilities	• adequate base flow • spill containment required for industrial sites	• residential areas	• remove debris (monthly) • remove sediment (monthly) • inspect inlet and outlet (annually)
Constructed Marshes – Section 5.0				
shallow marsh	Minimum of 20 acres	• adequate base flow • soil types C or D (a liner may be required for soil types A and B) • spill containment required for industrial sites • shade permanent pool to reduce water temperature	• industrial areas (without significant pretreatment) • soluble P removal • total nitrogen removal • heavy metal removal	• maintain landscaping (annually) • remove debris (annually) • remove sediment (annually) • inspect inlet and outlet (annually) • adjust water flow (as needed)
pond/marsh system	Minimum of 10 acres	• adequate base flow • soil types C or D (a liner may be required for soil types A and B) • spill containment required for industrial sites • shade permanent pool to reduce water temperature	• industrial areas (without significant pretreatment) • total nitrogen removal • soluble P removal	• maintain landscaping (annually) • remove debris (annually) • remove sediment (annually) • inspect inlet and outlet (annually) • adjust water flow (as needed)
extended detention marsh	Minimum of 10 acres	• adequate base flow • soil types C or D (a liner may be required for soil types A and B) • spill containment required for industrial sites • shade permanent pool to reduce water temperature	• industrial areas (without significant pretreatment) • zinc removal • soluble P & nitrogen (nitrate) removal • total P removal	• maintain landscaping (annually) • remove debris (annually) • remove sediment (annually) • inspect inlet and outlet (annually) • adjust water flow (as needed)

Table 2.2.2
Selection of Stormwater Quality Facilities Based on Site Conditions

Stormwater Quality Facility	Contributing Drainage Area	Design Factors	Inappropriate Applications	Maintenance Requirements
Parking Lot Treatment – Section 6.0				
Inlet filter inserts	Maximum of 5,000 sq. ft	• peak flows < 20 gpm • must prevent floating oil from escaping	• areas that will not be maintained	• follow recommendations by the manufacturer • maintain inlet during rainy season (at least monthly) • maintain inlet during dry season (at least every two months) • remove sediment > 6 inches deep • dewater accordintg to manufacturer
Oil water separators		• must bypass flows greater than the water quality design flow • must be installed off-line • must precede all other water quality treatment facilities	• suspended sediment removal • total P removal • heavy metal removal	• inspect (quarterly) • remove sediments > 6 inches deep • maintain by Sept. 15 (annually) • maintain when oil exceeds 1 inch • maintain after a spill of any polluting substance
Subsurface Infiltration Facilities – Section 8.0				
drywells		• must capture and infiltrate all of the design storm (Section 8.4) • soils engineer shall verify depth and suitability of sump installation to 30 ft. maximum • maximum design capacity shall not exceed 1200 gpm or 2.67 cfs	• may not receive runoff from high risk functional areas in designated wellhead protection areas	• inspect (twice annually) • remove sediment at 60% capacity
Infiltration trenches	Generally less than 15,000 sq ft	• soil type A & B • must capture and infiltrate all of the design storm (Section 8.4) • must be at least 10 feet above seasonal groundwater level • minimum of 24 inches wide • drawdown time shall not exceed 24 hours	• may not receive runoff from high risk functional areas in designated wellhead protection areas • sloped areas greater than 4:1 • total nitrogen removal	• inspect (3X/yr) for two years, annually after that time • remove sediment when ponding is occurring • reseed bare spots (as necessary) • mow (at least twice annually)
Soakage trenches	Maximum 1 acre per trench	• soil type A & B for publicly owned facilities, C for private facilities if drawdown times are met • must capture and infiltrate all of the design storm (Section 8.4) • soil must infiltrate at least 2 inches per hour • maximum drawdown time 10 hours	• may not receive runoff from high risk functional areas in designated wellhead protection areas • sloped areas greater than 5%	• inspect (3X/yr) for two years, annually after that time • remove sediment when ponding is occurring

Section 3.0 Flow-Through Water Quality Treatment Facilities

3.1 Overview

Stormwater pollutant filtration can be provided by flowing water through various types of media, such as vegetation, sand or synthetic materials. These media filter out pollutants through adsorption and absorption. This method is referred to as "flow-through treatment."

These facilities generally require more maintenance than other types of stormwater quality facilities; however maintenance efforts may be lessened by appropriate use and placement of native vegetation as the filter media in biofiltration (grassy) swales, vegetated swales or vegetated filter strips.

Vegetated filters are also referred to as "biofiltration facilities" or "biofilters." Biofiltration is a term describing the simultaneous processes of filtration, infiltration, adsorption, sedimentation, and biological uptake (absorption) of stormwater pollutants that occur as runoff travels over and through vegetated systems.

Acceptable treatment facilities include but are not limited to:

- biofiltration swale
- vegetated swale
- vegetated filter strip
- flow-through planter box
- infiltration planter box
- sand filter

Flow-through water quality treatment facilities discussed in this section include:

- **Biofiltration swales:** Vegetated (grassy) channels with a slope similar to that of standard storm drain channels (less than 6%), but wider and shallower to maximize flow residence time and promote pollutant removal. See Section 3.3.1 for more details.
- **Vegetated swales:** a broad shallow channel similar to a Bioswale except that vegetation along the bottom and sides are non-grassy. See Section 3.3.2 for more details.
- **Vegetated filter strips:** Vegetated sloped strips in which flow is distributed broadly along the length of the vegetated area as overland sheet flow. See Section 3.3.3 for more details.
- **Flow-through planter box:** A structure designed to hold additional rain flows, but has an impervious bottom over and impervious surface. See Section 3.3.4 for more details.
- **Infiltration planter box:** A structure designed to allow runoff to filter through the planter soils (thus capturing pollutants) and then infiltrate into native soils. The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil. See Section 3.3.5 for more details.
- **Porous Pavement:** Semi-impervious stones of which there are various types that allow for a hard surface for multi-uses and some rain water infiltration at the same time. See Section 3.3.6 for more details.

- **<u>Sand filters</u>:** Sand filters consist of an inlet structure, sedimentation chambers, sand bed, underdrain piping and liner. They filter runoff through the sand layer into an underdrain system that conveys treated runoff to a detention facility or to the point of ultimate discharge. See Section 3.3.7 for more details.
- **<u>Sand filter vaults</u>:** Similar to a sand filter, except that the sand layer and underdrains are installed under grade in a vault. See Section 3.3.8 for more details.
- **<u>Linear sand filters</u>:** Typically long, shallow, and rectangular and has two chambers. See Section 3.3.9 for more details.

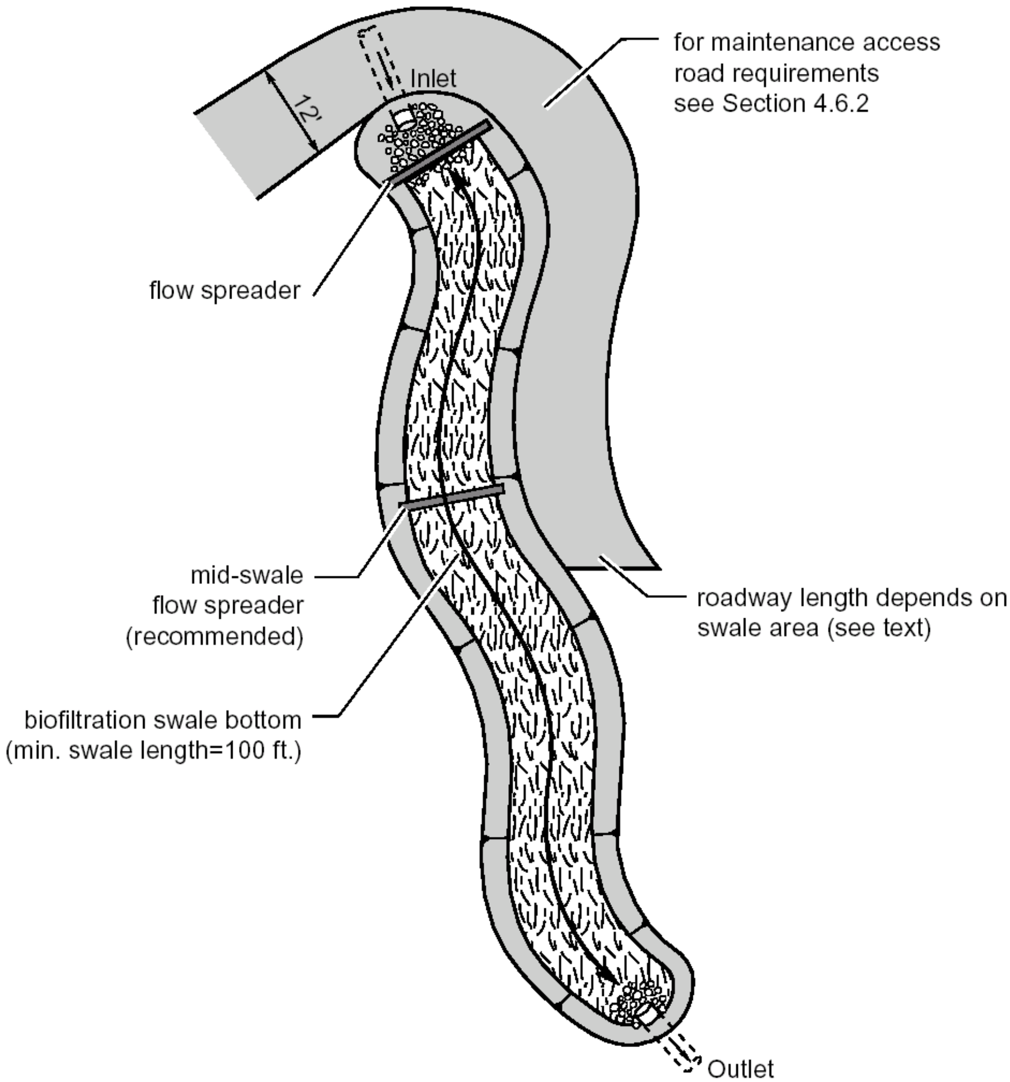
3.2 Applications

Table 2.2.2 in Section 2.2 of this *Manual* includes a summary of recommended stormwater quality facilities for specific land use. The designer should refer to that section for general guidance in selecting particular flow-through water quality treatment facilities to best meet the needs of the targeted pollutants. Additionally, DEQ has prepared guidance documents for flow-through treatment facilities that discharge to UICs, generally, flow-through facilities that overflow to UICs are permissible without additional treatment. Refer to DEQ's website for information relating to UIC determination and guidance at: http://www.deq.state.or.us/wq/groundwa/uichome.htm.

3.3 Design Criteria

3.3.1 Biofiltration Swales

The design flow rate for flow-through water quality treatment facilities is presented in Section 1.3.5 of this *Manual*. The required design flow rate shall be calculated using the Rational method.



NOTE: Longitudinal slope 1-6%.
Provide underdrain for slopes < 1.5%.

PLAN
NTS

Figure 3.3.1 Bioswale

Source: 1998 King County Water Quality Manual

The standards outlined below specify optimum design elements for a successful Bioswale, also called a grassy swale. If sufficient supporting data is submitted, the City will consider other swale design(s).

A rainfall intensity of 0.2 inches per hour for on-line facilities and 0.11 inches/hour for off-line facilities shall be used to calculate the peak flow rate.

1. The swale width and profile shall be designed to convey the water quality design storm event (0.2 inches per hour) at a maximum design storm depth of 0.4 foot and maximum design velocity of 1-foot per second.
2. The swale flow line slope shall not exceed 4% or, if check dams are used, 6%.
3. Use a Manning "n" value of 0.20 for frequently mowed (e.g., every 2 weeks) swales and a value of 0.24 for infrequently mowed swales.
4. Side slopes within the treatment area shall not exceed a 4:1 ratio.
5. The swale shall have a minimum length of 100 feet.
6. A 1-foot minimum of freeboard shall be provided above the design water surface for facilities not protected by high flow storm diversion devices.
7. Woody or shrubby vegetation shall not be planted in the swale's active treatment area.
8. The swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. On a swale wider than 8 feet, a flow spreader shall be installed every 100 feet.
9. To minimize flow channelization, the swale bottom shall be smooth, with longitudinal slope, with a minimum bottom width of 4 feet.
10. If check dams are used to reduce longitudinal slope of the swale, a flow spreader shall be provided at the top of each vertical drop.
11. The maximum flow velocity through the swale of the 100-year flow condition shall not exceed 5-feet per second.
12. See Section 3.4 of this *Manual* for erosion control requirements.
13. For appropriate seed mix, refer to Landscaping Requirements in Section 3.5 of this *Manual*. The initial rate of application shall be 80 pounds per acre. Any swale that is to be maintained by the City shall be seeded with native grasses and wildflower mixes designed to eliminate the need for mowing.
14. To stabilize drainage ways, install permanent turf where immediate erosion protection is needed.
15. Appropriate access and maintenance easement shall be provided to the swale. Refer to Section 4.6.2 and 4.6.3 of this *Manual* for details.

3.3.2 Vegetated Swale

The standards outlined below specify optimum design elements for a successful vegetated swale. If sufficient supporting data is submitted, the City will consider other swale design(s).

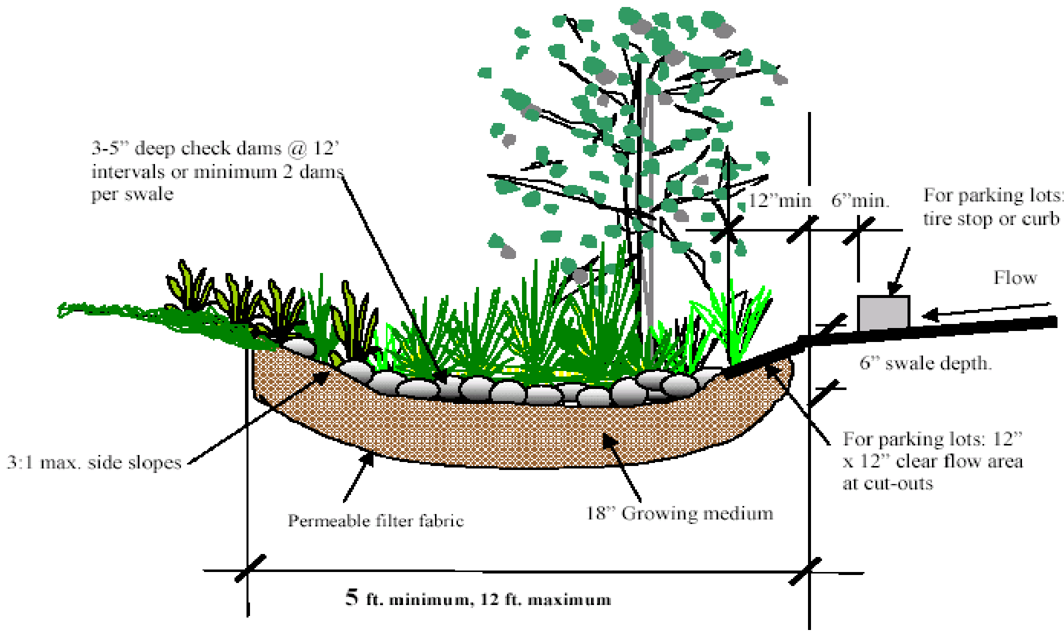


Figure 3.3.2: Vegetated Swale Section Not to Scale

Source: City of Portland Stormwater Management Manual, September 2002

1. The swale width and profile shall be designed to convey the water quality design storm event (0.2 inches per hour) at a maximum design storm depth of 0.4 foot and maximum design velocity of 1-foot per second.
2. Overflow routes and additional means for disposal must be provided.
3. Minimum swale length is 20 feet. Maximum slope is 6%.
4. Silty or clayey soils shall be amended with 50% sandy loam in the top 12 inches of the swale.
5. Check dams shall be of durable, non-toxic materials- i.e., rocks. Check dams shall be 12 inches in length x (width of swale) x 3 to 5 inches in height.
6. Liners may be required for groundwater protection or if the facility is located within 10 feet of a building foundation.
7. Appropriate access and maintenance easement shall be provided to the swale. Refer to Section 4.6.2 and 4.6.3 of this *Manual* for details.
8. See Section 3.4 of this *Manual* for erosion control requirements.

9. For appropriate seed mix, refer to Landscaping Requirements in Section 3.5.2. The initial rate of application shall be 80 pounds per acre. Any swale that is to be maintained by the City shall be seeded with native grasses, plants and wildflower mixes designed to eliminate the need for mowing.

3.3.3 Vegetated Filter Strips

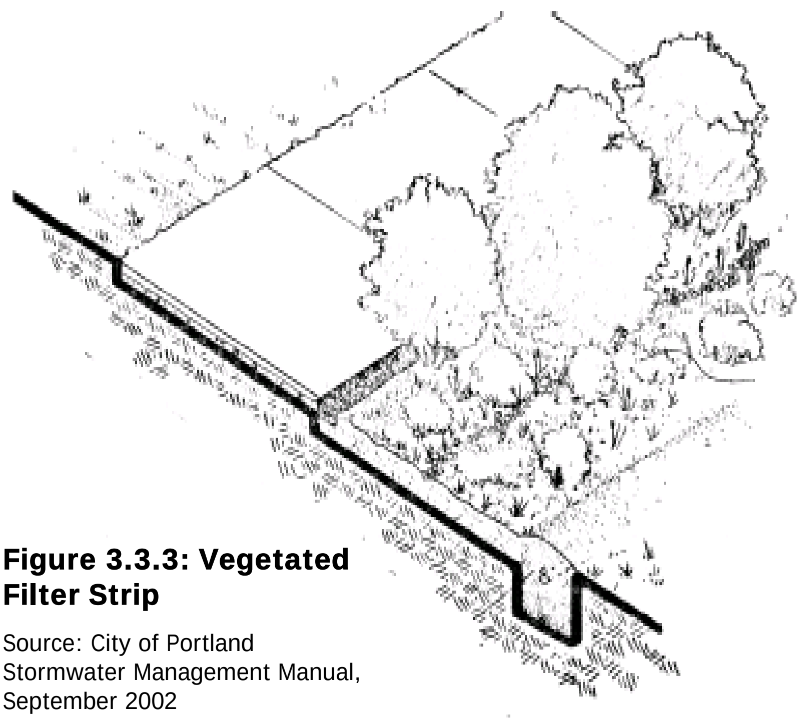


Figure 3.3.3: Vegetated Filter Strip

Source: City of Portland Stormwater Management Manual, September 2002

A vegetative filter strip is a facility designed to provide stormwater quality treatment from sheet flow--not point-source discharge--of conventional pollutants except nutrients and does not provide stormwater *quantity* treatment. The primary use of vegetative filter strips is along parking lots and driveways, where sheet flow from the impervious area will pass through the filter strip before entering a conveyance system or other type of stormwater structural BMP.

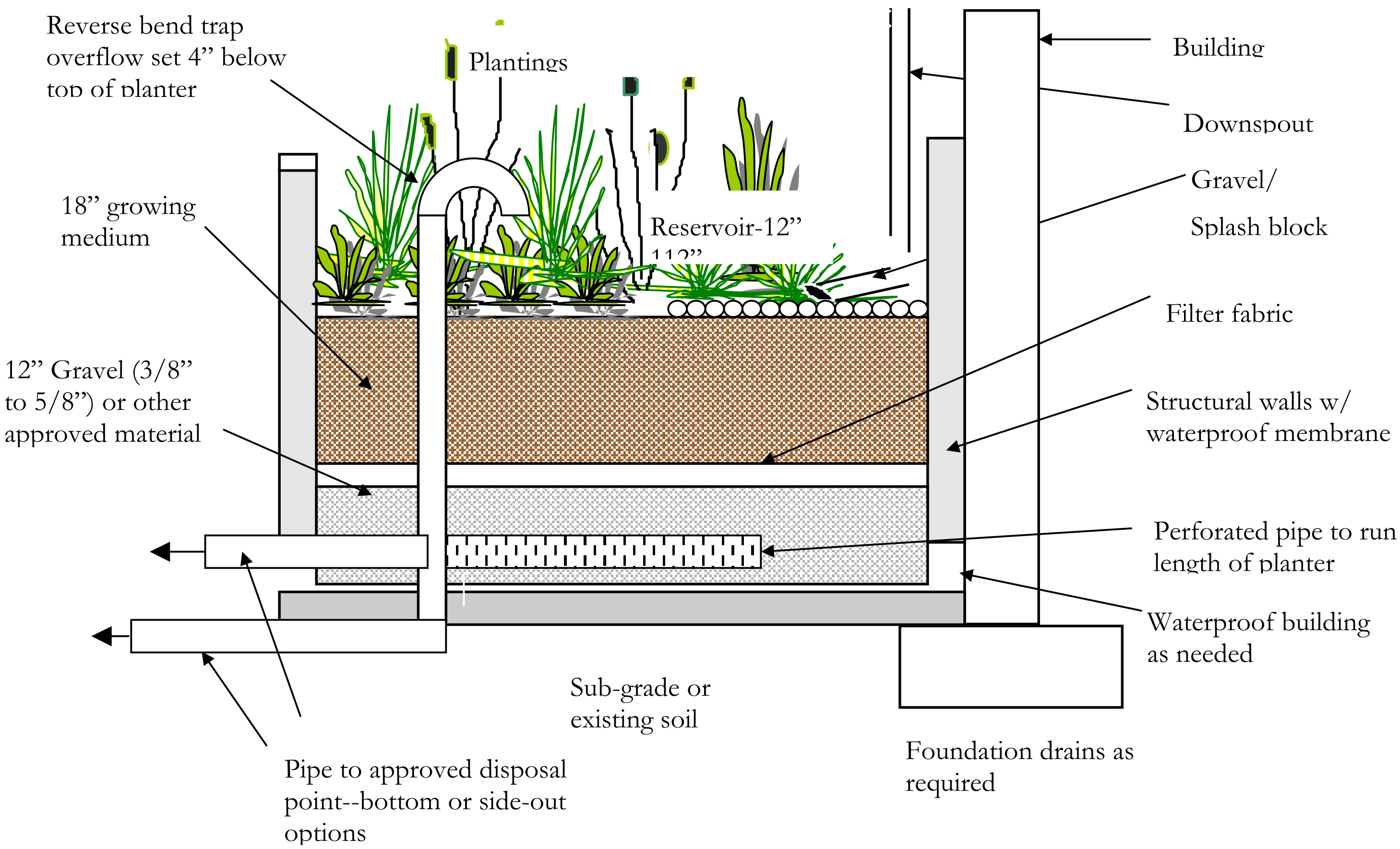
Filter strips are acceptable for use on any project that meets the General Criteria listed below:

1. A filter strip width shall be a minimum of 10 feet, with a transverse slope between 1 and 15%.
2. Filter strips may be placed 3 to 4 feet from the pavement edge to accommodate a vegetation-free zone.
3. Once a filter strip has treated stormwater, it shall be collected and conveyed to a stormwater quantity BMP.
4. Vegetative filter strips are to receive sheet flow and must not receive concentrated flow discharges. Discharges from tributary areas to parking lots and driveways shall not be routed to vegetated filter strips.
5. The flow path, draining to the filter strip, shall not exceed 150 feet.
6. Vegetative filter strips should not be used on parking lots and driveways with longitudinal slopes greater than 2%, because of the difficulty in maintaining the necessary sheet flow conditions.
7. Vegetative filter strips should be constructed after other portions of the project are completed. See Section 3.4 of this *Manual* for erosion control requirements.
8. See Section 3.5 of this *Manual* for landscaping requirements.

9. Appropriate access and maintenance easement shall be provided to the swale. Refer to Section 4.6.2 and 4.6.3 of this *Manual* for details.

3.3.4 Flow-Through Planter Box

The flow-through planter box is designed with an impervious bottom or is placed on an impervious surface. Pollutant reduction is achieved as the water filters through the soil; flow control is obtained by storing the water in a reservoir above the soil. This planter can be used adjacent to a building if lined properly.



Not to Scale

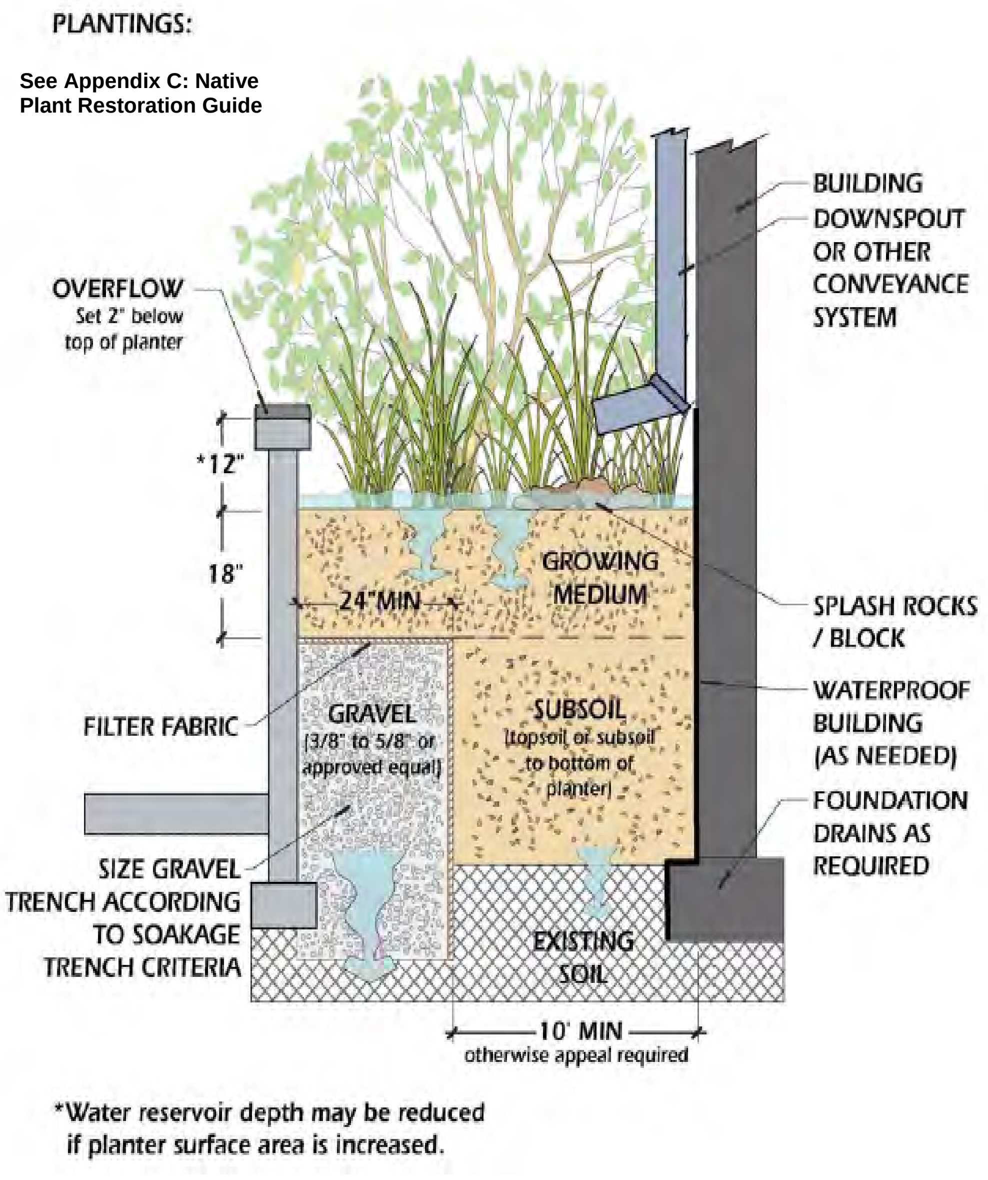
Figure 3.3.4: Flow-Through Planter Box

Source: City of Portland Stormwater Management Manual, September 2002

1. The planters shall be designed to hold water for no more than 3 to 4 hours after an average storm event.
2. Minimum planter width is 18 inches; there is no minimum length or required shape.
3. The structural elements of the planters shall be stone, concrete, brick, or other other inert material. Structural material shall not leach out toxic chemicals that can contaminate stormwater. The flow-through planter is contained and thus not designed to drain into the ground near a building.
4. Irrigation is optional, although plant viability shall be maintained. See Section 3.5 of this *Manual* for landscaping requirements.
5. Appropriate access and maintenance easement shall be provided to the swale. Refer to Section 4.6.2 and 4.6.3 of this *Manual* for details.

3.3.5 Infiltration Planter Box

The infiltration planter box is designed to allow runoff to filter through the planter soils (thus capturing pollutants) and then infiltrate into native soils. The planter is sized to accept runoff and temporarily store the water in a reservoir on top of the soil.



Not to Scale

Figure 3.3.5: Infiltration Planter Box

Source: City of Portland Stormwater Management Manual, September 2002

Infiltration Planter Boxes are acceptable for use on any project that meets the General Criteria listed below:

1. The planters shall be designed to allow captured runoff to drain out in 3 to 4 hours after a storm event. The sand/gravel area width, depth and length are to be determined by a qualified professional, or a drywell may be required for complete on-site infiltration.
2. Minimum planter width is 30 inches; there is no minimum length or required shape. The structural elements of the planters shall be stone, concrete, brick, or pressure-treated wood. Treated wood shall not leach out toxic chemicals that can contaminate stormwater.
3. Planters within 10 ft of structures must use the design criteria for flow-through planter boxes or request design approval from the City's Stormwater Manager to locate the structure within 10 feet of a structure. Required setback from property lines must be met.
4. See Section 3.5 of this *Manual* for landscaping requirements.
5. Appropriate access and maintenance easement shall be provided to the swale. Refer to Section 4.6.2 and 4.6.3 of this *Manual* for details.

3.3.6 Porous Pavement

Note: Minimum/ maximum dimensions and other specifications are product-specific and shall comply with manufacturer's recommendations.

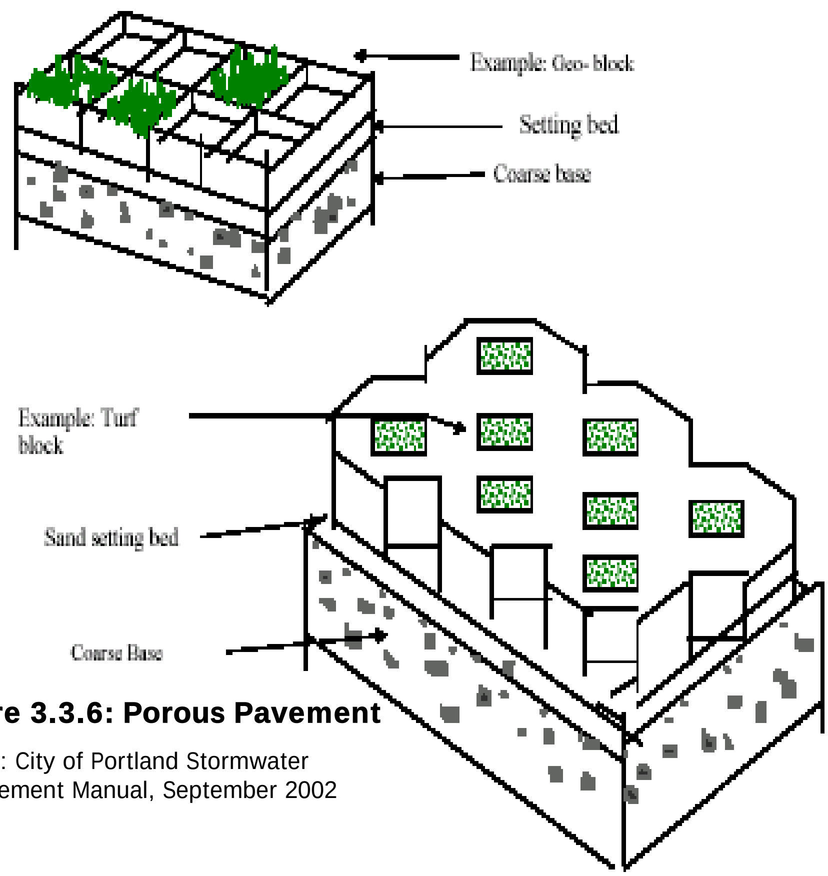


Figure 3.3.6: Porous Pavement

Source: City of Portland Stormwater Management Manual, September 2002

Note: Minimum/maximum dimensions and other specifications are product-specific and shall comply with manufacturer's recommendations.

A. Applications and Limitations

There are many types of porous pavement on the market today. Numerous products and design approaches are available, including special asphalt paving; manufactured products of concrete, plastic, and gravel; paving stones; and brick. Porous pavement accepts only precipitation, not stormwater runoff. It may be used for walkways, patios, plazas, driveways, parking lots (with less than 15 parking spaces), and some portions of streets. The material must be installed and maintained to manufacturer's specifications.

These materials are not allowed in the Wellfield Protection Area (refer to Section 1.7.2 for details) and other areas that have potential for pollution contamination from accidental spills. A professional engineer, registered in the State of Oregon must design porous pavement systems that will be supporting vehicular traffic. For

EPA's "Porous Pavement Phase I Design and Operational Criteria" (EPA-600/2-80-135), go to: http://www.epa.gov/ednnmrl/repository/abstrac2/abstra2.htm

B. Stormwater Control Plan Requirements

The following minimal information shall be included in the Stormwater Control Plan:

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

- Facility dimensions and setbacks from property lines and structures
- Profile view of facility, including typical cross-sections with dimensions
- Porous pavement materials specification
- Subgrade and base course specifications
- Filter fabric specification (if applicable)
- All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
- Maintenance and cleaning considerations

C. Maintenance Considerations

Inspect immediately after construction, and at least twice annually thereafter. Look for ponding after large storms; ponding could be an indication of clogging. Also look for an accumulation of petroleum products.

3.3.7 Sand Filters

A. Presettling Requirement

Filtration facilities are particularly susceptible to clogging. **Presettling must therefore be provided before stormwater enters a filtration facility**. A pre-settling pond or vault or detention pond can be integrated as the first cell of the filtration facility.

The required minimum volume of the presettling facility must equal 25% of the water quality design storm computed for the developed site.

A sand filter operates much like an infiltration pond. However, instead of infiltrating into native soils, stormwater filters through a constructed sand bed with an underdrain system. Runoff enters the pond and spreads over the surface of the filter. As flows increase, water backs up in the pond where it is held until it can percolate through the sand. As stormwater passes through the sand, pollutants are trapped in small spaces between sand grains or adhere to the sand surface. Over time, soil bacteria will also grow in the sand bed and some biological treatment may occur.

The treatment pathway is vertical (downward through the sand) rather than horizontal as it is in biofiltration swales and filter strips. High flows in excess of the water quality treatment goal simply spill out over the top of the pond at the overflow outlet works. To get better performance from a sand filter, the volume of water spilled over the top should be reduced. Increasing the sand thickness will not dependably improve performance. Water that percolates through the sand is collected in an underdrain system of drain rock and pipes which directs the treated runoff to the downstream drainage system.

Sand filters should not be installed in areas with high water tables where groundwater could potentially flood the underdrain system.

Nor should they be used in areas where heavy sediment loads are expected due to clogging issues.

B. Applications and Limitations

A sand filter can be used in most residential, commercial, and industrial developments where site topography and drainage provide adequate hydraulic head to operate the filter. However, sand filters are ineffective at reducing some stormwater contaminants, therefore pretreatment in the form a of treatment train may be necessary before disposal into a UIC system. To install a sand filter, an elevation difference of about 4 feet between the inlet and outlet of the filter is typically needed.

Sand filters are designed to prevent water from backing up into the sand layer (the underdrain system must drain freely). For vegetation and recreational use limitations, see Section 3.3.7 L.

C. Method of Analysis

A sand filter is designed with three parts:

1. A pre-settling pond (first cell), vault, or detention pond;
2. A temporary storage reservoir to store runoff; and
3. A sand filter bed through which the stored runoff must percolate.

Usually the storage reservoir is simply placed directly above the filter, and the floor of the reservoir pond is the top of the sand bed. The design of the storage also determines the hydraulic head over the filter surface, which as head is increased the rate of flow through the sand is increased.

Section 3.3.7 (cont.)

D. Background

The sand filter design is based on Darcy's law illustrated below:

$Q = KiA$

where Q = Water Quality design flow (cfs)
K = hydraulic conductivity (fps) = 0.00002315 feet per second
A = surface area of the sand filter perpendicular to the direction of flow (square feet)
i = hydraulic gradient (ft/ft) for a constant head and constant media depth, computed as follows:

$$i = (h + l)/l$$

where h = average depth of water above filter (ft), defined for this design as d/2
d = maximum storage depth above filter (ft)
l = thickness of sand media (ft)

Hydraulic conductivity does not change with head nor is it dependent on the thickness of the media. It only changes with the characteristics of the media and fluid. The hydraulic conductivity of 1-inch per hour (0.00002315 fps) used in the design is based on bench-scale tests of conditioned rather than clean sand. This value of K (hydraulic conductivity) represents the average sand bed condition as silt is captured and held in the filter bed.

E. Filter Area Sizing

The sand filter sizing method presented here does not route flows through the filter. Filter size is determined as if there were no storage volume. Because of this an adjustment factor of 0.7 is applied to compensate for the greater filter size resulting from this simplification.

1. Determine the maximum depth of water storage above the sand filter: This is defined as the depth at which water begins to overflow the reservoir pond, and it depends on site topography and hydraulic constraints. Because of these considerations, the designer chooses the depth.

2. Calculate the minimum required surface area for the sand filter:
A (area of the sand filter) = $(0.7Q)/Ki$ *where* Q = Water Quality design flow (cfs)
K = hydraulic conductivity (fps) = 0.00002315 feet per second
A = surface area of the sand filter perpendicular to the direction of flow (square feet)
i = hydraulic gradient (ft/ft) for a constant head and constant media depth, computed as follows:
$i = (h + l)/l$
where h = average depth of water above filter (ft), defined for this design as d/2
d = maximum storage depth above filter (ft)
l = thickness of sand media (ft)

3. Size the underdrain system:
The underdrain system is sized to convey the peak filtered flows to the outlet.

Section 3.3.7 (cont.)

F. Design Criteria

Sand Filter Geometry:

1.	Any shape sand bed may be used, including circular or free form designs.
2.	Sand depth (*l*) shall be 18 inches (1.5 feet) minimum.
3.	Depth of storage over the filter media (d) shall be 6 feet maximum.

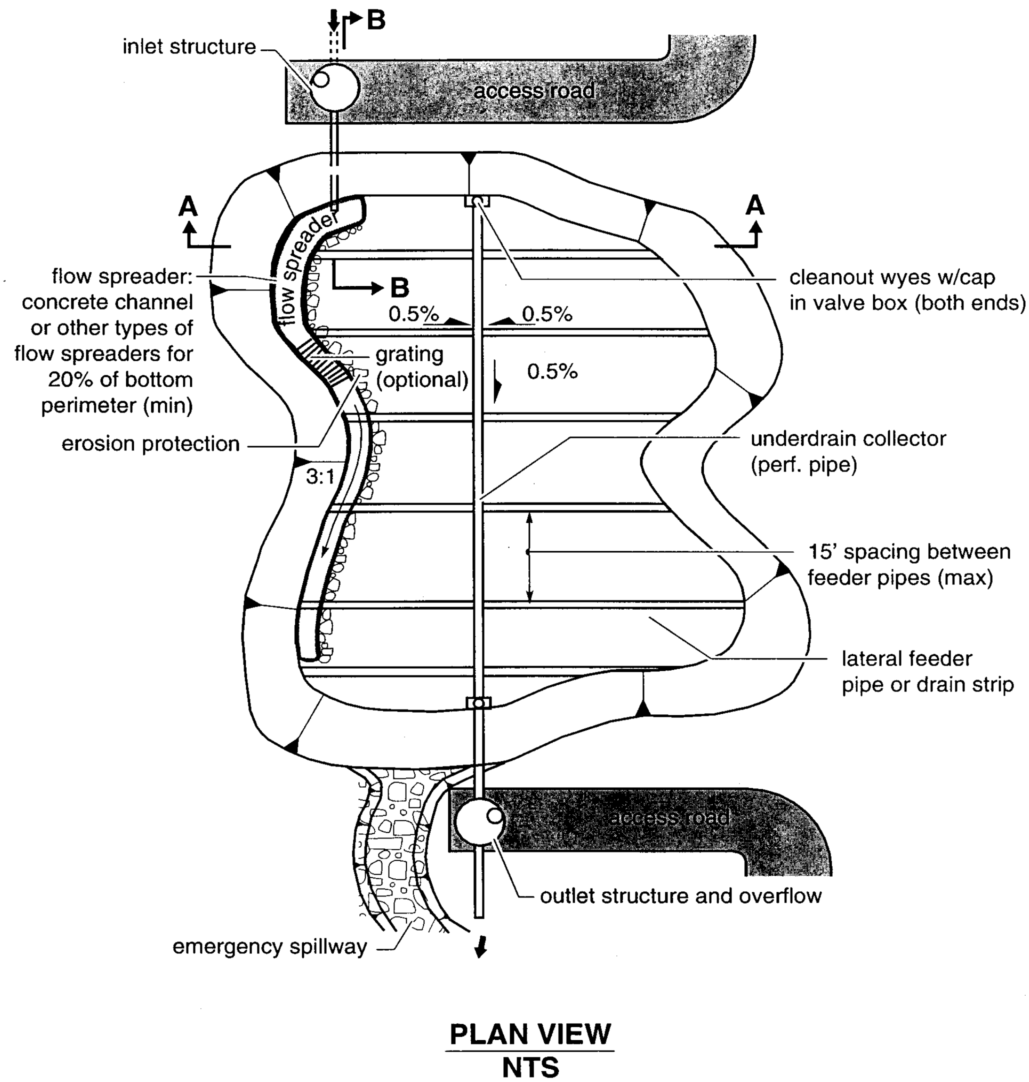


Figure 3.3.7A. Sand Filter with Level Spreader

Source: 1998 King County Water Quality Manual

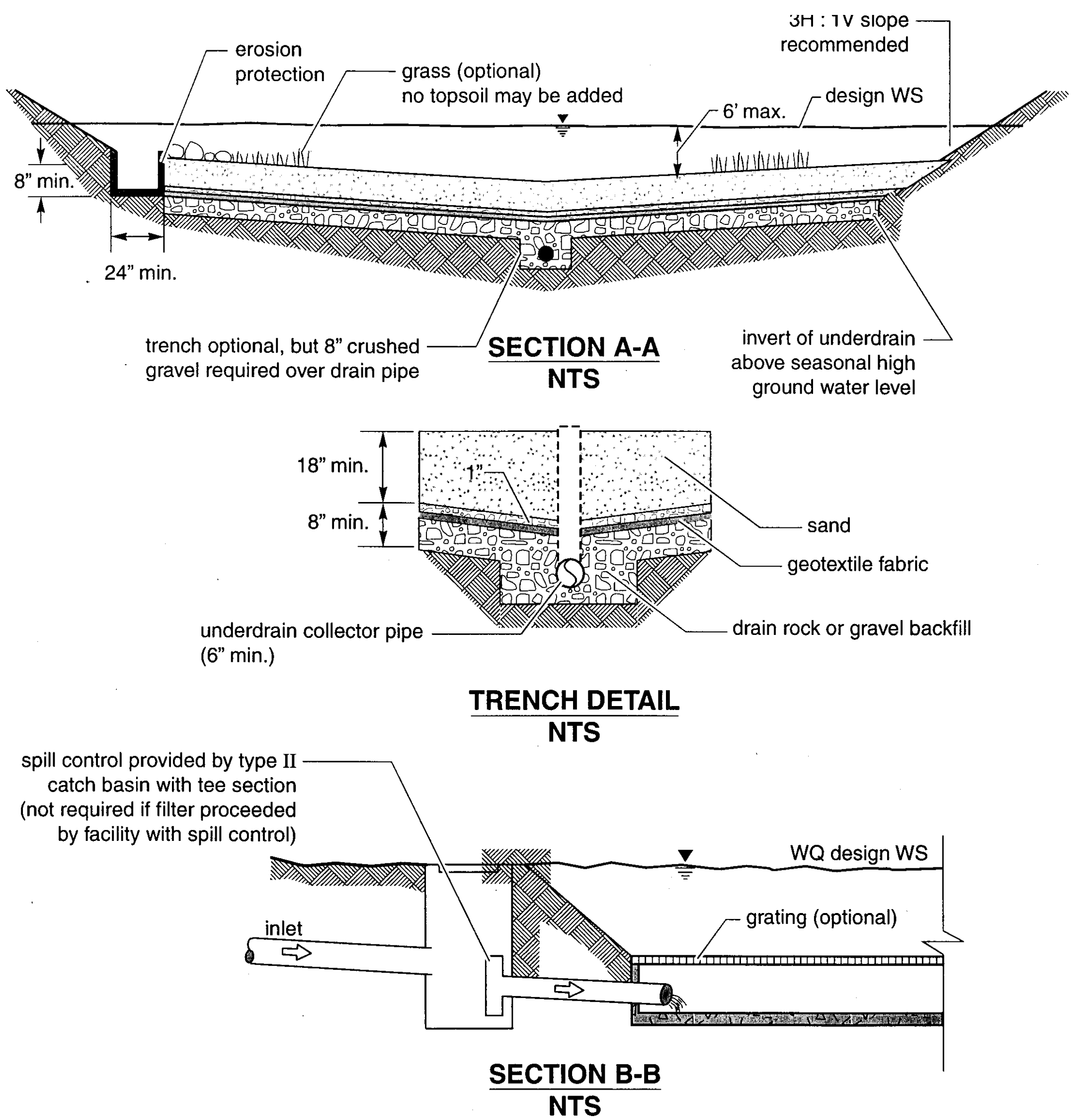


Figure 3.3.7B. Sand Filter with Level Spreader (*continued*)

Source: 1998 King County Water Quality Manual

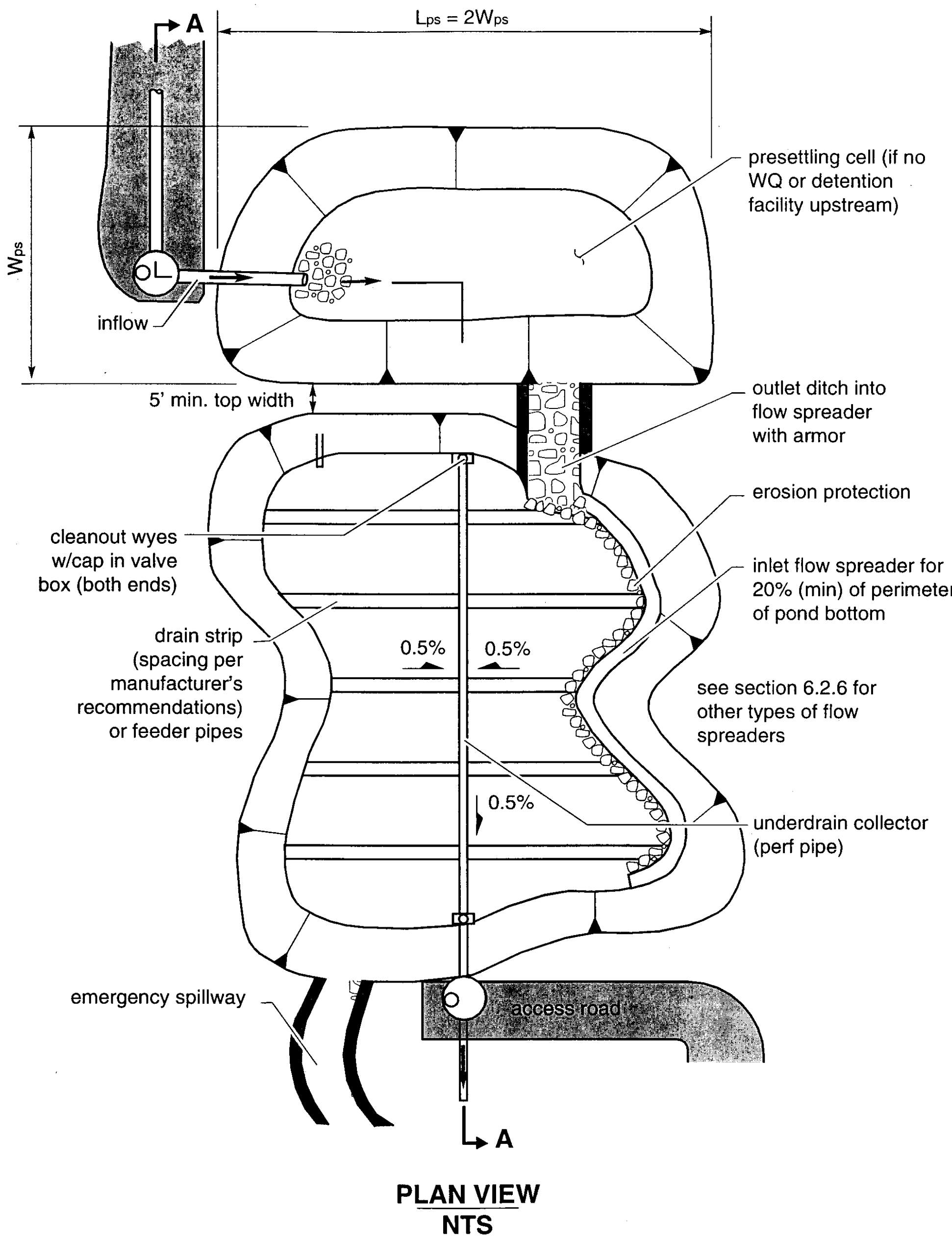
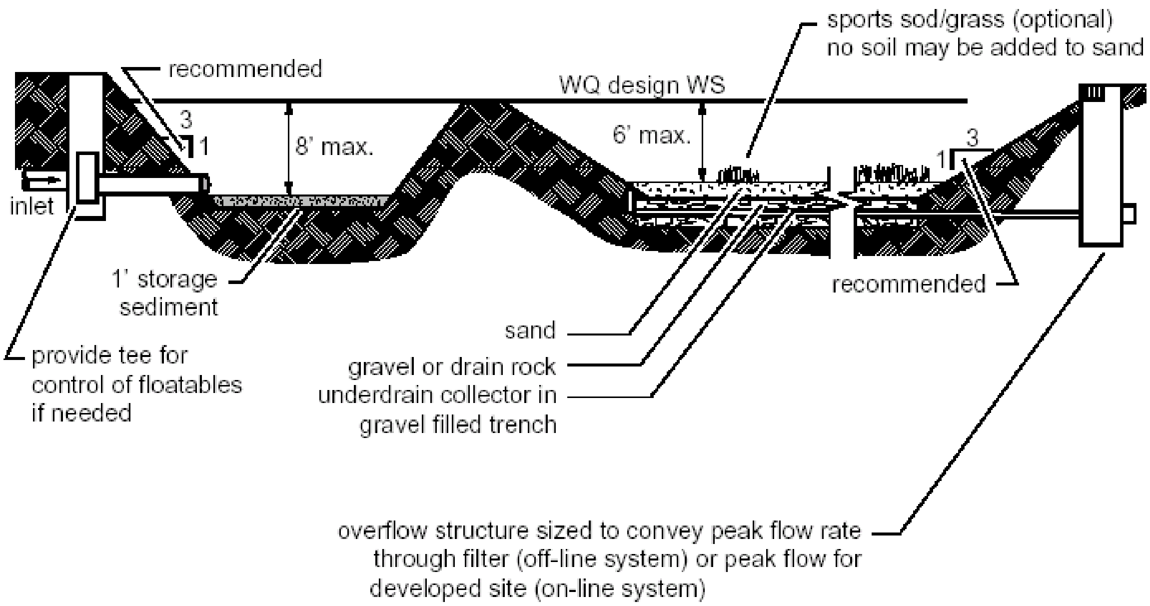


Figure 3.3.7C. Sand Filter with Pre-Treatment Cell

Source: 1998 King County Water Quality Manual



SECTION A-A
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Figure 3.3.7D. Sand Filter with Pre-Treatment Cell Cross Section

Source: 1998 King County Water Quality Manual

Section 3.3.7 (cont.)

G. Pretreatment, Flow Spreading, and Energy Dissipation:

Presettling and pretreatment is required to remove floatables and sediments prior to discharge to the sand filter. Oil control pretreatment will also be required for those land uses that generate high levels of hydrocarbons. Refer to Section 3.3.7A for presettling, Figure 3.3.7C & D for Pretreatment and Section 6.4 for oil control. A flow spreader shall be installed at the inlet along one side of the filter to evenly distribute incoming flow across the filter and prevent erosion of the filter surface. The flow spreader shall be provided for a minimum of 20% of the filter perimeter. Erosion protection shall be provided along the first foot of the sand bed adjacent to the flow spreader. Refer to Figure 3.3.7B and Section 3.3.7L. **No topsoil may be added for plantings.**

H. Overflow and Bypass Structures:

On-line filters shall be equipped with overflows capable of accommodating the stormwater design storm peak discharge.
For off-line filters the outlet structure must be designed to accommodate the entire flow that can be diverted from the inlet flow control structure.

<u>Filter Composition</u>: The following table lists the layers of a sand filter.

Table 3.3.7A: Layers of a Sand Filter	
1. Top layer (optional):	Grass seed or sod grown in sand
2. Second layer:	Sand
3. Third layer:	Geotextile fabric
4. Fourth layer:	Underdrain system

<u>Sand Specifications</u>: The sand in a filter shall consist of a medium sand with few fines meeting the size gradation (by weight) given in Table 3.3.7B below. The contractor must obtain a grain size analysis from the supplier to certify that the No. 100 and No. 200 sieve requirements are met.

Table 3.3.7B: Sand Media Specifications	
U.S. Sieve Size	Percent Passing
U.S. No. 4	95 to 100%
U.S. No. 8	70 to 100%
U.S. No. 16	40 to 90%
U.S. No. 30	25 to 75%
U.S. No. 50	2 to 25%
U.S. No. 100	Less than 4%
U.S. No. 200	Less than 2%

Geotextile materials requirements are as specified in GPWS: *Construction Specifications*, Section 205.02.14 for Drainage Geotextile Type 1.

Section 3.3.7 (cont.)

I. Underdrain Systems

1. Several underdrain systems are acceptable:

- A central collector pipe with lateral feeder pipes in an 8-inch depth of drain rock bed.
- A central collector pipe with a geotextile drain strip in an 8-inch depth of drain rock bed.
- Longitudinal pipes in an 8-inch gravel backfill or drain rock bed, with a collector pipe at the outlet end.
- In smaller installations, a single perforated pipe in an 8-inch depth of drain rock may be adequate.

2. The maximum perpendicular distance between any two feeder pipes, or the edge of the filter and a feeder pipe, shall be 15 feet. This spacing prevents the underdrain system from backing up into the sand filter during the early life of the filter when high filtration rates exist.

3. All pipe shall have a minimum slope of 0.5%.

4. The invert of the underdrain outlet shall be above the seasonal high groundwater water level. The "seasonal high groundwater level" is the highest elevation of groundwater observed (usually at the end of the wet season, that is, late winter or early spring). The underdrain must be capable of removing standing water from beneath the sand. If standing water remains, the sand will remain saturated. This could cause depletion of dissolved oxygen and allow some pollutants to become mobile and be released from the filter to downstream receiving waters.

5. Cleanout wyes with caps or junction boxes shall be provided at both ends of all collector pipes. Cleanouts shall extend to the surface of the filter.

- A valve box must be provided for access to the cleanouts.
- The cleanout assembly must be watertight to prevent short-circuiting of the filter.
- Caps are required on cleanout wyes. When the pond fills with water, caps prevent short-circuiting into the underdrain system.

6. If a drain strip is used for lateral drainage, the strip must be placed at the slope specified by the manufacturer or at least at 0.5%. All drain strips must extend to the central collector pipe. Drain strip installations must be analyzed for conveyance because manufactured products vary in the amount of flow they are designed to handle.

7. To prevent damage by heavy equipment during maintenance, at least 8 inches of gravel backfill must be maintained over all underdrain piping or drain strips, and 6 inches must be maintained on either side. Either drain rock or gravel backfill may be used between pipes or drain strip.

Section 3.3.7 (cont.)

8. A drainage geotextile fabric shall be used between the sand layer and the drain rocks or gravel that conforms to GPWS Section 205.02.14. Place the material so that one inch of drain rock or gravel is above the fabric, providing a transition layer. A layer of finely textured sand above a coarser one may cause water to pool due to the greater capillary forces in the finer material.

J. Underdrain Materials

1. Underdrain pipe shall be a minimum 6-inch-diameter perforated PVC, SDR 35.

2. Drain rock shall be 1 ½ to ¾ - inch rock backfill washed free from clay or organic material.

K. Access Roads

An access road shall be provided to the inlet and outlet of a sand filter for inspection and maintenance purposes (See Section 4.6.2 Access Roads).

L. Grass Cover

1. No topsoil may be added to sand filter beds because fine-grained materials reduce the hydraulic capacity of the filter, except "sport-field sod" that has been grown in sand, which may be applied to the surface of the sand filter.

2. Selected grass species must be able to tolerate the demanding environment of the sand bed, including long periods of saturation during the winter wet season and extended dry periods during the summer. Recommended plants are shown in the following table:

Table 3.3.7C: Recommended Plant Types for Sand Filters		
Pond Sides	1.	Redtop
	2.	Creeping bentgrass
	3.	Meadow foxtail
	4.	Pacific reed grass
	5.	Northern mannagrass
	6.	Common velvet grass
	7.	Fowl bluegrass
	8.	Kentucky bluegrass
	9.	Tapertip and soft rush
Pond Bottom (Sand Surface)	10.	Bentgrass and buffalo grass
	11.	Tall fescue
	12.	Dwarf tall fescues
	13.	Red fescue
	14.	Perennial ryegrass
	15.	Korean grass
	16.	White lawn clover

1. To prevent overuse that could compact and potentially damage the filter surface, permanent structures (e.g., playground equipment or bleachers) are not permitted.

2. Slow-release fertilizers such as rock phosphate or bone meal may be used to improve germination.

Section 3.3.7 (cont.)

3. A horticultural specialist should be consulted for advice on planting.
4. Seed should be applied in spring or mid to late fall. If the filter is seeded during the dry summer months, surface irrigation is needed to ensure that the seeds germinate and survive. Seed should be applied at a rate of 80 lbs/acre.
5. If recreational use is intended, such as for a volleyball play area, the interior side slopes of the filter embankment should be no steeper than 3:1.

3.3.8 Sand Filter Vaults

A sand filter vault is similar to an open sand filter except that the sand layer and underdrains are installed under grade in a vault.

A. Applications and Limitations

A sand filter vault can be used on sites where space limitations preclude the installation of above-ground facilities. Like sand filters, sand filter vaults are not suitable for areas with high water tables where infiltration of groundwater into the vault and underdrain system will interfere with the hydraulic operation of the filter. It is desirable to have an elevation difference of 4 feet between the inlet and outlet of the filter for efficient operation.

Sand filter vaults are prone to clogging from sediment and other debris and should not be used in areas where heavy sediment loads are expected.

B. Method of Analysis

Refer to Section 3.3.7 C.

C. Design Criteria

In addition to their water quality function, sand filter vaults may convey flows above the water quality design flow to the downstream drainage system. General design concepts for sand filter vaults are shown in Figure 3.3.8A below.

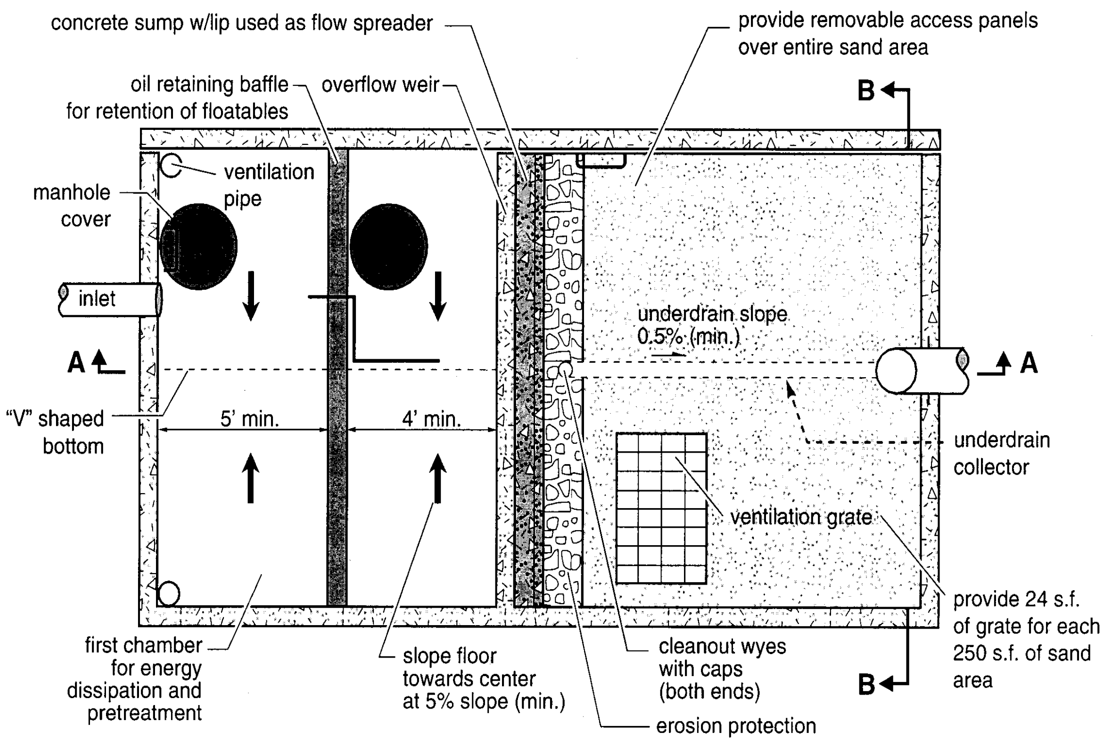

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Figure 3.3.8A. Sand Filter Vault

Source: 1998 King County Water Quality Manual

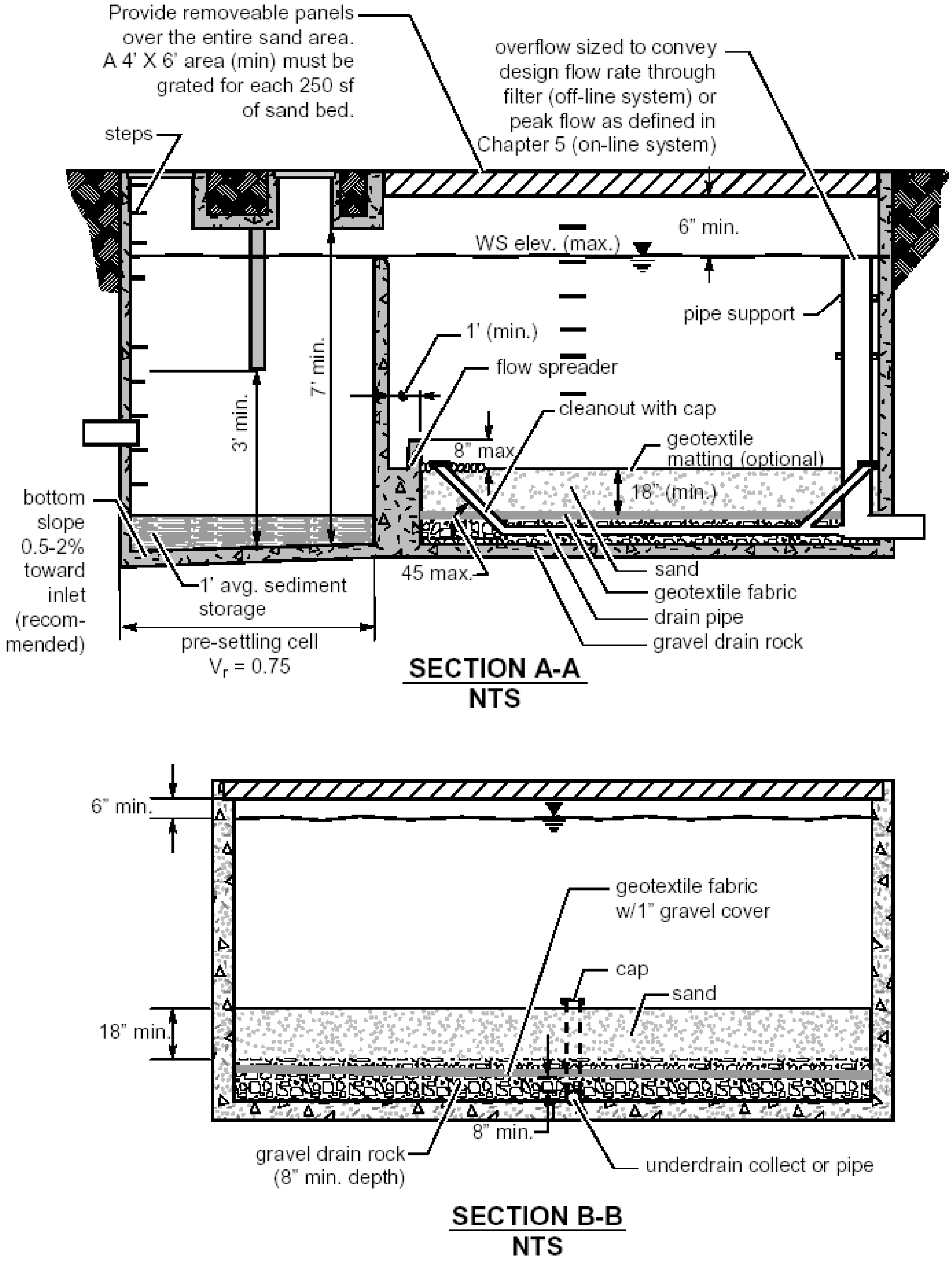


Figure 3.3.8B. Sand Filter Vault (*continued*)

Source: 1998 King County Water Quality Manual

Section 3.3.8 (cont.)

D. Sand Filter Geometry

Refer to Section 3.3.7 F.

E. Pretreatment, Flow-spreading, and Energy Dissipation

1. Presettling and pretreatment are required.
2. A flow spreader shall be installed at the inlet to the filter bed to evenly distribute incoming runoff across the filter and prevent erosion of the filter surface.
3. For vaults with presettling cells, the presettling cells shall be constructed so that the divider wall extends from the floor of the vault to the water quality design water surface. It must be watertight.
4. The flow spreader shall be positioned so that the top of the spreader is no more than 8 inches above the top of the sand bed. See Figure 3.3.8B.
5. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad. Alternatively, a pipe and manifold system may be designed and submitted for approval.

If a pipe and manifold system is used, the minimum pipe size shall be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities. Erosion protection must be provided along the first foot of the sand bed adjacent to the spreader. Refer to Section 3.3.7 L.

F. Sand Filter Vault Overflow and Bypass Structures

Refer to Section 3.3.7 H.

G. Sand Filter Vault Composition

The filter bed shall consist of three layers as follows:

Table 3.3.8: Filter Bed Media Types	
Top layer:	Sand
Second layer:	Geotextile fabric
Third layer:	Underdrain system

H. Sand Specifications and Geotextile Materials

Refer to Section 3.3.7 H.

I. Underdrain Systems and Underdrain Materials

Refer to Section 3.3.7 I and 3.3.7 J.

J. Vault Structure

- Sand filter vaults are typically designed as on-line (flow-through) systems with a flat bottom under the filter bed.
- If a presettling cell is provided, the cell bottom may be longitudinally level or inclined toward the inlet. To facilitate sediment removal, the bottom shall also slope from each side towards the center at a minimum of 5%, forming a broad "v".
- One foot of sediment storage must be provided in the presettling cell.
- Where pipes enter and leave the presettling cell below the water quality design water surface, they shall be sealed using a non-porous, non-shrinking grout.

Section 3.3.8 (cont.)

- If an oil-retaining baffle is used for control of floatables in the presettling cell, it must conform to the minimum requirements shown in Figure 3.3.8A.

K. Access Requirements
Access to the vault must be provided for maintenance. See Section 4.6.2 Access Roads for details.

L. Design Features
Design features are shown on Figure 3.3.8B.

3.3.9 Linear Sand Filters
Linear sand filters are typically long, shallow, rectangular vaults. The vaults consist of two cells or chambers, one for settling coarse sediment from the runoff and the other containing sand. Stormwater flows into the second cell via a weir section that also functions as a flow spreader to distribute flow over the sand. The outlet consists of an underdrain pipe system that connects to the storm drain system.

A. Applications and Limitations
The linear sand filter is used for stormwater flows for two different treatment purposes:

1. To provide basic water quality treatment for the water quality design storm.
2. To treat runoff from high-use sites (i.e., sites generating higher than typical concentrations of oil and grease).

Linear sand filters are best suited for treating small drainage areas (less than 5 acres), particularly long, narrow areas. A linear sand filter can be located along the perimeter of a paved impervious surface or can be installed downstream of a filter strip where additional treatment is needed. If used for oil control, the filter should be located upstream from the main water quality treatment facility (i.e., wet pond, biofiltration swale, or combined detention and wet pond).

B. Method of Analysis
A linear sand filter is sized based on the infiltration rate of the sand and the amount of runoff draining to the facility. The filter is sized to infiltrate the sand filter design flow without significant ponding (maximum of one foot) above the sand. The formulas contained in the sand filter section apply but in this case water depth = 1-foot maximum.

C. Filter Area Sizing:
A (area of the sand filter) = 0.7Q/Ki
See discussion under "Filter Area Sizing" in Section 3.3.7 E for more detail. Note that water depth = 1-foot maximum for linear sand filters.

D. Design Criteria
Linear sand filter details are shown in Figure 3.3.9.

Geometry, Sizing, and Overflow

1. A linear sand filter shall consist of two cells: a sediment cell and a sand bed cell, divided by a low divider wall. If the sand filter is preceded by another water quality facility, and the flow enters the sand filter as sheet flow, the sediment cell may be waived.
2. Stormwater may enter the sediment cell by sheet flow or via a piped inlet.

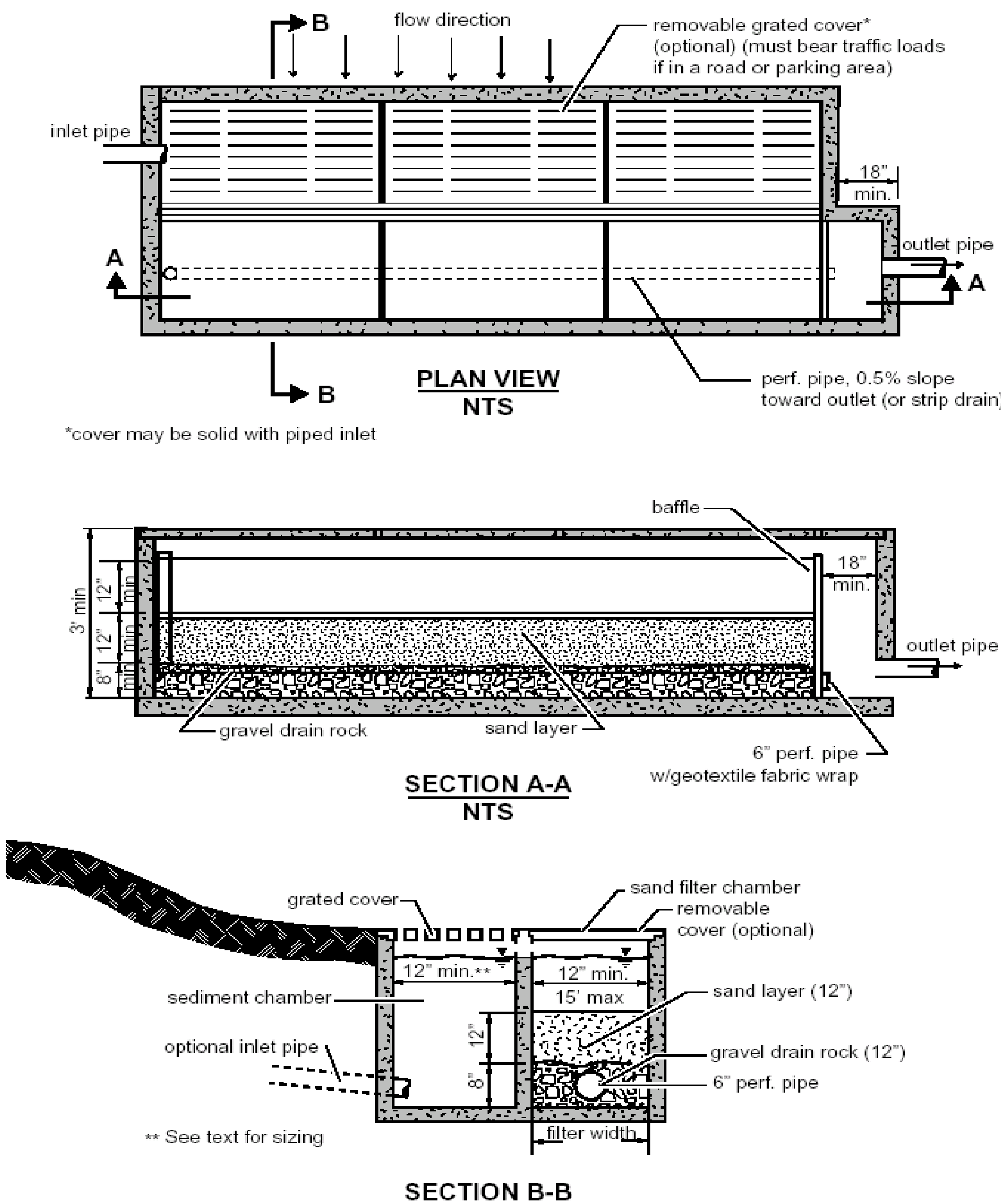


Figure 3.3.9. Linear Sand Filter

Source: 1998 King County Water Quality Manual

Section 3.3.8 (cont.)

3. The minimum inside width of the sand filter shall be 1 foot. The maximum width shall be 15 feet.
4. The divider wall must be level and extend 12 inches (maximum) above the sand bed.
5. The sand filter bed shall be 12 inches deep. An 8-inch layer of drain rock with perforated drainpipe shall be installed beneath the sand layer.
6. The drainpipe shall have a minimum diameter of 6 inches and be wrapped in geotextile and sloped 0.5% (minimum) to drain.
7. For design, the maximum depth of ponding over the sand shall be one foot.
8. If separated from traffic areas, a linear sand filter may be covered or open, but if covered, the cover must be removable for the entire length of the filter. Covers must be grated if flow to the filter is from sheet flow.
9. A linear sand filter shall have an emergency overflow route to safely control the overflow. The route, either surface over land or structure, shall meet the conveyance requirements for the stormwater design storm.

E. Linear Sand Filter Structure Specifications
A linear sand filter vault shall be concrete (precast/prefabricated or cast-in-place). Where linear sand filters are located in traffic areas, they must meet highway loading requirements. The sediment cell must have a removable grated cover and the cover over the sand filter cell may be either solid or grated.

F. Sand Specifications
Refer to Table 3.3.7 B.

G. Geotextile Materials
Refer to Section 3.3.7 H.

H. Underdrain Materials
Refer to Section 3.3.7 I & 3.3.7 J

I. Access Requirements
Access to the linear sand filter must be provided for inspection and maintenance. Refer to Section 4.6.2 of this *Manual* for details.

3.4 Erosion Control Methods

3.4.1 Biofiltration Swales, Vegetated Swales and Vegetated Filter Strips
If a biofiltration swale, vegetated swale or vegetated filter strip is put into operation before all construction in the drainage area of the swale/filter strip is completed, the swale/filter strip must be cleaned of sediment and reseeded. This must be completed prior to issuance of a certificate of occupancy.

Implement erosion prevention and sediment control measures before runoff enters a swale/filter strip. Swales and filter strips are designed to handle only minimal sediment loads from stabilized sites. Refer to the City's Erosion Prevention and Sediment Control Manual for proper techniques during site construction.

3.4.2 Recommended Seed Mixes for Swales and Filter Strips

Before a certificate of occupancy will be issued, the site owner must demonstrate that final cleaning and removal of all construction-related sediment from swales and filter strips. In addition, the following reseeding methods shall be utilized in order to obtain final approval from the City. The seed mixes recommended below have been reviewed for desirable characteristics for swales and filter strips. **For City of Gresham maintained facilities, native seed mixes shall be required.**

Table 3.4.2 A: Recommended Native Seed Mix: Pacific Northwest Natives, Willamette Valley Region Bioswale Native Mixture, percentages by weight	
Meadow Barley	20.0%
Blue Wildrye	20.0%
Sitka or California Brome	20.0%
American Sloughgrass	20.0%
Water Foxtail	10.0%
Spike Bentgrass	5.0%
Tufted Hairgrass	5.0%

Seed this mixture at 10-30 lbs per acre on well-prepared soil. Drill seed if possible to improve seed soil contact. Roll soil to firm up seedbed pre and post planting. If you hydroseed or broadcast seed, increase seeding rate about 30%. Harrow seed into soil with rake, chain or rug mat system or cover exposed seed with native straw or mulch (free of weed seed) to improve germination. This mixture will provide excellent seedling establishment on moderately eroded sites. Meadow barley, blue wildrye, American sloughgrass and sitka brome are short-lived large seeded species.

Table 3.4.2B: Recommended Non-Native Mixes: Options for Private Facilities Only Hobbs and Hopkins, Pro-Time 835, Bio-filter Summer Green Vegetative Cover (or equal), percentages by weight	
Elka Perennial Ryegrass	60.0%
Eureka Hard Fescue	15.0%
Yarrow Millefolium	8.0%
Sweet Alyssum	3.0%
Shamrock	3.0%
Dutch White Clover	7.0%
Salinas Strawberry Clover	4.0%

Table 3.4.2C: Recommended Non-Native Mixes: Options for Private Facilities Only Washington State Dept. of Ecology *Publication 657,* Montlake Terrace Mix	
Tall Fescue	67.0%
Seaside Bentgrass	16.0%
Meadow Foxtail	9.0%
Alsike Clover	6.0%
Marshfield Big Trefoil	1.0%
Inert Matter	1.5%
Weed Seed	0.5%

Seed these mixtures at 8 lbs per 1,000 square-feet on well-prepared soil. Drill seed if possible to improve seed soil contact. Roll soil to firm up seedbed pre and post planting. Harrow seed into soil with rake, chain or rug mat system or cover exposed seed with straw or mulch (free of weed seed) to improve germination.

3.4.3 Sand Filters

1. Sand filters cannot be constructed until all parcels within the catchment are complete and all disturbed soil in the sand filter catchment area has been stabilized.
2. Place the sand carefully. This is necessary to avoid forming voids within the sand that could lead to short-circuiting, particularly around penetrations for underdrain cleanouts, as well as to prevent damage to the underlying geomembranes and underdrain system.
3. Over-compaction must be avoided to ensure adequate filtration.
4. After the sand layer is placed, let the water settle. Flood the sand with 10 to 15 gallons of water per cubic foot of sand.

3.4.4 Sand Filter Vaults

Construction considerations are same as stated above for Sand Filters. In addition, upon completion, the vaults should be thoroughly cleaned and flushed before placing sand and drain rock.

3.4.5 Linear Sand Filters

If the site is put into service before it is stabilized, delay placing the sand layer. The linear sand filter may be used with the gravel layer only. The gravel layer must be replaced and the vault cleaned when the site is stabilized and the sand bed installed.

3.5 Maintenance Considerations

Proper functioning of flow-through BMPs requires adequate planning and forethought regarding the maintenance of the vegetation and sediment removal over time. Refer to Section 9.0 "Maintenance Agreement Requirements" in addition to this section.

3.5.1 Swales and Vegetated Filter Strips

A. Inspect the Facility

1. Inspect biofiltration swales and vegetated filter strips a minimum of three times a year, especially after significant storm events.
2. Inspect sand filters at least bi-annually; maintenance may be needed if drawdown does not occur within the time specified by the design.
3. Keep inspection records.

B. Remove Sediment

1. Remove sediment from biofiltration swales and filter strips when it builds up to 6 inches deep at any location or it causes vegetation to die. It is particularly important to remove sediment deposited in the upper portion of the swale.
2. Remove excess sediment by hand to minimize damage to vegetation. (Flat-bottomed shovels work well.) Removing sediment in the summer allows disturbed vegetation to re-stabilize before winter flows. Replant as needed.
3. A sediment layer will eventually build up on top of the filtration media. For sand filters, use a steel rake or a small shovel to scrape sediment off the filtration media at least twice a year, or more often based on observations of sediment build-up. The color of the sand should indicate the depth of removal.
4. Dispose of sediments removed in accordance with safe and best management practices specified by applicable local, state, and federal regulations. Determining the proper disposal method will require testing the accumulated sediment to determine the levels of pollutants. Periodic testing will also help determine appropriate schedules for sediment removal. Testing could include parameters such as oil and grease, heavy metals (e.g., copper, lead, zinc, and cadmium), nutrients (e.g., phosphorus), and/or organics such as pesticides.
5. Rapid accumulation of sediment and/or other pollutants may indicate a problem upstream. Investigate and identify the source of the pollutants and apply source control measures and BMPs to reduce or eliminate the discharge.

Consult with appropriate regulatory agencies and choose the sediment testing parameters based on site-specific conditions.

C. Remove Debris

Remove accumulated litter, branches, leaves, rocks, and other debris every 6 months, or as needed.

D. Maintain and Restore Vegetation

1. Maintain vegetation in filter strips to promote dense turf with extensive root growth. Immediately stabilize and reseed bare spots. Water the vegetation, if necessary, in times of drought. Use slow release fertilizers such as rock phosphate or bone meal to establish plants, but not for long-term maintenance.

Do not use animal manure within a swale or filter strip because it can lead to increased nutrients and low dissolved oxygen levels in runoff.

2. Mow grass in biofiltration swales and filter strips to promote growth and pollutant uptake. Twice in the summer is generally satisfactory to maintain design grass height
3. Remove grass clippings. Grass can collect and clog outlets, encouraging channelization and erosion. In addition, decomposing grass clippings can contribute both nitrogen and phosphorus to stormwater runoff.

E. Rehabilitate the Facility as Necessary

1. Regrade vegetated filter strips, if necessary, to prevent channelization of water flow.
2. Schedule replacement of the sand layer in a sand filter as needed to maintain permeability of the filtration media and to keep pollutant concentrations at acceptable levels. Acceptable levels are defined as those for which disposal as a dangerous or hazardous waste is not required. Frequency of replacement will depend on discoloration of the sand filter during the biannual sediment removal task.

3.5.2 Sand Filters

Sand filters are subject to clogging by fine sediment, oil and grease, and other debris. Filters and pretreatment facilities should be inspected every 6 months during the first year of operation. Inspections should also occur immediately following a significant storm event to assess the filtration capacity of the filter. Once the filter is performing as designed, the frequency of inspection may be reduced to once per year. During an inspection, the following features should be evaluated and maintained as needed:

1. Remove debris and sediment from the pretreatment facility when depth exceeds 12 inches.
2. Remove debris and sediment from the surface of the filter when accumulations exceed ½ inches.
3. Observe the overflow and drawdown time in the filter. Frequent overflows are indications of plugging problems. Under normal operating conditions, a sand filter should be completely empty 12 to 24 hours following a storm event. Generally, if the water level over the filter drops at a rate of less than ½ inch per hour, corrective maintenance is needed. Recommendations for improving sand filter performance are as follows:
   - Remove thatch accumulation in grass.
   - Aerate the filter surface to improve permeability.
   - Till the filter surface.
   - Replace the upper 4 to 6 inches of grass and sand.
4. Experience with sand filters used for stormwater has shown that the sand becomes clogged and must be replaced every 4 to 10 years.
5. Rapid drawdown in the filter indicates short-circuiting of the filter media. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.
6. Formation of rills and gullies on the surface of the filter indicates improper function of the inlet flow spreader or poor sand compaction. Check for accumulation of debris on or in the flow spreader, and refill rills and gullies with sand.

Other maintenance practices include:

- Avoid use of excess fertilizers
- Avoid driving heavy machinery or equipment on the sand filter
- Mow grass as needed, and remove the cut grass from the sand filter
- Water the vegetation periodically when needed, especially during the summer dry season

3.5.3 Sand Filter Vaults

Maintenance considerations for sand filter vaults are similar to those described for sand filters. Confined space entry procedures must be followed when entering a vault.

3.5.4 Linear Sand Filters

Maintenance considerations for linear sand filters are similar to those for basic sand filters except sediment must be removed for the sediment cell when the depth exceeds 6 inches.

Section 4.0 Detention-Based Water Quality Treatment Facilities

4.1 Overview

Detention of stormwater runoff allows for the settling of organic matter, fine & course sediment and the pollutants attached to these particles. Detention times for water quality control are typically longer than for flood control. Although a detention system for water quality could be combined with a flood control system, the volume assigned for water quality control must meet minimum recommended detention times for water quality treatment. Acceptable facilities include a wet pond, extended wet detention, extended dry detention, or constructed marsh. Smaller-scale facilities for sedimentation, such as underground wet vaults, are also acceptable.

Detention system can be designed with water quality requirements in mind to meet both minimum treatment and detention requirements.

4.2 Types of Stormwater Ponds

A. Wet Ponds

A wet pond is a facility that treats stormwater for water quality by using a permanent pool of water to remove conventional pollutants from runoff. Pollutants are removed through sedimentation, biological uptake, and plant filtration. Wet ponds have a constant pool (dead storage) volume. Wet ponds can be designed to provide water quantity benefits by adding a detention volume (live storage) above the dead storage.

B. Wet Extended Detention (ED) Ponds

Constructed ponds incorporate both a permanent pool and extended detention. These ponds are used for flood control by including additional temporary storage for peak flows (live storage) above the water quality storage and the dead storage. Wet extended ponds are also referred to as "combination ponds".

C. Dry Extended Detention (ED) Ponds

Outlets in constructed ponds are designed to detain the volume of a water quality design storm for a minimum time (48 hours) to allow for the settling of particles and associated pollutants. Dry ED ponds do not maintain a permanent pool between storm events. In addition, these ponds provide flood control by including additional temporary storage for peak flows (live storage) above the dead storage.

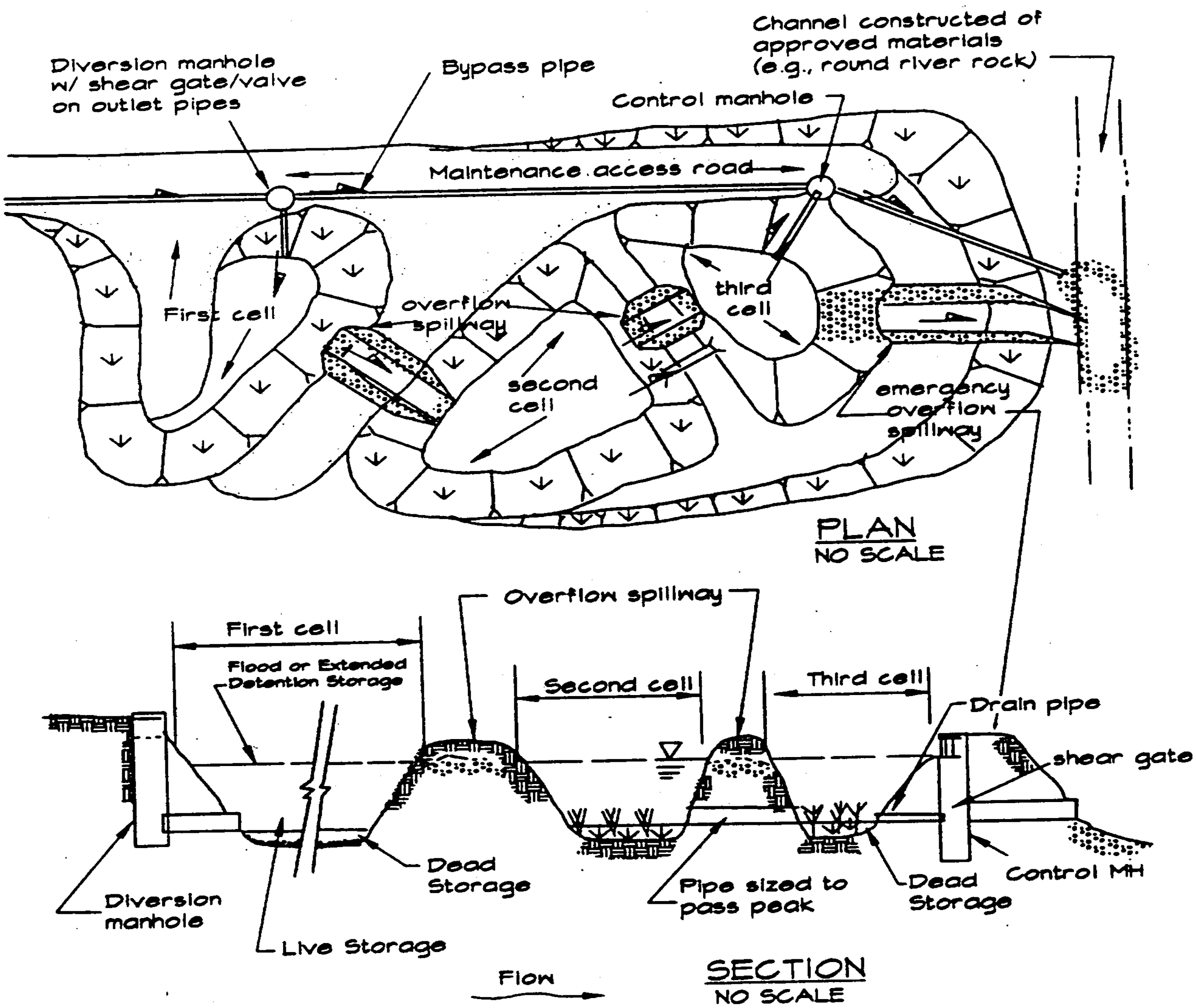


Figure 4.2A. Wet Pond

Source: 1998 King County Water Quality Manual

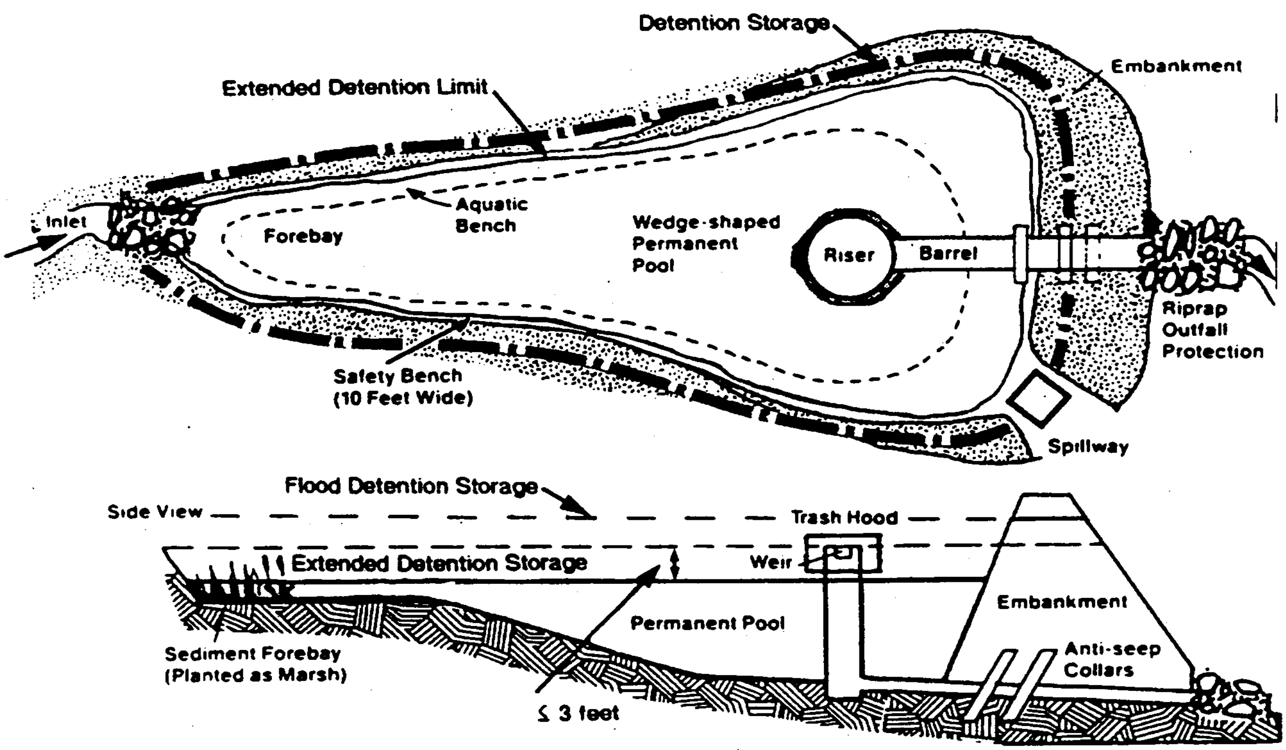


Figure 4.2B. Wet Pond Extended Detention

Source: 1998 King County Water Quality Manual

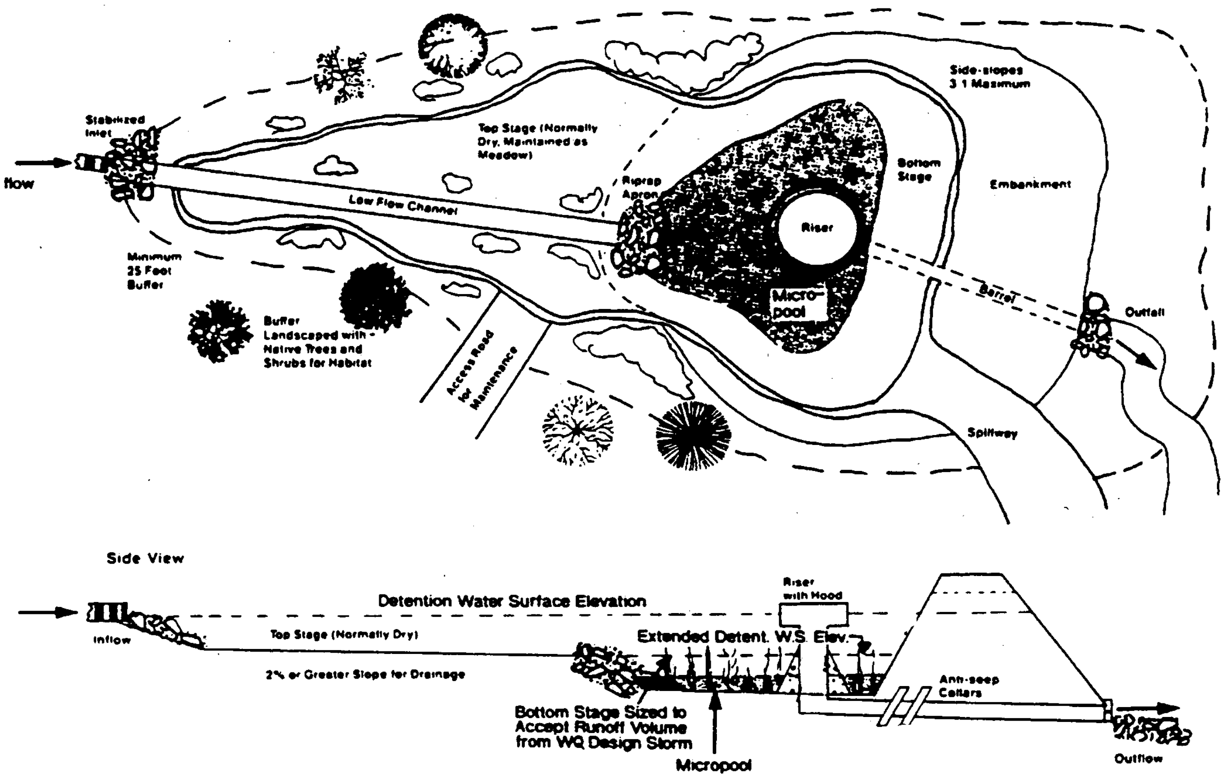
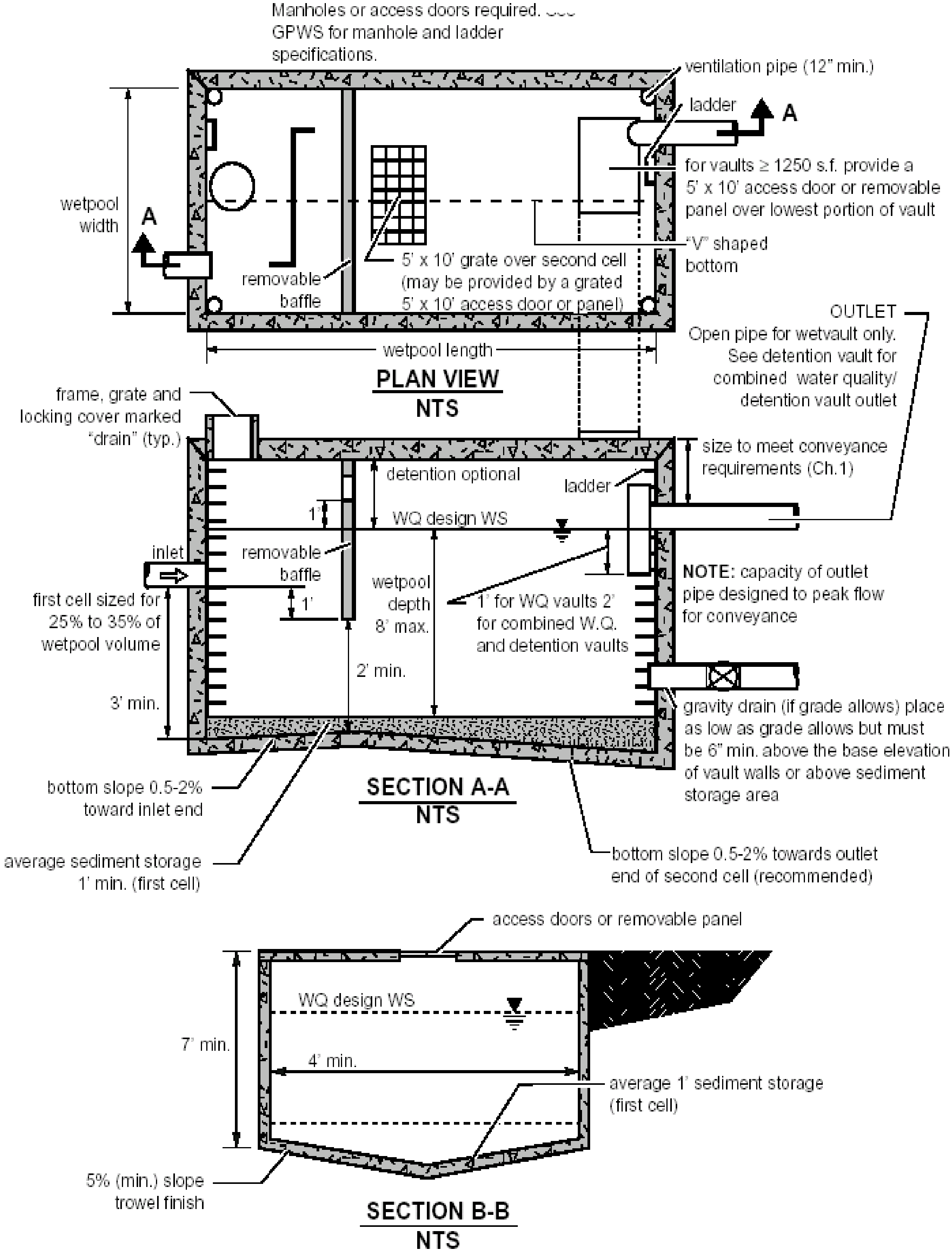


Figure 4.2C. Dry Pond Extended Detention

Source: 1998 King County Water Quality Manual

Figure 4.2D. Wet Vault

Source: 1998 King County Water Quality Manual



D. Wet Vaults

A wet vault is an underground structure similar in appearance to a detention vault, except that a wet vault has a permanent pool of water that dissipates energy and improves the settling of particulate pollutants. Because it is underground, the wet vault lacks the biological pollutant removal mechanisms, such as plant uptake, present in surface wetponds.

4.3 Pollutant Treatment Application

Stormwater ponds are designed to remove particulates through gravitational settling or sedimentation. Wet ponds and wet ED ponds also benefit from other physical, chemical, and biological pollutant removal processes such as plant uptake and vegetative filtration. Refer to *Appendix D* for more information on removal processes in pond and marsh systems. When properly maintained, wet ponds and wet ED ponds can attain high removal efficiencies for many stormwater pollutants including sediments, biochemical oxygen demand (BOD), heavy metals, and some nutrients. Dry ED ponds can attain relatively high removal efficiencies for the particulate fraction of most stormwater pollutants, including total suspended solids (TSS), heavy metals, BOD, and COD. Most ponds are generally not effective in removing dissolved pollutants from stormwater. One method of improving treatment effectiveness is to utilize a bioswale or vegetated swale leading up to the pond as the discharge point.

Refer to Table 2.2.2 in Section 2.0 for application criteria to determine the most appropriate stormwater pond facility.

The actual effectiveness of a stormwater pond depends on many factors including the portion of runoff detained and the length of detention. Short-circuiting of a pond occurs when inflow to the pond does not spread throughout the pond and portions of the ponds are not used. Lack of adequate detention due to short-circuiting is likely the primary cause of the failure to achieve the intended pollutant removal. Proper design will prevent hydraulic short-circuiting and ensure that an actual residence time that approximates the theoretical one is achieved.

4.4 General Criteria – All Ponds

1. All facilities shall be a minimum of 20 feet from any structure, right-of-way line, and any vegetative buffer, and 100 feet from any septic tank/drain field. All facilities shall be a minimum of 50 feet from any steep (greater than 15%) slope unless a geotechnical report has indicated that the steep slope will be stable.

2. Long, narrow, and irregularly shaped ponds are preferred, as these configurations are less prone to short-circuiting and tend to maximize available treatment area. The length-to-width ratio should be at least 3:1 and preferably 5:1. Irregularly shaped ponds generally perform more effectively and will have a more natural appearance. See Figure 4.2A.

3. If the site is located in a watershed and predicted to receive a pollutant of concern as defined in Section 1.2.2, the Stormwater Engineer may require

additional sizing, detention or drawdown times. See Section 1.6 for more details.

4. The pond bottom shall be level to facilitate sedimentation.

5. Interior side slopes up to the maximum water surface shall be no steeper than 3:1. Exterior side slopes shall be no steeper than 2:1. Slopes should be no steeper than 4:1 if they are to be mowed.

6. Pond walls may be retaining walls, provided that a fence is constructed along the top of the wall, and that at least 25% of the pond perimeter will be a vegetated soil slope of not greater than 3:1.

7. For berm embankments of 6 feet or less (including 1 foot of freeboard), the minimum top width shall be 6 feet or as recommended by the engineer. Where vehicle maintenance access is needed, use a minimum berm top width of 12 feet.

8. The toe of the exterior slope of pond berm embankment must be no closer than 5 feet from the right-of-way.

9. A "key" must be excavated that is equal to 50% of the berm embankment cross-sectional height and width (except on highly compacted till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till).

10. Anti-seepage collars must be placed on outflow pipes in all berm embankments impounding water greater than 8 feet in depth at the design water surface.

11. Construct embankment sections on suitable native consolidated soils that are free of loose soil materials, roots, and other debris. If recommended and approved by the City Project Engineer, other soil bases may be used, such as constructing the berm embankment on compacted soil (95% dry density, standard proctor method as per ASTM D698).

12. The inlet and outlet should be at opposite ends of the pond where feasible. If this is not possible, then baffles can be installed to increase the flow path and water residence time.

13. If a pond is used for sedimentation control during construction activity, the use of a sedimentation forebay shall be required. Prior to becoming a permanent water quality facility, the sediment shall be removed. The pond shall be cleaned of all construction sediment.

14. The design of the pond/detention facility must consider emergency overflows. Overflows may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Refer to the City's Erosion Prevention and Sediment Control (EPSC) Manual for appropriate erosion protection during construction.

All pond designs shall incorporate an emergency spillway system. The spillway shall be placed at an elevation such that the 25-year frequency storm does not flow through the primary receiving channel. The spillway shall be sized to safely pass the 100-year recurrence storm event. Refer to Section 2.0044 of the Public Works Design Standards.

15. Design with maintenance in mind. Effective maintenance will be crucial to successful operation of the facility. Hence, provisions to facilitate maintenance operations must be built into the design.

4.5 Specific Design Criteria

4.5.1 Design Criteria for Wet Pond

1. Evaluate the water budget to assure that adequate base flow requirements will be met to support a permanent pool volume. Refer to *Appendix D*.

2. Type A soils will require a clay blanket or liner to prevent infiltration/seepage. The liner shall consist of 40% clay with a minimum thickness of 12 inches; or consist of a synthetic waterproof liner. Typically, type B, C and D soils tend to seal over time. Refer to Figures 1.6 A-D and *Appendix A* for soil type references within the City of Gresham.

Soil maps are provided in Section 1.6 as guidance only. Soil type should be determined by actual soil testing for proper design assurance.

3. Develop a runoff hydrograph for the 1.2-inch, 24-hour water quality design storm as required by GDC Section 9.0522. Also note the requirements for the minimum drawdown times of the water quality treatment volume. The SCS 1A 12-hour distribution is acceptable and described in GPWS Section 2.0013.

4. The wet pond shall be designed with a permanent pool volume equal to the runoff volume of the 24-hour design storm.

5. Permanent pool depth shall not exceed 8 feet with an average depth between 4 and 6 feet.

6. Wet ponds shall have at least 2 cells, and preferably 3. The cells should be approximately equal in size. See Figure 4.2A.

   - The sediment forebay should be 3-feet deep to effectively trap coarser sediments and reduce turbulence which can re-suspend sediments. It should be easily accessible for maintenance purposes.

   - The berm dividing the pond into cells shall have a 5-foot minimum top width, a top elevation set 1 foot lower than the design water surface, maximum 3:1 side slopes, and a quarry spall and gravel filter "window" between the cells.

7. The minimum sediment forebay size shall be equal to 25% of, and in addition to, the permanent pool volume.

8. The inlet to the pond shall be submerged with the inlet pipe invert a minimum of 2 feet from the pond bottom (not including sediment storage). The top of the inlet pipe shall be submerged at least one foot. The Stormwater Division Engineer will consider alternative inlet designs such as inlet baffles, submerged weirs and/or berms that meet these objectives for approval.

Note: The intent of the submerged inlet is to dissipate energy of the inflow. The distance to the forebay bottom should minimize re-suspension of settled sediments.

9. If the wet pond is not used for stormwater quantity control, then design an outlet such as a weir or an orifice that will pass the 100-year recurrence event through the pond. Place the invert of the outlet at the same elevation as the top of the dead and water quality storage volume. The flow leaving the wet pond will discharge either to a receiving body of water or to a quantity control BMP.

10. An overflow outlet structure shall be provided. Either a grated G-2 type inlet, or a manhole with a cone-grated inlet (birdcage) may be used. No sediment sump is required for wet ponds not providing detention storage. The grate or birdcage provides an overflow route should the outlet pipe become plugged.

11. A gravity drain for maintenance shall be provided. The drain invert shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom. The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve.

12. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure. It is important to note that shear gates *often leak* if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

13. Operational access to the valve shall be provided to the finished ground surface. The valve location shall be accessible and well marked with one foot of paving placed around the box. It must be protected from damage and unauthorized operation.

    - A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5-feet deep, an access manhole or vault is required.

    - All metal parts shall be corrosion-resistant. Galvanized materials are not approved because of zinc leachate toxicity to wildlife.

When performing pond maintenance refer to GRC 4.40.030 and 4.40.040 and DEQ for specific requirements regarding discharges to natural outlets, the stormwater conveyance system or the sanitary sewerage system.

4.5.2 Design Criteria for Wet Pond Extended Detention (ED)

The following design criteria are required in addition to the above wet pond criteria (see also Figure 4.2B):

1. If the wet pond is to be used for quantity control (wet extended detention), determine the volume needed above the dead and water quality storage volume. Base the detention volumes per GPWS Section 2.0013.

2. Design the outlet device, such as a weir or a multiple orifice, to match each release rate.

3. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet requirements of GPWS Section 2.0044.

4.5.3 Design Criteria for Dry Pond Extended Detention (ED)

1. Provide a micropool for the dry pond ED near the outlet as part of the release structure. A hooded intake orifice or a reverse sloped pipe is required. See Figure 4.2C.

2. Develop the runoff hydrograph for the 1.2-inch 24-hour design storm as required by GDC section 9.0522. The SCS 1A 12-hour distribution is acceptable as described in GPWS Section 2.0013. Also note the requirements for the minimum drawdown times of the water quality treatment volume.

3. The dry pond (ED) allows for detention above the dead storage of the micropool and in addition to the water quality design storage volume. The detention (quantity control) volumes are to be determined as outlined in GPWS Section 2.0013.

4. Design the outlet device such as a weir or an orifice, to match each release rate for the water quality volume and for the detention volumes.

5. Identify an overflow route to be used in the event that the pond capacity is exceeded. This overflow route should be designed to meet requirements of GPWS Section 2.0044.

4.5.4 Approved Landscape Guidelines

1. Exposed earth on the side slopes shall be sodded or seeded with the appropriate seed mixture as soon as practicable after the pond is constructed. **For facilities to be maintained by the City, native plants are required.**

2. Refer to *Appendix C*: Native Plant Restoration Guide for guidelines on appropriate plantings in both the wet conditions of a pond and the much drier conditions of the dry pond.

3. The City strongly encourages the use of native plants, as this lessens the need for pesticides, herbicides and fertilizers, which are stormwater pollutants.

4.6 Maintaining Stormwater Ponds

4.6.1 Safety Features

Exception: The fence may be a minimum of 4 feet in height if the depth of the facility (measured from the lowest elevation in the bottom of the facility, directly adjacent to the bottom of the fenced slope, up to the maximum water surface) is 4 feet or less.

1. Incorporate all practical safety precautions. Reduce side slopes and/or fence off drops above outlets to minimize risk to the public.

2. Provide a safety/maintenance bench. If the pond surface exceeds 10,000 square feet, the bench should be a minimum of 15-feet wide. Provide a littoral shelf zero to 18 inches deep on the inside perimeter of the structure.

3. Fencing is not a required safety feature, except in conjunction with a retaining wall—see Section 4.4. It is preferred that

effective landscaping be used to inhibit public access. A chain-link fence may be constructed at the maximum water surface elevation or higher when a pond slope is a wall or if the slope exceeds 3:1. If fencing is used, it shall completely enclose the facility and be a minimum of 6 feet in height and shall have the following properties:

- Fence material shall be No. 11 gauge galvanized steel fabric with bonded vinyl coating. Vinyl coating shall be compatible with the surrounding environment (e.g., green in open, grassy areas, and black or brown in wooded areas).

- Fence posts shall be galvanized steel, with top caps, and set a minimum of 2-feet deep in concrete-filled posthole. Corner and gateposts shall be set a minimum of 3 feet in concrete. Crossbars shall connect adjacent fence posts.

- All posts, cross bars, and gates shall be painted or coated in the same color as the vinyl clad fence fabric.

- Soften fencing through landscaping. Refer to *Appendix C*: Native Plant Restoration Guide for suitable plant choices.

4.6.2 Access Roads

1. Access roads shall be a <u>minimum</u> of 12 feet wide, with 15 feet of clear pathway, with 3:1 shoulders (a grade no steeper than 10%, and capable of supporting heavy equipment with a GVW of 60,000 lbs and 34 feet long).

   - Base course shall consist of a minimum of 12 inch, 1½ inch minus crushed aggregate road base.

   - A maximum cross slope shall be 4%. A hammerhead turn-around shall be provided, with a 50 foot turning radius.

2. Preparation of access road subgrade:

   - Prior to construction of the access road, excavate and properly dispose of unstable material or unsuitable foundation material according to DEQ guidelines. Limit excavation to lines, grades, and cross sections shown.

   - Compact the natural ground underlying the access road. While under the observation of a City of Gresham inspector, proof-roll the compacted subgrade with a loaded 10-cubic-yard dump truck to identify soft, unstable soils. Over-excavate and replace soft, unstable areas with 1½ minus crushed aggregate.

3. Install a <u>subgrade</u> geotextile prior to placing the road base.

   - Place the crushed aggregate in lifts not exceeding 12-inches-loose thickness.

- Compact to 95% of the maximum density as determined by ASTM D 698-91. The moisture content of the aggregate should be within 2% of the optimum moisture content at the time of compaction.

4. Access road gates or bollards are permitted. Gates shall be 12-feet wide, consisting of two swinging sections 6-feet wide. Refer to design drawing detail 515 & 516 in the GPWS.

5. Pedestrian access gates (if needed) shall be 4 feet wide.

4.6.3 Provide for Maintenance Easements

1. Provide a right-of-way maintenance easement from a road to the pond (if not accessible from the public right-of-way), which also provides direct access to the pond bottom, the inlet sedimentation area, the control structure, pond bottom and other pond areas as needed.

2. If the access road faces the facility, then inlet and outlet structures shall not exceed a maximum distance of 8 feet. If the access road is adjacent to the facility, then the inlet and outlet structures shall not exceed a maximum distance of 14 feet.

4.6.4 Prepare a Maintenance Plan

1. A Maintenance Agreement for each facility is required to be filed with the City, refer to Section 9.0 and *Appendix B* for more details.
2. Prepare a maintenance plan that outlines the schedule, scope, and responsibilities for performing maintenance duties.
3. Maintenance plans should include at least an annual inspection.
4. Keep the outlet structure free of debris; inspect and clean it as required and at least annually to prevent over-topping.
5. Schedule maintenance around sensitive fish and wildlife and vegetation seasons. (August and September are the best months to disrupt pond vegetation).

4.6.5 Inspect the Pond

1. Annually monitor sediment forebay, pond cells and littoral shelf.

2. Keep inspection records per Maintenance Agreement requirements stated in Section 9.0.

4.6.6 Manage Sediment Deposits

1. Place a **sediment marker** (e.g., a graduated pipe) within the forebay for maintenance personnel. The removal of sediment from the forebay should be at a pre-determined depth, which may vary depending on pond location and size. As a rule, remove sediments whenever half of the forebay is full of sediment, or when 6 inches of sediment has accumulated on the pond bottom.

2. **Dispose of the removed sediments** in accordance with safe and best management practices specified by applicable local, state, and federal regulations. Studies have shown that sediments removed from ponds serving residential and commercial areas typically can be safely disposed of in a municipal landfill. In ponds serving heavily urbanized or industrialized catchments, test the accumulated sediment prior to removal to determine the levels of pollutants. Disposal should be performed in accordance with appropriate sediment removal procedures and disposal methods. Testing could include parameters such as oil and grease, heavy metals (copper, lead, zinc and cadmium), nutrients (e.g., phosphorus) and/or organics such as pesticides, which may accumulate on the pond bottom. Consult with appropriate regulatory agencies and choose the parameters based on site-specific conditions.

3. To **remove sediment**, first drain the pond or pond section and then use a compact 4x4 loader/scraper or other appropriate method, which minimizes disturbance to soil grades and vegetation. Remove sediment from the floor and sides, including benches, as appropriate.

4.6.7 Maintain Landscaping

1. Avoid disturbing plantings during maintenance.

2. Mow embankment, spillway, and maintenance access way at least twice a year (once during the fall).

   - Mow side slopes, if aesthetics is a factor.

   - Remove clippings after mowing. Ponds in residential or recreational areas may require more frequent mowing to maintain area aesthetics.

3. Maintain ground cover above the permanent pool in wet ponds, and on the basin floor and side slopes of extended detention ponds. This promotes dense turf and enhances infiltration. Immediately stabilize and revegetate any bare spots. Side slopes and buffer zones can be managed as meadow or wildflower zones. Refer to *Appendix C*: Native Plant Restoration Guide for guidance.

4. Harvest dead vegetation from the pond prior to the wet season to prevent the release of pollutants, especially nutrients.

5. Fertilizer, pesticide, and herbicide use is not recommended for long-term maintenance. These chemicals contribute to stormwater pollution problems. To avoid chemical application, use native species whenever possible.

6. Watering may be required in times of drought, particularly in the first months as vegetation is becoming established.

4.6.8 Control Insects

1. Installation of predacious bird and bat nesting boxes are recommended.

2. Stock ponds with predaceous fish and insects. Follow appropriate state guidelines and restrictions for their use.

3. Use selective mosquito larvicides (Bacillus thuringiensis or Altoside® formulations) when it is necessary to control mosquito populations. This minimizes wildlife impacts.

4. Altering the water level of the pond approximately every four days can disrupt the larval development cycle of mosquitoes. Contact Multnomah County Vector Control at (503) 988-3464 for additional assistance with mosquito monitoring and control.

4.7 Wet Vaults Overview

Wet vaults, may be used most practically in relatively small catchment areas (less than 10 acres of impervious surface) in areas of industrial and commercial development that have high land values and are not recommended for residential areas. Combined detention and wet vaults are allowed.

Wet vaults are ineffective in removing dissolved pollutants. There is also a concern that oxygen levels will be reduced, because of limited contact with air and wind. However, the extent of this potential problem has not been fully documented.

If oil control is required for a development, the wet vault may be combined with the baffle oil/water separator facility (Refer to Section 6.0, Parking Treatment Control Requirements).

4.7.1 Methods of Analysis

As with wet ponds, the primary design factor that determines the removal efficiency of a wet vault is the volume of the wetpool in relationship to the volume of runoff from the 1.2-inch, 12-hour storm. The larger the volume, the higher the potential for pollutant removal. **Performance is also improved by the following methods:**

- Avoiding dead zones where little exchange occurs
- Using large length-to-width ratios
- Dissipating energy at the inlet
- Ensuring that flow rates are uniform to the extent possible and not increased between cells

Wet vaults sized using the design criteria below (with a volume of 3 times the volume generated by the 1.2-inch, 12-hour water quality design storm) are expected to meet the water quality treatment standards presented in GDC Section 9.0522.

4.7.2 Design Criteria

A. Wet Pool Geometry

1. The wet pool shall be divided into two cells separated by a baffle or wall. The first cell shall contain between 25 to 35% of the total wet pool volume. The baffle or wall volume shall not count a part of the total wet pool volume.

2. **Sediment storage in the first cell shall be an average of one foot**. Because of the v-shaped bottom, the depth of sediment needed above the bottom of the inside wall is roughly proportional to vault width, according to the data shown in Table 4.7.2 below. See also Figure 4.2D.

Table 4.7.2: Recommended Sediment Depth of a Wet Vault

Vault Width (Feet)	Sediment Depth (inches; from bottom of side wall)
15	10
20	9
40	6
60	4

3. The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.

4. The second cell shall be a minimum of 3-feet deep. Plantings cannot be used to prevent re-suspension of sediment in shallow water as they can in open ponds.

5. Inlets and outlets shall be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The flowpath length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: width = (average top width + average bottom width)/2.

6. All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.

B. Vault Structure

1. Wet vaults shall be designed as flow-through systems. See Figure 4.2D.

2. The wet vault shall be separated into two cells by a wall or removable baffle.

   If a wall is used, a 5-foot by 10-foot removable maintenance access must be provided for both cells. If a removable baffle is used, the following criteria apply:

   - The baffle shall extend from a minimum of one foot above the water quality design water surface to a minimum of one foot below the invert elevation of the inlet pipe.

Note: As defined in this document, the term "baffle" means a divider that does not extend to the bottom of the vault, or if a bottom baffle, does not extend to the top of the water surface. A "wall" is a divider that extends from near the water surface to the bottom of the vault.

- The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.

3. The baffle or wall may be omitted, and the vault may be one-celled under the following conditions:

   - If the vault is less than 2,000 cubic feet (inside dimensions), **or**

   - If the length to width ratio of the vault pool is 5:1 or greater and a gravity drain is provided 12 to 18 inches from the vault bottom.

4. The two cells of a wet vault should not be divided into additional subcells by internal walls. If internal structural support is needed, it is preferred that post and pier construction be used to support the vault lid rather than walls. Any walls used within cells must be positioned so as to lengthen, rather than divide, the flowpath.

5. The bottom of the first cell shall be sloped toward the inlet. The slope should be between 0.5% (minimum) and 2% (maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells.

Note: Treatment effectiveness in wetpool facilities is related to the extent to which plug flow is achieved and short-circuiting and dead zones are avoided. Structural walls placed within the cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.

6. The vault bottom shall slope laterally a minimum of 5% from each side towards the center, forming a broad “v” to facilitate sediment removal. *Note: More than one “v” may be used to minimize vault depth.* ***Exception:*** The vault bottom may be flat if removable panels are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

7. The highest point of a vault bottom must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.

8. Provide for passage of overflows should the outlet become plugged.

9. Tanks shall meet structural requirements for overburden support and traffic loading, if appropriate. H-20 live loads must be accommodated for tanks lying under parking areas and access roads. The City of Gresham *Public Works Standards* may have different live load requirements for structures located in roadways. Tanks shall be placed on stable, well-consolidated native material with suitable bedding. Tanks shall not be allowed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

10. In moderately pervious soils, where seasonal groundwater may induce flotation, buoyancy tendencies must be balanced either by ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations must be submitted which demonstrate stability.

11. Materials shall consist of pre-cast, or cast-in-place reinforced concrete, or polyethylene. The use of treated or untreated galvanized materials in stormwater facilities is not allowed. Galvanized metals leach zinc into the environment, especially in standing water conditions. Others have observed high zinc concentrations, sometimes in the range that can be toxic to aquatic life. Pipes entering and leaving the vault shall be sealed using a non-porous, non-shrinking grout.

C. Inlet and Outlet

1. The inlet to the wet vault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom (not including sediment storage). The top of the inlet pipe should be submerged a minimum of 1 foot.

Note: The submerged inlet shall dissipate the energy of the incoming flow. The distance from the bottom shall minimize re-suspension of settled sediments. Alternative inlet designs that meet these objectives are acceptable.

2. Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet riser must be a minimum of 6 inches (however, 12 inches is preferred).

3. The outlet pipe shall be back-sloped or have a tee section, the lower arm of which should extend 1 foot below the water quality design water surface elevation to provide for trapping of oils and floatables in the vault.

4. A gravity drain for maintenance shall be provided with the following criteria:

   - The gravity drain shall be as low as the site condition allows; however, the invert shall be no lower than the average sediment storage depth. At a minimum, the invert shall be 6 inches above the base elevation of the vault sidewalls. The 6-inch minimum applies to vaults that incorporate a "v" bottom only. Flat bottom vaults require a minimum of 12 inches above the base elevation of the vault sidewalls.

   - The drain shall be a minimum of 8 inches in diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

   - Operational access to the valve shall be provided to the finished ground surface. The valve location shall be accessible and well marked with one foot of paving place around the box. It must be protected from damage and unauthorized operation.

   - If not located in the vault, a valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5-feet deep, an access manhole is required.

D. Access Requirements

1. Access shall be provided over the inlet pipe and outlet structure. Access openings shall be positioned a maximum of 50 feet from any location within the

tank; additional access points may be required on large vaults. If more than one "v" is provided for in the vault floor, access to each "v" must be provided.

2. A minimum of 50 square feet of grate shall be provided over the second cell. For vaults in which the surface area of the second cell is greater than 1,250 square feet, 4% of the top shall be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area.

Note: A grated access door can be used to meet this requirement. This grate allows air contact with the wetpool to minimize stagnant conditions that can result in oxygen depletion, especially in warm weather.

3. For vaults under roadways, the removable panel (used in flat bottom vaults) must be located outside the travel lanes.

   - Alternatively, multiple standard locking manhole covers shall be 12 feet, measured on center, to facilitate removal of sediment.

   - Handholds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements.

   - Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes, as specified in Item 9 below.

4. All access openings, except those covered by removable panels, shall have round, solid locking lids (see Standard Detail 309, City of Gresham *Public Works Standards*).

5. Vaults with widths of 10 feet or less must have removable lids.

6. The maximum depth from finished grade to the vault invert shall be 20 feet.

7. The minimum internal height shall be 7 feet from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. Note: The minimum internal height requirement may be waived for any areas covered by removable panels.

8. Vaults must comply with the OSHA confined space requirements.

9. Ventilation pipes (minimum 12-inch-diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation before maintenance personnel enter the vault. This requirement is waived if removable panels are provided over the entire vault.

4.7.3 Access Roads

Access roads are required to the access panel (if applicable), the control structure, and at least one access point per cell. They shall be designed and constructed as specified for ponds in Section 4.6.2

4.7.4 Maintenance Easement

1. **Right-of-Way:** Vaults to be maintained by City of Gresham but not located in City of Gresham right-of-way shall be in a tract dedicated to City of Gresham. Any tract abutting public right-of-way will require a 15-foot-wide extension of the tract to accommodate an access road to the vault.

2. **Setbacks:** Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet.

4.7.5 Sediment Removal

Construction Considerations: Sediment that has accumulated in the vault must be removed after construction. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be performed after building construction is complete. In general, sediment accumulation from stabilized drainage areas should not be expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise. The City will not release maintenance and defect financial guarantees or assume maintenance responsibility for a facility unless it has been cleaned of construction phase sediments.

4.7.6 Maintenance Considerations

1. Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault. Vault maintenance procedures must meet OSHA confined space entry requirements.

2. A Maintenance Agreement must be filed with the City. For details, refer to Section 9.0 and *Appendix B* of this *Manual*.

3. Facilities should be inspected annually. Floating debris and accumulated petroleum products should be removed as needed, at least annually. The floating oil should be removed from wet vaults when oil accumulation exceeds one inch.

4. Sediment should be removed when the one-foot (average) sediment zone (see Figure 4.2D) is full. Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed. Check with applicable regulatory agencies.

5. Specific requirements apply to drainage of wastewater from a vault during maintenance. (See Sidebar).

When performing pond maintenance refer to GRC 4.40.030 and 4.40.040 and DEQ for specific requirements regarding discharges to natural outlets, the stormwater conveyance system or the sanitary sewerage system.

4.7.4 Modifications for Combining with a Baffle Oil/Water Separator

If the project site requires oil/water separation (refer to Section 6.0, Table 6.0 – New Parking Lots BMP Selection Matrix) and a wet vault is proposed to meet water quality treatment requirements, the vault may be combined with a baffle oil/water separator to meet the requirements of Section 6.0, with one facility rather than two. Structural modifications and design criteria are given below. However, the maintenance requirements for baffle oil/water separators must be adhered to, in addition to those for a wet vault. This will result in more frequent inspection and cleaning than for a wet vault used solely for sediment (TSS) removal. Refer to *Appendix H*: 1998 King County *Surface Water Design Manual*, for information on maintenance of baffle oil/water separators.

1. The sizing procedures for the baffle oil/water separator should be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a large vault size, increase the wet vault size to match. Refer to *Appendix H*: 1998 King County *Surface Water Design Manual*, for more information.

2. An oil-retaining baffle shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow, which would cause the retained oil to be washed out of the vault during large storms.

Note: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

3. The vault shall have a minimum length-to-width ratio of 5:1.

4. The vault shall have a design water depth-to-width ratio between 1:3 and 1:2.

5. The vault shall be watertight.

6. Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.

7. Wet vaults used as oil/water separators must be off-line and must bypass flows greater than the water quality design flow.

Section 5.0 Constructed Marshes

5.1 Overview

5.1.1 Description

Constructed marshes are systems that are constructed to maintain a permanent shallow pool with emergent vegetation and to provide pollutant removal for stormwater runoff. They are similar to wet ponds, except that vegetation is used to enhance many of the pollutant removal mechanisms. Marshes are generally shallower than wet ponds and hence can have a greater surface area and land requirement. Marshes are also commonly referred to as "wetlands" but should not be confused with jurisdictional wetlands regulated by the Division of State Lands (DSL). Refer to Section 1.6 of this Manual for more environmental regulations background.

5.1.2 Types of Constructed Marshes

The following types of constructed marshes are discussed in this section:

- **Shallow marsh**: a marsh that is typically between zero and 18 inches deep and, therefore, can support the growth of emergent wetland plants that will slow water flow and help filter pollutants. A deeper forebay is located at the major inlet to trap sediment, and a deep micropool (smaller permanent pool) is located near the outlet to facilitate sedimentation and to prevent clogging.
- **Pond/marsh system:** a constructed system with two separate cells, a shallow marsh, and a deep pond that leads into it. The pond traps sediments, reduces water velocity, removes pollutants, and reduces the space required for the system.
- **Extended detention marsh:** a shallow stormwater marsh with live storage above the marsh for the temporary detention of runoff. As much as 50% of the total treatment volume can be provided as extended detention storage, which reduces the space requirements compared to a facility that is solely a shallow marsh. The extra runoff is stored to allow pollutants to settle out.

5.2 Applications

Table 2.2.2, Section 2.0 of this document includes a summary of recommended stormwater quality facilities for specific land use. The designer should refer to that section for guidance in selecting treatment facilities to best meet the needs of the targeted pollutants of concern.

5.3 General Design Criteria

This section applies to all types of marshes described in this *Manual*.

5.3.1 Site Screening for Constructed Marshes

A. Evaluate the Land Use/Expected Pollutant Loading

Constructed marshes are intended to handle the runoff from both residential and commercial areas. They are unsuitable for most industrial areas unless significant pretreatment occurs, because toxic pollutants may inhibit the biological activity of the vegetation.

B. Evaluate the Catchment Area

Constructed marshes require a large catchment area, typically at least 10 acres for an extended detention marsh, and 25 acres for a shallow marsh or pond/marsh.

1. **Assess available land** considering the proposed development, post-development drainage, topography, and other important environmental features, such as steep slopes and natural marshes/wetlands.
2. **Assess conditions** for presence of appropriate water balance. Large catchment areas help provide adequate base flow to maintain submerged conditions throughout most, if not all, of the year. This is the factor that usually determines facility size.
3. **Appropriate locations <u>are limited</u> to** areas with a shallow groundwater table or naturally occurring low-permeability substrate. Where groundwater quality or excessive seepage is of concern, impervious liners may be needed to maintain groundwater quality. Constructed marshes <u>should never</u> be located within natural marshes or in other environmentally sensitive areas that must be preserved. However, placing a constructed marsh next to an existing one can enhance the secondary values of the marsh, such as wildlife habitat and aesthetics.

5.3.2 Design Considerations for Constructed Marshes

Establish a design team that includes an engineer, a wetlands expert, a landscape architect, and a contractor to ensure an effective and practical design.

The following design criteria are general guidelines and pertain only to marsh design for water quality. If the marsh will also be used for stormwater quantity (flood) control, check with the City regarding required additional analysis and design features.

A. Ensure Soils are Suitable

If highly pervious soils exist onsite (Type A soils), then seepage may be problem, and perhaps an infiltration facility should be considered instead. If infiltration is not an intended part of the marsh design or is undesired because of a shallow groundwater table, prevent seepage by any of the following methods:

- Compacting suitable native soils (at least 10% clay)
- Constructing clay blankets from material at least 40 percent clay and at least 12-inches thick
- Using synthetic waterproof linings

Section 5.3.2 (cont.)

Refer to GPWS Construction Specifications Section 205.02.14 for Drainage Geotextile Type 1, for the specifications for recommended geotextile fabric. Note that most B, C, and D soil types will eventually seal on their own.

B. Determine the Water Budget and Maintain Saturated Soils

Constructed marshes with contributing watershed areas of less than about 20 to 25 acres are often unable to maintain a constant water elevation unless they are excavated to the water table.

Prepare a monthly water budget for the site, which includes direct precipitation, stormwater runoff, surface base flow, groundwater discharge, evapotranspiration, and storage (see *Appendix D*). If excavation into groundwater is planned, show a monthly groundwater level analysis to demonstrate when the marsh will be wet. The presence of standing water is not necessary for the entire year, as long as soils remain wet. Most emergent plants have very low dry depth tolerances and drawdowns below the depth zone will kill vegetation.

C. Size and Configure the Marsh

1. Calculate the required stormwater volume. Design a facility volume that can capture the runoff from the water quality design storm specified in GDC Section 9.0522. (See Section 1.3.5 of this Manual). Effective pollutant removal depends on volume as well as other factors.

2. Create a surface area that is at least 2 percent of the contributing drainage area.

3. Provide a high surface area to volume ratio (SA/V). This increases the effectiveness of several removal pathways including sedimentation, adsorption, microbial activities, and algal uptake. To do so, either:

   - Increase the total surface area of the marsh; or
   - Increase the number of surfaces within the marsh by creating complex micro-topography and/or establishing dense wetland vegetation. This will require careful supervision of construction activities to ensure proper implementation of the design.
   - See the design criteria for specific types of constructed marshes for suggested volume and surface area allocations among different depth zones.
   - Maximize the effective flow path through the marsh (to increase contact time over the surface areas, which increases pollutant removal). The following are ways to increase the flow path:
   - Extend the distance between the inlet and outlet. As a general rule, use a length to width ratio of at least one. This can be accomplished by routing flows in a pattern such as that shown later in this section in Figure 5.3.2D.
   - Maximize the sinuosity of the dry weather flow path. In other words, create a deeper, meandering, wide channel (6 to 18 inches below normal pool) surrounded by a shallower marsh of from zero to 6 inches below the normal

Section 5.3.2 (cont.)

- pool. In general, use a dry weather flow path with a length to width ratio of at least 2:1.
- Create shallow areas (one to 6 inches deep) where sheet flow can occur.
- Use multiple cells within the wetland system.

4. As a general rule, limit side slopes to steepness no greater than 5:1.
5. Design with maintenance in mind. Effective maintenance will be crucial to successful operation of the facility. Hence, provisions to facilitate maintenance operations must be built into the design.

D. Provide Runoff Pretreatment and Energy Dissipation at the Inlet

1. Include a pond cell or a forebay by the inlet to reduce velocities, trap sediment, and distribute the stormwater over the marsh. The forebay should be at least 10 percent of the total design storm volume. Flow exiting the forebay should be dispersed evenly across the outlet weir to achieve low entrance velocities and to prevent erosion within the marsh.
2. Distribute flow as uniformly as possible through the marsh using crested weirs, inflow baffles, or other methods.

E. Design the Outlet and Micropool

1. Include a 4- to 6-foot deep micropool by the outlet, comprising at least 10% of the total design storm volume, to protect the outlet from clogging. Locate the micropool outlet within one foot of the normal pool surface. Figure 5.3.2A shows a micropool cross-section.
2. Note that micropool depth can potentially intersect with rapidly draining sand and gravel deposits and a liner would be necessary to provide proper function and prevent potential groundwater contamination. Consider a geologic inspection when designing the micropool.
3. Equip the micropool with a drain so that the marsh can be de-watered within 24 hours.
   - To minimize clogging, drain with a 90º elbow, facing upward, that extends at least 6 inches into the micropool.
   - The pipe and elbow should be flanged ductile iron.
   - Place the elbow on the flanges but not bolted to the pipe so that it can be knocked off during pond draining.
   - Note that pumping of marsh water may also be allowed if pre-approved by the City of Gresham; however, this process is not recommended due to high-energy costs and high possibility of failure.

Section 5.3.2 (cont.)

4. Provide the low flow or extended detention release from the marsh with a reverse-slope pipe or a hooded, broad-crested weir. The use of a v-shaped or proportional weir is encouraged to assure a constant detention time for all storm events.

F. Provide Energy Dissipation at the Outlet

Use rock or some other energy dissipating measure to prevent erosion if the outfall discharges to a stream or an open channel. Also, if possible, design the facility to discharge at the site's natural pre-development discharge location.

G. Provide Overflow Protection

1. Provide a riser and/or a spillway as specified to safely pass the 100-year design storm event and to provide overflow protection.
2. Armor or pipe the spillway section in accordance with acceptable practices.

H. Develop the Landscaping and Aquatic Pondscaping Plan

Developing a landscaping plan in the design phase is extremely important. Many of the enhanced functions of a constructed marsh depend on the wetland type plants and their placement. Landscaping above the normal pool level is important as well, for a variety of reasons such as soil stabilization, aesthetics, wildlife habitat, and limiting access for safety. Landscaping can also provide shade to keep water temperatures down.

The following are some guidelines for plant selection. Also refer to *Appendix C*: Native Plant Restoration Guide. Consult a professional wetland biologist regarding the final planting plan.

- Choose at least three plant species suitable to each of the depth zones in the system. Include native species to minimize maintenance, and include some plants that are aggressive colonizers. Use *Appendix C* to select plants. Keep in mind that each plant species has a fairly narrow tolerance for soil moisture and inundation. Emergent plants primarily grow in the zone from zero to 18 inches below the normal pool level, and the greatest variety grow in the zero to 6-inch depth zone.
- If the marsh is formed by an earthen embankment, do not plant trees or shrubs with root balls, which could grow to more than 30 inches on the embankment. The root systems of large trees and shrubs can threaten the bank's structural stability.
- Plant about half the marsh surface area at a constant density throughout the marsh. If appropriate plants are selected, the marsh should be colonized within three years.
- Order plants 3 to 9 months before anticipated planting.
- Finalize the landscaping plan after the marsh has been constructed to confirm soil and moisture/inundation conditions.

Section 5.3.2 (cont.)

- Provide a detailed program for maintenance and possible replacement of the plantings for up to two growing seasons after the original planting.

I. Provide a Buffer

1. Provide a vegetated buffer next to the marsh to improve habitat functions and values, screen the system from adjacent land uses, and reduce exposure to any potential nuisance created by the marsh.
   - Use a buffer of at least 25 feet with an additional 15-foot setback to structures.
   - Use a wider buffer, 50 feet or more, when wildlife habitat creation is a priority.
2. Preserve existing trees in the buffer, whenever possible. If not, plant trees in at least 75 percent of the buffer perimeter to prevent geese loafing and create better wildlife habitat corridors.
3. Use *Appendix C*: Native Plant Restoration Guide to select marsh and buffer plants that provide food, cover, and habitat structure for wildlife. (Plants differ greatly in their wildlife value.)

J. Minimize Increases in Water Temperature

Temperature is considered one of the most serious pollutants that degrades water quality. Because aquatic wildlife is very sensitive to increases in temperature, stormwater control facility designs must utilize methods to keep temperature below pollutant level standards. Pollutant level standards for temperature are determined on the DEQ 303d list and vary by waterbody.

To minimize increases in water temperature, follow these steps:

1. Route a portion of the cooler incoming base flow around the marsh.
2. Locate the marsh away from the stream.
3. Maintain stream shading upstream and downstream of the marsh.
4. Minimize open water areas of the marsh.
5. Avoid excessive use of riprap and concrete (which collect and impart heat) at the outfall.
6. Plant trees and shrubs adjacent to the marsh (especially on the south side) to minimize increases in water temperature within the marsh system.

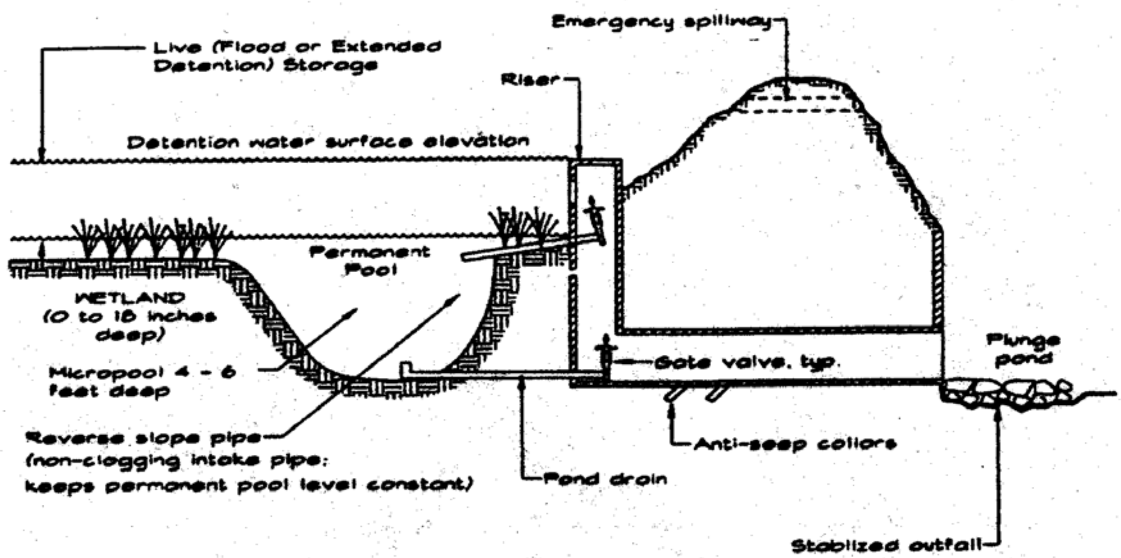


Figure 5.3.2A. Cross section of a micropool in a stormwater marsh.

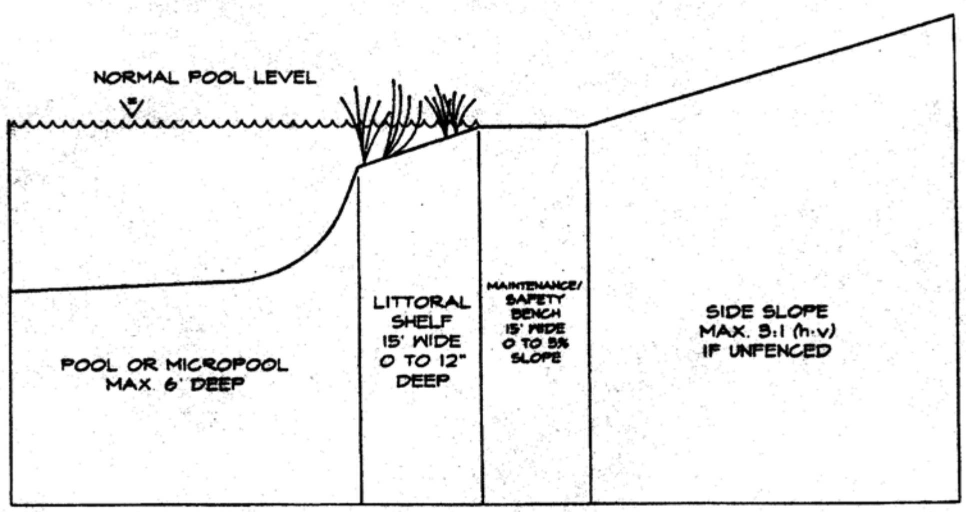


Figure 5.3.2B. Cross section of pond or micropool shoreline.

Wingwall Fence Detail

Source:
Washington Suburban Sanitary Commission

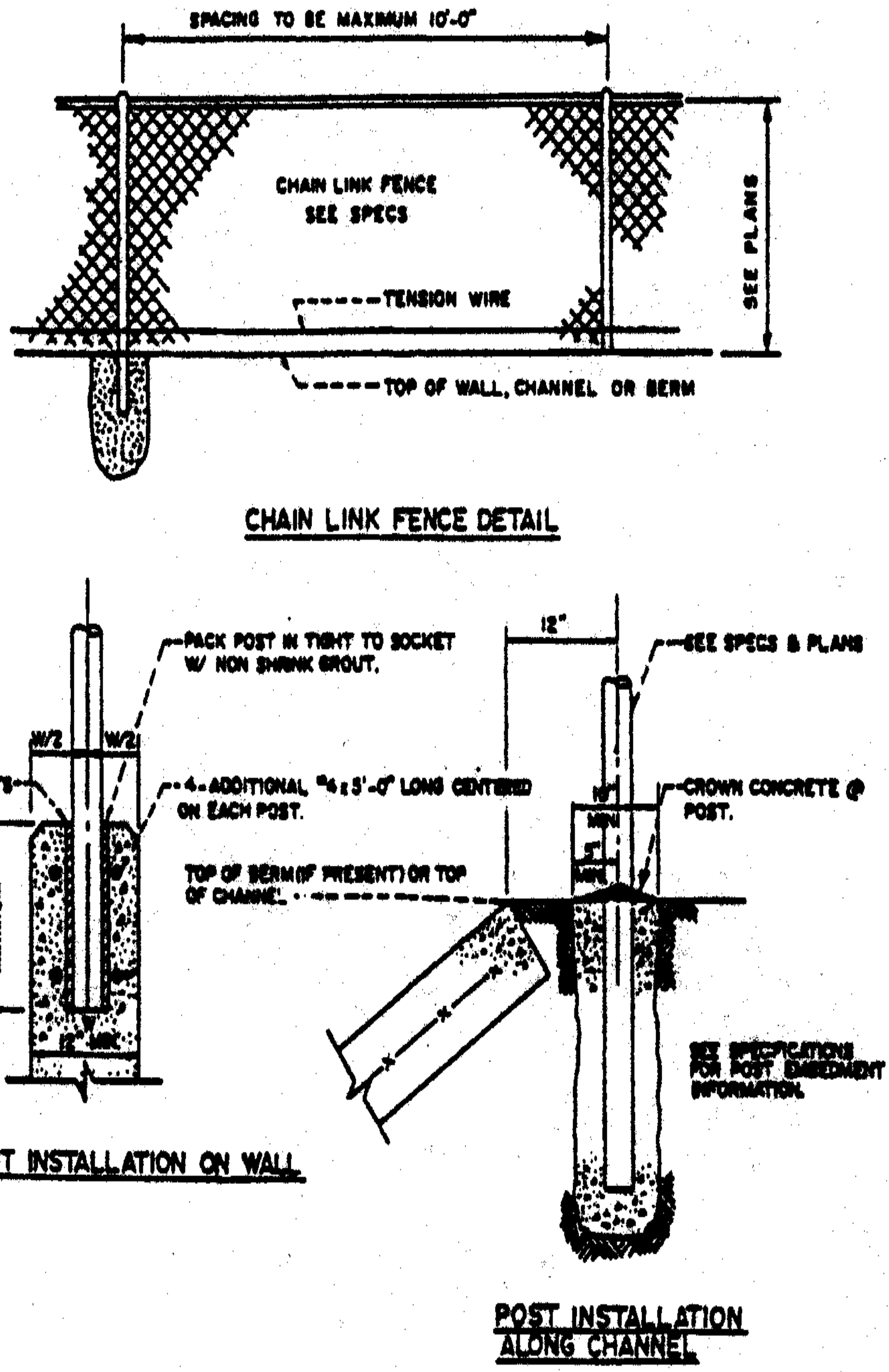


Figure 5.3.2 C. Wingwall Fence Detail

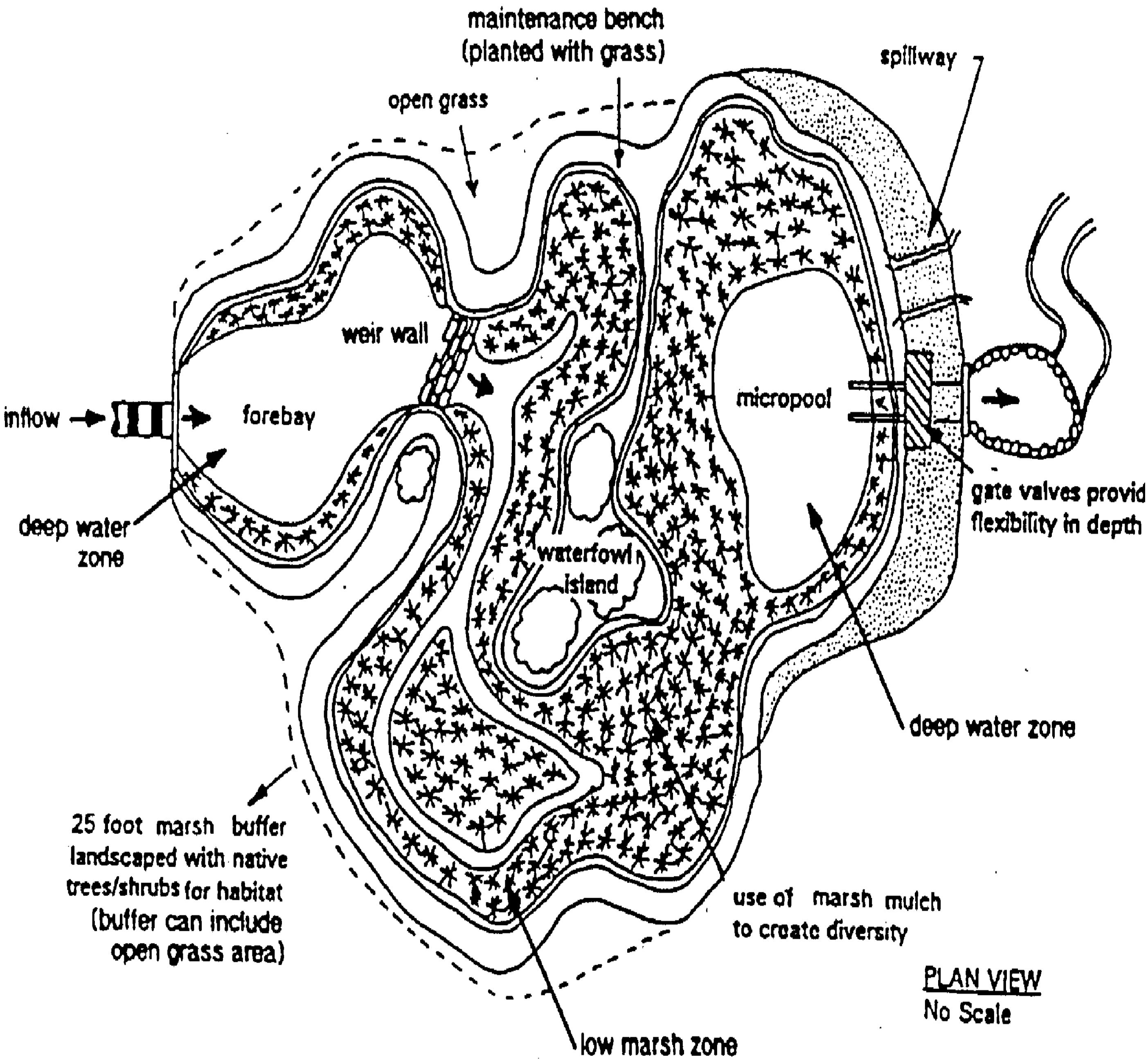


Figure 5.3.2D. Shallow marsh system.

5.4 Specific Design Criteria

5.4.1 Design Considerations for Shallow Marshes

A. Design the Forebay

1. Design the forebay – a separate cell near the inlet to trap sediment and reduce velocity – with a capacity of at least 10% of the total design volume.
2. Design the forebay to be 4- to 6-feet deep.

B. Allocate the Design Volume

Allocate the design volume among different depth zones considering the following guidelines:

Table 5.4.1A: Shallow Marsh Design Volume Allocation

Depth Zone	Percentage of Design Volume
Forebay	10
Micropool	10
Deep water	10
Low marsh (6 to 18 inches below normal pool):	45
High marsh (zero to 6 inches below normal pool):	25

C. Allocate the Surface Area

Allocate the surface area among different depth zones considering the following guidelines:

Table 5.4.1B: Shallow Marsh Surface Area Allocation

Depth Zone	Percentage of Surface Area
Forebay	5
Micropool	5
Deep water	5
Low marsh (6 to 18 inches below normal pool):	40
High marsh (zero to 6 inches below normal pool):	40
Semi-wet (zero to 2 feet above normal pool):	5

D. Establish Vegetation

In general, plant at least 75% of the marsh buffer with trees (or retain it as forest). This prevents geese loafing problems, improves the wildlife habitat quality of the system, and reduces the need for regular mowing. Thus, up to 25% of the buffer perimeter area can be maintained as grass or wet meadows.

5.4.2 Design Considerations for Pond / Marsh Systems

A. Allocate the Design Volume

Allocate the design volume among different depth zones considering the following suggested guidelines:

Table 5.4.2A: Pond/Marsh Design Volume Allocation	
Depth Zone	**Percentage of Design Volume**
Micropool	10
Deep water	60
Low marsh (6 to 18 inches below normal pool):	20
High marsh (zero to 6 inches below normal pool):	10

B. Allocate the Surface Area

Allocate the pond surface area among different depth zones considering the following suggested guidelines:

Table 5.4.2B: Pond/Marsh Surface Area Allocation	
Depth Zone	**Percentage of Surface Area**
Micropool	5
Deep water	40
Low marsh (6 to 18 inches below normal pool):	25
High marsh (zero to 6 inches below normal pool):	25
Semi-wet (zero to 2 feet above normal pool):	5

5.4.3 Design Considerations for Extended Detention Marshes

A. Provide a Forebay

Include a forebay as discussed for shallow marshes in Section 5.4.

B. Allocate the Design Volume

1. Allocate the permanent pool volume among the different depth zones. The following is a suggested guideline:

Table 5.4.3A: ED Marsh Design Volume Allocation	
Depth Zone	**Percentage of Design Volume**
Forebay	10
Micropool	10
Deep water	40
Low marsh (6 to 18 inches below normal pool):	20
High marsh (zero to 6 inches below normal pool):	10
Semi-wet (zero to 2 feet above normal pool; includes extended detention):	50

2. Allocate the water quality design volume between the permanent pool and the extended detention portion (no less than 50% extended detention).

3. Size the facility such that the volume of extended detention volume is no more than 50% of the total design volume. The extended detention volume can be stored for an average of 24 to 36 hours or more, depending on the facility design and the plant type. Some plants will die if underwater for extended periods. Refer to *Appendix C* for appropriate plant selections.

4. Limit the maximum extended water surface elevation to 3 feet or less above the normal marsh pool (to better accommodate marsh plant growth).

C. Allocate the Surface Area

Allocate the surface area among the different depth zones. The following is a suggested guideline:

Table 5.4.3B: ED Marsh Surface Area Allocation	
Depth Zone	**Percentage of Surface Area**
Forebay	5
Micropool	5
Deep water	40
Low marsh (6 to 18 inches below normal pool):	40
High marsh (zero to 6 inches below normal pool):	40
Semi-wet (zero to 2 feet above normal pool):	10

D. Establish Vegetation

Follow these guidelines for establishing vegetation in extended detention marshes:

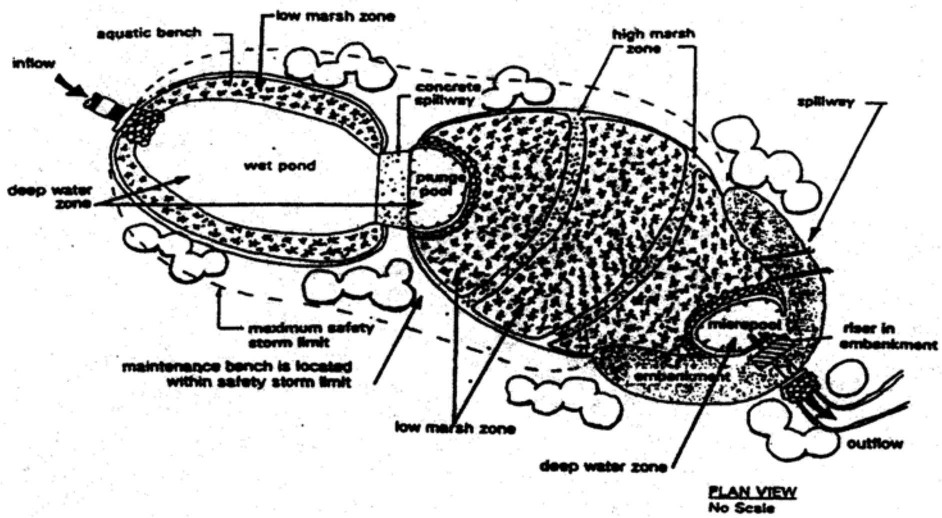
1. Be aware that the extended detention zone imposes severe physiological constraints for many wetland plant and animal species due to the extreme fluctuations in water level. Choose plants that will do best there. Refer to *Appendix C*: Native Plant Restoration Guide for appropriate plant selections.

2. Recommended techniques include hydroseeding using water-tolerant seed mixes.

E. Design the Orifice

1. Protect the extended detention orifice from clogging by using a reverse-slope submerged orifice or a perforated half-round hood over a broad-crested weir.

2. If a reverse-sloped pipe is used, increase the actual diameter of the orifice to the next greatest diameter on the standard pipe schedule, to allow the pipe to be equipped with a gate valve.



lo marsh (six to 18 inches below normal pool): 25 percent
hi marsh (zero to six inches below normal pool): 25 percent
semi-wet (zero to two feet above normal pool): five percent

Figure 5.4.3A. Pond / marsh system

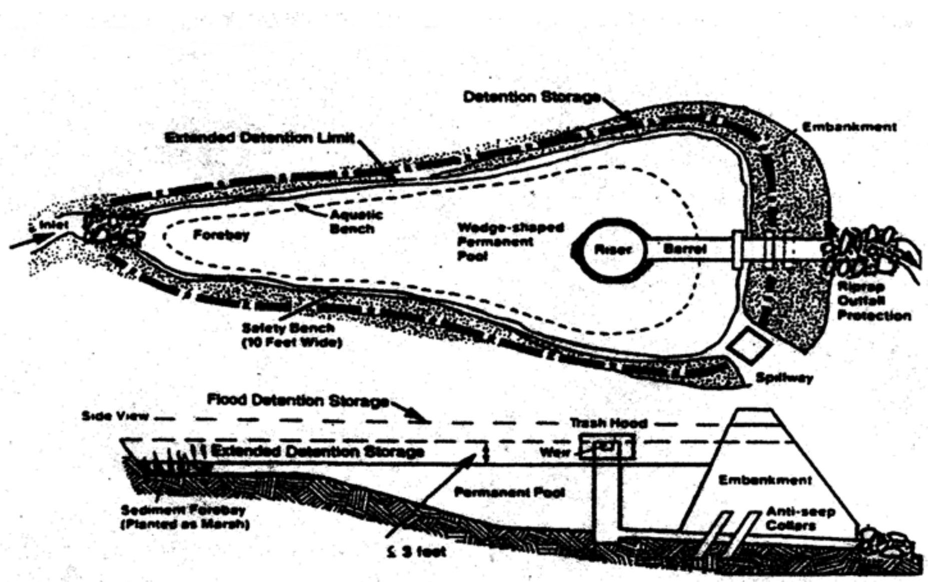


Figure 5.4.3B. Extended detention [ED] marsh

5.5 Maintaining Constructed Marshes

Active management of hydrology and vegetation is critical to proper function of constructed stormwater marshes. This is especially true during the first few years as vegetation becomes established.

When performing marsh maintenance refer to GRC 4.40.030 and 4.40.040 and DEQ for specific requirements regarding discharges to natural outlets, the stormwater conveyance system or the sanitary sewerage system.

5.5.1 Access Roads

Follow the requirements stated in Section 4.6.2.

5.5.2 Maintenance Easement

1. Provide a right-of-way maintenance easement from a road to the marsh, which also provides direct access to the riser and any forebay. The access road should be at least 15 feet wide, no steeper than 4:1, and capable of supporting heavy equipment.
2. If the access road faces the facility, then inlet and outlet structures shall not exceed a maximum distance of 8 feet. If the access road is adjacent to the facility, then the inlet and outlet structures shall not exceed a maximum distance of 14 feet.

5.5.1 Prepare a Maintenance Plan

A Maintenance Agreement for each facility is required to be filed with the City, refer to Section 9.0 and *Appendix B* for more details.

Prepare a maintenance plan that outlines the schedule, scope, and responsibilities for performing maintenance duties. Schedule maintenance around sensitive fish and wildlife and vegetation seasons. For example, time sediment removal to avoid sensitive life stages of marsh inhabitants (August and September are the best months to disrupt marsh vegetation).

5.5.2 Inspect the Marsh

1. Inspect the marsh at least twice a year in the first three years after construction, during both the growing and non-growing season. Inspect it annually thereafter.
   - Inspections should be conducted with the as-built and pondscaping plans in hand.
   - Measure sediment buildup using a measuring device and the depth marker installed during construction.
2. Note the location and types of plants, including intentionally planted species as well as any volunteers. Note also any changes in their area coverage.
3. Note whether the design water elevation of the normal pool is being maintained and whether the original depth zones and micro-topographic features have remained.
4. Note sediment accumulation and the condition of the outlet.
5. Maintain records so that the progressive development of the marsh system over time can be tracked. The inspection records should include:
   - Wetland plant species types and distribution

When performing marsh maintenance refer to GRC 4.40.030 and 4.40.040 and DEQ for specific requirements regarding discharges to natural outlets, the stormwater conveyance system or the sanitary sewerage system.

- Percent marsh cover
- Sediment depths in the forebay and in benchmarked planting zones
- Water elevation
- Condition of the outlet.

Other maintenance records on the condition of the riser, spillway, and embankment should also be maintained, as would be the case for any pond.

5.5.2 Manage Sediment Deposits

1. Annually monitor sediment in the forebay or first cell. For planning purposes, assume that sediment removal will be required for shallow marshes, and ED marshes every two years. For a pond/marsh system, assume removal from the pond portion every 10 to 15 years. In practice, however, sediment removal frequencies will depend on visual monitoring of accumulated sediment using the sediment markers installed during construction.

1. Place a sediment marker (e.g., a graduated pipe) within the forebay in an area, which is not likely to be damaged by incoming storm flows and can be easily seen by maintenance personnel. Place another marker near the marsh outlet.

2. Consider reserving an area for onsite storage and testing of sediment.

3. Dispose of sediments removed in accordance with safe and best management practices specified by applicable local, state, and federal regulations.

   - For stormwater marshes serving heavily urbanized or industrialized catchments, determining the proper disposal method will require testing of the accumulated sediment prior to removal to determine the levels of pollutants.
   - Periodic testing will also help determine appropriate sediment removal schedules and methods. Testing could include parameters such as oil and grease, heavy metals (e.g., copper, lead, zinc, and cadmium), nutrients (e.g., phosphorus) and/or organics such as pesticides, which may accumulate on the pond bottom.
   - Consult with regulatory agencies and choose the parameters to be tested based on the site-specific conditions.

4. To remove sediment, first drain the forebay and then use a compact 4x4 loader/scraper or other appropriate non-intrusive method. Remove sediment from the floor and sides, including benches, as appropriate.

5.5.3 Maintain Landscaping

1. Coordinate with a vegetation specialist (e.g., professional wetland scientist, and landscape architect) to maintain and monitor plant growth. Proper vegetation maintenance is critical to ensure effectiveness of a marsh system.

2. Care of plants (through watering, mulching, weed removal, etc.) during the first three years after planting to promote their survival is critical during the establishment phase. Plant more plants after the first or second growing season, if needed.

3. Mow the embankment and access roads twice a year to prevent the growth of trees. Using native plants should reduce mowing requirements. Also, in some cases, the embankment can be stabilized with suitable vegetation to eliminate the need for mowing.
4. Harvest the aboveground wetland vegetation before the plants die back in the fall, to control nutrient levels. De-water the marsh and manually cut vegetation to minimize disturbance. Harvest on a rotational basis, leaving some areas undisturbed to maintain some level of continuous pollutant removal. Compost or dispose harvested material away from the marsh.
5. Maintain existing trees in the buffer zone.

5.5.4 Adjust the Water Flow as Needed

If necessary, and with approval from the design engineer, add or subtract a few inches from the normal pool by using flashboards or mortar work on the broad-crested weir. If so equipped, adjust the permanent pool elevation using the gate valve leading to the pond drain.

5.5.5 Safety Considerations

1. Limit side slopes that lead to deep-water cells (such as the forebay and micropool) to a steepness no greater than 3:1.
2. Provide a 15-foot-wide safety bench where the toe of the side slope meets any deep water pool area (see Figure 5.3.2B). This usually coincides with the maintenance bench for direct access. Provide a second 15-foot-wide littoral shelf around the inside perimeter of the micropool and forebay, extending from the normal pool to a depth of one foot.
3. Place the riser within the embankment to make maintenance safer and easier (see Figure 5.3.2A). The weir openings in the riser can be "fenced" with pipe (8 inches on center) to prevent entry and block trash.
4. Provide trash racks on any large diameter (> 12-inch) outfalls. Trash rack spacing should be approximately half the orifice opening size (but not more than 8 inches as a safety measure) and the total openings of the trash rack should be at least three times the low flow orifice opening. Design trash racks to have sloped sides, which do not facilitate the collection of debris.

Provide wingwall (endwall) safety fencing as shown in Figure 5.3.2C. Refer to GPWS for other safety requirements.

5.5.6 Control Insects

The establishment of the littoral shelf and maintenance of constant water levels in the marsh systems should help prevent insect problems. However, if a problem arises with mosquitoes or other insects, consider the following:

1. Installation of predacious bird and bat nesting boxes are recommended.

2. Stock ponds with predaceous fish and insects. Follow appropriate state guidelines and restrictions for their use.
3. Use selective mosquito larvicides (Bacillus thuringiensis or Altoside® formulations) when it is necessary to control mosquito populations. This minimizes wildlife impacts.
4. Contact Multnomah County Vector Control at (503) 988-3464 for additional assistance with mosquito monitoring and control.

Section 6.0 Parking Lot Treatment Control Requirements

6.1 Overview

Impervious surfaces in urban areas are significant sources of stormwater pollution. Parking lots, because of their large impervious surfaces, are one such source. During dry weather, parking lots accumulate pollutants associated with exhaust emissions, brake pad wear, fluid leads from vehicles, atmospheric dryfall, and lack of maintenance. During wet weather, these and other pollutants (e.g., pesticides and fertilizers from landscaped areas) may be mobilized and transported into the storm drain system via rainwater. Thus, runoff from parking lots can contain metals, hydrocarbons, organic pollutants, and many other constituents.

This section is intended for owners and operators, design engineers and maintenance personnel of public and private parking lots. Its purpose is to provide guidelines for the selection, design, and maintenance of stormwater treatment controls for new parking lots.

Parking lot pollution prevention (source control) is one of the most cost-effective long-term solutions to stormwater management. Best Management Practices (BMPs) for pollution prevention through non-structural source control are not included in this document. For further information on non-structural source control BMPs, contact the City of Gresham, Stormwater Division. **Refer to Table 6.0 to determine required treatment controls.**

6.2 Required Treatment Controls for New Parking Lots

All parking lots are required to use various controls listed in Section 6.2.1 and must also utilize appropriate pretreatment methods listed in **Section 6.2.2** if the intended build out use falls under the following definition of "high vehicle trip usage" and/or "large parking lot." High vehicle trip usage is defined as several car usage per parking lot stall per day (average visit < two hours). Large parking lot is defined as having more than 15 stalls on site.

6.2.1 General Water Quality Treatment Controls

All parking lots are required to use the following BMPs:

1. Biofiltration Swale
2. Biofiltration Swale and Sand Filter Combination
3. Vegetated Filter Strip
4. Wet Vault
5. Proprietary Facilities

6.2.2 Additional pre-treatment control for oil, grease, and total petroleum hydrocarbons (TPH)

Either of the following BMPs must be installed if the intended build out use falls under the following definition of "high vehicle trip usage" and/or "large parking lot." **High vehicle trip usage** is defined as several car usage per parking lot stall per day (average visit < two hours). **Large parking lot** is defined as having more than 15 stalls on site.

1. Inlet Filter Inserts

2. Oil/Water separators (Coalescing plate separator)

6.3 General Water Quality Treatment Controls

Incorporation of landscaping into new parking lots early in site planning provides an opportunity to consider treatment control land requirements. In addition, well-planned grading considerations are required for vegetated treatment controls.

6.3.1 Biofiltration Swale

Biofiltration Swales may be used to treat runoff from new parking lots that produce relatively low concentrations of oil and grease. Therefore, swale treatment controls satisfy both the general requirements as well as additional treatment requirements for oil, grease and TPH. Refer to Section 3.0, *Flow-Through Water Quality Treatment Facilities,* for Design, Construction and Maintenance. Additionally, the following are supplementary guidance specific to biofiltration swales to be located in parking lots.

1. **Location:** The swale can be located on the perimeter of the parking lot or as an internal island. The optimal design requires grading the parking lot to have the initial flow enter at one end and large flows enter near the inlets, thereby bypassing the unit.

2. **Erosion Control:** If the runoff flow is to be introduced via curb cuts, place the pavement slightly above the swale elevation. Curb cuts should be at least 12 inches wide to prevent clogging. Receiving slopes downstream of curb cuts require energy dissipation for erosion protection. One method consists of an 18 inch by 24-inch wood framed drain rock landscaped pad. A gentle slope on any side slope that abuts the parking lot is also required to provide pretreatment and prevent erosion during heavy rainfall.

6.3.2 Biofiltration Swale & Sand Filter Combination

Biofiltration Swale & Sand Filter Combination may be used to treat runoff from new parking lots with a future intended use that do not meet the definition of "High Vehicle Trips" as defined in Section 6.2

Therefore, Biofiltration Swale & Sand Filter Combination treatment controls satisfy both the general requirements as well as additional treatment requirements for oil, grease and TPH for parking lots with predicted low hydrocarbon generation levels. This method is not recommended when high ground water is encountered. Appropriate Hydrology and Geotechnical reports, which support the use of this control facility, shall be required. Refer to Section 3.3.I, 3.3.2 & 3.3.7 for Design, Construction and Maintenance requirements.

6.3.3 Vegetated Filter Strip

Vegetated Filter Strips may be used to treat runoff from new parking lots that do not meet the definition of "High Vehicle Trips" in Section 6.2. Therefore, Vegetated Filter Strip treatment controls satisfy both the general requirements as well as additional treatment requirements for oil, grease and TPH for parking lots with future predicted low hydrocarbon generation levels. Refer to Section 3.3.3 for Design, Construction, and Maintenance requirements.

6.3.4 Wet Vaults

1. **Modification For Combining With A Baffle Oil/Water Separator:** If the project site requires oil/water treatment controls and a wet vault is proposed to meet general water quality treatment requirements, the vault may be combined with a baffle oil/water separator to meet the requirements of Section 6.0, with one facility rather than two. (Refer to Section 4.7 for Wet Vault requirements).

6.3.5 Proprietary Facilities

Proprietary vault treatment facilities are available. The developer needs to delineate the types of facilities proposed in the Stormwater Quality Control Plan (see Section 1.3.3) and seek City approval before finalizing the design.

6.4 Additional Pre-treatment Controls for Oil, Grease & Total Petroleum Hydrocarbons

6.4.1 Inlet Filter Inserts

Inlet filter inserts may be used to meet the additional oil control requirements for new parking lots. **Inlet filter inserts alone do not meet the general water quality treatment requirements as outlined in Section 1.3.5.**

An inlet filter insert is a device installed underneath an inlet basin that treats stormwater through filtration, settling, absorption, adsorption, or a combination of these mechanisms. Inserts vary greatly in form. Variations include type of media used for filtration, flow directions, construction material, number of chambers, size, etc. Inlet Filter Inserts are commercially available. Installation of Inlet Filter Inserts shall follow the manufacturers recommended procedures.

A. General Design Criteria

1. The maximum drainage area that contributes flow to the insert should be less than 5,000 square feet. This assumes peak flows into the filter are less than 20 gpm during most storm events.

2. The insert shall have the ability to create a positive seal around the grate to prevent low-flow bypass. The maximum height of the grate above the top of the frame, with the insert installed, should not exceed 3/16-inch, and the grate shall not rock.

3. Medium shall resist water saturation and maintain oil-absorbing properties for a minimum of 6 weeks under constantly wet conditions.

Note: The practice of in-lot surface detention is not an approved method where oil treatment control facilities, or oil/water/sedimentation interceptors (Lynch style basins) are used.

4. Insert shall have means of prevention floating oil from escaping the unit. The use of a tee section or down-turned elbow, or similar device is acceptable.

5. Insert shall have the ability to pass high flows without causing excessive ponding. No ponding is to occur for the 25-year peak flow rate.

6. Inserts shall be accessible for maintenance and should not be limited by continuous vehicle parking.

B. Maintenance Requirements

Filter inserts require more frequent maintenance than other oil treatment control facilities. A sound maintenance plan is essential to the success of inlet filter systems.

Refer to GDC Section 9.0526 for specific maintenance requirements of Stormwater Facilities.

The following are specific maintenance requirements for storm filter inserts:

1. Inlet filter inserts shall be maintained at a frequency recommended by the manufacturer, but at least monthly during the wet season (October through April) and once every two months during the remainder of the year. During the first year after installation, the inserts should be inspected after each storm to determine whether a more frequent maintenance schedule is needed.

When performing facility maintenance refer to GRC 4.40.030 and 4.40.040 and DEQ for specific requirements regarding discharges to natural outlets, the stormwater conveyance system or the sanitary sewerage system.

2. Maintenance shall include full replacement or renewal of oil absorbent/adsorbent material. In addition, the inlet basin sump should be inspected for sediment accumulation. Sediment should be removed if the depth of sediment in the sump is greater than six inches. An inspection and maintenance log shall be kept on-site and made available to the City on an as-needed basis. At a minimum, the maintenance log shall include the following information: date, type of maintenance performed, names of persons performing the work, and signature.

3. The operation and maintenance instructions from the insert manufacturer shall be kept with the maintenance log. Manufacturer's instructions should include installation, removal (including safety instructions), cleaning and replacement (including decanting of liquid wastes).

4. Owners should follow the manufacturer's instructions for de-watering the filter media. Generally, inserts that drain by gravity can be de-watered in place during dry weather. If an owner is unable to perform monthly maintenance because there has not been sufficient dry weather, the maintenance period may be extended up to an additional two weeks. If by the end of the additional two weeks there has been insufficient dry weather to allow de-watering; the owner shall make other arrangements for de-watering the filter media. Such arrangements could include the use of a commercial service, de-watering the insert in a watertight container, or other methods meeting environmental regulations. Media shall be disposed of in accordance with applicable regulations, including county and state hazardous waste regulations.

6.4.2 Oil/Water Separators

Oil/water separators may be used to pre-treat stormwater runoff from new parking lots and facilities that meet the definition of "High Vehicle Trips" in Section 6.2. **Note: API style separator is not considered effective and will not be accepted by the City.** Oil/water separators are not considered effective at removing concentrations of oil < 10 mg/l. They are most effective at removing larger concentrations of oil (> 200 mg/l). **Oil/water separators alone do not meet the general water quality treatment requirements as outlined in Section 1.3.5.** They must be used in conjunction with one of the general controls outlined in Section 6.3.

Oil/water separators are specifically designed to remove free oil and are not effective in separating oil that has become either chemically or mechanically emulsified or dissolved in water. Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than that of water.

The purpose of this section is to provide general guidelines for design and maintenance. For analysis methods and technical design criteria check with the specific manufacturer. For additional information see *Appendix H*: 1998 *King County 1998 Surface Water Design Manual.*

A. Design Guidelines & Requirements for Coalescing Plate Separators

1. Oil/water separators must be installed off-line, bypassing flows greater than the water quality design flow.

2. When a separator is required, it shall precede all other water quality treatment facilities. It may be positioned either upstream or downstream from flow control facilities.

3. In moderately pervious soils where seasonal groundwater may induce floatation, buoyancy tendencies shall be balanced by ballasting or other methods as appropriate.

4. Any pumping devices shall be installed downstream of the separator to prevent oil emulsification in stormwater.

5. Separator vaults shall be watertight. Where pipes enter and leave a vault below the water quality design surface, they shall be sealed using a non-porous, non-shrinking grout.

6. Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil or TPH discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided

7. Inlet and Outlet: The inlet shall be submerged. A tee section may be used to submerge the incoming flow and must be at least two feet from the bottom of the tank and extend above the water quality design water surface. The vault outlet pipe shall be sized to pass the water quality design flow before overflow. The vault outlet pipe shall be back-sloped or have a tee extending one foot above the water quality design water surface to provide for secondary trapping of oils and floatables in the wet vault.

B. Maintenance Requirements

Oil/water separators require regular maintenance to assure that accumulated oil does not escape from the separator. A sound maintenance plan is essential to the success of water/oil separators.

Refer to GDC Section 9.0526 for specific maintenance requirements of Stormwater Facilities.

The following are specific maintenance requirements for oil/water separators:

1. Oil/water separators shall be cleaned by September 15 of each year to remove accumulation during the dry season. They must also be cleaned after spills of polluting substances such as oil, chemicals, grease or other petroleum hydrocarbons.

   Vaults must also be cleaned when inspection reveals any of the following conditions:

   - Oil accumulation in the oil separation compartment equals or exceeds one inch unless otherwise specified by the manufacturer.

   - Sediment deposits in the bottom of the vault equals or exceeds six inches in depth.

2. For the first several years, oil/water separators should be checked on a quarterly basis for proper functioning and to ensure that accumulations of oil, grease, and solids in the separator are at acceptable levels. Effluent from the vault shall also be observed for the presence of oil sheen to ensure that oil concentrations are at acceptable levels and that expected treatment is occurring. Separators should be inspected after significant storm events (1 inch in 24 hours).

3. Access to separators shall be maintained free of all obstructions, and units shall be readily accessible at all times for inspection and maintenance.

4. Maintenance personnel entering oil/water separator vaults should follow State regulations pertaining to confined space entry.

5. An inspection and maintenance log shall be kept on-site and made available to the City on an as-needed basis. See Section 9.0 and *Appendix B* for details.

6.4.3 Modification For Combining With A Baffle Oil/Water Separator

If the project site requires oil/water treatment controls (refer to Table 6.0 – Flow Chart For Determining New Parking Lot Treatment Control), and a wet vault is proposed to meet general water quality treatment requirements, the vault may be combined with a baffle oil/water separator to meet the requirements of Section 6.2, with one facility rather than two. Structural modifications and added design criteria are given below. However, the maintenance requirements for baffle oil/water separators must be adhered to, in addition to those for a wet vault. This will result in inspection and cleaning that is more frequent than for a wet vault used for TSS removal.

1. The sizing procedures for the baffle oil/water separator should be run, as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a large vault size, increase the wet vault size to match.

2. An oil-retaining baffle shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow; or else the retained oil will be washed out of the vault during large storms.

3. The vault shall have a minimum length-to-width ratio of 5:1.

4. The vault shall have a design water depth-to-width ratio between 1:3 to 1:2.

5. The vault shall be watertight.

6. Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil or TPH discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.

7. Wet vaults used as oil/water separators must be off-line and must bypass flows greater than the water quality design flow.

Note: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

6.5 Parking Lot Maintenance BMP

Frequent and regular sweeping of parking lots are strongly encouraged. Pressure washing is strongly discouraged, unless all of the wash water can be controlled. If parking lots are pressure washed, special arrangements for the disposal of the wash water is required. Proper disposal may include holding the water in a blind sump with subsequent

Note: A waste discharge permit, issued by the City of Gresham Wastewater Services Division, shall be required to discharge wash water to the sanitary sewer.

hauling off site or discharge to the sanitary sewer system after holding the water for a minimum of 24 hours and skimming off the oil for recycling. If wash water is discharged to a sanitary sewer, detergents or emulsifiers should be avoided so that subsequent separation and removal of the oil can take place in a reasonable time frame. **Under no circumstances shall wash water be released to the stormwater system.**

6.6 Compliance with other Agency Requirements

If the site has an NPDES permit that specifically addresses oil control for the pollution-generating impervious surface of the site, compliance with NPDES permit conditions is adequate to comply with the oil control requirements of applicable sections of the Gresham Community Development Code. If the area under the covered fueling island drains to the sanitary system or controlled drain bay, then only the remaining high turnover rate area actually draining to the stormwater system needs to comply with the Parking Treatment Control Requirements.

6.7 Parking Lot Trees

Note: This list is borrowed from the City of Portland's Stormwater Management Manual and is provided for the reader's convenience as a general guidance only.

See also the City of Gresham's Street Tree List:
http://www.ci.gresham.or.us/departments/cedd/tpc.htm

Or call: 503-618-2421

The City of Gresham does not currently have its own guidance for parking lot trees. The City of Portland's list is provided for convenience in *Appendix E*. The list is intended to assist designers in selection of trees most appropriate for the potentially numerous microclimates that might exist in parking lots and often associated proximity to building walls. It is likely that most parking lots will be hot in summer months until the trees become established. The native species are listed according to their suitability to various conditions. **However, the designer should note that trees selected for sites within the City of Gresham must also take into account the strong east winds and ice storms that are specific to Gresham climate conditions.**

Table 6.0. Flow Chart for Determining New Parking Lot Treatment Control

Does the Development meet any of the following exceptions?

A. Development where construction will increase the impervious area by less than 2,500 sq ft.

B. Sites where it is infeasible to install on-site stormwater quality facilities. (GDC Section 9.0525)

C. Developments where the City has identified an existing public stormwater quality facility that satisfies the requirements of GDC Section A5223, prior to discharge to a stream or wetland.

Yes →

Treatment controls per Section 9.0522 not required. Recommend effective Source Control Best Management Practices. Contact City of Gresham Stormwater Division for further information.

NOTE: Developments exempt from requirements of Section 9.0052 may need to comply with other Agency's requirements. Refer to Section 6.6.

No ↓

Does the land use include any of the following?

1. Vehicle Servicing: Service Station or Oil Change Business, Service Station with Convenience Mart, Market with gas pumps, Convenience Market, Vehicle Repair, Car wash, Vehicle Parts Retail, Drive through Restaurants

2. Industrial or commercial sites storing chemicals, petroleum or heavy equipment usage.

3. For a use not listed, requirements shall be the same as for the most similar use listed, as determined by the City.

No ↓

Treatment controls required as identified in Section 6.2.1

Yes ↓

Pre-Treatment controls required as identified in Section 6.2.2.

Section 7.0 Flow By-Pass Facilities

7.1 Overview

In most cases, it is a designer's choice whether water quality facilities are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

Most water quality facilities can be designed as flow-through or on-line systems with flows above the water quality design flow or volume simply passing through the facility untreated. However, it is sometimes desirable to restrict flows to water quality treatment facilities and bypass the remaining higher flows around them (off-line facilities). This can be accomplished by splitting flows in excess of the water quality design flow upstream of the facility and diverting higher flows to a bypass pipe or channel. The bypass typically enters a detention pond or the downstream receiving drainage system, depending on flow control requirements.

A crucial factor in designing flow splitters is to ensure that low flows are delivered to the treatment facility up to the water quality design flow rate. Above this rate, additional flows are diverted to the bypass system with minimal increase in head at the flow splitter structure to avoid surcharging the water quality facility under high flow conditions.

Flow splitters are typically manholes or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half "tee" section with a solid top and an orifice in the bottom of the section. A full "tee" option may also be used (see design criteria in this subsection). Two possible design options for flow splitters are shown in Figures 7.0 A and B. Other equivalent designs are also acceptable, including those that split low flows, up to the water quality design flow, into the water quality treatment facility and divert higher flows around the facility.

7.2 Methods of Analysis

Flow splitters may be modeled using a two-outlet reservoir routine. The stage/discharge relationship of the outflow pipes should be determined using a backwater analysis. Weirs should be analyzed as sharp-crested weirs.

7.3 Design Criteria

1. A flow splitter shall be designed to deliver the required water quality design flow rate to the water quality treatment facility.

2. The top of the weir shall be located at the water surface for the design flow. Remaining flows enter the bypass line.

3. The maximum head shall be minimized for flow in excess of the water quality design flow. Specifically, flow to the water quality facility at the 100-year water surface shall not increase the design water quality flow by more than 10%.

4. Either design (shown in Figures 7.0 A or B) may be used. Equivalent designs are also acceptable.

5. Special applications, such as roads, may require the used of a modified flow splitter. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.

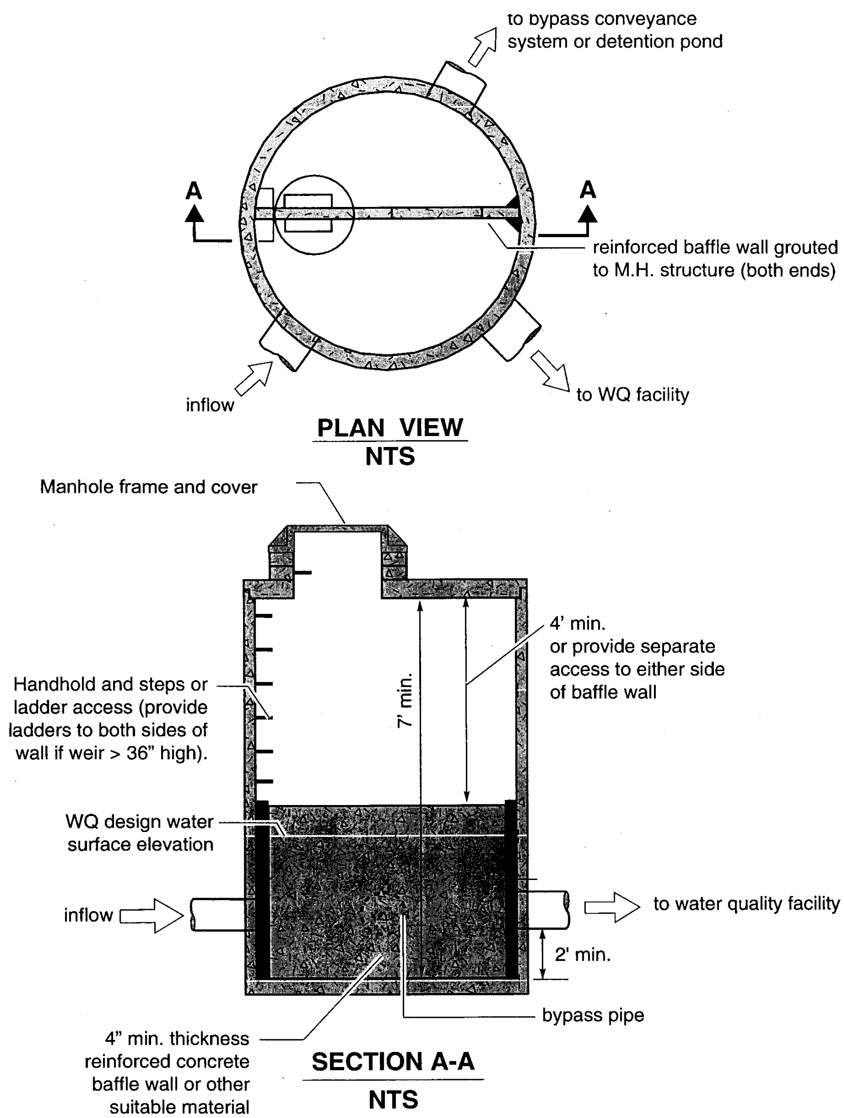
6. For ponding facilities, backwater effects must be included in designing the height of the standpipe in the catch basin.

7.4 Material Requirements

1. The splitter baffle shall be installed in suitable manhole or vault.

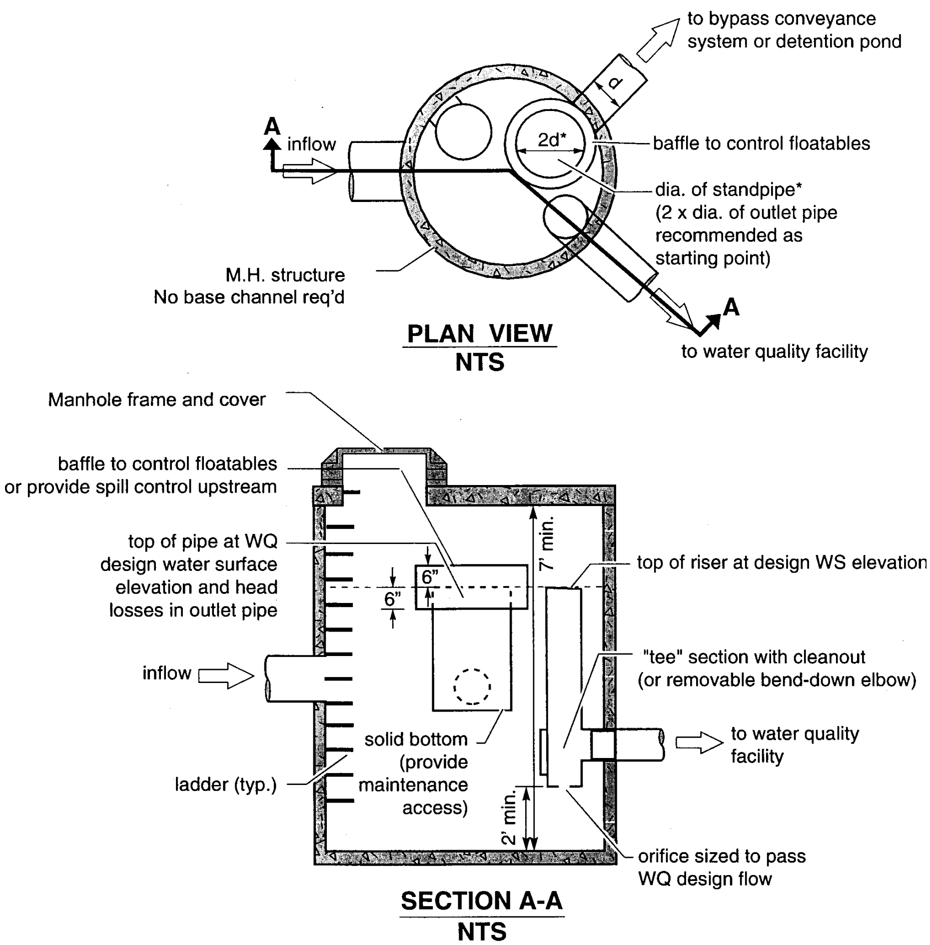
2. The baffle wall shall be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness. The minimum clearance between the top of the baffle wall and the bottom of the catch basin cover shall be 4 feet; other, dual access points shall be provided.

3. All metal parts shall be resistant to corrosion. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painting metal parts shall not be allowed because of poor longevity.



Note: The water quality discharge pipe may require an orifice plate be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimun headwater/diameter ratio of 2.0 on the outlet pipe.

Figure 7.0A. Flow Splitter, Option A



* **NOTE:** Diameter (d) of standpipe should be large enough to minimize head above WQ design WS and to keep WQ design flows from increasing more than 10% during 100-year flows.

Figure 7.0B. Flow Splitter, Option B

Section 8.0 Stormwater Subsurface Infiltration Facilities

8.1 Overview

At the adoption of this *Manual,* the full implementation details of the Underground Injection Control (UIC) rules were still being determined by the State. The *Manual* reflects the status of the UIC program as of August 2003. The manager may modify the requirements of this *Manual* in writing, if necessary, to ensure compliance with state and federal law. See also Section 1.7.3.

An Underground Injection System is defined in state law as "a well, improved sinkhole, sewage drain hole, subsurface fluid distribution system or other system or groundwater point source used for the *subsurface* emplacement or discharge of fluids." [Emphasis added.]

More information about the UIC Program can be found at DEQ's web site at:

http://www.deq.state.or.us/ wq/groundwa/uichome.htm

For technical questions call DEQ – UIC Program at 503-229-5945

For copies of applications or forms call 503-229-5189

8.1.1 Subsurface Infiltration v. Surface Infiltration

A device using only surface infiltration is not considered a UIC. State law defines "surface infiltration" as "fluid movement from the ground surface into the underlying soil material without the use of a subsurface fluid distribution system or injection system."

Treatment BMPs like grass swales, vegetated swales, sand filters, etc. will occasionally infiltrate water as the treatment occurs. This is regarded as "incidental" infiltration and is not currently regulated under the existing UIC rules. Likewise, the infiltration from aboveground retention facilities such as wetlands and ponds is not regulated under the UIC rules.

8.2 General Design Criteria

For engineered stormwater infiltration UICs, the following requirements apply:

1. All stormwater shall be treated via an approved water quality BMP prior to discharge either to ground or to subsurface.

2. Infiltration of treated roof water should always be considered first to minimize stormwater runoff from a site. To further minimize stormwater runoff, low impact development practices shall be considered. See Section 2.3 for more details.

3. Only treated roof water that is conveyed in its own separate system may be infiltrated in wellfield protection areas including the Columbia Southshore Wellfield Wellhead Protection Area, any other wellfield protection zone adopted by Council, and areas within the two-year time of travel or within 500 feet of a well. No other sources may use infiltration as the disposal method.

If your site lies within the Wellhead Protection Area (See Map in *Appendix G*), refer to the *Columbia South Shore Wellfield Wellhead Protection Manual:* http://www.water.ci.portland.or.us/groundwater/wellhdprotsplash.htm

A "high risk" functional area is any area that is associated with hazardous materials or fuel management and includes but it not limited to:

- **Storage areas**
- **Loading areas**
- **Transfer areas**
- **Transportation Routes**
- **Fuel dispensing facilities**

- For areas where reasonable surface discharge is not available, injection of stormwater runoff from "high-risk" functional areas (like loading docks and chemical storage areas) shall be treated, conveyed, and disposed in a separate system from water that drains from roofs.

- If a separate conveyance system is infeasible, containment or connection to sanitary system for the runoff from these high-risk functional areas shall be provided. Water that drains from residential areas with only neighborhood streets should also generally be separated from stormwater that drains high-risk functional areas. Mixing of roof runoff with such residential runoff may be considered, provided the residential runoff qualifies for rule authorization by DEQ.

- UICs that drain high-risk areas are strongly discouraged, but may be allowed in private ownership, provided DEQ has permitted the facility and the facility is managed and maintained in full compliance with the permit. All facilities shall conform to OAR 340-44-0018 (3).

The City's policy is intended to minimize potential risks associated with high-risk functional areas like parking lots and loading docks, while allowing for the infiltration of water that is less likely to carry contaminants, thereby providing a more natural hydrograph.

8.3 Acceptable Pretreatment Methods

Use of subsurface infiltration systems shall depend on the soil qualification and results of tests specified in GPWS Section 2.0046.

Infiltration facilities for subsurface disposal shall include appropriate pretreatment to remove pollutants expected from the intended use of the site and full build-out condition. GDC Section 9.0523 addresses the acceptable treatment methods and facilities, which are explained in Sections 3.0 through 8.0 of this *Manual*. For a discussion of proprietary facilities, see Section 1.5.1 of this *Manual*. A sedimentation manhole is considered as an appurtenance to the subsurface infiltration facility: it is not an acceptable pretreatment device.

Pretreatment can include the following (except UIC infiltration methods):

- Detention and Sedimentation (Section 4.0)
- Filtration (Section 3.0)
- Retention (Section 4.0 & 5.0)
- Oil and Water Separation (Section 6.0)
- Proprietary Facilities (Section 1.5.1)

8.4 Design Storm

Subsurface infiltration facilities must be designed to accommodate the entire runoff from a **24-hour storm** with an estimated **recurrence interval of 25-years.** Pretreatment of runoff must meet design standards are described in GDC Section 9.0522 and explained in Section 1.3.5 of this Manual.

8.5 Acceptable Subsurface Infiltration Facilities

Because of state and federal requirements for UICs that create potential liability for the City, **the City will only accept maintenance responsibility for new facilities that have been rule authorized by DEQ.**

All existing and proposed UICs, such as drywells and stormwater sumps, must be registered with and authorized by DEQ prior to construction and use.

- All existing drywells must be rule authorized or permitted by DEQ.
- All proposed drywells that will be publicly owned or maintained must meet rule authorization requirements. A letter or memo from DEQ stating that a proposed drywell meets the requirements for rule authorization is necessary prior to acceptance of the facility by the City. Rule-authorized UICs that require a treatment train using BMPs not on the approved list per Section 1.5.1 will not be accepted into the public system, unless the Stormwater Manager allows an exception.

Registration submittals for new construction or modification to existing drywells must be made to DEQ 60 to 90 days prior to construction to allow for requested design changes in order to meet rule authorization or permit requirements.

8.5.1 Drywells

Because the UIC Program states that drywells have a direct impact on groundwater, an adequate layer of confinement barrier or filtration medium must be present or appropriate BMPs are required to treat stormwater before it enters the ground. However, whether or not there is an adequate confinement layer, the City requires the treatment of stormwater based on the design storm as specified in Section 8.4.

Refer to GPWS Standard Detail Drawings, Detail 604 & 605 for sedimentation manhole and drywell/sump design requirements. See GPWS 2.0046 for design details.

8.5.2 Infiltration Trenches

Infiltration trenches can be an acceptable alternative to drywells and can be placed in parking areas, along the site periphery, or in other suitable linear areas.

Water quality treatment is required prior to discharge into the infiltration trench.

1. Within the Wellfield Protection Area or any delineated drinking water protection zone, these facilities can only be used to treat runoff from roof water. No runoff from high-risk functional area (like loading docks and storage

areas—see Side Bar on page 8-2 or Glossary) shall be disposed of via infiltration trenches. Additional treatment prior to discharge into an infiltration trench may be necessary to adequately treat pollutants of concern.

A. Sizing

1. The infiltration trench system shall be sized to capture and infiltrate the entire runoff of the design storm described in Section 8.4. The stage/discharge relationship shall be developed from the design infiltration rate recommended by a registered professional soils engineer.

2. The storage volume of the trench system shall be determined by considering the void space of the washed rock backfill and the maximum design water surface elevation at the crown of the distribution pipe.

3. At any given stage, the discharge can be computed using the area of pervious surface through which infiltration will occur (trench bottom area only) multiplied by the recommend design infiltration rate in appropriate units.

B. Design Criteria

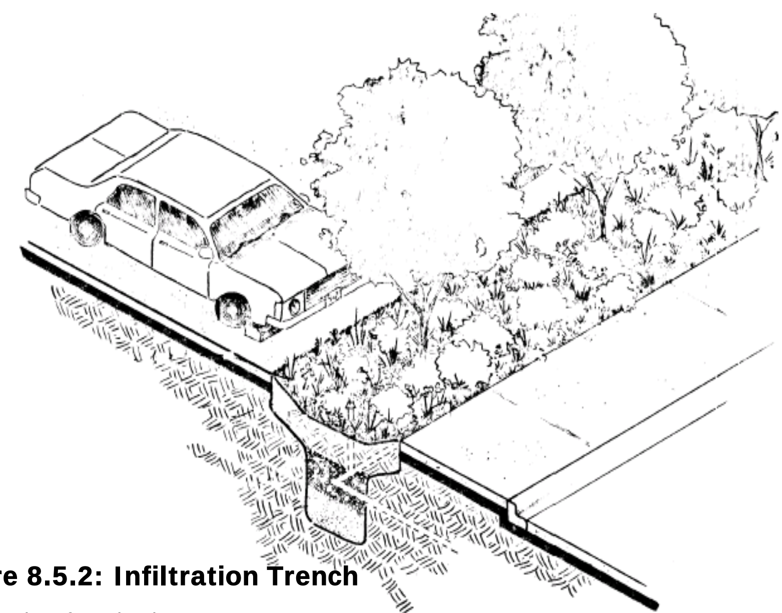


Figure 8.5.2: Infiltration Trench

Source: City of Portland Stormwater Management Manual, September 2002

2. The proposed trench bottom must be at least 10 feet above the seasonal high groundwater level depending on the soil type and 10 feet below finished grade. There must be at least 10 feet of permeable soil beneath the trench bottom.

3. The infiltration surface elevation (bottom of trench) must in native soil (excavated to at least 1 foot in depth).

4. Infiltration trenches are not allowed on slopes greater than 25% (4:1). A geotechnical analysis and report may be required on slopes over 15% or if located within 200 feet of the top of a steep slope or landslide hazard area.

5. Trenches shall be a minimum of 24-inches wide.

6. Trenches shall be backfilled with 1 ½ to ¾ inch washed rock, completely surrounded by filter fabric, and overlain by a minimum 1 foot of compact backfill.

7. Level 6-inch-minimum-diameter, rigid perforated distribution pipes shall extend the length of the trench. Distribution pipe inverts shall be minimum of 2 feet below finished grade. Provisions (such as clean-out wyes) shall be made for cleaning the distribution pipe.

8. A minimum of 2 feet of cover shall be provided in areas subject to vehicle loads.

9. Trenches shall be spaced no closer than 10 feet, measured on center.

10. Trench systems shall be set back 100 feet from proposed or existing septic system drainfields. This setback can be reduced to 30 feet with approval from the County Sanitarian.

11. Trench systems shall be a minimum of 50 feet from any sensitive area steep slope. The facility soils report must address the potential impact of infiltration on the steep slope.

12. Structures shall be set back 20 feet from individual trenches. This may be reduced if the facility soils report addresses potential impacts of trench phreatic surface on structures so located.

8.5.3 Soakage Trenches

A soakage or "infiltration" trench is a shallow trench in permeable soil that is backfilled with sand and coarse stone and lined with filter fabric. The trench surface may be covered with grating, stone, sand, or a grassed cover with a surface inlet.

Soakage trenches are not considered effective for all pollutants of concern and may, therefore, require additional pretreatment. They are acceptable for use as a pre-treatment facility for runoff from roofs.

A. General Design Criteria

1. No more than an acre of drainage shall be treated using one trench.

2. For publicly maintained facilities, NRCS soil classifications shall be either A or B. C class soils may be used for privately owned facilities if drawdown standards are met. See also Figures 1.6 A-D & *Appendix A* as guidance only.

3. The ground slope shall not exceed 5 percent.

4. Required soil tests shall conform to ASTM D 3385-88.

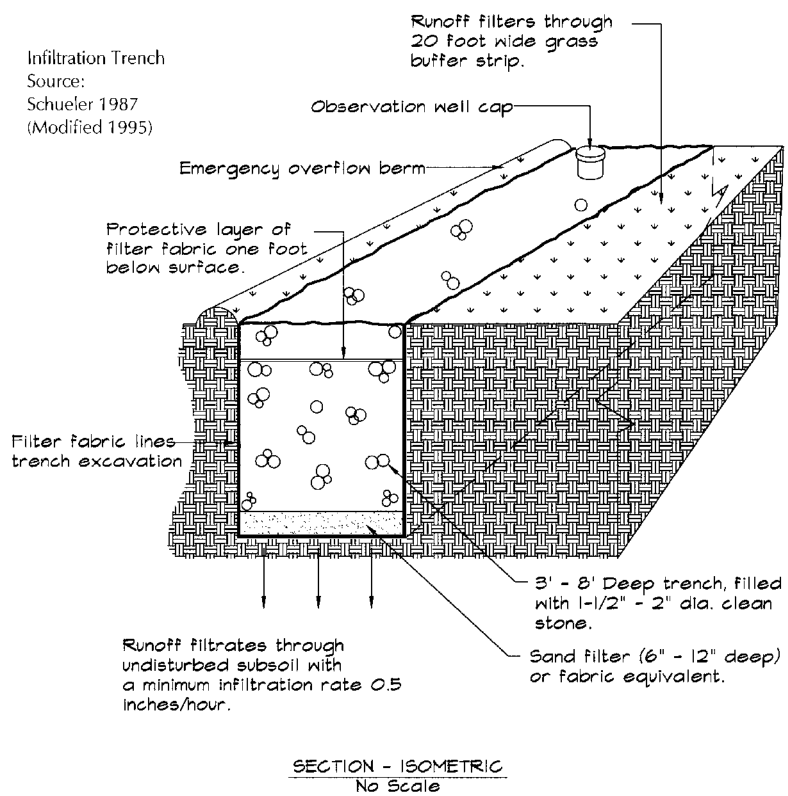


Figure 8.5.3: Soakage Trench

Source: City of Portland Stormwater Management Manual, September 2002

B. Specific Design Criteria

1. The soakage trench shall infiltrate the entire design storm without overflow.

2. Soakage trenches shall not be accepted in soils with a tested infiltration rate of less than 2 inches per hour.

3. There shall be no less than 10 feet of undisturbed depth of infiltration medium between the bottom of the facility and any impervious layer (hardpan, solid rock, etc.) or high groundwater levels.

4. Drawdown time (time for the trench to empty water from the water quality design storm) shall not exceed 10 hours.

5. Soakage trenches shall meet the following setback requirements for downstream slopes: minimum of 100 feet from slopes of 16%; add 5 feet of setback for each additional percent of slope up to 30%; 200-foot setback for slopes of 30%; infiltration trenches shall not be used where slopes exceed 30%.

6. All soakage trenches shall have an overflow that is capable of transporting high flows through the facility to an approved stormwater disposal system in the event the facility infiltration capacity is exceeded. Overflows shall be designed with appropriate erosion control devices.

7. Each trench shall have one slotted observation pipe (4-inch) that extends to the bottom of the trench, located at a point approximately halfway along the trench. The observation pipe shall have a threaded or hinged cap or plug.

8. Drain medium shall have filter fabric between the medium and native soils or backfill.

9. Soakage trench areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of soakage trench areas.

10. A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional engineer, shall inspect the soil after the system is excavated, before trenches are filled with drain medium, to confirm that soils remain in suitable condition to perform at anticipated infiltration rates.

11. Soakage trenches should be located down slope of structures, and are required to be at least 10 feet from buildings and shall meet setback requirements.

C. Stormwater Quality Control Plan Requirements

The following minimal information shall be included in the Stormwater Control Plan:(Additional information may be required on the drawings during permit review, depending on individual site conditions.)

1. Facility dimensions and setbacks from property lines and structures

2. Profile view of facility, including typical cross-sections with dimensions
3. Drain rock specification
4. Sand specification
5. Filter fabric specification
6. All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

8.6 Maintaining Infiltration Facilities

8.6.1 Maintaining Subsurface Infiltration Facilities

Proper maintenance is crucial for properly functioning infiltration facilities. The City has and will conduct periodic random inspections of these facilities. As is required in the Maintenance Agreement (See Section 9.0 and *Appendix B*).

The following general guidelines are included for information. The property owner should consult design engineers for specific maintenance practices to be followed to ensure integrity of these facilities.

8.6.2 Access Roads

Facilities that are intended to be maintained by the City must comply with access requirements necessary to accommodate City equipment as defined in the *Gresham Public Works Standards* and described in Section 4.6.2.

8.6.3 Prepare a Maintenance Plan

1. A Maintenance Agreement for each facility is required to be filed with the City, refer to Section 9.0 and *Appendix B* for more details.
2. Prepare a maintenance plan that outlines the schedule, scope, and responsibilities for performing maintenance duties.
3. Maintenance plans should include at least an annual inspection.
4. Keep the outlet structure free of debris; inspect and clean it as required and at least annually to prevent over-topping.
5. Keep leaves and other debris out of the infiltration facility.
6. Don't apply sand or gravel to the concrete grid system; they will clog the facility.

8.6.4 Inspect the Facility

1. Keep a record of inspections, indicating the rate at which the facility dewaters and the water depth in the well (if applicable).

2. If the facility is clogged, find the cause. It may be clogged due to upland erosion, excessive compaction with the facility, low spots, poor soils, soil compaction, or periphyton or algal buildup or matting. Sediment trap devices lose effectiveness at 60% capacity and should be monitored appropriately.

A. Facilities With Observation Wells

1. Frequently inspect the facility during the first year following construction. Do this monthly after every major storm (greater than one inch in 24 hours) from October through April, and quarterly during the rest of the year.

3. After the first year, determine an appropriate long-term inspection frequency. For planning purposes, assume this will be twice a year. Sediment trap devices lose effectiveness at 60% capacity and should be monitored appropriately.

B. Facilities Without Observation Wells

1. **Trenches:** Inspect trenches immediately after construction, three times per year for the first two years and once each successive year. Monitor sediment buildup on the trench surface. Check for clogging by looking at the upper layer of the trench and by looking for ponding or slow dewatering rates after significant storms (ponding indicates clogging).

2. **Basins:** Inspect the infiltration basin (and associated pretreatment facilities) after every significant storm during the first few months after construction to determine dewatering rates. Water remaining 48 to 72 hours after the storm event is likely to indicate clogging.

3. **Pretreatment Facilities:** Check any pretreatment devices at least bimonthly from October through June and after major storm events. Set up a cleaning schedule based on observations of the first nine months. Remove accumulated sediment when it fills 40% of the pretreatment facility. Where applicable, remove oil and grease deposits when they are over one-inch thick.

8.6.5 Remove Sediment

Consult with appropriate regulatory agencies and choose testing parameters based on the site-specific conditions.

1. The frequency of sediment removal will be a function of a facility's storage capacity, recharge characteristics, and the volume and sediment load of inflow. Remove sediment before it builds up to the point where it severely limits the infiltration capacity. Conduct visual observations to determine sediment accumulation rate and appropriate removal frequency.

2. If an infiltration trench clogs, it usually occurs in the upper layer, above the first layer of filter fabric. In that case, remove the top layer of stone and clean or replace it. If the clogging is also occurring below this layer or if the upper layer must be replaced often, consider additional upstream BMPs to reduce sediment and /or debris loads to the facility.

3. Dispose of sediments removed in accordance with safe and best management practices specified by applicable local, state, and federal regulations. Determining the proper disposal method will require a test of the accumulated sediment to determine the levels of pollutants. Periodic testing will also help determine appropriate sediment removal schedules. Testing could include parameters such as oil and grease, heavy metals (e.g., copper, lead, zinc, and cadmium), nutrients (e.g., phosphorus), and/or organics such as pesticides. If sediment and/or other pollutants are accumulating more rapidly than expected, it could be an indication of a problem upstream. Investigate and identify the source of pollutants, and apply source control and best management measures to reduce or eliminate the discharge if necessary.

4. To remove sediment from an infiltration basin, let the basin thoroughly dry out first. Use the lightest equipment possible to avoid soil compaction, which reduces infiltration.

8.6.6 Maintain Vegetation

1. Make sure vegetation on upland areas and any grass filter strips draining to the infiltration facility is dense and healthy. Re-seed any bare spots or eroded areas. Refer to *Appendix C*: Native Plant Restoration Guide for appropriate plantings.

2. Mow any grassed filter strips leading to the facility and facilities bottom and side slopes at least twice a year to prevent the growth of undesirable vegetation and for aesthetics. If needed for aesthetics, mow infiltration basins in residential or recreational areas more frequently.

3. Cut back trees and/or branches so their drip lines don't extend onto the grass filter strips that lead to an infiltration facility.

4. Remove volunteer trees in the immediate area of the infiltration trench or basin to avoid root penetration into the stone reservoir.

8.6.7 Till the Soils, if necessary

1. Consider annual or semi-annual tilling to enhance infiltration. Tilling is not recommended unless experience at the site shows it is needed to prevent clogging, since unnecessary disturbance can reverse soil development.

2. If tilling is needed, till in late summer when soil moisture is at a minimum. Quickly replant any disturbed areas to avoid damage from erosion.

Section 9.0 Maintenance Agreements

9.1 Overview

Proper operations and maintenance of stormwater quality treatment facilities are necessary to meet the desired runoff quality treatment. **A maintenance agreement must be signed prior to the approval of construction plans.** An example of an agreement is included in *Appendix B.*

Maintenance of private stormwater quality systems shall be the responsibility of the customer. Maintenance responsibility shall include all elements of the system up to the point of connection with a drainage structure of the public stormwater system. Such connection shall be subject to City approval. Maintenance requirements shall be specified in an approved maintenance plan at the time of project acceptance.

The customer shall enter into a maintenance agreement with the City to ensure the implementation of the maintenance plan and is responsible for keeping inspection records that delineate the parts of the facility inspected and the corresponding dates and personnel signatures. Private stormwater quality facilities are subject to periodic inspection by the City to ensure proper maintenance and performance and inspection records must be made available upon request of the City. **Should the facilities fail due to improper maintenance, the property will be responsible for any reduction in utility fee received during the life of the facility.**

APPENDIX A

Soil Code Legend from the Soil Survey of Multnomah County, Oregon

A complete copy of the document, including soil descriptions can be found at:
http://www.or.nrcs.usda.gov/pnw_soil/oregon/or051.html
The document was produces by the United States Department of Agriculture and the Soil Conservation Service in Cooperation with the United States Department of Agriculture, Forest Service and Oregon Agricultural Experimental Station.

Map Unit Symbol	Map Unit Name
1A	Aloha silt loam, 0 to 3 percent slopes
1B	Aloha silt loam, 3 to 8 percent slopes
2A	Aloha urban land complex, 0 to 3 percent slopes
3D	Aschoff cobbly loam, 5 to 30 percent slopes
3E	Aschoff cobbly loam, 30 to 60 percent slopes
3F	Aschoff cobbly loam, 60 to 80 percent slopes
4F	Aschoff rock outcrop wahkeena association, very steep
5B	Bull run silt loam, 3 to 8 percent slopes
5C	Bull run silt loam, 8 to 15 percent slopes
5D	Bull run silt loam, 15 to 30 percent slopes
5E	Bull run silt loam, 30 to 60 percent slopes
5F	Bull run silt loam, 60 to 80 percent slopes
6B	Burlington fine sandy loam, 0 to 8 percent slopes
6C	Burlington fine sandy loam, 8 to 15 percent slopes
7B	Cascade silt loam, 3 to 8 percent slopes
7C	Cascade silt loam, 8 to 15 percent slopes
7D	Cascade silt loam, 15 to 30 percent slopes
7E	Cascade silt loam, 30 to 60 percent slopes
8B	Cascade urban land complex, 0 to 8 percent slopes
8C	Cascade urban land complex, 8 to 15 percent slopes
8D	Cascade urban land complex, 15 to 30 percent slopes
9B	Cazadero silty clay loam, 0 to 8 percent slopes
9C	Cazadero silty clay loam, 8 to 15 percent slopes
9D	Cazadero silty clay loam, 15 to 30 percent slopes
9E	Cazadero silty clay loam, 30 to 60 percent slopes
10B	Cornelius silt loam, 3 to 8 percent slopes
10C	Cornelius silt loam, 8 to 15 percent slopes
10D	Cornelius silt loam, 15 to 30 percent slopes
11B	Cornelius urban land complex, 3 to 8 percent slopes
11C	Cornelius urban land complex, 8 to 15 percent slopes
12	Cryofibrists nearly level
13	Dabney loamy sand
14C	Delena silt loam, 3 to 12 percent slopes
15	Faloma silt loam
16	Faloma silt loam, protected
17C	Goble silt loam, 3 to 15 percent slopes
17D	Goble silt loam, 15 to 30 percent slopes
17E	Goble silt loam, 30 to 60 percent slopes
18C	Goble urban land complex, 3 to 15 percent slopes
18D	Goble urban land complex, 15 to 30 percent slopes
19E	Haploxerolls, steep
20C	Haplumbrepts, moderately steep
20F	Haplumbrepts, very steep
21B	Helvetia silt loam, 3 to 8 percent slopes
22D	Kinzel divers goodlow association, moderately steep
22E	Kinzel divers goodlow association, steep
23F	Kinzel lastance rubble land association, very steep
24D	Lastance stony fine sandy loam, 5 to 30 percent slopes
24E	Lastance stony fine sandy loam, 30 to 60 percent slopes

25A	Latourell loam, 0 to 3 percent slopes
25B	Latourell loam, 3 to 8 percent slopes
25C	Latourell loam, 8 to 15 percent slopes
25D	Latourell loam, 15 to 30 percent slopes
26A	Latourell urban land complex, 0 to 3 percent slopes
26B	Latourell urban land complex, 3 to 8 percent slopes
27B	Mershon silt loam, 0 to 8 percent slopes
27C	Mershon silt loam, 8 to 15 percent slopes
27D	Mershon silt loam, 15 to 30 percent slopes
28	Moag silty clay loam, protected
29A	Multnomah silt loam, 0 to 3 percent slopes
29B	Multnomah silt loam, 3 to 8 percent slopes
29C	Multnomah silt loam, 8 to 15 percent slopes
29D	Multnomah silt loam, 15 to 30 percent slopes
29E	Multnomah silt loam, 30 to 60 percent slopes
30A	Multnomah urban land complex, 0 to 3 percent slopes
30B	Multnomah urban land complex, 3 to 8 percent slopes
31	Pilchuck sand
32	Pilchuck sand, protected
33A	Pilchuck urban land complex, 0 to 3 percent slopes
34A	Powell silt loam, 0 to 3 percent slopes
34B	Powell silt loam, 3 to 8 percent slopes
34C	Powell silt loam, 8 to 15 percent slopes
34D	Powell silt loam, 15 to 30 percent slopes
35A	Powell urban land complex, 0 to 3 percent slopes
36A	Quafeno loam, 0 to 3 percent slopes
36B	Quafeno loam, 3 to 8 percent slopes
36C	Quafeno loam, 8 to 15 percent slopes
37A	Quatama loam, 0 to 3 percent slopes
37B	Quatama loam, 3 to 8 percent slopes
37C	Quatama loam, 8 to 15 percent slopes
37D	Quatama loam, 15 to 30 percent slopes
38A	Quatama urban land complex, 0 to 3 percent slopes
39	Rafton silt loam
40	Rafton silt loam, protected
41	Riverwash
42F	Rock outcrop rubble land complex, very steep
43C	Saum silt loam, 8 to 15 percent slopes
43E	Saum silt loam, 30 to 60 percent slopes
44	Sauvie silt loam
45	Sauvie silt loam, protected
46	Sauvie silty clay loam, protected
47A	Sauvie rafton urban land complex, 0 to 3 percent slopes
48	Sifton gravelly loam, occasionally flooded
49D	Talapus lastance association, moderately steep
49E	Talapus lastance association, steep
50A	Urban land, 0 to 3 percent slopes
50C	Urban land, 3 to 15 percent slopes
51A	Urban land latourell complex, 0 to 3 percent slopes
51B	Urban land latourell complex, 3 to 8 percent slopes

51C	Urban land latourell complex, 8 to 15 percent slopes
51D	Urban land latourell complex, 15 to 30 percent slopes
52A	Urban land multnomah complex, 0 to 3 percent slopes
52B	Urban land multnomah complex, 3 to 8 percent slopes
52C	Urban land multnomah complex, 8 to 15 percent slopes
53A	Urban land quafeno complex, 0 to 3 percent slopes
53B	Urban land quafeno complex, 3 to 8 percent slopes
53C	Urban land quafeno complex, 8 to 15 percent slopes
54B	Urban land quatama complex, 3 to 8 percent slopes
54C	Urban land quatama complex, 8 to 15 percent slopes
55	Wapato silt loam
56E	Wauld very gravelly loam, 30 to 70 percent slopes
57	Wollent silt loam
58D	Zygore gravelly loam, 5 to 30 percent slopes
58E	Zygore gravelly loam, 30 to 60 percent slopes
59F	Zygore rock outcrop complex, 60 to 90 percent slopes
M-W	Miscellaneous water
PT	Pits
W	Water

APPENDIX B

City of Gresham Sample Maintenance Agreement and Facilities Checklist

AGREEMENT TO MAINTAIN STORMWATER DETENTION AND WATER QUALITY TREATMENT FACILITIES

City of Gresham Contract #__________

Memorandum of Agreement to be recorded with Multnomah County

This agreement is made and entered into this _____day of _____ 20__, by and between the City of Gresham, a municipal corporation of the State of Oregon (hereinafter known as CITY), and ______________, (hereinafter known as OWNER).

RECITALS

1. OWNER has developed (select one, or both if applicable):
   - ❒ Private stormwater detention or retention Facilities
   - ❒ Water quality treatment Facilities

2. The Facilities enable development of property while mitigating the impacts of additional surface water and the pollutants associated with stormwater runoff prior to discharge from the property to the public stormwater system. The consideration for this agreement is connection to the public stormwater system.

3. The property benefited by the Facilities and subject to the obligation of this agreement are described in Exhibit A. The Operations and Maintenance Plan for the Facilities is described in Exhibit B. The CITY will provide "Instructions for Completing the Operations and Maintenance Plan" and an "Inspection Checklist" to assist with the successful completion of the Operation and Maintenance Plan.

4. Private stormwater detention or retention Facilities are designed by a registered professional engineer to accommodate the anticipated volume of runoff and detain runoff in a manner so as to release it at a rate no greater than would naturally occur on the undeveloped site for a 2, 5, 10 or 25-year/24-hour return storm event. Private stormwater quality treatment Facilities are designed by a registered professional engineer to accommodate the anticipated treatment control volume equal to 80% of the average annual volume of the site's stormwater runoff.

5. The stormwater detention, retention, and/or water quality treatment Facilities are required for the purpose of detaining, retaining, and/or treating stormwater runoff in accordance with the law.

6. CITY and OWNER agree that effective maintenance of the Facilities will best be facilitated by regular inspections, not less than twice a year, those times being generally described as once in the early spring and again in the fall prior to the onset of fall rains.

7. Failure to inspect and maintain private stormwater Facilities can result in an unacceptable impact to the public stormwater system.

NOW, THEREFORE, it is agreed by and between the parties as follows:

I. OWNER INSPECTIONS

OWNER shall provide inspections of the Facilities at least twice a year for conformity with the Operations and Maintenance Plan. At a minimum, one inspection shall occur prior to the onset of fall rains during the period of September 1 to October 15, and a second inspection shall occur in early spring during the period April 1 to May 31. Inspections shall also be performed following any storm event of a two-year recurrence interval or greater. OWNER shall maintain a log of inspection activities. The said log shall be available to the CITY upon request or during CITY inspections.

II. DEFICIENCIES

All aspects in which the Facilities fail to satisfy the Operations and Maintenance Plan shall be noted as “Deficiencies”.

III. OWNER CORRECTIONS

All Deficiencies shall be corrected at OWNER’S expense within thirty (30) days after completion of the inspection. If more than 30 days is reasonably needed to correct a Deficiency, OWNER shall have a reasonable period to correct the Deficiency so long as the correction is commenced within the 30-day period and is diligently prosecuted to completion.

IV. CITY INSPECTIONS

OWNER grants to the CITY the right to inspect the private stormwater water quality and/or detention Facilities. The CITY will endeavor to give ten (10) days prior written notice (as courtesy to OWNER), except that no notice shall be required in case of an emergency. The CITY shall determine whether Deficiencies need to be corrected. OWNER (at the address provided at the end of this Agreement, or such other address as OWNER may designate in writing to City) will be notified in writing through the US Mail of the Deficiencies and shall make corrections within 30 days of the date of the notice.

V. CITY CORRECTIONS

If correction of all OWNER or CITY identified Deficiencies is not completed within thirty (30) days after OWNER’S inspection or CITY notice, CITY shall have the right to have any Deficiencies corrected. The CITY (i) shall have access to the Facilities for the purpose of correcting such Deficiencies and (ii) shall bill OWNER for all costs reasonably incurred by CITY for work performed to correct such Deficiencies (“City Correction Costs”) following OWNER’S failure to correct any Deficiencies in the Facilities. OWNER shall pay to CITY the City Correction Costs within thirty (30) days of the date of the invoice. If payment is not made within 30 days, the CITY shall collect pursuant to Gresham Revised Code Article 7.50 regarding enforcement of cost assessment. OWNER understands and agrees that upon non-payment, City Correction Costs shall be secured by a lien on OWNER’S property for the City Correction Cost amount plus interest and penalties.

VI. EMERGENCY MEASURES

If at any time the CITY reasonably determines that the Facilities create any imminent threat to public health, safety or welfare, the CITY may immediately and without prior notice to the Owner take measures reasonably designed to remedy the threat. The CITY shall provide notice of the threat and the measures taken to OWNER as soon as reasonably practicable, and charge OWNER for cost of these corrective measures.

VII. FORCE AND EFFECT

This Agreement has the same force and effect as any deed covenant running with the land and shall benefit and bind all owners of the benefited property described in Exhibit A, present and future, and their heirs, successors and assigns.

VIII ASSIGNMENT TO HOMEOWNERS ASSOCIATION; PROPERTY OWNERS LIABLE

The OWNER may assign this Agreement to a homeowners association comprised of the owners of the benefiting properties described in Exhibit A. However, the respective owners of each property shall be jointly and severally liable for City Correction Costs if not otherwise paid. All notices to OWNER shall be sent to the address designated in writing by the homeowners association.

IX. AMENDMENTS

The terms of this Agreement may be amended only by mutual agreement of the parties. Any amendments shall be in writing, shall refer specifically to this Agreement, and shall be valid only when executed by both parties to this Agreement and recorded in the Official Records of Multnomah County.

X. PREVAILING PARTY

In any action brought by either party to enforce the terms of this Agreement, the prevailing party shall be entitled to recover all costs, including reasonable attorney's fees as may be determined by the court having jurisdiction, including any appeal.

XI. SEVERABILITY

The invalidity of any section, clause, sentence, or provision of this Agreement shall not affect the validity of any other part of this Agreement, which can be given effect without such invalid part or parts.

IN WITNESS WHEREOF, OWNER and CITY have signed this Agreement.

CITY OF GRESHAM	OWNER
___________________________	___________________________
City Manager	By: *Name and Title*
APPROVED AS TO FORM:	APPROVED AS TO CONTENT:
___________________________	___________________________
City Attorney	*Development Engineering Specialist*

Attachments:

Provided by OWNER:

Exhibit A Legal Description and Map of all Benefiting Properties and Facilities

Exhibit B Operations and Maintenance Plan

Instructions for Completing the Operations and Maintenance Plan

This outline summarizes the information that must be included in the Operations and Maintenance (O&M) Plan to be attached as Exhibit B to the Stormwater Maintenance Agreement.

1. Include design assumptions and expectations for the Facility and a description of other site activities and/or BMPs directly related to maintenance of the Facility (e.g., parking lot sweeping, site landscape maintenance, and business operations).
2. For each stormwater management system, identify how both the general maintenance requirements and the Facility-specific requirements will be satisfied.
3. At a minimum, identify how, when, where, for what purpose, and who will achieve each general and Facility-specific maintenance requirement presented in the Public Works Standards. For each Facility component, the O&M plan shall provide the following:

   - A written description of all the maintenance activities that will be performed.
   - A site plan clearly showing location of Facility components.
   - A performance measure for each maintenance activity.
   - An O&M inspection schedule that addresses each major Facility component. The maintenance schedule must demonstrate how the maintenance/inspection activities relate to storm events and seasonal issues.
   - Identification of equipment and materials required to perform the maintenance.

4. Include site inspection procedures, using the Inspection Checklist, as a guide.
5. Include maintenance procedures for Facility components that require relatively unique maintenance knowledge, such as specific plant removal/replacement, landscape features, or constructed wetlands maintenance. These procedures shall provide enough detail for a person unfamiliar with maintenance to perform the activity, or identify the specific skills or knowledge necessary to perform and document the maintenance.
6. Include a sediment storage, testing, and disposal plan for commercial, industrial, and multi-unit developments/structures. Testing requirements are dependent on the vendor receiving the sediment. The applicant must develop the plan based on expected site specific pollutants and proposed disposal methods.
7. Provide emergency contacts, responsibilities, and response procedures.
8. Include a spill prevention and pollution control plan.
9. Include record keeping or worksheets to facilitate and document completed activities. Use the Inspection Checklist as a guide. The O&M plan must specify record keeping and retention requirements. Minimum retention of completed checklists shall be 3 years.
10. Distinguish between the maintenance appropriate for a 3-year establishment period and expected long-term maintenance. For example, the maintenance requirements for vegetation in a constructed wetland may be more intensive during the first few years until the vegetation is established. The post-establishment O&M plan should address maintenance needs (e.g., pruning, irrigation, weeding) for a larger, more stable system.

NOTE: DO NOT SUBMIT THIS SHEET AS PART OF THE O&M PLAN.

Instructions for Inspection Checklist

The following pages contain maintenance requirements for most of the components that are part of your private stormwater system, as well as for some components that you may not have. Let the Development Engineering Specialist know if there are any components that you may not have. Ignore the requirements that do not apply to your system.Only insert the applicable portions of this Inspection Checklist that are applicable to your Operations and Maintenance Plan (Exhibit B). **Do not** include all the checklists.

(1) Monthly from November through April
(2) Once in late summer (preferably September)
(3) After any major storm (use 1-inch in 24 hours as a guideline), items marked "S" only.

Use photocopies of the following pages, or you may develop your own electronic copies., Check off the problems you look for each time you do an inspection. Add comments on problems found and actions taken. Keep these completed sheets in your files for a minimum of 3 years. Some items do not need to be looked at every time an inspection is done. Use the suggested frequency at the left of each item as a guideline for your inspection. **A checklist is only a guide to assist you in identifying inspection frequencies. A checklist is not an Operation and Maintenance Plan**.

You may call the Development Engineering Specialist for technical assistance. Please do not hesitate to call, especially if you are unsure whether a situation you have discovered may be a problem.

INSPECTION CHECKLIST COVER SHEET

Inspection Period: ________________________________

Number of Sheets Attached: ________________________________

Date Inspected: ________________________________

Name of Inspector: ________________________________

Inspector's Signature: ________________________________

Key

A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms

INSPECTION CHECKLIST

Maintenance Checklist for Closed Detention Systems (Pipes/Tanks)

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M	Storage area (pipe tank)		Plugged air vents (small pipe that connects catch basin to storage pipe)	One-half of the end of a vent is blocked at any point with debris and sediment. Plugged vent can cause storage area to collapse.	Vents free of debris and sediment
M			Debris and sediment	Accumulated sediment depth exceeds 15% of diameter. Example: 72-inch storage tank would require cleaning when sediment reaches depth of 10 inches	All sediment and debris removed from storage area. Contact City Public Works for guidance on sediment removal and disposal.
A			Joints between tank/pipe section	Any crack allowing material to leak into facility.	All joints between tank/pipe sections are sealed.
A			Tank/pipe bent out of shape	Any part of tank/pipe is noticeable bent out of shape.	Tank/pipe repaired or replaced to design. Contact a professional engineer for evaluation.
M,S	Manhole		Cover not in place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
A			Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than ½-inch of thread (may not apply to self-locking lids)	Mechanism opens with proper tools.
A			Cover difficult to remove	One maintenance person cannot remove lid after applying 80 pounds of lift. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
A			Ladder rungs unsafe	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks.	Ladder meets design standards and allows maintenance persons safe access.

If you are unsure whether a problem exists, please contact the Jurisdiction and ask for technical assistance.

Comments:

Key

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INSPECTION CHECKLIST

Maintenance Checklist for Control Structure/Flow Restrictor (structure that controls rate at which water exits facility)

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M	Structure		Trash & debris (includes sediment)	Distance between debris buildup and bottom of orifice plate is less than 1-½ feet.	All trash and debris removed.
A			Structural damage	Structure is not securely attached to manhole wall and outlet pipe structure should support at least 1,000 pounds of up or down pressure.	Structure securely attached to wall and outlet pipe.
A				Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
A				Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are watertight; structure repaired or replaced and works as designed.
M				Any holes-other than designed holes-in the structure.	Structure has no holes other than designed holds.
M,S	Cleanout gate		Damaged or missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
A				Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
M,S				Chain leading to gate is missing or damaged.	Chain is in place and works as designed.
A				Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
M,S			Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and woks as designed.
M,S	Overflow pipe		Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.

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INSPECTION CHECKLIST

Maintenance Checklist for Catch Basins and Inlets

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M,S	General		Trash, debris, and sediment in or on basin	Trash or debris in front of the catch basin opening is blocking capacity by more than 10%	No trash or debris located immediately in front of catch basin opening. Grate is kept clean and allows water to enter.
M				Sediment or debris (in the basin) that exceeds 1/3 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin.	No sediment or debris in the catch basin. Catch basin is dug out and clean.
M,S				Trash or debris in any inlet or pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
M			Structural damage to frame and/or top slab	Corner of frame extends more than ¾ inch past curb face into the street (if applicable)	Frame is even with curb.
M				Top slab has holes larger than 2 square inches or cracks wider than ¼ inch (intent is to make sure all material is running into the basin).	Top slab is free of holes and cracks.
M				Frame not sitting flush on top slab, i.e. separation of more than ¾ inch of the frame from the top slab.	Frame is sitting flush on top slab.
A			Cracks in basin walls/bottom	Cracks wider than ½ inch and longer then 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards. Contact a professional engineer for evaluation.
A				Cracks wider than ½ inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	No cracks more than ¼ inch wide at the joint of inlet/outlet pipe.
A			Settlement/ misalignment	Basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards. contact a professional engineer for evaluation
M,S			Fire hazard or other pollution	Presence of chemicals such as natural gas, oil, and gasoline. Obnoxious color, odor, or sludge noted.	No color, odor, or sludge. Basin is dug out and clean.
M,S			Outlet pipe is clogged with vegetation	Vegetation or roots growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

If you are unsure whether a problem exists, please contact the Jurisdiction and ask for technical assistance.

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INSPECTION CHECKLIST

Maintenance Checklist for Ponds

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M,S	General		Trash & debris buildup in pond	Dumping of yard wastes such as grass clippings and branches into basin. Unsightly accumulation of non-degradable materials such as glass, plastic, metal, foam, and coated paper.	Remove trash and debris and dispose as prescribed by City Waste Management Section
M,S			Trash rack plugged or missing	Bar screen over outlet more than 25% covered by debris or missing.	Replace screen. Remove trash and debris and dispose as prescribed by City Waste Management Section.
M			Poisonous vegetation	Any poisonous vegetation which may constitute a hazard to the public. Examples of poisonous vegetation include: tansy ragwort, poison oak, stringing nettles, devilsclub.	Remove poisonous vegetation. Do not spray chemicals on vegetation without obtaining guidance from the Cooperative Extension Service and approval from the City.
M,S			Fire hazard or pollution	Presence of chemicals such as natural gas, oil, and gasoline, Obnoxious color, odor, or sludge noted.	Find sources of pollution and eliminate them. Water is free from noticeable color, odor, or contamination.
M			Vegetation not growing or is overgrown	For grassy ponds, grass cover is sparse and weedy or is overgrown. For wetland ponds, plants are sparse or invasive species are present.	For grassy ponds, selectively thatch, aerate, and re-seed ponds. Grass cutting unnecessary unless dictated by aesthetics. For wetland ponds, hand plant nursery grown wetland plants in bare areas. Contact the Cooperative Extension Service for direction on invasive species such as purple loosestrife and reed canary grass. Pond bottoms should have uniform dense coverage of desired plant species.
M			Rodent holes.	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. contact the County Health Department for guidance.
M			Insects	When insects such as wasps and hornets interfere with maintenance activities, or when mosquitoes become a nuisance.	Insects destroyed or removed from site. Contact Cooperative Extension Service for guidance.
A			Tree growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e. slope mowing, silt removal, or equipment movements). If trees are not interfering with access, leave trees alone.	Trees do not hinder maintenance activities. Selectively cultivate trees such as alders for firewood.
M	Side slopes of pond		Erosion on berms or at extrance/exit	Check around inlets and outlets for signs of erosion. Check berms for signs of sliding or settling. Action is needed where eroded damage over 2 inches deep and where there is potential for continued erosion.	Find causes of erosion and eliminate them. Then slopes should be stabilized by using appropriate erosion control measure(s); e.g. rock, reinforcement, planting of grass, compaction.
M	Storage area		Sediment buildup in pond	Accumulated sediment that exceeds 10% of the designed pond depth. Buried or partially buried outlet structure probably indicates significant sediment deposits.	Sediment cleaned out to designed pond shape and depth; pond re-seeded if necessary to control erosion.
A	Pond dikes		Settlements	Any part of dike which has settled 4 inches lower than the design elevation.	Dike should be built back to the design elevation.
A	Emergency overflow/ spillway		Rock missing	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil.	Replace rocks to design standards.
One Time	Emergency overflow/ spillway		Overflow missing	Side of pond has no area with large rocks to handle emergency overflows.	Contact City for guidance.

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INSPECTION CHECKLIST

Maintenance Checklist for Infiltration Systems

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M,S	General		Trash & debris buildup in pond	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
M			Poisonous vegetation	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
M,S			Fire hazard or pollution	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
M			Vegetation not growing or is overgrown	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
M			Rodent holes	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
M			Insects	See Maintenance Checklist for Ponds.	See Maintenance Checklist for Ponds.
A	Storage area		Sediment buildup in system	A soil texture test indicates facility is not working at its designed capabilities or was incorrectly designed.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design. A sediment trapping area is installed to reduce sediment transport into infiltration area.
A			Storage area drains slowly (more than 48 hours) or overflows	A soil texture test indicates facility is not working at its designed capabilities or was incorrectly designed.	Additional volume is added through excavation to provide needed storage. Soil is aerated and rototilled to improve drainage. Contact the City for information on its requirements regarding excavation.
M			Sediment trapping area	Any sediment and debris filling area to 10% of depth from sump bottom to bottom of outlet pipe or obstructing flow into the connector pipe.	Clean out sump to design depth.
One Time			Sediment trapping area not present	Stormwater enters infiltration area directly without treatment.	Add a trapping area by constructing a sump for settling of solids. Segregate settling area from rest of facility. Contact City for guidance.
M	Rock Filters		Sediment and debris	By visual inspection little or no water flows through filter during heavy rainstorms.	Replace gravel in rock filter.

If you are unsure whether a problem exists, please contact the Jurisdiction and ask for technical assistance.

Comments:

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INSPECTION CHECKLIST

Maintenance Checklist for Energy Dissipaters

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
A	Rock pad		Missing or moved rock	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil.	Replace rocks to design standard.
A	Rock-filled trench for discharge from pond		Missing or moved rock	Trench is not full of rock.	Add large rock (+30 lb. each) so that rock is visible above edge of trench.
M	Dispersion trench		Pipe plugged with sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed.
M			Perforations plugged	Over ½ of perforations in pipe are plugged with debris and sediment.	Clean or replace perforated pipe.
M,S			Not discharging water properly (or property)	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench must be redesigned or rebuilt to standard. Elevation of lip of trench should be the same (flat) at all points.
M,S			Water flows out top of "distributor" catch basin	Maintenance person observes water flowing out during any storm less than the design storm or it is causing or appears likely to cause damage.	Facility must be rebuilt or redesigned to standards. Pipe is probably plugged or damaged and needs replacement.
M,S			Receiving area over-saturated	Water in receiving area is causing or has potential of causing landslide.	Stabilize slope with grass or other vegetation, or rock if condition is severe.

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INSPECTION CHECKLIST

Maintenance Checklist for Fencing/Shrubbery Screen/Other Landscaping

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M	General		Missing or broken parts/dead shrubbery	Any defect in the fence or screen that permits easy entry to a facility.	Fence is mended or shrubs replaced to form a solid barrier to entry.
M,S			Erosion	Erosion has resulted in an opening under a fence that allows entry by people or pets.	Replace soil under fence so that no opening exceeds 4 inches in height.
M			Unruly vegetation	Shrubbery is growing out of control or is infested with weeds.	Shrubbery is trimmed and weeded to provide appealing aesthetics. Do not use chemicals to control weeds.
A	Wire Fences		Damaged parts	Posts out of plumb more than 6 inches.	Posts plumb to within 1-½ inches of plumb.
A				Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
A				Any part of fence (including posts, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
A				Missing or loose tension wire.	Tension wire in place and holding fabric.
A				Missing or loose barbed wire that is sagging more than 2 ½ inches between posts.	Barbed wire in place with less than ¾ inch sag between points.
A				Extension arm missing, broken, or bent out of shape more than 1 ½ inches.	Extension arm in place with no bends larger than 3/4 inch.
A			Deteriorated paint or protective coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
M			Openings in fabric	Openings in fabric are such that an 8-inch diameter ball could fit through.	No openings in fabric

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INSPECTION CHECKLIST

Maintenance Checklist for Gates

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M	General		Damaged or missing components	Gate is broken, jammed, or missing.	Pond has a functioning gate to allow entry of people and maintenance equipment such as mowers and backhoes. If a lock is used, make sure City Stormwater Section field staff has a key.
M				Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.	Hinges intact and lubed. Gate is working freely.
A				Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
A				Missing stretcher bar, stretcher bands, and ties.	Stretcher bar, bands, and ties in place.

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Comments:

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INSPECTION CHECKLIST

Maintenance Checklist for Conveyance Systems (Pipes, Ditches, and Swales)

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M/S	Pipes		Sediment & debris	Accumulated sediment that exceeds 20% of the diameter of the pipe.	Pipe cleaned of all sediment and debris.
M			Vegetation	Vegetation that reduces free movement of water through pipes.	All vegetation removed so water flows freely through pipes.
A			Damaged (rusted, bent, or crushed)	Protective coating is damaged; rust is causing more than 50% deterioration to any part of pipe.	Pipe repaired or replaced.
M				Any dent that significantly impedes flow (i.e. decreases the cross section area of pipe by more than 20%)	Pipe repaired or replaced.
M				Pipe has major cracks or tears allowing groundwater leakage.	Pipe repaired or replaced.
M,S	Open ditches		Trash & debris	Dumping of yard wastes such as grass clippings and branches into basin. Unsightly accumulation of non-degradable materials such as glass, plastic, metal, foam, and coated paper.	Remove trash and debris and dispose as prescribed by City Waste Management Section.
M			Sediment buildup	Accumulated sediment that exceeds 20% of the design depth.	Ditch cleaned of all sediment and debris so that it matches design.
A			Vegetation	Vegetation (e.g., weedy shrubs or saplings) that reduces free movements of water through ditches.	Water flows freely through ditches. Grassy vegetation should be left alone.
M			Erosion damage to slopes	See Ponds Checklist.	See Ponds Checklist.
A			Rock lining out of place or missing (if applicable)	Maintenance person can see native soil beneath the rock lining.	Replace rocks to design standard.
Varies	Catch basins			See Catch Basins Checklist.	See Catch Basins Checklist
M,S	Swales		Trash & debris	See above for Ditches.	See above for Ditches.
M			Sediment buildup	See above for Ditches.	Vegetation may need to be re-planted after cleaning.
M			Vegetation not growing or overgrown	Grass cover is sparse and weedy or areas are overgrown with woody vegetation.	Aerate soils and re-seed and mulch bare areas. Maintain grass height at a minimum of 6 inches for best stormwater treatment. Remove woody growth, re-contour, and re-seed as necessary.
M,S			Erosion damage to slopes	See Ponds Checklist.	See Ponds Checklist.
M			Conversion by homeowner to incompatible use	Swale has been filled in or blocked by shed, woodpile, shrubbery, etc.	If possible, speak with homeowner and request that swale area be restored. Contact City to report problem if not rectified voluntarily.
A			Swale does not drain	Water Stands in swale or flow velocity is very slow. Stagnation occurs.	A survey may be needed to check grades. Grades need to be in 1-5% range if possible. If grade is less than 1%, underdrains may need to be installed.

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INSPECTION CHECKLIST

Maintenance Checklist for Grounds (Landscaping)

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
M	General		Weeds (non-poisonous)	Weeds growing in more than 20% of the landscaped area (trees and shrubs only).	Weeds present in less than 5% of the landscaped area.
M			Safety hazard	Any presence of poison ivy or other poisonous vegetation or insect nests.	No poisonous vegetation or insect nests present in landscaped area.
M,S			Trash or litter	See Ponds Checklist.	See Ponds Checklist.
M,S			Erosion of Ground Surface	Noticeable rills are seen in landscaped areas.	Causes of erosion are identified and steps taken to slow down/spread out the water. Eroded areas are filled, contoured, and seeded.
A	Trees and shrubs		Damage	Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	Trim trees/shrubs to restore shape. Replace trees/shrubs with severe damage.
M				Trees or shrubs that have been blown down or knocked over.	Replant tree, inspecting for injury to stem or roots. Replace if severely damaged.
A				Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Place stakes and rubber-coated ties around young trees/shrubs for support.

If you are unsure whether a problem exists, please contact the Jurisdiction and ask for technical assistance.

Comments:

Key

A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms

INSPECTION CHECKLIST

Maintenance Checklist for Access Roads/Easements

Frequency	Drainage Systems Feature	√	Problem	Conditions To Check For	Conditions That Shall Exist
One Time	General		No access road exists	If ponds or other drainage system features needing maintenance by motorized equipment are present, either an access road or access from public streets is required.	Determine whether an easement to drainage feature exists. If yes, obtain City permits and construct gravel (or equal) access road. If not, report lack of easement to City attention.
M			Blocked roadway	Debris which could damage vehicle tires (glass or metal).	Roadway free of debris which could damage tires.
A				Any obstructions which reduce clearance above road surface to less than 14 feet.	Roadway overhead clear to 14 feet high.
A				Any obstructions restricting the access to less than 15 feet width.	Obstruction removed to allow at least a 15-foot wide access.
A,S	Road surface		Settlement, potholes, mush spots, ruts	When any surface defect exceeds 6 inches in depth and 6 square feet in area. In general, any surface defect which hinders or prevents maintenance access.	Road surface uniformly smooth with no evidence of settlement, potholes, much spots, or ruts. Occasionally application of additional gravel or pit run rock will be needed.
M			Vegetation in road surface	Woody growth that could block vehicular access. Excessive weed cover.	Remove woody growth at early stage to prevent vehicular blockage. Cut back weeds if they begin to encroach on road surface.
M,S	Shoulders and ditches		Erosion damage	Erosion within 1 foot of the roadway more than 8 inches wide and 6 inches deep.	Shoulder free of erosion and matching the surrounding road.

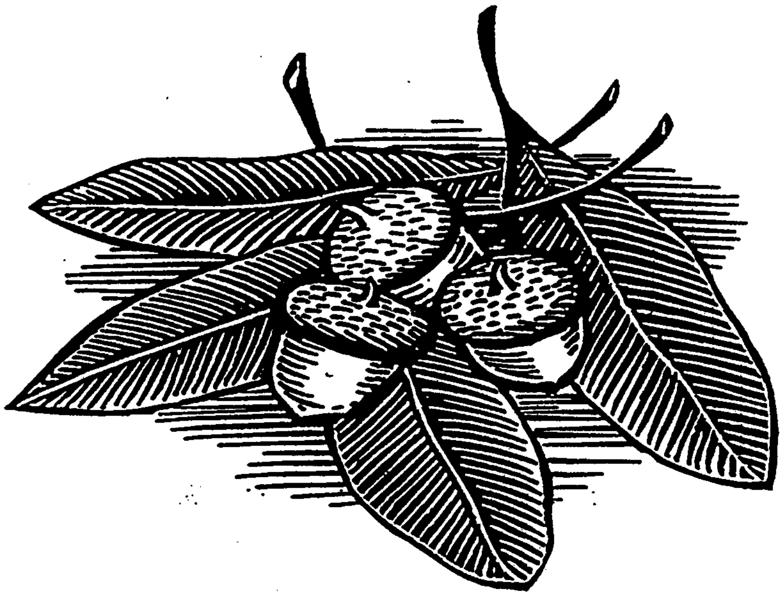
If you are unsure whether a problem exists, please contact the Jurisdiction and ask for technical assistance.

Comments:

APPENDIX C

City of Gresham Native Plant Restoration Guide

Native Plant Restoration Guide



CITY OF GRESHAM
DEPARTMENT OF ENVIRONMENTAL SERVICES
PARKS AND RECREATION DIVISION
FEBRUARY, 1997
Consultant: Dean Apostol

Purpose

The purpose of this document is to provide guidelines for restoration of native plant communities within the city of Gresham. There has been a growing interest in restoration over the past several years, as an outgrowth of concern over the general health of our environment. Healthy local native plant communities provide several important environmental benefits including wildlife habitat, botanical conservation, aesthetics, recreation settings, and watershed protection. Native plants, having evolved here, are well adapted to local conditions. Residents, land developers, commercial property owners, and public agencies all can benefit from these guidelines.

Background

The land in and around Gresham has changed substantially over the past 150 years. Multnomah, Clackamas, Kalapooyan, and other Indian bands occupied this area for thousands of years prior to Euro-American exploration and settlement. They made their living and built their cultures in the native forests, prairies, and streams. Indians modified this landscape through the use of fire and selective harvest of plants and animals. What the pioneers thought was a "natural" landscape was in fact a culturally changed one. The distribution and composition of plant communities resulted from the interaction of people and nature.

Early land surveys and pioneer journals indicate that Gresham was dominated by conifer forests. These forests had an open character with widely spaced old growth Douglas fir as the dominant tree. The open understory was filled with a carpet of herbaceous plants, bunchgrasses, and clumps of shrubs. On cooler, wetter, north facing slopes, western hemlock and western redcedar grew alongside or underneath the Douglas fir, and the forest had a dense character in the understory. Hardwood trees were much less abundant than they are today. Small openings created limited space for red alder and bigleaf maple. Cottonwoods, Oregon ash, and alder were common in the floodplain and along the banks of Johnson Creek and other streams, along with western redcedar. A few small prairie openings may have been found on some of the drier terraces, as well as in wet areas.

This landscape provided habitat for bear, wolves, cougar, deer, elk, bald eagle, and many other species. Over the past 150 years this landscape was radically altered by clearing the forest and draining the wetlands for farming, and in more recent times by urban development. The landscape continues to change today. The urban growth boundary has encouraged more infill, resulting in development pressure on remaining wetlands and forests. Lot sizes are getting smaller, providing less room for the occasional large tree or woodland grove. On the other hand, natural resource protection is stronger today than in the past. Remnant forests in the buttes are being purchased for public open space. Wetlands and floodplains along Johnson Creek are being restored. Many native wildlife species still inhabit the Gresham area. Deer are seen on many of the buttes, and migratory and resident songbirds find food and shelter in forest edges.

The following discussion describes the various native plant communities found in Gresham. A plant list providing common and botanical (in italics) names of plants is included for each plant community. The list provides the most common native plants found within that community that are generally available in local nurseries. These plants can be used to restore or create these plant communities. A few plant communities have been omitted from this discussion. Oak/Madrone woodlands are difficult to create and are very rare in Gresham, and are thus not included. Emergent wetlands are fragile plant communities and ecosystems, and should only be altered under the guidance of a professional environmental consultant. Wetlands in this state are governed by the Oregon Department of State Lands, and any alterations must be approved by them.

Upland Forest Plant Communities

Upland forests were, and still are, the most common native plant community type in and around Gresham. The largest and most intact remnant forests are found on Grant, Jenne, and Gresham buttes at the south end of the city. These are all "second growth" forests, grown up after the old-growth trees were logged. The dominant species are now red alder and bigleaf maple. The understory is much more brushy and dense than it used to be. Snags are missing. Restoration of upland forest communities can be divided into two categories - existing woodlands and new woodlands.

Restoring Woodlands

While existing deciduous-dominated woodlands do provide important habitat, watershed protection, and aesthetic benefits, they can be improved by careful management. Where dense hardwood "thickets" are found, it may be desirable to selectively thin some of the trees and to plant the understory with native conifers. These will eventually outgrow the hardwoods, and provide a more desirable forest structure for wildlife and aesthetics. Where conifers exist, some thinning may improve their growth rates and health. In some cases, it may be advantageous to thin out dense shrubby understories and plant native species such as ferns or salal. Leaving some dense shrub patches is a good idea, since some wildlife prefer them for cover. There are several non-native plants that often invade our woodlands. Where possible, these should be removed. English ivy is the most aggressive invader, competing for and overtaking native plant habitat. It should always be removed from woodlands.

Creating New Woodlands

Creating a new forest or small woodland is best done in stages. First, prepare the ground by removing weeds or sod. Second, add organic matter to the soil by tilling or digging in manure, rotted sawdust, or backyard compost. Third, plant sun loving "pioneer" forest plants such as red alder, Douglas fir, bigleaf maple, bitter cherry, and grand fir. Shrubs could include red flowering current, vine maple, salal, mock orange, Oregon grape, Nootka rose, or Indian plum. The ground should be mulched or seeded to clover or annual rye grass.

A new forest needs occasional weeding or watering, particularly in urban settings where weed seed is abundant. As the forest matures and the ground becomes shaded, weeds will only be a problem at the edges. Shade loving native plants can be added. These could include red huckleberries, ferns, trillium, violets, woods rose, cedar, and hemlock.

Trees	
Douglas fir	*Pseudotsuga menziesii*
Western hemlock	*Tsuga heterophylla*
Grand fir	*Abies grandis*
Western redcedar	*Thuja plicata*
Bigleaf maple	*Acer macrophyllum*
Red alder	*Alnus rubra*

Small trees and shrubs	
Vine maple	*Acer circinatum*
Cascara	*Rhamnus purshiana*
Serviceberry	*Amelanchier alnifolia*
Pacific yew	*Taxus brevifolia*
Chinkapin	*Castanopsis chrysophylla*
California hazel	*Corylus cornuta*
Pacific dogwood	*Cornus nuttallii*
Oceanspray	*Holodiscus discolor*
Western rhododendron	*Rhododendron macrophyllum*

Indian plum	*Osmaronia cerasiformis*
Red elderberry	*Sambucus racemosa*
Blue elderberry	*Sambucus cerulea*
Western mock-orange	*Philadelphia lewisii*
Common chokecherry	*Prunus virginiana*
Bitter cherry	*Prunus emarginata*
Tall Oregon grape	*Mahonia aquifolium*
Dull Oregon grape	*Mahonia nervosa*
Red huckleberry	*Vaccinium parvifolium*
Evergreen huckleberry	*Vaccinium ovatum*
Salal	*Gaultheria shallon*
Red flowering currant	*Ribes sanguineum*
Thimbleberry	*Rubus parviflorus*
Snowberry	*Symphoricarpus albus*
Woods rose	*Rosa woodsii*
Nootka rose	*Rosa nutkana*
Oval-leaf viburnum	*Viburnum ellipticum*

Herbaceous plants and wildflowers

Vanilla leaf	*Achylis triphylla*
Wild ginger	*Asarum caudatum*
Ladyfern	*Athyrium filix-femina*
Deerfern	*Blechnum spicant*
Swordfern	*Polystichum munitum*
Bunchberry dogwood	*Cornus stolonifera*
Twinflower	*Linnaea borealis*
Miners lettuce	*Montia siberica*
Oxalis	*Oxalis oregona*
False solomonseal	*Smilacena racemosa*
Starry solomonseal	*Smilacena stellata*
Foamflower	*Tiarella trifoliata*
Starflower	*Trientalis latifolia*
Piggyback plant	*Tolmiea menziesii*
Inside-out flower	*Vancouveria hexandra*
Trillium	*Trillium ovatum*
Wood violet	*Viola glabella*
Snow queen	*Synthris reniformis*
Red columbine	*Aquilegia formosa*
Western buttercup	*Ranunculus occidentalis*
Pacific bleedingheart	*Dicentra formosa*

Prairies

Oregon once had prairies as well as forests. Prairies were quite common from Oregon City south to Eugene in the Willamette Valley. They were also common in the Tualatin Valley, between Beaverton and Hillsboro. There are no historical records of prairies in the Gresham area, but in all likelihood there were a few small patches on drier soils. The native bunchgrasses form "clumps" rather than a dense sod. This leaves a lot of space for wildflowers to grow in between. The most common native grasses are red fescue, Idaho fescue, California oatgrass, and blue wildrye. There are dozens of possible native wildflowers one could plant in a prairie. Some of the more common are yarrow, aster, columbine, larkspur, shooting star, Oregon iris, lupine, blue-eyed grass, goldenrod, and mule's ears.

Why plant a prairie? They provide good bird habitat, are pretty to look at when flowering, protect watersheds with their deep roots, and are still open like a lawn, allowing views across. They are very drought tolerant, and once established require no watering and only occasional weeding. Prairies can be as small or as large as the space allows. Backyard "prairie gardens" have become quite popular in Midwestern states.

A prairie is best established by first ridding a site of all weeds, sod, roots, and even seed. Ideally, one is starting with a site that is south facing, well drained, with weed-free topsoil and plenty of sun. In a large area, grasses and wildflowers can be seeded onto the ground and lightly raked in, then watered. In a small area, individual grasses and flowers can first be grown as small plants, then placed out into the soil, as in a perennial garden. Establishment of a prairie is a race between the native plants and the non-native weeds, like dandelions, crabgrass, dock, morning glory, and others. The native plants will grow slowly at first, putting energy into their root systems so as to withstand drought. The weeds will grow much more quickly and aggressively. Thus frequent weedings are needed the first season and possibly the second. With time, the native prairie will take hold.

Grasses and Herbaceous Plants

California brome-grass	*Bromus carinatus*
Blue wildrye	*Elymus glaucus*
California fescue	*Festuca californica*
Idaho fescue	*Festuca idahohensis romeri*
Lemmon's needlegrass	*Stipa lemmoni*
White yarrow	*Achillea millefolium*
Western columbine	*Aquilegia formosa*
Menzies' larkspur	*Delphinium menziesii*
Leichtlin's camas	*Camassia leichtlinii*
Globe gillia	*Gillia capitata*
Shooting star	*Dodecatheon hendersonii*
Broadleaf strawberry	*Fragaria virginiana platypetala*
Oregon iris	*Iris tenax*
Smallflower prairiestar	*Lithophragma parviflora*
Barestem lomatium	*Lomatium nudicaule*
Nine-leaf lomatium	*Lomatium triternatum*
Common lomatium	*Lomatium utriculatum*
Sickle-keel lupine	*Lupinus albicaulis*
Slender cinquefoil	*Potentilla gracilis*
Heal-all	*Prunella vulgaris*
Rose checker-mallow	*Sidalcea virgata*
Canadian goldenrod	*Solidago canadensis*
Yellow violet	*Viola nuttallii*
Mule's ears	*Wyethia angustifolia*
Northern saitis	*Brodiaea congesta*
Harvest brodiaea	*Brodiaea coronaria*
Spanish clover	*Lotus purshianus*

Riparian, Wetland Forests, and Scrub/Shrub Wetlands

Wetlands

Planting or establishing a wetland is a difficult task, and best left to experts.Wetland plants are very sensitive to soil and "hydrologic" conditions. This means the soil has to be wet or even covered with water for a certain number of days each year. A wetland expert can study a site to help determine its suitability for particular wetland plants or plant communities. There are four basic types of wetlands: emergent, wet prarie, forest and scrub/shrub. Emergent and wet prarie wetlands are complex ecosystems best left to the experts to create or alter. Summarized below are descriptions and plant suggestions for forest and scrub/shrub wetlands. These plant communities occur in many locations in Gresham and could be augmented by the homeowner.

Riparian Forests and Forested Wetlands

Riparian forests are those that grow along streams, ponds, or wetlands. These are very important areas for wildlife and protection of water quality. It is relatively easy and fast to establish a riparian forest or woodland. They are dominated by deciduous trees, including black cottonwood, red alder, and Oregon ash. There are also a number of shrubby willows and the red osier dogwood. Western red cedar is the only native conifer tree typically found in riparian forests. Cottonwood and willow branches can be cut from nearby trees and simply stuck directly into the ground (right side up preferably).

Forested wetlands are areas that collect and hold water seasonally. Forested wetlands tend to be dominated by Oregon ash, with either a bare understory or shade tolerant sedges, water parsley, and skunk cabbage. A good example of an ash wetland forest can be seen along Johnson Creek, just west of the Springwater Trail at the far southern city limits. Ash woodlands tend to grow best on swampy sites that are wet across the surface for a month or more each year in late winter or early spring.

Scrub/shrub

Think of these as dense, impenetrable thickets of shrubs. These types of wetland make excellent habitat for many birds, as well as good screening for unsightly neighboring land uses.
Hardhack spirea, pacific crabapple, red-osier dogwood, salmonberry, and several species of willow are the most common species.

Trees

Oregon Ash	*Fraxinus oregona*
Black Cottonwood	*Populus trichocarpa*
Western redcedar	*Thuja plicata*
Cascara	*Rhamnus purshiana*
Columbia willow	*Salix fluviatilis*
Pacific willow	*Salix lasiandra*
Piper's willow	*Salix piperi*
Rigid willow	*Salix rigida*
Scouler willow	*Salix scouleriana*
Soft-leaved willow	*Salix sessiliflora*
Sitka willow	*Salix sitchensis*

Shrubs

Red-osier dogwood	*Cornus stolonifera*
Black twinberry	*Lonicera involucrata*
Indian plum	*Oemlaria cerasiformis*
Pacific ninebark	*Physocarpis capitatus*

Swamp rose	*Rosa pisocarpa*
Salmonberry	*Rubus spectabilis*
Blue elderberry	*Sambucus cerluea*
Red elderberry	*Sambucus racemosa*
Douglas spirea	*Spirea douglasii*
Nootka rose	*Rosa nootkana*

Herbaceous plants and wildflowers

Maidenhair fern	*Adiantum pedatum*
Douglas aster	*Aster douglasii*
Lady fern	*Athyrium filex-femina*
Big-leaf sedge	*Carex amplifolia*
Columbia sedge	*Carex aperta*
Dewey's sedge	*Carex deweyana*
Henderson's wood sedge	*Carex hendersonii*
Western corydalis	*Corydalis scouleri*
Elegant rein-orchid	*Habenaria elegans*
Soft rush	*Juncus effusus*
Skunk cabbage	*Lysichitum americanum*
Yellow monkey-flower	*Mimlulus quttatus*
Streambank springbeauty	*Montia parviflora*
Candyflower	*Montia siberica*
Forget-me-not	*Myostis laxa*
Water parsley	*Oenanthe sarmentosa*
Sweet coltsfoot	*Petasites frigidus*
False solomon-seal	*Smilacena racemosa*
Laceflower	*Tiarella trifoliata*
Piggyback	*Tolmiea menziesii*
Stream violet	*Viola glabella*

Bibliography

The following books provide additional information about northwest native plants:

Kruckeberg, Arthur. *Gardening with Native Plants of the Pacific Northwest.* University ofWashington Press, Seattle. 1982.

Weinmann, Fred. *Wetland Plants of the Pacific Northwest.* U.S. Army Corps of Engineers, Seattle District. 1984.

Native Plants Suppliers

The following is a list of retail and wholesale nurseries within a 50 mile radius of Gresham that carry some of the native plants listed. Prices and availability vary greatly. A more complete listing of nurseries specializing in native plants can be obtained by contacting Hortus Northwest, 3000 Market Street NE, Suite 521, Salem, Oregon 97031; phone number (503) 399-9601. All of the plants in the Gresham Native Plant List are available through nurseries listed in Hortus.

American Ornamental Perennials
29977 SE Weitz Lane
Eagle Creek, OR 97022-9633
(503) 6373095

Bosky Dell Natives
23311 SW Bosky Dell
West Linn, OR 97068
(503) 638-5945

Richard Bush's Nursery
8051 S. Lone Elder Road
Canby, OR 97031
(503) 266-9251

Cascadian Nurseries Inc.
13495 NW Thompson Road
Portland, OR 97229
(503) 645-3350

Chehalem Mountain Nursery
14375 SW Patricia Ave.
Hillsboro, OR 97123
(503) 628-0376

Collector's Nursery
16804 NE 102nd Ave.
Battle Ground WA, 98604
(360) 573-3832

Drakes Crossing Nursery
19774 Grade Road SE
Silverton, OR 97381
(503) 873-4932

Emerald Seed and Supply
9330 NE Halsey St
Portland, OR 97220
(800) 826-8873

Flora Lan Nursery
7940 NW Kansas City Road
Forest Grove, OR 97116
(503) 357-8386

Garden Gate Nursery
28383 S. Baurer Road
Colten, OR 97017
(503) 824-2532

Russell Graham Nursery
4030 Eagle Crest Road
Salem, OR 97304
(503) 362-1135

Wallace W. Hansen
2158 Bower Court Se.
Salem, OR 97301
(503) 581-2638

Hells Canyon Plant Company
PO Box 679
Sherwood, OR 97140
(503) 538-2133

Heritage Seedlings
4199 75th Ave. Se.
Salem, OR 97301-9242
(503) 585-9835

Hobbs & Hopkins
1712 SE Ankeny
Portland, OR 97214
(800) 345-3295

Holden Wholesale Growers
10374 Hazel Green Road NE
Silverton, OR 97381
(503) 873 5940

Hughes Water Gardens
25289 SW Stafford Rd.
Tualatin, OR 97062
(800) 858-1709

Joy Creek Nursery
20300 NW Watson Road
Scappoose OR 97056
(503) 543-7474

Krueger's Tree Farms
PO Box 32
North Plains, OR 97133
(503) 647-1000

Mahonia Vineyards and Nursery
4985 Battle Creek Road SE #205
Salem, OR 97302
(503) 585-8789

Mar-Lyn Farms
10227 S. Macksburg Road
Canby, OR 97013
(503) 266-2112

Meadow Lake Nursery
PO Box 1302
McMinnville, OR 97128
(503) 435-2000

Harold M. Miller
Landscape Nursery
PO Box 379
Hubbard OR 97032
(503) 651-2835

Mt. Angel Nursery
13318 Dominic Road NE
Mt. Angel, OR 97362
(503) 845-6570

Oisinn Ltd.
36700 SW Blooming Fernhill Road
Cornelius, OR 97113
(503) 357-3789

Quail Ridge Nursery
33689 S. Ball Road
Molalla, OR 97038
(503) 829-3105

Rare Plant Research
13245 SE Harold
Portland, OR 97236
(503) 762-0288

Red's Rhodies
15920 SW Oberst Lane
Sherwood, OR 97140
(503) 625-6331

Samuel J. Rich Nursery
9803 Yergan Road
Aurora, OR 97140
(503) 678-2828

Squaw Mountain Gardens
36212 SE Squaw Mt. Road
Estacada, OR 97023
(503) 630-5458

D Wells Farm
PO Box 336
Hubbard, OR 97032
(503) 982-1012

Whitman Farms
3995 Gibson
Salem. OR 97304
(503) 585-8728

Wichita Nursery
9413 S, Heinz Road
Canby, OR 97013
(503) 651-2279

APPENDIX D

Maintenance and Design Considerations for Ponds and Constructed Marshes or Wetlands

APPENDIX D
Removal Processes in Stormwater Pond and Marsh Systems

Process	SS	CS	BOD	N	P	HM	Org	Bacteria and virus	Stormwater Marsh	Wet Pond	Ext. Det. Pond	Description
Physical												
Sedimentation	P	S	I	I	I	I	I	I	1	1	1	Gravitational settling of solids
Filtration	S	S							1	1	2	Mechanical filtration through substrate, root mass, etc.
Adsorption		S							1	1	2	Adsorption by soils
Chemical												
Precipitation				P	P				1	2	3	Formation of insoluble compounds
Adsorption				P	P	S			1	2	3	Adsorption on substrate and plant surfaces
Decomposition							P	P	1	2	3	Decomposition due to UV irrad., oxidation and reduction, etc.
Biological												
Metabolism												
Bacterial		P	P	P			P		1	2	3	Removal by benthic and plant-supported bacteria. Bacterial nitrification/denitrification
Plant							S	S	1	1	3	Uptake and metabolism by plants
Adsorption				S	S	S	S		1	1	3	Under proper conditions, significant quantities may be taken up by plants
Natural Die-off								P	1	2	3	Natural decay of organisms in unfavorable environment.

P = Primary effect
S = Secondary Effect
I = Incidental effect

1 = Process highly likely
2 = Process somewhat likely
3 = Process highly unlikely

SS = Settleable solids
CS = Colloidal Solids
BOD = Bio-oxidation demand

N = Nitrogen
P = Phosphorus
HM = Heavy Metals
Org = Refractory Organics

Adapted from: Tchobanoglos G. and Culp, G.; "Wetland Systems for Wastewater Treatment: An Engineering Assessment" in ***Aquaculture Systems for Wastewater Treatment****. EPA430/9-80-007.*

GUIDELINES FOR EVALUATION OF WATER BUDGET FOR STORMWATER MARSHES

The following is an excerpt from Chapter 2 of *Creating Freshwater Wetlands* (1992) by Donald A. Hammer. It discusses the importance of maintaining a hydrologic balance in a stormwater marsh system by accounting for all inflows and outflows.

Additionally, the following is a water supply equation and other hydrology considerations recommended by Dr. Richard Horner of the University of Washington, Seattle:

Water supply according to design concept — should be established by a dry season (May 1 - September 30) water balance circulation:

$$B \text{ must be} > E + R - P - D - S$$

Where:
- B = Surface baseflow requirement (runoff inches over marsh surface)
- E = Evapotranspiration (24.2 inches in Portland area 5/1-9/30)
- R = Groundwater recharge (negligible in till areas and if lined)
- P = Precipitation (7.0 inches at Portland International Airport 5/1 - 9/30)
- D = Groundwater discharge (inches over wetland surface)
- S = Marsh storage on 5/1 (average permanent pool depth in inches, assuming negligible loss since winter runoff)

Should be estimated during site selection and checked after preliminary design (Note: Schueler (1992) recommends minimum baseflow of 0.1 cfs/50 acres of drainage area, assuming no infiltration.)

Low potential for disrupting flooding

Water supply of adequate quality to sustain biota

Low potential for the project to affect downstream water bodies and adjacent properties and their water supplies adversely

Need for lining to retain water or avoid groundwater contamination

For additional information, consult the following textbook by M. Wanilista: *Hydrology And Water Quality Control*, 1990, John Wiley & Sons, New York. pp 88-110.

APPENDIX D (cont'd)
Comparative Attributes of Four Stormwater Marsh Designs

Attribute	Shallow Marsh (Figure 4-3)	Pond/Marsh (Figure 4-4)	ED Marsh (Figure 4-5)	Pocket Marsh (Figure 4-6)
Pollutant Removal Capability	Moderate – reliable removal of sediments and nutrients.	Moderate to high – reliable removal of nutrients and sediment.	Moderate – less reliable removal of nutrients.	Moderate – can be subject to resuspension and groundwater displacement.
Land Consumption	High – shallow marsh storage consumes space.	Moderate – as vertical pool substitutes for marsh storage.	Moderate – as vertical ED substitutes for marsh storage.	Moderate – but can be shoehorned in site.
Water Balance	Dry weather base flow normally recommended to maintain water elevations. Groundwater not recommended as the primary source of water supply to wetland.			Water supply provided by excavation to groundwater.
Wetland Area as Percentage of Watershed Area	Minimum ratio of 2%	Minimum ratio of 1%	Minimum ratio of 1%	Minimum ratio of 1%
Contributing Watershed Area	DA of 25 acres or greater, with dry weather Q.	DA of 25 acres or greater, with dry weather Q.	Minimum of ten acres required for ED.	1 to 10 acres
Deep Water Cells	Forebay, channels micropool.	Pond micropool.	Forebay micropool.	Micropool, if possible.
Outlet Configuration	Reversed slope pipe extending from riser, withdrawn approximately one foot below normal pool. Pipe and pond drain equipped with gate valve.			Broad crested wier with half round trash rack, and pond drain.
Sediment Cleanout Cycle (approximate)	Cleanout of forebay every 2-5 years.	Cleanout of pond every ten years.	Cleanout of forebay every 2 to 5 years.	Cleanout of wetland every 5 to 10 years. Onsite disposal and stockpile mulch.
Native Plant Diversity	High – if complex microtopography is present.	High – with sufficient wetland complexity and area.	Moderate – fluctuating water levels impose physiological constraints.	Low to moderate – due to small surface area and poor control of water levels.
Wildlife Habitat Potential	High – with complexity and buffer.	High – with buffer, attracts waterfowl.	Moderate – with buffer.	Low – due to small area and low diversity.

Source: "Design of Stormwater Wetland Systems," Metropolitan Council of Governments, October 1992.

Appendix E:

City of Portland’s Parking Lot Tree List

Source: City of Portland, Stormwater Management Manual, 2000

Trees are listed by the scientific name of the species first, then the common name. Where applicable, names of cultivars are presented in single quote marks with the common name. The recommended minimum clearance from the pavement provides guidance on the amount of planting space each tree needs. It is expressed as the distance from the center of the planted tree trunk to the nearest paved surface. Comments provide guidance as to best applications of the different trees and additional information that may help in tree selection. For example, some trees are well suited to landscaped areas that will receive stormwater runoff, while others may not tolerate the additional moisture from runoff, largely depending on the soil.

Table A: Non-native trees
Source: City of Portland Stormwater Management Manual, September 2002

Species name	Common Name	Min. Distance from Pavement	Comments
Abies amabilis	Silver Fir	4 feet	Conifer, evergreen. Native to Oregon Cascades.
Acer campestre	Hedge maple	2 feet	Broadleaf, deciduous.
Acer campestre	Hedge maple 'Evelyn'	2 feet	Broadleaf, deciduous.
Acer pseudoplatanus	Sycamore maple	3 feet	Broadleaf, deciduous.
Acer rubrum	Red maple 'Embers Red,' 'October Glory,' 'Red Sunset,' 'Gerling,' 'Autumn Flame'	3 feet	Broadleaf, deciduous. Good for stormwater facilities
Acer saccharum	Sugar Maple (Except 'Legacy')	3 feet	Broadleaf, deciduous.
Calocedrus decurrens	Incense Cedar	3 feet	Conifer, evergreen Drought tolerant
Carpinus betulus	European Hornbeam	2 feet	Broadleaf, deciduous. Shade tolerant.
Celtis occidentalis	Hackberry	3 feet	Broadleaf, deciduous.
Cercidiphyllum japonicum	Katsura Tree	3 feet	Broadleaf, deciduous. Prefers well-drained soils. Needs summer irrigation

Table A: Non-native trees (con't) **Source: City of Portland Stormwater Management Manual, September 2002**			
Species name	**Common Name**	**Min. Distance from Pavement**	**Comments**
Cladrastis kentuckea	Yellowwood	3 feet	Broadleaf, deciduous. Prefers summer irrigation and well-drained soil.
Cornus kousa var. *chinensis*	Chinese Dogwood	3 feet	Broadleaf, deciduous. Small tree. Fruits, but is not messy. Needs summer water.
Crataegus x *lavallei*	Lavalle Hawthorn	2 feet	Broadleaf, deciduous. Fruit can be messy.
Fagus grandifolia	American Beech	4 feet	Broadleaf, deciduous.
Fagus sylvatica	European Beech	4 feet	Broadleaf, deciduous.
Fagus sylvatica	European Beech 'Roseo-marginata,' 'Tricolor'	3 feet	Broadleaf, deciduous.
Fraxinus americana	White Ash	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Fraxinus excelsior	European Ash	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Fraxinus pennsylvanica	Green Ash 'Marshall,' 'Patmore,' 'Summit,' 'Urbanite'	3 feet	Broadleaf, deciduous. Needs plenty of water until established
Ginkgo biloba	Ginkgo 'Shangri-la,' 'Saratoga'	3 feet	Measured as a broadleaf, deciduous. Use the male only; Female produces messy, smelly fruit.
Liquidambar styraciflua	Sweetgum	4 feet	Broadleaf, deciduous.
Liriodendron tulipifera	Tulip Tree or Tulip Poplar	4 feet	Broadleaf, deciduous.
Magnolia grandiflora	Southern Magnolia	4 feet	Broadleaf, evergreen.
Magnolia kobus	Kobus Magnolia	2 feet	Broadleaf, deciduous.
Metasequoia glyptostroboides	Dawn Redwood	4 feet	Conifer, deciduous.
Nothofagus dombeyi	South American Beech or Southern Beech	3 feet	Broadleaf, evergreen.
Nothofagus obliqua	Roble Beech	3 feet	Broadleaf, deciduous.
Nyssa sylvatica	Black Gum or Black Tupelo	3 feet	Broadleaf, deciduous. Good for stormwater facilities.
Ostrya virginiana	American Hornbeam	2 feet	Broadleaf, deciduous.
Pinus contorta	Shore Pine	3 feet	Conifer, evergreen. A smaller tree.

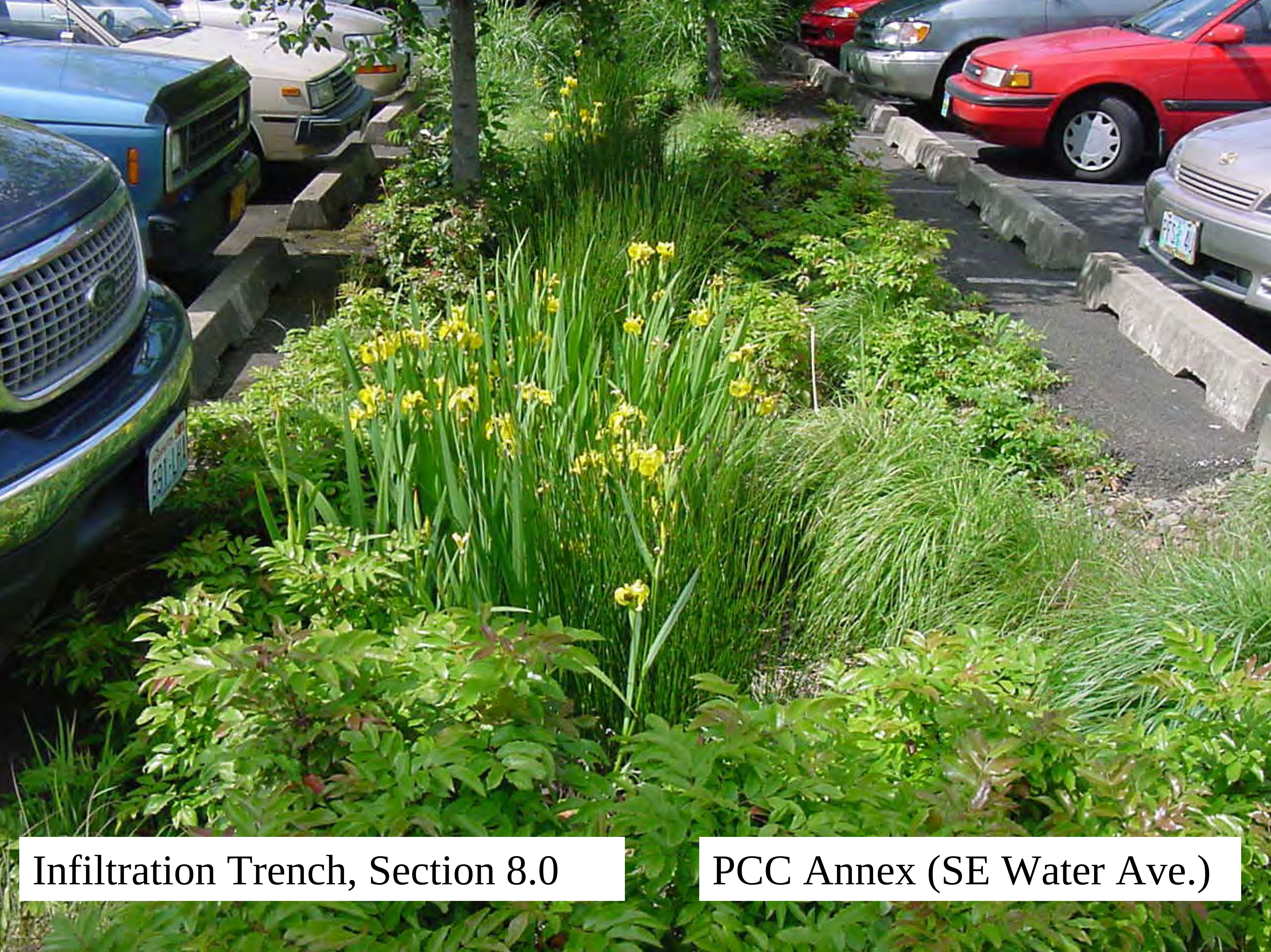
Table A: Non-native trees (con't) Source: City of Portland Stormwater Management Manual, September 2002			
Species name	**Common Name**	**Min. Distance from Pavement**	**Comments**
Pinus monticola	Western White Pine	3 feet	Conifer, evergreen.
Quercus bicolor	Swamp White Oak	3 feet	Broadleaf, deciduous. Tolerates wet soil.
Quercus coccinea	Scarlet Oak	3 feet	Broadleaf, deciduous. Intolerant of wet soil.
Quercus frainetto	Hungarian Oak 'Forest Green'	3 feet	Broadleaf, deciduous.
Quercus nigra	Water Oak	3 feet	Broadleaf, evergreen. Tolerates wet conditions.
Quercus phellos	Willow Oak	3 feet	Broadleaf, deciduous.
Quercus robur	English Oak	3 feet	Broadleaf, deciduous.
Quercus rubra	Northern Red Oak	4 feet	Broadleaf, deciduous.
Quercus velutina	Black Oak	4 feet	Broadleaf, deciduous.
Sequoia sempervirens	Coast Redwood	6 feet	Conifer, evergreen. Grows very tall.
Sequoiadendron giganteum	Giant Sequoia	8 feet	Conifer, evergreen. Trunk quickly becomes massive, needs ample space.
Sophora japonica	Japanese Pagoda Tree	3 feet	Broadleaf, deciduous.
Taxodium distichum	Bald Cypress	4 feet	Conifer, deciduous. Tolerates extremely wet conditions, but does not require it.
Umbellularia californica	California Laurel, Oregon Myrtle, Bay	4 feet	Broadleaf, evergreen. Drought tolerant.
Zelkova serrata	Sawleaf Zelkova 'Green Vase,' 'Halka,' 'Village Green'	3 feet	Broadleaf, deciduous.

Table B: Native Parking Lot Trees Source: City of Portland Stormwater Management Manual, September 2002			
Species name	**Common Name**	**Min. Distance from Pavement**	**Comments**
Abies grandis	Grand Fir	4 feet	Conifer, evergreen. Can grow very tall.
Acer macrophyllum	Big Leaf Maple	4 feet	Broadleaf, deciduous.
Alnus rubra	Red Alder	3 feet	Broadleaf, deciduous. Moisture loving. ***Short lived species.****
Crataegus douglasii, var. douglasii	Black Hawthorn, wetland form	3 feet	Broadleaf, deciduous. A smaller tree. Wetland form tolerates wet areas.
Fraxinus latifolia	Oregon Ash	3 feet	Broadleaf, deciduous. Tolerates wet conditions.
Pinus ponderosa, ssp. Valley	Ponderosa Pine, Valley subspecies	4 feet	Conifer, evergreen. Prefers drier conditions, but Valley subspecies is adapted to Willamette Valley climate.
Pseudotsuga menziesii	Douglas Fir	4 feet	Conifer, evergreen. Can grow very tall.
Quercus garryana	Oregon White Oak	4 feet	Broadleaf, deciduous. Drought tolerant.
Rhamnus purshiana	Cascara	3 feet	Broadleaf, deciduous. A smaller tree.
Thuja plicata	Western Red Cedar	4 feet	Conifer, evergreen. Prefers moist conditions and some shade. **Does not do well in direct sunlight, Shade tolerant**
Thuja plicata	Western Red Cedar 'Hogan'	4 feet	Conifer, evergreen. Prefers moist conditions and some shade. 'Hogan' is a narrow-growing variety.

* According to the "Western Tree Book" maximum age of a Red Alder is thought to be 100 years. Relatively speaking these trees have a life span sufficient for urban parking lot swales. A report by the Portland Planning Bureau in 1997 indicated that the life expectancy of most trees in non-residential areas was 20-40 years.

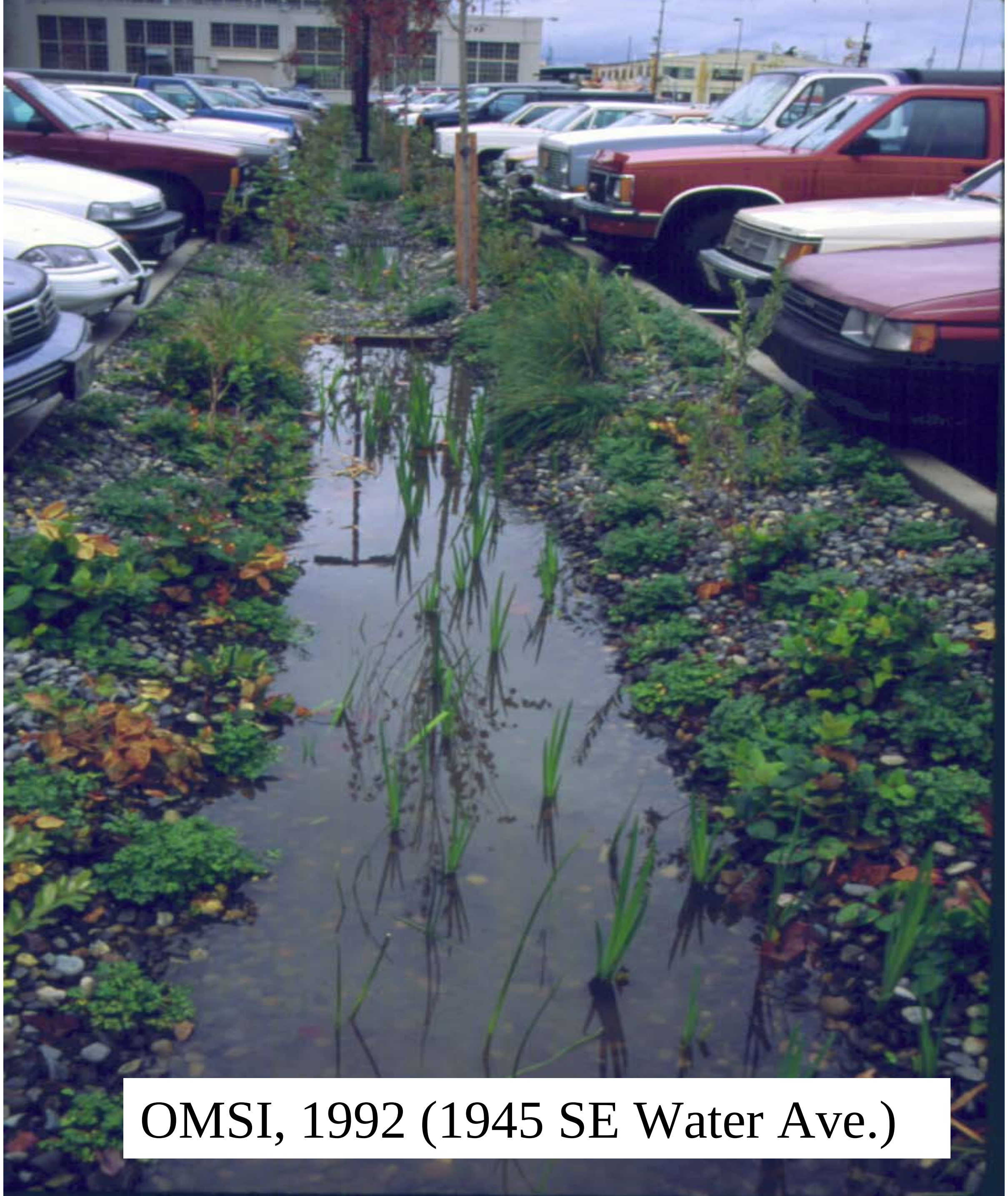
APPENDIX F
Stormwater Management Facility Photos

Photos courtesy of the City of Portland September 2002
Stormwater Management Manual



Infiltration Trench, Section 8.0

PCC Annex (SE Water Ave.)



OMSI, 1992 (1945 SE Water Ave.)

OMSI, 2001 (1945 SE Water Ave.)

Troutdale Arata Creek School Site

Troutdale Arata Creek School Site

Troutdale Arata Creek School Site

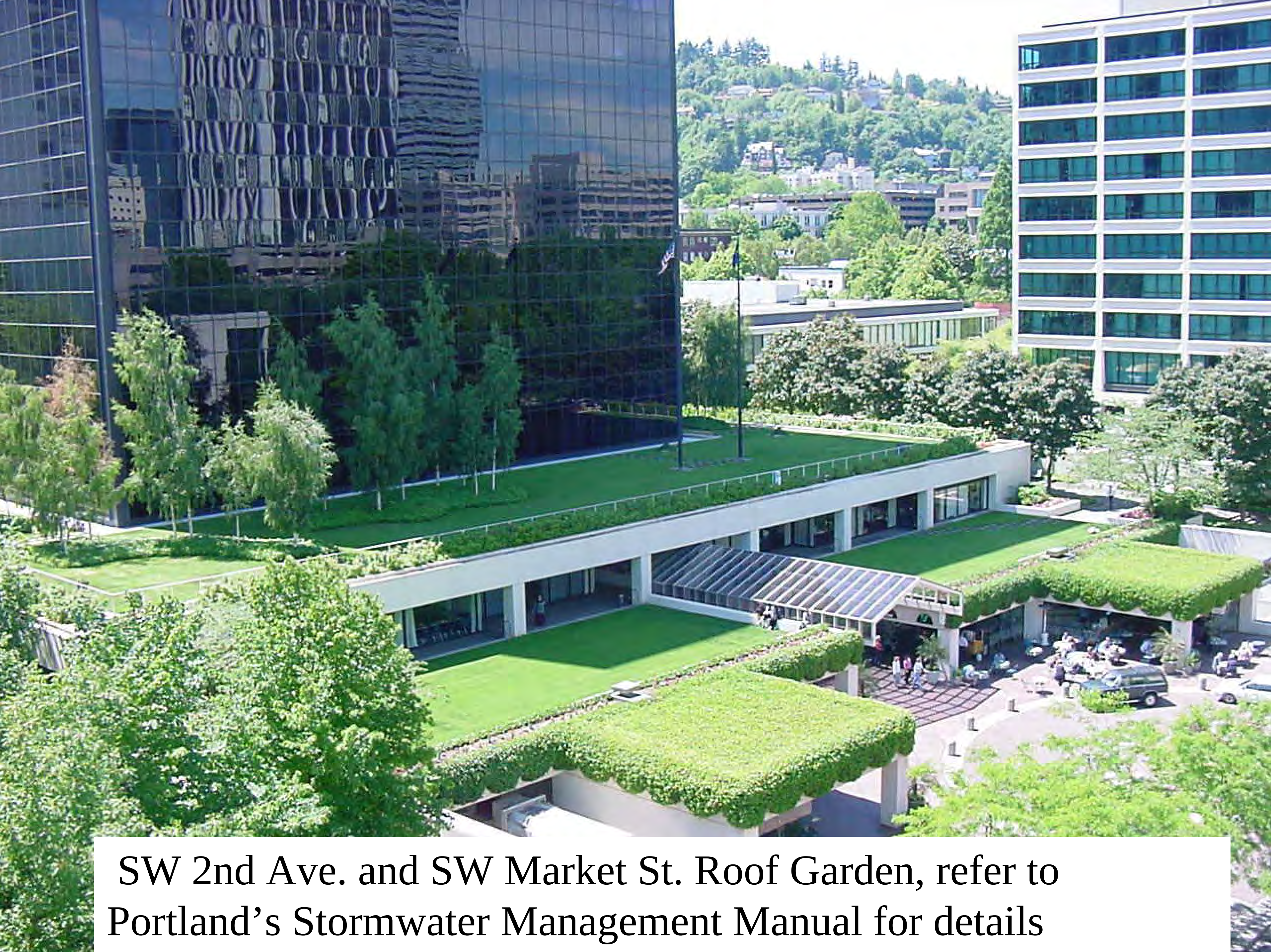
SW Community Center (6820 SW 45th Ave.)

Buckman Heights Apartments (430 NE 16th Ave.)

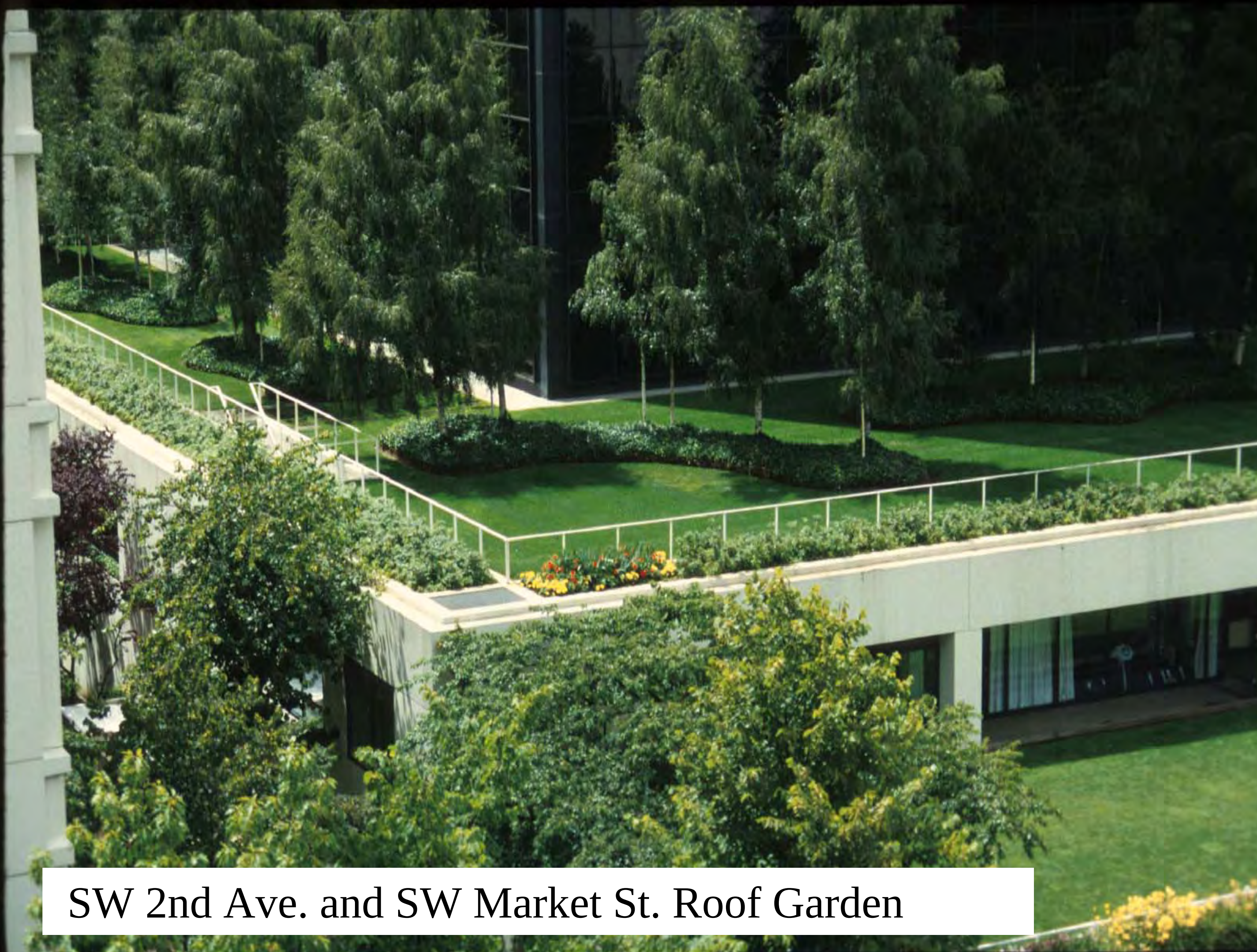
Seattle's Street Edge Alternatives Program

Low Impact Development, Section 2.0

SW Lodi Lane Subdivision (SW Lodi Lane & Shattuck)



SW 2nd Ave. and SW Market St. Roof Garden, refer to Portland’s Stormwater Management Manual for details



SW 2nd Ave. and SW Market St. Roof Garden

Hamilton Apartments Eco-Roof (1212 SW Clay St.), refer to Portland’s Stormwater Management Manual for details

Hamilton Apartments Eco-Roof (1212 SW Clay St.)

Hamilton Apartments Eco-Roof (1212 SW Clay St.)

Hamilton Apartments Eco-Roof (1212 SW Clay St.)

Buckman Terrace Eco-Roof (303 NE 16th Ave.)

Buckman Terrace Eco-Roof (303 NE 16th Ave.)

Eco-Roof in Philadelphia

Porous Pavement, Section 3.0

Vegetated Swale, Section 3.0

Hawthorne Ridge Subdivision (SE 162nd, South of Foster)

Hawthorne Ridge Subdivision (SE 162nd, South of Foster)

OMSI Vegetated Swale
(1945 SE Water Ave.)


BES Water Pollution Control Lab (6543 N. Burlington)

BES Water Pollution Control Lab (6543 N. Burlington)

Bioswale (grassy), Section 3.0

Reed College (SE 28th Ave.)

Bioswale, Russell Pond Site (NE 88th Ave. and Freemont Dr.)

Bioswale, SW Scholls Ferry Road

Vegetated Filters, Section 3.0

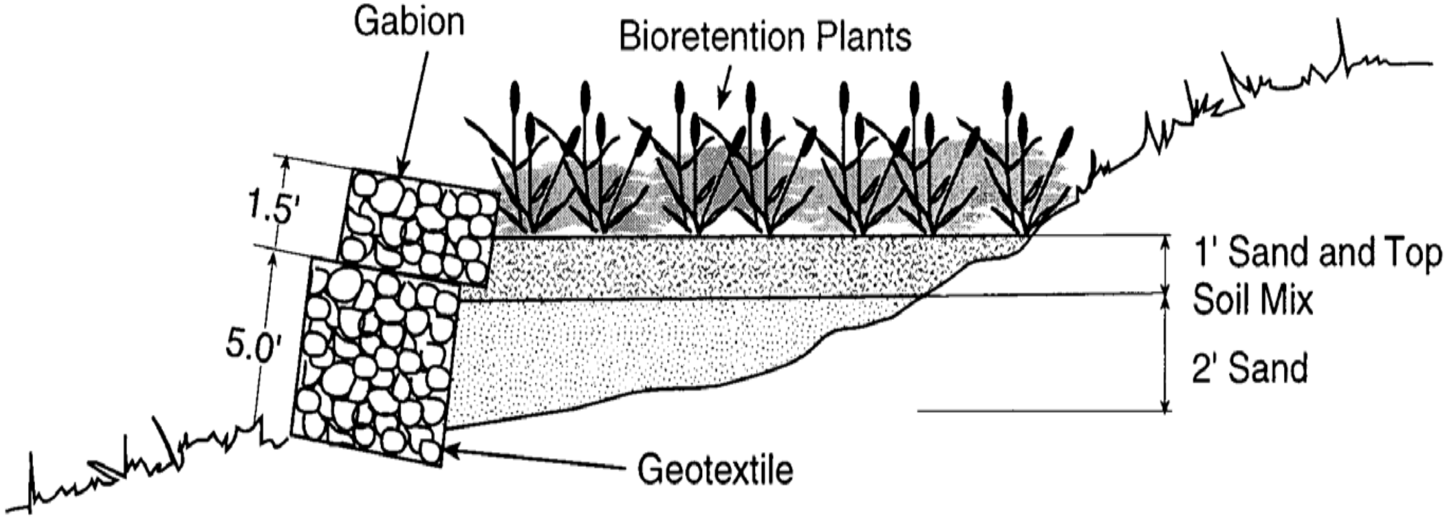
SW Community Center (6820 SW 45th Ave.)

Contained Planter Boxes, Section 3.0

1100 block of bus mall, downtown Portland

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

Infiltration Planter Boxes, Section 3.0



Flow-Through Planter Boxes, Section 3.0
Buckman Terrace Apartments (303 NE 16th Ave.)

Buckman Terrace Apartments (303 NE 16th Ave.)

Buckman Terrace Apartments (303 NE 16th Ave.)

Buckman Terrace Apartments (303 NE 16th Ave.)

Ritzdorf Apartments (SE 12th Ave. & SE Belmont St.)

Vegetated Infiltration Basin, Section Buckman Heights courtyard infiltration basins (430 NE 16th Ave.)

Buckman Heights courtyard infiltration basin (430 NE 16th Ave.)

Buckman Heights courtyard planter overflow (430 NE 16th Ave.)

Sand Filter, Section 3.0

Cascade Station (NE Airport Way & I-205)

Cascade Station (NE Airport Way & I-205)

Cascade Station (NE Airport Way & I-205)

Cascade Station (NE Airport Way & I-205)

Unknown Location

Soakage Trench, Section 8.0

7123 SE Powell

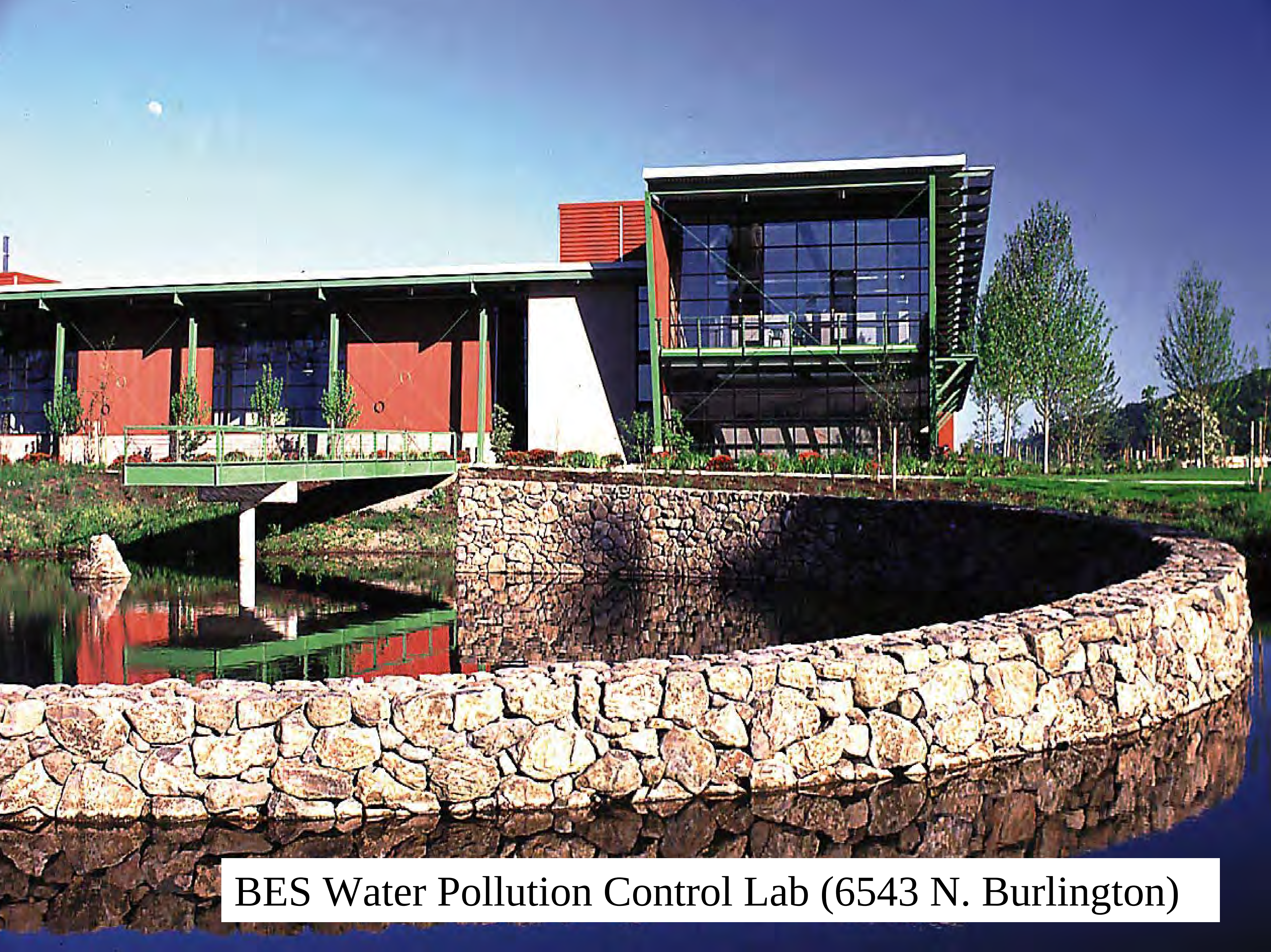
Soakage Trench,
7123 SE Powell

Wet Pond, Section 4.0, Mill Pond (NW Mill Pond Rd., Forest Heights Subdivision)

Troutdale Arata Creek School Site

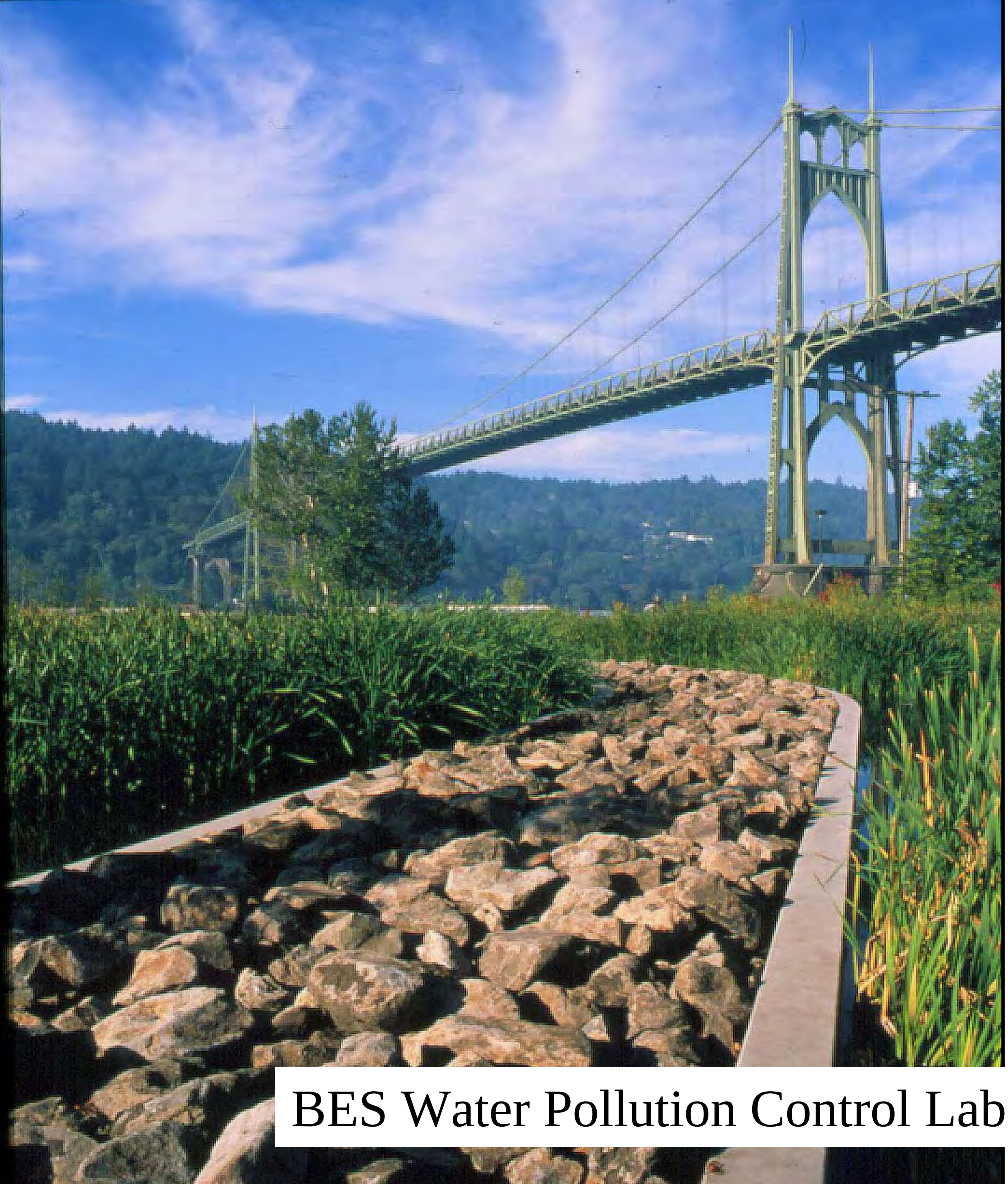
Troutdale Arata Creek School Site

Troutdale Arata Creek School Site



BES Water Pollution Control Lab (6543 N. Burlington)

BES Water Pollution Control Lab (6543 N. Burlington)



BES Water Pollution Control Lab (6543 N. Burlington)

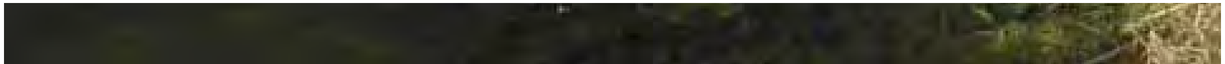
BES Water Pollution Control Lab (6543 N. Burlington)

MacGregor Heights Subdivision (SE 158th Ave. & Belmore)

Extended Detention Pond, Section 4.0, Hawthorne Ridge Subdivision

(SE 162nd, S. of Foster)

Hawthorne Ridge Subdivision (SE 162nd, S. of Foster)



Constructed Marsh, Section 5.0, Russell Pond Site (NE 88th Ave. and Freemont)

Russell Pond Site (NE 88th Ave. and Freemont)

Low Impact Development Tree Examples, Section 2.0

Buckman Terrace tree preservation and at grade infiltration planter
(303 NE 16th Ave.)

Stormwater Re-Use: Rain Barrels, Cisterns and Storage Tanks

APPENDIX G
Map of Wellhead Protection Area

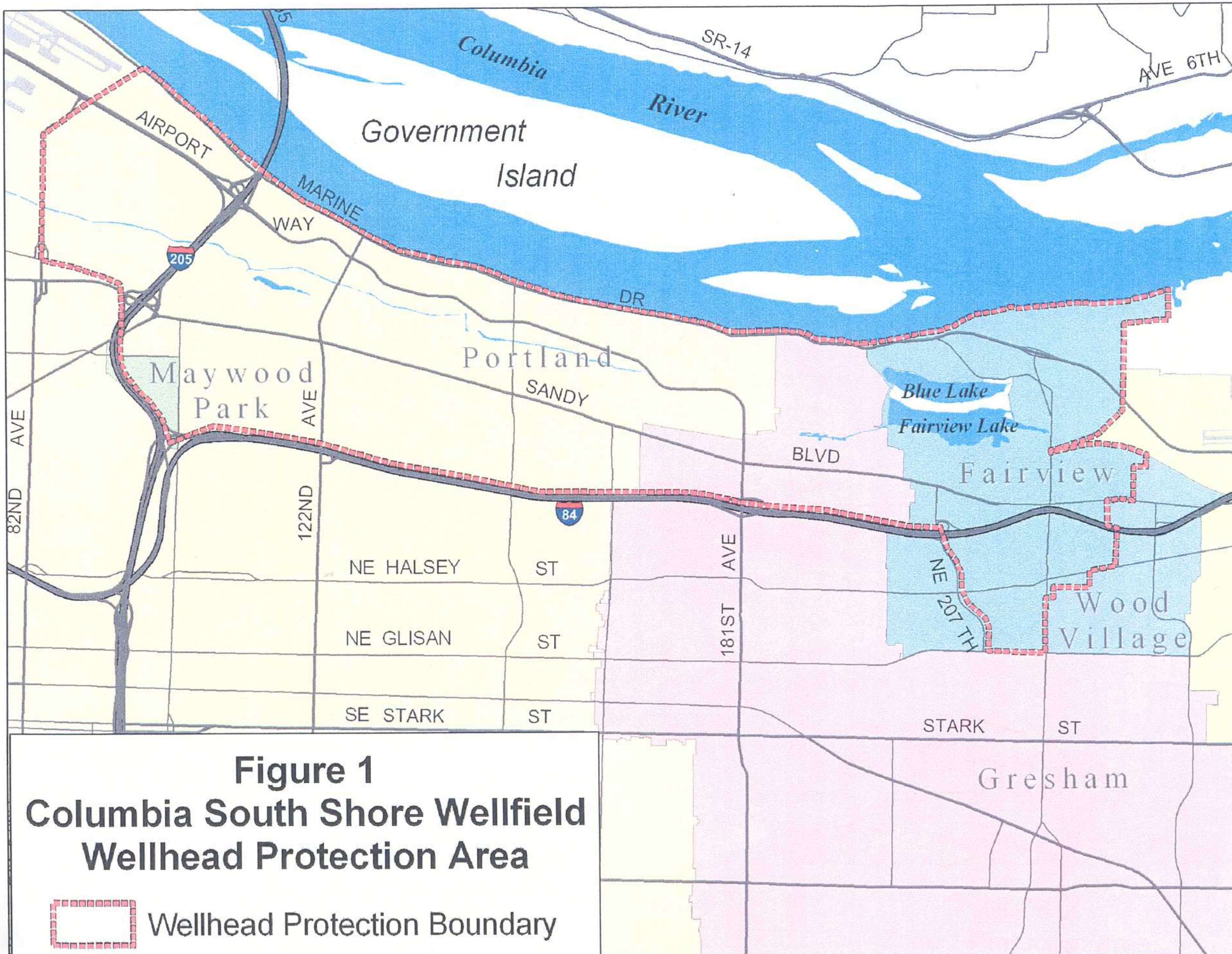


Figure 1
Columbia South Shore Wellfield Wellhead Protection Area

APPENDIX H

1998 King County Surface Water Design Manual,
Section 6.6 Oil Control Facility Designs

6.6.2 OIL/WATER SEPARATORS

Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. The two types of oil/water separators typically used for stormwater treatment are the baffle type or API (American Petroleum Institute) oil/water separator and the coalescing plate oil/water separator.

Baffle oil/water separators baffle Baffle use vaults that have multiple cells separated by baffles extending down from the top of the vault (see Figure 6.6.2.D on page 6-151 for schematic details). The baffles block oil flow out of the vault. Baffles are also commonly installed at the bottom of the vault to trap solids and sludge that accumulate over time. In many situations, simple floating or more sophisticated mechanical oil skimmers are installed to remove the oil once it has separated from the water.

Coalescing plate separators are typically manufactured units consisting of a baffled vault containing several inclined corrugated plates stacked and bundled together (see Figure 6.6.2.E on page 6-152 for schematic details). The plates are equally spaced (typical plate spacing ranges from 1/4-inch to 1 inch) and are made of a variety of materials, the most common being fiberglass and polypropylene. Efficient separation results because the plates reduce the vertical distance oil droplets must rise in order to separate from the stormwater. Once they reach the plate, oil droplets form a film on the plate surface. The film builds up over time until it becomes thick enough to migrate upward under the influence of gravity along the inclined plate. When the film reaches the edge of the plate, oil is released as large droplets which rise rapidly to the surface, where the oil accumulates until the unit is maintained. Because the plate pack increases treatment effectiveness significantly, coalescing plate separators can achieve a specified treatment level with a smaller vault size than a simple baffle separator.

Oil/water separators are meant to treat stormwater runoff from more intensive land uses, such as high-use sites, and facilities that produce relatively high concentrations of oil and grease. Although baffle separators historically have been used to remove larger oil droplets (150 microns or larger), they can also be sized to remove smaller oil droplets. Both separators can be used to meet a **performance goal of 10 to 15 mg/L** by designing the unit to removal oil particles 60 microns and larger.

Applications and Limitations

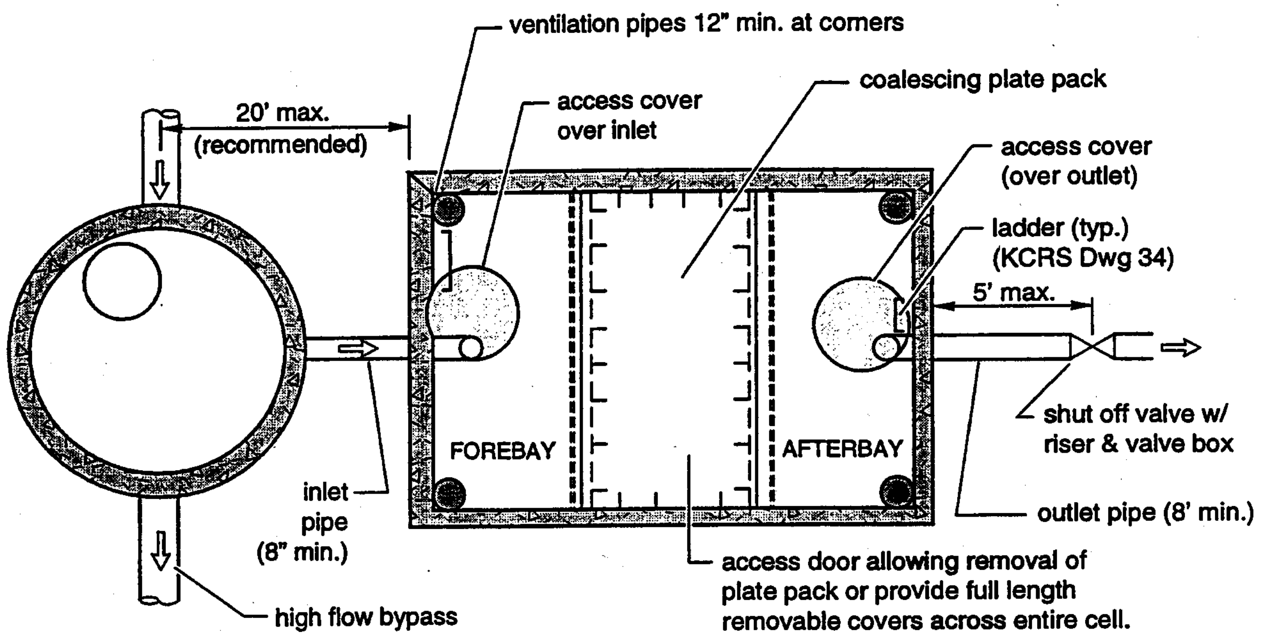
Oil/water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Therefore, it is **desirable for separators be installed upstream of facilities and conveyance structures that introduce turbulence and consequently promote emulsification.** Emulsification of oil can also result if surfactants or detergents are used to wash parking areas that drain to the separator. Detergents should not be used to clean parking areas unless the wash water is collected and disposed of properly (usually to the sanitary sewer).

Oil/water separators are **best located in areas where the tributary drainage area is nearly all impervious, and a fairly high load of petroleum hydrocarbons is likely to be generated.** Oil/water separators are not recommended for areas with very dilute concentrations of petroleum hydrocarbons since their performance is not effective at low concentrations. Excluding unpaved areas helps to minimize the amount of sediment entering the vault, reducing the need for maintenance. A unit that fails and ceases to function can release previously trapped oil to the downstream receiving water, both in release from the oily sediments and from entrainment of surface oils.

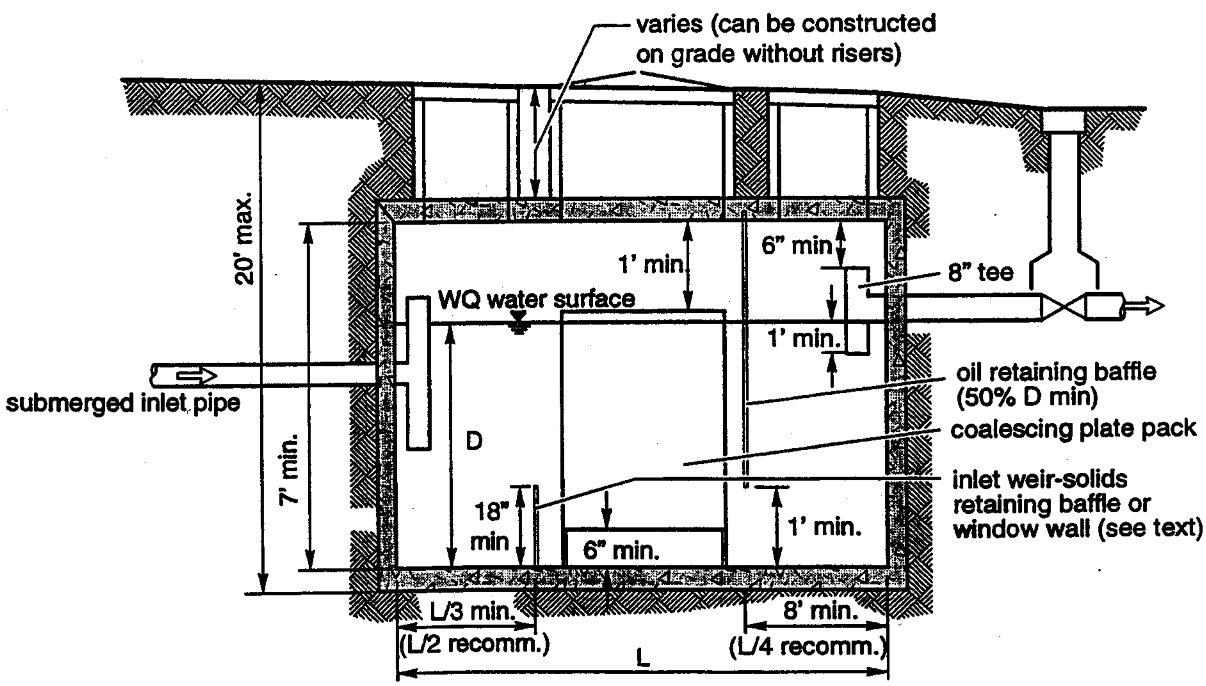
Wetvaults may also be modified to function as baffle oil/water separators (see design criteria for wetvaults, Section 6.4.2.2, p. 6-80).

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how baffle and coalescing plate oil/water separators can be used to meet Special Requirement # 5.

FIGURE 6.6.2.E COALESCING PLATE OIL/WATER SEPARATOR



PLAN VIEW
NTS



SECTION VIEW
NTS

$$V_T = \frac{Q}{A_s} \tag{6-24}$$

where A_s = surface area of the separator unit

The ratio in Equation (6-24) is designated as the surface overflow rate or loading rate. It is this rate that governs the removal efficiency of the process and predicts whether an oil droplet will be removed by the separator.

Method for Baffle Separators

Design steps for the baffle separator are summarized below:

Step 1: Determine the WQ design flow (Q). The facility is sized based on the WQ design flow (see Section 6.2.1, p. 6-17). The separator **must be designed as an off-line facility**. That is, flows higher than the WQ design flow must bypass the separator.

Step 2: Calculate the minimum vertical cross-sectional area. Use the following equation:

$$A_c = \frac{Q}{V_H} \tag{6-25}$$

where A_c = minimum cross-sectional area (sf)
Q = water quality design flow (cfs)
V_H = design horizontal velocity (fps)

Set the horizontal velocity V_H equal to 15 times the oil droplet's rise rate V_T. A **design rise rate of 0.033 feet per minute shall be used** unless it is demonstrated that conditions of the influent or performance function warrant the use of an alternative value. Using the 0.033 feet per minute rise rate results in V_H = 0.008 fps (= 0.495 fpm).

Step 3: Calculate the width and depth of the vault. Use the following equation:

$$D = \frac{A_c}{W} \tag{6-26}$$

where D = maximum depth (ft)
W = width of vault (ft)
and where A_c is from Step 2 above.

The computed depth D must meet a depth-to-width ratio r of between 0.3 and 0.5 (i.e., $0.3 \le D/W \le 0.5$).

Note: $D = (r A_c)^{0.5}$ and
$W = D/r$ and
r = the depth-to-width ratio

Step 4: Calculate the length of the vault. Use the following equation:

$$L = FD\left(\frac{V_H}{V_T}\right) \tag{6-27}$$

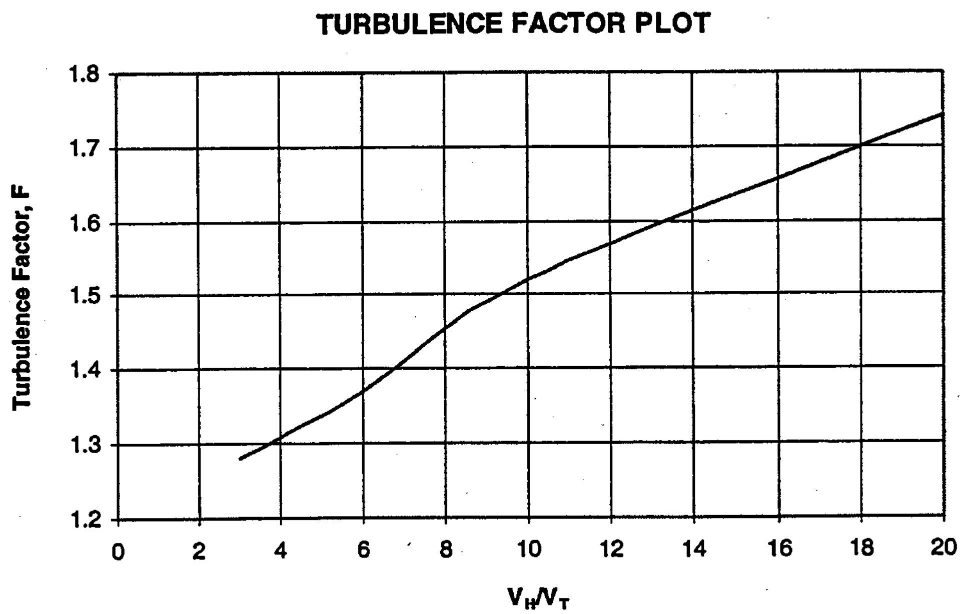
where L = length of vault (ft)

F = turbulence and short-circuiting factor (unitless, see Figure 6.6.2.A)
V_H = horizontal velocity (ft/min)
V_T = oil droplet rise rate (ft/min)
D = depth (ft)

The turbulence factor F should be selected using a V_H/V_T ratio of 15, so $F = 1.64$.

Therefore Equation (6-27) becomes: $L = 1.65 \times 15 \times D$

FIGURE 6.6.2.A TURBULENCE FACTOR PLOT



Step 5: Check the separator's length-to-width ratio. The length L of the vault must be at least 5 times its width in order to minimize effects from inlet and outlet disturbances. The length of the forebay shall be approximately $L/3$.

Step 6: Compute and check that the minimum horizontal surface area (A_H) criterion is satisfied. This criterion is expressed by the following equation:

$$A_H = \left(\frac{1.65Q}{0.33}\right) \leq LW \qquad (6\text{-}28)$$

Step 7: Compute and check that the horizontal surface area of the vault forebay. This area must be greater than 20 square feet per 10,000 square feet of tributary impervious area. The length of the forebay ($L/3$) may be increased to meet this criterion without having to increase the overall length of the vault.

Step 8: Design the flow splitter and high-flow bypass. See Section 6.2.5 (p. 6-27) for information on flow splitter design.

Method for Coalescing Plate Separators

Coalescing plate separators are designed using the same basic principles as baffle separators. The major difference is that in the baffle separator, horizontal separation is related only to water surface area, while in the coalescing plate separator, horizontal separation is related to the sum of the plan-areas of the plates. The treatment area is increased by the sum of the horizontal projections of the plates being added, and is referred to as the plate ***effective separation area.***

The basic procedure for designing a coalescing plate separator is to determine the effective separation area required for a given design flow. The specific vault sizing then depends on the manufacturer's plate design. The specific design, analysis, configuration, and specifications for coalescing plates are empirically based and variable. Manufacturers' recommendations may be used to vary the recommendations given below.

Step 1: Determine the WQ design flow. The coalescing plate oil/water separator must be sized based on the WQ design flow (see Section 6.2.1, p. 6-17). The separator **must be designed as an off-line facility**; flows higher than the WQ design flow must bypass the separator.

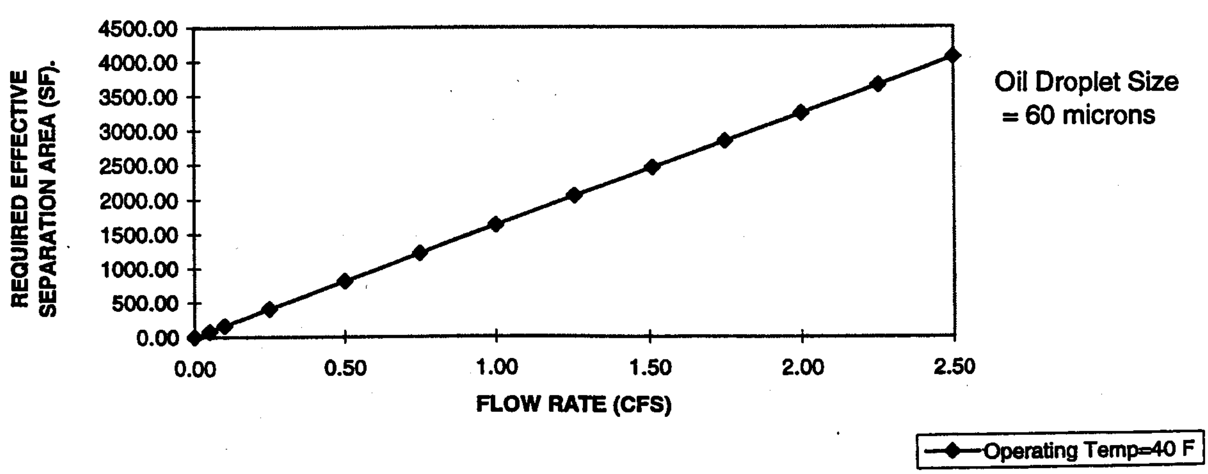
Step 2: Calculate the plate minimum effective separation area (A_h). A_h is found using the following equation:

$$A_h = \frac{60Q}{0.00386\left(\dfrac{S_w - S_o}{\mu}\right)} \qquad (6\text{-}29)$$

where
S_w = specific gravity of water = 1.0
S_o = specific gravity of oil = 0.85
μ = absolute viscosity of water (poises); use 0.015674 for temp = 39° F
Q = water quality design flow rate (cfs)
A_h = required effective (horizontal) surface area of plate media (sf).

Equation (6-29) is based on an oil droplet diameter of 60 microns. A graphical relation of Equation (6-29) is shown in Figure 6.6.2.B below. This graph may be used to determine the required effective separation surface area of the plate media.

FIGURE 6.6.2.B EFFECTIVE SEPARATION SURFACE VS FLOW RATE



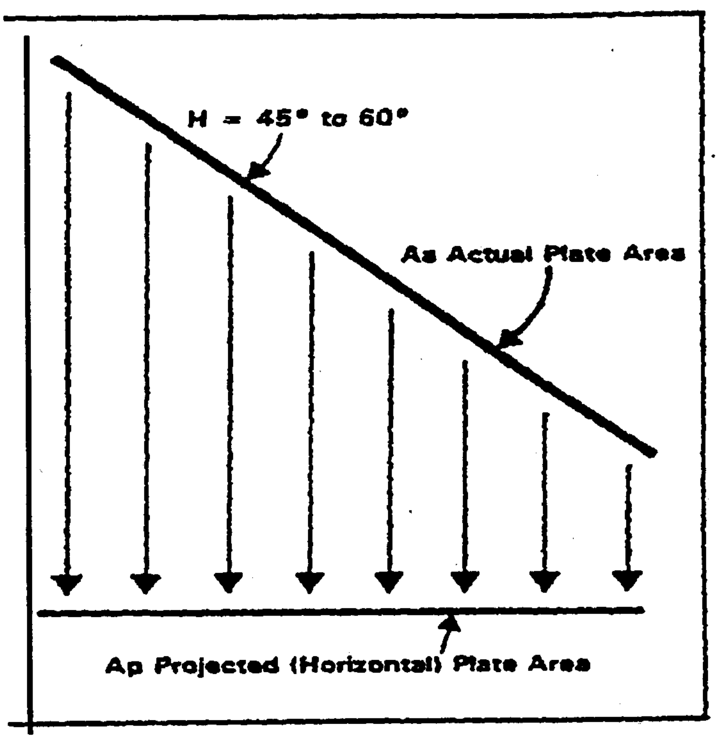
Step 3: Calculate the collective projected surface area (A_p). A key design step needed to assure adequate performance of the separator unit is to convert the physical plate area (the surface area of the plates if laid flat) into the effective (horizontal) separation surface area A_h (calculated in step 2). The effective separation surface area A_h is based on the collective projected horizontal surface area A_p of the plates where the plates are inclined, rather than their laid flat.

$$A_h = A_p = A_a (\cos H) \quad (6\text{-}30)$$

where A_a = actual collective plate area of the plate configuration (sf)
H = angle of the plates to the horizontal (degree)

This equation is represented graphically in Figure 6.6.2.C below. The designer should make sure that the manufacturer sizes the oil/water separator using the projected surface area rather than the actual plate area. *Note: For this method, only the lower plate surface may be counted as effective separation surface, regardless of manufacturer's claims.*

FIGURE 6.6.2.C PROJECTED HORIZONTAL PLATE AREA FOR COALESCING PLATE OIL/WATER SEPARATOR



Step 4: Check with specific separator manufacturers. Check with specific manufacturers to choose a separator that provides the required actual collective plate area calculated in Step 3, and meets the other design criteria given in the next section, p. 6-147. The specific vault design will depend upon each manufacturer's design. The geometric configuration and dimensions of the plate pack as well as the vault design are variable and flexible depending on each manufacturer's product.

Table 6.6.2.A (p. 6-147) provides approximate vault sizes for rough planning purposes. In reality, various manufacturer's have quite different designs, both for the plate packs themselves as well as for forebay and afterbays. In addition, standard pre-cast vault dimensions vary with each manufacturer. These various

factors can greatly affect the volume of vault needed to provide a given effective separation area. The numbers in Table 6.6.2.A should, then, be considered "order of magnitude" estimates only.

TABLE 6.6.2.A
APPROXIMATE COALESCING PLATE OIL/WATER SEPARATOR VAULT DIMENSIONS*

Area of Effective Separation (square feet)	Approximate vault volume required (cubic feet) for plates with 1/2 inch spacing and inclined 60 degrees from horizontal (cubic feet)
100	150
200	240
300	330
600	530
1,200	890
2,400	1150
3,200	2090
4,800	2640

* *Order of magnitude estimates for planning purposes only. Actual vault volumes vary considerably depending on separator design features and pre-cast vault dimensions.*

6.6.2.2 DESIGN CRITERIA

Details for a typical baffle oil/water separator are shown in Figure 6.6.2.D (p. 6-151). **Other designs** and configurations of separator units and vaults are allowed, including above ground units. However, they must produce equivalent treatment results and treat equivalent flows as conventional units.

General Siting

1. Oil/water separators **must be installed off-line**, bypassing flows greater than the WQ design flow.
2. When a separator is required, it **shall precede other water quality treatment facilities** (except wetvaults). It may be positioned either upstream or downstream from flow control facilities, since there are both advantages and disadvantages with either placement.
3. In moderately pervious soils where **seasonal groundwater** may induce flotation, buoyancy tendencies shall be balanced by ballasting or other methods as appropriate.
4. Any **pumping devices** shall be installed downstream of the separator to prevent oil emulsification in stormwater.

Vault Structure — General

The following criteria apply to both baffle and coalescing plate separators:

1. Separator vaults shall be **watertight**. Where pipes enter and leave a vault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.
2. Separator vaults shall have a **shutoff mechanism** on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided according to the design criteria for wetponds (see "Inlet and Outlet Criteria," Section 6.4.1.2, p. 6-71).

Vault Structure — Baffle Separators

In addition to the above general criteria, the following criteria apply specifically to baffle separators:

1. Baffle separators shall be divided into **three compartments**: a forebay, an oil separation cell, and an afterbay. The **forebay** is primarily to trap and collect sediments, encourage plug flow, and reduce turbulence. The **oil separation cell** traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area. The **afterbay** provides a relatively oil-free cell before the outlet, and it provides a secondary oil separation area and holds oil entrained by high flows.
2. The **length of the forebay** shall be approximately 1/3 to 1/2 of the length of the vault, *L*. In addition, the **surface area of the forebay** must be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator.
3. A **removable flow-spreading baffle**, extending from the surface to a depth of up to 1/2 the vault depth (D) is recommended to spread flows.
4. The **removable bottom baffle** (sediment-retaining baffle) shall be a minimum of 24 inches (see Figure 6.6.2.D, p. 6-151), and located at least 1 foot from the oil-retaining baffle. A "window wall" baffle may be used, but the area of the window opening must be at least three times greater than the area of the inflow pipe.
5. A **removable oil retaining baffle** shall be provided and located approximately 1/4 *L* from the outlet wall or a minimum of 8 feet, whichever is greater (the 8-foot minimum is for maintenance purposes). The oil-retaining baffle shall extend from the elevation of the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.
6. Baffles may be fixed rather than removable if additional entry ports and ladders are provided so that both sides of the baffle are accessible by maintenance crews.
7. Baffle separator vaults shall have a minimum **length-to-width ratio** of 5.
8. The **design water depth** (*D*) shall be no deeper than 8 feet unless approved by DDES. Depths greater than 8 feet may be permitted on a case-by-case basis, taking into consideration the potential for depletion of oxygen in the water during the warm summer months.
9. Baffle separator vaults shall have a **design water depth-to-width** ratio of between 0.3 and 0.5.

Vault Structure — Coalescing Plate Separators

In addition to the above general criteria, the following criteria apply specifically to coalescing plate separators:

1. Coalescing plate separators shall be divided by baffles or berms into **three compartments**: a forebay, an oil separation cell which houses the plate pack, and an afterbay. The **forebay** controls turbulence and traps and collects debris. The **oil separation cell** captures and holds oil. The **afterbay** provides a relatively oil-free exit cell before the outlet.
2. The **length of the forebay** shall be a minimum of 1/3 the length of the vault, *L* (but 1/2 *L* is recommended). In addition, it is recommended that the **surface area of the forebay** be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator. In lieu of an attached forebay, a separate grit chamber, sized to provide be at least 20 square feet per 10,000 square feet of tributary impervious area, may precede the oil/water separator.
3. An **oil-retaining baffle** shall be provided. If maintained by the County, the baffle must be a minimum of 8 feet from the outlet wall (for maintenance purposes). For large units, a baffle position of 0.25*L* from the outlet wall is recommended. The oil-retaining baffle shall extend from the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.

4. A bottom **sediment-retaining baffle** shall be provided upstream of the plate pack. The minimum height of the sludge-retaining baffle shall be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.

5. It is recommended that entire space between the sides of the plate pack and the vault wall be filled with a solid but light-weight removable material such as a **plastic or polyethylene foam** to reduce short-circuiting around the plate pack. Rubber flaps are not effective for this purpose.

6. If a separator will be maintained by King County, the **separator plates** shall meet the following requirements:

   a) Plates shall be inclined at 45° to 60° from the horizontal. This range of angles exceeds the angle of repose of many solids and therefore provides more effective droplet separation while minimizing the accumulation of solids on the individual plates.

   b) Plates shall have a minimum plate spacing of 1/2-inch and have corrugations.

   c) Plates shall be securely bundled in a plate pack so that they may be removed as a unit.

   d) The plate pack shall be a minimum of 6 inches from the vault bottom.

   e) There should be 1 foot of head space between the top of the plate pack and the bottom of the vault cover.

Inlet and Outlet

1. The **inlet shall be submerged.** A tee section may be used to submerge the incoming flow and must be at least 2 feet from the bottom of the tank and extend above the WQ design water surface.

   Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Extending the tee to the surface allows air to escape the flow, thus reducing turbulence. Alternative inlet designs that accomplish these objectives are acceptable.

2. The **vault outlet pipe** shall be sized to pass the WQ design flow before overflow (using the pipe sizing methods in Chapter 4). The vault outlet pipe shall be back-sloped or have a tee extending 1 foot above and below the WQ design water surface to provide for secondary trapping of oils and floatables in the wetvault. *Note: The invert of the outlet pipe sets the **WQ design water surface** elevation.*

Material Requirements

1. All **metal parts shall be corrosion-resistant.** Zinc and galvanized materials are to be avoided when substitutes are available because of aquatic toxicity potential. Painting metal parts for corrosion resistance is not allowed due to lack of longevity.

2. **Vault baffles** shall be concrete, stainless steel, fiberglass reinforced plastic, or other acceptable material and shall be securely fastened to the vault.

3. **Gate valves,** if used, shall be designed for seating and unseating heads appropriate for the design conditions.

4. For coalescing plate separators, **plate packs** shall be made of fiberglass, stainless steel or polypropylene.

Access Requirements

Same as for **detention vaults** (see Section 5.3.3) except for the following **modifications:**

1. Access to **each compartment** is required. If the length or width of any compartment exceeds 50 feet, an additional access point for each 50 feet is required.

2. Access points for the **forebay and afterbay** shall be positioned partially over the inlet or outlet tee to allow visual inspection as well as physical access to the bottom of the vault.

3. For **coalescing plate separators**, the following also apply:

   a) Access to the **compartment containing the plate pack** shall be a removable panel or other access able to be opened wide enough to remove the entire coalescing plate bundle from the cell for cleaning or replacement. Doors or panels shall have stainless steel lifting eyes, and panels shall weigh no more than 5 tons per panel.

   b) A **parking area or access pad** (25-foot by 15-foot minimum) shall be provided near the coalescing plate bundles to allow for their removal from the vault by a truck-mounted crane or backhoe, and to allow for extracting accumulated solids and oils from the vault using a vactor truck.

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

Recommended Design Features

1. A **gravity drain** for maintenance is recommended if grade allows. The drain invert should be at a depth equal to the depth of the oil retaining baffle. Deeper drains are encouraged where feasible.

2. The recommended design features for wetvaults should be applied.

3. If large amounts of oil are likely to be captured, a bleed-off pipe and separate waste oil tank can be located adjacent to the vault to channel separated oils into the tank. This improves the overall effectiveness of the facility, especially if maintenance is only annually. It also improves the quality of the waste oil recovered from the facility.

Construction Considerations

1. Construction of oil/water separators should follow and conform to the manufacturer's recommended construction procedures and installation instructions as well as Chapter 7 of the *King County Road Standards*. Where the possibility of vault flotation exists, the vault shall be properly anchored in accordance with the manufacturer's recommendations or an engineer's design and recommendations.

2. Particular care must be taken when inserting coalescing plate packs in the vault so as not to damage or deform the plates.

3. Upon completion of installation, the oil/water separator shall be thoroughly cleaned and flushed prior to operating.

Maintenance Considerations

1. Oil/water separators must be cleaned regularly to ensure that accumulated oil does not escape from the separator. Separators should be cleaned by November 15 of each year to remove accumulation during the dry season. They must also be cleaned after spills of polluting substances such as oil, chemicals, or grease. Vaults must also be cleaned when inspection reveals any of the following conditions:

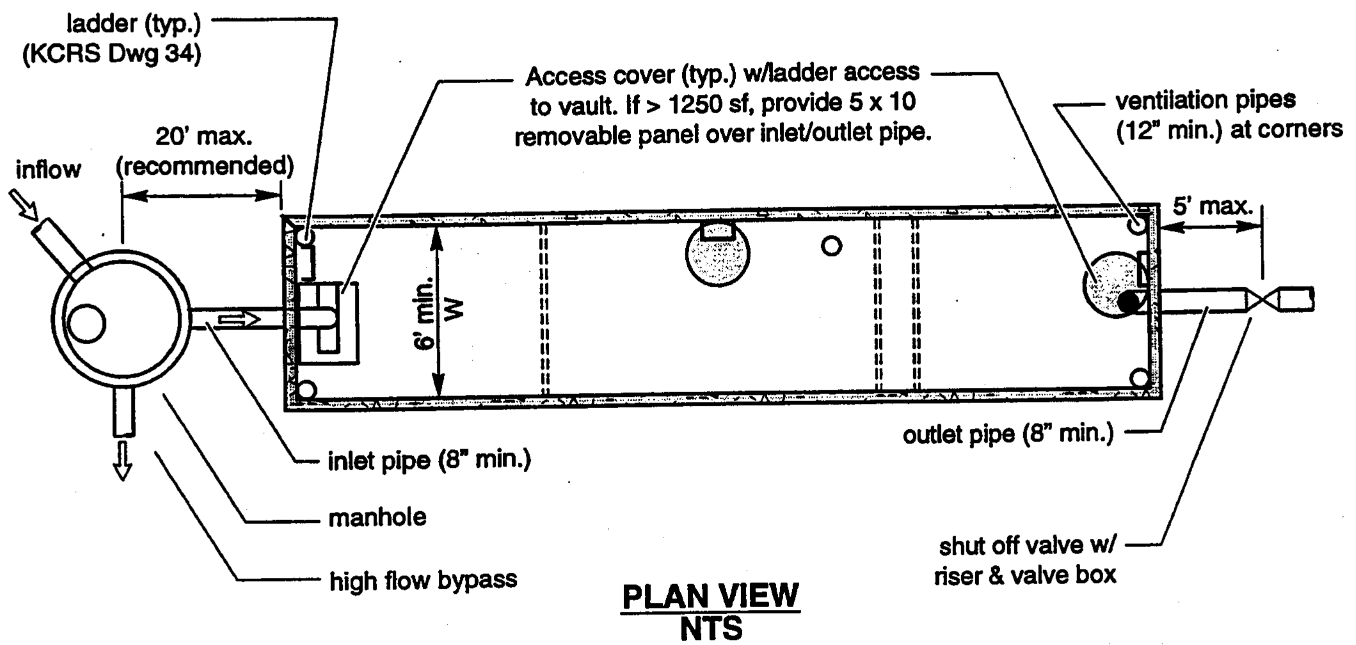
   a) Oil accumulation in the oil separation compartment equals or exceeds 1 inch, unless otherwise rated for greater oil accumulation depths recommended by the specific separator manufacturer.

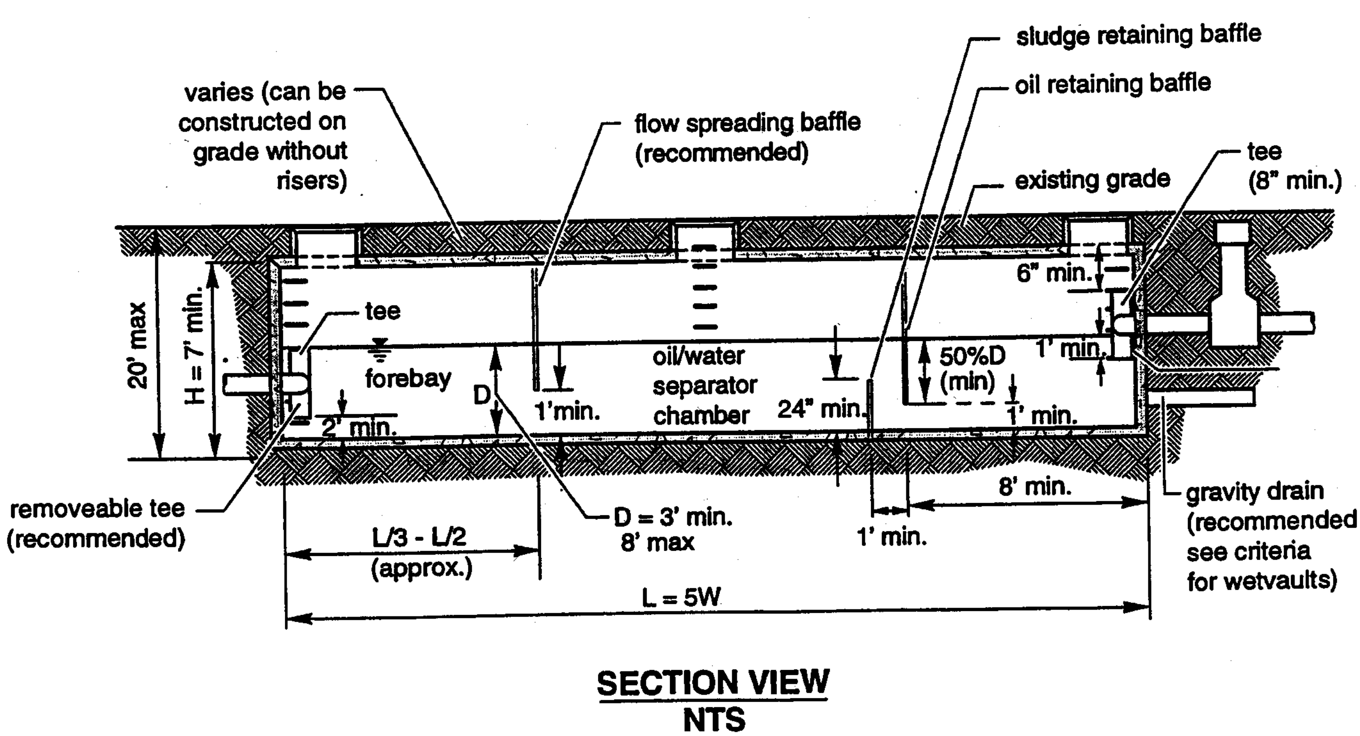
   b) Sediment deposits in the bottom of the vaults equals or exceeds 6 inches in depth.

2. For the first several years, oil/water separators should be checked on a quarterly basis for proper functioning and to ensure that accumulations of oil, grease, and solids in the separator are at acceptable levels. Effluent from the vault shall also be observed for an oil sheen to ensure that oil concentrations are at acceptable levels and that expected treatment is occurring. Separators should also be inspected after large storm events (about 2 inches in 24 hours).

3. Access to separators shall be maintained free of all obstructions, and units shall be readily accessible at all times for inspection and maintenance.
4. Maintenance personnel entering oil/water separator vaults should follow the state regulations pertaining to confined space entry, if applicable.

FIGURE 6.6.2.D BAFFLE OIL/WATER SEPARATOR





6.6.2.1 METHODS OF ANALYSIS

Background

Generally speaking, in most oil and water mixtures the degree of oil/water separation that occurs is dependent on both the time the water is detained in the separator and the oil droplet size. The sizing methods in this section are based on Stokes' law:

$$V_T = \frac{g(d_p - d_c)D_o^2}{18\mu} \qquad (6\text{-}21)$$

where V_T = rise velocity of oil droplet
g = gravitational constant
d_p = density of droplet to be removed
d_c = density of carrier fluid
D_o = diameter of oil droplet
μ = absolute viscosity of carrier fluid

1. The basic assumptions inherent in Stokes' law are: (1) flow is laminar, and (2) the oil droplets are spherical.

Traditional baffle separators are designed to provide sufficient hydraulic residence time to permit oil droplets to rise to the surface. The residence time T_r is mathematically expressed as follows:

$$T_r = \frac{V}{Q} \qquad (6\text{-}22)$$

where V = effective volume of the unit or container, or $A_s \times H$, where
A_s = surface area of the separator unit, and
H = height of water column in the unit

Q = hydraulic capacity or flow through the separator

The time required for the oil droplet to rise to the surface within the unit is found by the relation:

$$T_T = \frac{H}{V_T} \qquad (6\text{-}23)$$

where V_T = rise velocity of the oil droplet

The oil droplet rises to the water surface if the residence time in the separator is at least equal to the oil droplet rise time. This can be expressed as follows:

$$T_r = T_T$$

By substituting terms and simplifying:

APPENDIX I

Glossary of Terms

Appendix I: Glossary of Terms

Note: Definitions are intended to be consistent with Gresham Revised Code, Public Works Standards and Gresham Development Code.

Absorption: the process of being taken up, as in "a plant's roots absorb water".

Adsorption: the adhesion in an extremely thin layer of molecules (as of gases, solutes, or liquids) to the surfaces of solid bodies or liquids with which they are in contact

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

Best Management Practices (BMPs): Procedures, practices, prohibition of practices, activities, educational activities used to prevent or reduce the discharge of pollutants directly or indirectly to waters of the state or the United States. BMPs include but are not limited to treatment requirements, operating and maintenance procedures, practices to control site runoff, spillage or leaks, waste disposal, and drainage of materials from storage; and the prohibition of specific activities, practices, and procedures.

Biological Oxygen Demand (BOD): The amount of oxygen used for biochemical oxidation by a unit volume of water at a given temperature and for a given time. BOD is an index of the degree of organic pollution in water. Also called biochemical oxygen demand. See also chemical oxygen demand.

Bioswale: A broad bottomed, shallow, vegetation (grass only) lined channel, which allows for reduced flow velocity and filtration of stormwater, generally with flow depths less than one foot. (See also Vegetated Swale).

Building Footprint: The area enclosed by the perimeter walls of the house and the garage. If there is a carport instead of a garage, the area of the carport shall be included.

Capacity: The capacity of a stormwater drainage system is the flow volume or rate that a facility (e.g., pipe, pond, vault, swale, ditch, drywell, etc.) is designed to safely contain, receive, convey, reduce pollutants from or infiltrate stormwater that meets a specific performance standard. There are different performance standards for pollution reduction, detention, conveyance, and disposal, depending on location. Example: Public storm sewer pipes are required to convey the 10-year storm without surcharge, and the 25-year storm without damage to property or endangering human life or public health. Public infiltration sumps are required to infiltrate the 10-year storm with a safety factor of two. Combined sewers that overflow during a 25-year storm are not considered to have adequate capacity.

Catch Basin: A structural facility located just below the ground surface, used to collect stormwater runoff for conveyance purposes. Generally located in streets and parking lots, catch basins have grated lids, allowing stormwater from the surface to pass through for collection.

Chemical Oxygen Demand (COD): The quantity of oxygen used in biological and non-biological oxidation of materials in water; a measure of water quality. See also biological oxygen demand.

Combination Facilities: Systems that are designed to meet two or more of the multiple objectives of stormwater management.

Constructed Marsh: Wetlands (see definition) designed and constructed for the specific purpose of providing stormwater management. Unlike natural wetlands, the Corps of Engineers and the Division of State Lands do not regulate constructed marshes. See **Section 5.0** for information regarding the design.

Contained Planter Box: A structural facility filled with topsoil and planted with vegetation. When placed over impervious surfaces such as sidewalks or rooftops, contained planter boxes intercept rainfall that would otherwise contribute to stormwater runoff.

Control Structure: A device used to hold back or direct a calculated amount of stormwater to or from a stormwater management facility. Typical control structures include vaults or manholes fitted with baffles, weirs, or orifices.

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

DDE (dichloro-diphenyl-ethylene): See DDT.

DDT (dichloro-diphenyl-trichloroethane): An organochlorine insecticide used to control mosquitoes and other insects. DDT is very toxic, very persistent in the environment, and bioaccumulates in many animals to a large degree. DDT commonly degrades to DDE (dichloro-diphenyl-ethylene) in the environment. DDT was banned from use in the United States in 1972.

Design Intensity: The uniform rainfall intensity, inches per hour, associated with a duration equal to the time of concentration of the basin and a specified return frequency (e.g., 2yr., 10 yr., etc.), that is used to calculate the peak discharge rate to be used for conveyance system design.

Design Storm: A rainfall event of a specified duration (e.g., 6-, 12-, 24 hr.) and return frequency (e.g., 2yr., 10 yr., etc.) that is used to calculate the runoff volume and/or discharge rate to be used for system design.

Detention: The storage and subsequent release of excess stormwater runoff to control peak discharge rates prior to discharge to the storm sewer or natural drainageway.

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

Detention Tank, Vault, or Oversized Pipe: A structural subsurface facility used to provide flow control for a particular drainage basin. See **Section 4.0** for information regarding the design of detention tanks, vaults, and oversized pipes.

Detention Volume: The storage volume required to control the peak discharge rates at the point of discharge from a development.

Development: Physical improvement to real property, including the construction of structures or the placement of pavement or other impervious surfaces that result in an increase in the area of impervious surface on the property.

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

Dioxins: A family of chlorinated hydrocarbon compounds known chemically as dibenzo-p-dioxins. Dioxins are highly toxic and persist in the environment for extended periods. They are produced during incineration of wastes, metal smelting and are a contaminant in chemical manufacturing processes. In general, the term "dioxin" only includes both PCDD (polychlorinated-dibenzo-p-dioxins or "dioxin") and PCDF (polychlorinated-dibenzo-furans or "furan"). Also closely related in molecular structure to PCBs, see definition.

Disposal: The ultimate discharge point for the stormwater from a particular site. Disposal points can include drywells and sumps, soakage trenches, ditches, drainage ways, rivers and streams, off-site storm pipes, and off-site combination sewers.

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

Drainage Residential Unit (DRU): One drainage residential unit is the impervious surface area which is estimated to place approximately equal demand on the public stormwater system as that placed by an average dwelling unit. One DRU equals 2500 square feet of impervious surface.

Dry Detention Pond: A surface vegetated basin used to provide flow control for a particular drainage basin. Stormwater temporarily fills the dry detention pond during large storm events and is slowly released over a number of hours, reducing peak flow rates. See **Section 4.0** for information regarding the design of dry detention ponds.

Drywell: A structural subsurface facility with perforated sides or bottom, used to infiltrate stormwater into the ground. See **Section 8.0** for information regarding the design and use of drywells. (See also Stormwater Sump).

Dwelling Unit: One or more rooms designed for occupancy by one family for living purposes and having only one cooking facility.

Easement: Areas located outside of dedicated rights-of-way, which are granted to the City for special uses and public facilities.

Eco-Roof: A low-maintenance vegetated roof system used in place of a conventional roof. Eco-roofs provide stormwater management by capturing, filtering, and evaporating rainfall.

Extended Wet Detention Pond: A surface vegetated basin with a permanent pool of water and additional storage volume, used to provide pollution reduction and flow control for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. During large storm events, stormwater temporarily fills the additional storage volume and is slowly released over a number of hours, reducing peak flow rates. See **Section 4.0** for information regarding the design of extended wet detention ponds.

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

Flow-Through Planter Box: A structural facility filled with topsoil and gravel and planted with vegetation. The planter is completely sealed, and a perforated collection drain is placed in its bottom and directed to an acceptable disposal point. The stormwater planter receives runoff from impervious surfaces, where it is filtered and retained for a period of time. See **Section 3.0** for information regarding the design of flow-through planter boxes.

Groundwater: Water located below the ground surface or surface water, which has infiltrated into the ground.

Hazardous Materials: Any material, including any substance, waste, or combination thereof, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to, a substantial present or potential hazard to human health, safety, property, or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

Illicit Discharge: Any discharge to the public stormwater system that is not entirely stormwater, not covered under a Municipal or Industrial NPDES permit, or not exempted as described in the Clean Water Act.

Impervious Area: Those hard surface areas located upon real property which either prevent or retard saturation of water into the land surface, as existed under natural conditions pre-existent to development, and cause water to run off the land surface in greater quantities or at an increased rate of flow from that present under natural conditions pre-existent to development.

Impervious Surface: Any structures or surface improvements that prevent or retard infiltration of water into the surface of the soil or that cause water to run off the surfaces in greater quantity or at an increased rate of flow compared to the natural condition of the property before development. Common impervious surfaces include, but are not limited to rooftops, concrete or asphalt sidewalks, walkways, patio areas, driveways, parking lots or storage areas, oiled or macadam surfaces, or other surfaces that similarly impede the natural infiltration or increase runoff patterns.

Improved Property: Any property, public or private, which the manager determines has been altered such that the net stormwater runoff from the site is greater than that which could be expected without the alteration. Improved property shall not include highways and roads within the State of Oregon or Multnomah County rights-of-way.

Improvement Fee: A fee for costs associated with capital improvements to be constructed after the date the fee is adopted.

Indirect Discharge: Any stormwater discharged into or that ultimately reaches the public stormwater system from a private source such as, but not limited to, private detention and retention systems, dams, sumps, recharging wells, injection wells, culverts, levees, and wetlands.

Industrial Discharger: Discharger of stormwater associated with industrial activity as defined by 40 CFR 122.26.

Industrial NPDES Stormwater Discharge Permits: General, group, or individual permits issued by Oregon DEQ regulating facilities defined in 40 CFR 122.26 which engage in industrial activity pursuant to the Clean Water Act.

Infiltration: The percolation of water into the ground.

Infiltration Planter Box: A structural facility filled with topsoil and gravel and planted with vegetation. The planter has on open bottom, allowing water to infiltrate into the ground. Stormwater runoff from impervious surfaces is directed into the planter box, where it is filtered and infiltrated into the surrounding soil. See **Section 3.0** for information regarding the design of infiltration planter boxes.

Inlet: The point at which stormwater from impervious surfaces or conveyance piping enters a stormwater management facility. The term "inlet" can also be used in reference to a catch basin (see definition).

Littoral: Pertaining to the shore zone between high and low marks.

Low Impact Development: Development that utilizes stormwater management techniques that rely principally on retention, infiltration and evapotranspiration to treat runoff, and reduce the volume and duration of a stormwater discharge. These stormwater management techniques are generally referred to as "green development practices" because they mimic and incorporate the predevelopment hydrology of a site after development has occurred. These techniques are most effective when designed, constructed and located on-site as close to the runoff as possible. Refer to **Section 2.0.**

Major Storm Event: A rain or snow storm, or combined rainfall and snow melt event which produces stormwater runoff equivalent to that produced by the ten year to 100 year rainfall events.

Maximum Extent Practicable (MEP): See definition of *Practicable*.

Net Stormwater Runoff: The increment of stormwater runoff from a property that is attributable to development on that property.

Non-Stormwater Discharge: Any discharge to the public stormwater system that is not entirely stormwater.

Off-site stormwater facility: Any stormwater management facility located outside the property boundaries of a specific development, but designed to reduce pollutants from and/or control stormwater flows from that development.

Oil-Water Separator: A facility intended to remove oil and grease from stormwater. See **Section 6.0** for oil-water separator design criteria.

On-Site Detention: The detention of stormwater from a private storm drain in a privately owned and maintained storm system to provide a controlled release, at or below a maximum allowable rate, to the public storm drain system.

On-site Mitigation Facilities: Facilities, which the manager has determined, reduce net stormwater runoff from an improved property and reduce pollution into the surface water and groundwater. These mitigation facilities include systems, which retain, or otherwise dispose of stormwater runoff in a manner prescribed by the city. On-site mitigation facilities must be designed, constructed, and maintained to the city's standards. Acceptable on-site mitigation facilities shall be described by the city.

Open Drainage way A natural or man-made path, swale, ditch, or channel that has the specific function of conveying natural stream water or stormwater runoff.

Operations and Maintenance (O&M): The continuing activities required to keep stormwater management facilities and their components functioning in accordance with design objectives. See

Section 9.0 and ***Appendix B*** regarding operations and maintenance requirements for stormwater management facilities.

Outfall: The point at which stormwater is discharged from a contained conveyance system, such as a pipe, to a surface drainage system.

Peak Run-off: The maximum stormwater run-off rate (cfs) determined for the design storm, or design rainfall intensity.

Pollutant: Anything which causes or contributes to pollution.

Pollutants of Concern: Watershed-specific parameters identified by the Oregon Department of Environmental Quality (DEQ) and the City of Gresham as having a negative impact on the receiving water body. Pollutants of concern can include suspended solids, heavy metals, nutrients, bacteria and viruses, organics, floatable debris, and increased temperature. See **Section 1.0** of this *Manual*.

Pollution: The degradation of the physical, thermal, chemical, biological or radioactive properties of the public stormwater system or the waters of the state or the United States. Pollution also means the discharge of any pollutant into the public stormwater system or the waters of the state or the United States, which will or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety, or welfare, or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

Polyaromatic Hydrocarbons: Hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases. They are also called Polycyclic Aromatic Hydrocarbons.

Polychlorinated Biphenyls: A "dioxin-like" substance that is similar in molecular structure, chemical properties, environmental persistence, bioaccumulation potential and toxic nature. See Dioxins.

Porous Pavement: The numerous types of pavement systems that allow stormwater to percolate through them and into subsurface drainage systems or the ground. See **Section 3.0** for design requirements related to porous pavement.

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

Practicable: Available and capable of being done as determined by the Stormwater Division Manager, after taking into consideration cost, existing technology, and logistics in light of overall project purpose, referred to in the Clean Water Act as "Maximum Extent Practicable".

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

Qualified Public Improvements: A capital improvement that is required as a condition of development approval, identified in the plan adopted pursuant to section 3.40.035 of the GRC, and either:
(1) Not located on or contiguous to property that is the subject of development approval; or

(2) Located in whole or in part on or contiguous to property that is subject of development approval and required to be built larger or with greater capacity than is necessary for the particular development project to which the improvement fee is related.

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

Reimbursement Fee: A fee for costs associated with capital improvements constructed or under construction on the date the fee is adopted.

Retention Facility: A facility designed to receive and hold stormwater runoff. Rather than storing and releasing the entire runoff volume, retention facilities permanently retain water on-site, where it infiltrates, evaporates, or is absorbed by surrounding vegetation. In this way, retention facilities reduce the total volume of excess water released to downstream conveyance facilities.

Right-of-Way: All land or interest therein which (by deed, conveyance, agreement, easement, dedication, usage, or process of law) is reserved for or dedicated to the use of the public for sidewalk, utility, and/or roadway purposes which the City has sole responsibility to maintain.

Roof Garden: A heavyweight roof system of waterproofing material with a thick soil and vegetation cover. Roof gardens provide stormwater management by capturing, filtering, and evaporating rainfall.

Runoff: Stormwater flows across the ground surface during and after a rainfall event.

Sand Filter: A structural facility with a layer of sand, used to filter pollutants from stormwater. See **Section 4.0** for information regarding the design of sand filters.

Sedimentation: Deposition of erosional debris-soil sediment transported by water from a higher elevation to an area of lower gradient where sediments are deposited as a result of slack water.

Soakage Trench: A long linear excavation backfilled with sand and gravel, used to filter pollutants from and infiltrate stormwater into the ground. See **Section 8.0** for information regarding the design of soakage trenches.

Stormwater: Surface runoff and drainage associated with rain/storm events and snowmelt.

Stormwater Customer: The stormwater customer shall be the person responsible for the property, or the person who causes or permits the discharge of net stormwater runoff, directly or indirectly into the public stormwater system. The State of Oregon and Multnomah County shall not be considered stormwater customers for any highway or road improvements within their rights-of-way. The State and Multnomah County shall be stormwater customers for all other property they own within Gresham.

Stormwater Discharge Associated with Industrial Activity: Discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. This term does not include discharges from the Municipal NPDES program under 40 CFR 122.

Stormwater Management: As used in this manual: The overall culmination of techniques used to reduce pollutants from, detain and/or retain, and dispose of stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows, or to incorporate sustainable building practices by reusing stormwater, on a development site. Public health and safety, aesthetics, maintainability, capacity of existing infrastructure and sustainability are important characteristics of a site's stormwater management plan.

Stormwater Management Facility: A single technique used to treat, detain, and/or retain stormwater to best preserve or mimic the natural hydrologic cycle, or to fit within the capacity of existing infrastructure, on a development site.

Stormwater Sump: A drainage facility (or system), also called "underground injection control", designed to utilize the infiltration capability of the ground, commonly referred to as percolation, to dispose of surface and stormwater runoff. See **Section 8.0** for information regarding Infiltration. (See also Drywell).

Surface Water: Water which travels over the ground surface to the public stormwater system or to private stormwater facilities.

Swale: A general term for a channeled facility designed to reduce flow velocity and increase infiltration. See specifically Bioswale and Vegetated Swale. See **Section 3.0**.

System Development Charge (SDC): An improvement fee collected at the time of increased usage of a capital improvement, at the time of issuance of a development permit or building permit, or at the time of connection to the capital improvement. System development charge does not include fees assessed or collected as part of a local improvement district or a charge in lieu of a local improvement district assessment, or the cost of complying with requirements or conditions imposed by a land use decision.

Time of Concentration (T of C): The time it takes stormwater runoff to travel from the most distant point on a particular site or drainage basin to a particular point of interest.

Total Maximum Daily Load (TMDL): A calculation of the some of the allowable pollutant loading that a body of water can receive from all contributing point and non-point sources. The calculation includes a measure of safety to ensure that the body of water complies with Section 303 of the Clean Water Act, which is established by the DEQ or EPA.

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

Toxic: Relating to a poison or toxin; poisonous.

Toxin: a poisonous substance that is a specific product of the metabolic activities of a living organism and is usually very unstable, notably toxic when introduced into the tissues, and typically capable of inducing antibody formation.

Underground Injection Control: A general term for stormwater facilities designed to percolate water into the ground, rather than allowing any flow to surface water. Refer to **Section 8.0** of this *Manual* and see specifically Drywell and Stormwater Sump.

Underground Injection Control (UIC) Program: A federal program under the Safe Drinking Water Act, delegated to the Oregon Department of Environmental Quality (DEQ), which regulates the injection of water below ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. Refer to **Section 8.0.**

Vegetated Filter Strip: A gently sloping, densely vegetated area (trees, shrubs and grasses) used to filter, slow, and infiltrate stormwater. See **Section 3.0** for information regarding the design of vegetated filter strips.

Vegetated Infiltration Basin: A vegetated surface facility that temporarily holds and infiltrates stormwater into the ground. See **Section 8.0** for information regarding the design of vegetated infiltration basins.

Vegetated Swale: A long, narrow, trapezoidal or circular channel, planted with a variety of trees, shrubs, and grasses. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out. Check dams are used to create small ponded areas to facilitate infiltration. See **Section 3.0** for information regarding the design of vegetated swales. (See also Swale).

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

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

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

Wet Pond: A surface vegetated basin with a permanent pool of water, used to provide pollution reduction for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. See **Section 4.0** for information regarding the design of wet ponds.

Wetlands: Those lands adjacent to watercourses or isolated therefrom which may normally or periodically be inundated by the waters from the watercourse or the drainage waters from the drainage basin which it is located. These include swamps, bogs, sinks, marshes, and lakes, all of which are considered to be part of the watercourse and drainage system of the City and shall include the headwater areas where the watercourse first surfaces. They may be, but are not necessarily, characterized by special soils such as peat, muck, and mud.